Vermont Agency of Transportation

2024 Standard Specifications for Construction

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PREFACE

This edition of the *Standard Specifications for Construction* was adopted in June 2023 in compliance with *19 V.S.A. § 10(4)* and is on file at the Vermont State Library and at the office of the Secretary, Vermont Agency of Transportation. The provisions of these specifications shall apply to all construction Contracts entered into by the Vermont Agency of Transportation. Variations from these specifications will not be permitted except as provided for by the Special Provisions included in the Contract.

Plans are approved by the Agency with the understanding that the work covered by such Plans shall be performed in accordance with these specifications and any Special Provisions included in the Contract. The Contract will, by citing the title and date of adoption, incorporate the *Standard Specifications for Construction* by reference.

Printed copies of the *Standard Specifications for Construction* may be purchased from the Agency. Information on ordering printed copies may be found at: https://vtrans.vermont.gov/highway/construct-material/construct-services/pre-contractspecifications/purchasing.

Electronic copies of the *Standard Specifications for Construction* and other Agency specifications may be viewed and downloaded for free at: https://vtrans.vermont.gov/highway/construct-material/construct-services/pre-contractspecifications/vermont.

Should you have any questions, comments, or suggestions regarding the *Standard Specifications for Construction*, please contact the Vermont Agency of Transportation, Pre-Contracts and Specifications Office by e-mail at: AOT.HWYPrecontractSpecifications@vermont.gov.

Joe Flynn

Secretary of Transportation

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ACKNOWLEDGEMENTS

With the addition of 40 new sections, over 550 pages of content, more than 400 new pay items, and the complete revision of numerous existing sections, the 2024 edition of the *Standard Specifications for Construction* represents one of the most substantial modifications to the Agency's specifications in decades. These changes would not have been possible without the help of dozens of people throughout the Agency, including, but in no way limited to, those listed below.

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Many other people throughout the Agency, far too numerous to mention by name, assisted in writing and compiling this book over the past five years, and their contributions are greatly appreciated. Particular thanks are given to those subject matter experts who helped incorporate hundreds of pages of Special Provision content into the *Standard Specifications for Construction*.

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101.01 ABBREVIATIONS. All standard recognized abbreviations may be used in connection with the Contract. In addition, wherever the following abbreviations are used in these in the Contract, they are to be construed the same as the respective expressions represented. For abbreviations of pay units, see Table 109.01A.

AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ABS	Acrylonitrile-Butadiene-Styrene
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
AISC	American Institute of Steel Construction
AITC	American Institute of Timber Construction
AHCWS	Automatic Highway Crossing Warning System
ANR	Vermont Agency of Natural Resources
ANSI	American National Standards Institute
API	American Petroleum Institute
APL	Approved Products List
AQL	Acceptable Quality Level
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASD	Allowable Strength Design
ASME	American Society of Mechanical Engineers
ASNT	American Society of Nondestructive Testing
ASR	Alkali-Silica Reactivity
ASTM	ASTM International
ATC	Advanced Transportation Controller
AWPA	American Wood Protection Association
AWS	American Welding Society
AWWA	American Water Works Association
BTU	British Thermal Unit

CAAP	Corrugated Aluminum Alloy Pipe
CCRL	Cement and Concrete Reference Laboratory
CF, ft^3	Cubic Foot
C.F.R.	Code of Federal Regulations
CLP	Clarendon and Pittsford Railroad
CPEP	Corrugated Polyethylene Pipe
CPPP	Corrugated Polypropylene Pipe
CRSI	Concrete Reinforcing Steel Institute
CSP	Corrugated Steel Pipe
CVEP	Conceptual Value Engineering Proposal
CWHSSA	Contract Work Hours and Safety Standards Act
CWR	Continuous Welded Rail
CY, yd^3	Cubic Yard
DI	Drop Inlet
DTA	District Transportation Administrator
DVEP	Detailed Value Engineering Proposal
ECTC	Erosion Control Technology Council
EPA	U.S. Environmental Protection Agency
EPSC	Erosion Prevention and Sediment Control
ES	End Section (Section 601)
FAA	Federal Aviation Administration, U.S. Department of Transportation
FDR	Full Depth Reclamation
FHWA	Federal Highway Administration, U.S. Department of Transportation
FPQ	Final Pay Quantity
FRA	Federal Railroad Administration, U.S. Department of Transportation
FSS	Federal Specifications and Standards (General Services Administration)
FTA	Federal Transit Administration, U.S. Department of Transportation
g	Gram
GMRC	Green Mountain Railroad
HDPE	High Density Polyethylene
Hz	Hertz
ID/IQ	Indefinite Delivery/Indefinite Quantity
IFI	Industrial Fasteners Institute
IMSA	International Municipal Signal Association
$in.^2$	Square Inch
ISEA	International Safety Equipment Association
ITE	Institute of Transportation Engineers
JMF	Job Mix Formula
JOC	Job Order Contract

kg	Kilogram
kip	Thousand Pounds-Force
kPa	Kilopascal
ksi	Kips per Square Inch
kW	Kilowatt
lb	Pound
lbf	Pound-Force
LRFD	Load and Resistance Factor Design
LSL	Lower Specification Limit
LVRT	Lamoille Valley Rail Trail
MASH	Manual for Assessing Safety Hardware
Mbps	Megabits per second
MM	Mile Marker
mm	Millimeters
MP	Mile Post
MSM	Materials Sampling Manual
MUTCD	Manual on Uniform Traffic Control Devices for Streets and Highways
MVRT	Missisquoi Valley Rail Trail
N.A.B.I.	Not A Bid Item
NCHRP	National Cooperative Highway Research Program
NDS	National Design Specification
NDT	Nondestructive Testing
NEC	National Electrical Code
NECR	New England Central Railroad
NEPCOAT	North East Protective Coating Committee
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NETC	New England Transportation Consortium
NHS	National Highway System
NPS	Nominal Pipe Size
NSBA	National Steel Bridge Alliance
NSPE	National Society of Professional Engineers
OSPC	On-Site Plan Coordinator
OSA	Off-Site Activity
OSHA	U.S. Occupational Safety and Health Administration
OTM	Other Track Material
Pa	Pascal
PCA	Portland Cement Association
PCC	Portland Cement Concrete
PCCSP	Polymeric Coated Corrugated Steel Pipe

pcf	Pounds per Cubic Foot
PCI	Precast/Prestressed Concrete Institute
PI	Paved Invert
PRLT	Preferred Rail Laying Temperature
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
PWL	Percent Within Limits
QAP	Quality Assurance Program
QC	Quality Control
RAM	Recycled Asphalt Materials
RAP	Recycled Asphalt Pavement
RAS	Recycled Asphalt Shingles
RCP	Reinforced Concrete Pipe
ROW or R.O.W	Right-Of-Way
RQL	Rejectable Quality Level
SAE	Society of Automotive Engineers
SF, ft^2	Square Feet
SL	Smooth Lined
SSPC	The Society for Protective Coatings
STD	Single Test Deviation
SY, yd^2	Square Yard
TL	Test Level
TO	Turnout
UL	Underwriters Laboratories, Inc.
U.S.C.	United States Code
USL	Upper Specification Limit
UTO	Uniformed Traffic Officer
V	Volt
VAOT, AOT, or VTrans	Vermont Agency of Transportation
V:H	Vertical to Horizontal
VOSHA	Vermont Occupational Safety and Health Administration
VRS	Vermont Rail System
V.S.A.	Vermont Statutes Annotated
VTR	Vermont Railway
W	Watt
WACR	Washington County Railroad
yd	Yard

°C	Degrees Celsius
°F	Degrees Fahrenheit
MΩ	Megaohm
µg	Microgram
µm	Micrometer
µW	Microwatt
Ω	Ohm

101.02 DEFINITIONS. Wherever in these specifications or elsewhere in the Contract the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

ACCEPTABLE MATERIAL – Material that is compliant with all designated acceptance criteria.

ACCEPTABLE QUALITY LEVEL – In Section 406, the level of actual quality of the material, which, if equaled or exceeded, will result in a pay adjustment greater than or equal to zero.

ACCEPTANCE DATE – The date noted in the Completion and Acceptance Memorandum on which designated responsible Agency personnel have accepted the completeness and quality of all material incorporated in and work performed to complete the Contract.

ACT OF GOD – An act of God means an earthquake, flood, cyclone, or other cataclysmic phenomena of nature beyond the ability of a prudent Contractor to foresee and make preparation to defend against damage.

ADMINISTRATIVE SUBMITTALS – Submittals related to the safe mobility of the travelling public, schedule, and environmental protections that are required to be received prior to the preconstruction conference and approved or found to be in conformance prior to the Notice to Proceed as specified in the respective sections.

AGENCY – The Agency of Transportation of the state of Vermont (VAOT, AOT, or VTrans).

APPROVED PRODUCTS LIST – A listing of products and materials that have been evaluated by the Agency, for applicable specifications, and have been deemed satisfactory for use on Contracts without additional certification requirements.

AUTHORIZATION TO PROCEED – Written notice confirming that the Contract has been successfully executed and the Contractor may progress Contract work, including administrative submittals required by the Contract.

AUTHORIZED REPRESENTATIVE –

(a) Contractor's. An individual registered with the Contract Administration Section having the legal authority to sign the Contract on behalf of the Contractor.

(b) Agency's. The Chief Engineer's authorized representative(s) responsible for engineering supervision of the construction project.

BASE COURSE – The layer or layers of specified or selected material of designed thickness on a subbase to support a surface course.

BEDROCK – Solid rock in its native location; solid rock exposed at the surface of the earth or overlain by unconsolidated material.

BIWEEKLY – Occurring once every two weeks.

BORROW AREA – All borrow pits, gravel pits, quarries, sand pits, and similar sources of materials used in the construction of the project.

BOULDER – A rock fragment, usually rounded by weathering or abrasion, with an average dimension of 12 inches or more.

BRIDGE –

(a) Highway Bridge. A structure, including supports, erected over a depression or an obstruction such as water, a highway, or a railroad, having a passageway for carrying traffic or other moving loads and having a clear span of more than 20 feet (6 feet on non-federal-aid projects) measured along the center of the roadway between abutments, spring lines of arches, extreme ends of openings for multiple boxes, or multiple pipes where the clear distance between openings is less than 50% of the smaller contiguous opening.

    (1) Highway Bridge Length. The dimension of a structure measured along the center of the roadway between the backs of abutment backwalls or between the ends of a bridge floor, whichever is greater.

    (2) Highway Bridge Width. The clear dimension of a structure measured at right angles to the center of the roadway between the inner faces of parapet or railing.

(b) Railroad Bridge. Any structure with a deck, regardless of length, which supports one or more railroad tracks, or any other under grade structure with an individual span length of 10 feet or more located at such a depth that it is affected by live loads.

(1) Railroad Bridge Length. The dimension of a structure measured along the center of the railroad between the backs of abutment backwalls or between the ends of a bridge floor, whichever is greater.

(2) Railroad Bridge Width. The clear dimension of a structure measured at right angles to the center of the railroad between the inner faces of parapet or railing.

CALENDAR DAY – Any day shown on the calendar, beginning at midnight and ending immediately before midnight of the following day.

CHANGE ORDER – A written agreement made and entered into by and between the Contractor and the Agency covering work not otherwise provided for in the Contract, revisions in or amendments to the terms of the Contract, a change to the original quantities as set forth in the original Contract, or conditions specifically described in these specifications as requiring a change order. Change orders constitute amendments to the original Contract once properly signed and executed.

CHIEF ENGINEER – The authorized representative of the Agency, appointed by the Secretary of Transportation to administer the Highway Division.

CLAIM –

(a) Contractor's Claim. A claim by the Contractor for adjustment or dispute under Subsection 105.20.

(b) Damage Claim. A claim by an individual or entity for damage to property or for personal injury.

(c) Labor and Materials Claim. A claim by a subcontractor, supplier, or other entity covered by the provisions of *19 V.S.A. § 10(9)* for monies claimed to be due and payable.

CLAY – Fine-grained soil or the fine-grained portion of soil that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dried.

CLEAR ZONE – The roadside border area starting at the edge of the traveled way available for use by errant vehicles. Specified clear zones are as shown in the Plans.

COBBLE – A rock fragment, usually rounded or semi-rounded, with an average dimension between 3 inches and 12 inches.

COLLUSION – A secret agreement among two or more persons, companies, or organizations for a deceitful or fraudulent purpose.

COMPACTION – Densification by means of mechanical manipulation.

COMPLIANT MATERIAL – In Section 406, a material that has a PWL greater than or equal to the specified RQL, or, for the single test departure evaluation method, material where the single test result is greater than or equal to the specified RQL.

CONDUIT – A tube used for carrying, holding, and protecting electrical or other utilities.

CONSTRUCTION AREA – The entire portion of a project site within the right-of-way and easement limits during construction.

CONSTRUCTION EASEMENT – See EASEMENT.

CONSTRUCTION ENGINEER – The authorized representative of the Agency responsible for engineering supervision once the Contract has been signed and until completion and final acceptance.

CONSTRUCTION ENVIRONMENTAL ENGINEER – The authorized representative of the Agency that provides guidance and technical assistance to the Engineer and Contractor on environmental compliance issues.

CONSTRUCTION OPERATIONS – A visible presence at the project site that may impact traffic or environmental resources.

CONSTRUCTION SEASON – The period from April 1st through November 15th, inclusive.

CONSTRUCTION STRUCTURES ENGINEER – The authorized representative of the Agency that provides guidance and technical assistance to the Engineer and Contractor on structural issues.

CONTRACT – The written agreement between the Agency and the Contractor setting forth the obligations of the parties relative to the performance of the work.

The Contract includes the Contract agreement, Contract bonds, project permits, Contract Plans, Standard Drawings, Standard Specifications, Special Provisions, and any change orders or supporting documents that are required to complete the work in an acceptable manner.

CONTRACT BONDS – The approved forms of security, signed, notarized, and furnished by the Contractor and the Contractor's surety or sureties, guaranteeing complete performance of the Contract, compliance with the Contract, and the payment of all legal debts pertaining to the construction of the project or work.

CONTRACT COMPLETION DATE – The calendar date specified in the Contract, and as adjusted by change order when applicable, by which the Contractor shall achieve substantial completion.

CONTRACT DURATION – The number of working days or calendar days prescribed in the Contract to complete the work.

CONTRACT ITEM – A specific unit of work for which a price is provided in the Contract.

CONTRACTOR – The individual, partnership, firm, corporation, any acceptable combination thereof, or a joint venture which is a party to the Contract with the Agency which is undertaking the performance of the work under the terms of the Contract and acting directly or through its agent(s) or employee(s). The term Contractor means the prime Contractor as differentiated from a subcontractor. All Contractors shall be registered with the Vermont Secretary of State. The Contractor will act in an independent capacity and not as officers or employees of the state.

CONTRACT PLANS – See PLANS.

CONTROL LIMITS – In Section 406 and Section 407, the limits established by the Contractor in their QC plan that will trigger them to cease production, develop a corrective action plan, and take corrective action to improve the quality of the material being produced.

CRITICAL PATH – The critical path is the sequence of project activities with the longest total duration, which must be completed on time for the Contract to be finished by the completion date.

CRITICAL PATH METHOD (CPM) SCHEDULE – A schedule that depicts work activities in a time-based, logic diagram format showing the relationship with preceding and succeeding activities with the critical path clearly indicated.

DAY – When not specified as a working day or a calendar day, any 24 hour period.

DETOUR – A temporary route to carry traffic.

DIRECT MELT GLASS BEADS – Glass beads derived from recycled glass by returning the glass to a molten form, removing impurities, and refining the glass into near-virgin glass beads.

DIRECTOR OF THE HIGHWAY DIVISION – See CHIEF ENGINEER.

DIRECTOR OF THE POLICY, PLANNING, AND INTERMODAL DEVELOPMENT DIVISION – The authorized representative of the Agency, appointed by the Secretary of Transportation to administer the Policy, Planning and Intermodal Development Division.

DISTRICT TRANSPORTATION ADMINISTRATOR – The authorized representative of the Agency for a maintenance district subdivision of the state who is responsible for maintenance of state transportation facilities.

EARTH – See SOIL (EARTH).

EASEMENT – A right acquired to use or control property outside of the established right-of-way limits for a designated purpose.

EMBANKMENT – That portion of a filled area situated between the previously existing ground level and the subgrade (roadbed).

ENCROACHMENT – Use of highway or railroad right-of-way or easement unlawfully and/or without authority or permission.

ENGINEER – The authorized representative of the Agency and the Chief Engineer who is responsible for engineering supervision of a Contract.

EQUIPMENT – All machinery, instruments, tools, vehicles, and apparatuses together with the necessary supplies for upkeep and maintenance, for the proper construction and acceptable completion of the work.

EXTRA WORK – An item of work not provided for in the Contract as awarded but determined to be essential to the satisfactory completion of the Contract. Extra work shall be performed at agreed upon prices or on a force account basis as provided in the Contract.

EXTRA WORK ORDER – A form used to provide for the performance of work or furnishing of materials involving extra work.

FINAL ESTIMATE – A compilation of item quantities prepared upon completion of the Contract stating the whole amount of work done by the Contractor and the final amount to be paid under the Contract.

FINALS ENGINEER – The authorized representative of the Agency responsible for handling all issues related to finalizing a Contract.

FORCE ACCOUNT – Prescribed work paid for on the basis of actual costs, including appropriate extra work, as defined in Subsection 109.06.

FOULING – The condition arising when the location of an individual or an item of equipment is in such proximity to a railroad track that the individual or equipment could be struck by a moving train or on-track equipment, and as defined by the Operating Railroad.

GAGE – The distance between the heads of railroad rails, measured at a point 5/8 inches below the top of the railroad rail. Standard gage measures 4 feet 8-1/2 inches.

GEOLOGIST – The authorized representative of the Agency who provides expertise pertaining to the field of geology, such as bedrock and unbound aggregates, as specified in the Contract.

GEOTECHNICAL ENGINEERING MANAGER – The authorized representative of the Agency who provides guidance and technical assistance relating to soils and aggregates, and geotechnical and geological engineering.

GRAVEL – Rounded or semi-rounded particles of rock that will pass the 3 inch (75.0 mm) sieve and be retained on the No. 10 (2.00 mm) sieve.

HARDNESS – The resistance of a material to deformation, particularly permanent deformation, indentation, or scratching.

HAZARDOUS MATERIALS AND WASTE COORDINATOR – The authorized representative of the Agency who provides guidance and technical assistance to the Engineer and Contractor on hazardous materials and waste issues.

HIGHWAY – See ROADWAY.

INSPECTOR – An authorized representative of the Engineer assigned to make detailed inspections of Contract performance.

JOB MIX FORMULA – The project-specific formula that specifies the target value for each property of the mixture.

LABORATORY – The Agency's Materials Testing and Certification Section Central Laboratory or any other testing laboratory which may be designated by the Engineer.

LIQUIDATED DAMAGES – The charge assessed to the Contractor pursuant to the Contract because the Contractor did not achieve substantial completion within the Contract time or by the Contract completion date. Liquidated damages are not a penalty but an assessment of damages that are impossible or difficult to determine with accuracy.

LOAD TICKET – A ticket accompanying a load of material and indicating the gross weight of the load, less the tare weight of the delivery vehicle, and other information as specified and/or as required by the Engineer.

LOAM – A mixture of sand, silt, or clay, or a combination of any of these, with organic matter.

LOT – A specific quantity of material from a single source that is assumed to be produced and placed by the same controlled process.

LOWER SPECIFICATION LIMIT – In Section 406 and Section 407, the limit below which the material characteristics become undesirable. It is one of the components used to calculate the total PWL.

MAJOR ITEM – Any Contract item that has a total bid value greater than 20% of the total bid amount of the Contract.

MASS – The words mass and weight are used interchangeably. Mass must be converted to force before computing structural reactions, shears, moments, or internal stresses.

MATERIALS – Any substances specified for use in the construction of the project and its appurtenances.

MATERIALS MANAGER – The authorized representative of the Agency responsible for the acceptance testing and certification of materials incorporated in Contracts.

MEDIAN – Unless different in context, the portion of a divided highway separating opposing traveled ways.

MOISTURE CONTENT (WATER CONTENT) – The ratio, expressed as a percentage, of the mass (weight) of water in a given material to the mass (weight) of solid particles.

MUCK – A soil of very soft consistency containing greater than 10% organic matter.

NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM – The national evaluation and auditing program for manufactured products.

NIGHT – The period from sunset until sunrise of the following day, as determined by the *NOAA Solar Calculator* for the location of the project.

NON-PARTICIPATING – Designates work in which the cost is not shared by the federal and/or state government.

NOTICE TO PROCEED – Written notice to the Contractor stipulating the date on which the Contractor can begin construction operations subject to other Contract requirements.

OFF-SITE ACTIVITY AREA – An area located outside of the project's defined construction limits that is a necessary adjunct used for supporting the construction activities, including access roads, waste, borrow, and staging areas.

OPERATING RAILROAD – The entity with operating rights on a publicly or privately owned railroad.

OPTIMUM MOISTURE CONTENT (OPTIMUM WATER CONTENT) – The water content at which a soil can be compacted to the maximum dry density by a given compactive effort.

OTHER TRACK MATERIAL – Other railroad track material includes, but is not limited to, spikes, nuts, bolts, tie plates, tie plugs, railroad anchors, joint bars, and other ancillary components necessary for the construction of a track. OTM does not include ties or ballast.

PAVEMENT STRUCTURE – The combination of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

PAY ADJUSTMENT – In Section 406 and Section 407, the actual monetary adjustment, either positive or negative, which is assessed for accepted material based on the pay factor calculated for the given material characteristic. The intent of a pay adjustment is to relate payment to the quality of the work and expected service life.

PAY FACTOR – In Section 406 and Section 407, a numerical factor applied to accepted material in order to calculate the pay adjustment. It is related to the quality of the material and is calculated based on one or more measured characteristics.

PAY ITEM – A specific unit of work.

PERCENT WITHIN LIMITS – A statistical procedure for estimating the percent compliance with a specification that is affected by shifts in the arithmetic mean of the test results and by the sample standard deviation.

PLANS – The Contract drawings that show the location, character, and dimensions of the work, including layouts, profiles, cross-sections, and other details.

PLANT INSPECTOR – An authorized representative of the Agency assigned to perform detailed inspections of methods and materials at plants, including bituminous, concrete, and structural steel assembly plants.

PROFESSIONAL ENGINEER – A qualified registered professional engineer licensed in Vermont pursuant to *26 V.S.A., Chapter 20*.

PROGRAM MANAGER – The authorized representative of the Agency responsible for the allocation of funding and coordination of projects on a programmatic level.

PROJECT – The specific portion(s) of the transportation facility infrastructure on which work is to be performed under one or more Contracts.

PROJECT MANAGER – The authorized representative of the Agency responsible for the development of a specific project's design and its costs.

PUNCH LIST – List of items which are minor adjustments, repairs, or corrections to work that shall be completed prior to the acceptance of the project.

QUALITY ASSURANCE PROGRAM – The program that prescribes the practices for acceptance of material in construction and maintenance.

RAILBANKING – A railbanked line is an inactive line from which the tracks may or may not have been removed which has been approved for railbanking and interim trail use by the United States Surface Transportation Board under *16 U.S.C. § 1247(d)* or by the Vermont Secretary of Transportation under *5 V.S.A. § 3408*.

RAILROAD – The area within the limits of construction that is used for the movement of trains and that may include track, ties, ballast, subbase, and OTM.

RECYCLED ASPHALT MATERIAL – Recycled asphalt pavement, recycled asphalt shingles, or a combination of both.

REGIONAL CONSTRUCTION ENGINEER – The authorized representative of the Agency for a construction regional subdivision of the state who is responsible for administering and overseeing construction Contracts.

REJECTABLE MATERIAL – Material that is non-compliant with one or more designated acceptance criteria.

REJECTABLE QUALITY LEVEL – In Section 406, the level of actual quality below which the material or construction is deemed non-compliant with the specifications. If the PWL or single test departure is less than the RQL, then the material is non-compliant.

RESIDENT ENGINEER – See ENGINEER.

REVIEW FOR CONFORMANCE – A review of a working drawing for compliance with the requirements of the Contract.

RIGHT-OF-WAY – The land or property, or interests therein, devoted to transportation purposes.

ROADBED – See SUBGRADE.

ROADSIDE – The area adjoining the outer edge of the traveled way or shoulder of a highway. Extensive median areas between the roadways of a divided highway may also be considered roadside.

ROADWAY – The area within the limits of construction that is used for the movement of vehicular and pedestrian traffic and that may include the traveled way, shoulder, and sidewalk.

SAFETY DATA SHEETS – Sheets prepared by a manufacturer or importer providing detailed information about a hazardous material as required by OSHA. Safety data sheets shall be in accordance with OSHA.

SAFETY OFFICER –

(a) Contractor's. An individual designated by the Contractor charged to ensure that all construction operations under the Contract are performed safely and according to all VOSHA regulations.

(b) Agency's. The Agency's authorized Occupational Safety Coordinator.

SAMPLING – Taking a representative portion of a material for evaluation.

SAND – Particles of rock that will pass the No. 10 (2.00 mm) sieve and be retained on the No. 200 (0.075 mm) sieve.

SCREENED SAND – The product resulting from the mechanical screening of natural sands or gravels.

SECRETARY – The appointed head of the Agency of Transportation of the state of Vermont.

SHOULDER – The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

SIDEWALK – That portion of the roadway primarily constructed for the use of pedestrians.

SILT – Material passing the No. 200 (0.075 mm) sieve that is non-plastic or very slightly plastic and that exhibits little or no strength when air-dry.

SLOPES – The inclined areas extending from the shoulders to the previously existing surface of the ground.

SOIL (EARTH) – Sediments or other unconsolidated accumulations of solid particles produced by the chemical and physical disintegration of rocks and which may or may not contain organic matter.

SPECIAL PROVISIONS – See SPECIFICATIONS.

SPECIALTY ITEMS – Work that requires highly specialized knowledge, ability, or equipment not ordinarily available in contracting organizations qualified to bid on the Contract as a whole. In general, specialty items are limited to minor components of the overall Contract.

SPECIFICATION LIMITS – In Section 406 and Section 407, the range of values greater than or equal to the LSL and less than or equal to the USL. If no USL is specified, it is all values greater than or equal to the LSL. If no LSL is specified, it is all values less than or equal to the USL.

SPECIFICATIONS – The compilation of provisions and requirements for the performance of prescribed work, including the following primary types of specifications and any other requirements included in the Contract.

(a) Standard Specifications. This book, entitled the *Standard Specifications for Construction*, which is approved for general application and repetitive use and is applicable to all Contracts. Standard Specification pay item numbers will be in the form of XXX.YYYY, where XXX indicates which section the pay item belongs to and YYYY identifies the individual pay item.

(b) Special Provisions. Information and provisions specific to a particular Contract. The Special Provisions are further subdivided into two parts:

(1) Notices to Bidders. Contract-specific information and requirements that the Agency wishes to emphasize, as well as Contract-specific additions, revisions, and corrections to the Standard Specifications.

(2) Special Specifications. Special Specifications are specifications for Contract-specific pay items. Special Specification pay item numbers will be in the form of XXX.YYYYZZZ, where XXX.YYYY is a Standard Specification pay item that is related to the Special Specification pay item and ZZZ identifies the individual Special Specification pay item.

STAGING AREA – Any areas that the Contractor uses for storage of materials and equipment or for general use and access for Contract operations.

STANDARD DRAWINGS – Agency approved drawings used for typical repetitive use, showing details to be used where appropriate.

STANDARD SPECIFICATIONS – See SPECIFICATIONS.

STATE – Unless different in context, the state of Vermont acting through its Agency of Transportation and authorized representative(s).

STATE BRIDGE ENGINEER – The authorized representative of the Agency responsible for structural engineering supervision of the project. Sometimes referred to as the Structures Program Manager.

STONE SCREENINGS – The product resulting exclusively from the mechanical crushing of quarried bedrock.

STRUCTURAL CONCRETE ENGINEER – The authorized representative of the Agency responsible for the evaluation and approval of various aspects of cast-in-place concrete and precast concrete as detailed in these specifications. Also responsible for supervision of plant inspectors used at concrete plants and for the evaluation of Portland cement concrete mix designs.

STRUCTURAL EMBANKMENT AREA – The cross-sectional area of an embankment situated between the lines projected downward from the outer edges of the subgrade on a 1:1.5 (V:H) slope to the intersection with the previously existing ground.

STRUCTURAL STEEL FABRICATION ENGINEER – The authorized representative of the Agency responsible for the supervision of inspectors used for steel fabrication and for the evaluation of field welding procedures and qualifications.

SUBBASE – The layer or layers of specified or selected material of designated thickness placed to support a base and/or surface course.

SUBCONTRACTOR – An individual or legal entity to whom or which the Contractor sublets part of the work.

SUBGRADE – The graded surface prepared as a foundation for the pavement structure and shoulders of a transportation facility.

SUBLOT – A subdivision of a lot.

SUBSTANTIAL COMPLETION DATE – The date when, in the opinion of the Engineer, all Contract items, with the exception of the Contractor's demobilization and punch list type items, have been completed.

SUBSTRUCTURE – All of that part of a structure below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames; included are backwalls, wingwalls, and wing protection railings.

SUPERINTENDENT – The Contractor's authorized representative in responsible charge of the work.

SUPERSTRUCTURE – All that part of a structure supported by the substructure, except approach slabs.

SURETY – The individual, partnership, firm, or corporation, or any acceptable combination thereof, other than the Contractor, executing the bond or bonds furnished by the Contractor. Surety companies must be authorized to do business in Vermont in accordance with *19 V.S.A. § 10(8)*.

SURFACE COURSE – The layers of bound materials or unbound materials above the subbase or base course in the pavement structure.

TRAVELED WAY – The portion of the roadway for the movement of vehicles, exclusive of shoulders, sidewalks, and auxiliary lanes.

UNIT PRICE – The price for one unit of work, as defined by the Contract.

UTILITY – The privately, publicly, or cooperatively owned lines, facilities, and systems for producing, transmitting, or distributing communications, power, electricity, light, heat, gas, oil, crude products, water, steam, waste stormwater not connected with highway drainage, and other similar commodities, which directly or indirectly serve the public. This includes publicly owned fire and police signal systems and street lighting systems, which directly or indirectly serve the public or any part thereof. The term utility shall also mean the utility company, inclusive of any wholly owned or controlled subsidiary.

UPPER SPECIFICATION LIMIT – In Section 406 and Section 407, the limit above which the material characteristics become undesirable. It is one of the components used to calculate the total PWL.

WASTE AREA – Any area where excess material or materials unsuitable for construction are disposed.

WEARING COURSE – The uppermost component of a pavement structure.

WEIGHT – See MASS.

WEIGHTS AND MEASURES – The Weights and Measures Section of the Vermont Agency of Agriculture, Food, and Markets.

WORK – The furnishing of all labor, materials, equipment, and incidentals necessary or convenient to the successful completion of the project and carrying out of the duties and obligations imposed by the Contract.

WORKING DAY – Weekdays during the construction season during which construction operations may proceed. If the Contractor works on Saturdays, Sundays, holidays, or during the seasonal closure period, those days will be considered working days.

WORKING DRAWINGS – Supplemental design sheets or similar data which the Contractor is required to submit to the Agency as stated in Subsection 105.06.

WRITTEN ORDER – A statement in writing from the Engineer to the Contractor that:

(a) Authorizes Work. Authorizes or directs work to be done that is not part of the Contract, including the method of payment.

(b) Identifies Work not Meeting Specifications. Informs the Contractor of work that is not being accomplished according to the Plans and specifications.

(c) Documents Final Pay Quantities. Documents final pay quantities to be paid for designated FPQ Contract items.

(d) Directs Adherence to Requirements. Directs that safety, environmental, or other requirements or measures be followed.

(e) Orders Discontinuation of Work. Directs that certain work or all work be stopped or discontinued.

(f) Provides Additional Information. The Engineer may bring any information or concerns to the Contractor's attention.

101.03 INTENTION OF TERMS.

(a) By/To the Engineer. In order to avoid cumbersome and confusing repetition of expressions in these specifications, whenever anything is, or is to be, done if, as, when, or where "contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered necessary, deemed necessary, permitted, reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected, or condemned," it shall be read and understood as if the expression were followed by the phrase "by the Engineer" or "to the Engineer."

(b) As Ordered/Directed by the Engineer. When the phrases "as ordered by the Engineer," "as directed by the Engineer," or similar phrases are used in the Contract, they shall be understood to provide the Engineer latitude to meet field conditions, but in no case shall these phrases be construed to permit changing the intent of the Contract.

(c) Furnish and Provide. "Furnish," "provide," and words of similar meaning, when used in relation to the Contractor, shall mean at the Contractor's expense unless otherwise specifically provided in a Contract item.

(d) Titles of Sections, Subsections, Subparts, and Tables. All titles are inserted for convenience and identification only and are in no way intended to define, limit, or expand the scope or intent of the Contract.

(e) Approval of/Ordered by/Consent of the Engineer. As they appear in these specifications, phrases like "approval of the Engineer," "as ordered by the Engineer," "with the consent of the Engineer," and any similar phrase indicating the acceptance or direction by the Engineer shall not supersede any requirement of the Contract or relieve the Contractor of their contractual obligations, including but not limited to, compliance with permit conditions and applicable laws, rules, regulations, ordinances, and bylaws.

(f) Construction/Interpretation of the Contract. The Contract and its provisions shall not be construed or interpreted for or against the Agency because the Agency drafted or caused its representative(s) to draft its provisions.

101.04 REFERENCED SPECIFICATIONS AND REQUIREMENTS. When external specifications (e.g. AASHTO, ACI, AREMA, ASTM, *MUTCD*, NDS, CRSI, etc.) or requirements (e.g. the *Materials Sampling Manual*) are cited and incorporated by reference, they shall become effective only if the work or material covered by them is not covered by the Standard Specifications or Special Provisions. Specifications and requirements incorporated by reference shall be the latest revision in effect on the date of the advertisement for bids, unless otherwise specified.

101.05 COORDINATION OF CONTRACT DOCUMENTS.

(a) General. The project permits, Contract Plans, Standard Drawings, Standard Specifications, Special Provisions, and all supplemental documents are essential parts of the Contract. These documents are complementary and are intended to describe and provide for a complete description of the work. A requirement occurring in one is as binding as though occurring in all.

(b) Contract Document Precedence. In case of a discrepancy, precedence of the Contract documents will be determined in the following order:

(1) Project Permits. In the event of a conflict between permit requirements, the more protective or stringent shall take precedence as determined by the Engineer.

(2) Special Provisions.

a. Notices to Bidders.

b. Special Specifications.

(3) Contract Plans.

a. Labeled dimensions.

b. Calculated dimensions.

c. Scaled dimensions.

(4) Standard Design Detail Sheets.

a. Labeled dimensions.

b. Calculated dimensions.

c. Scaled dimensions.

(5) Standard Drawings.

a. Labeled dimensions.

b. Calculated dimensions.

c. Scaled dimensions.

(6) Standard Specifications for Construction.

(7) Specifications Incorporated by Reference. Where any conflict arises between specifications incorporated by reference, the more stringent specification shall apply as determined by the Engineer.

(c) No Advantage from Errors or Omissions in the Contract. Neither the Contractor nor the Agency shall take advantage of or be afforded any benefit as the result of apparent errors or omissions in the Contract. If either party discovers any errors or omissions, it shall immediately notify the other.

(d) Corrections to the Contract. The Engineer will make corrections and interpretations deemed necessary and appropriate to fulfill the intent of the Contract. When there is an apparent absence or mention of a detail or an apparent omission of a detailed description in the Contract, the detail or description shall be interpreted, understood, or determined using the best general engineering and construction practice.

SECTION 102 – BIDDER REQUIREMENTS AND CONDITIONS

102.01 INTERPRETATION OF QUANTITIES IN BID PROPOSAL. The estimates of quantities of work to be performed and/or materials to be furnished as shown on the proposal are approximate and are provided only as a basis of calculation upon which the award of the Contract is to be made.

Except as otherwise provided, the Agency disclaims responsibility, and shall not be held responsible, for the estimates of quantities, whether they be less than, equal to, or greater than the quantities used in the actual performance of the work.

The Contractor shall not plead misunderstanding or deception because of the estimates of quantities or of the character, location, or other conditions pertaining to the estimates of quantities.

The Agency, in its sole discretion, reserves the right to increase or decrease any or all of the estimated quantities of work or to omit any of them as deemed necessary.

102.02 EXAMINATION OF PLANS, PROPOSAL, AND PROJECT SITE.

(a) General Requirements. Each and every bidder shall examine carefully the site of the work contemplated and the relevant Plans, specifications, and proposal forms. It is the responsibility of each and every bidder to investigate and become aware of:

(1) The conditions to be encountered;

(2) The character, quality, and quantities of the work to be performed;

(3) The materials to be furnished; and

(4) The requirements of the Plans, specifications, and all proposal documents.

(b) Subsurface Investigations. To assist in the design for a project, the Agency normally investigates subsoils, foundation conditions, and potential sources of material for character, quality, and/or quantity by various means, including borings, test pits, samples, tests, and classifications. Information concerning any investigations normally appears on the Plans or in the proposal.

(1) Disclaimer. Boring logs and other subsurface information provided to bidders were obtained with reasonable care and recorded in good faith by the Agency. This subsurface information has been collected for the use of the Agency only, to assist the Agency in developing a design suitable for the subsurface conditions in the area of the foundation for the structure and/or for preparation of the Engineer's estimate. This subsurface information is made available to prospective bidders as a public document relating to a project. Such information is not intended to provide prospective bidders with a subsurface analysis for purposes of bid preparation. It is up to the prospective bidder to conduct whatever subsurface investigation may inform its bid preparation.

The Agency disclaims any liability for claims based upon a prospective bidder's reliance on the subsurface information provided by the Agency unless, following Contract award, the Contractor can establish by clear and convincing evidence that the subsurface information provided by the Agency was inadequate to support the structure as designed.

(2) No Responsibility or Warranty by the Agency. Soil classifications have been made from laboratory tests of soil samples extracted and/or collected. Rock and soil descriptions, engineering properties, or classifications are from visual inspection and tests of rock cores and/or soil samples. Observed water levels and/or water conditions indicated are as recorded at the time of exploration and may vary considerably with time according to the prevailing rainfall and other factors.

The information provided may not represent existing conditions. The Agency is not responsible for the information. The Agency does not warrant in any way the completeness or accuracy of the information. Disclosure of the information is not a substitute for personal investigations, interpretations, and/or judgments by each prospective bidder. It is the responsibility of each prospective bidder and/or subcontractor to satisfy itself, through its own independent investigations, concerning the conditions and materials to be encountered.

(c) Contractor's Obligation to Convey Information. It is the Contractor's responsibility to convey any and all information relative to Contract requirements to any proposed suppliers, fabricators, or subcontractors.

102.03 FAMILIARITY WITH LAWS, ORDINANCES, AND REGULATIONS.

(a) General. By submitting a bid, an entity certifies that it is familiar with all federal, state, and local laws, ordinances, and regulations which affect in any way the materials, equipment, haul roads used in or upon the work, the conduct of the work, and the persons engaged or employed in performance of the work to be performed pursuant to a Contract.

(b) Duty to Report.

(1) Inconsistency or Conflict with Federal, State, or Local Law, Ordinance, or Regulation. By submitting a bid, an entity certifies that it shall immediately report in writing to the Contract Administration Section any provision in the Plans, specifications, or proposal documents that the bidder/Contractor believes is in conflict with or inconsistent with any federal, state, or local law, ordinance, or regulation.

(2) Differing Site Conditions. By submitting a Request for Contract Specific Prequalification (*Form CA-82*), a prospective bidder certifies that if, during its investigation of the work, it discovers or encounters differing site conditions as described in Subsection 104.08, it shall immediately notify the Contract Administration Section in writing.

(3) Failure to Notify. A prospective bidder further certifies that if it fails to notify the Contract Administration Section of any differing site conditions as described above, it shall waive any and all rights that it might have to additional compensation from the Agency for additional work as a result of the differing site conditions and that it shall not bring a claim for additional compensation because of the differing site conditions.

(c) No Claim or Defense of Ignorance or Misunderstanding. By submitting a Request for Contract Specific Prequalification (*Form CA-82*) a bidder certifies that no claim or defense of ignorance or misunderstanding concerning federal, state, or local laws, ordinances, or regulations will be employed by a bidder or considered by the Agency in claims, litigation, alternative dispute resolution procedures, or other matters concerning the proposal for which the bid is submitted.

102.04 ERRORS OR INCONSISTENCIES IN THE CONTRACT.

(a) Duty to Report. By submitting a Request for Contract Specific Prequalification (*Form CA-82*), a bidder certifies that it shall report in writing to the Contract Administration Section any error or inconsistency discovered in the Plans, specifications, or proposal documents immediately upon discovery of the error or inconsistency.

(b) Errors and Inconsistencies Not Used Against the State. By submitting a Request for Contract Specific Prequalification (*Form CA-82*), a bidder certifies that it shall assert no claim, cause of action, litigation, or defense against the state unless notice was provided to the state in writing of any error or inconsistency found in the Plans, specifications, or proposal documents immediately upon discovery of such error or inconsistency. Failure to provide such notice to the Contract Administration Section, in writing, within 48 hours of such discovery constitutes waiver of any claim or demand by the prospective bidder based, in whole or in part, directly on the existence of such error or omission.

SECTION 103 – TAXES AND INSURANCE

103.01 CONSTRUCTION EQUIPMENT TAX. The Contractor shall pay all construction equipment tax assessed under *32 V.S.A. § 3603* for machinery and other personal estate.

103.02 WITHHOLDING OF TAXES. The Contractor shall comply with the requirements of *32 V.S.A., Chapter 151, Subchapter 4* relating to the withholding of taxes from employees, and all taxes withheld pursuant to *32 V.S.A., Chapter 151, Subchapter 4* shall be reported and paid to the Commissioner of the Vermont Department of Taxes.

103.03 STATE SALES TAX. Contractors are not required to pay the Vermont sales tax for materials incorporated into a state funded project completed on property owned or held in trust for the benefit of any governmental body or agency and used exclusively for public purposes, or owned or held in trust for the benefit of any organization holding a valid exemption certificate and used exclusively in the conduct of its business or purpose, or for materials incorporated in a rail line in connection with the construction, maintenance, repair, improvement, or reconstruction of the rail line (see *32 V.S.A. § 9743(4)*, *32 V.S.A. § 9741(30)*, *32 V.S.A. § 9741(44)*, the *Vermont Sales and Use Tax Regulations, Reg. § 1.9741(34)-5*, and the *Vermont Sales and Use Tax Regulations, Reg. § 1.9743*).

Therefore, no sales tax shall be included in the cost of these materials.

Contractors are responsible for maintaining records sufficient to justify eligibility for sales tax exemption. Forms for maintaining these records are available from the Vermont Department of Taxes.

103.04 INSURANCE REQUIREMENTS. Insurance obtained by the Contractor to cover the below-listed requirements shall be procured from an insurance company with an A.M Best Rating of A- or better and which is registered and licensed to do business in Vermont. Before the Contract is executed, the Contractor shall file with the Agency a certificate of insurance, executed by an insurance company or its licensed agents, on a form satisfactory to the Agency, stating that with respect to the Contract awarded, the Contractor carries insurance in accordance with the following requirements. Renewal certificates for keeping the required insurance in force for the duration of the Contract shall also be filed as specified above.

No warranty is made that the coverages and limits listed herein are adequate to cover and protect the interests of the Contractor and any subcontractor for the Contractor's and subcontractor's operations. These are solely minimums that have been established to protect the interests of the state.

(a) Workers' Compensation Insurance. With respect to all operations performed the Contractor shall carry workers' compensation insurance in accordance with *21 V.S.A., Chapter 9*. The Contractor shall also ensure that all subcontractors carry workers' compensation insurance in accordance with *21 V.S.A., Chapter 9* for all work performed by them.

(b) Commercial General Liability Insurance. With respect to all operations performed by the Contractor and subcontractors, the Contractor shall carry commercial general liability insurance on an occurrence form providing all major divisions of coverage, including but not limited to:

(1) Premises – operations

(2) Independent contractors

(3) Products and completed operations continuously in effect for three years past the acceptance date

(4) Personal injury liability

(5) Contractual liability applying to the Contractor's obligations under Subsection 107.15, broad form property damage

(6) Limits of coverage shall be not less than:

$2,000,000	Each occurrence.
$4,000,000	General aggregate with a per project aggregate. In cases of Contracts with multiple projects, the per project aggregate applies to the entire Contract.
$2,000,000	Products/completed operations.

(c) Automobile Liability Insurance. The Contractor shall carry automobile liability insurance covering all motor vehicles including owned, hired, borrowed, and non-owned vehicles, used in connection with the project.

(1) Combined single limit for bodily injury and property damage shall not be less than $2,000,000.

(2) If performance of the Contract involves the transport of hazardous materials, the policy shall include the *MCS-90* endorsement.

(d) Railroad Protective Liability Insurance. When the Contract involves work on, over, or under the right-of-way of any railroad, the Contractor shall carry, with respect to operations performed by the Contractor or by the Contractor's subcontractors, railroad protective liability insurance in a form and amount as required by the Operating Railroad and as specified in *23 C.F.R. § 646.107*. If not available from insurance companies registered and licensed to do business in Vermont, this insurance may be procured from Eligible Surplus Lines companies approved by the Vermont Department of Financial Regulation.

Upon request by the Agency the Contractor shall provide a copy of the railroad protective liability policy within 24 hours.

The Contractor shall defend, indemnify, and save harmless the Operating Railroad and all of its officers, employees, and agents against any claim or liability arising from or based on any delay to the Contractor as a result of railroad construction or maintenance, whether by the Operating Railroad, its employees, or agents.

(e) Contractor Pollution Legal Liability Insurance. With respect to all operations performed by the Contractor and subcontractors, the Contractor and, if applicable, its subcontractors, shall maintain a policy covering third-party injury and property damage, contractual liability, and claims arising from owned and non-owned disposal sites utilized. Coverage will also include clean-up costs as a result of pollution conditions arising from the Contractor's operations and completed operations.

Limits of coverage shall not be less than $2,000,000 per occurrence or claim and $2,000,000 in the aggregate. The Contractor is responsible for reporting all pollution incidences in accordance with federal and state laws, regulations, and applicable insurance policy reporting deadlines.

(f) General Insurance Conditions. All applicable insurance coverages shall be maintained until the acceptance date. Completed operations coverage under Subsection 103.04(b) and all coverage under Subsection 103.04(e) shall be maintained continuously in effect for three years past the acceptance date.

Under Subsection 103.04(d), the liability protective policy shall remain in force until all work required to be performed on railroad property is completed to the satisfaction of the Operating Railroad and of the authorized representative of the Agency.

The contractual liability insurance requirements detailed in the Contract, including Subsection 107.15, are to indemnify, defend, and hold harmless the municipalities, the state, the Agency, and Operating Railroads, as applicable, and their officers, agents, representatives, and employees, with respect to any and all claims, causes of actions, losses, expenses, or damages that arise out of, relate to, or are in any manner connected with the Contractor's work or the supervision of the Contractor's work on the project.

Each policy, except the workers' compensation policy, shall name the municipalities, the state, the Agency, and Operating Railroads, as additional insureds for actions, losses, expenses, or damages that arise out of, relate to, or are in any manner connected with the Contractor's work or the supervision of the Contractor's work on the project. The additional insured endorsements under Subsection 103.04(b) and Subsection 103.04(e) shall use Insurance Services Office form *CG 20 10* and form *CG 20 37* or its equivalent and will be on a primary, noncontributory basis.

All policies shall include a waiver of subrogation in favor of the state of Vermont.

Umbrella or excess liability policies may be used in conjunction with primary automobile liability and commercial general liability policies only to comply with any of the limit requirements specified above.

Claims-made coverage forms are not acceptable without the prior written consent of the Agency.

The Contractor or the insurance company shall investigate and shall either adjust or defend all claims against the insured for damages covered, even if groundless.

Each policy furnished shall contain a rider or non-cancellation clause reading in substance as follows:

> *There shall be no cancellation or non-renewal of insurance coverages without 30 calendar days' written prior notice to the state, except for non-payment of premium, which will require 15 calendar days' written prior notice to the state.*

There shall be no directed compensation allowed the Contractor on account of any premium or other charge necessary to take out and keep in effect such insurance or bond. The cost of any premium or other charge shall be considered included in the general cost of the work.

(g) Contract Insurance Requirements. In cases that a discrepancy between the stated insurance requirements of *Bulletin 3.5 Attachment C: Standard State Provisions for Contracts and Grants* and this section occurs, the higher limit shall govern.

SECTION 104 – SCOPE OF WORK

104.01 INTENT OF THE CONTRACT. The intent of the Contract is to provide for the construction and completion of the work described. The Contractor shall furnish all labor, materials, equipment, tools, transportation, and supplies required to complete the work in accordance with the Contract.

104.02 ALTERATION OF PLANS OR CHARACTER OF WORK. To suit conditions disclosed as the work progresses, the Engineer may, without notice to the sureties on the Contractor's bonds, make alterations in the design, in type of materials, in the quantities or character of the work or materials required, in the cross-sections, in dimensions of structures, in length of project, in locations, and any other ways deemed appropriate. Alterations will not constitute a change in other parts of the Contract or a waiver of any condition of the Contract and shall not invalidate any of the provisions of the Contract.

Payment for work occasioned by changes or alterations will be made according to Subsection 109.04 and Subsection 109.05. If the altered or added work is of sufficient magnitude to require additional time in which to complete the project, a time adjustment will be made in accordance with the demonstrated impact to the critical path caused by the altered work.

104.03 EXTRA WORK. The Contractor shall perform extra or unforeseen work for which there is no quantity and price included in the Contract according to the Contract or as directed by the Engineer whenever it is deemed necessary or desirable by the Engineer in order to complete the work as contemplated. Payment for extra work will be made pursuant to Subsection 109.06.

104.04 MAINTENANCE OF TRAFFIC.

(a) Maintenance of Vehicular and Pedestrian Traffic.

(1) All Facilities Safe and Passable. All facilities to be used by the traveling public, including temporary highways, bridges, pedestrian facilities, and approaches as necessary to accommodate the vehicular or pedestrian traffic diverted from the facility undergoing improvements, shall be provided and maintained in a safe and passable condition. All traffic control plans and devices shall conform to the *MUTCD*.

(2) Service Shall Be Maintained. During working hours, the Contractor shall maintain, at a minimum, alternating one-way vehicular traffic unless otherwise shown on the Plans or directed by the Engineer. Working hours will be limited to the period between sunrise and sunset for daytime operations and the approved scheduled night shift for night work.

Wherever one-way vehicular traffic is being maintained by the Contractor, the traveling public shall not be delayed more than 10 minutes per operation or not more than 15 minutes cumulatively for the project. However, two-way traffic shall be re-established during all holiday periods, temporary shutdowns, and any other periods designated by the Engineer, unless otherwise specified in the Contractor's approved traffic control plan.

The Contractor shall also provide measures that maintain pedestrian access through the work zones in compliance with the *MUTCD*, the *Public Rights-of-Way Accessibility Guidelines*, and the Agency's *Work Zone Safety & Mobility Policy and Guidance*.

(3) Detours, Diversions, and Temporary Bridges. Detours necessary for public travel which are not contiguous to the work will be designated by the Agency unless otherwise provided.

When contiguous to the work, diversions shall be constructed and maintained by the Contractor and no compensation will be allowed to the Contractor except as provided in the Contract. If the Contractor elects to construct a temporary bridge on a diversion contiguous to the work over which vehicular or pedestrian traffic is to be maintained while a culvert or bridge is being constructed, the temporary bridge shall be constructed according to Section 528. The expense of the construction, maintenance, and removal of a temporary bridge and its approaches, and all incidental work pertaining thereto, will not be paid directly but will be incidental to all other Contract items, unless otherwise provided for in the Contract. The Contractor shall be responsible to the public for the structural adequacy and safety of these structures and approaches. The Contractor shall provide, erect, and maintain all necessary barricades, lights, signs, signals, other traffic control devices, and flaggers as required in accordance with the applicable subsections.

(4) Winter Maintenance on Active Projects. The condition of highway and pedestrian facilities on active projects shall be maintained such that snowplowing, sanding, and salting may occur without unduly burdening the properly designated entity from performing such tasks. If the condition of the highway, temporary highway, sidewalks, detours, or bridges, are such that ordinary winter maintenance activities cannot occur, the Contractor shall assume the responsibility to perform winter maintenance. The costs for snowplowing, sanding, and salting shall be considered incidental to the appropriate traffic control items.

(5) Winter Maintenance on Closed Projects. When a project is closed down for the winter season, the Contractor shall leave the project in a satisfactory condition for the traveling public and in a condition suitable for normal and satisfactory winter maintenance. The full depth of subbase shall be placed over portions of the road under construction and used by the traveling public unless otherwise shown on the Plans or directed by the Engineer.

During the period that the project is officially closed down for the winter season, the state, a political subdivision thereof, or other properly designated entity will assume responsibility for snowplowing, salting, and sanding. This shall not relieve the Contractor of any other responsibilities regarding public convenience and safety as specified in this section, from the liabilities as specified in Section 107, or as specified elsewhere in the Contract.

If unsatisfactory travel conditions or ruts develop in the traveled way or other construction defects or conditions dangerous to the traveling public develop, whether arising from the execution or non-execution of the work, the Contractor may be directed to return to the construction work site and carry out necessary measures to satisfactorily remedy the situation. The cost for said work will be included as part of the cost of the items in the Contract, with no additional payment. If the Contractor fails to carry out the measures to satisfactorily remedy the situation immediately, the Engineer may cause the work to be performed and deduct the cost from any monies due or to become due to the Contractor. If the closing of a project is due to the Contractor's inability to complete the Contract before the Contract completion date, the Contractor shall bear all costs associated with making the project acceptable to the Engineer for winter shut down.

(6) Closed Projects; Temporary Traffic Control Measures. When a project is closed down for the winter season or for any other reason, the Contractor shall erect and maintain temporary guardrail, guide posts, barricades, warning signs, and other traffic control devices throughout the length of the project as shown on the traffic control plan or as directed by the Engineer. These temporary installations shall conform to requirements for the permanent items, except that approved, used material may be substituted. Temporary installations shall be removed when the Engineer indicates they are no longer required. The installation, maintenance and removal of temporary guardrail, guide posts, barricades, warning signs, and other traffic control devices will not be paid for directly, but will be incidental to all other items in the Contract.

(7) Closed Projects; Guardrail. When any course of permanent pavement is placed prior to suspension of work for the winter season, permanent, rather than temporary, guardrail shall be installed in accordance with the Contract. No payments will be made for adjustments to these permanent installations in order to accomplish work when construction resumes in the spring.

(8) Suspension of Work; Contractor's Responsibility. If, regardless of the cause, construction is suspended on the project before the completion, acceptance, and termination of the Contractor's responsibility as defined under Subsection 108.15, the Contractor shall take precautions against injury or damage to the work and shall repair and/or replace any damaged work as specified under Subsection 107.17.

(9) Traffic Control Devices. All traffic control devices shall be presented to the Engineer for approval prior to placement on the project. At no time will traffic control devices that do not have the specified retroreflective sheeting or are dirty, damaged, or unacceptable to the Engineer be placed or remain on the project.

All traffic control devices, including, but not limited to, signs, pavement markings, pavement marking removals, temporary traffic barrier, barricades, reflectorized plastic drums, cones, flashing arrow boards, and detours shall conform to the *MUTCD*, shall be installed to the satisfaction of the Engineer, and shall be functioning prior to the beginning of field work.

(10) Reflectorized Sheeting; Cleaning; Costs. All reflectorized sheeting on the project shall be cleaned on a biweekly basis unless more frequent cleaning is directed by the Engineer. The cost of this work will not be paid for directly but will be incidental to all other Contract items.

(11) Traffic Control Devices During Construction; Costs. Costs involved in covering, uncovering, and otherwise adjusting the signing and traffic control devices during construction to conform to the changing requirements of traffic flow around and through various operations will not be paid for directly, but will be incidental to all other Contract items.

(12) Suspension of Work; Treatment of Signing; Costs. Costs involved in covering or removing signs at the beginning of a suspension of work, including winter shutdown, and in uncovering or re-installing the signs at the end of a suspension of work will not be paid for directly, but will be incidental to all other Contract items. Such signing adjustments shall be performed as directed by the Engineer.

(b) Maintenance And Protection of Railroad Traffic and Infrastructure.

(1) General Requirements. Operating Railroad traffic shall be maintained at all times with safety and continuity, and the Contractor shall be responsible for conducting all operations on, over, or under the railroad right-of-way fully within the rules, regulations, and requirements of the Agency and the Operating Railroad.

The Contractor shall cooperate with and allow the Operating Railroad or its agents free and full access to the project during construction along with all materials and equipment necessary in order that their authorized employees or agents may do any and all railroad work, inspection, flagging, and watching.

The Contractor shall perform its work in such a manner that the tracks, traffic, and appurtenances of the Operating Railroad shall be safeguarded. The Contractor shall comply with the requirements of the Operating Railroad relative to the Contractor's work on or adjacent to the railroad and shall make all efforts to prevent fouling of the tracks.

The Contractor must anticipate unscheduled trains.

(2) Railroad Clearances and Fouling. In the construction of any staging, falsework or forms, the Contractor shall not foul the tracks and shall coordinate with the Engineer.

(3) Contractor Equipment and Materials. The Contractor shall maintain its equipment so as to prevent any failure that would cause delay in the operation of trains or damage to railroad facilities.

Materials and equipment belonging to the Contractor shall not be stored or operated within the foul zone of the tracks without first obtaining permission from the Operating Railroad. The Agency and/or the Operating Railroad will not be liable for damage to such materials and equipment from any cause. The Contractor shall keep the tracks and the site adjacent to the tracks clear of all refuse and debris and shall leave the property in the condition existing before the start of construction operations.

(4) Railroad Safety Personnel. The Contractor shall consult with the Operating Railroad to determine the type of protection required to ensure the safety and continuity of Operating Railroad traffic incidental to the particular methods of operation and equipment to be used in the work. Any construction inspectors, track foremen or track watchmen, signalmen, or other employees deemed necessary for protective services by the Operating Railroad, or its authorized representative, to ensure the safety of trains contingent upon the Contractor's operations, shall be obtained from the Operating Railroad by the Contractor. The providing of such precautionary measures or protective services shall not relieve the Contractor from liability for payment of damages caused by the Contractor's operations. Refer to Subsection 107.09(b) and Section 632 for information on railroad flaggers.

(5) Damage to the Railroad. During the execution of the Contract, if the trains, tracks, or other facilities of the Operating Railroad are endangered, the Contractor shall immediately restore safe conditions. If the Contractor fails to make conditions safe, the Agency may take whatever steps necessary to restore safe conditions. All costs of restoring safe conditions or any damage to trains, tracks, or other facilities due to the Contractor's operations shall be the sole responsibility of the Contractor.

(6) Fouling of Ballast. In performing construction operations, the Contractor shall prevent the fouling of railroad track ballast with earth, mud, silt, or other foreign matter. To prevent fouling of the ballast, it may be necessary for the Contractor to construct temporary erosion control measures or sheeting or provide other precautionary measures.

The Contractor shall take preventive measures to protect the entire ballast section to the satisfaction of the Engineer. The protective measure shall remain in place until there is no further possibility of fouling the ballast and then shall be removed by the Contractor. In the event that the railroad track ballast does become fouled after the protective measures are taken, the Contractor shall remove and replace the fouled ballast with clean ballast. All costs of restoring the ballast to the satisfaction of the Engineer shall be the sole responsibility of the Contractor.

(7) Existing Signage. All existing signs, markers, and other informational indicators associated with the Agency or the Operating Railroad that are removed by the Contractor shall be preserved. All signs shall be in place prior to the operation of any trains as directed by the Engineer. All costs associated with installing or re-installing signs prior to train operations to the satisfaction of the Engineer shall be the sole responsibility of the Contractor.

104.05 REMOVAL AND DISPOSAL OF STRUCTURES AND OBSTRUCTIONS. The Contractor shall remove any existing structure, parts of structure, or other obstructions which interfere in any way with the new work or which is shown on the Plans to be removed.

Unless otherwise specified, all salvageable material being removed shall become the property of the Contractor and shall be disposed of and/or recycled in compliance with all applicable federal, state, and local laws and regulations. Salvage generated by utility relocation shall remain the property of the applicable utility.

104.06 USE OF MATERIALS FOUND IN THE PROJECT LIMITS.

(a) General. With the written approval of the Engineer the Contractor may use stone, gravel, sand, or other materials found in the excavation for other work items for the project provided the materials meet the requirements of the Contract.

The Contractor will be paid for the removal of such materials used for the project at the proper Contract unit price for items of excavation.

The Contractor shall not excavate or remove any material that is not within the slope and grade lines of an excavation as shown on the Plans without written authorization from the Engineer. If the Engineer allows over-excavation for the use of the Contractor, the Contractor shall compensate the state for the quantity of material removed, and the replacement of material, if necessary, shall be done at no additional cost to the Agency and shall conform to the requirements of embankment construction as specified in the Contract. Over-excavation, if allowed by the Engineer, shall only occur within the state's right-of-way.

(b) Quantities. Whenever any material, except Granular Borrow, is removed from an excavation and used in the construction of other items in the Contract, the total quantity measured for payment of these items shall be multiplied by 1.15, and the resulting quantity deducted from the total quantity of the Contract item Earth Borrow. If the final quantity of Earth Borrow is zero, no deductions will be made for material used for other items.

Whenever material meeting the requirements for Granular Borrow is taken from an excavation on the project and used for Contract item Granular Borrow, its removal and use shall be paid for by single payment under the appropriate excavation item in Section 203.

104.07 FINAL CLEANUP FOLLOWING COMPLETION OF THE PROJECT.

(a) Cleanup of Project. Upon completion of the work, before acceptance, and before final payment will be made, the Contractor shall satisfactorily and completely clean and remove from the right-of-way and grounds occupied by the Contractor in connection with the work all equipment, falsework, surplus and discarded materials, rubbish, temporary structures, buildings, tools, lumber, refuse, and other debris.

(b) Restoration of Property. The Contractor shall restore in an acceptable manner satisfactory to the Engineer all property, both public or private, which has been damaged during the prosecution of the work; replace or renew any fences damaged; leave the waterways unobstructed; and leave the work area in a neat and presentable condition throughout the entire length of the work.

(c) Drainage Structures and Ditches. The removal and disposal of silt, debris, and other material from drainage structures and ditches, deposited during construction under the Contract, shall be accomplished prior to acceptance of the Contract as ordered by the Engineer.

(d) Closure of Material Supply and Disposal Areas. Material supply and disposal areas shall be closed in accordance with Subsection 105.27.

(e) Costs. Costs involved with final cleanup following completion of the project will either be paid for under specific pay items or be incidental to all other Contract items.

104.08 DIFFERING SITE CONDITIONS.

(a) Discovery and Notification. During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the Contract, or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the site is disturbed and before the affected work is performed.

(b) Investigation and Adjustment. Upon written notification, the Engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment, excluding anticipated profits, will be made and the Contract modified in writing accordingly. The Engineer will notify the Contractor of the determination of whether or not an adjustment of the Contract is warranted.

(c) No Adjustment Unless Notice Submitted. No Contract adjustment that results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

(d) No Adjustment for Unchanged Work. No Contract adjustment will be allowed under this subsection for any effects caused on unchanged work.

SECTION 105 – CONTROL OF THE WORK

105.01 ROLE OF THE ENGINEER.

(a) General. The Engineer will decide all questions which arise concerning the quality and acceptability of materials furnished, the manner of performance of the work, the rate of progress of the work, and compliance with the requirements of the Contract. The Engineer will decide all questions concerning interpretation of the Contract.

(b) Quantities, Orders, Disputes, Rejection of Materials or Work, Suspension of Work. The Engineer will determine the amount and quantity of the work performed and materials furnished that are to be paid for under the Contract. The Engineer will have the authority to enforce and make effective decisions and orders the Contractor fails to carry out promptly. In case of any dispute arising between the Contractor and the Engineer as to materials furnished or the manner of performing the work, the Engineer has the authority to reject the materials or to suspend the work until the dispute is decided by the Chief Engineer. The Engineer is not authorized to revoke, alter, enlarge, relax, or release any requirements of the Contract. The Engineer has the authority to suspend the work or withhold payment of all estimates due to the Contractor when necessary to secure proper compliance with the Contract.

(c) Performance of Work by the Engineer; Setoff. If the Contractor fails to perform work ordered by the Engineer, the Engineer may, upon written notice, proceed to perform the work as deemed necessary. The cost of performing the work will be deducted from any monies due or which may become due the Contractor under the Contract.

(d) Advice by the Engineer. Advice given to the Contractor by the Engineer shall not be construed as binding the Agency in any way or releasing the Contractor from any obligations under the Contract.

105.02 AUTHORITY AND DUTIES OF THE ENGINEER. As the direct representative of the Chief Engineer, the Engineer on a project has immediate charge of the engineering details of the project and is responsible for the administration and satisfactory completion of the projects. The Engineer has the authority to reject defective material, to suspend any work that is being improperly performed, and to withhold payment until defective work has been corrected. The Engineer also has the authority to suspend work, or specific aspects of the work, if necessary to address a concern for safety of the workers or traveling public, or a serious environmental concern or violation. Notwithstanding any other provision of law, case law, regulation, or the Contract, no additional compensation shall be provided for any work suspensions of this sort.

105.03 AUTHORITY AND DUTIES OF INSPECTORS. Inspectors employed by the Agency are authorized to inspect all work done and materials furnished and to perform other duties as directed by the Engineer. Inspections can extend to all or any part of the work and to the preparation, fabrication, or manufacture of the materials used. An inspector is not authorized to alter or waive the provisions of the Contract, to issue instructions contrary to the Contract, or to act for the Contractor.

105.04 CHIEF ENGINEER TO BE REFEREE.

(a) General. The Chief Engineer will act as referee in all questions of dispute arising under the terms of the Contract. If the Contractor is aggrieved by the decision of the Chief Engineer, the Contractor may appeal the decision in writing to the Transportation Board via the Chief Engineer. Included with the notice of appeal shall be a complete outline of the nature and extent of the question or questions appealed together with any supporting documentation.

(b) Limitation of Time to Appeal. Notwithstanding any other provision of law, case law, regulation, or the Contract, all appeals shall be made within 30 calendar days of the decision to which the Contractor is aggrieved, and not thereafter.

105.05 COMPONENTS OF THE CONTRACT. A complete description of the work requires both the Contract, which is furnished to the Contractor by the Agency, and the working drawings, which are submitted to the Agency by the Contractor or the Contractor's suppliers. The Agency will make available the Contract in a digital format and the Contractor shall keep the Contract available on the project at all times.

105.06 PLANS AND WORKING DRAWINGS.

(a) General. Certain items and work activities require Plans, drawings, procedures, and other information to document the Contractor's proposed actions to conform with Contract requirements.

Drawings and procedures shall be submitted sufficiently in advance of the anticipated work to allow for reviews, comments, corrections, and if necessary, resubmittal.

In the event that any condition requires a change to any previously approved or conforming working drawings, the Contractor is required to submit updated drawings prior to performing the work.

Design calculations shall be included with the submittal of the working drawings for structural elements that have not been designed and detailed in the Contract, including temporary and permanent work. When a Contract item requires additional calculations to be submitted, the calculations shall be included with the submittal of the working drawings. Manufacturer's engineering data for prefabricated materials, including that for falsework and forms, shall be submitted with each set of working drawings.

All submittals shall be transmitted electronically to the Agency unless prior approval has been granted by the Engineer. Submittals shall be flattened prior to transmitting so that information added to the submittal becomes an integral part of the document rather than separate information on top of the document. The document shall have a clean appearance so that any comments or stamps placed as part of the submission cannot be mistaken as review comments. Resubmittals shall be free from previous review comments and have a clean appearance so that any comments or stamps placed cannot be mistaken as a review comment. All resubmittals shall include a separate summary of review comments and responses, including an explanation of how each review comment was addressed in the resubmittal.

Drawing and detail sheets shall be provided as an ISO standard Portable Document Format (PDF) file. The PDF document properties shall be set up with an appropriate page size and engineering or architectural scale. The page size and scale shall be of sufficient size to permit to-scale plotting of the document(s) on paper for review, use in construction, and shall include the following:

(1) Project name and number

(2) Route number and location information

(3) Contractor's name and address

(4) Fabricator or supplier's name and address

(5) Sheet title or identification of details shown

(6) The name of the detailer and the checker

(7) Date and version of the drawings

(8) Sheet number _____ of _____

(b) Required Submittals. Working drawings submitted to detail work that has been designed and detailed in the Plans shall be submitted to the Agency for approval. Fabrication drawings are a type of working drawing that are submitted for approval.

Working drawings submitted to detail work that has not been designed in the Plans shall be designed and detailed by a professional engineer and submitted to the Agency to be reviewed for conformance with the Contract. These working drawings shall ensure that the Contractor or Contractor's suppliers have correctly interpreted the intent of the Contract. Construction drawings and design drawings are types of working drawings that are submitted to be reviewed for conformance.

Exceptions to this guidance will be detailed by the specification for the individual pay item.

No work shall begin on any item associated with a working drawing until all of the associated drawings have been approved, approved as noted, marked as conforming, or conforming with comments by the Agency. The Contractor or fabricator shall assume all risk for materials ordered or work performed prior to written notification by the Agency.

(1) Submittals for Approval. Approval of drawings and/or procedures does not relieve the Contractor or fabricator of compliance with all specifications and code requirements. The Agency assumes no responsibility for errors and/or omissions in the drawings and procedures.

Drawings and procedures identified as being approved as noted indicate that specific clarification or conditional changes have been identified and take precedence over submitted information. Withholding of approval by the reviewer for selected details or procedures shall not constitute a basis for delay of performance of a non-related item of work that has approval to proceed.

After approval of the drawings and/or procedures, no changes shall be made without the written approval of the Agency.

(2) Submittals to be Reviewed for Conformance. When the submittal is reviewed for conformance, the Agency will review the submittal for compliance with the requirements of the Contract. The Contractor shall submit the required drawings and/or procedures in advance of the proposed work. The Contractor is entirely responsible for the work associated with these submittals. The Agency will not be responsible for errors in dimensions, incorrect erection procedures, or design requirements.

If the drawings and/or procedures have misinterpreted the Plans or specifications, the submittal will be returned as non-conforming. The submittal shall not be marked as conforming or conforming with comments until all of the required information has been received and reviewed.

After the drawings have been marked conforming or conforming with comments, no changes shall be made without the written approval of the Agency. The Contractor or fabricator shall assume all risk for materials ordered or work performed prior to the changes being marked as conforming by the Agency.

(c) Categories of Working Drawings.

(1) Fabrication Drawings.

a. General. Fabrication drawings are required for work performed by or in conjunction with materials furnished by a fabricator or supplier. They shall consist of complete details developed from information in the Contract, and field measurements to define dimensions, sizes, procedures, and materials necessary to complete fabrication and installation or erection of the work specified.

Once a complete submittal has been received for approval, the reviewer shall be allowed 28 calendar days for the initial review period and a 14 calendar day review period for each subsequent resubmittal unless stated otherwise in the specification requirements. The Contractor is entirely responsible for the work associated with these submittals. The Agency will not be responsible for errors in dimensions, incorrect erection procedures, design requirements, or successful completion of the work.

b. Ownership; Delivery; Procedures. Fabrication drawings shall be the property of the Agency. Prior to processing the final estimate, the Engineer shall verify that all as-builts have been received by the Agency.

(2) Construction Drawings. For an item or element of work that permits the Contractor optional details, procedures, and materials, the Contractor shall prepare and submit to be reviewed for conformance detailed drawings, calculations, and procedures of how the Contractor proposes to perform and control the work. Construction drawings, calculations, and procedures shall be stamped and signed by a professional engineer. The professional engineer is responsible for the design, performance of the designed element, and preparation of the construction drawings calculations, and procedures.

Once a complete submittal has been received, the reviewer shall be allowed 21 calendar days for the initial review period and 14 calendar days for review of a submittal returned as non-conforming unless stated otherwise in the specification requirements. The Contractor is entirely responsible for the work associated with these submittals. The Agency will not be responsible for errors in dimensions, incorrect erection procedures, design requirements, or successful completion of the work.

(3) Design Drawings. For an item or element of work to be permanently incorporated in the project which has not been designed and detailed in the Plans, the Contractor shall prepare and submit to be reviewed for conformance detailed design calculations, procedures, and drawings for the item or element of work. Design drawings, calculations, and procedures shall be stamped and signed by a professional engineer.

105.07 CONFORMITY WITH PLANS AND ALLOWABLE DEVIATIONS.

(a) General. The work shall be performed in reasonably close conformity with the lines, grades, cross-sections, dimensions, and material requirements, including tolerances, shown in the Contract. Any deviation from the Contract required will be determined by the Engineer and authorized in writing.

(b) Acceptance of Non-Conforming Materials or Work; Price Adjustment. If the materials or the finished product in which the materials are used do not conform to the Contract requirements, but reasonably acceptable work has been produced, the Engineer will determine if the work will be accepted and remain in place. If accepted, the Engineer will document the basis of acceptance, which may require a Contract modification and price adjustment.

(c) Rejection of Non-Conforming Materials or Work; Treatment of Rejected Materials or Work. If the materials or the finished product in which the materials are used do not conform to the Contract requirements, and the Engineer determines that the product is unsatisfactory, the Engineer will direct the work or materials be removed, replaced, or otherwise corrected by the Contractor at the Contractor's expense.

105.08 COOPERATION BY THE CONTRACTOR. The Contractor shall:

(a) Provide Bid Documents. Promptly provide copies of all bid documents upon request by the Engineer, including but not limited to all information used to prepare the bid proposal. Failure to provide such documents may result in the waiver of any right to bring a claim for additional compensation under Subsection 105.20.

(b) Have a Competent Superintendent. Have on the project at all times a competent and reliable English-speaking superintendent authorized to receive orders and to act for the Contractor. The Contractor shall make every effort to provide continuity in the position of superintendent. However, the Agency reserves the right to refuse or terminate the assignment of any superintendent on the project; this shall not be grounds for a claim under Subsection 105.20.

(c) Have a Competent Safety Officer. Have available on the project at all times during the prosecution of the work a competent and reliable English-speaking employee designated as the safety officer. This person shall be authorized to receive orders and issue binding directions concerning safety to all persons associated with the project who are employed by the Contractor, subcontractors, or material suppliers. This individual shall be well versed in all applicable OSHA regulations, shall be capable of implementing a plan to conform to these regulations, and shall have the authority to stop operations on the project.

The safety officer shall maintain a complete copy of the safety plan(s) for the Contract, which shall be available at all times during the prosecution of the work for inspection and/or copying by the Engineer.

(d) Provide Emergency Contacts. Furnish to the Engineer a list of addresses and telephone numbers of the Contractor's personnel who can be reached in an emergency. The Contractor shall alert certain personnel to stand by and shall inform the Engineer of all arrangements therefore.

(e) Provide Facilities; Information; Assistance; Samples; Control Points. Provide all reasonable facilities and furnish the information, assistance, and samples required by the Engineer or inspector to properly inspect and test materials and quality of work; and cooperate in setting and preserving stakes, benchmarks, and other control points used in laying out the work.

105.09 COOPERATION WITH UTILITIES.

(a) General. The Agency will notify all utility companies, pipeline owners, and other known parties affected and endeavor to have all necessary adjustments of the public or private utility fixtures, pipelines, and other appurtenances within or adjacent to the limits of construction made as soon as practical.

(b) Moving Utility Property; Owner's Expense. Water lines, gas lines, wire lines, service connections, water and gas meter boxes, water and gas valve boxes, light poles, cableways, signals, and all other utility appurtenances within the limits of the proposed construction which are to be relocated or adjusted are to be moved by the owners at their expense, unless otherwise provided in the Contract.

(c) Utility Interference; No Claim for Delays. The Contractor acknowledges and understands that, at the time of bid submission, it has considered all of the permanent and temporary utility facilities or appurtenances in their present and/or relocated positions as shown on the Plans and evident at the site. Notwithstanding any other provision of law, case law, regulation, or the Contract, no additional compensation will be allowed for any delays, inconvenience or damage sustained by the Contractor due to any interference from utilities, utility companies, utility facilities, appurtenances, or the operation of moving them.

(d) Utility Relocation for Contractor's Convenience. Should the Contractor desire temporary changes of location of any utility facilities or appurtenances for convenience in performing the work, the Contractor shall satisfy the Agency that the proposed relocation does not interfere with its own or other Contractors' operations or the requirements of the work and does not cause an obstruction or a hazard to the traveling public. The Contractor shall be responsible for requesting such relocation work of a utility and/or other affected parties. Such relocation work shall be done solely at the Contractor's expense.

105.10 COOPERATION BETWEEN CONTRACTORS.

(a) Agency Right to Contract. The Agency reserves the right to contract for and perform other or additional work on or near the work covered by the Contract at any time.

(b) No Interference with Other Contractors. When separate Contracts are let within the limits of a project, each Contractor shall conduct its own work so as not to interfere with or hinder the progress or completion of the work being performed by other Contractors. Contractors working on the same project shall cooperate with each other as specified or ordered by the Engineer.

(c) Liability, Indemnification, Defense. Each Contractor involved shall assume all liability, financial or otherwise, in connection with its own Contract and shall defend, indemnify, protect, and save harmless the Agency from any and all damages or claims that may arise because of inconvenience, delay, or loss experienced by the Contractor because of the presence and operations of other Contractors working within the limits of the same project.

105.11 CONSTRUCTION STAKES.

(a) Initial Layout. Unless other methods of placing stakes are provided in the Contract, the Engineer will be responsible for setting sufficient points to establish the initial alignment and elevation of the proposed work. The Contractor shall check the proposed grades; any mistakes or errors identified shall immediately be brought to the attention of the Engineer, and adjustments will be made by the Engineer.

(b) Permanent Marking Layout. Once the wearing course has been placed, the Engineer will establish the layout for the permanent centerline traffic markings, including passing zones, breaks for town highways and side roads, and any other items required for the centerline markings. The Contractor shall be responsible for the layout of all non-centerline markings.

(c) Responsibility for Layout. The Contractor shall be responsible for the preservation of all stakes and markings and shall replace any stakes or grades that are destroyed or disturbed. No claim shall be brought and no additional compensation will be paid on account of any alleged inaccuracies in the construction layout, including any additional layout that the Engineer may perform that is not covered in this subsection, unless the Contractor notifies the Engineer of the inaccuracies in writing at least 24 hours prior to commencement of the work.

(d) Qualified Personnel. All other stakes, templates, and other materials, either in addition to or in replacement of the original set, which may be required for the construction operations, shall be furnished, set, and properly referenced by qualified personnel employed by the Contractor.

(e) Contractor Layout. The Contractor shall stake out the work and make known the immediate plan or procedure of the next work contemplated. The Contractor shall inform the Engineer sufficiently in advance of construction to permit the Engineer to take the necessary measurements for the computation of quantities and to check the Contractor’s layout. The Contractor shall lay out in a timely manner and maintain a sufficient number of grade stakes so the Engineer can monitor and regulate all portions of the Contract work.

(f) Cost. The cost of this work shall be considered as incidental to the Contract as a whole and shall be included in the unit price bid for the Contract items involved.

105.12 INSPECTION OF WORK.

(a) General; Contractor to Help Engineer. The Engineer or their designated representative shall be allowed access to all parts of the work at all times and shall be furnished by the Contractor all information and assistance necessary to make a complete and detailed inspection. The Contractor shall furnish such help as the Engineer desires and/or needs to ascertain whether or not the work is performed in accordance with the requirements and the intent of the Contract.

(b) Examination of Completed Work. If, before the acceptance of the work, the Engineer requests, the Contractor shall remove or uncover portions of the finished work as the Engineer may direct. After the examination, the Contractor shall restore the portion of the work to the standard required by the Contract. If the work thus exposed or examined proves acceptable, the expenses of uncovering or removing and replacing the parts removed shall be paid for as extra work as defined in Subsection 109.06; but if the work exposed or examined is unacceptable, the expenses of uncovering or removing and replacing the parts removed shall be borne by the Contractor.

(c) All Work Requires Supervision or Inspection. The Agency will not be required to pay for any work done or materials used without supervision or inspection by the Engineer or an inspector. Supervision/inspection includes project, mill, plant, or shop inspection of any work furnished under the Contract.

(d) Inspection by Others. When any unit of government or of a public or private entity is to pay a portion of the cost of the work covered by the Contract, its respective representatives shall have the right to inspect the work. Such inspection shall not make any entity a party to this Contract and shall not interfere with the rights of either party hereunder.

105.13 REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK.

(a) General. All work which does not conform to the requirements of the Contract will be considered unacceptable unless otherwise determined to be acceptable under the provisions of Subsection 105.07.

(b) Removal and Replacement of Unacceptable Work. Unacceptable work, whether the result of poor quality of work, use of defective materials, damage through carelessness, or any other cause found to exist prior to the acceptance of the work, shall be removed immediately and replaced in an acceptable manner.

(c) All Work Must Be Authorized. Work shall be performed only with lines and grades having been provided by the Engineer. Work performed contrary to the instructions of the Engineer, beyond the lines shown on the Plans, or without authority will be considered unauthorized and no payment therefore will be made. Work so done may be ordered removed or replaced at the Contractor's expense.

(d) Failure to Comply with Order of Engineer. Upon failure by the Contractor to comply forthwith with any order of the Engineer communicated under the provisions of this subsection, the Engineer will have authority to require unacceptable work to be remedied or removed and replaced and to require unauthorized work to be removed. In either case, the Engineer is authorized to deduct the costs from any monies due or to become due to the Contractor.

(e) Responsibility for Agency Expense. Any expense incurred by the Agency in making removals, renewals, or repairs which the Contractor has failed or refused to make shall be paid for out of any monies due or which may become due the Contractor or may be charged against one or more Contract bonds.

(f) No Compensation for Additional Time. No additional Contract time shall be warranted for any of the work described in this subsection.

105.14 SUNDAYS, HOLIDAYS, HOURLY RESTRICTIONS, AND NIGHT WORK.

(a) Sundays. Unless otherwise specified in the Contract or authorized in writing by the Engineer, the Contractor shall not perform construction operations on Sundays.

(b) Holidays. Unless otherwise specified in the Contract or authorized in writing by the Engineer, the Contractor shall not work during the following holiday periods:

New Year's Day	January 1st
Martin Luther King Jr. Day	Third Monday in January
Presidents' Day	Third Monday in February
Town Meeting Day	First Tuesday in March
Memorial Day	Last Monday in May
Independence Day	July 4th
Bennington Battle Day	August 16th
Labor Day	First Monday in September
Indigenous Peoples' Day	Second Monday in October
Veterans Day	November 11th
Thanksgiving Day	Fourth Thursday in November
Day After Thanksgiving	Day After Thanksgiving
Christmas Day	December 25th

If a holiday falls on a Sunday, the Monday immediately following it shall be considered the holiday. If a holiday falls on a Saturday, the Friday immediately preceding it shall be considered the holiday.

Designated holiday periods shall begin at 12:00 noon on the day before the weekend or holiday, whichever applies, and shall end at 6:00 a.m. on the day after the holiday or the weekend, as appropriate. The Engineer may require the Contractor to cease construction operations for the entire day before if a holiday falls on a Tuesday, or for the entire day after if a holiday falls on a Thursday.

(c) Hourly Restrictions. The Contract may specify that the Contractor is either prohibited from or required to work during certain hours or may limit the type of operations that may be performed during certain hours.

If work is performed between 7:00 p.m. and 6:00 a.m., the Contractor shall take measures to mitigate the noise caused by its construction operations. Wherever practicable, the Contractor should sequence work such that noisy activities occur concurrently. Other potential noise reduction mitigation measures are outlined in the *FHWA Highway Construction Noise Handbook*. In addition, the Contract may specify a maximum decibel limit or other required noise restrictions. The cost for mitigating noise will not be paid for separately but will be considered incidental to all other Contract items. At a minimum, the Contractor shall use the following noise mitigation techniques:

(1) Use broadband sound (i.e. white-noise, whooshing sound) types of backup alarms, or adjustable backup alarms where the volume can be adjusted down for the ambient noise level.

(2) Shield or insulate stationary equipment such as air compressors and generators.

(3) Employ systems to prevent slamming tailgates on dump trucks.

(d) Night Work. Work performed at night, as defined in Subsection 101.02, will require a lighting plan as specified in Section 641.

(e) Applicability. The limitations in this subsection shall not apply for the purposes of maintenance, emergency repairs, and proper protection of the work, including but not limited to the curing of concrete and the repair and servicing of equipment.

The limitations in this subsection also shall not relieve the Contractor of any responsibility for the work involved as set forth in Subsection 105.08, Subsection 107.17, or elsewhere in the Contract.

105.15 CONVICT LABOR. No incarcerated convict labor shall be employed on the Contract.

105.16 LOAD RESTRICTIONS.

(a) General. The Contractor and all subcontractors, suppliers, or others involved in any project-related activities shall comply with all legal load restrictions specified in *23 V.S.A. § 1392* in the hauling of equipment or material on public roads, including that beyond the limits of the project. The application for and possession of any hauling or related permit will not relieve the Contractor or others involved in any project-related activities of any liability that may arise due to any damage resulting from the use or moving of equipment, vehicles, or any other project-related activity.

(b) Limitations on Use of Equipment and Vehicles. Use of equipment and vehicles is subject to the following:

(1) No vehicle or equipment exceeding the load restrictions cited in *23 V.S.A. § 1392* will be permitted on any structure as defined by the Engineer.

(2) The operation of any equipment or vehicle of such weight or any other project-related equipment loaded so as to cause damage to structures, the roadway, or to any other type of active construction will not be permitted, regardless of the limits set forth in *23 V.S.A.*

(3) Hauling or operation of said vehicles or equipment over any permanent course of any bituminous pavement or any structure during active construction will not be permitted.

(4) Notwithstanding those restrictions above, the Contractor shall be responsible for any and all damage incurred to any public roadway as defined in *23 V.S.A.* due to the use of any equipment or vehicles related to project activities.

(c) Penalty and Reduction for Overweight Operation. Each vehicle entering or leaving the project limits shall be within the legal load limit or the load limit imposed by a current overload permit for the roadways and structures. Should any vehicle not meet these requirements, in addition to the appropriate penalty under *23 V.S.A. § 1391a*, the difference in weight between the legal load limit and the gross vehicle weight shall be converted to the appropriate measurement quantity for the item involved and treble this amount shall be deducted from the quantity of the item to be paid the Contractor. The Contractor shall not deduct this amount from the payment to its trucking subcontractors or suppliers.

(d) Provision of Overweight Permit Copies. The Contractor shall provide copies of overweight permits to the Engineer prior to the commencement of hauling. Copies of permits provided after hauling has begun will not be considered to be in effect for the project prior to the time that the Engineer receives the copy.

(e) Provision of Tare Weight. The Contractor shall provide the Engineer with tare weights for all vehicles carrying or delivering materials to be used on a project. A tare weight shall be the weight of the unloaded vehicle with full fuel tank and water tank as applicable.

(f) Application to All Vehicles Used for the Project. These requirements, including the overload reduction, shall apply to the Contractor's vehicles as well as all other vehicles used in conjunction with the construction of this project, including the vehicles of subcontractors and suppliers.

105.17 MAINTENANCE OF THE PROJECT DURING CONSTRUCTION.

(a) General. The Contractor shall maintain the work during construction and until the work is accepted. This maintenance shall constitute continuous and effective performance of the work day-by-day with adequate equipment and forces so that the project is kept in satisfactory condition at all times.

(b) Costs. All cost of maintenance work during construction and before acceptance of the work shall be included in the Contract unit prices for the various pay items, and the Contractor will not be paid an additional amount for such work.

(c) Maintenance During Shutdown. In the event the work is ordered shut down for failure to comply with the provisions of the Contract or for any other reason, the Contractor shall maintain the project as provided herein and provide such ingress and egress for local residents as necessary during the period of shutdown.

105.18 FAILURE TO MAINTAIN THE PROJECT. Failure on the part of the Contractor to properly maintain the work will result in the Engineer immediately notifying the Contractor to comply with the required maintenance provisions. If, after receipt of such notice, the Contractor fails to remedy the situation to the Engineer's satisfaction, the Engineer will proceed with adequate forces and equipment to maintain the project; the cost of this maintenance will be deducted from monies due or which may become due the Contractor under the Contract.

105.19 FINAL INSPECTION AND ACCEPTANCE.

(a) General. The Contract will not be accepted until all of the work required by the Contract has been satisfactorily completed.

(b) Procedure. Upon notice from the Contractor of their intent to achieve substantial completion, the Engineer will review the work and issue a written order if the project has achieved substantial completion. The written order will document the date on which the project achieved substantial completion.

The Engineer will arrange a date for a final inspection of the work. As a result of the final inspection a final punch list will be developed and provided to the superintendent.

When the punch list is completed and all work provided for and contemplated by the Contract is found to be completed, the Contractor will be informed in writing that the project is complete and accepted.

105.20 CLAIMS FOR ADJUSTMENT.

(a) Claims Process – In General. Whenever the Contractor learns that a condition and/or issue may result in costs and/or delays that were not anticipated by the Contractor at the time of bid, the Contractor shall provide the Engineer with notice of that fact immediately or as soon as reasonably possible. It is critical that the Agency be aware of potential Claims at the earliest opportunity so that it can carefully monitor the potential additional costs and potentially assist the Contractor in taking steps to mitigate those additional costs. Thus, the Contractor shall promptly file a Notice of Intent to File a Claim.

If the Contractor later decides to file a Claim for additional compensation under the Contract, that Claim must provide certain key pieces of information to the Construction Engineer so that the claim can be evaluated expeditiously. If necessary, the Construction Engineer will contact the Contractor for additional information about the Claim and may request a meeting with the Contractor. The Construction Engineer typically does not invite legal counsel to such meetings unless the Contractor chooses to have its own legal representation at the meeting.

(b) Notice – Procedural Requirements. In order to bring a Claim for additional compensation for costs and conditions not clearly covered under the Contract, the Contractor shall provide written notice ("Notice of Intent to File a Claim for Additional Compensation" or the "Notice") to the Engineer before incurring any costs or conducting any work that could in any way be included in any such Claim for additional compensation under the Contract (the "Claim"). The Engineer's written acknowledgement of receipt of the Notice and the Contractor's daily reporting under this subsection, shall not be construed as an approval by the Agency of the merits of the Claim.

(c) Notice – Substantive Requirements. The words "Notice of Intent to File a Claim" shall appear in large print at the top of the document. The Notice shall specify the basis for the Claim, including the nature of the Claim, the reason why the Contractor believes that the Agency is responsible for payment of the Claim, and a description of the additional compensation, including reference to each activity associated with the work and/or materials, including reference to any impacts to the Contractor's progress schedule, as defined in Subsection 108.03(a), or CPM schedule, as defined in Section 633. If the Contractor fails to provide the Notice as specified herein, the Contractor waives its right to bring the Claim under the Contract and the Agency may deny the Claim on this basis alone.

(d) Notice Documentation Requirements. Upon providing the Notice of Intent to File a Claim, the project superintendent shall commence daily records for all labor hours, equipment hours (idle and operating), and materials involved with the work or materials at issue in the Notice and submit such records to the Engineer on a daily basis. ("Daily Records"). Such records shall separate the work and/or materials subject to the Claim from the undisputed work, and include a written analysis of how the work and/or materials at issue in the Notice impact(s) the critical path. If the Contractor fails to provide such records to the Engineer as required herein, the Contractor waives its right to bring the Claim, and the Agency may deny the Claim on this basis alone.

(e) Claim Documentation Requirements. The Contractor shall provide the Construction Engineer with the following documentation in support of the claim ("Claim Documentation"). This documentation shall be structured, formatted, and labeled as noted.

(1) Part 1. A detailed statement of the claim, including the date on which the Contractor first became aware of the actions or conditions giving rise to the Claim, all necessary dates, locations, and work and material items at issue in the Claim, including copies of the Daily Records. Pages shall be labeled page 1-1 through page 1-X.

(2) Part 2. A copy of the Notice of Intent to File a Claim. Pages shall be labeled page 2-1 through page 2-X.

(3) Part 3. A list of the names of all Agency employees and agents, including consultants, the Contractor believes have knowledge or information concerning the facts giving rise to the Claim. Pages shall be labeled page 3-1 through page 3-X.

(4) Part 4. A list of the names of all Contractor employees and agents, including subcontractors, whom the Contractor believes have knowledge or information concerning the facts giving rise to the Claim. Pages shall be labeled page 4-1 through page 4-X.

(5) Part 5. A list of the specific provisions of the Contract that the Contractor believes support the Claim, and a description of why the Contractor believes those provisions support the Claim. Pages shall be labeled page 5-1 through page 5-X.

(6) Part 6. A list of all documents and all written statements that the Contractor believes support the Claim, and copies of the same. Pages shall be labeled page 6-1 through page 6-X.

(7) Part 7. A statement as to whether additional compensation, an extension of time, or both, are being requested in the Claim. Pages shall be labeled page 7-1 through page 7-X.

(8) Part 8. If a time extension is being requested in the Claim, a statement as to the specific number of days being requested, supported with reference to how the facts underlying the Claim affected the Contractor's performance schedule, including how such facts affected the critical path. Reference shall be made to the Contractor's baseline CPM schedule and any updates or revisions thereto, and a schedule analysis providing evidence of delays to the critical path shall be provided. If no time extension is being requested in the Claim, a statement to that effect shall be provided. Pages shall be labeled page 8-1 through page 8-X.

(9) Part 9. If additional compensation is being requested, an itemized listing of the total amount of any and all costs being sought in the Claim, listed by category of work, including, but not limited to, work items, labor and materials costs, and costs relating to delays associated with performing the work. Such documentation shall include invoices for rented equipment, the EquipmentWatch *Rental Rate Blue Book* analysis for owned equipment, and subcontractor agreements. If no additional compensation is being requested in the Claim, a statement to that effect shall be provided. Pages shall be labeled page 9-1 through page 9-X.

(10) Part 10. For every Claim, the Contractor shall provide a separate document containing the following Claims Certification.

> *Under penalty of law for perjury or falsification, the undersigned, [insert individual's name, job title, and company name], certifies that this claim for additional compensation for work on the Contract is a true and accurate statement of the actual costs incurred (in the amount of [insert amount], exclusive of interest) and is fully documented and supported under the Contract between the parties.*

The Claims Certification shall be signed, dated, and notarized and executed by a senior officer of the Contractor with legal authority to bind the Contractor, or if the Contractor is a sole proprietor, by the proprietor. The Claims Certification may be used in any proceedings regarding false Claims under *31 U.S.C. § 3729* or *32 V.S.A. § 631*. This page shall be labeled page 10-1.

(f) Procedure for the Initial Adjudication of Claims. The initial determination of the merits of the Claim will be made by the Construction Engineer.

(1) Completeness Determination. The Construction Engineer will determine whether the Claim Documentation provided by the Contractor meets the requirements of Subsection 105.20(e). If the Claim Documentation is not complete, structured, formatted, and labeled as required, it will be deemed incomplete and the Contractor will be required to resubmit it in its entirety.

The Construction Engineer will endeavor to make the Completeness Determination within 30 calendar days of receipt of the Claim. Where this 30 calendar day period is unfeasible, the Construction Engineer will inform the Contractor as to the status of the Completeness Determination, if necessary, on a quarterly basis. The review and analysis of the merits of the Claim may be postponed pending the Completeness Determination. The Construction Engineer will inform the Contractor, in writing, that the Completeness Determination has been issued.

(2) Claims Analysis. Once the Construction Engineer has issued the Completeness Determination, the Construction Engineer will begin a principled, merits-based analysis of the Claim ("Initial Claim Judgment" or "ICJ"). The Construction Engineer may seek additional documentation from the Contractor, including but not limited to a full set of the Contractor's original bid preparation package.

a. The Construction Engineer may interview employees of the Contractor and subcontractors and conduct other interviews or seek additional documents from other entities, including the Agency. The Construction Engineer may also hold an informal hearing with the Contractor to ask any follow-up and clarifying questions, and to give the Contractor a full and fair opportunity to present the merits of the Claim. The Construction Engineer will endeavor to keep the Contractor informed as to the status of the Claim, if necessary, on a quarterly basis.

b. The Construction Engineer will make all reasonable efforts to issue, in writing, the ICJ, allowing or denying the Claim, in whole or in part, within 180 calendar days of the Completeness Determination. The ICJ shall include findings of fact and conclusions of law with respect to the specific contractual provisions governing the Claim.

(g) Appeal to the Chief Engineer. If the Contractor is aggrieved by the ICJ, an appeal may be made to the Chief Engineer. Notwithstanding any other provision of law, case law, regulation, or the Contract, all appeals shall be made within 30 calendar days of the decision to which the Contractor is aggrieved, and not thereafter.

(1) Review. The Chief Engineer will review the ICJ and determine whether additional documents or interviews will be necessary to decide the appeal. The Chief Engineer may interview or re-interview employees of the Contractor and subcontractors and conduct other interviews or seek additional documents from other entities, including the Agency. The Chief Engineer may also hold an informal hearing with the Contractor to ask any follow-up and clarifying questions, and to give the Contractor a full and fair opportunity to present the merits of the Claim. The Chief Engineer will endeavor to keep the Contractor informed as to the status of the Claim, if necessary, on a quarterly basis.

(2) Decision-Making. The Chief Engineer will make all reasonable efforts to issue, in writing, the Agency's final determination on the merits of the Claim ("Final Claim Judgment" or "FCJ"), as required under paragraph eight of *Form CA-111B*, "Dispute Resolution, Exclusivity of Administrative Remedies," within 180 calendar days of the date of the appeal.

The FCJ may affirm the ICJ in whole or in part, or may allow or deny the Claim, in whole or in part, on other grounds. The FCJ shall include findings of fact and conclusions of law with respect to the specific contractual provisions governing the Claim.

(3) Quasi-Judicial Appeal. If the Contractor is aggrieved by the FCJ, it may seek appellate review of the FCJ before the Transportation Board pursuant to Subsection 105.04. The Transportation Board shall defer to the factual findings of the FCJ and review the legal conclusions of the FCJ de novo.

(h) Time for Claims; Appeals. Notwithstanding any other provision of law, case law, regulation, or the Contract, all Claims by the Contractor shall be submitted in writing within 90 calendar days after the acceptance date of the Contract or within 90 calendar days of the Notice of Intent to File a Claim, whichever occurs first, and not thereafter (the "Claim Filing Period"). Such Claims shall meet the requirements set forth above, including, but not limited to, complete documentation supporting the Claim. Any additional time granted by the Construction Engineer because the Claim was incomplete or for the time to produce supplemental information shall not be the subject of any demand for interest payments or for attorneys' fees and/or other costs.

If the Contractor fails to file the Claim within the Claim Filing Period, the Contractor waives its right to bring the Claim. If the disputed work continues to be performed beyond the Claim Filing Period, the Contractor shall submit a written request to extend the Claim Filing Period prior to the expiration of the Claim Filing Period. The Contractor shall submit such requests for extension of the Claims Filing Period every 90 calendar days until the disputed work is completed. Once the disputed work is complete, the Contractor must submit the complete Claim within the latest approved Claim Filing Period, or 90 calendar days from the date the disputed work was completed, whichever is first, and not thereafter.

105.21 PAYROLLS.

(a) General. The Contractor shall maintain and make available payroll records as required in the Contract. This requirement shall also apply to the work of any subcontractor having a subcontract for any part of the work performed on the job. Any costs associated with this work will not be paid for directly but will be considered incidental to the Contract pay items.

(b) Examination, Authority. The Contractor hereby authorizes the Engineer or the Engineer's authorized representative to examine the Contractor's orders for construction workers on file with the local employment office of the Vermont Department of Labor.

(c) Additional Contract Requirement. For construction and transportation projects with a value over $250,000, the Contractor shall implement a payroll process by which during every pay period the Contractor shall submit a list all workers who were on the jobsite during the pay period, including those employed by subcontractors and independent contractors, the work performed by those workers on the jobsite, and a daily census of the jobsite.

This information, including confirmation that Contractors, subcontractors, and independent contractors have the appropriate workers' compensation coverage for all workers at the jobsite, and similar information for the subcontractors regarding their subcontractors, shall also be provided to the Vermont Department of Labor and to the Vermont Department of Financial Regulation, upon request, and shall be available to the public.

105.22 ENVIRONMENTAL REGULATION. The Contractor shall perform all project related operations so as to give protection to the natural and cultural resources of the state.

The Contractor shall conduct the work in conformance with all regulations and permit conditions applicable to the Contract. If the Contractor proposes to perform the work differently than the manner provided in the Contract, the Contractor shall obtain approval from the appropriate regulating entities prior to performing the work. The costs associated with obtaining and complying with permits required to perform the work will not be paid for directly, but will be considered incidental to the Contract.

105.23 EROSION PREVENTION AND SEDIMENT CONTROL.

(a) Submission of Plans. Unless otherwise required by Contract to comply with Subsection 653.03, the Contractor shall submit a plan in writing for the prevention of erosion and control of sedimentation and pollution on the project and on associated access roads, material waste and borrow areas, and staging areas. The plan shall be submitted no later than the preconstruction conference and a Notice to Proceed will not be issued until the plan has been found to be in conformance.

(b) Erosion Prevention and Sediment Control Measures. Erosion prevention and sediment control measures shall be installed and maintained in conformance with the Contract. Unless otherwise specified in the Contract, this work shall be performed as described in this section, Section 653, and *The Low Risk Site Handbook for Erosion Prevention and Sediment Control* published by the Vermont Agency of Natural Resources.

(c) Engineer's Authority; General. The Engineer has authority to limit the surface area of erodible earth material exposed by construction activities and to direct the Contractor to provide immediate permanent or temporary erosion prevention and sediment control measures to minimize adverse effects on resources. This may include restricting the area of clearing and grubbing, excavation, borrow, and embankment operations such that these activities are commensurate with the Contractor's capability to install erosion prevention and sediment control measures in accordance with the erosion prevention and sediment control plan.

(d) Temporary and Permanent Erosion Prevention and Sediment Control. The Contractor shall incorporate all temporary and permanent erosion prevention and sediment control measures into the project at the earliest reasonable time. Temporary erosion prevention and sediment control measures shall be used to prevent erosion and to correct conditions that develop during construction prior to installation of permanent measures. As the earthwork proceeds, slopes shall be graded to finish grade whenever practical, and all disturbed areas shall be stabilized by seeding and mulching or other acceptable methods within 48 hours of disturbance.

(e) Erosion Control for Clearing and Grubbing. Clearing and grubbing shall be performed so that the resulting exposed surfaces are stabilized with temporary or permanent measures within 48 hours.

(f) Conflicts. In the event of conflict between the requirements of this subsection and those of federal, state, or local agencies, the more restrictive provisions shall apply as determined by the Engineer.

(g) Suspension of Operations. If construction operations are suspended, areas of exposed earth shall be stabilized. If permanent stabilization is not possible, exposed areas shall be shaped and then covered with mulch or matting to intercept and divert runoff to locations where the least amount of erosion will result. During a suspension of construction operations, the Contractor shall act immediately to correct any deficiencies that develop with the erosion prevention and sediment control measures and/or stabilized areas.

(h) Maintenance of Temporary Erosion Prevention and Sediment Control Measures. Temporary erosion prevention and sediment control measures shall be acceptably maintained until both the permanent drainage facilities have been constructed and vegetation has been established throughout the project.

105.24 POLLUTION CONTROL.

(a) General. The Contractor shall exercise every reasonable precaution to prevent pollution of the air, land and water of the state and shall comply with applicable statutes and regulations relating to the prevention and remediation of pollution.

(b) Bridge Operations. For projects with bridge activities including demolition, painting, cleaning, cutting, welding, or grinding operations, the Contractor shall include a description of any proposed containment measures as part of their erosion prevention and sediment control plan, submitted in accordance with Subsection 105.23(a). When the bridge activities listed above are in progress where lead paint is known or suspected, the Contractor shall use containment devices to retain all generated materials. The Contractor shall also consult with the Vermont Department of Health to determine if a lead abatement permit is required. When required, the Contractor shall coordinate with the Agency's Hazardous Materials and Waste Coordinator to administer the permit request.

(c) Coated/Treated Materials. The Contractor shall comply with all pollution control, health, and transportation regulations when cleaning, handling, moving, repainting, cutting, welding, sanding, or grinding any coated or treated materials.

(d) Noise and Air Pollution. The Contractor shall employ standard methods to minimize noise and air pollution associated with construction operations. The methods employed shall be acceptable to the Engineer and compatible with the location of the work. The burning of tires or other manufactured products is prohibited.

In accordance with *23 V.S.A. § 1110*, equipment shall not be permitted to idle for more than 5 minutes in a 60 minute period.

(e) Contaminated Materials and Hazardous Waste.

(1) Unanticipated Contamination. Should evidence of unanticipated contamination (such as chemical or petroleum odors or presence of non-native materials including, but not limited to, solid waste, asphalt, or ash) be discovered during construction, the Contractor shall immediately notify the Engineer. The Agency will work with the Contractor to notify regulators as necessary and to develop a plan to manage the materials, waste, or both.

(2) Generated Contamination. The Contractor shall provide documentation to the Engineer that any generated contaminated material or hazardous waste was characterized as necessary and disposed of in conformance with all applicable regulations.

(f) Limits on Use of Mechanized Equipment. Unless otherwise approved in writing and permitted by the appropriate federal or state regulating authority, mechanized equipment shall not be operated in the waters of the state.

(g) Water Quality. Pollutants, including, but not limited to, chemicals, paints, fuels, lubricants, bitumen, raw sewage, sediment, or other waste, shall not be discharged into or alongside wetlands, waters of the state, or natural or constructed channels leading thereto. Any construction activity in or adjacent to regulated waters shall comply with the *Vermont Water Quality Standards*.

105.25 OPENING OFF-SITE ACTIVITY AREAS.

(a) General. The Contractor shall demonstrate that the proposed off-site activity (OSA) area is in accordance with all Contract permits and that the following requirements are met:

(1) The final shape, slope, and contour of the land in and about the area will not be undesirable aesthetically or as it relates to drainage.

(2) The OSA area is consistent with any duly adopted development plan, land use plan, or land capability plan, whether site specific, local, or regional.

(3) The entrance is at the most desirable angle or perspective from any nearby highways, residences, and other facilities.

(4) Clearing performed in OSA areas shall comply with the requirements of Subsection 201.06. The Contractor shall remove, stockpile, and preserve topsoil, sod, and other suitable material from the surface of the area prior to proceeding with other operations.

(5) The Contractor shall have all erosion prevention and sediment control measures, as indicated in the conforming erosion prevention and sediment control plan, in place prior to use of the area. At a minimum, the requirements of *The Low Risk Site Handbook for Erosion Prevention and Sediment Control* published by the Vermont Agency of Natural Resources shall be used as best management practices for OSA areas.

(b) Clearances.

(1) Exempt Sites. Certain types of sites for certain activities are exempt from requiring further review of potential natural and cultural resource impacts. A list of these exemptions is part of the *Off-Site Activity Exemption Record* form that is available on the Agency's website. To use an exempt OSA area, the Contractor shall complete this form and then submit it to the Engineer.

(2) Non-exempt Sites. For non-exempt OSA areas, the Contractor shall complete the *Off-Site Activity Submittal* form that is available on the Agency's website. The completed form shall be submitted to the Environmental Section to review potential natural and cultural resource impacts. A copy of this form shall also be submitted to the Engineer. Within 21 calendar days, the Environmental Section will provide an OSA review form indicating conformance or non-conformance of the site, along with any specific conditions.

(c) Permits. The Contractor and/or the property owner shall be required to obtain or amend all necessary federal, state, and local permits and clearances prior to using an area for an Agency project. Any fees related to applications for such permits shall be the responsibility of the Contractor.

105.26 MAINTAINING OFF-SITE ACTIVITY AREAS.

(a) General. The Contractor shall conduct operations at OSA areas so as to minimize air pollution. The Contractor shall keep in a condition acceptable to the Engineer the portions of an area where a pit or pits have been opened and shall maintain all access roads with sufficient dust control and proper drainage to prevent damage to adjacent properties. Area operations shall be restricted to normal working hours except with the express written approval of the Engineer and shall be in accordance with all permit conditions. All OSA areas shall comply with the environmental regulations described in Subsection 105.22 and the pollution control described in Subsection 105.24.

(b) Area Erosion Prevention and Sediment Control Measures. Installation and maintenance of erosion prevention and sediment control measures at OSA areas shall be consistent with the conforming erosion prevention and sediment control plan for the specific area. The on-site plan coordinator (OSPC) shall review these areas as required in the Contract.

(c) Seasonal Shutdown. For areas that will be used for more than one construction season, the Contractor shall grade to no steeper than 1:3 (V:H) and seed and mulch disturbed fill areas prior to shutting down for the season.

105.27 CLOSING OFF-SITE ACTIVITY AREAS. With the exception of those areas which will remain open for commercial use, the Contractor shall complete the following prior to the completion and acceptance of the project:

(a) Shaping. The Contractor shall shape the entire area to leave banks in a neat and presentable condition, properly and thoroughly graded and drained.

(b) Vegetation Establishment. Vegetation shall be established on all disturbed areas.

(c) Removal of Debris. All stones, boulders, stumps, and debris shall be removed or satisfactorily disposed of.

(d) Angle of Slopes. Slopes shall not be left steeper than 1:3 (V:H) for earthen fills. Slopes shall not be left steeper than 1:2 (V:H) for fill made up of stone or concrete. The tops of slopes and toes of slopes shall be neatly rounded.

(e) Spreading Stripped Material. Stockpiled sod, topsoil, and other stripped material shall be evenly spread over the surface of the area. The complete area shall be seeded and mulched in accordance with Section 651.

105.28 PAYMENT FOR EROSION PREVENTION AND SEDIMENT CONTROL.

(a) General. Unless otherwise indicated in the Contract, all materials, installation, monitoring, maintenance and, where necessary, removal for those erosion prevention and sediment control measures required by the Plans and/or the Engineer that are not items in the Contract will not be paid for directly, but will be considered incidental to all other Contract items.

Environmental protection work in connection with erosion prevention and sediment control for the opening, maintaining, and closing of OSA areas and pollution control measures will not be paid for directly, but will be considered incidental to all other Contract items.

Costs for damage to OSA areas, to the owners thereof, or to adjacent property owners shall be the responsibility of the Contractor.

(b) Temporary Erosion Prevention and Sediment Control Measures. Required temporary erosion prevention and sediment control work not attributable to the Contractor's negligence, carelessness, or failure to install permanent controls will be performed and paid for as specified in Subsection 105.28(a), or as ordered by the Engineer.

Temporary erosion prevention and sediment control measures required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of the scheduled work or as ordered by the Engineer shall be performed by the Contractor at the Contractor's expense.

(c) Failure to Control Erosion, Pollution, or Siltation. In case of repeated failures by the Contractor to control erosion, pollution, or siltation, the Engineer may employ outside assistance or use state forces to provide the necessary corrective measures. Such incurred direct costs, plus project engineering costs, will be charged to the Contract and appropriate deductions made from any money or monies due or to become due the Contractor.

105.29 VALUE ENGINEERING.

(a) General. The intent of value engineering (VE) is to provide an incentive to the Contractor to initiate, develop, and present to the Engineer for consideration cost reduction proposals involving changes in the drawings, designs, specifications, or other requirements of the Contract. These provisions do not apply unless the proposal submitted is specifically identified by the Contractor as being presented for consideration as a VE proposal.

The change in cost proposals contemplated are those that would require a change order modifying the Contract and would produce an overall savings to the public by providing items or methods other than those specified in the Contract and/or reduce future maintenance costs without impairing or compromising essential functions and characteristics such as service life, safety, durability, reliability, economy of operation, ease of maintenance, and necessary standardized features.

A VE proposal shall contain proven features that have been used under similar conditions, and is presented as such, and does not contain equivalent options already provided in the Contract.

The Agency will not be responsible for schedule delays that occur as a result of the Contractor's desire to pursue a VE proposal.

(b) Procedure.

(1) General. Unless mutually agreed otherwise, the VE proposal approval process will occur in three steps:

a. A conceptual VE proposal submission and review.

b. A detailed VE proposal submission and evaluation.

c. If the VE proposal is approved, a change order modifying the Contract, including the amount of payment due to the Contractor and credit due to the Agency.

(2) Conceptual Value Engineering Proposal. To begin the VE proposal approval process, the Contractor shall submit a written Conceptual Value Engineering Proposal (CVEP) to the Engineer for consideration. The CVEP is not a formal and complete submittal based upon detailed technical analysis, but instead relays a conceptual idea based upon the Contractor's knowledge and expertise. The CVEP shall include the following information based upon the Contractor's best knowledge and understanding:

a. General Description. A narrative that describes the proposed change in concept and includes the basic differences between the existing Contract and the proposed change.

b. Advantages and Disadvantages. A listing and brief description of the comparative advantages and disadvantages of the CVEP including effects on the service life, safety, durability, reliability, economy of operation, ease of maintenance, and any other factors significantly altered by the CVEP.

c. Impacts to Permits and/or Third-Party Agreements. A description of steps necessary to address existing permits, new permits, or third-party agreements that may be impacted or required in order to initiate the proposed change(s). In addition, the Contractor shall describe its expectation of securing or modifying these documents, who is responsible for securing them, and required timeframe(s).

d. Identification of Prior Similar CVEPs. If the CVEP was submitted previously on another Agency project, the date, the project name and number, and the action taken by the Agency shall be indicated.

e. Known Use or Testing. A description of any previous use or testing of the concept(s) included in the CVEP that is known to the Contractor, including the tester, the conditions, and the results.

f. Estimate of Net Savings. An estimate of the Net Savings as defined in Subsection 105.29(c). This amount shall not include the cost to prepare and submit the CVEP.

g. Estimate of Development Costs. A scope of work and related cost estimate to develop and submit a Detailed Value Engineering Proposal (DVEP). This estimate shall include a detailed estimate of both the engineering costs the Contractor will incur in preparing the DVEP (the "Internal DVEP Costs") and the cost the Contractor will incur to obtain specialty engineering services that the Contractor cannot perform and which are necessary to prepare the DVEP (the "External DVEP Costs") (collectively, the "DVEP Costs"). If the Contractor establishes, to the satisfaction of the Construction Engineer, that it does not have the financial resources to incur the DVEP Costs, the Agency may, in its sole discretion, decide to advance the Contactor up to 50% of the DVEP Costs. In no event will the Agency pay more than 50% of the DVEP Costs, nor will the DVEP Costs exceed 50% of the Net Savings amount, as defined in Subsection 105.29(c)(3).

h. Savings and Schedule Impacts. An estimate of the time necessary for the Contractor to submit a DVEP and the time-sensitivity of the savings identified. Such estimate shall specify the date by which the Agency must approve the DVEP to obtain the maximum cost reduction, and the latest date by which the Agency must approve the DVEP for the Contractor to avoid significant impacts on the estimated Net Savings or the Contractor's schedule of work. If the Agency determines that the time for response is insufficient for review, the Contractor will be promptly notified. The Contractor shall identify the date by which if the DVEP is not approved the VE will be withdrawn and the original work can commence without delay to the project.

i. Plans and Specifications. A set of preliminary plans and specifications, prepared as construction drawings in accordance with Subsection 105.06, showing the proposed revisions relative to the original Contract features and requirements. VE proposals that require engineering design, computations, or analysis shall be prepared under the responsible charge of, and sealed and signed by, a professional engineer. The plan, specification, and engineering changes should be progressed far enough along to clearly show the design intent and be able to provide a quality cost estimate.

j. CVEP Presentation. Within 7 calendar days of submitting a CVEP, the Contractor shall be available to attend a meeting scheduled by the Agency for the purpose of presenting and answering questions regarding the CVEP. The purpose of the meeting is to discuss possible risks, design implications, and schedule impacts associated with the VE proposal. If applicable, the Contractor shall be accompanied by their engineer responsible for the plan and specification revisions associated with the VE proposal.

k. Agency Review. The Agency will use its best efforts to review a conforming CVEP and respond to the Contractor within 14 calendar days of receipt. The Agency may, at its sole discretion:

1. Invite the Contractor to submit a DVEP.

2. Reject the CVEP for reasons that will be described briefly.

3. Request additional information.

(3) Detailed Value Engineering Proposal. If invited by the Agency as provided in Subsection 105.29(b)(2)k.1., the Contractor may submit a Detailed Value Engineering Proposal (DVEP). DVEPs will be processed in the same manner as prescribed for any other alterations of the Contract that require a change order and shall contain, as a minimum, the following information:

a. Description. A description of what is being changed, altered, or deleted, and why, and what is being proposed to improve upon the originally designed feature.

b. Itemization. An itemization of the requirements of the Contract (Plans, specifications, pay items, and unit prices) that must be changed and a recommendation of how to make each change, including a description of the advantages and disadvantages and where these items have been successfully used on other projects before or tested elsewhere.

c. Computation of Net Savings. A detailed computation of the estimated net savings to be generated as defined in Subsection 105.29(c)(3), actual DVEP development costs, and estimated savings and schedule impacts, including approval date(s) required. If the Agency determines that the time for response is insufficient for review, the Contractor will be promptly notified.

d. Prediction of Other Costs. A prediction of any effects the proposed changes would have on other costs to the Agency, including environmental effects, traffic impacts, and preventive action or treatment costs.

e. Plans and Specifications. A complete set of plans and specifications, prepared as construction drawings in accordance with Subsection 105.06, showing the proposed revisions relative to the original Contract features and requirements. All DVEPs that require engineering design, computations, or analysis shall be prepared under the responsible charge of and signed and sealed by a professional engineer.

f. Contract Completion. A statement as to the effect the proposal would have on the time for the completion of the Contract. An extension to the original Contract completion date will generally not be approved.

(4) Evaluation of the DVEP. The Agency will evaluate the DVEP and consider the following:

a. The Agency may request any additional information that it determines is necessary to properly evaluate the DVEP. Where design changes are proposed, such additional information may include results of field investigations and surveys, design computations, specifications, and any field changes already incorporated into the project. The Contractor shall promptly provide any such requested information.

b. The Agency may require the Contractor to provide additional information to verify the Contractor's cost analysis.

c. When the Agency is acting as the contracting authority for a locally owned facility, the local governing body must also provide approval. The Contractor shall present their proposal to the local governing body and allow sufficient time to present the proposal and receive comments.

(5) Evaluation Response. The Agency will use its best effort to evaluate a conforming DVEP and provide the Contractor with a written response within 30 calendar days of receipt of all of the information it has determined was necessary to properly evaluate the DVEP. Such a response will include a brief description of the Agency's reason(s) for its decision. The Agency, at its sole discretion, will either accept the DVEP, accept it with contingencies, or reject it.

(6) No Liability for Delay. The Agency shall not be liable for any delay in acting upon any VE proposal submitted. The Contractor may withdraw in whole or in part any VE proposal not accepted within the period specified in the proposal. The decision of the Agency as to the acceptance or rejection of VE proposals will be final and will not be subject to the provisions of Subsection 105.04 or Subsection 105.20.

(7) Contingencies. The Agency may accept a DVEP with contingencies, which, if not met by the Contractor, will prompt the Agency to reject the DVEP before the execution of a change order. Contingencies may include, but are not limited to, the necessary approvals of permits, amendments, execution or amendments to third-party agreements, specific deadlines for completion of submittals, or execution of permits, agreements, and/or amendments thereof.

(8) Rejection/Termination. If the Agency rejects the DVEP, the DVEP process will terminate. The Agency, in its sole discretion, will determine whether to reimburse the Contractor for DVEP Costs, and if so, what percentage of those costs. In no event will the Agency pay more than 50% of the DVEP Costs. These costs will not include the cost to prepare the CVEP.

(c) Accepted Proposals; Change Order. If a DVEP is accepted, or if it is accepted with conditions and the Contractor wants to proceed, the necessary Contract modifications will be effected by execution of a change order which will provide for equitable price adjustments giving the Contractor and the Agency equal shares in the net savings. Unless and until a proposal is effected by such Contract modification, the Contractor shall remain obligated to perform in accordance with the terms of the existing Contract.

In addition to the requirements of Subsection 109.04 and Subsection 109.05, the DVEP will set forth the credit due the Agency calculated as the difference between the cost of performing the work, as originally specified, and the amount payable to the Contractor for the revised work. The payment for this Contract modification will only include the following amounts:

(1) The cost of performing the work as revised by the DVEP at agreed upon unit or lump sum prices.

(2) The DVEP development costs that the Agency agreed to reimburse the Contractor as provided in Subsection 105.29(b)(2)g., if any.

(3) An amount equal to 50% of the Net Savings generated by the DVEP as determined by the Agency, calculated as follows:

$$NS = EGS + CSP - CUDC - AVEC$$

where:

NS = Net Savings generated by the DVEP.

EGS = Estimated Gross Savings is an agreed upon difference between the cost of performing the work as originally specified in the Contract and the cost of performing the work as revised by the DVEP.

CSP = Cost Savings to the Public are those funds not expended by the public, including but not limited to reduced maintenance costs and reduced road user costs. CSP shall not include any cost savings attributable to a time period exceeding 10 years from the Contract completion date.

CUDC = Contractor's Unreimbursed Development Costs related to the preparation of the DVEP, including costs of the Contractor's design subconsultants and subcontractors, but excluding all such costs already paid by the Agency under Subsection 105.29(b)(2)g.

AVEC = Agency's VE Costs related to review, approval, and implementation of the DVEP including design costs, field inspection, and the value of any Agency-provided property.

The change order effecting the necessary Contract modifications shall establish the Net Savings agreed upon and shall provide for such adjustment in the Contract price as will divide the Net Savings equally between the Contractor and the Agency. All reasonably incurred costs of developing the cost reduction proposal and implementing the changes, including any increased costs to the Agency resulting from its application, will be deducted from the total estimated decrease in the Contractor's costs of performance to arrive at the Net Savings.

(d) Subsequent Payment Adjustments. Upon completion of the portion of the work revised by the DVEP, the Agency, on its own initiative or upon request by the Contractor, may review the actual Net Savings realized by the DVEP. The Contractor will be afforded an opportunity to review and comment on such a review.

If the actual Net Savings were greater than set forth in the change order, the increased savings will be shared equally between the Agency and the Contractor. If the Net Savings were less than set forth in the change order, the reduction in savings will be borne equally by the Agency and the Contractor by a reduction of amounts otherwise due to the Contractor.

(e) General Conditions.

(1) DVEPs will remain the property of the Contractor, provided that the Agency will have the unrestricted right to use any approved DVEP, or any DVEP in which the Agency has reimbursed the Contractor for any portion of the development costs, on other Agency projects without notice, cost, or liability to the Contractor.

(2) Only the Contractor may submit DVEPs. The Contractor shall review, be responsible for, and submit all proposals initiated by the Contractor's subcontractors.

(3) The Contractor shall not anticipate Agency approval of a VE proposal when bidding or otherwise before approval of a DVEP. The Contractor is responsible for all delays caused by the VE proposal that were not negotiated in the change order.

(4) If a VE proposal is rejected by the Agency, the Contractor shall perform the work in accordance with the Contract.

(5) Except as otherwise provided in this subsection, the Contractor shall have no claim against the Agency for additional compensation or time resulting from the delayed review or rejection of a DVEP, including but not limited to development costs, loss of anticipated profits, and increased material or labor costs.

(6) Cost sharing applies only to the Contract for which the DVEP was submitted.

(7) Upon acceptance of a cost reduction proposal, any restrictions imposed by the Contractor on its use or on disclosure of the information submitted shall be void, and the Agency shall thereafter have the right to use, duplicate, and disclose in whole or in part any data necessary to the use of the proposal on this project or other projects.

(8) Any time savings realized by implementation of VE proposals may result in a corresponding adjustment in the Contract completion time. No incentive pay will be provided for early completion days resulting from time savings of any approved VE proposals.

(9) Because the Agency has no obligation to change the terms of the original Contract, all VE proposal decisions by the Agency are final and are not subject to the dispute resolution provisions provided in this Contract or otherwise available in law.

(10) The Contractor may withdraw any DVEP prior to the time the Contractor signs the change order. If the Contractor elects to withdraw the DVEP in accordance with this provision, the Contractor waives its right under Subsection 105.29(b)(2)g. for reimbursement of DVEP costs, including any costs advanced to the Contractor. If such costs have been advanced, the Contractor shall reimburse the Agency for those costs within 30 calendar days of withdrawing its DVEP.

(11) Acceptance of a DVEP by the Agency does not indicate any assumption of liability by the Agency for any design errors and/or omissions associated with the DVEP implementation.

SECTION 106 – CONTROL OF MATERIAL

106.01 SOURCE OF SUPPLY AND QUALITY REQUIREMENTS. The material used in the work shall meet the requirements of the Agency's *Quality Assurance Program*. The Agency's *Quality Assurance Program*, including the *Materials Sampling Manual*, has been developed to clearly articulate the processes for acceptance of materials in construction and maintenance. In order to expedite the inspection and testing of materials, the Contractor shall notify the Engineer of the proposed approved sources of materials at least 96 hours prior to delivery. Sources not previously approved by the Agency will require a minimum of four weeks' advanced notification to complete the necessary inspection and testing of materials.

At the option of the Engineer, materials may be approved at the source of supply before delivery is started. If it is found during acceptance that supplied materials from previously approved sources do not meet specifications, the Contractor shall take action to supply materials that meet specifications.

106.02 LOCAL MATERIAL SOURCES. The Contractor shall determine potential sources of material and the amount of equipment and work required to produce material meeting the specifications. The Agency's Geologist maintains a list of material sources that have previously produced materials meeting specifications. The ability to purchase from the owner(s) of the source(s) and the quality of the material are not guaranteed by the Agency. The Contractor acknowledges that it is not possible to ascertain from samples the limits of a deposit and that variations in quality in a material source are normal and to be expected. Exploration for new material sources will be the responsibility of the Contractor. The Engineer may order procurement of material from any portion of a material source and may reject portions of the material sources as unacceptable.

It shall be the responsibility of the Contractor to acquire the right to take materials from any source together with the right to use such property as required for whatever purpose, including plant sites, stockpiles, and haul roads. The Contractor shall pay all costs related thereto together with any costs resulting from exploring and developing these sources.

106.03 SAMPLES AND TESTS. All materials will be inspected, sampled, tested, or accepted by the Engineer as incorporated into the work. Under any applicable quality acceptance (QA) specifications, the Contractor shall perform all process quality control testing with the Engineer performing all quality acceptance testing. Any work in which untested and/or unaccepted materials are used without the approval or written permission of the Engineer shall be performed at the Contractor's risk. Any work determined to be unacceptable and unauthorized will not be paid for.

When modified AASHTO or ASTM test methods or Agency test methods are designated, the test method will be available from the Agency's Materials Testing and Certification Section. Tests for compliance with specification requirements will be made by and at the expense of the Agency.

Samples will be taken by authorized representatives of the Agency in accordance with the requirements of the *Materials Sampling Manual*. The Contractor shall provide such facilities, as specified in these specifications or as the Engineer may require, for collecting and/or forwarding samples. In all cases, the Contractor shall furnish the required samples without charge.

All materials used are subject to inspection, testing, and acceptance/rejection at any time during the Contract period. Materials contaminated by the Contractor's operations shall be removed. No work or materials shall be deemed approved until accepted by the Engineer. Copies of all test results will be furnished to the Contractor's representative upon request.

106.04 PLANT INSPECTION. The Engineer may undertake the inspection of materials at the source.

In the event plant inspection is undertaken the following conditions shall be met:

(a) Cooperation. The Engineer shall have the cooperation and assistance of the Contractor and the producer with whom the Contractor has contracted for materials.

(b) Right of Entry. The Engineer shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished.

(c) Testing Facilities. When required by the Contract, the Contractor shall arrange for an approved building or trailer with the necessary equipment for testing for the use of the inspector; such building or trailer shall be located conveniently near the plant.

(d) Safety. Adequate safety measures shall be provided and maintained.

The Agency reserves the right to retest all materials that have been tested and accepted at the source of supply prior to incorporation into the work after delivery and to reject all materials that do not meet the requirements of the Contract when retested.

106.05 STORAGE OF MATERIALS. Materials shall be stored so as to ensure the preservation of their quality and fitness for the work. Stored materials, even though approved before storage, may be inspected prior to their use in the work; they shall meet the requirements of the Contract at the time of use. Stored materials shall be located so as to facilitate inspection. Upon approval, portions of the right-of-way not required for public travel may be used for storage purposes and for the placing of the Contractor's plant and equipment, but any additional space required shall be at the Contractor's expense. The Contractor shall not store materials under any bridge without written approval from the Engineer. Private property shall not be used for storage purposes without written permission of the owner and/or lessee. All storage sites shall be restored to their original condition at the Contractor's expense; this shall not apply to the stripping and storing of topsoil, or to other materials salvaged from the work or specifically prescribed in the Contract.

106.06 HANDLING OF MATERIALS. All materials shall be handled so as to preserve their quality and fitness for the work.

When working on or adjacent to railroad tracks, the Contractor shall take special care and vigilance during handling, loading, unloading, and transport of materials during removal, construction, and renewal work to avoid damage to trains, active tracks, or other facilities of the Operating Railroad, and shall not interfere with the movement of trains or other railroad operations.

106.07 UNACCEPTABLE MATERIALS. At the discretion of the Engineer, all materials not in conformance with the requirements of the Contract shall be considered unacceptable and all such materials, whether in place or not, shall be rejected and removed immediately from the site of the work unless otherwise instructed by the Engineer. Rejected materials that have been subsequently corrected shall not be used unless and until approval has been given.

106.08 EXPLOSIVE AND FLAMMABLE MATERIALS. The Contractor shall comply with all local, state, and federal laws regarding the sale, storage, use, manufacturing, handling, and transportation of explosive and flammable materials and substances. Explosives being transported by carriers in motor vehicles, railroad cars, or vessels shall comply with the regulations adopted by the U.S. Department of Transportation, the U.S. Coast Guard, and the Vermont Secretary of Transportation under the provisions of *5 V.S.A. § 2001* and Subsection 107.10.

106.09 STOCKPILING OF MATERIALS.

(a) Ordering Materials; Stockpiling Authority. The Contractor is urged to place orders for materials with producers and suppliers as early as practicable.

The Contractor may submit a written request to the Agency to pay for stockpiled material.

The Engineer may authorize payment for the Contractor's cost of materials, including freight.

The Agency may deny any and all requests to stockpile materials and to make stockpile payments.

(b) Request and Procedure; Criteria. To request stockpiling, the Contractor shall submit the following for consideration by the Agency:

(1) Listing of material(s) by specific Contract pay item and quantity to be stockpiled.

(2) Invoice for all materials, or a receipt for delivery.

(3) Drafts of documents that show that ownership of the material(s), without encumbrances, will be in the name of the Contractor and will be for the benefit of the Agency.

(4) Appropriate certifications and/or passing samples as required for the specific material(s)

(5) Statement that the material shall be clearly marked so as to easily identify the project in which the material will be incorporated and shall be available for inspection by the Agency.

(6) The location where and condition(s) under which the material will be stockpiled.

The storage location and security of the stockpiled material(s) shall be the responsibility of the Contractor.

(c) Raw Materials. In addition to the criteria set out above for other materials, raw material stockpiles shall be approved by the Construction Engineer and meet the following additional criteria:

(1) The various components of the finished product shall include all of the appropriate certifications, passing samples, passing tests, and any other documentation that may be required to certify that the materials are acceptable.

(2) For stockpiles of structural steel, invoices or quotes from the fabricator shall include supporting documentation such as mill invoices or quotes that show actual dimensions, quantities, and costs to the fabricator for the raw materials.

The intent of this raw material payment is to reimburse the actual amount it cost the fabricator to purchase the raw materials for the specific Contract item. There will be no allowance for mark up of any type by the Contractor or fabricator.

Stockpile payments will be limited to one payment per 6 months, per Contract item. There will be no raw material stockpile payment allowed for materials that do not meet the dimensions provided on the mill invoices.

(3) Any other criteria the Engineer deems necessary to allow for payment.

(d) Cap; Payment to Supplier; Charge Back; Minimum to Stockpile. Payment will be made for the invoiced amount, not to exceed 75% of the total Contract bid amount for each specific item for which stockpiling is allowed. The Contractor may request an exception to the 75% cap. Any such request shall be included in the original request for stockpile and shall include all information to support the request.

The quantity of stockpiled material shall not exceed the Contract quantity for the specific item. Under no circumstances shall stockpiling be allowed for an item with a Contract bid amount totaling less than $25,000.

The Contractor shall furnish the paid invoice within 28 calendar days after the cutoff date for the estimate in which the stockpile amount is paid. If the Contractor fails to furnish the paid invoice within this time limit, the amount of the stockpile payment will be deducted from one or more subsequent payments.

The stockpile credit amount shall be reduced once installation of the item begins, and the reduction shall correspond with the installation and payment of the specific stockpiled item.

(e) Finished Product. Payment for stockpiled materials shall not relieve the Contractor from providing an acceptable finished product or from its responsibility for the condition of the materials as specified elsewhere in the Contract. Any defects, flaws, or poor craftsmanship shall be the responsibility of the Contractor and shall be corrected to the Agency's satisfaction at the Contractor's expense.

SECTION 107 – LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.01 LAWS TO BE OBSERVED.

(a) General; Defense and Indemnification. The Contractor shall observe and comply with all federal and state laws and local bylaws, ordinances, and regulations in any manner affecting the conduct of the work and the action or operation of those engaged in the work, including all orders or decrees as exist at present and those which may be enacted later by bodies or tribunals having jurisdiction or authority over the work, and the Contractor shall defend, indemnify, and save harmless the state and all its officers, agents, and employees against any claim or liability arising from or based on the violation of any such law, bylaws, ordinances, regulations, order, or decree, whether by the Contractor in person, by the employees of the Contractor, or by a subcontractor or supplier.

(b) Contract Contrary to the Law. If the Contractor discovers any provisions in the Contract that are contrary to or inconsistent with any law, ordinance, regulation, order, or decree, the Contractor shall immediately report it to the Engineer in writing.

(c) OSHA, VOSHA, and Environmental Protection Regulations. The Contractor shall comply with all regulations promulgated and enforced by OSHA, VOSHA, and state and federal environmental protection agencies.

(d) Hazardous Wastes. The Contractor shall comply with all regulations regarding the management of hazardous wastes, such as waste crankcase and hydraulic oils and waste paint generated by construction operations. Refer to the Vermont Agency of Natural Resources, Department of Environmental Conservation and *10 V.S.A., Chapter 159*.

(e) Americans with Disabilities Act. The Contractor shall comply with the *Americans with Disabilities Act* and shall ensure that individuals with disabilities have equal access to the services, programs, and employment activities/opportunities offered by the Contractor under the Contract.

(f) Prompt Payment Act. The Contractor shall fully comply with the provisions of *9 V.S.A. § 4002*, as amended.

On all Contracts, the Contractor shall submit a listing of payments to subcontractors using the Contractors Reporting – Prompt Pay system on the Agency's Office of Civil Rights and Labor Compliance website. This report shall be submitted by an authorized representative on a monthly basis for the duration of the Contract and shall be received on or before the tenth working day after the end of the month.

Contractors without access to the prompt pay reporting website shall submit manual reports to the Office of Civil Rights and Labor Compliance using the *Prompt Pay Manual Reporting Form*. The form can be found on the Agency's Office of Civil Rights and Labor Compliance website. Manual reports shall be signed by an authorized representative, sent to the Agency's Office of Civil Rights and Labor Compliance, and postmarked on or before the tenth working day after the end of the month. The cost for this work will be incidental to the Contract.

In accordance with *9 V.S.A. § 4003*, notwithstanding any contrary agreement, payments made to subcontractors after 7 calendar days from receipt of a corresponding progress payment by the state to the Contractor, or 7 calendar days after receipt of a subcontractor's invoice, whichever is later, violate this agreement.

Violations shall be reported to the Agency's Office of Civil Rights and Labor Compliance for review. Failure to resolve disputes in a timely manner may result in a complaint made to the Agency's Prequalification Committee. This committee may impose appropriate penalties for failing to comply with this specification. Penalties may include suspension, reduction, or revocation of the Contractor's prequalification rating.

This clause shall be included in the Contractor's contract made with all of its subcontractors.

(g) Labor Laws.

(1) General Requirements. The Contractor and all subcontractors shall comply with the provisions and requirements of all federal and state labor laws and with the wage requirements set forth in detail in the Contract. In case of conflicts between wage determinations made by the U.S. Department of Labor and the minimum wage established by statute, the larger of the two amounts shall be the minimum wage for that classification.

(2) Fair Labor Standards Act.

a. General. The Contractor shall comply with the requirements of the *Fair Labor Standards Act of 1938*, as amended, *29 U.S.C., Chapter 8*.

b. Contacts for More Information. Information about the *Fair Labor Standards Act of 1938*, as amended, can be found on the U.S. Department of Labor website or by contacting the U.S. Department of Labor Wage and Hour Division:

U.S. Department of Labor
Wage and Hour Division
Manchester District Office
1155 Elm Street, Suite 501
Manchester, NH 03101
Phone: 1-603-666-7716
1-866-4-USWAGE (1-866-487-9243)

(3) Contract Work Hours and Safety Standards Act.

a. General. The *Contract Work Hours and Safety Standards Act* is administered by the Wage and Hour Division. This act applies to Contractors and subcontractors with federal service contracts and federally funded and assisted construction contracts over $100,000. Covered contracts include those entered into by the United States, any agency or instrumentality of the United States, any territory of the United States, or the District of Columbia.

This act also extends to federally assisted construction contracts subject to *Davis-Bacon and Related Acts* wage standards where the federal government is not a direct party, except those contracts where the federal assistance takes the form only of a loan guarantee or insurance.

b. Basic Provisions and Requirements. The *Contract Work Hours and Safety Standards Act* requires Contractors and subcontractors with covered Contracts to pay laborers and mechanics employed in the performance of the Contracts one and one-half times their basic rate of pay for all hours worked over 40 in a workweek.

(4) Davis-Bacon and Related Acts. Where the Contract includes *Davis-Bacon and Related Acts* wage rate requirements, the following also applies.

a. General. The wage rate determination of the U.S. Department of Labor which has been incorporated in the proposal may not contain all job classifications necessary for the work contemplated under the Contract. The Contractor is independently responsible for ascertaining area practice with respect to the necessity, or lack thereof, for the use of any job classifications in the prosecution of the work contemplated by the project. No inference concerning prevailing area practices relative to their use may be drawn from the omission of these job classifications. Further, the omission of a job classification shall not be construed as establishing governmental liability for increased labor cost.

b. Missing Job Classifications and Wage Rates. The Contractor shall submit to the Agency any requests for missing job classifications and proposed wage rates.

(5) Vermont Labor Laws. The Contractor shall comply with all provisions and requirements of the Vermont *Workers' Compensation Act* and to Vermont statutes regulating employment of minors.

(6) Fair Employee Practices Act. The Contractor shall comply with all requirements of *21 V.S.A., Chapter 5, Subchapter 6* relating to fair employment practices to the extent applicable. A similar provision shall be included in all subcontracts.

(h) Cargo Preference Requirement. All Contractors and subcontractors shall follow the requirements of *46 C.F.R. § 381.7*. Guidance on cargo preference requirements can be found on the FHWA website.

107.02 PERMITS, LICENSES, AND TAXES. The Contractor shall procure all permits and licenses, pay all charges, fees, and taxes, and give all notices necessary and incidental to the lawful prosecution of the work.

107.03 PATENTED DEVICES, MATERIALS, AND PROCESSES. If any design, device, material, or process covered by letters of patent or copyright is used by the Contractor, whether required or not, the Contractor shall provide for such use by suitable legal agreement with the patentee or owner. A copy of this agreement shall be filed with the Agency. The Contractor and the Contractor's surety shall defend, indemnify, and save harmless the state, any affected third party, or political subdivision from any and all claims for infringement by reason of the use of any such patented design, device, material, or process, or any trademark or copyright, and shall indemnify the state for any costs, expenses, and damages including reasonable attorney's fees which it may be obliged to pay by reason of any infringement at any time during the prosecution or after the completion of the work.

107.04 FEDERAL-AID PROVISIONS. The Contractor acknowledges that pursuant to the provisions of *23 U.S.C.*, and acts amendatory thereto, as well as any and all other federal legislation appropriating funds to the state, the federal government may pay a portion of the cost of this project. The above act of Congress provides that the construction work and labor on any federal-aid project in Vermont shall be done in accordance with its laws and under the direct supervision of the Agency, subject to the inspection and acceptance of the U.S. Department of Transportation or appropriate federal agency and in accordance with the rules and regulations made pursuant thereto. Therefore, the construction work will be subject to such inspection by the U.S. Department of Transportation or appropriate federal agency or its agent as deemed necessary to meet the above requirements. Such inspection will in no sense make the federal government a party to the Contract and will in no way interfere with the rights of either party hereunder.

107.05 SANITARY PROVISIONS. The Contractor shall provide and maintain, in a neat and sanitary condition, such accommodations for the use of its employees as necessary to comply with the requirements and regulations of the state or local Boards of Health at no expense to the Agency.

107.06 PLANT PEST CONTROL REQUIREMENTS. Soil and soil moving equipment are subject to plant quarantine regulations. In general, these regulations provide for cleaning soil from equipment before it is moved from a project. Complete information may be secured from the Vermont Agency of Agriculture, Food, and Markets and the U.S. Department of Agriculture plant and pest control inspectors.

107.07 PUBLIC CONVENIENCE AND SAFETY.

(a) General. The Contractor shall conduct all work so as to ensure the least possible obstruction to all types of traffic. The safety and convenience of the general public and the residents within the construction area and the protection of persons and property shall be provided for by the Contractor as specified in Subsection 104.04.

(b) Dust Control. The Contractor shall use all necessary dust control on haul road(s) and maintenance yard(s) in the same manner as required for material sources and disposal areas in Subsection 105.26 and shall be performed in accordance with Section 609 or as directed by the Engineer. Unless otherwise provided, dust control will not be paid for directly, but will be considered incidental to all other Contract items.

The Engineer will direct the use of all necessary dust control within the limits of the work performed under the Contract. Under those Contracts which contain pay items for dust control, the dust control within the construction area shall be performed in accordance with the requirements of Section 609 and will be paid for under the appropriate Contract item(s). Under those Contracts which do not contain pay items for dust control, the necessary dust control shall be performed in accordance with the requirements of Section 609 and the cost will not be paid for directly but will be considered incidental to all other Contract items.

(c) Stored Materials. Materials stored within the construction area shall be placed so as to cause the minimum obstruction to the traveling public and snow removal operations.

(d) Fire Hydrants. Fire hydrants located within the construction area shall be kept accessible to fire apparatuses at all times, and no material or obstruction shall be placed within 15 feet of any hydrants.

(e) Adjoining Ways. Sidewalks, gutters, drainage inlets, and portions of highways adjoining the roadway under construction shall be obstructed only when necessary. If a sidewalk is obstructed, temporary pedestrian access meeting the requirements of the *Americans with Disabilities Act* and the *MUTCD* shall be provided around the obstructed area.

(f) Lane Restrictions. When the total useable width of a traveled way will be decreased to 14 feet or less for a period longer than one working day, the Contractor shall notify the Engineer of the date of the first day and the anticipated period of time such a lane restriction will be in effect. This notification shall be provided at least 14 calendar days prior to the beginning of the lane restriction so that the Engineer may provide proper notification to the Oversized/Overweight Permits section of the Commercial Vehicle Operations unit of the Vermont Department of Motor Vehicles and the Agency's Transportation Management Center. When the date of the removal of the restriction becomes known, the Contractor shall notify the Engineer so that notification can be provided to these entities.

(g) Parking Restrictions. Only such vehicles and equipment as are necessary for the construction of this Contract will be permitted to stop or park on the travel lane or shoulders of the highway or intersecting highways. All vehicles or equipment so stopped or parked shall be at least 4 feet from the edge of the through traffic lanes. Parking or stopping on the traveled portion of the roadway will not be permitted unless authorized by the Engineer to meet field conditions.

Private automobiles of workers will not be permitted to stop or park on the travel lane or shoulders of the highway or intersecting highways.

Each of the Contractor's trucks or equipment used for the construction of this project and permitted to park or stop as provided above shall be equipped with flashing light signals on the front and rear and the signals shall be operating at all times when parked or stopped on the highway unless otherwise authorized by the Engineer.

The flashing light signals shall be visibly distinct from and physically separate from the hazard warning system required by federal and state motor vehicle laws and regulations. At least one of these flashing light signals shall be visible to traffic approaching from any angle at all times.

The procedure shown on the traffic control plan shall be strictly adhered to whenever the Contractor's vehicles or equipment (including that belonging to the individual workers) enter or leave the traffic flow. All movement, in or out of the traffic flow, shall be with the flow of traffic.

Equipment, materials, or vehicles shall be parked or placed a minimum of 30 feet from the edge of pavement in all directions or a minimum of 10 feet behind guardrail when not being used.

107.08 TRAFFIC CONTROL DEVICES.

(a) General. All approach signs shown on the Plans or in the Contractor's approved traffic control plan shall be installed prior to beginning other work. Additional traffic control devices necessary for work on any portion of the project shall also be installed prior to beginning work on that portion.

All traffic control devices shall conform to the *MUTCD*. The Contractor shall have available on the project the current applicable editions of both the *MUTCD* and the *Standard Highway Signs and Markings* book.

The Contractor shall furnish, erect, and maintain all signs, barricades, lights, signals, and other traffic control devices necessary for the protection of the work and safety of the traveling public.

(b) Existing Pavement Markings. Whenever existing pavement markings conflict with desired traffic patterns within a construction or detour area, or otherwise create a potentially misleading, confusing, or hazardous condition for the traveling public, the markings shall be completely removed or obliterated by the Contractor to the satisfaction of the Engineer. Painting over the existing lines is not acceptable. Unless otherwise specified in the Contract, no direct payment will be made for this work, which will be considered incidental to all other Contract items.

(c) Warning Signs. The Contractor shall erect warning signs in advance of any location on the project where operations interfere with the use of the road by traffic and all locations where the new work crosses or coincides with an existing road.

(d) Detour Signs. The Contractor shall provide and maintain throughout the project acceptable warning, direction, and detour signs at all closures and intersections. Along the construction and detour routes, the Contractor shall provide and maintain acceptable warning, direction, and detour signs directing traffic around the closed portion or portions of the highway so that the temporary detour routes shall be indicated clearly throughout their entire length.

(e) Closed Highways or Sidewalks. Highways closed to traffic shall be protected by barricades and/or other approved barriers, which shall be reflectorized or illuminated.

When a section of an existing sidewalk is closed to pedestrians, suitable barricades and warning signs conforming to the *Americans with Disabilities Act* and the *MUTCD* shall be installed. If channelizing devices are used to establish a temporary pedestrian route, those devices shall conform to the *MUTCD*.

(f) Delineation. Delineation will be required through the construction area as shown on the Plans or as directed by the Engineer.

(g) Warning Lights. Warning lights may be required by the Engineer for use on signs and barricades to call attention to special or hazardous conditions. If warning lights are used those devices shall conform to the *MUTCD*.

(h) Costs Incidental. The cost of furnishing, fabricating, installing, maintaining, and removing traffic control devices shall be considered incidental to all other items in the Contract unless otherwise specified.

(i) Failure to Install, Maintain, Remove. If the Contractor fails to satisfactorily install, maintain, or remove traffic control devices, the Engineer may have such installations made, maintained, or removed, and the cost thereof shall be deducted from the monies due the Contractor.

107.09 RESPONSIBILITY FOR THE USE OF FLAGGERS.

(a) Highway Flaggers. As conditions warrant, the Contractor shall employ one or more highway flaggers at any location on the project where equipment or construction operations will interfere with the movement or safety of the traveling public. This includes operations where equipment enters, leaves, or crosses normal traffic lanes being used or set aside for the traveling public and locations where heavy equipment is operating adjacent to areas where traffic is moving. Highway flaggers may not be required at locations manned by uniformed traffic officers assigned for the protection of the traveling public as a pay item of the Contract. Where needed to ensure safe ingress and egress for activities associated with the construction of the project, the Engineer may require the use of highway flaggers at locations off the project site.

The dress, equipment, and procedures of all highway flaggers shall conform to the requirements of the *MUTCD* and Section 630.

(b) Railroad Flaggers. The Contractor shall request flagging protection from the Operating Railroad where equipment or construction operations will interfere with the movement or safety of the trains in advance of entry into the Operating Railroad right-of-way. This includes any operation where equipment enters, leaves, or crosses the Operating Railroad right-of-way within the project limits. Also refer to the provisions of Section 632 as they may apply to the use of railroad flaggers. Where needed to ensure safe ingress and egress for activities associated with the construction of the project, the Engineer or the Operating Railroad may require the use of railroad flaggers at locations outside of the project site.

107.10 USE OF EXPLOSIVES.

(a) General Requirements. Explosives shall only be used during daylight hours. The Contractor shall use the utmost care to protect life and property and, whenever directed by the Engineer, shall reduce the number and size of explosive charges. Blasting mats shall be used when required by regulation or deemed necessary by the Engineer.

(b) Insurance. Each of the insurance policies required for a project shall include coverage for injury to persons and injury or destruction of any property arising out of the storage and use of explosives.

(c) Liability. The Contractor acknowledges full responsibility and assumes full liability for any and all damage or injury to persons or property caused either directly or indirectly by the Contractor's or a subcontractor's use of explosives. The liability of the Contractor shall apply equally to damage or injury to persons or property whether said injury or damage occurs within or outside of the right-of-way. The cost of all precautionary measures will not be paid for directly but will be considered incidental to the Contract.

(d) Documentation of Structure Condition. It shall be the responsibility of the Contractor to document the existing condition of all structures that have the potential to be damaged by blasting operations. This documentation shall be in the form of a video or pictures, with sufficient description, and shall be supplied to the Engineer prior to any blasting on the project. The costs of preparing this documentation will not be paid for directly but will be considered incidental the Contract.

(e) Detonators and Explosive Materials. To ensure the accuracy of firing times of detonators, all period delay detonators shall come from the same lot number. Mixing of lot numbers for any one detonator period is prohibited.

All explosives and detonators used on the project shall be clearly marked and dated from the manufacturer and be one year or less of age. No blasting product shall be brought to the job site if the date codes are missing.

When, in the opinion of the Engineer, any blasting product appears to be in a deteriorated condition, all work shall cease until the product's quality can be determined.

(f) Handling and Storage of Explosive Materials. Explosives shall be handled, transported, used, controlled, stored, and monitored as prescribed by the most stringent rules promulgated by the federal, state, and local governments, including the VOSHA *Safety and Health Regulations for Construction, Subpart U*.

The blaster-in-charge shall be responsible for ensuring the security of explosive materials used or kept on the project site at all times. Explosives shall only be handled by or under the direct supervision of the blaster-in-charge. All explosives shall be stored securely at locations clearly marked "DANGER – EXPLOSIVES" and all storage locations shall be supervised and controlled by a competent, trained person at all times.

No unexploded charges shall remain in the work area unattended or be left on the project when construction operations cease for the day. Overnight explosive storage on the project site is prohibited. All unused explosives materials shall be returned to the explosive supplier's or the Contractor's licensed off-site facilities at the end of each day.

(g) Blasting Cap Danger. Due to the propagation of radiofrequency energy from radio, cellular telephone, radar, television, and related transmitters, premature explosion of electric blasting caps may occur. Such transmitters are in general use in Vermont, including by police departments, fire departments, political subdivisions, utility companies, commercial carriers, private and public enterprises, and individuals.

The Contractor and subcontractors shall take all precautions necessary to prevent premature explosions of electric blasting caps either individually or when they are connected into a circuit.

(h) Lightning Protection. The Contractor shall furnish, maintain, and operate lightning detection equipment during the entire period of blasting operations and during the periods that explosives are on site. The equipment shall provide real time audio and visual alarms based on combined detection of electromagnetic, electrostatic, light wave spectral, and audio disturbances, or a commercial service based on these at a minimum as approved by the Engineer. Equipment shall be capable of detecting lightning within a minimum radius of 25 miles from the center of the blast area. When a lightning detector indicates a blasting hazard potential exists, the following actions shall be taken:

(1) Personnel shall be evacuated from all areas where explosives are present.

(2) The blasting area shall be cleared of all personnel.

(3) The Agency shall be notified of the potential hazards and precautions to be taken.

(4) The loading of holes shall be terminated, and unused explosives shall be returned to the day storage area or explosives transport and storage truck.

(5) If blastholes are loaded and would pose a hazard to traffic if detonated, roads shall be closed until the lightning hazard has passed.

(6) When the hazard dissipates, the Engineer shall be informed that blasting activities will continue.

(i) Notice and Warning. The Contractor shall notify each person, company, corporation, or public utility that owns, leases, or occupies property or structures near the site of the work, of plans to use explosives. Notice shall be given at least 24 hours in advance of the pending blast and again at least 2 hours prior to blasting to enable people to take such steps to protect their property or structure from injury as they may deem necessary. Provision of notice shall not relieve the Contractor of responsibility for any damage resulting from the Contractor's blasting operations.

No person shall be inside the blasting zone, as defined by the blaster-in-charge, at the time of blasting. The Contractor shall establish a method of warning all employees on the project site and the public of an impending blast. Five minutes prior to the blast, three long signals on an air horn, siren, or whistle shall be sounded. One minute prior to the blast, two short signals on an air horn, siren, or whistle shall be sounded. After the Contractor confirms complete detonation of the blast, the all-clear shall be one long signal of at least 10 seconds in duration on an air horn, siren, or whistle to indicate that blasting has ceased. The meaning and timing of these signals shall be communicated to residents, property owners, and businesses near the site of work prior to performing any blasting operations.

If blasting is within 200 feet of a railroad, a notification shall be provided to the Agency.

Prior to blasting operations, the Contractor shall install warning signs in conformance with the *MUTCD*. Warning signs shall be located in prominent positions and be visible to any person approaching the blasting point. Flaggers shall be stationed outside the blasting zone to stop all approaching traffic during blasting operations. Payment for furnishing, erecting, and maintaining warning signs will be considered incidental to the Contract.

(j) Suspension of Blasting. Blasting operations may be suspended by the Engineer for, but not limited to, the following reasons:

(1) Inadequate safety precautions.

(2) Blasting methods which endanger the stability of or cause damage to areas outside the prescribed limits of excavation.

(3) Methods of drilling and blasting which do not produce acceptable results.

(4) Damage to existing facilities or adjacent property due to blasting.

(5) Failure to provide required submittals.

Suspension of blasting operations shall in no way relieve the Contractor of their responsibilities under the terms of the Contract. Blasting operations shall not resume until modifications have been made to correct the conditions that resulted in suspension and based on approval by the Engineer. No additional payments or time extensions will be made by the Agency due to the suspension of blasting operations.

(k) Blast Surveys. The Contractor shall monitor all blasts and provide a report to the Engineer that shall indicate the peak particle velocity (PPV) of the blast. The PPV sensitivity as reported shall range from less than 0.02 inches per second to more than 5.0 inches per second. The Engineer reserves the right to request more than one instrument to monitor the blasting if there is a need for monitoring in more than one direction from the blasting area. The costs of the monitoring and preparing the reports will not be paid for directly but will be considered incidental to the Contract.

107.11 PROTECTION AND RESTORATION OF PROPERTY.

(a) General. The Contractor shall:

(1) Not enter upon private property for any purpose without obtaining written permission.

(2) Be responsible for the preservation of all public and private property along and adjacent to the work.

(3) Use every precaution necessary to prevent damage or injury to public and private property.

(4) Protect from disturbance or damage all land monuments and property markers until an authorized agent has witnessed or otherwise referenced their locations, monuments, and property markers.

(5) Not move any land monuments and property markers until directed by the Engineer.

(6) Protect all trees, shrubs, and other plants not marked by the Engineer for removal from damage by construction operations.

(b) Protection of Existing Infrastructure. The Contractor shall make sure that any portions of the existing roadway and existing structures which are to be retained for public travel are left in as good a condition as when the Contractor commenced work. The Contractor shall not move or use equipment on any pavement or structure in a manner that may or does cause damage.

(c) Contractor's Responsibility. The Contractor shall be responsible for all claims involving damage or injury to, or destruction of, property of any type resulting from any act, omission, neglect, or misconduct of the Contractor's manner or method of executing the work, due to the Contractor's non-execution of said work, or due to defective work or materials. The Contractor's responsibility shall not be released until the work has been completed and accepted and the applicable statute of limitations has expired.

(d) Restoration of Damaged Property. When any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work or in consequence of the non-execution thereof on the part of the Contractor, such property shall be restored at the Contractor's expense to a condition similar or equal to that existing before such damage or injury was done or the Contractor shall make good such damage or injury in an acceptable manner.

(e) Cleaning Traffic Signals and Street Lighting. When the Contractor's operations compromise the functionality of existing traffic signals and/or street lighting equipment, the Engineer may require the Contractor to clean said equipment prior to project completion. Cleaning of traffic signals and ancillary equipment shall include all vehicle and pedestrian signal face lenses (inside and outside). Further, the inside of the controller cabinet shall be vacuumed and any vent filter shall be replaced; cleaning of streetlights shall include both the lens (inside and outside) and the reflector. The cleaning of electrical equipment shall be done by a traffic signal/electrical contractor. Any equipment that is damaged in the cleaning process shall be repaired or replaced at the Contractor's expense. The costs for cleaning will not be paid for directly but will be considered incidental to all other items in the Contract.

(f) Ground Vibration Limits. The maximum peak particle velocity (PPV) of ground vibration in any of the three mutually perpendicular components of particle velocity shall be limited as shown in Table 107.11A.

TABLE 107.11A – MAXIMUM PEAK PARTICLE VELOCITY

Type of Structure	Max. PPV Limit (in./sec.)	
	Frequencies < 40 Hz	Frequencies ≥ 40 Hz
Modern homes, drywall interior	0.75	2.0
Older homes, plaster on wood or lath	0.50	2.0

The Agency reserves the right to lower the PPV limit in areas where there may be structures or elements with a higher sensitivity to ground vibration. Adherence to this specification does not waive the Contractor's responsibility for damage as specified in this subsection and in Subsection 107.15.

107.12 PROTECTION AND RESTORATION OF UTILITIES AND SERVICES.

(a) General. The Contractor shall take proper precaution during construction to avoid damage to public and private services. These services include, but are not limited to, gas, water, sewer and drainage pipes, springs, wells, septic tanks, cesspools, telephone, television, and other communication and electrical services. Services may be located on or adjacent to the project, above, on, or under the ground, and may not be shown on the Plans.

(b) Dig Safe. The Contractor shall comply with the requirements of Dig Safe, per *30 V.S.A., Chapter 86*.

(c) Notice of Work. At commencement or resumption of construction, the Contractor shall notify the owners, operators, occupants, or lessees of all the public or private services of any work to be done on, over, under, adjacent to, or in proximity to said utilities during the construction of the project. Further, the Contractor shall again notify the aforesaid parties 7 to 14 calendar days in advance of starting such work to enable them to take steps as they may deem necessary to protect their property or structures from damage. Provision of notice shall not relieve the Contractor of its responsibility for any damage resulting from the Contractor's work.

(d) Owner Access. Owners, employees, or agents of public or private services located within the project limits shall be allowed free and full access with the tools, materials, and equipment necessary to install, operate, maintain, place, replace, relocate, and remove service facilities. No compensation will be paid to the Contractor for any inconvenience caused by working with these parties or around or with their services.

(e) Service Relocation. The exact location of any service facility relocated within the project limits shall be as shown in the Contract or as directed by the Engineer.

(f) Cooperation. The Contractor shall cooperate with the owners of any of the aforementioned services in order that the service removal and/or relocation operation will progress in a reasonable manner, that duplication or temporary relocation work may be reduced to a minimum, and that services rendered by the concerned parties will not be unnecessarily interrupted.

(g) Service Interruption. If in connection with the work interruption in service occurs, the Contractor shall promptly notify the owner or the owner's authorized representative and cooperate with the owner to promptly restore service. In no case shall interruption to water or sewer service be allowed to exist without the substitution of acceptable alternate service.

(h) Fire Hydrants. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

(i) Responsibility for Damage. The Contractor shall be responsible for all damage done to services from the beginning of construction to the satisfactory completion of the project, including all damage to water supplies and sewage systems, including but not limited to damage to springs and wells, septic tanks, cesspools, and underground pipes, whether located within or outside the project right-of-way or whether or not shown on the Plans, except as otherwise provided in the Contract.

(j) Restoration of Service by Agency. If the Contractor fails to restore a service or to make good on a damage or injury to service(s), the Engineer may proceed to repair, rebuild, or otherwise restore the service as deemed necessary and the cost thereof will be deducted from any monies due, or which may become due, the Contractor under the Contract.

107.13 PROTECTION OF HISTORICAL AND ARCHAEOLOGICAL SITES. When the Contractor's excavation operations encounter sites or artifacts of historical or archaeological significance, the operations shall be immediately discontinued. The Engineer will contact the Agency's Archaeology Officer for instructions.

107.14 FOREST PROTECTION. When working within or adjacent to forests or other plant growth, the Contractor shall satisfactorily chip or otherwise dispose of all trees and logs, stumps, roots, brush, weeds, grass, and other objectionable material. Disposal of such material shall be in conformance with the laws, rules, and regulations of the state of Vermont pertaining thereto and other authorities having jurisdiction governing the protection of forests and in carrying out work within forests.

107.15 RESPONSIBILITY FOR DAMAGE CLAIMS.

(a) General. The Contractor shall defend, indemnify and save harmless the municipalities, the state, the Agency, and Operating Railroad and all of their officers, agents, and employees from all suits, actions, or claims of any character, name, and description brought for or on account of any injuries or damage received or sustained by any person, persons, or property that arise out of, relate to, or are in any manner connected with the Contractor's work or the supervision of the Contractor's work on the project; or by or in consequence of any neglect in safeguarding the work; or through use of unacceptable materials in constructing the work; or by or on account of any act of omission, neglect, or misconduct of the Contractor; or by or on account of any claims or amounts recovered for any infringement of patent, trademark, or copyright; or from any claims or amounts arising or recovered under the Vermont *Workers' Compensation Act*, or any other law, bylaw, ordinance, order, or decree. The state will notify the Contractor in the event of any such claim or suit, and the Contractor shall immediately retain counsel and otherwise provide a complete defense against the entire claim or suit.

After a final judgment or settlement, the Contractor may request recoupment of specific defense costs and may file suit in Washington County Superior Court requesting recoupment. The Contractor shall be entitled to recoup costs only upon a showing that such costs were entirely unrelated to the defense of any claim arising from an act or omission of the Contractor.

The Contractor shall indemnify the state and its officers and employees in the event that the state, its officers or employees become legally obligated to pay any damages or losses arising from any act or omission of the Contractor.

(b) Right to Retention of Funds. Money due to the Contractor under and by virtue of the Contract as shall be considered necessary by the Agency for such purpose may be retained for the use of the state. If no money is due, the Contractor's surety shall be held until such suit or suits, action or actions, or claim or claims for injuries or damage shall have been resolved and suitable evidence to that effect furnished by the Agency.

(c) Submission of Damage Claims. With regard to each and every damage claim, the Contractor shall:

(1) Provide the claimant with a damage claim form for the submission of damage claims to the Contractor.

(2) Submit the claim to the insurance carrier.

(3) Pay, settle, or otherwise resolve the claim.

(4) Treat all claimants with respect.

(5) Maintain a record of all claims submitted against the Contract. This record shall be available to the Agency and provided immediately upon request. At a minimum, the record shall contain the name of the claimant, a description of the claim, the claim date, the amount claimed, the date that the claim was sent to the insurance company (if applicable), the date resolved, the amount paid, an indication of how the claimant was notified of the resolution, and a notation of how the resolution was determined.

107.16 OPENING SECTIONS OF THE PROJECT TO TRAFFIC.

(a) General. Opening of a section of a project to traffic prior to substantial completion of the entire Contract may be desirable in some instances. Discussions concerning such an opening shall involve, but are not limited to, the Regional Construction Engineer, Project Manager, District Transportation Administrator, and, when appropriate, local municipal officials. Such an opening shall be made when directed by the Engineer and documented in a written order. Such an opening shall not constitute acceptance of the work or a part thereof or a waiver of any provisions of the Contract.

(b) Maintenance; Expense. On any section opened by direction of the Engineer prior to substantial completion of the Contract, the Contractor will not be required to assume any expense entailed in maintaining the road for traffic beyond that required of a Contractor when opening a section of roadway to traffic. When extraordinary work is required to open a section of work prior to substantial completion of the Contract, the Engineer in their sole discretion may determine that compensation for any additional expense incurred by the Contractor to maintain traffic and allowance of additional time needed to complete the work will be made to the Contractor.

(c) Delayed Completion of Project. If the Contractor delays completion of shoulders, drainage structures, or other features of the work, the Engineer will notify the Contractor in writing and establish a reasonable period of time in which the work shall be completed. If the Contractor fails to complete the work by the time specified, the Engineer may order all or a portion of the project opened to traffic at no additional cost to the Agency.

On sections that are ordered to be opened, the Contractor shall conduct the remainder of construction operations so as to cause the least obstruction and disruption to the traveling public, including vehicular, railroad, and pedestrian traffic, adjacent landowners, and commercial businesses. The Contractor shall not receive any additional compensation due to the added cost caused by opening such section(s) to traffic.

(d) Opening the Project to Traffic for Winter Season. As specified in Subsection 104.04, the Contractor shall open the roadway for the winter shutdown period from November 16th to March 31st, inclusive. However, when work is being done because the Contractor did not complete the work before the Contract completion date, any work that is not covered by a pay item in the Contract shall be considered incidental to the original Contract items and shall be performed at no additional cost to the Agency. This shall include any work required by the Agency's District Transportation Administrator(s) and/or municipal highway or public works officials to aid in the performance of winter maintenance activities. None of the time associated with the performance of this work will be considered for an extension of time under Subsection 108.11. Furthermore, the Contractor will not be entitled to any additional compensation for the completion of remaining work that has to be performed under the influence of pedestrian, vehicular, or railroad traffic.

(e) Compensation for Work on Opened Sections. Except as provided for in this subsection, notwithstanding any other provision of the Contract, the Contractor shall receive no additional compensation for work on a section of the project that has been opened to traffic as described herein.

107.17 CONTRACTOR'S RESPONSIBILITY FOR WORK.

(a) General. Until acceptance of the project by the Engineer, the Contractor shall be responsible therefore and shall take every precaution against injury or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the non-execution of the work. The Contractor shall rebuild, repair, restore, and make good all injuries or damage to any portion of the work before acceptance and shall bear the expense thereof, except damage to the work due to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor, including but not restricted to acts of God, of a public enemy, or governmental authorities. For the purposes of this paragraph, the term work shall exclude Contractor owned, rented, or leased materials, equipment, and incidentals.

(b) Suspension of Work. When work is suspended for any reason, the Contractor shall be responsible for the project and shall take precautions to prevent damage to the project, provide for normal drainage, and erect any necessary temporary structures, signs, or other facilities solely at the Contractor's expense.

During a period of suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seedings, and sod furnished under the Contract and take adequate precautions to protect new tree growth and other important vegetative growth against injury.

(c) Winter Maintenance. The performance by the state, a subdivision thereof, or other authorized agent of any snowplowing, salting, and/or sanding shall not relieve the Contractor of its responsibility as outlined herein or elsewhere in the Contract.

107.18 NO PERSONAL LIABILITY OF PUBLIC OFFICIALS. It being understood that in all such matters relative to the Contract that they act solely as agents and representatives of the state, neither the Vermont Secretary of Transportation, Deputy Secretary of Transportation, the Chief Engineer, Engineer, or their authorized representatives shall be liable, either personally or as officials of the state, for their actions pursuant to authority granted to them by the Contract.

107.19 NO WAIVER OF LEGAL RIGHTS.

(a) General. Upon completion of the work, the Agency will expeditiously make a final inspection and notify the Contractor of acceptance. Acceptance of the Contract, however, will not preclude or prevent the Agency from correcting any measurement, estimate, or certificate made before or after completion of the work; and the Agency will not be precluded or prevented from recovering from the Contractor, the Contractor's surety, or both, any overpayment it may have made by failure on the part of the Contractor to fulfill the Contractor's obligations under the Contract.

A waiver on the part of the Agency of any breach of any part of the Contract shall not be held to be a waiver of any other or subsequent breach.

(b) Latent Defects, Fraud, and Gross Mistakes. Without prejudice to the terms of the Contract, the Contractor shall be liable to the Agency for latent defects, fraud, and such gross errors, omissions, or mistakes as may amount to fraud, and as regards the Agency's rights under any warranty or guaranty.

107.20 FURNISHING RIGHT-OF-WAY. It will be the responsibility of the Agency or appropriate political subdivision to secure all of the permanent rights-of-way which may be necessary for a construction Contract and to make said rights-of-way completely and physically available to the Contractor.

Any additional rights-of-way and/or additional rights to use land outside of the right-of-way as shown on the Plans which the Contractor desires for its own convenience shall be obtained and paid for by the Contractor.

107.21 BUY AMERICA PROVISIONS.

(a) Iron and Steel.

(1) General. All steel or iron products permanently incorporated into federal-aid projects shall be products that have been entirely manufactured within the United States as per *23 U.S.C. § 313* and *23 C.F.R. § 635.410*. All manufacturing processes of the steel or iron material in a product (i.e. smelting and any subsequent process which alters the steel material's physical form or shape or changes its chemical composition) must occur within the United States for the steel or iron to be considered of domestic origin. This includes processes such as rolling, extending, machining, bending, grinding, and drilling. If an item is used and in the opinion of the Contractor it is impossible, impractical, or undesirable to remove the item, then Buy America provisions apply.

(2) Use of Foreign Materials. Buy America provisions do not prevent a minimal use of foreign materials, provided the cost of foreign materials used does not exceed 0.1% of the total Contract price or $2,500, whichever is greater. The cost of foreign steel or iron is defined as its value delivered to the project. The Contractor shall notify the Engineer if it intends to use any foreign materials on the project.

(3) Coatings on Steel and Iron. In accordance with *23 C.F.R. § 635.410*, iron has been added to the materials subject to the Buy America requirements, and the action of applying a coating to a covered material (i.e. steel and iron) is now deemed a manufacturing process subject to Buy America. Coating includes epoxy coating, galvanizing, painting, and any other coating that protects or enhances the value of a material subject to requirements of Buy America.

(4) Temporary Items. Temporary items are not subject to Buy America provisions where the Contract specifications provide that the steel or iron products used on the project are to be removed at the end of the project or may be removed at the Contractor's convenience. Where the state can document that steel or iron products will be removed in subsequent near-term stages as part of phased construction, such products are considered temporary and not subject to Buy America. Where steel or iron products will remain in place at the end of the Contract and where phased construction is not imminent, such products are considered permanent and Buy America shall apply.

(b) Manufactured Products and Construction Materials. The *Infrastructure Investment and Jobs Act* (*Public Law 117-58*) includes the *Build America, Buy America Act* (*Public Law 117-58, Division G, Title IX*). The U.S. Office of Management and Budget issued memorandum *M-22-11* to provide guidance on the law. All construction materials, as defined in the law, that are permanently incorporated into federal-aid projects shall meet Build America, Buy America requirements.

107.22 DEFENSE OF LAWSUITS. When defending any claim that may arise under the Contract, the Contractor shall not raise or impose any defense involving the jurisdiction of the tribunal before which said claim is pending, the immunity of the state of Vermont, the governmental nature of the state, or the provision of any statutes respecting suits against the said state of Vermont without obtaining the express advance permission of the Vermont Attorney General's Office.

107.23 INTEREST. Notwithstanding any statutory or other provisions to the contrary, interest on monies owed pursuant to the Contract shall be paid as follows:

(a) Claims for Adjustment or Dispute – Pre-Decision or Judgment. Interest shall be allowed the Contractor on a decision or judgment for money in a claim for adjustment or dispute. Pre-decision or judgment interest shall be calculated for 21 calendar days after the date of the claim, but for the failure of the Agency to make the payment to the date of decision or judgment, at a simple rate equal to the weekly average 1-year constant maturity Treasury yield, as published by the Board of Governors of the Federal Reserve System, for the calendar week preceding the date of the decision or judgment.

(b) Claims for Adjustment or Dispute – Post-Decision or Judgment. Interest shall be allowed the Contractor on a decision or judgment for money in a claim for adjustment or dispute. Post-decision or judgment interest shall be calculated from the date of decision or judgment to the date of payment at a simple rate equal to the weekly average 1-year constant maturity Treasury yield, as published by the Board of Governors of the Federal Reserve System, for the calendar week preceding the date of the decision or judgment.

SECTION 108 – PROSECUTION AND PROGRESS

108.01 SUBLETTING OR ASSIGNMENT OF THE CONTRACT.

(a) General. The Contractor shall not sublet, assign, sell, transfer, or otherwise dispose of the Contract or any portion thereof, or of its right, title, or interest therein to any individual, firm, corporation, or other entity without the written consent of the Engineer. The Contractor shall file with the Agency copies of all executed subcontracts and other documents. An approved subcontractor shall not in turn sublet or assign any of the work pertaining to the subcontract without the Contractor obtaining further permission from the Agency. In no event shall Agency approval release the Contractor from responsibility and liability under the Contract and bonds.

(b) Performance of the Contract Work. The Contractor shall perform Contract work with its own organization amounting to at least 50% of the total Contract work amount, minus specialty items. The Contractor's own organization includes only workers employed and paid directly by the Contractor and equipment owned, leased, or rented by it from a non-debarred individual or entity, with or without operators. The term own organization does not include employees or equipment of a subcontractor, assignee, agent, or supplier of the Contractor. When determining whether the Contractor is in compliance with this 50% requirement, the following shall apply:

(1) The cost of materials and manufactured products to be purchased or produced under the Contract shall be included in the amount upon which the 50% requirement is computed.

(2) The percentage of subcontracted work shall be based on the Contract, rather than subcontract, unit prices. If only a part of a Contract item is to be sublet, its proportional value shall be determined on the same basis.

(3) When a firm sells materials to a Contractor and performs the work of incorporating the materials into the project, these actions must be considered in combination and as constituting a single subcontract.

(c) Specialty Items. The cost of specialty items may be deducted from the total Contract price before computing the amount of work required to be performed by the Contractor's own organization. Specialty items will be designated as such in the Special Provisions and may be performed by subcontract.

(d) Performance Requirements. The Contractor and its subcontractor(s) shall, in the staffing and administration of the Contract, comply with the following performance requirements:

(1) Commercially Useful Function. The Contractor and subcontractor(s) must each perform a commercially useful function. This means that the Contractor/subcontractor is responsible for the execution of a distinct element of the work of a Contract and carries out its responsibilities by actually performing, managing, and supervising the work involved. The Contractor/subcontractor must have the latitude to independently:

a. Select Contracts to be bid.

b. Determine prices to be quoted.

c. Select material suppliers.

d. Hire, fire, supervise, and pay employees.

e. Direct or cause the direction of the management and policies of the firm. The Contractor/subcontractor shall not broker work for another firm or act as a bidding conduit.

(2) Contractor to Furnish Competent Representative, Safety Officer, Others. To ensure that any subcontracted work is performed in accordance with the Contract requirements, the Contractor shall be required to furnish:

a. A competent, reliable, English-speaking representative employed by the Contractor who has full authority to direct performance of the work in accordance with the Contract requirements and who is responsible for all construction operations on the project regardless of who performs the work.

b. A competent, reliable, English-speaking employee designated as the safety officer who is authorized to receive orders and to issue binding directions concerning safety to all persons except Agency representatives associated with the project, whether employed by the Contractor, subcontractors, or material suppliers.

c. Such other individuals from the Contractor's organization as the Agency's Construction Engineer determines are necessary to ensure the performance of the Contract (e.g. supervisory, managerial, and engineering personnel).

(3) Employees on Payroll. The Contractor/subcontractor is not permitted to place on the payroll the employees of another firm for the purpose of avoiding federal or state regulations or the provisions of the Contract.

108.02 APPROVAL TO BEGIN WORK. Prior to being issued a Notice to Proceed (NTP), a preconstruction conference shall be held with the Agency and the Contractor. The purpose of this conference will be to discuss the Contractor's general plan of operation and any special requirements of the Contract. The Contractor shall be prepared to discuss their schedule, EPSC plan, and any special methods or equipment they intend to use.

The Contractor shall not commence construction operations until the written NTP has been issued. The NTP will be issued once all administrative submittals have been approved or found to be in conformance by the Agency and all other preconstruction activities required by the Contract have been completed.

108.03 PROSECUTION AND PROGRESS OF THE WORK.

(a) Progress Schedule. A progress schedule shall be submitted a minimum of 7 calendar days prior to the preconstruction conference. The progress schedule shall show the proposed sequence of work and when the Contractor proposes to complete the various items of work within the times established in the Contract.

During the progress of the work, the Contractor shall confer with the Engineer concerning performance of the work in accordance with the conforming schedule. The conforming schedule shall be used as a basis for establishing major construction operations and for checking the progress of the work.

A Notice to Proceed will not be issued until the progress schedule has been found to be in conformance.

(b) Performance of the Work. The work shall be performed from as many points, in as many parts, at times, in a manner, and with sufficient materials, equipment, and labor so as to ensure its completion within the times set forth in the Contract.

(c) Resumption of Work After Discontinuance with Consent. Should the performance of the work be discontinued by the Contractor for any reason, the Contractor shall notify the Engineer at least 24 hours before resuming operations.

108.04 LIMITATIONS OF OPERATIONS. The Contractor shall conduct the work at all times in a manner and sequence that will ensure the least interference with traffic. The Contractor shall have due regard to the location of detours and to the provisions for handling traffic. The Contractor shall not commence work to the prejudice or detriment of work previously started. The Engineer may require the Contractor to complete an area on which work is in progress before work is commenced on other areas if the opening of the area in progress is essential to public convenience.

108.05 CHARACTER OF WORKERS, METHODS, AND EQUIPMENT.

(a) General. The Contractor shall at all times employ sufficient labor and equipment to complete the work in the manners and times required by the Contract.

(b) Worker Skill and Experience. All workers shall have sufficient skill and experience to properly perform the work assigned to them. Workers engaged in specialty or skilled work shall have sufficient skill, experience, and experience with equipment required to perform such work properly and satisfactorily.

(c) Electrical Work. All electrical work shall be performed by or under the supervision of a licensed electrician (master or journeyman). Electrical work shall be defined as any work which involves making connections to electrical components or splices in wiring that are, or will be, carrying 100 volts or more. Under the supervision of means that the licensed electrician employed on the project shall be physically present on the project and shall be actively supervising the work.

(d) Removal of Workers from Project. Any person employed by the Contractor or a subcontractor who, in the opinion of the Engineer, does not perform work in a proper and skillful manner or is intemperate or disorderly shall, at the written order of the Engineer, be removed immediately by the Contractor or subcontractor employing such person and shall not be employed again in any portion of the work without the approval of the Engineer.

(e) Failure to Remove Worker from Project. If the Contractor fails to remove a person or persons as required in Subsection 108.05(d) or fails to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may withhold all monies which are or may become due and/or may suspend the work by written order until the Contractor complies with the order.

(f) Equipment Sufficiency. All equipment used to perform the work shall be of sufficient size and mechanical condition to meet the requirements of the work and to produce work of satisfactory quality. Equipment used on the project shall not cause injury to the roadway, adjacent property, or other highways.

(g) Methods and Equipment Not Prescribed. When the methods and equipment to be used by the Contractor are not prescribed in the Contract, the Contractor is free to use any methods or equipment that it demonstrates to the satisfaction of the Engineer will accomplish the work in conformity with the requirements of the Contract, and provided they pose no safety risk to the workers, inspection staff, traveling public, or general public.

(h) Methods and Equipment Prescribed. When the Contract specifies that the work be performed by the use of certain methods and equipment, those methods and equipment shall be used unless otherwise authorized by the Engineer.

If the Contractor desires to use a method or type of equipment other than those specified in the Contract, the Contractor shall request approval from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing work in conformity with Contract requirements.

If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet Contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining work with the specified methods and equipment. The Contractor shall remove the deficient work and replace it with work of specified quality or take such other corrective action as the Engineer may direct. No change will be made in basis of payment for the construction items involved or in Contract time as a result of authorizing a change in methods or equipment. The changing of methods and equipment prescribed shall not be justification for a claim.

108.06 LABOR AND RENTAL PREFERENCE. In accordance with *19 V.S.A. § 17*, the Contractor shall give preference to Vermont labor and trucks owned in Vermont. This requirement shall not apply to any Contract, or any part thereof, financed with federal funds.

108.07 MEETING PERSONNEL REQUIREMENTS. Contractors are encouraged to use the services of the local offices of the Vermont Department of Labor to meet their personnel requirements. Recruitment of workers in all occupations and skills is conducted by the Vermont Department of Labor, initially from the immediate labor market areas, and when workers with the required skills are not available locally, through the nationwide workforce clearance system of the U.S. Department of Labor.

Available workers may be obtained from the Vermont Department of Labor and from the Agency's Office of Civil Rights and Labor Compliance.

108.08 TEMPORARY SUSPENSION OF WORK.

(a) General. Work may be suspended by the Engineer, wholly or in part, for such period or periods as necessary on account of:

(1) Unsuitable weather conditions.

(2) Failure on the part of the Contractor to carry out an instruction or a written order, to perform satisfactory work, or to perform one or more provisions of the Contract.

(3) Any other conditions which, in the judgment of the Engineer, make work impractical, dangerous, harmful to the environment, or in violation of a permit or other authorization for the project.

(b) Seasonal Closure. From November 16th to March 31st, inclusive, no construction work of any kind shall be done except by written permission from the Regional Construction Engineer, and only under such conditions as specified therein. Permission will only be granted for work which will result in a direct benefit to the state or the traveling public, unless otherwise stated in the Contract. Items which may be considered as a benefit include, but are not limited to, shorter Contract duration, a cost savings, increased safety for the traveling public, and an ability to ensure the quality of work. The Contractor shall request permission in writing, detailing what Contract items may be affected, a schedule of work, and the benefits to the state or traveling public. The Agency reserves the right, at its sole discretion, to rescind permission to work during the seasonal closure period. The rescission will not be justification for additional compensation.

(c) Seasonal Closure Procedure. The construction procedure prior to closing down the project for the seasonal closure period shall be as specified in Subsection 104.04.

(d) Contractor Suspension of Work. The Contractor shall not suspend the work without the permission of the Engineer. Such permission will not be unreasonably withheld.

(e) Contract Applicable. If the work is suspended for any reason, all appropriate requirements of the Contract shall continue.

108.09 SUSPENSIONS OF WORK ORDERED BY THE ENGINEER.

(a) Additional Compensation/Time Request; Time Limit. If the performance of all or any portion of the work is suspended or delayed by the Engineer for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation and/or Contract time is due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing a request for adjustment within 7 calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

(b) Evaluation of Request. Upon receipt of the request for adjustment, the Engineer will evaluate the Contractor's request in accordance with Subsection 108.16. If the Engineer agrees that the cost and/or time required for the performance of the Contract has increased as a result of the suspension/delay and the suspension/delay was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors at any approved tier, and not caused by weather, the Engineer will make an adjustment (excluding profit) and modify the Contract in writing accordingly. The Contractor will be notified of the Engineer's determination of whether or not an adjustment of the Contract is warranted.

(c) No Adjustment Unless Notice Submitted. No Contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed.

(d) No Adjustment if Work Would Have Been Delayed Regardless. No Contract adjustment will be allowed under this subsection to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided or excluded under any other term or condition of the Contract.

108.10 INCENTIVE AND DISINCENTIVE PERIODS. When specified in the Contract, the Contractor will be required to complete certain identified work during an incentive, disincentive, or incentive/ disincentive period, hereinafter referred to as an I/D period. The intent of this period is to incentivize the Contractor to complete the identified work as rapidly as possible. The following requirements will apply to the I/D period.

(a) Dates. The allowable I/D period dates will be as specified in the Notice to Bidders. The Contractor shall submit a letter to the Engineer for review and approval specifying the begin construction date for the I/D period. This letter shall be received by the Engineer a minimum of 14 calendar days prior to the begin construction date specified in the letter.

The I/D period is a fixed date and will not be changed for any reason whatsoever unless done so by the Chief Engineer, and then only under extreme conditions as determined by, and at the sole discretion of, the Chief Engineer.

(b) Meetings. There shall be a pre-I/D period meeting held on site with the Contractor's superintendent, Contractor's project manager, the Engineer, the Project Manager, Public Outreach Coordinator (if applicable), municipal officials, the local emergency service providers, Vermont State Police, and the local Regional Planning Commission to discuss durations of work, types of night work, work sequencing, and other issues. The Contractor shall be responsible for setting this meeting up and making appropriate contacts. This meeting shall be held a minimum of 14 calendar days prior to the start of the I/D period.

When specified in the Contract, there shall also be a public information meeting prior to the start of the I/D period. The Contractor's superintendent and Contractor's project manager shall be available to attend. The Contractor shall be prepared to discuss the construction schedule with the public. The Public Outreach Coordinator will be responsible for setting this meeting up and making appropriate contacts. This meeting shall be held a minimum of 21 calendar days prior to the start of the I/D period.

Weekly meetings between the Contractor, Engineer, and other pertinent parties as determined by the Engineer shall be held during the I/D period to discuss the project progress and future construction activities, and current CPM progress schedules and narratives.

(c) Identified Work. All work identified in the Notice to Bidders shall be completed before the end of the I/D period.

All prefabricated concrete elements, or other components as specified in the Contract, required to complete the identified work shall be authorized for shipment prior to the start of the I/D period.

(d) Pay Schedule. The pay schedule will be as specified in the Notice to Bidders.

(e) Underruns and Overruns. The Contract indicates an estimated quantity for each pay item. The fact that the actual amounts used in the construction of a project may vary from the estimate will not be a basis or cause for changing any of the conditions for I/D.

The Agency recognizes that additional work beyond the work indicated in the Plans is always possible in any Contract. The Agency is willing to pay for necessary additional work in accordance with the terms and requirements of the Contract, however, the Contractor shall absorb any resulting construction time within the original project and CPM schedules, and there will be no adjustments or changes to the I/D dates or conditions.

(f) Payment. Payment will be made as specified in Section 199.

108.11 DETERMINATION OF EXTENSION OF CONTRACT TIME FOR COMPLETION.

(a) General; Request for Extension of Contract Completion Date. When a definite date or a fixed number of days for completion is specified in the Contract, and when the Contractor fails to substantially complete the work within the Contract time specified due to unforeseen conditions beyond the control and without fault or negligence of the Contractor, the Contractor will be credited additional Contract completion time on a full day basis as provided in Subsection 108.11(b). The Finals Engineer will submit to the Contractor a *Request for Extension of Time* form containing a preliminary review of extension of time in accordance with Subsection 108.11(b). If the Contractor concurs with the preliminary review, the Contractor shall sign and return the form to the Finals Engineer within 60 calendar days of the date of presentation (the "60 calendar day period").

If the Contractor disputes the preliminary review, the Contractor shall notify the Finals Engineer within the 60 calendar day period and provide supportive documentation regarding the dispute. Upon notification of a dispute, the Construction Section will research and provide a decision to the Contractor. The Contractor may appeal this decision within 30 calendar days to the Chief Engineer as provided in Subsection 105.04. Notwithstanding Subsection 105.04 and Subsection 105.20, failure to notify the Finals Engineer of a dispute within the 60 calendar day period shall constitute concurrence with the preliminary review and be deemed a waiver of the Contractor's right to appeal, in which case the extension of time will be processed without the Contractor's signature.

The Contractor may request an extension of time from the Engineer during the course of the project.

No extension of time will be required when a substantial completion date is established prior to the Contract completion date, as modified by applicable change orders.

(b) Determination of Contract Completion Date Extension. Whenever the work is delayed or suspended through no fault of the Contractor, a Contract completion date extension may be made by the Engineer in the following circumstances:

(1) Delay by the Agency in awarding the Contract and/or in issuance of the Authorization to Proceed or the Notice to Proceed.

(2) Federal or state laws passed subsequent to the date of the Contract adversely affecting progress of the work.

(3) Acts of God, including but not limited to unusually severe storms of extended duration or impact which could not generally be anticipated by the Contractor, either during the bidding process or during construction, and catastrophic weather events such as floods, droughts, fires, hurricanes, tornadoes, earthquakes, or landslides.

(4) Suspension of work by order of the Engineer. In such cases, the time for completion will be extended by an amount equal to the elapsed time between effective dates of order to suspend and order to resume.

(5) Differing site conditions pursuant to Subsection 104.08.

(6) Significant changes in the character of the work pursuant to Subsection 109.04.

(7) Extra work ordered by the Engineer pursuant to Subsection 104.03.

(8) Delays in the issuance of permits, approvals, or other government regulatory action that are not attributable to the Contractor.

(9) Court orders, including but not limited to temporary restraining orders, preliminary and permanent injunctions, or judgments that are not attributable to the Contractor.

(10) Industry-wide labor unrest.

(11) The days from April 1st to November 15th, inclusive, on which the weather or the condition of the ground caused suspension of the work.

(12) Industry-wide material or supply shortages not reasonably anticipated by the Contractor at the time the Contract was entered.

(13) Delays caused by a shortage of materials, but only when the Contractor furnishes to the Engineer documentary proof that a diligent effort has been made to obtain the materials from all known sources and the inability to obtain the materials when originally planned did in fact cause a delay in final completion of the entire work, and the delay could not be avoided by revising the sequence of the Contractor's operations. The Contractor shall notify the Engineer in writing of the causes of delay caused by material shortages no later than 15 calendar days from the beginning of any such delay and not thereafter.

(14) Any other conditions which in the opinion of the Chief Engineer warrant consideration for an extension of time.

108.12 FAILURE TO COMPLETE WORK ON TIME.

(a) Time as an Essential Element. Time is an essential element of the Contract. The Contractor shall plan its progress schedule and progress the work in order to complete the Contract on or before the completion date or duration set forth in the Contract.

(b) Liquidated Damages for Failure to Meet Interim Completion Date. The Contract may identify one or more interim completion dates and specify elements of the work which must be completed by such dates. For each working day following the interim completion date that the specified work is not completed, liquidated damages of the amount specified in the Notice to Bidders will be assessed. This amount will be specified as a percentage of the applicable daily charge per working day of delay identified in Table 108.12A.

These liquidated damages are separate from, and will be imposed in addition to, liquidated damages which may be imposed for failure to complete the Contract on time.

The provisions of Subsection 108.11 will not apply to the interim completion date unless otherwise authorized by the Agency.

(c) Liquidated Damages for Failure to Meet Contract Completion Date. For each working day on which any work remains incomplete after the completion date or duration specified in the Contract for completion of the work involved, there shall be deducted from any monies due the Contractor the amount shown in Table 108.12A, unless otherwise specified in the Contract. The deduction is not a penalty but is liquidated damages to defray the cost to the Agency to administer the Contract, including but not limited to the cost of engineering, inspection, supervision, inconvenience to the public, obstruction of traffic, and interference with business. Due account will be provided for any adjustment of the Contract time for completion of the work under the provisions of Subsection 108.11.

TABLE 108.12A – DAILY LIQUIDATED DAMAGES CHARGE PER WORKING DAY OF DELAY

Original Contract Amount		Daily Charge per Working Day of Delay
From More Than	To and Including	
$0	$500,000	$1,900
$500,000	$1,000,000	$2,000
$1,000,000	$1,500,000	$2,100
$1,500,000	$3,000,000	$2,400
$3,000,000	$5,000,000	$2,800
$5,000,000	$10,000,000	$3,800
$10,000,000	$15,000,000	$4,800
$15,000,000	--	$5,800

Should the Contractor elect to work on Saturdays, Sundays, holidays, or days from November 16th to March 31st, inclusive, after the Contract completion date, the Contractor will be charged liquidated damages for such days worked.

(d) No Waiver. Permitting the Contractor to continue to finish the work or any part of the work after the time fixed for its completion or after the date to which the time for completion may have been extended shall not operate as a waiver on the part of the Agency of any of its rights under the Contract.

(e) Liability for Liquidated Damages. The Contractor covenants and agrees that should the amount of monies due or that may become due the Contractor be less than the amount of ascertained liquidated damages, the Contractor and the Contractor's surety shall be liable to the state for the deficiency.

(f) Liquidated Damages Cutoff Date. No liquidated damages will be charged after the establishment of a substantial completion date.

108.13 TERMINATION OF THE CONTRACT.

(a) Notice. Upon written notice from the Engineer or other proof satisfactory to the Secretary, the Secretary will give notice in writing to the Contractor and the Contractor's surety of delay, neglect, or default if the Contractor:

(1) Fails to begin the work under the Contract within the time specified in the Notice to Proceed.

(2) In the opinion of the Engineer, fails to perform the work with sufficient workers and equipment or with sufficient materials to ensure the prompt completion of said work.

(3) In the opinion of the Engineer, performs the work unsuitably or neglects or refuses to remove materials or to redo or replace work rejected as defective and unsuitable.

(4) Discontinues the prosecution of the work without the authorization of the Engineer.

(5) Fails to resume work that has been discontinued within a reasonable time after notice to do so.

(6) Becomes insolvent, is declared bankrupt, or commits any act of bankruptcy or insolvency.

(7) Allows any final judgment to stand against the Contractor unsatisfied for a period of 10 calendar days.

(8) Makes an assignment for the benefit of creditors.

(9) In the opinion of the Engineer, fails, for any cause whatsoever, to carry on the work in an acceptable and timely manner.

(b) Failure of Contractor to Proceed. If the Contractor or the Contractor's surety does not proceed in accordance with the notice within 10 calendar days of being issued the notice, the Agency may, without violating the Contract, terminate the Contract by taking performance of the work out of the hands of the Contractor.

The Agency may appropriate and use any or all materials and equipment on the project as are suitable and acceptable and may enter into an agreement for the completion of the Contract, according to the terms and provisions thereof or use such other methods as, in the discretion of the Engineer, will be required for the completion of the Contract in an acceptable manner and in the best interest of the Agency.

(c) Agency's Costs. All costs and charges incurred by the Agency, together with the costs of completing the work under Contract, shall be deducted from any monies due or which may become due the Contractor. If the expense incurred by the Agency is less than the sum which would have been payable under the Contract had it been completed by the Contractor, the Contractor shall be entitled to receive the difference; if the expense exceeds the sum which would have been payable under the Contract, the Contractor and the Contractor's surety shall be liable and shall pay to the Agency the amount of the excess.

108.14 TERMINATION OF THE CONTRACT FOR CONVENIENCE.

(a) General. The Agency may, by written order to the Contractor, terminate the Contract or any portion thereof when such termination would be in the best interest of the Agency.

Any such termination shall be by delivery to the Contractor an Order of Termination specifying the termination is for the convenience of the Agency, the extent to which performance of work under the Contract is terminated, and the effective date of the termination.

In the event such termination occurs, without fault and for reasons beyond the control of the Contractor, all completed items of work as of the date of termination will be paid for at the Contract bid price. Payment for partially completed work will be made either at agreed prices or by force account methods provided elsewhere in the Contract.

Pursuant to Subsection 109.07, no compensation will be allowed for items eliminated from the Contract.

Upon request the Contractor shall make all Contract-related records available to the Agency.

(b) Contractor Obligations. After receipt of the Order of Termination and except as otherwise directed by the Engineer, the Contractor shall immediately proceed to:

(1) To the extent specified in the Order of Termination, stop work under the Contract on the date specified.

(2) Place no further orders or subcontracts for materials, services, and/or facilities except as may be necessary for completion of such portions of the work under the Contract as are not terminated.

(3) Terminate and cancel all orders or subcontracts for materials, services, and/or facilities except as may be necessary for completion of such portions of the work under the Contract as are not terminated.

(4) Submit to the Engineer a material inventory list, certified as to quantity and quality of materials in its possession or in transit to the project.

(5) Transfer to the Agency all completed or partially completed plans, drawings, information, and other property which, if the Contract had been completed, would be required to be furnished to the Agency in electronic format.

(6) Take other action as may be necessary or as directed by the Engineer for the protection and preservation of the property related to the Contract which is in the possession of the Contractor and in which the Agency has or may acquire any interest.

(c) Claim by Contractor. After receipt of the Order of Termination from the Agency, the Contractor shall submit any claim for additional damages or costs not covered herein or elsewhere in the Contract within 60 calendar days of the effective termination date, and not thereafter.

Should the Contractor fail to submit a claim within the 60 calendar day period, the Agency may, at its sole discretion, based on information available to it, determine what, if any, compensation is due the Contractor and pay the Contractor the determined amount.

(d) Materials. At the option of the Agency, acceptable materials included in the material inventory in Subsection 108.14(b)(4) that have been obtained by the Contractor for the Contract but which have not been incorporated into the work may be purchased from the Contractor at actual cost and delivered to a location prescribed by the Engineer or otherwise disposed of as mutually agreed.

Payment for materials included in the material inventory chosen to be purchased by the Agency will be made at actual cost delivered to the project or storage site designated by the Engineer, including transportation charges, to which 10% overhead and profit will be added.

(e) Idle Equipment. Idle equipment time claimed by the Contactor will be paid as follows:

(1) Contractor-Owned Equipment. For the portion of any claim relating to idle equipment time for equipment owned by the Contractor, the Contractor will be entitled to recover equipment rates based on the Contractor's internal ownership costs. Recovery for idle equipment time shall not be based on published rental rates.

(2) Rented or Leased Equipment. For the portion of any claim relating to idle equipment time for equipment rented or leased by the Contractor, the Contractor shall be entitled to recover the lesser of the actual rental costs or fair market rental costs, and the amount shall not exceed 30 calendar days rental.

(3) Limitations on Recovery for Idle Equipment. Claims for idle equipment time, whether for Contractor owned equipment or leased/rented equipment, following termination of the Contract pursuant to this subsection are limited to a maximum of 30 calendar days and may not include any operating expenses.

(f) Negotiation; No Anticipated Profit. Negotiation to settle a timely claim shall be for the sole purpose of reaching a settlement equitable to both the Contractor and the Agency. Settlement shall be based on actual costs incurred by the Contractor plus overhead and profit as specified in Subsection 109.06. Consequential damages, loss of overhead, loss of overhead contribution of any kind, and/or loss of anticipated profits on work not performed shall not be included in the Contractor's claim and will not be considered, allowed, or included as part of any settlement.

(g) Records. The Contractor shall make available to the Agency all cost records relevant to a determination of an equitable settlement.

(h) Contractual Responsibilities Continue. Termination of the Contract, or portion thereof, shall not relieve the Contractor of its contractual responsibilities for work completed and shall not relieve the Contractor's surety of its obligation for and concerning any just claim arising out of the work performed.

108.15 TERMINATION OF THE CONTRACTOR'S RESPONSIBILITY.

(a) Completion and Acceptance. Whenever the projects provided for by the Contract have been completely performed by the Contractor, all parts of the work have been approved and accepted by the Engineer, and all Contract requirements complied with, the Contractor will then be released from further obligations except as set forth in the bonds provided, and the Agency will provide the Contractor with a Completion and Acceptance Memorandum.

(b) Limited Completion and Acceptance. If the Contract includes work at more than one location as separate projects or as separate locations on a single project, the Agency may accept the work at any location when the work at that location is completely finished and all responsible parties agree to acceptance in the same manner as a normal final inspection.

If a portion of the Contract is accepted by the Engineer, and all Contract requirements related thereto are complied with, the Contractor shall remove all construction warning signs from that portion and the Contractor will then be released from further obligations as to that portion except as set forth in the bonds provided. If substantial completion of the work is accomplished, but additional work is required to achieve final acceptance, the Agency may accept the work under the Contract with exceptions and/or reservations.

108.16 COMPENSABLE AND NON-COMPENSABLE DELAYS.

(a) Compensable Delays. The Engineer may allow additional compensation for the time-related issues specifically enumerated in this subsection only if the delays and other time-related issues result from one or more of the following:

(1) Differing site conditions pursuant to Subsection 104.08.

(2) Significant changes in the character of the work pursuant to Subsection 109.04.

(3) Suspensions of work ordered by the Engineer pursuant to Subsection 108.09.

(b) Recoverable Costs. Only the following costs may be recovered for compensable delays under Subsection 108.16(a):

(1) Labor, Materials, and Equipment. The costs provided for in Subsection 109.06 for actual work performed associated with the delay and properly documented and maintained pursuant to that subsection.

(2) Field Office Overhead. The actual cost paid by the Contractor to third parties for field office rental, utilities, and routine cleaning, plus 5% for Contract supervision, overhead, and profit.

(3) Home Office Overhead. Unabsorbed home office overhead is only recoverable pursuant to Subsection 108.14.

(c) Non-Recoverable Costs. The following costs are not recoverable under the Contract:

(1) Home office overhead in excess of that provided in Subsection 109.06.

(2) Loss of profit in excess of that provided in Subsection 109.06.

(3) Loss of productivity and/or inefficiencies in labor and equipment.

(4) Consequential damages, such as loss of interest or investment with respect to funds at issue in the dispute.

(5) Attorneys' fees, mediation expenses, claims analysis, or preparation expenses.

(6) Any other costs attributable to the Contractor's failure to advance the work in a reasonable manner.

(d) Non-Compensable Delays. The Engineer may allow an extension of the Contract completion date or the interim completion date but may not allow additional compensation except for those situations specifically enumerated in Subsection 108.16(a).

(e) Failure to Perform Adequately. Failure to perform the work continuously and effectively with an adequate work force and as scheduled for the full time allowed will be cause for denial of a time extension that might otherwise be allowed.

SECTION 109 – MEASUREMENT AND PAYMENT

109.01 MEASUREMENT OF QUANTITIES.

(a) General. All work completed under the Contract will be measured by the Engineer according to U.S. customary units.

The measurement and determination of the number of units of each pay item will be made as specified in this section and as are specifically described under the Method of Measurement and Basis of Payment subsections for each item. The abbreviations listed in Table 109.01A will be used on the quantity sheet to represent the indicated pay unit.

TABLE 109.01A – PAY UNIT ABBREVIATIONS

Abbreviation	Pay Unit	Exact Conversion
ACRE	Acre	43,560 square feet
CF	Cubic foot	1,728 cubic inches
CWT	Hundredweight	100 pounds
CY	Cubic yard	27 cubic feet
DAY	Day	24 hours
DL	Dollar	--
EA	Each	--
GAL	Gallon	231 cubic inches
HR	Hour	--
IN	Inch	--
LB	Pound	16 ounces
LF	Linear foot	12 inches
LS	Lump sum	--
MFBM	Thousand feet board measure	83-1/3 cubic feet or 144,000 cubic inches
MGAL	Thousand gallons	--
MILE	Mile	5,280 feet or 1,760 yards
MLF	Thousand linear feet	--
MSY	Thousand square yards	9,000 square feet
SF	Square foot	144 square inches
SY	Square yard	9 square feet
TON	Ton	2,000 pounds

(b) Length. All items measured by the linear foot will be measured parallel to the base or foundation upon which the item is placed, unless otherwise shown on the Plans.

(c) Area. Unless otherwise specified in the Contract, area computations will be made horizontally, and no deductions will be made for individual fixtures having an area of 10 square feet or less. Measurements for area computations will be to the neat dimensions shown on the Plans or authorized in writing by the Engineer.

(d) Volume. The volume of excavation and borrow pits will be calculated from cross-sections, the use of average end area formulae, 3-dimensional models created by survey, or by another approved method. Volumes of other work (e.g. Cement Masonry or Removal of Concrete or Masonry) will be calculated by using arithmetical formulae. Where the volume is bounded by varying dimensions and there is no simple volumetric formula applicable, frequent cross-sections will be taken and the volume computed from average end area formulae. Other methods of measurement for small quantities may be authorized when approved in writing by the Engineer.

(e) Weight. All materials that are measured or proportioned by weight shall be done so on accurate, approved scales by competent, qualified personnel.

(f) Bituminous Materials Measurements. When liquid bituminous materials are shipped by truck or transport, net certified weight may be used for computing quantities.

(g) Final Bridge Quantities. In order to save engineering resources and expedite payment of the final estimate, the Agency will pay for the original Plan quantities, exclusive of estimated overrun allowances, for all bridge quantities if the Agency and the Contractor agree to the acceptance of the Plan quantities by the time the final survey is made. However, if either the Contractor or the Agency challenges the quantities, final quantities will be computed in accordance with the Contract. When one or more changes in design generate changes in quantities, final quantities shall be based on final measurements.

109.02 PURCHASES OF MATERIALS BASED UPON AGENCY MEASUREMENTS.

(a) Estimates Are Not Guarantees. The Agency does not furnish or guarantee estimates of measurements of borrow, gravel, sands, soils, fill, or other construction materials to be used on the project for the benefit and/or convenience of the Contractor either in dealings with sellers of those materials or for any other purpose.

(b) Purchase of Materials. Except by written agreement, with a copy of the agreement furnished to the Agency prior to removal of materials for the project, the Contractor shall not purchase materials on terms that require payment on the basis of the estimates of measurement made by the Agency.

109.03 SCOPE OF PAYMENT.

(a) General. The Contractor shall receive and accept the compensation provided in the Contract as full payment for:

(1) Furnishing all materials, labor, tools, and equipment and performing all work contemplated and required under the Contract.

(2) All loss or damage arising out of the work from the actions of the elements, or from any unforeseen difficulties or obstructions which may arise or be encountered during the prosecution of the work until its acceptance by the Agency.

(3) All risks of every description connected with the prosecution of the work.

(4) All expenses incurred by or in consequence of the temporary suspension or discontinuance of the work for any infringement of patent, trademark, or copyright, and for completing the work in an acceptable manner according to the Contract.

(b) Payment of Estimates; Obligations of Contractor. The payment of any current or final estimate shall not prejudice or affect the obligation of the Contractor under the Contract, at its own cost and expense, to repair, correct, renew, or replace any defects or imperfections in the project and its appurtenances or the strength of or quality of materials used on the project. Payment of an estimate, including a final estimate, shall not relieve the Contractor from the payment of any and all damages due or attributed to defects or imperfections.

(c) Damage Claims and Liabilities; Payment by Agency. Relative to damage, labor and materials, and other claims against the Contractor or project, no monies payable under the Contract or any part thereof shall become due and payable if the Agency so elects until the Contractor satisfies the Agency that the Contractor has fully settled or paid all damage, labor, or materials claims and all liabilities incurred in connection with the work. If it so elects, the Agency may pay any or all claims or liabilities wholly or in part and deduct the amount or amounts so paid from any biweekly or final estimates.

(d) Written Evidence of Releases. If it so elects, the Agency may require the Contractor to furnish written evidence of release from all claims and obligations connected with the work.

109.04 CHANGES IN THE CHARACTER OF WORK.

(a) General. The Engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project. Such changes in quantities and alterations shall not invalidate the Contract nor release the surety, and the Contractor agrees to perform the work as altered.

(b) Significant Alterations or Changes to Character of Work. If the alterations or changes in quantities significantly change the character of the work under the Contract, whether such alterations or changes are in themselves significant changes to the character of the work or by affecting other work cause such other work to become significantly different in character, an adjustment, excluding anticipated profit, will be made to the Contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

(c) Insignificant Alterations or Changes to Character of Work. If the alterations or changes in quantities do not significantly change the character of the work to be performed under the Contract, the altered work will be paid for as provided elsewhere in the Contract.

(d) Meaning of Significant Change. The term significant change shall be construed to apply only to the following circumstances:

(1) When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction; or

(2) When a major item of work, as defined in Subsection 101.02, is increased in excess of 25% or decreased below 75% of the original Contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125% of the original Contract item quantity, or in case of a decrease below 75%, to the actual amount of work performed.

109.05 COMPENSATION FOR ALTERED PLANS OR QUANTITIES.

(a) General. When alterations in the Plans or quantities of work are ordered and performed as provided in Subsection 104.02 and when such changes or alterations result in an increase or decrease of not more than 25% of the total original Contract amount, or the length of the project is not increased or decreased more than 25% of the original length shown in the Contract, the Contractor shall accept payment in full at the Contract unit price for the actual quantities of work done.

(b) Adjustment When Exceeded. When changes or alterations result in a sum total change of more than 25% of the total cost of the Contract calculated from the original bid quantities and the original Contract unit prices, or a length increased or decreased more than 25%, and a demand is made by the Contractor or the Agency, a negotiated change order shall be signed by both parties setting forth the necessity for the change and an adjustment of unit prices agreed upon as satisfactory to both parties. An agreement shall be signed by both parties setting forth the necessity for the change and an adjustment of unit prices agreed upon as satisfactory to both parties.

In order to bring a claim for additional compensation, the Contractor shall meet all applicable requirements of Subsection 105.20.

(c) No Further Allowance. No further payments will be made for changes/alterations, including the changes/alterations, or indirectly from unbalanced allocation of overhead expense among the Contract items by the Contractor, and subsequent loss of expected reimbursements therefore or from any other cause.

109.06 EXTRA AND FORCE ACCOUNT WORK. Extra work ordered and accepted as specified in Subsection 104.03 will be paid for on a unit price or lump sum basis. If an agreement for payment is not made before the work is started, work will be tracked and paid for under the force account provisions below until such time as the Agency and the Contractor agree upon a unit price or lump sum payment. If an agreement cannot be made, pay item 199.9061 will be added to the Contract and payment will be made in accordance with the provisions below.

When the Engineer deems it impractical to handle any extra work ordered on a unit price or lump sum basis, a change order will be made and the work will be ordered done and paid for on a force account basis as follows:

(a) Labor. For all machine or equipment operators, other workers, and supervisors in direct charge of the specific operation, the Contractor shall receive the actual wages agreed upon before beginning the work and were paid to the workers performing the work, to which shall be added an amount equal to 10% for profit. If the Contractor elects to use employees more skilled than required to perform the extra work, the Agency reserves the right to allow compensation for said employees to be capped at 125% of the applicable Davis-Bacon wage rate of the base skill level required to perform the work.

Workers' compensation insurance, unemployment compensation insurance, and Social Security charges on labor items as paid by the Contractor will be allowed. Other employee insurances (e.g. health, disability) being paid by the Contractor just prior to the work being ordered will also be allowed, provided the Contractor submits an applicable notarized insurance rate schedule from its insurance agent. The Contractor shall submit an Agency form indicating all applicable insurances and overhead items for each employee involved in the extra work.

The Contractor will be allowed an additional 10% of the actual wages paid to the employee as compensation for administration charges and any other additional costs. Additional cost or charge for the superintendent will not be allowed.

(b) Materials. The Contractor shall receive the actual cost, including freight charges (both as submitted on original receipted bills), for all materials furnished and used. An amount of 10% will be added thereto for overhead, profit, and any other costs incurred in supplying the materials. Vermont sales tax shall not be included.

(c) Equipment. The Contractor will be reimbursed as described below. Equipment that is used shall be specifically described by year, manufacturer, model number, and any other information required to identify the appropriate hourly rate in the EquipmentWatch *Rental Rate Blue Book*. In the event the Contractor elects to use equipment of a higher rental value than equipment suitable for the work, payment will be made at the rate applicable to suitable equipment.

(1) Contractor-Owned Equipment.

a. Ownership Costs. The Contractor will be reimbursed for its ownership costs for self-owned equipment at the rates agreed to before the work begins. These rates shall be on an hourly basis and shall not exceed the monthly ownership rates listed in the current EquipmentWatch *Rental Rate Blue Book* divided by 176. The rates will be adjusted for depreciation as computed and published in the EquipmentWatch *Rental Rate Blue Book* rate adjustment tables but will not be adjusted as recommended on the EquipmentWatch *Rental Rate Blue Book* regional adjustment maps. The rates for ownership costs will be total reimbursement to the Contractor for all non-operating costs of the equipment, including depreciation, insurance, taxes, interest, storage, overhead, repairs, and profit.

The maximum duration for reimbursement in a day shall not exceed eight hours unless the equipment is actually operated for more than eight hours on a particular day, in which case the rate shall be paid for all hours the equipment actually worked on that day.

b. Operating Costs. The rates for operating costs include fuel, lubricants, other operating expendables, and preventative and field maintenance. The Contractor will be reimbursed the amount derived as the product of the number of hours of actual use multiplied by the EquipmentWatch *Rental Rate Blue Book* estimated operating cost per hour. Operating costs do not apply to equipment idle time. Operating costs do not include the operators' wages.

Except as otherwise provided, the rates to be used for computation shall be those in effect at the time the force account work is performed as reflected in the applicable publication of the EquipmentWatch *Rental Rate Blue Book*.

c. Establishing New Rates. In the event that an ownership cost rate and/or an operating cost rate is not established in the EquipmentWatch *Rental Rate Blue Book* for a particular piece of equipment, the Engineer will establish a rate for that piece of equipment consistent with its costs and expected life. The Contractor shall make no charge for small tools that are considered as having a replacement value of less than $1,000.

(2) Rented Equipment. In the event the Contractor does not own a specific type of equipment and must rent, the Contractor will be reimbursed the actual cost for the equipment, as submitted by invoice, for the time that the equipment is used to accomplish the work. Vermont sales tax shall not be included.

The Agency reserves the right to limit the hourly rate to the maximum amount allowed by the EquipmentWatch *Rental Rate Blue Book* in the event that the Contractor is a subsidiary of, or has a close affiliation with, the firm supplying the rented equipment.

(3) Maximum Amount Payable. The maximum amount of reimbursement for the ownership cost of Contractor owned equipment or the rental cost of rented equipment is limited to the original purchase price of the equipment.

(4) Equipment Downtime. No rental cost or operating cost will be paid for downtime for either rented equipment or for Contractor owned equipment.

(5) Transportation Costs. The Contractor will be paid for the reasonable documented cost of transporting both Contractor owned and rented equipment to the work location and back to its original location, or a new location if the cost is less.

(d) Subcontracted Work. The Contractor shall receive the actual cost, as submitted on original receipted bills, for all extra work and force account work subcontracted to others. An amount of 10% will be added thereto for overhead, profit and any other costs incurred to perform the subcontracted work. However, the Agency reserves the right to use the force account procedures as depicted previously in this subsection in the event that the cost of reimbursable subcontracted work is deemed excessive.

(e) Compensation to be Full Payment. The compensation as herein provided shall be received by the Contractor as payment in full for extra work done on a force account basis. The Contractor's representative and the Engineer shall compare records of extra work on a force account basis at the end of each day. Copies of these records shall be made on Agency forms provided for this purpose and shall be signed by both the Engineer and Contractor's representative.

All requests for compensation for extra work done on a force account basis, including original receipted bills to verify cost and freight charges for all materials, shall be submitted to the Agency as soon as possible. However, if the required request, invoices, and other documentation are not filed before 90 calendar days have lapsed following final acceptance of the project, the costs associated with such extra work and force account work shall not be reimbursable.

(f) Additional Costs. Any additional costs for public liability insurance and property damage insurance that are required in the Contract will be allowed and reimbursed at the actual cost to the Contractor.

109.07 ELIMINATED ITEMS. Should any items contained in the Contract be found unnecessary for proper completion of the work, the Engineer may, upon written order to the Contractor, eliminate the items from the Contract. Such action shall have no effect on the other provisions of the Contract and shall in no way invalidate the Contract. No compensation will be allowed for items eliminated from the Contract.

109.08 PARTIAL AND FINAL PAYMENTS.

(a) General. Partial payments, computed upon the basis set forth in the Contract, will be made by the Engineer. On or before the Saturday of each alternate week during satisfactory progress of the work, the Engineer will make a biweekly estimate of the amount of work performed and will compute and report the value thereof under the Contract. Such estimates may be approximate only and not be based on actual measurements. All biweekly and partial estimates will be paid in full except as set forth below, and no payment will be made when the total value of the work done since the last estimate amounts to less than $1,000.

(b) Tax Compliance. If the Contractor is found to not be in good standing with respect to, or in full compliance with a plan to pay, any and all taxes due to the state as required in *32 V.S.A. § 3113*, money otherwise owed to the Contractor will be withheld from one or more biweekly estimates and the final estimate.

(c) Claims and Withholdings. For the protection of the state, creditors, and other claimants of the Contractor, payment for all or part of one or more biweekly estimates and/or the final payment as determined by the final estimate may be held for the use of the state, if the Agency so elects, until the Contractor has fully settled for or paid for all materials and equipment used in or upon the work and labor done in connection therewith and fully settled for or paid for all damage claims or liabilities incurred in connection with said work. Upon satisfactory settlement of all such accounts, the final estimate will be paid to the Contractor.

(d) Final Payments. Payment of the final estimate will be made when an agreement is reached between the Agency and the Contractor regarding the final quantities of all Contract pay items, the acceptance date as defined in Subsection 101.02 is established, all materials and certifications are accepted, and all other Contract requirements have been met. The Finals Engineer will present the Agency's determination of final quantities to the Contractor for their concurrence. If the Contractor wishes to dispute the final quantities, the Contractor shall notify the Finals Engineer within 60 calendar days of the date of presentation (the "60 calendar day period") of final quantities. The Contractor shall indicate which specific quantities are being disputed and provide supportive documentation regarding the disputed quantities. The Contractor may request a 30 calendar day extension to review the quantities by notifying the Finals Engineer within the 60 calendar day period.

Upon notification of a dispute, the Construction Section will research and provide a decision to the Contractor. The Contractor may appeal this decision within 30 calendar days to the Chief Engineer as provided in Subsection 105.04. Notwithstanding Subsection 105.04 and Subsection 105.20, failure by the Contractor to notify the Finals Engineer of dispute of final quantities within the 60 calendar day period (or 90 calendar days from the date of presentation if a 30 calendar day extension is granted) will be deemed as agreement to the final quantities as presented, and deemed a waiver of the Contractor's right to appeal.

Following the resolution of final quantities, the Finals Engineer will present the Contractor with close-out documents consisting of the final estimate for signature and a form verifying the status of any claims. Failure by the Contractor to sign the final estimate and the form within 20 calendar days will result in closure of the Contract, provided that there are no claims on file with the Agency.

At the discretion of the Finals Engineer, the Contractor may be presented with close-out documents concurrent with the final quantities. In such case, notwithstanding Subsection 105.04 and Subsection 105.20, failure by the Contractor to notify the Finals Engineer of dispute of final quantities within applicable time durations specified in this subsection will be deemed as agreement to the final quantities as presented, and closure of the Contract without the Contractor's signature will result.

In cases when presentation of final quantities to the Contractor indicates that the Agency has overpaid the Contract, the Contractor shall remit payment to the Agency by the end of the 60 calendar day period, unless the Contractor is disputing final quantities. Failure to make payment may result in notification to the Agency's Prequalification Committee by the Construction Engineer, and/or may result in set off pursuant to the *Bulletin 3.5* compliance requirements in the Contract.

(e) Retainage. The Agency will not withhold retainage on the Contract; the Contractor shall not withhold retainage on any subcontract, and subcontractors shall not withhold any retainage on any of their subcontracts.

109.09 FINAL PAY QUANTITY. Certain Contract items may be designated final pay quantity or FPQ items on the Plans. If an item is so designated, the Contract quantity shall be considered the final pay quantity for the item, unless the Plan dimensions of any portion for measurement of the item or the Contract quantity of that item are revised by the Engineer, or the Contract quantity of the item or any portion of the Contract quantity of the item is eliminated.

If the dimensions of any portion for measurement of the item or the Contract quantity of the item are revised, and the revision results in an increase or decrease in the Contract quantity of the item, the final pay quantity for the item will be revised in the amount represented by the changes in the dimensions or by the imposed revision. If the item is eliminated, the Contract quantity for the item will be eliminated. If a portion of the item is eliminated, the Contract quantity will be revised in the amount represented by the eliminated portion of the item.

No adjustment will be made to the Contract quantity for an FPQ pay item, except as allowed under this subsection.

SECTION 199 – ADMINISTRATIVE PAY ITEMS

199.01 DESCRIPTION. This section will provide for either a payment to the Contractor or a deduction from monies otherwise due to the Contractor as a result of claim settlements, value engineering proposals, incentive or disincentive provisions, interim completion date liquidated damages, force account work, or train delay liquidated damages.

199.02 REQUIREMENTS.

(a) Claim Settlements. Claims will be evaluated and processed as specified in Subsection 105.20.

(b) Value Engineering Proposals. Value engineering proposals will be evaluated and processed as specified in Subsection 105.29.

(c) Incentive or Disincentive Provisions. Incentive or disincentive provisions will be applied as specified in Subsection 108.10 and the Notice to Bidders.

(d) Interim Completion Date Liquidated Damages. Liquidated damages for failing to meet an interim completion date will be assessed as specified in Subsection 108.12(b) and the Notice to Bidders.

(e) Force Account Work. Force account work will be compensated for as specified in Subsection 109.06.

(f) Train Delay Liquidated Damages. Train delay liquidated damages will be assessed as specified in the Notice to Bidders.

199.03 METHOD OF MEASUREMENT. The quantity of Claim Decision Payment, Administrative (N.A.B.I.) to be measured for payment will be the amount of money, to the nearest hundredth of a dollar, determined to be due to the Contractor by the Agency according to the requirements of Subsection 105.20.

The quantity of Claim Settlement, Administrative (N.A.B.I.) to be measured for payment will be the amount of the final claim settlement, to the nearest hundredth of a dollar, determined according to the requirements of Subsection 105.20.

The quantity of Claim Decision, Judicial (N.A.B.I.) to be measured for payment will be the amount of the final claim settlement, to the nearest hundredth of a dollar, determined according to the requirements of Subsection 105.20.

The quantity of Claim Decision Attorney Fees (N.A.B.I.) to be measured for payment will be the amount of attorney fees, to the nearest hundredth of a dollar, as determined by the applicable judicial body.

The quantity of Claim Decision Interest Payment (N.A.B.I.) to be measured for payment will be the amount of interest due, to the nearest hundredth of a dollar, as determined by the applicable judicial body.

The quantity of Value Engineering Proposal Development Costs (N.A.B.I.) to be measured for payment will be the portion of the costs associated with developing the accepted Detailed Value Engineering Proposal which the Agency has agreed to pay, to the nearest hundredth of a dollar, as specified in Subsection 105.29(b)(2)g.

The quantity of Value Engineering Proposal Net Savings (N.A.B.I.) to be measured for payment will be 50% of the net savings generated by the Detailed Value Engineering Proposal, to the nearest hundredth of a dollar, as specified in Subsection 105.29(c)(3).

Payment for Value Engineering Proposal Payment Adjustment (N.A.B.I.) to be measured for payment will be 50% of any additional savings or reduced savings resulting from an additional analysis of the Detailed Value Engineering Proposal after completion of the work, to the nearest hundredth of a dollar, as specified in Subsection 105.29(d).

The quantity of Incentive or Disincentive (N.A.B.I.) to be paid or deducted will be the amount calculated, to the nearest hundredth of a dollar, as specified in Subsection 108.10 and the Notice to Bidders.

The quantity of Liquidated Damages, Interim Completion Date (N.A.B.I.) to be measured for deduction will be the value in dollars, to the nearest hundredth of a dollar, calculated as specified in Subsection 108.12(b) and the Notice to Bidders.

The quantity of Force Account Work (N.A.B.I.) to be measured for payment will be all costs associated with the required force account work, to the nearest hundredth of a dollar, as specified in Subsection 109.06.

The quantity of Liquidated Damages, Train Delay (N.A.B.I.) to be measured for deduction will be the value in dollars, to the nearest hundredth of a dollar, calculated based on the number of minutes the train was delayed, as specified in the Notice to Bidders.

199.04 BASIS OF PAYMENT. Payment for Claim Decision Payment, Administrative (N.A.B.I.) will be credited against the Contract price for Claim Decision Payment, Administrative (N.A.B.I.). Payment will be partial compensation for those issues related to the claim that are agreed to by the Construction Engineer, with the disposition of remaining issues of the claim to be settled through other processes.

Payment for Claim Settlement, Administrative (N.A.B.I.) will be credited against the Contract price for Claim Settlement, Administrative (N.A.B.I.). Payment will be full and final compensation for all issues related to the claim.

Payment for Claim Decision, Judicial (N.A.B.I.) will be credited against the Contract price for Claim Decision, Judicial (N.A.B.I.). Payment will be full and final compensation for all issues related to the claim.

Payment for Claim Decision Attorney Fees (N.A.B.I.) will be credited against the Contract price for Claim Decision Attorney Fees (N.A.B.I.). Payment will be full and final compensation for all attorneys' fees.

Payment for Claim Decision Interest Payment (N.A.B.I.) will be credited against the Contract price for Claim Decision Interest Payment (N.A.B.I.). Payment will be full and final compensation for all interest owed to the Contractor.

Payment for Value Engineering Proposal Development (N.A.B.I.) will be credited against the Contract price for Value Engineering Proposal Development (N.A.B.I.). Payment will be full compensation for any value engineering development costs that the Agency has agreed to reimburse.

Payment for Value Engineering Proposal Net Savings (N.A.B.I.) will be credited against the Contract price for Value Engineering Proposal Net Savings (N.A.B.I.). Payment will be full compensation for 50% of the net savings generated by the Detailed Value Engineering Proposal. The cost of performing the actual work contemplated by the value engineering proposal will be paid for separately under the appropriate Contract items.

Payment for Value Engineering Proposal Payment Adjustment (N.A.B.I.) will be debited or credited against the Contract price for Value Engineering Proposal Payment Adjustment (N.A.B.I.). Payment will be full compensation for any additional savings or reduced savings resulting from an additional analysis of the value engineering proposal after completion of the work.

Payment for Incentive or Disincentive (N.A.B.I.) will be debited or credited against the Contract price for Incentive or Disincentive (N.A.B.I.). A value in dollars has been included in the bid proposal for Incentive or Disincentive (N.A.B.I.). This dollar amount is the maximum amount payable under the incentive clause, but the actual payment or deduction will be computed as specified in Subsection 108.10 and the Notice to Bidders. The calculated quantity of incentive will be paid to the Contractor, while the calculated quantity of disincentive will be deducted from monies otherwise due to the Contractor.

Payment for Liquidated Damages, Interim Completion Date (N.A.B.I.) will be debited against the Contract price for Liquidated Damages, Interim Completion Date (N.A.B.I.). The Engineer will deduct the liquidated damage amount from the monies otherwise due to the Contractor.

Payment for Force Account Work (N.A.B.I.) will be credited against the Contract price for Force Account Work (N.A.B.I.). Payment will be full compensation for performing all force account work and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment for Liquidated Damages, Train Delay (N.A.B.I.) will be debited against the Contract price for Liquidated Damages, Train Delay (N.A.B.I.). The Engineer will deduct each train delay liquidated damage amount due to the Operating Railroad from monies otherwise due to the Contractor on the biweekly estimate following the concurrence of final documentation regarding the delay.

Payment will be made under:

Pay Item		Pay Unit
199.5201	Claim Decision Payment, Administrative (N.A.B.I.)	Dollar
199.5202	Claim Settlement, Administrative (N.A.B.I.)	Dollar
199.5203	Claim Decision, Judicial (N.A.B.I.)	Dollar
199.5204	Claim Decision Attorney Fees (N.A.B.I.)	Dollar
199.5205	Claim Decision Interest Payment (N.A.B.I.)	Dollar
199.5291	Value Engineering Proposal Development Costs (N.A.B.I.)	Dollar
199.5292	Value Engineering Proposal Net Savings (N.A.B.I.)	Dollar
199.5293	Value Engineering Proposal Payment Adjustment (N.A.B.I.)	Dollar
199.8101	Incentive or Disincentive (N.A.B.I.)	Dollar
199.8121	Liquidated Damages, Interim Completion Date (N.A.B.I.)	Dollar
199.9061	Force Account Work (N.A.B.I.)	Dollar
199.9999	Liquidated Damages, Train Delay (N.A.B.I.)	Dollar

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DIVISION 200

EARTHWORK

SECTION 201 – CLEARING

201.01 DESCRIPTION. This work shall consist of performing all clearing, grubbing, thinning, and trimming within the limits of the project.

201.02 GENERAL CONSTRUCTION REQUIREMENTS. The Contractor shall protect all trees, shrubs, and vegetation as identified in the Contract or as directed by the Engineer, in accordance with Subsection 656.09. The Contractor shall take care to avoid damaging trees, shrubs, and vegetation that is to remain standing and that is otherwise unprotected or outside of the limits of clearing items. Where any trees that are to be left standing have been damaged through the Contractor's operations, the Contractor shall be responsible for repairing all damage caused to trees in accordance with the *VTrans Technical Landscape Manual* at no additional compensation.

The Contractor shall protect public utilities, buildings, or other property in accordance with Subsection 104.04 and Section 107.

All branches of trees overhanging the roadway surface shall be removed to a minimum height of 20 feet above finished grade. This work will not be paid for directly but will be considered incidental to other clearing items.

Where branches are to be removed from trees that are to remain standing, the branches shall be removed in accordance with the *VTrans Technical Landscape Manual*. Work associated with the removal of branches shall be considered incidental to other clearing items.

Where stumps are not to be removed, they shall be cut flush with existing ground, or as close as practical.

In performing the work under this section, the Contractor shall not use any chemical growth retardants, herbicides, poisons, or defoliants unless otherwise specified on the Plans.

201.03 CLEARING AND GRUBBING.

(a) Clearing. Clearing shall consist of cutting and disposing of all trees, down timber, brush, bushes, and debris from all areas extending from the centerline to 10 feet beyond the limits of all cut or fill sections, or to applicable right-of-way limits, whichever is less. Clearing areas shall also include any other areas shown in the Contract. Any trees designated for removal under another Contract item are excluded from this work.

Where structures are to be constructed, clearing shall include the area within the structure limits and 20 feet beyond the structure limits.

Except for vegetation, trees, and shrubs that are to remain standing, all trees, shrubs, down timber, brush, and other objectionable material shall be removed and disposed of prior to grading operations beginning.

If it is deemed impractical to fell the tree as a whole, it shall be removed in sections according to standard practices of professional tree removal.

(b) Grubbing. Grubbing shall consist of removing and disposing of all stumps, roots, grass, turf, debris, or other objectionable material within the construction limits. Grubbing areas shall also include any other areas shown in the Contract. The grubbing shall progress in such a manner to prevent erosion as required in Subsection 105.23.

Any voids left through grubbing operations shall be backfilled with approved excavated material or borrow and compacted to conform to the surrounding area.

201.04 REMOVING TREES AND STUMPS. Removing trees and stumps shall consist of removing and disposing of single trees and stumps as shown in the Contract or as directed by the Engineer. Removing trees shall include the removal and disposal of the entire tree including the stump, limbs, and brush. A stump is designated as that portion of the tree remaining after the trunk has been severed.

Tree and stump size will be determined by circumferential measurement at a height 4.5 feet above the ground line or at the point of cutoff, whichever applies. Small trees and stumps will be classified as having a circumference of 40 inches or less (approximately 12 inches in diameter). Medium trees and stumps will be classified as having a circumference greater than 40 inches (approximately 12 inches in diameter) and less than 120 inches (approximately 38 inches in diameter). Large trees and stumps will be classified as having a circumference 120 inches (approximately 38 inches in diameter) or greater.

The work shall be in accordance with Subsection 201.02 and Subsection 201.03.

201.05 THINNING AND TRIMMING.

(a) Thinning and Trimming. Thinning and trimming shall consist of selective cutting and trimming beyond the limits of clearing and grubbing to clear brush, remove undesirable growths, dead trees, vegetation, and stumps, thin out trees, trim branches, allow for passage of overhead wires, or improve visibility at locations shown on the Plans or directed by the Engineer.

(b) Thinning and Trimming for Signs. Thinning and trimming for signs shall consist of selective cutting and trimming to provide full visibility for a sign at a single designated sign location.

The Contractor shall remove all woody stemmed growth including brush, saplings, trees, and tree limbs growing within or projecting into the required clear viewing area for the designated sign to the minimum horizontal and vertical dimensions shown on the Plans or as directed by the Engineer.

The dimensions are for the standard area of sign visibility, however, the Contractor shall not cut, trim or clear any vegetation outside the right-of-way limits. The Engineer will designate the right-of-way limits.

201.06 DISPOSAL.

(a) General Requirements. Unless otherwise specified in the Contract or herein, all trees, limbs, stumps, and other vegetation removed through this work shall become the property of the Contractor.

(b) National Forest Lands. On National Forest lands, the Contractor shall comply with the requirements included in the Contract for the specific project and with the requirements of Subsection 107.14.

(c) Dutch Elm Disease. To prevent the spread of Dutch elm disease, whenever elm trees are trimmed or removed, all portions removed shall be chipped and remain on site.

(d) Emerald Ash Borer. The presence of emerald ash borer (EAB), *Agrilus planipennis*, has been confirmed in Vermont. Known EAB infestation areas are changing rapidly. Therefore, to ensure compliance with state and federal EAB laws, the Contractor shall consult the current *EAB Infested Area Map* on the same calendar day cutting is to occur.

If the project is located with an EAB infested area, all tree material, regardless of species, within the project area shall be handled in accordance with the *Recommendations to Slow the Spread of Emerald Ash Borer* as developed by the Vermont Department of Forests, Parks, and Recreation and the Vermont Agency of Agriculture, Food, and Markets. Tree material shall not be moved out of state.

Alternatively, the Contractor may choose to hire a qualified professional (an arborist certified by the International Society of Arboriculture or a licensed forester), at their own expense, to identify the presence of ash trees. Those identified ash trees would be subject to the above referenced requirements, however, other tree species would not.

201.07 METHOD OF MEASUREMENT. The quantity of Clearing and Grubbing, Including Individual Trees and Stumps to be measured for payment will be on a lump sum basis for providing clearing and grubbing in the complete and accepted work. If limits are changed an adjustment for the increased or decreased area will be measured in acres. No adjustment will be made for changes involving less than 0.1 acres. Clearing and grubbing completed for the convenience of the Contractor will not be considered for adjustment.

When specified to be measured by area, the quantity of the Clearing and Grubbing, Including Individual Trees and Stumps to be measured for payment will be the number of acres cleared and grubbed in the complete and accepted work. Clearing and grubbing completed for the convenience of the Contractor will not be included in the measurement for payment.

The quantity of Removing Medium Trees, Removing Large Trees, Removing Medium Stumps, and Removing Large Stumps to be measured for payment will be for the number of each removed, for the various classes, in the complete and accepted work.

The quantity of Thinning and Trimming to be measured for payment will be the number of acres thinned and trimmed in the complete and accepted work, as determined by using horizontal measurements.

The quantity of Thinning and Trimming for Signs to be measured for payment will be the number of each sign's viewing area cleared in the complete and accepted work.

201.08 BASIS OF PAYMENT. The accepted quantity of Clearing and Grubbing, Including Individual Trees and Stumps will be paid for at the Contract lump sum price or Contract unit price per acre. Progress payments will be made based on the percentage of the total area cleared. When the clearing and grubbing limits are changed, an adjustment for the increased or decreased area will be made by change order.

The accepted quantity of Removing Medium Trees, Removing Large Trees, Removing Medium Stumps, and Removing Large Stumps will be paid for at the Contract unit price for each. Small trees and stumps will not be paid for directly but will be considered incidental to other Contract items.

The accepted quantity of Thinning and Trimming will be paid for at the Contract unit price per acre.

The accepted quantity of Thinning and Trimming for Signs will be paid for at the Contract unit price for each location designated in the Contract.

If the Contract does not contain a quantity for a Contract item listed in this section, but such work is required, the work will not be paid for directly but will be considered incidental to all other Contract items.

Payment as indicated will be full compensation for performing the work specified, including disposal, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
201.1000	Clearing and Grubbing, Including Individual Trees and Stumps	Lump Sum
201.1100	Clearing and Grubbing, Including Individual Trees and Stumps	Acre
201.1500	Removing Medium Trees	Each
201.1600	Removing Large Trees	Each
201.2000	Removing Medium Stumps	Each
201.2100	Removing Large Stumps	Each
201.3000	Thinning and Trimming	Acre
201.3100	Thinning and Trimming for Signs	Each

SECTION 202 – DEMOLITION AND DISPOSAL OF BUILDINGS

202.01 DESCRIPTION. This work shall consist of the removal, in whole or in part, and the satisfactory disposal of all buildings, including accessories and appurtenances, erosion prevention and sediment control, and the backfilling of holes and pits when required.

202.02 GENERAL CONSTRUCTION REQUIREMENTS. Basements shall be completely cleared of all unsuitable materials, debris, partition walls, and supports. Concrete or masonry floors or foundations shall be removed to a depth not less than 2 feet below subgrade or 1 foot below final ground level. Floors below these levels shall be broken or holes approximately 1 foot × 1 foot shall be provided at 10 foot intervals to provide vertical drainage.

Septic tanks, cesspools, or appurtenant pipes shall be emptied of their contents and filled with suitable material or removed. Underground fuel storage tanks shall be removed, unless otherwise approved by the Engineer and the Agency's Hazardous Materials and Waste Coordinator. All work related to all underground storage tanks shall be in accordance with all local, state, and federal regulations. The removal of any underground storage tank shall be coordinated through the Agency's Hazardous Materials and Waste Coordinator prior to commencing the removal of any underground storage tank.

Basements or cavities left by building removal shall be either filled with suitable material to the level of the existing ground and thoroughly compacted, or the area shall be regraded to present a smooth, free-draining surface. A combination of filling and regrading methods may be used. Where filling and regrading operations occur within the limits of construction, manipulation, and placement of material shall conform to Subsection 203.11. All regraded areas shall be seeded and mulched in accordance with Section 651 and to the satisfaction of the Engineer.

All debris shall be removed from the parcel, and the area shall be cleaned up and graded to the satisfaction of the Engineer.

All materials resulting from the demolition shall become the property of the Contractor and shall be disposed of or recycled in accordance with all applicable laws, rules, regulations, and protocols.

If applicable, the Contractor shall provide for the discontinuance of all utility services including, but not limited to, electricity, telephone, sewer, water, and gas lines and utility meters. The Contractor shall be responsible for any claim arising from failure to provide for the discontinuance of such utility services. If permission has been given to the previous owner to occupy a building until a specified date, the previous owner shall not be required to pay rent to the Contractor or to move on a date earlier than that specified. The Contractor shall provide for the discontinuance of all utility services after the specified date.

The Agency will not be responsible for any changes in the condition of the buildings, or for loss of fixtures or equipment, at any time.

Once work has commenced, the Contractor shall complete the demolition and disposal of each Contract item in a continuous manner to the satisfaction of the Engineer.

The Contractor shall erect barriers around the site in accordance with all applicable safety guidelines.

The Contractor shall be responsible for finding, opening, and maintaining all disposal areas and shall comply with all applicable regulations.

When identified in the Plans the Contractor shall be responsible for the removal and disposal of lead or asbestos. The removal and disposal of lead or asbestos shall be done in accordance with all applicable local, state, and federal regulations. The Contractor shall submit, to the Engineer and the Agency's Hazardous Materials and Waste Coordinator, all applicable certifications, licenses, permits, and plans for approval prior to the commencement of this work.

202.03 METHOD OF MEASUREMENT. The quantity of Demolition and Disposal of Building to be measured for payment will be on a unit basis for each building, as shown on the Plans

202.04 BASIS OF PAYMENT. The accepted quantity of Demolition and Disposal of Building will be paid for at the Contract unit price for each building specified in the Contract. Payment will be full compensation for removing, disposing or recycling of buildings; for excavating, backfilling, removal of hazardous materials and regrading incidental to their removal; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. When turf establishment, mulch, or erosion prevention and sediment control items are not part of the Contract, they shall be considered incidental to the Demolition and Disposal of Building item.

Payment will be made under:

Pay Item	Pay Unit
202.1000 Demolition and Disposal of Building	Each

SECTION 203 – EXCAVATION AND EMBANKMENTS

203.01 DESCRIPTION. This work shall consist of excavating and grading roadways, runways and railways, slides, borrow pits, waterways, channels, intersections, approaches, and steps in hillside embankments and excavating unsuitable material from the construction area and beneath embankment areas, surfaces, and pavements. This work shall consist of excavating selected material found in the construction area for specific use in the construction, constructing and removing detours shown on the Plans or directed by the Engineer, trimming and shaping of slopes, performing test borings for the purpose of determining areas of roadway and embankment subsurface voids, and disposing of all unsuitable or surplus excavated material. The work shall also consist of placing material in embankments and the grading of all material placed up to subgrade to the tolerance specified in the Plans.

The work is classified as follows:

(a) Common Excavation. Common excavation shall consist of the removal of all material encountered in grading the project which can be accomplished with normal excavating machinery, and which is not classified to be removed as solid rock excavation, muck excavation, channel excavation, excavation of surfaces and pavements, or excavation for structures.

Excavation required beyond the finished slope neat lines for slope stabilization, removal of sod and unsuitable material other than muck located in embankment areas, removal and stockpiling of topsoil, and removal of unsuitable material existing at or below subgrade elevation in excavation areas is also classified as common excavation.

(b) Solid Rock Excavation. Solid rock excavation shall consist of the removal of hard igneous, metamorphic, or sedimentary rock that requires blasting or the use of rippers; detached rock, boulders, mortared stone masonry, or concrete each having a volume of 2 cubic yards or more; and Portland cement concrete pavement, including any bituminous surface overlay material, encountered in the limits of excavation.

(c) Unclassified Excavation. Unclassified excavation shall consist of common excavation and solid rock excavation as classified above and not measured separately.

(d) Muck Excavation. Muck excavation shall consist of the removal, disposal, and backfill of a saturated or unsaturated mixture of soils and organic matter encountered below the original ground line in an embankment area that is not suitable to be used as foundation material regardless of its moisture content.

(e) Channel Excavation of Earth. Channel excavation of earth shall consist of the removal of all material encountered in the excavation which can be accomplished with normal excavating machinery, except as classified as channel excavation of rock; for widening, deepening, and straightening of existing channels and waterways, or in the construction of new channels; and any other excavation designated to be removed as channel excavation as shown on the Plans or as directed by the Engineer.

(f) Channel Excavation of Rock. Channel excavation of rock shall consist of the removal of rock in definite bedrock formation that requires blasting or the use of rippers; and detached rock, boulders, stone masonry, and concrete each having a volume of 2 cubic yards or more encountered in the excavation for widening, deepening, and straightening of existing channels and waterways, or in the construction of new channels.

(g) Unclassified Channel Excavation. Unclassified channel excavation shall consist of channel excavation of earth and channel excavation of rock as classified above and not measured separately.

(h) Excavation of Surfaces and Pavements. Excavation of surfaces and pavements shall consist of the removal and disposal of existing surfaces and pavements that are located outside other excavation and embankment limits.

(i) Borrow. Borrow shall consist of material required for the construction of embankments or for other portions of the work and shall be obtained from approved sources located outside the limits of the right-of-way, unless otherwise shown on the Plans or directed by the Engineer.

Borrow is further classified as earth borrow, sand borrow, or granular borrow.

(j) Test Borings. Test borings shall consist of an investigative and planned approach to determining areas of roadway and embankment subsurface voids and repairing bored areas.

(k) Gravel Filter for Slope Stabilization. Gravel filter for slope stabilization shall consist of an approved graded material placed against slopes and any other places designated for use of this material.

(l) Shoulder Berm Removal. Shoulder berm removal shall consist of removing the berm of debris and sand resulting from guardrail that is to be retained. The removal may be performed by hand labor or mechanical means. The Contractor shall remove the berm down to the proper line and grade for the shoulder from which the berm is being removed.

The removed sand and fine debris may be scattered into the turf on the roadway slope outside the point of shoulder unless otherwise directed by the Engineer. Larger debris such as stones in excess of 2 inches in diameter, automobile parts, wood, glass, and other bulky items shall be disposed of properly by the Contractor.

203.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Concrete for backfilling subsurface voids shall meet the requirements of Section 541 for Flowable Fill, Excavatable.

Bituminous concrete pavement shall conform to the requirements of Section 716, as applicable for the Contract.

203.03 GENERAL CONSTRUCTION REQUIREMENTS. Prior to beginning excavation, grading, and embankment operations in any area, all necessary clearing and grubbing in that area shall have been completed in accordance with Section 201.

All slopes in cut and embankment sections, ditches, and waterways, whether old or newly constructed, shall be satisfactorily cleaned and cleared of obstructions and left in a neat and trim condition. Excavation shall be performed in accordance with the Contract or as directed by the Engineer.

The construction area shall always be maintained to ensure proper drainage. Where traffic is maintained, care shall be exercised to keep the portion of the roadway or the traveled way open to traffic in a satisfactory condition as specified in Subsection 104.04.

All suitable material removed by excavating shall be used in the formation of embankments as shown on the Plans or as directed by the Engineer. Any excavation that cannot be incorporated in embankments shall be disposed of as directed by the Engineer. No material shall be wasted without permission from the Engineer.

The Contractor shall be responsible for the stability of all constructed embankments and shall replace, at no cost to the Agency, any portions that have become displaced and that are not attributable to the unavoidable movement of the natural ground upon which the embankment is made, or to an act of God.

Unless directed by the Engineer, borrow material shall not be placed until all suitable material has been excavated and placed in the embankments, except when sand borrow or granular borrow is shown on the Plans or when granular borrow is required by the Engineer for use under embankments or used with material from excavation in making embankments. Should a surplus of excavated material result from the Contractor placing more borrow than required, the amount of this surplus will be measured by the Engineer and 115% of the total surplus will be deducted from the total quantity removed from the borrow source.

When not otherwise shown in the Contract, at all bridge approaches in excavation areas, excavation for additional subbase shall be made to a depth of 4 feet below finish grade for a distance not less than 50 feet from the end of the bridge. The transition depth from normal subgrade level to any extra depth level shall be at a rate of 1:25 (V:H).

Prior to the construction of test borings and the placement of flowable fill, the Contractor shall submit to the Engineer site-specific plans, detailing the schedule of work (for these two items), type and location of drilling, sleeve installation, pumping system, confirmatory boring operation, method of filling bore hole (with or without voids being encountered), and repair of the roadway section (sand, gravel, and pavement).

Construction drawings shall be submitted in accordance with Subsection 105.06 whenever OSHA or VOSHA regulations require a design by a professional engineer.

203.04 EXCAVATION. Any loose material resulting from breakage and slides shall be removed and disposed of as directed by the Engineer.

Excavated material shall be sorted so that the best material is placed in embankments beneath the traveled way.

The Contractor shall not excavate or remove any material outside the limits of the excavation slope and grade lines shown on the Plans unless authorized in writing by the Engineer. Grading shall be to full cross-section width at subgrade before placing of any type of subbase or pavement, except that partial-width construction is permissible where necessary for the maintenance of traffic, and shall be done within the allowable tolerances as indicated on the Plans.

The Contractor shall strip bedrock and then notify the Engineer that the area is ready for cross-sectioning prior to making any rock excavation. Any bedrock removed prior to the taking of cross-sections will be paid for as common excavation. The Contractor may use other means of locating the rock line with the approval of the Engineer.

When excavating solid rock by the blasting method, the Contractor shall drill slope holes to the full depth of the rock lift along the line and plane of inclination of the slope, as shown on the Plans or as otherwise directed by the Engineer. Spacing for the slope holes shall not exceed 3 feet, center to center of holes. The diameter of the slope holes shall be not greater than 3 inches. The line of blast holes shall be drilled parallel to the plane of the slope holes. No portion of any blast hole in this line shall be closer than 4 feet to the proposed finished slope. No portion of any blast hole larger than 3 inches in diameter will be permitted closer than 12 feet to the proposed finished slope.

When it is shown on the Plans that concrete shall be placed on or against the limits of rock excavation, care shall be taken to avoid disturbing, shattering, or removing rock outside such limits. Any costs incurred due to the unauthorized removal, shattering, or disturbing of the material outside the indicated limits shall be at the Contractor's expense.

The explosives used in the slope holes along the line of the finished slope and the adjacent slope holes shall be explosives for pre-splitting use only, prepared and packaged by explosives manufacturing firms and approved by the Engineer.

The slope holes along the line of the finished slope shall be loaded with approved explosives containing not more than 0.5 pounds of explosives per foot of hole depth. The spaced charges on a detonating cord shall be equal in length to the full depth of the hole. If spacers are used, the holes shall be completely stemmed so that uniform breakage of the rock will result from top to bottom of the hole. A bottom charge of not more than 8 pounds of explosive may be used. No explosive charge shall be placed within 30 ± 6 inches of the collar of the finished slope holes.

The Contractor shall complete the drilling, loading, stemming, and blasting of the slope holes at least 25 feet in advance of any other blasting.

In areas other than along the proposed finished rock cut slopes and adjacent slope holes, the spacing of holes, distribution of explosives, the methods of relief, and fractional second delay blasting shall be adjusted by the Contractor. The Contractor shall make adjustments according to the characteristics and structure of the rock encountered in order to obtain the required finished slopes with a minimum of overbreak.

The depth of the rock lift within any one excavation area will be approved by the Engineer and shall be reduced by the Contractor if the proper alignment of the slope holes cannot be maintained.

203.05 MUCK EXCAVATION. The material shall be excavated to the widths and depths shown on the Plans or as required to give a stable foundation for the placement of necessary backfill, embankment, or subbase material. The excavation of this material shall be handled in a manner that will prevent the entrapment of muck within the backfill.

Unless otherwise specifically shown in the Contract, the material that has been excavated under this Contract item shall be spread on the fill slopes as shown on the Plans or as directed by the Engineer. If provision is not shown in the Contract for the disposition of the muck excavation, or if, in the opinion of the Engineer, its use on the slopes is impractical, then the excavated material shall be disposed of by the Contractor, in accordance with Subsection 203.09.

The backfilling of the excavated area shall immediately follow the excavation of the muck so that any soft material that is pushed ahead of the backfill can be removed.

The material used for backfilling the excavated area up to the ground line or water level, whichever is higher, shall be rock or other granular material selected from the excavation, if available. When this material is not available, it shall be obtained as Granular Borrow from an approved source.

After removal of the muck and prior to backfilling, the Contractor shall allow the Engineer adequate time to take all necessary measurements for determining the volume removed.

203.06 CHANNEL EXCAVATION. The area where the channel is to be excavated shall be cleared and grubbed as required. The work involved shall be considered as incidental work to channel excavation when item 201.1000 or 201.1100 are not included in the Contract.

The channel shall be excavated to the lines, grades, and cross-sections shown on the Plans or as ordered by the Engineer. All suitable material excavated shall be used in the formation of roadway embankments or for other construction purposes as shown on the Plans or as directed by the Engineer. Unsuitable material or waste material, when directed by the Engineer, shall be wasted and disposed of by the Contractor at no additional compensation in accordance with Subsection 203.09.

203.07 EXCAVATION OF SURFACES AND PAVEMENTS. All excavation shall be made strictly to the required alignment, grade, and cross-sections shown on the Plans, or as directed by the Engineer for areas located outside of the limits of roadway excavation and embankment.

All suitable materials removed shall be used, as far as practical, in the formation of embankments and at other locations as directed by the Engineer.

The completed excavation shall be properly graded and shaped prior to receiving any cover or top dressing.

203.08 BORROW. Opening, maintaining, and closing borrow pits shall be in accordance with Section 105. The simultaneous extraction of more than one borrow item from a given pit will require the written permission of the Engineer.

203.09 DISPOSAL OF SURPLUS EXCAVATION AND WASTE MATERIAL. All surplus excavation and waste material shall be deposited as shown on the Plans or as authorized in writing by the Engineer. Excavated material shall not be wasted unless authorized by the Engineer. Compaction requirements for surplus or waste material used to flatten slopes outside the embankment limits shown on the Plans may be waived, however, placement procedures shall ensure a stable fill slope.

Disposal of all surplus or waste material shall be in accordance with Section 105.

Disposal of surplus or waste material will not be paid for directly but shall be considered as incidental work pertaining to the grading or excavation Contract item from which the material was obtained.

When sufficient on-site disposal areas are not shown on the Plans, it shall be the responsibility of the Contractor to locate disposal areas in accordance with Section 105 and any applicable permits.

203.10 HAUL ROADS. Particular care shall be taken in the locating of haul roads. In wooded areas, haul road width shall be minimized and placed at approximate right angles or angled away from the view of oncoming traffic and, where feasible, shall incorporate one bend to eliminate the tunnel effect. Large and well-shaped trees shall be preserved.

203.11 EMBANKMENTS.

(a) Preparation of Embankment Area. When embankments are to be made on a hillside, the slope of the original ground on which the embankments are to be constructed shall be stepped and properly drained as the fill is constructed in accordance with the Plans or as directed by the Engineer.

(b) Use of Materials. The excavated rock, boulders, and stone, except where required in the construction of other items or otherwise directed, shall be used in the construction of embankments to the extent of the project requirements and, generally, shall be placed to form the base of an embankment. When shown on the Plans, certain portions of rock excavation may be reserved for special use such as rock fill, for embankment construction at locations below high water, or at locations susceptible to erosion.

Frozen material shall not be used in the construction of embankments. The embankments or successive layers of the embankments shall not be placed upon frozen material. Placement of material other than rock shall stop when the sustained ambient air temperature, below 32°F, prohibits attainment of the required compaction. If the material is otherwise acceptable, it shall be stockpiled and reserved for future use when its condition is acceptable to the Engineer for use in embankments.

(c) Procedure for Placing and Spreading. When an embankment is to be constructed across open water or across swampy, wet ground, the first layer of the fill shall be granular borrow.

The first layer of the embankment may be constructed in one thickness of granular borrow, to the minimum elevation at which equipment may be operated, as directed by the Engineer. Above this elevation, the embankment shall be constructed as specified below. Material from excavation on the project shall be used to the extent available and when not available shall be obtained from sources of granular borrow when authorized in writing by the Engineer.

When trucks are used to place earth from excavation or borrow, the material shall be deposited on the layer of embankment being constructed, bladed or dozed into place, and shaped and compacted. Dumping directly onto previously constructed layers will not be permitted.

Embankments of either earth or rock material shall be placed in horizontal layers of uniform thickness and across the full section width. When it is impractical to construct a full width layer across an embankment, partial width layers may be authorized, provided the full width procedure is resumed as soon as practical.

Logs, stumps, waste material, and oversized cobbles or boulders shall not be placed within the structural embankment area. They may be placed outside the structural embankment area at locations directed by the Engineer or, when authorized, disposed of as surplus material. Initial layers shall begin at the deepest part of the fill. Except for the first layer of fill over swampy ground and cleared areas, the loose layer thickness shall be limited to 8 inches.

When conditions necessitate, the Engineer may authorize layers in excess of 8 inches but not more than 24 inches. The Contractor shall make all necessary excavations up to 24 inches deep so that the Engineer can determine moisture, density, and stability, solely at the Contractor’s expense.

Effective spreading equipment shall be used on each layer to obtain uniform thickness. Cobbles or boulders having their least dimension greater than the loose layer thickness being placed shall be removed prior to compaction. Each layer shall be compacted as specified, and, if necessary, stabilized prior to a successive layer being placed. Each layer shall be kept crowned to shed water. As the compaction of each layer progresses, continuous leveling and manipulating will be required to ensure uniform density, a uniform and satisfactory moisture content, and acceptable stability. The last lift constructed each working day shall be graded, crowned, and rolled to ensure adequate drainage.

When A-4, A-5, A-6, or A-7 cohesive soils, as identified in Table 703.01A, have excess moisture and cannot effectively be air dried or dried by manipulation, the Contractor may layer or mix the material with dry A-1, A-2, or A-3 granular soils to obtain acceptable compaction and stability. The Contractor is responsible for making prudent use of available granular excavation from the project prior to being authorized the use of granular borrow. The combined loose thickness of mixed or layered materials prior to compaction shall not exceed 16 inches.

During the construction of the embankments, if bulging, cracking, or unstable movement occurs, the placing of the fill material shall be stopped, retarded, or corrected to allow the material to stabilize as directed by the Engineer. Rutting, rolling, shoving, or other displacement in excess of 6 inches under the action of construction equipment may be considered evidence of stability problems.

When soft or wet clay or silt excavation is being used between layers of reasonably clean stable rock fill, the rock embankment layers shall not exceed 24 inches in loose measurement. The clay or silt layers shall not exceed 8 inches in loose measurement.

If embankments are to be constructed by using rock excavation, all reasonable precaution must be taken to ensure a solid embankment. The fill shall be made in uniform layers consistent with the size of the rock being used, but not to exceed 24 inches in thickness. Individual pieces of rock or boulders with their least dimension exceeding the thickness of the layer being placed shall either be reduced to an acceptable size or placed outside the structural embankment area in such a manner that all voids are filled.

Rock shall not be dumped over the end of a fill. Rock shall be deposited on the fill and distributed by blading or dozing to ensure proper placement in the embankment so that voids, pockets, and bridging are reduced to a minimum.

(d) Compaction. Each layer between the design embankment limits shown on the Plans shall be uniformly compacted using compaction equipment to not less than 95% of the material's maximum dry density as determined by *AASHTO T 99, Method C*. Field density determination will be made in accordance with *AASHTO T 191*, *AASHTO T 310,* or other approved procedures. Field moisture determination will be made in accordance with *AASHTO T 99* or measured in accordance with *AASHTO T 310*. Locations within the embankment limits where waste materials have been placed shall be compacted to the extent that stability is ensured.

All fill material shall be compacted at a moisture content determined by the Engineer to be suitable for obtaining the required density. The moisture content in each layer under construction shall not exceed 2% above the optimum moisture content, and it shall be less than that quantity that will cause the embankment to become unstable during compaction. The Engineer will consider sponginess, shoving, or other displacement under heavy equipment sufficient evidence of a lack of stability under this requirement, and the Contractor shall stop or retard further placement of material in the area affected to allow the material to stabilize.

When the moisture content of the material in the layer under construction is less than the amount necessary to obtain the required compaction by mechanical compaction methods, water shall be added by pressure distributors or other approved equipment. Water may also be added in excavation or borrow pits. The water shall be uniformly and thoroughly incorporated into the soil by discing, harrowing, blading, or other approved methods. This manipulation may be omitted for sand and gravel.

When the moisture content of the material is in excess of 2% above the optimum moisture content, dry material shall be thoroughly incorporated into the wet material, or the wet material shall be aerated by disking, harrowing, blading, rotary mixing, or other approved method, or compaction of the layer of wet material shall be deferred until the layer has dried to the required moisture content by evaporation.

The density requirements do not apply to those portions of embankments constructed of material so coarse that it cannot be properly tested with a conventional density testing apparatus. Instead, the material shall be compacted to the satisfaction of the Engineer.

In areas inaccessible to power rolling, the embankment material shall be placed in uniform horizontal layers of not more than 6 inches in depth and compacted by means of approved mechanical tampers to the density requirements specified above. The use of hand tamps will not be permitted.

(e) Test Borings. Test borings shall be performed at the approximate locations indicated in the Plans or as directed by the Engineer.

When used adjacent to culverts, test borings shall extend to a depth equal to the bottom of the culvert using casing advance drilling methods. Alternate drilling equipment that provides a suitably clean, open hole may be submitted to the Engineer for approval.

If voids are encountered, flowable fill shall be placed to completely fill the voids. Confirmatory borings shall be performed in these locations as directed by the Engineer.

The roadway surface at boring hole locations shall be backfilled and then patched using bituminous concrete pavement.

203.12 SUBGRADE. The subgrade shall be constructed to the lines, grades, and cross-sections shown on the Plans. After all drainage structures have been installed and the subgrade has been shaped correctly, the subgrade shall be brought to a firm, unyielding surface compacted to attain at least 95% of the maximum dry density. This density will be determined by *AASHTO T 99, Method C*.

A power grader or other approved equipment shall be used during the placement and compaction to obtain the specified cross-section.

Areas of soft, yielding, or otherwise unsuitable material that will not compact readily shall be removed, replaced with a suitable material, and properly compacted as directed by the Engineer.

All loose rock or boulders encountered at subgrade in the earth excavation shall be removed or broken off to a depth not less than 12 inches below the subgrade.

In excavation areas, the ground shall not be excavated or disturbed below the subgrade except as shown in the Contract or as directed by the Engineer. All ditches and drains shall be constructed so they will effectively drain the construction area before the placement of any subbase or surface course material. In handling materials, tools, and equipment, the Contractor shall protect the subgrade from damage. Vehicles shall not travel in a single track and form ruts. If ruts are formed, the subgrade shall be reshaped and compacted. Any pockets of clay, sand, or soft material that may have been left in the subgrade shall be removed and replaced with approved material and properly compacted at the Contractor’s expense.

The subgrade shall be kept in a condition that it will drain. Frozen material shall not be used in the construction of subbase. Subbase, base, or surface material shall not be deposited on frozen subgrade, and successive layers shall not be placed on material that has frozen. Subbase, base, or surface material shall not be deposited on the subgrade until the subgrade has been checked and approved by the Engineer. After the subgrade has been approved, the Contractor shall not perform hauling or move equipment that will distort the cross-section over the subgrade.

A tolerance of 1/2 inch above or below the finished subgrade will be allowed provided that this tolerance is not maintained for a distance longer than 50 feet and that the required cross-section is maintained. Grading shall be done with a power grader or other approved equipment to conform to the requirements as specified above.

203.13 METHOD OF MEASUREMENT.

(a) Excavation. The quantity of all excavation items to be measured for payment will be the number of cubic yards of the material removed from the areas shown on the Plans or as directed by the Engineer. The quantity will be measured in its original position by cross-sections and computed by the method of average end areas. When impractical, other acceptable methods involving three-dimensional measurement may be used to determine the quantity. The limits shall not exceed those shown on the Plans or authorized in writing by the Engineer.

The method of mass centers for computing volumes will be allowed only when the method has been used in the original design computations. Excavation requiring more than one handling prior to final placement in embankments will not be measured for payment for the additional handling unless specifically stated in the Contract.

(1) Common Excavation. Excavation for stepping of original ground under hillside embankments will not be measured for payment.

Excavation for removal of soft spots in the subgrade of embankment areas and the material required for replacement will not be measured for payment. Any costs will be considered included in the Contract items involved.

However, where the embankments were constructed as part of another contract, the quantities of excavation for removal of soft spots and the material for replacement will be measured for payment.

(2) Solid Rock Excavation. The measurement limits for Solid Rock Excavation will coincide with the depth shown on the Plans or as directed by the Engineer. Excavation below subgrade will not be measured. Measurement limits for determining the amount of Solid Rock Excavation will be that amount actually removed up to a limit 12 inches outside of and parallel to the slope lines shown on the Plans or as directed by the Engineer. Measurement for payment will not be made for rock removed beyond these limits unless authorized. If natural fissures or faults exist making removal of rock beyond these limits necessary, the Engineer will authorize removal in writing, and the limits of excavation will be adjusted accordingly.

(3) Unclassified Excavation. The quantity of Unclassified Excavation to be measured for payment will be the number of cubic yards of material excavated as shown on the Plans or as directed by the Engineer. There shall be no differentiation made between common or solid rock excavation for this item.

(4) Muck Excavation. The quantity of Muck Excavation to be measured for payment will be the number of cubic yards of material excavated as shown on the Plans or as directed by the Engineer.

(5) Channel Excavation of Earth. The quantity of Channel Excavation of Earth to be measured for payment will be the number of cubic yards of material excavated from its original position. No differentiation will be made between the channel excavation of dry or wet material.

Where excavation (Common, Solid Rock, or Unclassified) and Channel Excavation occur jointly or separately at the same location, measurement for Channel Excavation will be made only below the lower limits of Common, Solid Rock, or Unclassified Excavation.

(6) Channel Excavation of Rock. Measurement limits for determining the amount of Channel Excavation of Rock will be as specified in Subsection 203.13(a)(2).

Where excavation (Common, Solid Rock, or Unclassified) and Channel Excavation occur jointly or separately at the same location, measurement for Channel Excavation will be made only below the lower limits of Common, Solid Rock, or Unclassified Excavation.

(7) Excavation of Surfaces and Pavements. The quantity of Excavation of Surfaces and Pavements to be measured for payment will be the number of cubic yards of material removed and disposed of, measured in its original position. The measurement limits of excavation will not exceed those shown on the Plans or directed by the Engineer.

(b) Borrow. The quantity of borrow to be measured for payment of the type indicated, except Sand Borrow, will be the number of cubic yards of the material removed and used in the complete and accepted work from approved borrow sources measured in its original position. The quantity of Granular Borrow used to replace solid rock excavated below subgrade will be allowed and measured for payment to a depth not to exceed 3 inches. Any solid rock excavated below this depth shall be replaced by the Contractor with material from solid rock excavation or granular borrow, furnished and placed at the Contractor's expense.

For small quantities of borrow, with the written permission of the Engineer, the quantity to be measured for payment of the type of borrow indicated will be the number of cubic yards of material used in the complete and accepted work, as determined by the vehicle loads using three-dimensional measurements. A load ticket including truck identification and date of delivery shall be furnished to the Engineer upon delivery for each load delivered to the site. All vehicles shall be loaded to at least their water level capacity, and any load designated shall be leveled at the point of delivery when directed by the Engineer. All quantities computed from vehicle load measurement will be divided by a factor of 1.15 and the resulting volume paid at the Contract unit price for those Contract items.

Stripping of pits to obtain borrow will not be paid for separately but will be considered incidental to the various borrow Contract items.

Any material removed or excavated from a borrow pit before cross-sections and measurements have been taken will not be paid for. No borrow quantity will be allowed that is not taken from measured borrow pits, unless otherwise agreed upon in writing by the Engineer and the Contractor.

Should more borrow be placed than required, resulting in a waste of excavated material, or should embankments be constructed beyond the neat lines shown on the Plans, unless otherwise authorized in writing by the Engineer, 115% of the amount of such waste or excess will be deducted from the total amount of specified borrow being used.

When requested by the Contractor and authorized in writing by the Engineer, material specified to be measured by the cubic yard may be weighed and the weight converted to cubic yards for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before the method of measurement of pay quantities is used.

The simultaneous extraction of more than one borrow item from a given pit will require the written permission of the Engineer, and the method of measurement shall be as specified by the Engineer.

(1) Earth Borrow. With the written permission of the Engineer, the method of measurement for Earth Borrow may be changed to the number of cubic yards in place in the complete and accepted work multiplied by a factor of 1.15.

When material from excavation is removed and either used for payment under another Contract item or diverted for the Contractor’s use, such as the construction of haul roads, the quantity measured for these uses will be multiplied by a factor of 1.15. The resulting quantity will be deducted from the total quantity of Earth Borrow.

(2) Sand Borrow. The quantity of Sand Borrow to be measured for payment will be the number of cubic yards placed in the complete and accepted work, as determined by the Plan dimensions of the compacted material. No allowance will be made for material placed to a greater depth or width than shown on the Plans unless authorized in writing by the Engineer.

(3) Granular Borrow. With the written permission of the Engineer, the method of measurement for Granular Borrow may be changed to the number of cubic yards in place in the complete and accepted work multiplied by a factor of 1.15.

(c) Gravel Filter for Slope Stabilization. The quantity of Gravel Filter for Slope Stabilization to be measured for payment will be the number of cubic yards placed in the complete and accepted work. Measurements will be confined to the limits shown on the Plans or as directed by the Engineer.

(d) Shoulder Berm Removal. The quantity of Shoulder Berm Removal to be measured for payment shall be the number of linear feet of shoulder from which the berm was properly removed, measured from the beginning point of removal to the end point of removal.

(e) Test Borings. The quantity of Test Borings to be measured for payment will be the number of linear feet of test boring performed in the complete and accepted work.

203.14 BASIS OF PAYMENT. The accepted quantities as measured will be paid for at the Contract unit price per cubic yard for the specified items, except for Shoulder Berm Removal and Test Borings, which will be paid for at the Contract unit price per linear foot. Payment will be full compensation for performing the work specified, submitting site-specific plans as required, performing test borings, installing sleeves, backfilling, patching with bituminous concrete pavement, including any drilling and blasting required, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

No added compensation will be made for any special manipulation or delay resulting in the drying or wetting of soils necessary to obtain the required compaction. The entire cost of such manipulation and delay will be considered included in the Contract unit price for the excavation item involved.

Compensation for the construction of embankments, as defined in Subsection 203.11, shall be considered incidental to the various excavation items. Water added to embankment material to aid in compaction will not be paid for directly but will be considered incidental to the Contract items involved.

All work and material required to grade, loam, seed, and mulch waste areas, borrow pits, and haul roads, as specified, to eliminate unsightly conditions and prevent erosion will not be paid for directly but will be considered incidental to the various types of excavation and borrow.

Material used for backfilling voids created by the removal of unsuitable material below subgrade and on slopes will be paid for at the Contract unit price per cubic yard for the particular Contract item used in making the backfill. If the particular item required for backfill is not included in the Contract, a change order for this item will be negotiated, with the exception of backfilling for Muck Excavation, which shall be incidental to the item.

The work specified in Subsection 203.12 will not be paid for directly but will be considered as incidental work pertaining to the excavation and borrow items.

On borrow projects, solid rock removed beyond the authorized limit, as specified for solid rock measurement, may be paid at the Contract unit price for other excavation or borrow items in the Contract, whichever unit price is the least, provided the material is used in constructing approved embankments.

When the subgrade has been prepared by others under another contract, the excavation necessary to bring the subgrade to the required grade and cross-section or for the removal of soft spots in the subgrade will be paid for as Common Excavation.

All grading and shaping required after removing material paid for as Excavation of Surfaces and Pavements will not be paid for directly but will be considered incidental to this item.

Filling of subsurface voids encountered in performing test borings will be paid for under item 541.4600.

Payment will be made under:

Pay Item		Pay Unit
203.1500	Common Excavation	Cubic Yard
203.1600	Solid Rock Excavation	Cubic Yard
203.1700	Unclassified Excavation	Cubic Yard
203.2000	Muck Excavation	Cubic Yard
203.2500	Channel Excavation of Earth	Cubic Yard
203.2600	Channel Excavation of Rock	Cubic Yard
203.2700	Unclassified Channel Excavation	Cubic Yard
203.2800	Excavation of Surfaces and Pavements	Cubic Yard
203.3000	Earth Borrow	Cubic Yard
203.3100	Sand Borrow	Cubic Yard
203.3200	Granular Borrow	Cubic Yard
203.3500	Gravel Filter for Slope Stabilization	Cubic Yard
203.4000	Shoulder Berm Removal	Linear Foot
203.4500	Test Borings	Linear Foot

SECTION 204 – EXCAVATION FOR STRUCTURES

204.01 DESCRIPTION. This work shall consist of the excavation and backfill or disposal of material removed.

All excavation for structures below the designated slope or subgrade line as shown on the Plans shall be included in this work.

The work is classified as follows:

(a) Trench Excavation. Trench excavation shall consist of excavation for the construction of all conduits, culvert headwalls, drop inlets, manholes, catch basins, leaching basins, underdrains, concrete steps, and other minor structures; excavation for the removal of all existing drainage structures; exploratory excavation for locating underground utility services or other structures; excavation for new culverts and pipes with a clear span of 4 feet or less; drainage ditches at the inlet and outlet of drainage structures with a clear span of 4 feet or less; and any other excavation designated in the Contract to be removed under this item.

(1) Trench Excavation of Earth. Trench excavation of earth shall consist of all material excavated within the limits shown in the Contract, except boulders measuring 18 cubic feet or more, solid rock, mortared stone masonry, or concrete. Trench excavation of earth shall include the removal of all existing pipes with a clear span of 4 feet or less, regardless of material.

(2) Trench Excavation of Earth, Exploratory. Exploratory trench excavation of earth to locate underground utility services or other structures shall be conducted where directed by the Engineer. The Contractor shall use protective measures during this excavation to avoid damage to any underground service or structure. When necessary, the Contractor shall cooperate with representatives of the utility companies to avoid damage to the utilities by permitting the utility companies to erect suitable supports, props, shoring, or other means of protection.

(3) Trench Excavation of Rock. Trench excavation of rock shall consist of all solid rock in formation, or boulders measuring 18 cubic feet or more, excavated within the limits shown in the Contract. All mortared stone masonry and concrete excavated within the above limits, irrespective of the size of its components, shall likewise be considered as rock.

(b) Structure Excavation. Structure excavation shall consist of excavation for the construction of foundations and substructures of all structures with a clear span of over 4 feet, pipe culverts and storm sewers of over 4 foot clear span, grade separation structures, retaining walls, cribs, and any other excavation designated to be removed under this Contract item. If temporary bracing, sheeting, or other means of supporting the excavation is required, construction drawings shall be submitted in accordance with Subsection 105.06.

(c) Granular Backfill for Structures. Granular backfill for structures shall consist of approved material placed within the limits shown on the Plans or directed by the Engineer.

204.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Coarse Aggregate for Concrete.....704.02
Crushed Gravel for Subbase, Fine Graded .....704.05(b)
Granular Backfill for Structures.....704.08

Concrete shall have a minimum 28-day compressive strength of 3,000 psi and shall conform to the requirements of Section 541.

When approved in writing by the Engineer, material meeting the gradation requirements for coarse aggregate for concrete may be substituted for granular backfill for structures under footings.

When approved in writing by the Engineer, material meeting the gradation requirements of fine graded crushed gravel for subbase may be substituted for granular backfill for structures.

204.03 GENERAL CONSTRUCTION REQUIREMENTS. The locations and elevations for excavation shown on the Plans shall be considered as approximate only. The Engineer may order removal of poor foundation material below the designed elevation and replacement with an approved material.

All suitable excess excavated material shall be used in the formation of embankments, at other locations shown on the Plans, or as directed by the Engineer. The Contractor shall haul and dispose of the material at no additional compensation.

Construction drawings shall be submitted in accordance with Subsection 105.06 whenever OSHA or VOSHA regulations require a design by a professional engineer.

204.04 PREPARATION OF FOUNDATION. The foundation pits shall be excavated so that the footings are the full lengths and widths shown on the Plans. The footings shall be constructed with full horizontal beds. Unless otherwise specified or authorized in writing, foundations shall be constructed in the dry. The site shall be dewatered to or below the footing elevation or lowest elevation of a structural component.

The excavation shall continue to either bedrock or the elevation specified for footings on soil. All loose material shall be removed, and all seams in the rock shall be cleaned out and filled with concrete or as directed by the Engineer. No excavation shall be done below the elevations shown on the Plans unless authorized in writing by the Engineer. Any material excavated without authority shall be replaced with concrete or as directed by the Engineer at the Contractor's expense.

When the footing is to be constructed on an excavated surface other than rock, particular care shall be taken not to disturb the bottom of the excavation. No excavation shall be done below the elevations shown on the Plans, unless authorized in writing by the Engineer. Any material excavated without authority shall be replaced with approved backfill and thoroughly compacted in accordance with Subsection 204.05(a) at the Contractor's expense.

When poor foundation material is encountered at the designed foundation level, it shall be removed as structure excavation or trench excavation and replaced with granular backfill for structures or other suitable material as shown on the Plans or as directed by the Engineer, and thoroughly compacted in accordance with Subsection 204.05(a).

204.05 BACKFILL.

(a) General Requirements. All spaces excavated and not occupied by structures or select backfill shall be backfilled with material from excavation, unless otherwise specified. The Contractor shall backfill up to the elevation of existing ground or 2 feet over the pipe, whichever is less, as shown on the Plans or as directed by the Engineer.

All backfill material shall be placed in 6 inch maximum (loose measure) horizontal layers, and each layer shall be thoroughly compacted by means of air or mechanical tampers. Backfill material placed within the limits of trench excavation or structure excavation shall have a maximum stone size less than 3 inches.

Compaction by means of hand tamping will not be permitted.

(b) Backfill of Trenches. Backfill for trenches shall be carried to the upper-most level of the trench or subgrade. No stones or blasted bedrock exceeding 3 inches in diameter shall come in contact with pipes during backfill operations.

(c) Backfill of Structures. No backfill material shall be placed against a newly completed structure until the concrete has cured for 7 days or until it has obtained 85% of the designed compressive strength, and then only with the permission of the Engineer.

Where backfill is to be placed on both sides of a structure, the layers on both sides shall be brought up simultaneously and at approximately the same level to avoid unbalanced pressure. Care shall be taken to prevent wedging action against the structure.

Evidence of satisfactory compaction of the backfill adjacent to structures will consist of the attainment of the density required for the adjacent embankment material by testing at least every third layer in accordance with Subsection 203.11(d).

204.06 METHOD OF MEASUREMENT.

(a) Trench Excavation. The quantity of Trench Excavation of Earth; Trench Excavation of Earth, Exploratory; and Trench Excavation of Rock to be measured for payment will be the actual number of cubic yards excavated up to the maximum dimensions as follows:

(1) The horizontal dimensions for excavation for culverts and pipes (excluding underdrain and underdrain carrier pipe) shall be the distance between vertical planes 18 inches outside of the interior lines of the culvert or pipe.

(2) The horizontal dimensions for drop inlets, manholes, end sections, and other minor structures shall be 18 inches outside the exterior lines of the structure.

(3) The width dimensions for underdrain shall be shown on the Plans.

(4) The depth dimension for culverts, pipes, underdrain, drop inlets, manholes, and other minor structures shall be the vertical dimension from the original ground surface or bottom limits of other excavation to the bottom of authorized excavation. Unless otherwise specified in the Plans, or directed by the Engineer, limits of excavation shall extend 1 foot below the pipe or structure.

(5) When culverts, pipes, underdrains, drop inlets, manholes, and other minor structures are in embankment areas, the natural ground line as cross-sectioned shall be the uppermost level of computation, unless otherwise specified. Vertical measurements will be used for the depth in making computations of trench excavation as follows:

a. 100% of the volume for the first 5 feet of vertical depth.

b. 150% of the volume below the first 5 feet of vertical depth.

(6) When Trench Excavation of Rock and Drilling and Blasting of Solid Rock Subgrade occur at the same location, the quantity of Trench Excavation of Rock will be measured for payment below the subgrade.

(7) The quantity of any material that the Engineer directs to be removed after the embankments have been placed will be included in the total amount for Trench Excavation.

(8) In measuring masonry or concrete as Trench Excavation of Rock, for all openings having cross-sectional areas of 4 square feet or less, the volume will be included as part of the rock. For all openings having cross-sectional areas greater than 4 square feet, the volume will be deducted and not allowed as either Trench Excavation of Rock or Trench Excavation of Earth.

(9) The quantity of Trench Excavation of Earth, Exploratory to be measured for payment will be the number of cubic yards of excavation, regardless of depth, for locating underground utility services or other structures where directed by the Engineer.

(b) Structure Excavation. The quantity of Structure Excavation to be measured for payment will be the number of cubic yards measured and computed by average end area method as follows:

(1) Vertically. Between the original ground surface or the bottom limits of any other excavation item, whichever is the lower elevation, and the bottom of the structure excavation.

Where Common Excavation, Solid Rock Excavation, Unclassified Excavation; Channel Excavation; and Structure Excavation occur at the same location, measurement for Channel Excavation will be made only below the lower limits of Common Excavation, Solid Rock Excavation, or Unclassified Excavation, and measurement for Structure Excavation will be made only below the lower limits of Channel Excavation.

The removal of authorized material below the elevation of the bottom of the excavation as shown on the Plans will be measured in accordance with Table 204.06A.

TABLE 204.06A – STRUCTURE EXCAVATION MULTIPLIERS

Vertical Depth (D) Below Bottom of Excavation Indicated on the Plans (feet)	Volume of Structure Excavation Multiplied By
$0 \leq D < 1$	100%
$1 \leq D < 5$	150%
$5 \leq D < 10$	450%
$10 \leq D < 15$	750%
$15 \leq D$	Paid as extra work

Where a foundation or component of a structure is designed or directed to be placed on bedrock, an average 6 inch maximum allowance for overbreakage will be allowed for measurement. Additional overbreakage shall be at the Contractor's expense.

(2) Horizontally. Between vertical planes 18 inches outside the neat lines of footings, beams, or other structural components, and parallel thereto except for the following:

a. The horizontal measurements of the Structure Excavation for reinforced concrete boxes shall be the overall width of the box, plus 18 inches on each side, and the length of the structure, plus 18 inches on each end.

b. The horizontal measurements for corrugated plate arches shall be the width of each abutment, plus 18 inches on each side, and the length of the arch, plus 18 inches on each end.

c. The horizontal measurements for pipes and pipe arches having a diameter or span over 48 inches shall be between vertical planes 3 feet outside the exteriors of each side, and the length of the pipes or pipe arches plus 18 inches on each end.

d. When footings are not used, the neat lines shall be the junction line between the new concrete and the old masonry or bedrock.

(c) Granular Backfill for Structures. The quantity of Granular Backfill for Structures to be measured for payment will be the number of cubic yards placed in the complete and accepted work within the confines of the limits shown on the Plans or as directed by the Engineer.

When Coarse Aggregate for Concrete or Crushed Gravel for Subbase, Fine Graded is substituted for Granular Backfill for Structures, it will be measured and paid for as Granular Backfill for Structures.

204.07 BASIS OF PAYMENT. The accepted quantities for Trench Excavation, Trench Excavation of Earth, Exploratory, Structure Excavation, and Granular Backfill for Structures will be paid for at the Contract unit price per cubic yard for each of the Contract items specified in the Contract. Payment will be full compensation for performing the work specified, including placement and compaction of backfill, disposal or placement in embankments of all surplus material, and the cleaning up of the site following completion of construction areas, and for furnishing all labor, materials, tools, equipment, sheeting, bracing, and incidentals necessary to complete the work.

Unless otherwise specified, Structure Excavation will include all sheeting, bracing, dewatering, and siltation control, preparing and submitting construction drawings where required, and incidentals necessary for properly constructing, in the dry, a foundation or structural component.

All material removed beneath a vertical depth of 15 feet below the bottom of Structure Excavation limits shown on the Plans, or changes in sheeting, bracing, or dewatering necessitated by excavating below the 15-foot limit, will be paid for as extra work.

No differentiation will be made in Structure Excavation between the excavation of wet or dry material, earth, gravel, boulders, rock, old masonry, or reinforced concrete.

When exploratory excavation is conducted exclusively for the purpose of locating existing underground utility services or other structures when directed by the Engineer, the costs of such excavation, regardless of depth, will be paid for at the Contract unit price bid per cubic yard for Trench Excavation of Earth, Exploratory. Payment will be full compensation for all labor, materials, tools, equipment and incidentals necessary to complete the work, including locating and protecting existing underground utility services or other structures, and for restoring the work area to the satisfaction of the Engineer.

Payment will be made under:

Pay Item	Pay Unit
204.2000 Trench Excavation of Earth	Cubic Yard
204.2100 Trench Excavation of Rock	Cubic Yard
204.2200 Trench Excavation of Earth, Exploratory (N.A.B.I.)	Cubic Yard
204.2500 Structure Excavation	Cubic Yard
204.3000 Granular Backfill for Structures	Cubic Yard

SECTION 205 – DRILLING AND BLASTING

205.01 DESCRIPTION. This work shall consist of drilling and blasting of rock, in accordance with these specifications, the Plans, and as directed by the Engineer.

205.02 DRILLING AND BLASTING OF SOLID ROCK SUBGRADE. Solid rock subgrade areas shall be shattered in place to the dimensions shown on the Plans or directed by the Engineer.

The area of blasted rock subgrade shall extend sufficiently beyond the beginning and end of cut areas to ensure the shattering of all rock to a depth of 4 feet below the bottom of subbase material elevation.

After detonation, any rock protruding above the bottom of subbase shall be removed. When directed by the Engineer, the Contractor shall excavate a trench with conventional earth moving equipment across the blasted rock to determine if the rock is sufficiently shattered to a depth of 4 feet below the bottom of subbase. Afterwards, the trench shall be backfilled with the rock removed.

205.03 DRILLING AND BLASTING USING PERIMETER CONTROL. Perimeter control blasting refers to the use of explosives and blasting accessories in carefully spaced and aligned drill holes to produce a final excavation surface or shear plane in the rock along the specified excavation backslope. These blasting techniques are used to better distribute the explosive charge to minimize damage, such as fracturing and overbreak, backbreak, or endbreak, beyond the final excavation face. This is accomplished by using small diameter, decoupled charges in closely spaced blastholes placed on the perimeter of an excavation. Perimeter control blasting methods include line drilling, presplitting, and precision presplitting.

(a) Blasting Personnel.

(1) Blasting Contractor. The blasting contractor shall be a company specializing in the use of explosives for breaking rock. The blasting contractor shall be responsible for loading and firing each blast, as well as the design and management of blasting operations.

(2) Blaster-in-Charge. The blaster-in-charge shall have total authority over the handling, use and security of explosives, and is responsible for coordinating, planning, and supervising explosives use. The blaster-in-charge shall be responsible for inspecting blast areas after each blast event. The blaster-in-charge will be required to be on-site during blasting.

(3) Blasting Consultant. The blasting consultant shall have specialized experience and academic knowledge of commercial explosives, perimeter control blasting applications, vibration, and air-overpressure control. The blasting consultant shall use this knowledge to evaluate, plan, and oversee the safe use of explosives in commercial applications in accordance with blasting industry and regulatory standards. The blasting consultant shall review and sign all blasting plans and required submittals provided by the blasting contractor. The blasting consultant shall not be an employee of the Contractor or any affiliated companies or suppliers of products to the project and shall not have any conflict-of-interest affiliations with the Agency, or other entities involved with the work. The Blasting Consultant shall be required per the Contract documents.

(4) Vibration Specialist. The vibration specialist shall be responsible for the vibration and airblast monitoring for blasting events. The vibration specialist shall conduct the operation and deployment of seismographs, geophones, and airblast monitoring equipment for all blasting operations. The vibration specialist shall also be available to discuss vibration results at the request of the Agency. The vibration specialist shall not be an employee of the Contractor or any affiliated companies or suppliers of products to the project and must not have any conflict-of-interest affiliations with the Agency, or other entities involved with the work.

(b) Submittals. The Contractor shall submit to the Engineer, the following information for completing the work. Review and acceptance of submittals does not relieve the Contractor of responsibility for the blast results or liability. The Contractor is entirely responsible for the work associated with these submittals.

(1) Pre-Construction Submittals. The Contractor shall submit the following information prior to the beginning of the work. Once a complete submittal has been received, the Agency shall be allowed 21 calendar days for the initial review period and shall be allowed 14 calendar days for review of each subsequent resubmittal. The pre-construction submittals shall be submitted at least 10 working days prior to the pre-blast meeting, outlined in Subsection 205.03(d). Drilling and blasting operations shall not begin until all of the submittals have been approved in writing by the Engineer.

a. Qualifications.

1. Blasting Contractor. The Contractor shall submit documentation that the blasting contractor has successfully completed at least five blasting projects within the last 3 years with subsurface conditions and blasting of a similar scope and complexity to that anticipated.

Documentation shall include the names of the general contractor and the owner, descriptions of each past project, and current contact information of a representative of the construction manager or project owner. Contact information shall include at least one valid phone number.

2. Blaster-in-Charge. The Contractor shall verify that they employ the blaster-in-charge and any alternates assigned to the project.

The Contractor shall provide documentation of valid licenses for each blaster-in-charge, including state of Vermont Department of Public Safety Explosive License and U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives License.

Documentation shall be provided showing that each blaster-in-charge has a minimum of 10 years of experience in blasting with past projects of scope and complexity similar to that anticipated. University education in the field of explosive engineering may be submitted by the Contractor to supplement experience per approval of the Engineer. Documentation shall include resumes, references, certifications, project lists, experience descriptions and details. References shall include valid phone numbers for the representatives of the construction manager or project owner from at least 3 past projects involving similar perimeter control blasting.

The Contractor shall also provide documentation that each blaster-in-charge attended at least 5 blasting seminars, short courses, or blasting conferences in the last 10 years, and shall include a signed statement from the proposed blaster-in-charge certifying that during the past 5 years they:

i. Have not been involved in incidents where flyrock traveled within the active travel way, out of the construction right-of-way, onto private property, caused damage of property, or resulted in injury.

ii. Have not had a blasting license restricted or revoked in any state.

iii. Have not been fined or sanctioned personally in any way by a regulating authority.

3. Blasting Consultant. The Contractor shall provide documentation that the blasting consultant has a minimum of 10 years of experience in using perimeter control blasting on projects of scope and complexity similar to that anticipated. The blasting consultant shall have directly participated in at least three projects of similar scope and complexity. Documentation shall include the names of the general contractor and the owner, descriptions of each past project, and current contact information of a representative of the construction manager or project owner. Contact information shall include at least one valid phone number.

4. Vibration Specialist. The Contractor shall provide documentation that the vibration specialist has directly participated in at least five rock slope and rock removal projects. The documentation shall contain a description of the projects, details of the vibration control plans, and modifications made during the project. The documentation shall include the names of the general contractor and the owner, and current contact information of a representative of the construction manager or project owner. Contact information shall include at least one valid phone number.

b. Preliminary Blast Plan. The Contractor shall submit a preliminary blast plan before beginning drilling, when revised drilling or blasting methods are proposed, or as directed by the Agency. The preliminary blast plan shall clarify the means and methods anticipated to be used during construction to meet blasting tolerances stated in the Contract. The preliminary blast plan shall include, but not be limited to:

1. A description of the sequence and procedures to be employed to execute the anticipated blasting operations including the drilling, blasting, fragmentation size, number of blasts, benching details if applicable, and proposed blasting schedule.

2. A description of drilling methods, including production holes, buffer holes and perimeter control holes as applicable, the type of drills, size and type of drill bits, drill hole inclinations, anticipated subdrill depths, burden between rows, hole spacing within rows, and hole diameter.

3. Figures depicting the typical plan and area of blasts with profile and sectional views, free faces, burden, bench or lift heights, station limits, blast limits, hole types, burden, hole spacing, depths, diameters, subdrill depths, and inclination.

4. A description of blasting methods, including types of anticipated explosives to be used, detonators, boosters, blasting agents, type and amount of stemming, method of primary initiation, sequence of delays, any blank or unloaded holes, and detonation methods and timing and loading diagrams.

5. A description and preliminary calculations of charge-weight-per-delay.

6. Manufacturer’s data sheets and safety data sheets (SDS) on all blasting material and equipment proposed, including the type of explosives, blasting agents, cartridge sizes and weights, detonators, blast initiation devices, and other equipment required to perform the blast.

7. Station limits for proposed test blast locations.

8. Technical specifications for blasting mats used to cover blasts, including type, size, weight, and number.

9. Plans for control of water, disposal of spoils, disposal of blasting related equipment, materials and waste, and other significant aspects of the work related to drilling and blasting.

10. An organizational chart identifying the key personnel and points of contact for the portion of the work involving drilling and blasting.

11. Examples of all forms used in the Contractor's submissions. Individual forms may require revision for the Agency's approval.

12. Signature of the blasting consultant, confirming they have reviewed the preliminary blast plan.

c. Vibration and Noise Control Plan. The vibration and noise control plan shall include a pre-blast condition survey of all buildings, structures, or utilities within a radius of the blasting area limits as specified on the Plans. The Contractor shall also notify the residents and owners of these buildings, structures, or utilities of the scheduled blasting activities. At a minimum, notification shall include a certified letter.

The pre-blast condition survey shall be conducted by the vibration specialist. Additional buildings, structures, or utilities outside of the radius of the blasting area limits may require a survey and notification, as directed by the Engineer.

The vibration and noise control plan shall include, but is not limited to:

1. A summary naming the person who performed the pre-blast condition survey, including the address or location, owner, and date and time of the survey.

2. Description and measurements of each building, structure, and utility and its existing condition included in the pre-blast condition survey. The Contractor shall also furnish the Engineer with a list of the residents and owners who were contacted and proof of notification.

3. Photos or digital recordings of all cracks and other damaged, weathered, or otherwise deteriorated structural conditions documented in the pre-blast condition survey. Photos and digital recordings shall contain an accurate date stamp.

4. Safe ground vibration and airblast limits for each building, structure, and utility within the radius of the blasting area limits.

5. Calculations for ground vibration, airblast control, and regression analysis to be used to estimate ground vibrations and airblasts.

6. Seismograph and airblast monitoring equipment locations, including a scaled map showing locations and the distance from the center of the blast area to the instrument location.

7. Plan and methods for adequately coupling geophones to the ground surface at the project location.

8. Certificates of calibration for all monitoring equipment, including recorders, seismographs, sensors, and microphones. The records shall show that the monitoring equipment has been calibrated within 12 months.

9. Examples of all forms used in the Contractor's submissions. Individual forms may require revision for the Agency's approval.

Any equipment used to monitor the condition of any existing conditions revealed during the pre-blast surveys shall be installed and maintained per the direction and recommendation of the vibration specialist. The vibration specialist shall be responsible for recommending the appropriate equipment to be used.

d. Explosives Transportation, Handling, and Storage Plan. This plan shall include work procedures and safety precautions for the storage, transportation, and handling of explosives including:

1. A list of all authorities having jurisdiction over operations involving the transportation, storage, handling, and use of explosives; copies of all required blasting permits regarding explosive use and storage; and copies of necessary blasting licenses or authorizations obtained from the state and pertinent localities.

2. A scaled map showing locations where explosives will be kept in temporary day boxes or delivery vehicles while on site.

3. Information describing how explosives will be inventoried, secured, and guarded to prevent unauthorized use of explosives.

e. Blasting Safety Plan for Use of Explosives. This plan shall include work procedures and safety precautions for the detonation of explosives including:

1. Worker, site, and public safety procedures; blast communication procedures; signage; and equipment details.

2. Means to prevent contamination and deleterious effects to environmental and other natural resources.

3. A complete description of the clearing and guarding procedures that will be employed to ensure personnel, staff, visitors, and all other persons are at safe locations during blasting. This information shall include details regarding visible warning signs or flags, audible warning signals, method of determining blast area zones, access blocking methods, guard placement and guard release procedures, primary initiation method, and the system by which the blaster-in-charge will communicate clearing and guarding procedures.

4. A description of the equipment and procedures that will be used to monitor the approach of lightning storms and, in the event of such, evacuation and site safety security plans. This includes specifications of the lightning detection equipment.

5. Contingency plans for handling of misfires.

6. Fire prevention plan details, including smoking policies, procedures and limitations for work involving any open flames or sparks, description and location of all firefighting equipment, and firefighting and evacuation plans.

(2) Pre-Blast Submittals. The Contractor shall submit the following information to the Engineer no later than 8:00 a.m. on the weekday prior to the proposed upcoming blast. The Agency shall be allowed 8 hours to review the submittal and each resubmittal. Reviews will only be conducted on weekdays. Explosive materials shall not be delivered to the site until the submittals have been approved in writing by the Engineer.

a. Pre-Blast Plan. The blaster-in-charge shall submit a pre-blast plan for review by the Engineer. The review of a blasting plan by the Agency shall not relieve the Contractor of responsibility to produce adequate rock breakage, to limit breakage to within the design excavation final lines and grades, that project vibration limits are not exceeded, and to ensure that flyrock does not result from the blasting operation. The pre-blast plan shall include, but not be limited to:

1. A scaled drawing showing the location, orientation, number, diameter, and depth of blastholes relative to the specified stations, slopes, lines, and grades.

2. Calculations showing determinations of maximum charge-per-delay.

3. A detailed log showing the proposed amounts of all explosives, by type, and stemming used in all charged holes, rock volume calculations, and powder factor calculations.

4. Drawing showing surface initiation and in-hole firing times of all charges.

5. Proposed date and time of blast.

6. A description of methods that will be used to reduce and control flyrock potential.

7. Methods to prevent overbreak, backbreak, endbreak, and loosening of rock not intended to be removed or disturbed by the blast.

8. Locations and distances from the center of the blast area to the seismographs and instruments that will measure ground and air blast vibrations. Locations shall be in degrees latitude and longitude, recorded with a hand-held GPS unit.

9. Proposed location of digital video recorders, from a minimum of two different angles or locations. Videos must be obtained from a location that is close enough to adequately show the blast occurring.

10. Proposed changes to the preliminary blast plan based on review of the drilling logs.

b. Drill Logs. The blasting contractor shall submit a completed and detailed drill log that includes a record of all holes drilled. An example drill log form is available from the Agency Geologist per request. At a minimum, drill logs shall include:

1. Project name, date and time of drilling, general weather conditions, and the drilling equipment used.

2. Station limits and bench identification number, if applicable for the drilling operation.

3. Layout, location, and identification of drill holes. Note that production holes, buffer holes, presplit or precision presplit holes, and line drilling holes shall be identified as appropriate.

4. Diameter and depth of each drill hole.

5. Planned borehole inclination, drill inclination during operation, final borehole inclination, and any deviation from planned angle at each borehole drilled.

6. Detailed description and depth of key observations and deviations encountered during drilling of each hole, including but not limited to:

    i. Jointing or voids.

    ii. Zones where loss or gain of fluid or air is encountered.

    iii. Changes in lithology.

    iv. Changes in the rate of drilling not due to equipment.

    v. Color variation in cuttings.

    vi. Odors emanating from the drill hole.

    vii. Soil types encountered.

    viii. Water bearing zones.

7. Any unrecovered equipment left in a drilled hole.

8. Any collapse of drilled holes or backfilling of holes for any reason.

9. Signature of the drill operator acknowledging review of the data contained in the drill log.

10. Signature of the blaster-in-charge acknowledging review of the data contained in the drill logs.

c. Borehole Tracking Report. The blasting contractor shall submit a borehole tracking report. An example borehole tracking report form is available from the Agency Geologist upon request. For each perimeter control blasthole, this shall include, but is not limited to:

1. Perimeter control blasthole number, correlated to drill logs.

2. Measured depth (the total length of the blasthole measured along the actual borehole path).

3. Design inclination.

4. Average azimuth.

5.. Average inclination.

6.. Deviation from the inclination shown on the Plans.

7. True vertical depth (measured vertically from the surface down to the depth of the borehole).

8. Drilled offset.

9. Difference between deviation and drilled offset.

10. A statement stating the number of holes in conformance with the specification tolerances for inclination, the number of holes not in conformance, and the amount to which they are out of tolerance.

11. Description of corrective measures taken for blastholes that are out of tolerance.

12. Signed copy of measured data.

(3) Post-Blast Submittals. The Contractor shall submit the following information for approval not less than 48 hours after each blast and before any further blasting operations can continue. Post-blast reports must be completed and accepted by the Agency before the next pre-blast plan is submitted. The Agency shall be allowed 8 hours to review the submittal and each resubmittal. Reviews will only be conducted on weekdays.

a. Post-Blast Report. The blaster-in-charge shall submit a post-blast report to provide a full detailed account of the blast. An example post-blast report is available from the Agency Geologist upon request. This shall include, but is not limited to:

1. Blast Details.

i. Blast number, date, time, station location, and weather conditions.

ii. Final burden, spacing and number of holes blasted.

iii. Calculated volume of blast.

iv. Explosive details, including, load parameters, including type, quantity, size, weight of explosives, per type, overall total, and stemming type and depths.

v. Maximum charge weight per delay, for production holes and perimeter control blastholes.

vi. Total number and type of delays used, number of holes for each delay period, and sequence of time delay.

vii. Typical blasthole profiles showing the details of the loading, including subdrilling.

viii. Number of blasting mats used, type, placement, or other methods to control flyrock.

2. Overall Performance Details.

i. Relative quality of rock fragmentation, including identifying high-bottom areas.

ii. Evidence of backbreak, overbreak, endbreak or blast damage along the new slope face including within any half barrel casts. Include station limits and estimated dimensions of damage.

iii. Amount and measured distance of flyrock ejected.

iv. Any intersections or areas of over loading or under loading as shown in the constructed rock slope face.

v. A section that includes an evaluation by the blaster-in-charge and blasting consultant of the blast performance.

vi. Corrective actions to the blast design and methods should the results of the blasting violate any section of the specification, or the tolerances and intent shown on the Plans.

3. Digital Video Records of Blast.

i. The recordings shall be labeled to identify the blast and location of camera (e.g. Blast 01 – Position A).

ii. Video recordings shall begin at least 10 seconds before the blast and continue recording until there is no evidence of visible dust.

b. Vibration and Airblast Data and Report. The vibration specialist shall submit vibration and airblast data. This shall include, but is not limited to:

1. Instruments used.

2. Name of qualified observer and interpreter.

3. Blast number and date.

4. The location of the blast (station and offset, latitude and longitude, and elevation) and the blast area center location (station and offset, latitude and longitude, and elevation).

5. A scaled map showing the location of the blast and the seismographs.

6. Surface material type the geophone has been coupled to at the recording station and the coupling method.

7. Summary report from each seismograph, including, but not limited to:

   i. Peak particle velocity and frequency of the peak.

   ii. Peak particle displacement.

   iii. Peak acceleration.

   iv. Peak vector sum.

   v. Distance from blast center.

   vi. Maximum charge weight per delay.

   vii. Airblast overpressure.

   viii. Confirmation that the vibration data shows conformation with the vibration limits.

   ix. Calibration verification.

8. Ground vibration and airblast regression analysis, relating scaled distance (square root) to peak particle velocity, and scaled distance (cube root) to airblast pressure level.

9. A dated and signed copy of records of all seismograph ground vibrations and airblast readings.

c. Flyrock Report. If flyrock travels within the active travel way, out of the construction right-of-way, onto private property, causes damage of property, or results in injury, the blasting contractor shall file a flyrock report. This report shall be reviewed by the blasting consultant and submitted to the Engineer for approval before blasting operations resume. This shall include, but is not limited to:

   1. Cause of the flyrock.

   2. Methods used to prevent the flyrock, if used.

3. Methods to be employed on subsequent blasts to reduce the throw of flyrock.

4. Plans to prevent future encroachments of private property if applicable.

d. Misfire Report. If a misfire is discovered, the blasting contractor shall file a misfire report. This report shall be reviewed by the blasting consultant and submitted to the Engineer for approval before blasting operations resume. This includes, but is not limited to:

1. Cause of the misfire.

2. How the misfire was discovered.

3. Procedure followed for handling the unexploded explosives.

4. Methods to be employed on the subsequent blasts to prevent future misfires.

(c) Site Preparations. The blasting limits as shown in the Plans shall be cleared of all vegetation, overburden, and boulders prior to beginning blasting work. Use of explosive charges is not permitted to blast boulders or remove less than 3 feet of rock above grade. Boulders shall be broken in a manner that shall not dislodge them and cause them to move downslope. The methods allowed for boulder breaking include hydraulic splitter and hydraulic hammer. Alternative methods of boulder removal may be proposed by the Contractor and submitted to the Engineer for approval.

(d) Pre-Blast Meeting. A pre-blast meeting shall be held prior to the start of drilling and blasting work and shall be attended by the Agency, the Contractor, the blasting contractor, blaster-in-charge, blasting consultant, and vibration specialist. The pre-blast meeting shall be conducted to clarify the construction requirements for the work, to coordinate construction activities, and to identify contractual relationships and responsibilities. The pre-construction submittals, outlined in Subsection 205.03(b)(1), shall be submitted at least 10 working days prior to the pre-blast meeting.

(e) Public Meeting. To better inform the public about anticipated drilling and blasting operations, at the request of the Engineer, the Contractor shall make their blasting consultant, blasting contractor, and vibration specialist prepare for and participate in a public meeting conducted by the Engineer. The participants shall be prepared to answer any questions regarding the blasting operations, ground vibrations, airblast overpressure, and flyrock expected to impact the public.

(f) Blasting Progress Meetings. At the request of the Agency, meetings may be held at any time during the project to review the progress of the blasting operations, discuss modifications to the methods and procedures of the written blast plan, or discuss issues with upcoming blasts. Blasting progress meetings shall be attended by the Agency, the Contractor, the blasting contractor, and other interested parties.

(g) Explosive Material Handling and Storage. Explosives shall be handled, transported, used, controlled, stored, and monitored in accordance with Subsection 107.10.

(h) Test Blasting Program. Prior to commencing full-scale blasting operations, the blasting contractor shall drill, blast, and muck test sections, up to 100 feet in length, to determine if their proposed blast design, including hole spacing, timing, and charges, will meet the objectives of the Contract. If more than one blast design is tested in one test blast, each design section shall be at least 20 feet in length along the final face surface.

All requirements for blasting operations covered elsewhere in this specification shall apply to the blasting carried out in conjunction with the test blast.

The blasting contractor will not be allowed to drill ahead of the test blast until the results have been evaluated and approved by the Engineer. If the results of the test blasts are unsatisfactory, then, notwithstanding the Engineer's prior review of such methods, the blasting contractor shall adopt revised methods as necessary to achieve the required results.

Unsatisfactory test blast results include an excessive amount of overbreak, backbreak, or endbreak beyond the indicated lines and grade, flyrock, ground vibration, airblast or violation of other requirements within these specifications, or unsatisfactory condition of the constructed rock slope face, such as not producing a uniform rock slope face. No additional compensation will be allowed for costs incurred by the blasting contractor in adopting revised blasting methods necessary to produce an acceptable test blast.

If the Engineer suspends blasting operations after full scale blasting has begun, test blasts will be required before full scale blasting can resume.

(i) Blasting Methods.

(1) Types of Perimeter Control Blasting.

a. Line Drilling. Line drilling is defined as a controlled perimeter excavation technique consisting of a series of closely spaced holes that are not loaded with explosives and are drilled along the excavation line. The line drill hole spacing shall be no greater than twice the line drill hole diameter as stated in the Plans.

b. Presplitting. Presplitting is defined as a method of controlled blasting utilizing a row of closely spaced, lightly loaded blastholes placed on the perimeter of the excavation and fired before the production holes.

The presplit blastholes shall be a minimum of 2 inches and maximum of 3 inches in diameter. The presplit holes shall be drilled with a minimum spacing of 10 times the presplit hole diameter and a maximum spacing of 12 times the presplit hole diameter. Presplit hole loads are limited to 0.35 pounds of explosive per foot of blasthole. The maximum diameter of explosives used in presplit holes shall not be greater than half the diameter of the presplit hole.

Presplit blastholes shall be fired before production holes. If presplitting and production holes are fired within the same blast, all presplit blastholes shall be fired at least 25 milliseconds before the production blastholes are detonated. Line drilling along final walls may be required at corners where presplit lines meet. Subdrilling 2 feet below ditch bottom will be allowed to facilitate removal of the toe berm.

c. Precision Presplitting. Precision presplitting is defined as utilizing more closely spaced blastholes than presplitting with lighter explosives loads. This method of perimeter control matches the strength of the explosives to the strength requirements of the rock to cause the web of rock between the precision presplit holes to fail in tension with the minimum energy needed and to create the split without damaging the constructed rock cut face.

The precision presplit blastholes shall be a minimum of 2 inches and maximum of 3 inches in diameter. The precision presplit holes shall be drilled with a minimum spacing of 4 times the precision presplit hole diameter and a maximum spacing of 8 times the precision presplit hole diameter. Subdrilling 2 feet below ditch bottom will be allowed to facilitate removal of the toe berm.

(2) Production Blasting. Production blasting is blasting in the mass of rock to be excavated and shall be designed to control flyrock, minimize ground vibration and airblast, and result in loosened and fragmented rock suitable for excavation using conventional earth moving equipment.

Production blastholes shall be in a consistent pattern that does not affect the perimeter control blastholes. To control blasting effects, the blasting contractor shall maintain a burden distance that is not more than one half the bench height and between 25 times and 35 times the diameter of the explosive charge in the blasthole. If the first row of production holes adjacent to the presplit face are intended to be buffer holes, they shall be drilled no less than 4 feet from the presplit line and shall maintain a stand-off distance between the production explosive charges and the presplit line of no less than three 3 feet. Sub drilling 2 feet below ditch bottom will be allowed to facilitate removal of the toe berm.

(3) Buffer Holes. Buffer holes are located between the production holes and the perimeter control blast line. Buffer holes may be battered at the same angle as the presplit face or may be vertical.

(4) Blasthole Drilling.

a. General Requirements. All blastholes shall be covered after drilling to keep overburden and debris from falling into the holes. All blastholes shall be marked with the hole number and depth. Blastholes shall be free of obstructions for their entire depth.

b. Equipment. The blasting contractor shall control drilling operations using proper equipment and techniques to ensure that no hole deviates from the tolerance set for both depth and alignment.

All drilling equipment used to drill blastholes shall be equipped with an electro-mechanical or electronic device that accurately determines the angle, within 1 degree, at which the drill steel enters the rock. Drilling will not be permitted if these devices are either missing or inoperative.

c. Tolerances. The blasting contractor will be required to use a borehole alignment unit affixed to a laser profiler to determine blasthole orientation on all perimeter control blastholes. The blasting contractor shall submit the borehole tracking data as outlined in Subsection 205.03(b)(2)c. This requirement may be waived temporarily when, in the opinion of the Engineer, the borehole alignment is satisfactory. Required borehole tracking may be reinstated at the discretion of the Engineer.

Any blastholes deviating from alignment on the plane of the planned slope, either parallel or normal to the slope, by more than the tolerances shown on the Plans, shall be refilled with crushed stone stemming or cementitious grout, re-drilled at the proper location and at the proper alignment, and borehole tracked, at no additional cost to the Agency.

(5) Blasthole Loading. The blastholes shall be cleaned out prior to loading to remove cuttings, collapses, or other debris, including removal of water if using non-water-resistant explosives. All blastholes shall be checked and measured before any explosives are loaded into any of the holes to eliminate any safety hazard resulting from drilling near loaded holes.

Stemming material used in production holes shall consist of dry, unfrozen, angular crushed stone having an optimum average diameter of 0.05 times the diameter of the blasthole. Drill cuttings shall not be used as stemming, with the exception of precision presplit blastholes.

If fractional portions of standard explosive cartridges are used, they shall be firmly affixed to the detonating cord in such a manner that the cartridges will not slip down the detonating cord nor bridge across the hole. Spacing of fractional cartridges along the length of the detonating cord shall not exceed 30 inches center to center and shall be adjusted to produce the desired results.

Continuous column cartridge types of explosives used with detonating cord shall be assembled and affixed to the detonating cord in accordance with the explosive manufacturer’s instructions, a copy of which shall be furnished to the Engineer.

The bottom charge of a presplit or precision presplit hole may be larger than the line charges but shall not be large enough to cause overbreak. The top charge of the presplit or precision presplit hole shall be placed far enough below the collar, and reduced sufficiently, to avoid overbreaking and heaving. The upper portion of all presplit and precision presplit holes, from the topmost charge to the hole collar, shall be stemmed.

(6) Required Mucking of Constructed Blast Face. The Contractor shall complete mucking following each blast to allow inspection of the rock cut, approval of the blast face, and allow for adjustments to the blast design for subsequent blasts. All rock on the constructed cut face that is loose, hanging, or which creates a potentially dangerous situation due to risk of rockfall occurring shall be removed to the satisfaction of the Engineer during or upon completion of the mucking. Drilling and loading for the next blast will not be allowed until the required mucking of the previous blasts has been completed and the face is approved. If subsequent blasting causes damage to an already approved area, then the damaged areas will be readdressed to the satisfaction of the Engineer.

(j) Stabilization. Stabilization of the rock cut shall be performed in accordance with Section 221 and as directed by the Engineer, as needed.

If subsequent blasting causes damage to an already approved stabilized area, then the area may be required to be restabilized at the discretion of the Engineer.

(k) Vibration and Noise Control. The vibration specialist shall submit the pre-blast condition survey as outlined in Subsection 205.03(b)(1)c. The vibration specialist shall establish the safe ground vibration and airblast limit for each building, structure, and utility within the radius of the blasting area limits, as specified on the Plans.

(1) Vibration Control and Monitoring. The vibration specialist shall monitor ground vibrations and airblast at each building, structure, and utility within the radius of the blasting area limits, as specified on the Plans.

a. Locations.

1. A minimum of 3 seismographs shall be used for every blast event. The vibration specialist shall be responsible for guaranteeing the appropriate number of seismographs are used in blasting operations. Locations shall be included in the vibration and noise control plan, as outlined in Subsection 205.03(b)(1)c., and be approved by the Engineer. The vibration data collected by these seismographs will be used to ensure excessive vibration is not being transmitted into the rock mass beyond the presplit face.

2. The placement of seismographs and geophones shall be made with the concurrence of the Agency and the vibration specialist.

3. Whenever vibration damage to adjacent structures is possible, the blasting contractor shall monitor each blast with approved seismographs located between the blast area and the closest structures subject to blast damage.

4. The geophones shall be affixed to exposed bedrock or buried sufficiently in natural soils to ensure full coupling.

b. Equipment.

1. All vibration measuring equipment shall be used in accordance with the standards established by the Vibration Section of The International Society of Explosives Engineers.

2. The seismographs used shall be capable of recording peak particle velocity in the three mutually perpendicular components of vibration in the range generally found with perimeter control blasting, the vector sum of these peak particle velocities, and the frequency history of the vibrations.

3. The vibration measuring equipment shall be calibrated within 12 months of the time of use and operated by properly trained personnel.

c. Limits.

1. The peak particle velocity and dynamic displacement of each component shall not be allowed to exceed the safe limits of the nearest structure subject to vibration damage or at areas designated in the Plans, as determined by the vibration specialist, and as approved by the Engineer.

(2) Airblast and Noise Control. The vibration specialist shall conduct airblast monitoring for each blast.

a. Location.

1. The vibration specialist shall be responsible for guaranteeing the appropriate number of airblast monitoring instruments are used in blasting operations. Locations shall be included in the vibration and noise control plan, as outlined in Subsection 205.03(b)(1)c., and be approved by the Engineer.

2. Airblast monitoring equipment shall be installed between the main blasting area and the nearest structures subject to blast damage, annoyance, or at areas designated on the Plans.

b. Equipment.

1. The equipment used to measure the airblast shall be of the type specifically manufactured for that purpose and shall be approved by the Engineer.

2. The equipment shall be calibrated within 12 months of the time of use and operated by properly trained personnel.

c. Limits.

1. Peak overpressure shall be held below 130 decibels at the nearest structures or other designated locations when measured using a 0.1 Hz high-pass linear peak method.

2. Appropriate blasthole patterns, detonation systems, and stemming shall be used to prevent venting of blasts and to minimize airblast and noise levels produced by the blasting operations.

3. The overpressure limit shall be lowered if it proves too high based on damage or complaints.

(3) Vibration and Airblast Data and Report. The vibration specialist shall submit the vibration and airblast data and report as outlined in Subsection 205.03(b)(3)b.

The vibration specialist shall keep an up-to-date database of the vibration data that shall include ground vibration and airblast data for each blast event. The database shall include regression analysis of both ground vibration and airblast data. The information from this database shall be made available to the Agency upon request.

(l) Flyrock.

(1) Flyrock Control. Where flyrock could cause property damage or injury to the public, the following shall apply:

a. The blasting contractor shall protect all overhead and underground utilities prior to blasting and immediately repair or replace any utilities damaged by the blasting operations. If the blasting contractor wishes to temporarily relocate any utility lines that lie near a blast zone, they shall have written approval from the governing utilities and pay all relocation costs.

b. Where required by the Engineer, the exposed faces of the blast shall also be covered with blasting mats or other suitable materials to prevent formation of any flyrock. The method of covering shall be approved by the Engineer.

(2) Flyrock Report. If flyrock travels within the active travel way, out of the construction right-of-way, onto private property, causes damage to state or private property, or results in injury, the blasting contractor shall file a flyrock report as outlined in Subsection 205.03(b)(3)c.

(m) Suspension of Blasting. Blasting operations may be suspended by the Engineer as outlined in Subsection 107.10.

(n) Safety. The Agency shall have the authority to prohibit or halt the Contractor's blasting operations if it is apparent that through the methods being employed the blasted slopes are unstable or that the safety and convenience of the traveling public is being jeopardized.

(1) Warnings and Signals. Warnings and signals shall be in accordance with Subsection 107.10.

(2) Lightning Protection. Lightning protection shall be in accordance with Subsection 107.10.

(3) Misfires.

a. Post-Blast Check. The blasting contractor shall observe the entire blast area following a blast to guard against rockfall before commencing work in the cut. The delay between blasting and allowing anyone but the blaster-in-charge to enter the area is needed to make sure that no misfires have occurred.

It is the blaster-in-charge's responsibility to go into the blast area and check all holes to make sure that they have detonated. If any holes have not fired, these misfires will be handled by the blaster-in-charge before others enter the work area.

b. Handling. When it is discovered that that complete detonation of all charges did not occur, only critical personnel involved in the blasting operation or excavation of the unexploded material will be allowed within the established blasting area. Access to the site shall be restricted until the blaster-in-charge indicates that the site is safe.

If the misfire poses problems that cannot be safely corrected by the blaster-in-charge, a consultant, or an explosives company representative skilled in correcting misfires shall be consulted to resolve the problem. Compliance with this or any other provision in the Contract shall not relieve the Contractor of responsibility for any damage or injuries caused by, related to, or arising out of blasting or associated blasting activities. Costs associated with resolving misfire problems will be the sole responsibility of the Contractor.

c. Misfire Report. If a misfire is discovered, the blasting contractor shall file a misfire report as outlined in Subsection 205.03(b)(3)d.

205.04 METHOD OF MEASUREMENT. The quantity of Drilling and Blasting of Solid Rock Subgrade to be measured for payment will be the number of square yards of subgrade plan area drilled and detonated in accordance with this section, measured at the bottom of subbase. The number of cubic yards of excavation required by the Engineer to inspect the depth of shattered and rearranged rock, computed at a maximum width of 30 inches, will be measured for payment as Trench Excavation of Earth. Any area designated as Trench Excavation of Rock will not be included in the measurement and payment for Drilling and Blasting of Solid Rock Subgrade.

The quantity of Drilling and Blasting Using Perimeter Control to be measured for payment will be the number of cubic yards of rock blasted and mucked to the constructed rock slope face limits shown on the Plans.

205.05 BASIS OF PAYMENT. The accepted quantity of Drilling and Blasting of Solid Rock Subgrade will be paid for at the Contract unit price per square yard. Payment will be full compensation for performing the work specified including any necessary stripping of rock below the bottom of subbase and refilling with approved material to the bottom of subbase, the removal of blasted subgrade rock that may swell above subgrade, and its disposition on the project as shown in the Plans or as directed by the Engineer. Excavation and backfill required to inspect the depth of broken rock below subgrade will be paid for at the Contract unit price per cubic yard for Trench Excavation of Earth.

The accepted quantity of Drilling and Blasting Using Perimeter Control will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for clearing, grubbing, and removing overburden prior to blasting; drilling, borehole profiling, loading of blastholes; performing blasting; mucking and removal of the excavated rock; vibration and noise control; and for furnishing all labor, tools, equipment, and incidentals to complete the work.

Payment for preparing and making required submittals will not be made separately but will be considered incidental to the work under this section.

Payment will be made under:

Pay Item		Pay Unit
205.1000	Drilling and Blasting of Solid Rock Subgrade	Square Yard
205.2000	Drilling and Blasting Using Perimeter Control	Cubic Yard

SECTION 206 – ROCK SLOPE SCALING

206.01 DESCRIPTION. This work shall consist of excavating loose and dilated rock on slopes. This work includes high-angle construction to be completed via hand scaling using industrial rope access methods or machine scaling.

206.02 SUBMITTALS. The Contractor shall submit to the Engineer the following information for completing the work. Work shall not begin until the submittals have been approved in writing by the Engineer.

(a) Qualifications. Not less than 14 calendar days prior to beginning any rock slope scaling, the Contractor shall provide qualifications of Contractor's personnel to the Engineer. The Contractor shall provide written evidence that the rock slope hand scaling foreman has a minimum of 5 years of demonstrated scaling experience as a foreman and rock slope hand scalers have a minimum of 2 years of demonstrated scaling experience. Operators for machine scaling shall have at least 1 year of demonstrated experience in machine scaling rock slopes.

(b) Work Plan. Not less than 14 calendar days prior to beginning the work, the Contractor shall submit a detailed work plan for each rock slope to be scaled.

The plan shall include:

(1) The proposed rope access methods and safety plan.

(2) The proposed construction sequence and schedule.

(3) The types of equipment and tools to be utilized during the proposed work.

(4) The number of rock slope scaling crews and the numbers of qualified working supervisors and qualified scalers in each crew.

(5) The number of qualified machine scaling operators.

(6) Rock removal and disposal plan for rock debris generated from the rock slope scaling work.

(7) Full details of protection measures to be used during rock slope scaling that shall protect the roadway from scaled rock.

(c) Field Reports. The Contractor shall submit a field report to the Engineer on a daily basis. The field report shall include weather information, work area, a brief description of work performed that day, description and cause of any delays, and number of crew hours and equipment hours for that day for each pay item.

206.03 GENERAL REQUIREMENTS. Prior to the beginning of ledge removal, all necessary clearing and grubbing in the project area shall be completed in accordance with Section 201. Vegetation removal performed as part of hand scaling or machine scaling operations shall meet the applicable requirements of Section 201.

All material from previous activities shall be removed from the ditch line prior to beginning ledge removal.

Work shall proceed according to the approved work plan and schedule submitted by the Contractor.

Under no circumstances shall any material be pushed towards or over the crest of the rock slope, unless otherwise approved by the Engineer.

Devices for protecting the roadway and adjacent facilities shall be provided by the Contractor and installed prior to the beginning of scaling.

206.04 HAND SCALING WITH VEGETATION REMOVAL. Hand scaling with vegetation removal shall consist of removing loose, dilated or potentially dangerous rocks; cleaning out soil and weathered rock exposed during removal; and removing trees, root structures, and shrubs from the slope face using hand removal techniques requiring the use of rope access. Methods may include, but are not limited to, the use of standard steel miner pry bars and pneumatic or hydraulic devices.

Slopes identified on the Plans shall be scaled at such frequency as required to remove all hazardous loose rock or overhangs.

Slopes shall be scaled using a suitable standard steel mine scaling rod, bar, hand placed jacks, and inflatable air bags, as approved by the Engineer. Other methods such as hydraulic splitters or expansive grout may be used in lieu of, or to supplement, hand scaling upon approval of the Engineer.

Scaling shall start at the top of the slope and work shall proceed downward, removing all loose rock blocks and vegetation as the work progresses.

The rock face will be inspected by the Engineer and Geologist to determine whether the rock slope scaling has been completed. If other rocks, soil, or vegetation are identified that require removal, the Contractor shall continue to scale the slope until the scaling has been completed to the satisfaction of the Engineer.

206.05 MACHINE SCALING WITH VEGETATION REMOVAL. Machine scaling with vegetation removal shall consist of removing loose and dilated or potentially dangerous rocks; cleaning out soil and weathered rock exposed during removal; and removing trees, root structures, and shrubs from the slope face using heavy equipment such as excavators or specialized high-reach excavators. Attachments may include a hydraulic hammer, a bucket, or other attachments as necessary to complete the work. The work may be performed from the base of the slope, top of the slope, or from work pads.

Slopes identified on the Plans shall be machine scaled at such frequency as required to remove all hazardous loose rock or overhangs. Equipment used for machine scaling shall be as specified in the approved work plan.

206.06 REMOVAL OF LEDGE MATERIAL. When the scaling work is complete, all material from inside the excavation line, as shown on the Plans, and all loose material from the rock slopes outside the excavation line shall be removed from the work area.

Portable scales sufficient to weigh trucks with up to 12 wheels (i.e. tri-axle dump trucks) shall be provided by the Contractor. Trucks having more than 12 wheels will not be permitted. All trucks will be single-unit type. The scales shall be certified and sealed. Calibration shall be performed according to the manufacturer's recommendations. Storage, placement, and handling of the truck scales shall be the responsibility of the Contractor. Any damage done to the truck scales by the Contractor's operation shall be the Contractor's responsibility. Damaged scales shall be replaced or repaired to the satisfaction of the Engineer at no cost to the Agency.

When scales are no longer needed, as determined by the Engineer, they shall remain the property of the Contractor.

In lieu of providing portable scales, the Contractor may utilize local permanent truck scales for weighing trucks. Use of local scales shall be approved by the Engineer prior to beginning work.

A printed load ticket, which indicates the truck identification, date, and time, shall be furnished to the Engineer for each load removed from the site.

(a) Ledge Salvage Material. When applicable, the quantity of ledge salvage material specified in the Contract shall be salvaged to the state of Vermont.

(b) Ledge Waste Material. Ledge waste material shall be disposed of in accordance with Section 105. Material to be wasted on site shall meet the requirements of Subsection 703.05. The material, when placed in the waste area, shall be leveled and walked in by bulldozer and need not be heavily compacted.

206.04 METHOD OF MEASUREMENT. The quantity of Hand Scaling with Vegetation Removal to be measured for payment will be the number of crew hours of qualified hand scaling performed in the complete and accepted work. The number of hours measured will be the number of hours worked by the scaling crew as a unit, pro-rated as necessary if the crew size differs from that specified. A scaling crew shall consist of three scalers and one scaling foreman. Hours worked by individual scalers will not be measured separately. No additional allowance will be made for premium time (overtime), foremen, superintendents, training, clothing, or equipment required.

The quantity of Machine Scaling with Vegetation Removal to be measured for payment will be the number of hours of qualified heavy equipment used in the complete and accepted work.

The quantity of Ledge Salvage Material to be measured for payment will be the number of tons of ledge material salvaged in the complete and accepted work. Existing ledge material in the ditch line that is salvaged will be included for measurement.

The quantity of Ledge Waste Material to be measured for payment will be the number of tons of ledge material removed in the complete and accepted work. Existing ledge material in the ditch line that is removed will be included for measurement.

206.05 BASIS OF PAYMENT. The accepted quantity of Hand Scaling with Vegetation Removal will be paid for at the Contract unit price per hour. Payment will be full compensation for hours of scaling operations accrued on the project; for furnishing all materials required; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Machine Scaling with Vegetation Removal will be paid for at the Contract unit price per hour. Payment will be full compensation for performing the work specified; for furnishing, operation, and supervising the use of this equipment, including fuel, repairs, and attachments; and for furnishing all labor, tools, other equipment, and incidentals necessary to complete the work.

The accepted quantities of Ledge Salvage Material and Ledge Waste Material will be paid for at the Contract unit price per ton. Payment will be full compensation for performing the work specified; including refining, handling, loading, transporting, and placing the specified materials; for breaking down large blocks of rock prior to removal from the site; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment for preparing and making required submittals and for furnishing truck scales will not be made separately but will be considered incidental to the work under this section.

Payment will be made under:

Pay Item		Pay Unit
206.1000	Hand Scaling with Vegetation Removal	Hour
206.1500	Machine Scaling with Vegetation Removal	Hour
206.3000	Ledge Salvage Material	Ton
206.3500	Ledge Waste Material	Ton

SECTION 208 – COFFERDAMS

208.01 DESCRIPTION. This work shall consist of the construction, material excavation within, dewatering, maintenance, and removal of cofferdams in accordance with the Contract.

The work will be classified as follows:

(a) Cofferdam. This item shall consist of providing a method for constructing, in the dry, a specific foundation or other component of a structure in accordance with Contract requirements. This may involve the design, construction, maintenance, and removal of a watertight structure or may involve alternate methods of dewatering and stabilizing the specific site.

Construction of foundation seals as specified in the Contract or as required by Contractor plans and schedule of operations is also within the scope of work for the cofferdam item. The Contractor shall obtain any and all necessary permits or clearances for alternate methods.

(b) Cofferdam Excavation, Earth. This item shall consist of all material excavated within the pay limits as set forth in these specifications or indicated on the Plans except solid rock, mortared stone masonry, concrete, and boulders measuring 0.5 cubic yards or more.

(c) Cofferdam Excavation, Rock. This item shall consist of all solid rock material excavated within the pay limits as set forth in these specifications or indicated on the Plans, including all solid rock, mortared stone masonry, concrete, and boulders measuring 0.5 cubic yards or more.

208.02 MATERIALS. Concrete used in a cofferdam foundation seal or for replacing overbreakage shall have a minimum 28-day compressive strength of 3,000 psi and shall conform to the requirements of Section 541.

208.03 GENERAL CONSTRUCTION REQUIREMENTS. The locations and elevations for excavation shall be as indicated on the Plans. The Engineer may order removal of poor foundation material below the normal designated elevation and replacement with an approved material.

All suitable excess excavated material shall be used in the formation of embankments as indicated on the Plans, or as directed by the Engineer. Unsuitable material shall be hauled and disposed of with no additional compensation to the Contractor.

208.04 PRESERVATION OF CHANNEL. Unless otherwise indicated on the Plans or ordered by the Engineer, the Contractor, in performing the excavation, shall confine excavating operations to the site of the proposed structure and to the limits of the cofferdam. The natural stream bed shall not be disturbed without permission of the Engineer.

208.05 PREPARATION OF FOUNDATION. The foundation pits shall be excavated so that the footings will be the full lengths and widths indicated on the Plans. The footings shall be constructed with full horizontal beds. Unless otherwise specified or authorized by written order, foundations shall be constructed in the dry. In the dry means foundations and other structural components being constructed are not in or under water. The site shall be dewatered to, or below, the bottom of footing elevation or lowest elevation of a structural component.

The excavation shall continue to either bedrock or the elevation specified for footings on soil. All loose material shall be removed and all seams in the rock shall be cleaned out and filled with concrete or as directed by the Engineer. No excavation shall be done below the elevations indicated on the Plans unless directed by the Engineer in writing. Any material so excavated without authority shall be replaced with concrete or as directed by the Engineer at the Contractor's expense.

When the footing is to be constructed on an excavated surface other than rock, particular care shall be taken not to disturb the bottom of the excavation. No excavation shall be performed below the elevations indicated on the Plans unless directed by the Engineer in writing. Any material excavated without authority shall be replaced with approved backfill, which shall be thoroughly compacted in accordance with Section 204, at the Contractor's expense.

When poor foundation material is encountered at the foundation design elevation, it shall be removed as cofferdam excavation of the appropriate type and replaced with granular backfill for structures or other suitable material, as indicated on the Plans or as directed by the Engineer, and thoroughly compacted in accordance with Section 204.

208.06 COFFERDAMS. The Contractor shall prepare detailed plans and a schedule of operations for each cofferdam specified in the Contract. Construction drawings shall be submitted in accordance with Subsection 105.06.

(a) The professional engineer is responsible for ensuring that the proposed cofferdam meets the following criteria:

(1) The design is structurally stable for all conditions to be encountered (e.g., soils, water, forces, and loadings)

(2) The design and details conform with the Contract and the applicable requirements in the *AASHTO Standard Specifications for Highway Bridges* or the *AASHTO LRFD Bridge Design Specifications*

(3) The design and details are in conformance with applicable safety codes

(4) Adequate size and shape to construct the foundation and structural components specified

(5) The cofferdam is adequately watertight for proper performance of the work

(6) The foundation seals are adequate to achieve their design function

(b) The submittal shall include plan, elevation, and section details indicating the following:

(1) The waterway

(2) Information regarding the cofferdam and any indication that a foundation seal is required to ensure the structural integrity of the cofferdam during dewatering and foundation construction and inspection

(3) Substructure location

(4) Dimensions of any temporary restrictions that are to be placed in the waterway (e.g., barges, lines, earth dams, causeways, temporary diversion channels, and access bridging)

(5) The location, dimensions, clearances, and other relevant information for any temporary scaffolding or netting

(6) Dewatered heads, taking into consideration water level fluctuations

(7) Details for screening, pumping, and filtering discharges from the cofferdam

(8) Details of siltation control and sediment isolation measures

(9) A statement stipulating whether any equipment will be removed at night

(10) A schedule or sequence of operations that includes placement of the foundation seal, time from placement to dewatering, and foundation construction and inspection

The Contractor shall be responsible for performing the work in accordance with the submitted details and schedule of operations. All welding shall be performed per Subsection 506.10.

Cofferdam construction shall conform to the *AASHTO LRFD Bridge Construction Specifications*.

Cofferdams shall be constructed so as to protect freshly placed concrete against damage from sudden rising of the water level and to prevent damage to the foundation or other structural component by erosion. The cofferdam shall be constructed so that no timber, bracing, or forms will extend into the foundation or other structural component.

In the event the Contractor elects to place fill material in the stream to facilitate access to, or be part of, a cofferdam operation, it shall be clean stone fill.

The Contractor shall take measures to prevent all sediments and pollutants from entering waters of the state during installation, use, and removal of the cofferdam. The sediment isolation measures used shall completely enclose the portion of the work area that will be under water. The Contractor shall design and construct the measures to deflect and withstand existing current or wave action, to be anchored continuously along the bottom, and to be effective at the anticipated water levels.

The Contractor shall maintain the sediment isolation measures while in use and shall repair or replace damaged or otherwise ineffective measures as ordered by the Engineer.

208.07 PUMPING. Pumping from or dewatering of the interior of any cofferdam enclosure shall be performed so that disturbance of the subsoil or freshly placed concrete will not occur. Dewatering of a sealed cofferdam will be in conformance with the Contractor's sequence or schedule of operations. Pumping during the construction of a foundation or other structural component shall be from a suitable sump separated from the concrete work.

The discharge from any pumping operation, filtration system, or settling basin shall conform to the requirements of Section 105 and the Contract.

208.08 INSPECTION OF FOUNDATION PIT. Immediately following the completion of each foundation pit, the Contractor shall notify the Engineer, who shall approve the depth of the pit and the nature of the bearing surface before the placement of the concrete.

208.09 BEDDING FOR STRUCTURES. Excavation and preparation of the bed for a structure shall conform to the specifications for the specific structure being installed.

208.10 METHOD OF MEASUREMENT.

(a) Cofferdam. The quantity to be measured for payment will be on a lump sum basis for each cofferdam specified on the Plans or in the Contract.

(b) Cofferdam Excavation, Earth. The quantity to be measured for payment will be the number of cubic yards of earth excavated from within the pay limits of the cofferdam as set forth in these specifications or as shown on the Plans.

The removal of earth excavation authorized by the Engineer below the elevation of the bottom of the excavation, as indicated on the Plans, will be factored in accordance with Table 208.10A.

TABLE 208.10A – COFFERDAM EXCAVATION MULTIPLIERS

Vertical Depth (D) Below Bottom of Excavation Indicated on the Plans (feet)	Volume of Cofferdam Excavation Multiplied By
$0 \leq D < 1$	100%
$1 \leq D < 5$	150%
$5 \leq D < 10$	450%
$10 \leq D < 15$	750%
$15 \leq D$	Paid as extra work

(c) Cofferdam Excavation, Rock. The quantity to be measured for payment will be the number of cubic yards of rock excavated from within the pay limits of the cofferdam as set forth in these specifications or as shown on the Plans.

The removal of rock excavation authorized by the Engineer below the elevation of the bottom of the excavation, as indicated on the Plans, will be factored in accordance with the list shown above.

Where a foundation or component of a structure is designed or directed to be placed on bedrock, a maximum of 6 inches average allowance for overbreakage will be allowed. Additional overbreakage will be at the Contractor's expense.

(d) Bottom of Excavation. The bottom of excavation shall be as indicated on the Plans.

When a foundation seal is specified in the Contract, the bottom of excavation shall be considered to be the bottom of the excavation required for the foundation seal. For a seal proposed by the Contractor, no excavation shall be measured for payment below the bottom of excavation as indicated on the Plans.

208.11 BASIS OF PAYMENT. The accepted quantity of Cofferdam will be paid for at the Contract lump sum price. Payment will be full compensation for the preparation of detailed plans and schedule of operations, performing the work specified, and furnishing of all labor, tools, equipment, materials, and incidentals necessary to complete the work. Payment will include the cost of altering the cofferdam; foundation seals; sheeting; bracing; dewatering; installation, maintenance, repair, and replacement of siltation and sedimentation control measures; incidentals necessary for properly constructing the foundation or structural component; maintaining the cofferdam in a dewatered condition; and removing the cofferdam and associated siltation and sediment control measures when no longer required.

The accepted quantities of Cofferdam Excavation, Earth and Cofferdam Excavation, Rock will be paid for at the Contract unit price per cubic yard for each of the pay items in the Contract. Payment will be full compensation for performing the work specified and the furnishing of all labor, materials, tools, equipment, disposal of surplus material, and any other incidentals necessary to complete the work.

Partial payments for Cofferdam will be made as follows:

(a) A payment of 75% of the lump sum bid price will be made when excavation within the limits of the structural unit is completed and the cofferdam has been successfully dewatered.

(b) The remaining 25% of the lump sum price will be paid when the cofferdam is completely removed, or, if the Contract requires the cofferdam to be left in place, when the associated foundation or other component of a structure is completed.

If the Engineer, by written order, requires that the cofferdam be left in place and this requirement is not specified in the Contract, a change order will be processed in accordance with Section 109.

Payment will be made under:

Pay Item	Pay Unit
208.3000 Cofferdam Excavation, Earth	Cubic Yard
208.3500 Cofferdam Excavation, Rock	Cubic Yard
208.4000 Cofferdam	Lump Sum

SECTION 209 – TRENCHLESS CONSTRUCTION

209.01 DESCRIPTION. This work shall consist of performing trenchless construction as specified in the Contract and in accordance with standard industry practice.

209.02 SUBMITTALS. The Contractor shall submit a detailed work plan that encapsulates a wide range of procedural precautions necessary to ensure a proper trenchless installation. The work plan shall be submitted to the Engineer for acceptance in accordance with Subsection 105.06(c)(2) prior to the beginning of any work associated with the trenchless work.

The work plan shall contain, at a minimum, entry and exit points, entry and exit angles, any horizontal bend radii, a profile showing points of tangency and curvature, vertical radii, the depth of the bore along the proposed alignment, equipment details and specifications, anticipated duration of the drill and assembly, and the Contractor's qualifications. The qualifications, at a minimum, shall be three projects in the last 5 years where the Contractor or subcontractor performing the work has successfully used the trenchless construction method for projects of similar diameter, length, and difficulty as required for this project. The work plan shall also indicate if the Contractor intends to do any preliminary subsurface investigation.

209.03 EQUIPMENT REQUIREMENTS.

(a) Horizontal Directional Drilling. Horizontal directional drilling equipment shall consist of a directional drilling rig of sufficient capacity to perform the bore and pull-back, a drilling fluid mixing and delivery system of sufficient capacity to successfully complete the work, and a guidance system to accurately guide drilling operations. Equipment shall include a vacuum trailer to withdraw excess drilling fluid and a drilling fluid cleaning system truck for mixing and recycling bentonite. All equipment shall be in good and safe operating condition with sufficient supplies, materials, and spare parts on hand to maintain the system in good working order for the duration of the work.

(1) Drilling System.

a. Drilling Rig. The directional drilling machine shall consist of a hydraulically powered system to rotate, push, and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head. The machine shall be anchored to the ground to withstand the pulling, pushing, and rotating pressure required to complete the work. The hydraulic power system shall be self-contained with sufficient pressure and volume to power drilling operations. The hydraulic system shall be free of leaks. The drill rig shall have a system to monitor and record maximum pull back pressure.

b. Drill Head. The drill head shall be steerable by rotation direction changes and through drilling fluid jets.

c. Mud Motors. Mud motors, when required, shall be of adequate power to turn the required drilling tools.

d. Drill Pipe. Drill pipe shall be constructed of high quality AISI 4130 seamless tubing, Grade E or better, with threaded box and pins. Tool joints shall be hardened to between 32 RC and 36 RC.

(2) Guidance System. The guidance system shall be of a proven type and shall be set up and operated by personnel trained and experienced with the system. If using a magnetic system, the operator shall be aware of any magnetic anomalies and shall consider such influences in the operation of the guidance system. The guidance system shall be capable of identifying the exact location of the drill head, horizontally, vertically, and degree of inclination, at all times during drilling operations. The guidance system shall be capable of accurately monitoring the location of the drill head beneath a reinforced concrete slab.

(3) Drilling Fluid System.

a. Mixing System. The drilling fluid mixing system shall be self-contained, closed, and be of sufficient size to mix and deliver drilling fluid composed of bentonite clay, potable water, and appropriate additives. The mixing system shall be able to molecularly shear individual bentonite particles from the dry powder to avoid clumping and ensure thorough mixing. The drilling fluid reservoir tank shall be of sufficient size for the work. The mixing system shall continually agitate the drilling fluid during drilling operations.

b. Drilling Fluid. Drilling fluid shall be composed of clean water and an appropriate additive. Water shall be from a clean source with a pH of 8.5 to 10. Water of a lower pH or with excessive calcium shall be treated with the appropriate amount of sodium carbonate or equal. The water and additives shall be mixed thoroughly and be free of any clumps or clods. No hazardous additives shall be used.

Drilling fluid shall be maintained at a viscosity sufficient to suspend cuttings and maintain the integrity of the bore wall.

c. Delivery System. The mud pumping system shall have sufficient capacity and be capable of delivering the drilling fluid at a constant pressure to meet the needs of the work. The delivery system shall have filters in-line to prevent solids from being pumped into the drill pipe. Connections between the pump and the drill pipe shall be relatively free of leaks. Used drilling fluid and drilling fluid spilled during drilling operations shall be contained and properly disposed of. Pumps or vacuum trucks of sufficient size shall be in place to convey excess drilling fluid from containment areas to storage facilities.

(4) Other Equipment.

a. Pipe Rollers. Pipe rollers, if required, shall be of sufficient size to fully support the weight of the pipe while being hydro-tested and during pull back operations. A sufficient number of rollers shall be used to prevent sagging of the pipe.

b. Restrictions. Devices or placement systems for providing hydraulic thrust other than those previously defined shall not be used unless approved by the Engineer. Consideration for approval will be made on an individual basis for each specified location.

209.04 CONSTRUCTION REQUIREMENTS. The Contractor shall notify the Engineer at least 48 hours prior to starting work. The trenchless work shall not begin until the Engineer is present at the job site and agrees that preparations are in place as specified in the approved work plan. The Engineer's approval for beginning the installation shall in no way relieve the Contractor of the ultimate responsibility for the satisfactory completion of the work as authorized under the Contract.

(a) Horizontal Directional Drilling Requirements.

(1) Site Preparation. Prior to any alterations to the work site, the Contractor shall photograph or video the entire work area, including entry and exit points, one copy of which shall be provided to the Engineer and one copy of which shall remain with the Contractor.

The work site shall be graded or filled to provide a level working area. No alterations beyond what is required for operations shall be made. The Contractor shall confine all activities to designated work areas.

Prior to anchoring the drilling rig to the ground, the Contractor shall confirm locations of all underground utilities in the area of the drilling rig.

(2) Drill Path Survey. The entire drill path shall be accurately surveyed, with entry and exit stakes placed in the appropriate locations within the areas indicated on the Plans. If the Contractor uses a magnetic guidance system, the drill path shall be surveyed for any surface geo-magnetic variations or anomalies.

(3) Environmental Protection. The Contractor shall adhere to all applicable environmental regulations and install any EPSC measures necessary to contain all drilling material and fluid around the drilling operation, drilling fluid mixing systems, entry and exit pits, and drilling fluid recycling system. EPSC measures shall be shown on the EPSC plan submittal, or on the work plan if pay item 653.0100 is not included in the Contract. At a minimum, the plan shall show perimeter controls that will contain the drilling material and fluid.

(4) Drilling. If a deviation greater than 5% of depth occurs, the Engineer may require the Contractor to pull back and re-drill from the location along the bore path before the deviation.

In the event that drilling fluid fractures, inadvertent returns, or return losses occur during the pilot hole drilling operations, the Contractor shall cease drilling, wait at least 30 minutes, inject a quantity of drilling fluid with a viscosity exceeding 120 seconds as measured by a March funnel, and then wait another 30 minutes. If mud fracture or returns continue, the Contractor shall cease drilling operations and notify the Engineer. The Engineer and the Contractor will discuss additional options and work will then proceed accordingly.

(5) Reaming. Upon successful completion of the pilot hole, the Contractor shall ream the bore hole to a minimum diameter 25% greater than the outside diameter of the pipe to be installed using the appropriate tools. The Contractor shall not attempt to ream at one time more than the drilling equipment and mud system are designed to safely handle.

(6) Pull Back. The Contractor shall pull the pipe, casing, or sleeve through the bore hole. In front of the pipe shall be a pull head and swivel to connect to the drill rig for pull back. Once pull back operations have commenced, operations shall continue without interruption until the pipe is completely pulled into the drill hole. During the pull back, the Contractor shall not apply more than the maximum safe pull pressure at any time.

In the event that the pipe becomes stuck, the Contractor shall cease pulling operations to allow any potential hydro-lock to subside and shall then re-commence pulling operations. If the pipe remains stuck, the Contractor shall notify the Engineer. The Engineer and the Contractor will discuss options and then work will proceed accordingly.

(7) Inlet Grouting. Upon the completion of the installation, the inlet of the casing shall be sealed and capped to the satisfaction of the Engineer.

209.05 SITE RESTORATION. Following trenchless operations, the Contractor shall demobilize equipment and restore the work site to its original conditions. All excavations shall be backfilled with material from excavation or borrow, unless otherwise specified. The material shall be compacted to 95% of the material's maximum dry density as determined in accordance with *AASHTO T 99, Method C*. Landscaping shall be restored to the original conditions, or to the satisfaction of the Engineer.

209.06 RECORD KEEPING. The Contractor shall maintain a daily project log of trenchless operations and a guidance system log with a copy given to the Engineer at the completion of the work. At a minimum, the logs shall include the date, location of work, description of work, and pitch and depth of trenchless operations. The Contractor shall also give to the Engineer, at the completion of work, a revised work plan that shows any deviations made during construction.

209.07 METHOD OF MEASUREMENT. The quantity of Trenchless Excavation, Horizontal Directional Drilling of the type and size specified to be measured for payment will be the number of linear feet of drilling performed in the complete and accepted work.

209.08 BASIS OF PAYMENT. The accepted quantity of Trenchless Excavation, Horizontal Directional Drilling will be paid for at the Contract unit price per linear foot. Payment will be full compensation for all work required for a complete installation, including clearing, site preparation, excavation or grading needed, site restoration, grubbing, erosion control, excavation, excavation support, dewatering, drilling, removal of tailings, backfilling, compaction and flushing; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
209.0100 Trenchless Excavation, Horizontal Directional Drilling	Linear Foot

SECTION 210 – MILLING

210.01 DESCRIPTION. This work shall consist of the removal, disposal, and clean-up of bituminous pavements by coarse-milling or fine-milling.

210.02 EQUIPMENT AND OPERATION.

(a) General Requirements. Milling equipment shall be power-driven, self-propelled, and of a size and shape to allow traffic safe passage through areas adjacent to the work. The equipment shall have grade and slope controls capable of operating from a ski and based on mechanical or sonic operation.

The equipment shall have a positive means for controlling cross slope elevations. The equipment shall have sufficient weight to perform milling without lifting, and sufficient and positive down pressure on the drum assembly at all times when milling. The equipment shall also have conveyors capable of side or front loading to transfer the removed material from the roadway to a truck and an effective means of preventing dust from escaping into the air.

The cutting head shall use carbide or polycrystalline diamond (PCD) tipped cutting teeth designed for milling bituminous pavement to close tolerances. The cutting head shall be properly maintained so that the depth of cut is within a tolerance of 1/8 inch throughout the width of the head. The grinding and texturing mandrel shall have multiple wraps of flighting with a weld-on or quick-change block system that accepts carbide or PCD tipped cutting bits.

Bituminous surfaces adjacent to objects such as drop inlets and curbs that are inaccessible to milling equipment shall be milled with equipment designed for that purpose.

(b) Coarse-Milling Equipment. Equipment used for coarse milling shall have a cutting head with the teeth arranged in a manner such that the final pavement surface will have a center-to-center transverse pattern of 5/8 inch between each strike area. The target difference between ridge and valley (RVD) measurements of the mat surface shall not exceed 5/16 inch. The maximum axial distance between the tips of the teeth shall be 5/8 inch.

(c) Fine-Milling Equipment. Equipment used for fine milling shall have a cutting head with the teeth arranged in a manner such that the final pavement surface will have a center-to-center transverse pattern of 3/8 inch between each strike area. The target difference between ridge and valley (RVD) measurements of the mat surface shall not exceed 3/16 inch. The maximum axial distance between the tips of the teeth shall be 3/8 inch.

210.03 GENERAL CONSTRUCTION REQUIREMENTS. The bituminous surface shall be removed to the depth, width, and cross slope as shown on the Plans. The milling depth shall not vary from the typical cross-section depth by more than 1/8 inch. The milling operation shall produce a uniform surface and maintain a constant cross slope between extremities in each lane and shoulder.

Unless otherwise specified, all milled material, including dust and other material remaining on the milled surface after milling, shall become the property of the Contractor and shall be removed from the roadway immediately and disposed of properly. A Type II power broom shall be used to clean-up the milled surface after coarse-milling. Type II and Type III power brooms shall be used to clean-up the milled surface after fine-milling. The milled surface shall be cleaned prior to allowing traffic onto the surface.

The Contractor shall use caution when milling operations occur on bridge decks. Should any damage occur to the deck or membrane as a result of milling operations the Engineer will contact the Construction Structures Engineer to provide an assessment of the damage and recommend any necessary repairs. All damage determined to be the fault of the Contractor shall be repaired by the Contractor at no cost to the state.

When traffic shall be maintained for any period of time on a milled area, the following conditions apply:

(a) All butt joints 3/4-inch deep or greater shall have a temporary taper or wedge of bituminous concrete pavement installed with slope of 1:30 (V:H) or flatter. Tapers or wedges shall be in place prior to allowing traffic on the butt joint.

Longitudinal edges 2 inches in depth or greater and located at ramp areas shall be tapered a minimum of 7 feet. Suitable temporary aprons or fillets shall be constructed at side road intersections and driveways.

The Contractor shall be responsible for maintaining and repairing wedges and tapers throughout their use, to the satisfaction of the Engineer. Tapers and wedges shall be totally removed prior to placing permanent pavement at the respective butt joint.

(b) The Contractor shall repave any coarse-milled areas within 14 calendar days and any fine-milled areas within 35 calendar days of milling. Should the area remain unpaved for a period longer than specified herein, with the exception of milling ahead of full depth reclamation, no payment whatsoever will be made for the milled areas left exposed in excess of the 14 calendar day or 35 calendar day period. If the Contractor lays down temporary pavement to avoid the above nonpayment for milling, temporary pavement and subsequent milling shall be at the Contractor's expense.

(c) Milled areas susceptible to ponding of water shall be drained by cutting slots through the adjoining non-milled area. The slots shall then be filled with bituminous pavement up to existing grade. All costs of cutting and filling the slots will not be paid for directly but will be considered incidental to the applicable Contract item for milling.

210.04 FINE-MILLING. Fine-milling operations shall be performed as specified on the Plans with each travel lane being milled full width in a maximum of two passes of the fine-milling equipment.

Substantially all of the pavement surface shall be textured. Extra depth fine-milling of isolated low spots will not be necessary if it requires lowering of the overall profile of the pavement. The accumulated total of excluded areas shall not exceed 5% of the total area to be milled.

210.05 METHOD OF MEASUREMENT. The quantity of Coarse-Milling, Bituminous Pavement and Fine-Milling, Bituminous Pavement to be measured for payment will be the number of square yards of surface from which bituminous pavement has been removed.

210.06 BASIS OF PAYMENT. The accepted quantity of Coarse-Milling, Bituminous Pavement and Fine-Milling, Bituminous Pavement will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing all labor, tools, and equipment, including the Power Broom, Type II and Power Broom, Type III, necessary to complete the work.

All costs associated with installing, maintaining, and removing temporary tapers or wedges will not be paid for directly, but will be considered incidental to the applicable milling Contract item.

Payment will be made under:

Pay Item	Pay Unit
210.1000 Coarse-Milling, Bituminous Pavement	Square Yard
210.1200 Fine-Milling, Bituminous Pavement	Square Yard

SECTION 213 – MILLED RUMBLE STRIPS

213.01 DESCRIPTION. This work shall consist of texturing bituminous concrete pavement to construct rumble strips, disposing of waste millings, and cleaning up the pavement.

213.02 EQUIPMENT. The equipment for milling rumble strips shall consist of a power operated machine with a rotary type cutting head of a size that will provide milled depressions to the dimensions as shown on the Plans. The cutting heads shall have cutting tips arranged to provide a smooth cut.

The cutting heads shall be on a suspension independent from that of the power unit to allow the tool to self-align with the slope, or any irregularities, of the surface being milled. The cutting tool shall be equipped with guides to provide consistent alignment of each cut in relation to the roadway and to provide uniformity and consistency throughout the project. Equipment that tears, distorts, or otherwise damages the pavement adjacent to the milled depressions will not be allowed.

213.03 GENERAL CONSTRUCTION REQUIREMENTS. Rumble strips shall be milled to the finished dimensions, locations, and tolerances shown on the Plans, in accordance with these specifications or as directed by the Engineer.

Unless otherwise specified, the milled material shall become the property of the Contractor. All material shall be removed from the roadway immediately with a Type II power broom and shall become the property of the Contractor.

213.04 METHOD OF MEASUREMENT. The quantity of Milled Rumble Strips; Milled Rumble Strips, Shoulder; Milled Rumble Strips, Sinusoidal Shoulder; Milled Rumble Strips, Centerline; and Milled Rumble Strips, Sinusoidal Centerline to be measured for payment will be the longitudinal length in linear feet of treated surface measured. The measurement will include the non-milled lengths between adjacent strips. Gaps or breaks greater than 10 feet will not be measured for payment.

213.05 BASIS OF PAYMENT. The accepted quantity of Milled Rumble Strips; Milled Rumble Strips, Shoulder; Milled Rumble Strips, Sinusoidal Shoulder; Milled Rumble Strips, Centerline; and Milled Rumble Strips, Sinusoidal Centerline will be paid for at the Contract unit price per linear foot. Payment shall be full compensation for furnishing all labor, tools, and equipment, including the Type II power broom, necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
213.1000	Milled Rumble Strips	Linear Foot
213.2010	Milled Rumble Strips, Shoulder	Linear Foot
213.2015	Milled Rumble Strips, Sinusoidal Shoulder	Linear Foot
213.3010	Milled Rumble Strips, Centerline	Linear Foot
213.3015	Milled Rumble Strips, Sinusoidal Centerline	Linear Foot

SECTION 217 – REINFORCED SOIL SLOPE

217.01 DESCRIPTION. This work shall consist of constructing a reinforced soil slope in accordance with the Contract and as directed by the Engineer.

217.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Granular Borrow 703.04
Geotextile for Roadbed Separator.....720.02

Geogrid shall be new, clean, and in accordance with manufacturer recommendations.

The geogrid reinforcement for primary slope stabilization shall be a uniaxially oriented grid structure. The geogrid reinforcement for secondary slope stabilization shall be a biaxially oriented grid structure.

Uniaxial geogrid shall have a regular grid structure. The geogrid shall have high resistance to deformation under sustained long-term design load while in service and shall also be resistant to ultraviolet degradation, damage under normal construction practices, and all forms of biological or chemical degradation normally encountered in the material being reinforced.

Biaxial geogrid shall have a regular grid structure. The geogrid shall maintain its reinforcement and interlock capabilities under repeated dynamic loads while in service and shall be resistant to ultraviolet degradation, damage under normal construction practices, and all forms of biological or chemical degradation normally encountered in the material being reinforced.

In addition, geogrid shall conform to the following requirements:

(a) Long Term Tensile Strength. The Contractor shall provide manufacturer certified tested geogrid meeting the long term allowable tensile strengths shown on the Plans and conforming to the following criteria:

$$T_{al} = \frac{T_{ult}}{RF}$$

where:

T_{al} = Long term allowable tensile strength

T_{ult} = Ultimate tensile strength, as determined in the primary strength direction in accordance with *ASTM D6637*

RF = Total reduction factor

and,

$$RF = RF_{cr} \times RF_{id} \times RF_{d}$$

where:

RF_{cr} = Reduction factor for creep deformation for 100 year design life, calculated in accordance with Geosynthetic Research Institute *GG4(a)* and *GG4(b)* using *ASTM D5262*

RF_{id} = Reduction factor for installation damage, calculated in accordance with *ASTM D5818*

RF_{d} = Reduction factor for durability, as determined in accordance with *EPA 9090* and *ASTM D4355*

(b) Minimum Pullout Resistance Factor. The minimum pullout resistance factor shall be 0.50 as determined by *ASTM D6706*.

(c) Markings. Each roll of geogrid shall be plainly and permanently marked with the following information:

(1) Name or trademark of manufacturer.

(2) Date of manufacture.

(3) Product identification.

217.03 SUBMITTALS. The Contractor shall submit fabrication drawings and a narrative in accordance with Subsection 105.06. The submittals shall include, but are not limited to, the following:

(a) Data for each roll of material documenting that the strength and elongation at yield and break comply with the product specifications and material requirements in the Plans and herein.

(b) A geogrid placement plan.

(c) Installation details, including a description of sequence and backfill placement as well as how the proposed grade will be maintained.

Submittals shall be made to the Engineer 30 calendar days prior to geogrid installation.

Within 14 calendar days of completing the geogrid installation, the Contractor shall submit record drawings showing panel layout and installation sequence to the Engineer.

217.04 CONSTRUCTION REQUIREMENTS.

(a) Product Delivery, Storage, and Handling. The Contractor shall deliver sufficient materials to the site to prevent interruption of the work.

The Contractor shall inspect all materials upon delivery and shall notify the Engineer, and vice versa, of any damage. Damaged materials shall be returned and replaced at no cost to the Agency.

Geogrid shall be stored above 32°F. The Contractor shall prevent mud, wet cement, epoxy, and similar materials which may affix themselves to the grid, from coming into contact with the geogrid material. Rolled geogrid material shall be laid flat or stood on edge for storage. Geogrid shall be kept covered with protective wrapping until ready for use.

Geogrid shall be handled carefully with approved handling devices in strict conformance with the manufacturer's recommendations. Products shall not be dropped or rolled off trucks, nor shall products be otherwise dragged, rolled, or skidded.

(b) Site Preparation. All areas immediately beneath the installation area for the geogrid shall be properly prepared. The subgrade surface shall be level and free from deleterious material and loose or otherwise unsuitable soils in accordance with Section 203. The subgrade surface shall be inspected and approved by the Engineer prior to backfill placement.

(c) Geogrid Placement. The Contractor shall provide on-site representatives for consultation from the geogrid supplier for a minimum of 3 working days at the start of the geogrid installation.

The geogrid shall be installed in accordance with the manufacturer's recommendations. The geogrid shall be placed in continuous longitudinal strips in the direction of the main reinforcement. However, if the Contractor is unable to complete a required length with a single continuous length of geogrid, a joint may be made in accordance with manufacturer's recommendations with the approval of the Engineer. Adjacent strips need not be overlapped.

The Contractor shall only place that amount of geogrid required pending work to prevent undue damage. After a layer of geogrid has been placed in its entirety, the next succeeding layer of soil shall be placed in its entirety and compacted. After the specified layer has been placed in its entirety, the next geogrid layer shall be installed in its entirety. The process shall be repeated for each subsequent layer of geogrid and soil.

Geogrid reinforcement shall be placed to lay flat and pulled tight prior to backfilling. After a layer of geogrid has been placed, suitable means, such as pins or small piles of soil, shall be used to hold geogrid in position until the subsequent soil layer can be placed.

Geogrid shall be placed directly on the compacted horizontal fill surface. Geogrids are to be placed within 3 inches of the design elevations and extend the length as shown on the elevation view, unless otherwise directed by the Engineer. The Contractor shall verify correct orientation of the geogrid.

(d) Backfill Placement. Any damaged geogrid shall be replaced prior to placement of any overlying material at no cost to the Agency. Backfill shall be granular borrow and shall be compacted to at least 95% of the maximum density determined in accordance with *AASHTO T 99*. Backfill within 3 feet of slope face shall typically be compacted with hand equipment.

In-place density testing shall be performed by the Contractor for every soil lift at a frequency of one test for every 4,300 square feet, or as otherwise specified by the Engineer. Backfill shall be placed, spread, and compacted in such a manner to minimize the development of wrinkles or displacement of the geogrid.

Fill shall be placed in 8 inch maximum lift thicknesses.

Backfill shall be graded away from the slope crest and rolled at the end of each work day to prevent ponding of water on the reinforced soil mass. The site shall be maintained to prevent the flow of water from overtopping slope crest during construction and after completion of slope. The slope face shall be trimmed such that geogrid reinforcement extends to surface.

Under no circumstances shall a tracked vehicle be allowed on the geogrid before at least 6 inches of soil has been placed. Turning of tracked vehicles shall be kept to a minimum to prevent tracks from displacing the fill and the geogrid. All equipment shall travel at speeds of less than 10 mph. Sudden braking and sharp turning shall be avoided.

217.05 METHOD OF MEASUREMENT. The quantity of Reinforced Soil Slope to be measured for payment will be the quantity of geogrid, excluding overlaps, in square yards, in place in the complete and accepted work. The geogrid shall be measured from intact transverse rib to intact transverse rib.

217.06 BASIS OF PAYMENT. The accepted quantity of Reinforced Soil Slope will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing and installing the specified materials in accordance with the Contract, including on-site supplier representation, site preparation, geogrid reinforcement, geotextile placed under backfill, and backfill, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment for excavation, topsoil, turf establishment, mulch, erosion matting, and stone fill will be made separately under the appropriate Contract items.

Payment will be made under:

Pay Item	Pay Unit
217.1000 Reinforced Soil Slope	Square Yard

SECTION 219 – SLOPE STABILIZATION SYSTEM

219.01 DESCRIPTION. This work shall consist of furnishing all materials, equipment, labor, and services necessary to install and test a slope stabilization system (SSS), including, but not limited to, slope stabilization nails and a stabilizing facing, in accordance with these specifications, the Plans, and as directed by the Engineer.

219.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Mortar, Type III .....707.01(d)
Bar Reinforcement 713.01
Welded Wire Reinforcement 713.03
Slope Stabilization Nails 760.01
Shotcrete 760.02
Slope Drainage 760.03
Wire Mesh Facing 760.04

In addition to the requirements of Subsection 713.03, the welded wire reinforcement shall be galvanized in accordance with *ASTM A767*.

(a) Centralizers. Centralizers for solid bars shall be made from plastic, such as schedule 40 PVC. Centralizers for hollow bars shall be mobile metal type centralizers that have an inside diameter larger than the outside diameter of the slope stabilization nail but smaller than the outside diameter of the couplers.

(b) Grout. Grout shall be Type III mortar in accordance with Subsection 707.01(d).

(c) Slope Drainage. Slope drainage shall be strip drain, sheet drain, or PVC drain as shown on the Plans.

219.03 GENERAL WORK REQUIREMENTS. Work required for the SSS includes but is not limited to slope clearing and scaling as needed, installation and testing of slope stabilization nails of length and orientation as indicated in the Contract, installation or placement of facing material and related materials, and attachment to slope stabilization nails at specified pre-tensioned levels when applicable.

The Contractor shall be responsible for construction means and methods and control of the work associated with SSS construction, including slope stabilization nail and stabilizing facing. This includes, but is not limited to, the construction sequence, the safety of the workers, temporary handrails, work area access, barriers, and lifting of materials and construction equipment into and out of the work area.

The construction sequence shall be in accordance with the approved SSS manufacturer's instructions, unless approved otherwise by the Engineer.

219.04 SUBSURFACE INFORMATION. Available information concerning subsurface soil, rock, and groundwater conditions at designated SSS areas is presented in the Contract. If the Contractor requires additional subsurface information, the Contractor may obtain such information at no additional cost to the Agency.

219.05 EXISTING SITE CONDITIONS. The Contractor shall verify all existing dimensions and site slope conditions where SSS and slope stabilization nails are required and shall be responsible for determining actual locations of all existing utilities shown on the Plans, as well as those utilities or underground obstructions not shown on the Plans that may impact or conflict with the SSS and slope stabilization nail installation.

219.06 PRE-INSTALLATION MEETING. A pre-installation meeting shall be held prior to the start of work on the SSS and shall be attended by the Engineer, Contractor, and subcontractors. The pre-installation meeting shall be conducted to clarify the construction requirements for the work, to coordinate construction activities, and to identify contractual relationships and responsibilities.

219.07 SUBMITTALS.

(a) Pre-Construction Submittals. The Contractor shall submit the following information not less than 14 calendar days prior to the beginning of the work. Work shall not begin on the SSS until the submittals have been approved in writing by the Engineer.

(1) Qualifications. The Contractor shall submit proof and details of the following qualifications:

a. Three projects in the past 3 years where the Contractor or subcontractor performing the work has successfully installed slope stabilization nails and the specified slope facing system on slopes of similar height and steepness as shown on the Plans. A reference list shall be provided for the company and the on-site superintendent. A brief description of each project with the owner’s name and current phone number shall be included.

b. The on-site superintendent shall have a minimum of 2 years supervising construction of slope stabilization nails and slope stabilization facing systems of similar nail diameter and slope height and similar geotechnical conditions to those shown in the Contract. The work experience shall be direct supervisory responsibility for the on-site operation.

c. The shotcrete nozzleman shall be certified as an ACI Shotcrete Nozzleman in accordance with *ACI CP-60*. The shotcrete nozzleman shall have a minimum of 5 years of demonstrated experience in the installation of shotcrete. The shotcrete finishers and delivery equipment operators shall have a minimum of 2 years of demonstrated experience.

(2) Work Plan. The Contractor shall submit a detailed work plan for the slope stabilization nail and facing system installation. The work plan shall include, if applicable, but not be limited to:

a. The proposed construction sequence and schedule.

b. The proposed rope access methods and safety plan.

c. The proposed nail type and installation methods.

d. The proposed drilling and grouting methods and equipment, including drill rig type and drillhole diameter; and the method of cuttings removal.

e. Grout mix design, including brand and type of Portland cement; source, gradation, and quality of all aggregates; proportions of mix by weight and water-cement ratio; and manufacturer and brand name of all admixtures.

f. Nail grout placement procedures and equipment.

(3) Testing. The following information concerning testing of slope stabilization nails shall be submitted to the Engineer:

a. The number and locations of nails to be subjected to performance and proof testing, and the test load to be used in testing.

b. Details of the testing equipment and arrangement, including details of the jacking frame and the method of distributing test load pressures to the excavation surface or reaction frame, test nail bar size, and reaction plate dimensioning.

c. Methods of installing test nails, bonded and unbonded test lengths and methods for maintaining the unbonded length. Identification numbers and certified calibration records for each test jack and pressure gauge pair to be used shall be provided. Calibration records shall include the date tested, device identification number, and the calibration test results and shall be certified for an accuracy of at least 2% of the applied certification loads by a qualified independent testing laboratory within 90 calendar days prior to submittal.

(b) Record Drawings. Accurate records documenting the SSS as-built construction shall be maintained by the Contractor and submitted to the Engineer. The Contractor shall obtain as-built nail locations and all other information as required by the Agency.

219.08 CLEARING AND CLEANING OF SLOPE. The limits of clearing shall extend a minimum of ten feet outside the limits of the slope protection system or as approved by the Engineer.

Vegetation shall be cut flush with the ground surface in a manner that promotes complete contact of the facing system with the protected surface. Should removal of face protrusions result in voids beneath the facing system, the Contractor shall determine the appropriate method of backfilling based on field conditions. The proposed method shall be approved by the Engineer.

219.09 SLOPE STABILIZATION NAILS.

(a) Material Handling and Storage.

(1) Cement shall be adequately stored to prevent moisture degradation and partial hydration. Cement that has become caked or lumpy shall not be used.

(2) All nail bars shall be carefully handled and shall be stored on supports to keep the steel from contacting the ground. Steel bars shall be picked up in such a way as to prevent overstressing. Damage to the steel or galvanized coating as a result of overstressing, abrasion, cuts, nicks, welds, and weld spatter shall be cause for rejection by the Engineer.

Grounding of welding leads to the dowel steel will not be allowed.

Nail steel shall be protected from and sufficiently free of dirt, rust, and other deleterious substances prior to installation. Heavy corrosion or pitting of bars shall be cause for rejection by the Engineer. For damaged galvanized bars, the coating shall be repaired in accordance with the manufacturer's recommendations.

(b) Nail Testing.

(1) For each different method of nail installation, two successful performance tests shall be performed to verify the Contractor's installation methods, nail pullout capacity, and design assumptions. The tests shall be performed prior to installation of production nails at locations within the limits of work specified by the Engineer.

(2) Proof testing shall be performed on 5% of production slope stabilization nails. Nail testing shall not be performed until the nail grout has attained the 3-day compressive strength requirement. Proof test locations shall be selected by the Engineer. All test data shall be recorded and submitted to the Engineer in writing.

(3) Testing equipment shall include two dial gauges, a dial gauge support, jack with pressure gauge, a load cell, and a reaction frame. A minimum of two dial gauges capable of measuring to 0.001 inch shall be available at the site to measure the nail movement. The dial gauges shall have a minimum travel sufficient to allow the test to be performed without re-setting the dial gauge. The dial gauges shall be aligned within 5° of the axis of the nail and shall be supported independent of the jacking set-up and the rock surface. A hydraulic jack, pressure gauge, and pump shall be used to apply and measure the test load. Test set-up shall be as approved by the Engineer.

(4) The jack and pressure gauge shall be calibrated by an independent test laboratory as a unit. The pressure gauge shall be graduated in 100 psi increments or less. The jack shall be capable of tensioning nail bars to 80% of the guaranteed ultimate tensile strength of the bars within the rated pressure capacity of the pumping units, unless approved otherwise by the Engineer.

(5) The jack shall be independently supported and centered over the nail so that the nail does not carry the weight of the jack. The stressing equipment shall be placed over the nail in such a manner that the jack, bearing plates, and stressing anchorage are in alignment. The jack shall be positioned at the beginning of the test such that unloading and repositioning of the jack will not be required during the test. The Contractor will be required to provide a reaction bearing pad for each test. The bearing pad shall be constructed to a size and thickness that will prevent failure of the pad or movement of the test jack or bearing plate.

(6) The test nails shall be constructed using the same equipment, methods, and hole diameter as planned for the production nails. Changes in the drilling or installation method may require additional nail testing as determined by the Engineer and such testing shall be provided at no additional cost to the Agency.

(7) Performance test nails shall have both bonded and unbonded lengths. Prior to testing, only the bonded length of the test nail shall be grouted. The unbonded length of the test nail shall be at least 3 feet unless approved otherwise by the Engineer. The bond length shall be determined by the Engineer based on the design pullout load for the nails and the design bond strength indicated in the Plans. The design test load (DTL) shall not exceed 1.5 times the design load (DL) and shall not exceed 80% of the guaranteed ultimate tensile strength for the bar.

(8) Performance test nails shall be cyclically and incrementally loaded and unloaded in accordance with the schedule shown in Table 219.09A. The load shall be decreased to the alignment load (AL, defined as 0.05 DL) after each cycle maximum, and the movement of each successive alignment load step shall be recorded. At each load increment, the total movement of the pulling head shall be recorded to the nearest 0.001 inch with respect to an independent fixed reference point. The load shall be held at each increment just long enough to obtain the movement reading but no longer than 1 minute. Movement readings at the test load of 1.125 DL shall be taken at 1, 2, 4, 5, 6 and 10 minutes to measure creep rate. If the total creep movement between 1 minute and 10 minutes exceeds 0.040 inches the test load shall be maintained for an additional 50 minutes. Total movements shall then be recorded at 20, 30, 40, 50, and 60 minutes from the start of the test load hold time.

TABLE 219.09A – PERFORMANCE TEST NAIL LOADING SCHEDULE

Cycle	Load Increment							
	Alignment	1	2	3	4	5	6	7
1	AL	0.25 DL	--	--	--	--	--	--
2	AL	0.25 DL	0.50 DL	--	--	--	--	--
3	AL	0.25 DL	0.50 DL	0.75 DL	--	--	--	--
4	AL	0.25 DL	0.50 DL	0.75 DL	1.00 DL	--	--	--
5	AL	0.25 DL	0.50 DL	0.75 DL	1.00 DL	1.125 DL	--	--
6	AL	0.25 DL	0.50 DL	0.75 DL	1.00 DL	1.125 DL	1.25 DL	--
7	AL	0.25 DL	0.50 DL	0.75 DL	1.00 DL	1.125 DL	1.25 DL	1.50 DL

(9) Proof test nails shall be incrementally loaded in accordance with the schedule shown in Table 219.09B. At each load increment the total movement of the pulling head shall be recorded to the nearest 0.001 inch with respect to an independent fixed reference point. Movement readings at the maximum test load (1.125 DL) shall be taken at 1, 2, 4, 5, 6, and 10 minutes to measure creep rate. If the total creep movement between 1 minute and 10 minutes exceeds 0.040 inches, the test load shall be maintained for an additional 50 minutes. Total movements shall then be recorded at 20, 30, 40, 50, and 60 minutes from the start of the test hold time.

TABLE 219.09B – PROOF TEST NAIL LOADING SCHEDULE

Increment	Load	Movement Measurement?	Notes
1	AL	No	--
2	0.25 DL	Yes	--
3	0.50 DL	Yes	--
4	0.75 DL	Yes	--
5	1.00 DL	Yes	--
6	1.125 DL	Yes	Test load start
7	Hold	Yes	Test load at final hold

(c) Nail Testing Acceptance. A test nail shall be considered acceptable when all of the following are true:

(1) The creep rate is observed to be less than 0.040 inches per log cycle of time between the 1 minute and 10 minute readings or, if exceeded, less than 0.080 inches per log cycle of time between the 6 minute and 60 minute readings and the rate is linear or decreasing at the end of the creep test load hold period.

(2) The total movement at the test load exceeds 80% of the theoretical elongation of the unbonded length (plus jack length).

(3) A pullout failure does not occur during testing. Pullout failure is defined as the load at which attempts to increase the test load simply result in continued pullout movement of the test nail.

The Contractor shall evaluate the results of each performance test and submit a test results summary to the Engineer. Nail installation methods that do not satisfy the nail testing requirements shall be considered inadequate. The Contractor shall propose alternative methods and install replacement performance test nails at no additional cost to the Agency.

(e) Nail Installation. Nail installation of the slope stabilization nail type specified in the Plans shall proceed as detailed in the approved work plan. In addition, the following requirements shall be met:

(1) Successful nail performance tests shall be performed as described in Subsection 219.09(b) prior to starting installation of production nails.

(2) Nails shall be installed at the locations and to the lengths indicated on the Plans or as directed by the Engineer during construction. The Engineer may add, eliminate, or relocate nails to accommodate actual field conditions.

(3) The Contractor shall select the drilling equipment and methods suitable for the ground conditions. The drillhole diameter shall be selected to provide the minimum specified grout cover over the bar and to develop the specified pullout resistance. If solid bar is specified and caving conditions are encountered in the drillhole, the Contractor shall use cased or augercast drilling methods to support the sides of the drillhole. The use of hollow bars (also known as self-drilling, self-grouting, or pressure-grouted nail bars) will only be allowed if specified on the Plans. Water, drilling mud, or other fluids used to assist in cuttings removal shall not be allowed. Uncased and open drillholes shall be observed for cleanliness prior to insertion of the nail.

(4) For open or cased holes, nail bars shall be inserted into the drillhole to the required length without difficulty and in such a manner as to prevent damage to the drillhole. Nail bars that cannot be fully inserted to the design depth shall be removed from the drillhole and the drillhole shall be cleaned sufficiently to allow unobstructed installation of the bar.

(5) The nail shall be installed in a local depression with an approximate relative depth shown on the Plans.

(6) Nail bar couplers may be used in accordance with the manufacturer's recommendation as required.

(7) Centralizers shall be securely attached to the slope stabilization nail, sized to position the bar within 1 inch of the center of the drillhole, sized to allow the tremie tube insertion to the bottom of the drillhole, and sized to allow grout to flow freely up the drillhole.

(f) Grouting. Grouting procedures may differ based on allowable bar types specified in the Plans.

(1) Grout equipment shall produce a uniformly mixed grout free of lumpy and undispersed cement. A positive displacement grout pump shall be used. The pump shall be equipped with a pressure gauge that can measure at least twice but no more than three times the intended grout pressure. The grouting equipment shall be sized to enable the entire nail bar to be grouted in one continuous operation. The mixer shall be capable of continuously agitating the grout during usage.

(2) No portion of the nail hole shall be left open for more than 1 hour prior to grouting unless approved otherwise by the Engineer. The grout shall be injected at the lowest point of each drillhole through a tremie tube with the drillhole filled in one continuous operation. Grout pressures shall be controlled to prevent excessive ground heave or fracturing.

(3) Nail bars shall be inserted prior to grouting and cement grout shall be placed using a 0.75 inch diameter polyethylene (or similar) permanent grout tube attached to the nail bar. The grout tube shall have three openings cut into the lower 4.0 feet of the bond zone to allow free flow of grout. If the grout tube bottom opening becomes clogged, grout shall be placed by pumping grout into the grout tube.

(4) Hollow bar nails using self-drilling techniques shall be drilled with continuous grout injection unless otherwise approved by the Engineer.

(5) A grout sock may be used to reduce grout loss as determined by the Contractor based on drilling conditions encountered.

(6) During casing removal for drill holes advanced by either cased or augercast methods, the grout surface within the casing shall be continually monitored for maintenance of head sufficient to offset the external groundwater and soil pressure.

(7) Nail grout will be tested by the Agency in accordance with *AASHTO T 106* or *ASTM C109*. The compressive strength shall be the average of the 3 cubes tested. Grout consistency as measured by grout density shall be determined by the Contractor in accordance with *AASHTO T 133*, *ASTM C188*, or *API RP 13B-1* at a frequency of at least one test per day, conducted just prior to start of nail grouting. The Baroid mud balance used in accordance with *API RP 13B-1* is an approved device for determining the grout density of neat cement grout. The measured grout shall have a specific gravity of between 1.9 and 2.0, or as approved in the mix design submittal.

(8) The Engineer shall verify that the Contractor is using the approved grout mix on a daily basis. Any deviations from the approved mix will require additional testing.

(g) Tolerances. The nails shall not extend beyond the limits shown in the Plans unless approved otherwise by the Engineer. Nail bars shall be centered within 1 inch of the center of the drillhole. Individual nails shall be positioned no more than one foot from the design spacing shown on the Plans. Nail inclination shall be within ± 3° of that shown on the Plans. Nails that encounter unanticipated obstructions during drilling shall be relocated by the Contractor with the approval of the Engineer. Nails that do not satisfy the specified tolerances due to the Contractor's installation methods shall be replaced to the Engineer's satisfaction at no additional cost to the Agency.

219.10 WIRE MESH FACING. If wire mesh facing is specified on the Plans, installation procedures shall be as follows:

(a) The wire mesh shall be installed after placement of nails following the manufacturer's guidelines. The top and sides of the mesh shall be secured as recommended by the manufacturer. Horizontal and vertical connectors shall be as recommended by the manufacturer.

(b) The specified erosion control product shall be placed prior to the mesh placement. Matting shall be overlapped as recommended by the manufacturer.

(c) The wire mesh shall be pulled tightly across the slope over the nail tips to ensure contact between the ground and the mesh.

(d) The mesh shall be extended a distance beyond the boundary rope as shown on the Plans.

(e) Ground around the nails shall be recessed as shown on the Plans.

(f) Spike plates shall fit within the recessed area around the nail and be pressed firmly in the ground.

(g) Following installation of the spike plates, the nuts on the nail bars shall be tightened to the pre-stress level or tightening torque levels shown on the Plans using methods recommended by the manufacturer.

219.11 SHOTCRETE FACING. If shotcrete facing is specified on the Plans, installation procedures shall be as follows:

(a) Material Handling and Storage. Materials shall be delivered, stored, and handled to prevent contamination, segregation, corrosion, or damage. Liquid admixtures shall be stored to prevent evaporation and freezing

(b) Surface Preparation.

(1) The shotcrete facing shall be installed after placement of nails and installation of the permanent wall drainage as specified on the Plans.

(2) The geocomposite drain strips shall be 12 inches wide and shall be secured to the excavation face with the geotextile side against the ground as specified per the Plans. Drain strips shall be made continuous by using the shingle method of splicing with a 12 inch minimum overlap such that the flow of water is not impeded, or through use of splices supplied by the manufacturer.

(3) The joint between the weep pipe and the geocomposite drain strip, and the discharge end of the weep pipe shall both be sealed to prevent shotcrete intrusion. Damage to the geocomposite drain strip which, in the opinion of the Engineer, may cause interruption in flow shall require installation of additional weep pipes above the damaged section.

(4) The Contractor shall remove all loose material from the surface of the ungrouted zone above the nail grout at the excavation cut face (bird's beak) prior to shotcreting.

(5) The Contractor shall remove all loose materials and loose dried shotcrete from previous placement operations and from all receiving surfaces by methods acceptable to the Engineer. The removal shall be accomplished in such a manner as not to loosen, crack, or shatter the surfaces to receive the shotcrete. Any surface material that, in the opinion of the Engineer, is so loosened or damaged shall be removed to sufficient depth to provide a base that is suitable to receive the shotcrete. Material that loosens as the shotcrete is applied shall be removed. Shotcrete shall not be placed on frozen surfaces.

(6) Surfaces receiving shotcrete shall be damp but free of standing water.

(c) Delivery and Application.

(1) A clean, dry, oil-free supply of compressed air sufficient for maintaining adequate nozzle velocity for all parts of the work and simultaneous operations of the blow pipe for cleaning away rebound shall be maintained at all times. The equipment shall be capable of delivering the premixed material accurately, uniformly, and continuously through the delivery hose.

(2) The shotcrete shall be applied from the lower part of the work area upwards to prevent accumulation of rebound on uncovered surfaces. Thickness, methods of support, air pressure, and rate of placement of shotcrete shall be controlled to prevent sagging or sloughing of freshly applied shotcrete. Where shotcrete is used to fill the bird's beak, the nozzle shall be positioned into the mouth of the drill hole to completely fill the void. Rebound shall not be worked back into the placement nor shall the rebound be salvaged. Rebound that does not fall clear of the working area shall be removed. The nozzle shall be held at a distance and at an angle approximately perpendicular to the working face so that the rebound will be minimal and compaction will be maximized. The nozzle shall be rotated steadily in a small circular pattern.

(3) Shotcrete placement shall be by the bench gunning method when the thickness of the shotcrete layer is 6 inches or greater. The gunning method shall consist of building up a thick layer of shotcrete from the bottom of the lift and maintaining the top surface at approximately a 45° slope.

(d) Visual Observations.

(1) A clearly defined pattern of continuous horizontal or vertical ridges or depressions at the reinforcing elements after they are covered will be considered indication of insufficient cover of reinforcement or poor application and probable void. In this case, the work shall be immediately suspended and the work carefully inspected by the Engineer. The Contractor shall implement and complete corrective measures prior to resuming the shotcrete operations.

(2) The shotcreting procedure may be corrected by adjusting the nozzle distance and orientation perpendicular to the surface, adjusting the water content of the shotcrete mix, or other means acceptable to the Engineer. All overspray and rebound shall be removed from the surface.

(3) Surface defects shall be repaired as soon as possible after initial placement of shotcrete. All shotcrete that lacks uniformity, exhibits segregation, sagging, honeycombing, or lamination, or contains any voids or sand pockets shall be removed and replaced with fresh shotcrete by the Contractor to the satisfaction of the Engineer.

(4) If field inspection or testing, by the Engineer, indicates that any shotcrete produced fails to meet the requirements, the Contractor shall immediately modify procedures, equipment, or systems, as necessary, and as approved by the Engineer, to produce shotcrete meeting specifications. All substandard shotcrete already placed shall be repaired by the Contractor, to the satisfaction of the Engineer, at no additional cost to the Agency. Such repairs may include removal and replacement of all affected materials.

(e) Nail Head Connection Hardware.

(1) For bearing plate connections, the plate shall be wet-set while the shotcrete is plastic to ensure full shotcrete bearing behind the plate. However, the retention nut shall only be hand tightened such that full bearing is achieved without excessively squeezing fresh shotcrete out from under the plate.

(2) For embedded plate connections, the embedments shall be located within the wall such that the proper shotcrete cover is provided as shown on the Plans. In addition, the plate, washer, and nut shall be pulled up flush together by wiring to the reinforcement or other means necessary to ensure adequate contact between these parts.

(f) Finishing and Curing Requirements. The shotcrete shall be protected from loss of moisture for at least 7 days after placement. When shotcrete is being protected from low temperatures, curing shall be terminated no sooner than 24 hours after the removal of low temperature protection. Curing of shotcrete shall commence within one hour of shotcrete application. When the ambient temperature exceeds 80°F, the Contractor shall plan the work such that curing can commence immediately after finishing. The curing shall be completed using water, membrane, or film curing methods in accordance with the following requirements.

(1) If water curing is used, the rate of water application shall be regulated to provide complete surface coverage with minimum runoff.

(2) Curing compounds shall not be used on any surfaces against which additional shotcrete or other finishing materials are to be bonded unless the surface is sandblasted in a manner acceptable to the Engineer. Membrane curing compounds shall be spray applied as quickly as practical after initial shotcrete set, at a coverage of not less than 40 square feet per gallon.

(3) Polyethylene sheeting may be used to supplement water curing on shotcrete that will be covered later with additional shotcrete. The sheeting shall completely cover all surfaces, and have edges overlapped for proper sealing and anchorages.

(g) Weather Limitations.

(1) Shotcrete shall not be applied when ambient, substrate, and material temperatures are below 40°F or above 95°F, or during rainfall events. Shotcrete shall not be placed in cold weather unless adequately protected when the ambient temperature is below 40°F or when the shotcrete is likely to be subjected to freezing temperatures before reaching a minimum strength of 750 psi. Cold weather protection shall be maintained until the strength of the shotcrete is greater than 750 psi. Cold weather protection shall include heating under tents, blankets, or other means acceptable to the Engineer. The temperature of the shotcrete, when deposited, shall not be less than 50°F nor more than 80°F. The air in contact with shotcrete surfaces shall be maintained at temperatures above 32°F for a minimum of 7 days.

(2) Shotcrete application shall also be suspended during high winds and heavy rains when in the opinion of the Engineer the quality of the application is not acceptable. Newly placed shotcrete exposed to rain that washes out cement or otherwise makes the shotcrete unacceptable to the Engineer shall be removed and replaced. The Contractor shall provide adequately secured polyethylene sheeting or equivalent when adverse exposure to weather is anticipated.

(h) Test Panels.

(1) Two shotcrete test panels shall be required for pre-production. One shotcrete test panel shall be required per specified test frequency. Once per job, the Engineer may require a second test panel during the specified testing frequency to test for encapsulation. Panels shall be in the same shooting orientation as the production work. Panels shall not be disturbed or moved within the first 24 hours after shooting. Panels shall be field-cured under conditions similar to those anticipated for the work. Shotcreting of test panels shall be performed by qualified personnel in the presence of the Engineer.

Test panels and pre-production test panels shall be cored by the Contractor in the presence of the Engineer. Cores shall be delivered to the lab for testing no more than 24 hours after being taken. Cores for encasement scoring may be taken when the shotcrete has attained sufficient strength to not be damaged by coring. The testing frequency, if not specified elsewhere, shall be once per working day if the daily lot is less than 50 cubic yards, or every 50 cubic yard sublot, whichever is greater. If a daily sublot is anticipated to be 35 cubic yards or greater, another test set shall be performed.

(2) Pre-production and acceptance test panels shall be 30 inches by 30 inches (minimum) along with the following:

a. One pre-production test panel, or one test panel during acceptance testing frequency if specified by the Engineer, shall be the maximum shotcrete thickness shown on the Plans and shall include the maximum anticipated reinforcing congestion. Cores extracted from the reinforced test panel shall demonstrate encapsulation of the reinforcement in accordance with *ACI 506.2* equal to core grade 2 or better. At least two reinforcing intersections shall be cored.

b. One pre-production test panel and one test panel shall be unreinforced, at least 6 inches thick, and used for absorption and compressive strength testing. Pre-production test panel shotcrete shall be approved based on the same criteria as the shotcrete in the test panel.

c. The sides of the test panels shall be chamfered outward at 45° over the full thickness of the panel.

d. Panels shall be shot at approximately the same pressure as anticipated for the work.

(3) Shotcrete will be accepted based on the 7-day or 28-day strength of cores taken from the panels. The shotcrete strengths may be accepted if the average 7 day compressive strength of each set of three cores extracted from test panels or wall face is equal to or exceeds 85%, with no individual core less than 75%, of the specified 28 day compressive strength in accordance with *ACI 506.2*. The frequency specified for the test panels is approximate. A greater number of panels may be required by the Engineer.

(4) At least nine cores will be cut from each pre-production test panel and test panel for compressive strength and absorption testing. Cores shall be taken at a minimum distance from the edge of core to the edge of test panel in accordance with *ASTM C1140* and with a minimum of 1 inch between cores. Cores shall be conditioned accordance with *AASHTO T 24*. Cores shall be at least 4 inches in diameter and shall have a minimum length to diameter ratio of one. An alternate core size may be requested but shall be no less than 3 inches in diameter. When the length of the core is less than twice the diameter, the correction factors given in *ASTM C42* shall be applied to obtain the compressive strength of individual cores. Three cores shall be tested at 7-days, and three cores shall be tested at 28-days for compressive strength. Three cores shall be tested at 7-days for absorption in accordance with *ASTM C642*.

(i) Tolerances. The tolerances for shotcrete facings shall be as follows:

(1) The shotcrete wall thickness shall be no less than that shown on the Plans minus 0.5 inches.

(2) The horizontal and vertical locations of reinforcing bars shall be within 1 inch of the locations shown on the Plans.

(3) Reinforcing lap lengths shall be no less than that shown on the Plans minus 1 inch.

(4) Spacing of reinforcing bars shall not exceed that shown on the Plans plus 1 inch.

219.12 METHOD OF MEASUREMENT. The quantity of Slope Stabilization Nail to be measured for payment will be the number of linear feet of nail installed in the complete and accepted work, as determined by the Engineer.

The quantity of Slope Stabilization Nail Testing to be measured for payment will be the number of tests completed and accepted, as determined by the Engineer.

The quantity of Slope Stabilization System, Shotcrete Facing to be measured for payment will be the square feet of surface area of the completed facing measured to the neat lines of the facing shown on the Plans at the thickness specified on the Plans. Test panels will not be measured for payment.

The quantity of Slope Stabilization System, Wire Mesh Facing to be measured for payment will be the number of square feet of wire mesh installed in the complete and accepted work.

219.13 BASIS OF PAYMENT. The accepted quantity of Slope Stabilization Nail will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, drilling, installing, and grouting the slope stabilization nail, including all required submittals and for furnishing all labor, tools, equipment, and incidentals to complete the work.

The accepted quantity of Slope Stabilization Nail Testing will be paid for at the Contract unit price for each. Payment will be full compensation for performance testing the slope stabilization nails, proof testing slope stabilization nails, including all required submittals, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Slope Stabilization System, Shotcrete Facing will be paid for at the Contract unit price per square foot. Payment will be full compensation for furnishing and installing the specified materials for a complete in place shotcrete and welded wire mesh slope stabilization system in accordance with the Contract, including all required submittals, providing samples for acceptance testing, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Test panels will be considered incidental to Slope Stabilization System, Shotcrete Facing.

The accepted quantity of Slope Stabilization System, Wire Mesh Facing will be paid for at the Contract unit price per square foot. Payment will be full compensation for furnishing and installing the specified materials for a complete in place wire mesh slope stabilization system in accordance with the Contract, including all required submittals, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
219.1000	Slope Stabilization Nail	Linear Foot
219.1500	Slope Stabilization Nail Testing	Each
219.2000	Slope Stabilization System, Shotcrete Facing	Square Foot
219.3000	Slope Stabilization System, Wire Mesh Facing	Square Foot

SECTION 221 – ROCK SLOPE STABILIZATION

221.01 DESCRIPTION. This work shall consist of installing and testing various rock slope stabilization (RSS) items, including, but not limited to, rock dowels, shear keys, rock anchors, rock drains, rock nails, and shotcrete, in accordance with these specifications, the Plans, and as directed by the Engineer. This work may require using industrial rope access methods.

221.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Mortar, Type III .....707.01(d)
Welded Wire Reinforcement 713.03
Slope Stabilization Nails.....760.01
Shotcrete 760.02
Slope Drainage.....760.03

In addition to the requirements of Subsection 713.03, the welded wire reinforcement shall be galvanized in accordance with *ASTM A767*.

(a) Centralizers. Centralizers for solid bars shall be schedule 40 PVC or as stated on the Plans.

(b) Grout. Grout shall be Type III mortar in accordance with Subsection 707.01(d).

(c) Slope Drainage. Slope drainage shall be strip drain, sheet drain, PVC drain, or unlined drilled holes in rock as shown on the Plans.

221.03 SUBMITTALS. The Contractor shall submit to the Engineer, in accordance with Subsection 105.06, the following information for completing the work.

(a) Pre-Construction Submittals. The Contractor shall submit the following information not less than 14 calendar days prior to the beginning of the work. RSS work shall not begin until the submittals have been approved in writing by the Engineer.

(1) Qualifications. The Contractor shall submit proof and details of the following qualifications:

a. Three projects in the past 3 years where the Contractor or subcontractor performing the work has successfully installed the specified RSS items on rock slopes of similar height and similar geotechnical conditions to those shown on the Plans. A reference list shall be provided for the company and the on-site superintendent. A brief description of each project with quantities of relevant rock slope work performed and the owner's name, and current phone number and email shall be included.

b. The on-site superintendent shall have a minimum of 2 years of experience supervising construction of the specified RSS items on rock slopes of similar height and similar geotechnical conditions to those shown on the Plans. The work experience shall be direct supervisory responsibility for the on-site operation.

c. The shotcrete nozzleman shall be certified as an ACI Shotcrete Nozzleman in accordance with *ACI CP-60*. The shotcrete nozzleman shall have a minimum of 5 years of demonstrated experience in the installation and application of shotcrete. Nozzlemen shall be certified in either dry-mix or wet-mix shotcrete based on the process to be used for the work. The shotcrete finishers and delivery equipment operators shall have a minimum of 2 years of demonstrated experience.

(2) Work Plan. The Contractor shall submit a detailed work plan for the RSS installation. The work plan shall include, if applicable, but not be limited to:

a. The proposed construction sequence and schedule.

b. The proposed rope access methods and safety plan.

c. The proposed specifications for RSS material and associated hardware including manufacturer's certificates and data sheets.

d. The proposed drilling and grouting methods and equipment, including drill rig type, drillhole diameter, and the method of cuttings removal.

e. Grout mix design, including brand and type of Portland cement; source, gradation, and quality of all aggregates; proportions of mix by weight and water-cement ratio; and manufacturer and brand name of all admixtures.

f. Grout installation method and related equipment.

g. The proposed corrosion protection for RSS materials.

h. The proposed shotcrete product specifications mix design with material testing and data sheets.

i. The proposed steel reinforcement, including rock nails for shotcrete used to support the buttresses during curing, and steel fiber reinforcement.

j. The proposed shotcrete application procedure, anticipated time durations and curing methods, when curing will be applied (including alignment control), surface preparation, delivery and application, rock nails for shotcrete, and finishing methods.

k. The proposed color admixture manufacturer's product technical data sheets, design mixes, manufacturer's color charts showing the full range of colors available, and list of completed colored shotcrete projects if colored shotcrete is required per the Contract.

l. The proposed geotextile drainage material, including manufacturer's product data sheets, manufacturer's certifications, and the Contractor's installation methods.

(3) Testing. The Contractor shall submit the following information concerning testing of RSS items:

a. The number and locations of rock dowels and rock anchors to be subjected to performance and proof testing, and the test load to be used in testing.

b. Details of the testing equipment and arrangement, including details of the jacking frame and the method of distributing test load pressures to the excavation surface or reaction frame, test bar size, and reaction plate dimensioning.

c. Methods of installing test dowels and anchors, bonded and unbonded test lengths, and methods for maintaining the unbonded length.

d. Identification numbers and certified calibration records for each test jack and pressure gauge pair to be used. Calibration records shall include the date tested, device identification number, and the calibration test results and shall be certified for an accuracy of at least 2% of the applied certification loads by a qualified independent testing laboratory within 90 calendar days prior to submittal.

(b) Field Reports. The following information shall be submitted to the Engineer daily.

(1) Borehole location, diameter, direction, and angle measured from horizontal.

(2) Date and time of drilling, drilling equipment used, and name of driller.

(3) Details of encountered subsurface conditions.

(4) Location and length of RSS items installed, if applicable.

(5) Number of cement bags used, and water cement ratio used.

(6) Performance and proof tests performed.

(7) Location and volume of shotcrete applied including reinforcement details.

(c) Record Drawings. Accurate records documenting the RSS items as-built construction shall be maintained by the Contractor and submitted to the Engineer. The Contractor shall obtain as-built RSS materials locations, identification labels for RSS items and any other information as required by the Agency.

221.04 ROCK DOWELS.

(a) Material Handling and Storage.

(1) All RSS rock dowels shall be carefully handled and shall be stored on supports to keep the steel from contact with the ground. Steel bars shall be picked up in such a way as to prevent overstressing. Damage to the steel or galvanized coating as a result of overstressing, abrasion, cuts, nicks, welds, and weld spatter shall be cause for rejection by the Engineer. Grounding of welding leads to the steel will not be allowed. Steel shall be protected from and sufficiently free of dirt, rust, and other deleterious substances prior to installation. Heavy corrosion or pitting of bars shall be cause for rejection by the Engineer. All exposed parts of the RSS rock dowels, bearing plate, and hemispherical nuts on the surface shall be galvanized. Steel ends, where cut, shall be painted with a cold galvanizing compound following installation. For damaged galvanized bars, the coating shall be repaired in accordance with the manufacturer’s recommendations.

(b) Testing.

(1) For each different method of installation, two successful pre-production proof tests shall be performed to verify the Contractor's installation methods, pullout capacity, and design assumptions. The tests shall be performed prior to installation of production dowels at locations within the limits of work specified by the Engineer.

(2) Unless otherwise stated in the Plans or directed by the Engineer, 5% of production RSS rock dowels will be proof tested.

(3) Drilling boreholes for production rock dowels prior to successful pre-production proof tests will be prohibited unless approved by the Engineer. The bars used for the pre-production proof tests shall be sacrificial and shall not be incorporated as production.

(4) Testing shall not be performed until the grout has attained at least 50% of its specified compressive strength as shown in the Contact Documents. All test data shall be recorded by the Contractor and submitted to the Engineer.

(5) Testing equipment shall include two dial gauges, a dial gauge support, jack with pressure gauge, a load cell, and a reaction frame. A minimum of two dial gauges capable of measuring to 0.001 inch shall be available at the site to measure the movement. The dial gauges shall have a minimum travel sufficient to allow the test to be performed without re-setting the dial gauge. The dial gauges shall be aligned within 5° of the axes of the bars and shall be supported independent of the jacking set-up and the rock surface. A hydraulic jack, pressure gauge, and pump shall be used to apply and measure the test load. Test set-up shall be as approved by the Engineer.

(6) The jack and pressure gauge shall be calibrated by an independent test laboratory as a unit. The Contractor shall submit calibration reports for the jack and pressure gauge indicating calibration within 90 calendar days prior to use. Testing will not be allowed until approval of the calibration report by the Engineer.

(7) The pressure gauge shall be graduated in 100 psi increments or less. The jack shall be capable of tensioning dowel bars to 80% of the guaranteed ultimate tensile strength of the bars within the rated pressure capacity of the pumping units, unless approved otherwise by the Engineer.

(8) The jack shall be independently supported and centered over the bar so that the bar does not carry the weight of the jack. The stressing equipment shall be placed over the bar in such a manner that the jack, bearing plates, and stressing anchorage are in alignment. The jack shall be positioned at the beginning of the test such that unloading and repositioning of the jack will not be required during the test. The Contractor will be required to provide a reaction bearing pad for each test. The bearing pad shall be constructed to a size and thickness that will prevent failure of the pad or movement of the test jack or bearing plate.

(9) Details of the testing arrangement, including the method of distributing test load pressures to the rock surface or reaction frame, test bar size, grouted hole diameter and reaction plate dimensioning shall be developed by the Contractor and submitted to the Engineer for approval. The test bars shall be constructed using the same equipment, methods, and hole diameter as planned for the production. Changes in the drilling or installation method may require additional testing as determined by the Engineer. Additional testing shall be provided at no additional cost to the Agency.

(10) Rock dowels for pre-production proof testing shall have both bonded and unbonded lengths. Prior to testing, only the bonded length of the test bar shall be grouted. The unbonded length of the test bar shall be at least 3 feet unless approved otherwise by the Engineer. The bond length shall be determined by the Engineer based on the design pullout load and the design bond strength indicated in the Plans. The design test load (DTL) shall not exceed 1.33 times the design load (DL) and shall not exceed 80% of the guaranteed ultimate tensile strength for the bar.

(11) Proof tests shall be performed by incrementally loading the test dowel in accordance with the schedule shown in Table 221.04A. At each load increment the total movement of the pulling head shall be recorded to the nearest 0.001 inch with respect to an independent fixed reference point. Movement readings at the maximum test load (1.33 DL) shall be taken at 1, 2, 4, 5, 6, and 10 minutes to measure the creep rate. If the total creep movement between 1 minute and 10 minutes exceeds 0.040 inches, the test load shall be maintained for an additional 50 minutes. Total movements shall then be recorded at 20, 30, 40, 50, and 60 minutes from the start of the test hold time. The alignment load (AL) shall be the minimum load required to align the testing apparatus and shall not exceed 0.25 DL. During load hold periods, the rock dowel load shall not be allowed to deviate from the test pressure by more than 50 psi. The load shall be returned to the cycle maximum load prior to taking the movement reading at the cycle interval.

TABLE 221.04A – PROOF TEST DOWEL LOADING SCHEDULE

Increment	Load	Movement Measurement?	Notes
1	AL	No	--
2	0.25 DL	Yes	--
3	0.50 DL	Yes	--
4	0.75 DL	Yes	--
5	1.00 DL	Yes	--
6	1.25 DL	Yes	--
7	1.33 DL	Yes	Test load start
8	Hold	Yes	Test load at final hold

(c) Proof Testing Acceptance. A test shall be considered acceptable when all of the following are true:

(1) The creep rate is observed to be less than 0.040 inches per log cycle of time between the 1 minute and 10 minute reading or, if exceeded, less than 0.080 inches per log cycle of time between the 6 minute and 60 minute readings and the rate is linear or decreasing at the end of the creep test load hold period.

(2) A pullout failure does not occur during testing. Pullout failure is defined as the load at which attempts to increase the test load simply result in continued pullout movement of the test.

The Contractor shall evaluate the results of each proof test and submit a test results summary to the Engineer. Installation methods that do not satisfy the testing requirements shall be considered inadequate. The Contractor shall propose alternative methods and install replacement proof test dowels at no additional cost to the Agency.

(d) Dowel Installation and Grouting. Dowels shall be installed as specified on the Plans and shall proceed as detailed in the approved work plan. In addition, the following requirements shall be met:

(1) Successful pre-production rock dowel proof tests shall be performed as described in Subsection 221.04(b) prior to starting installation of production dowels.

(2) Dowels shall be installed at the locations and to the lengths indicated on the Plans or as directed by the Engineer during construction. The Engineer may add, eliminate, or relocate dowels to accommodate actual field conditions.

(3) The Contractor shall flush the drill hole of all drill cuttings and debris with compressed air prior to the installation of rock dowel. Holes drilled for which installation is considered by the Engineer to be unacceptable or impractical shall be re-drilled at the Contractor's expense.

(4) The cement grout shall be mixed for a minimum of five minutes in a paddle-type grout mixer and passed through a No. 4 (4.75 mm) sieve before being used. Grout may be pumped or fed by gravity into the tremie pipe or grout tube. Grout containing lumps or that has been in the grout mixer for more than 30 minutes shall not be used. The Contractor shall flush the drill hole of all drill cuttings and debris with compressed air prior to grout installation.

(5) For installed bar lengths of 7 feet or less, the Contractor shall tremie neat cement grout into hole with tremie pipe at the toe of the hole. The hole shall be filled with grout while the tremie pipe is withdrawn at a rate such that the bottom of the tremie pipe remains at or below the rising grout surface. For installed bar lengths of greater than 7 feet, the Contractor shall leave hole full of fluid grout for five minutes. If the grout level drops by less than 1 inch, the Contractor shall insert the bar with centralizers into the hole. If the grout level drops by more than 1 inch in five minutes, the Contractor shall re-fill the hole with grout. If the grout level continues to drop for more than 15 minutes, the grout mix shall be thickened as directed by the Engineer. The bar with centralizers shall be inserted once the level stabilizes.

(6) The annular space between the rock dowel and the drill hole perimeter in the completed installation shall be completely filled with cement grout over the full depth of the hole. Sufficient grout shall be used such that, at a minimum, a small amount of grout extrudes from the collar of the hole when the dowel is inserted to ensure that no voids are left around the bar. The quantity of grout that is required to fill each dowel hole will vary and is highly dependent on geological conditions.

(7) For rock dowels, the bird's beak annulus between the dowel and the hole shall be filled with hand-packed grout as shown on the Plans, and the face plates and nuts shall be attached and tightened with a wrench as directed by the Engineer.

(8) The Engineer shall verify that the Contractor is using the approved grout mix on a daily basis. Any deviations from the approved mix will require additional testing.

(e) Grout Testing.

(1) The strength of the grout shall be tested for at least every 10 rock dowels installed. Grout will be tested by the Agency. Any grout cubes tested by the Contractor will be considered quality control. Acceptable grout shall have a minimum compressive strength as detailed in the Contact.

(2) Grout will be tested by the Agency in accordance with *AASHTO T 106* or *ASTM C109*. The compressive strength shall be the average of the 3 cubes tested. Grout consistency as measured by grout density shall be determined by the Contractor in accordance with *AASHTO T 133*, *ASTM C188*, or *API RP-13B-1* at a frequency of at least one test per day, conducted just prior to the start of dowel grouting. The Baroid mud balance used in accordance with *API RP 13B-1* is an approved device for determining the grout density of neat cement grout. The measured grout shall have a specific gravity of between 1.9 and 2.0, or as approved in the mix design submittal.

(f) Tolerances. The RSS items shall not extend beyond the limits shown in the Plans unless approved otherwise by the Engineer. Bars shall be centered within 1 inch of the center of the drillhole. Individual dowels shall be positioned no more than one foot from the design spacing shown on the Plans. Inclination shall be within ± 5° of that shown on the Plans. RSS items that encounter unanticipated obstructions during drilling shall be relocated by the Contractor with the approval of the Engineer. RSS items that do not satisfy the specified tolerances due to the Contractor's installation methods shall be replaced to the Engineer's satisfaction at no additional cost to the Agency.

221.05 ROCK ANCHORS.

(a) Material Handling and Storage. Materials shall be handled and stored as specified in Subsection 221.04(a).

(b) Testing. Testing shall be performed as specified in Subsection 221.04(b) with the following additional requirement:

(1) Performance tests shall be performed by cyclically and incrementally loading and unloading the test anchor in accordance with the schedule shown in Table 221.05A. The load shall be decreased to the alignment load (AL, defined as 0.05 DL) after each cycle maximum, and the movement of each successive alignment load step shall be recorded. At each load increment, the total movement of the pulling head shall be recorded to the nearest 0.001 inch with respect to an independent fixed reference point. The load shall be held at each increment just long enough to obtain the movement reading but no longer than 1 minute. Movement readings at the test load of 1.33 DL shall be taken at 1, 2, 4, 5, 6 and 10 minutes to measure creep rate. If the total creep movement between 1 minute and 10 minutes exceeds 0.040 inches the test load shall be maintained for an additional 50 minutes. Total movements shall then be recorded at 20, 30, 40, 50 and 60 minutes from the start of the test load hold time.

TABLE 221.05A – PERFORMANCE TEST ANCHOR LOADING SCHEDULE

Cycle	Load Increment							
	Alignment	1	2	3	4	5	6	7
1	AL	0.25 DL	--	--	--	--	--	--
2	AL	0.25 DL	0.50 DL	--	--	--	--	--
3	AL	0.25 DL	0.50 DL	0.75 DL	--	--	--	--
4	AL	0.25 DL	0.50 DL	0.75 DL	1.00 DL	--	--	--
5	AL	0.25 DL	0.50 DL	0.75 DL	1.00 DL	1. 25 DL	--	--
6	AL	0.25 DL	0.50 DL	0.75 DL	1.00 DL	1.25 DL	1.33 DL	--

(c) Testing Acceptance. A test shall be considered acceptable when all of the following are true:

(1) The creep rate is observed to be less than 0.040 inches per log cycle of time between the 1 minute and 10 minute reading or, if exceeded, less than 0.080 inches per log cycle of time between the 6 minute and 60 minute readings and the rate is linear or decreasing at the end of the creep test load hold period.

(2) The total movement at the test load exceeds 80% of the theoretical elongation of the unbonded length (plus jack length) and is less than 100% of the theoretical elongation of the unbonded length (including the jack length) plus 50% of the bonded length.

(3) A pullout failure does not occur during testing. Pullout failure is defined as the load at which attempts to increase the test load simply result in continued pullout movement of the test.

The Contractor shall evaluate the results of each anchor test and submit a test results summary to the Engineer. Installation methods that do not satisfy the testing requirements shall be considered inadequate. The Contractor shall propose alternative methods and install replacement test anchors at no additional cost to the Agency.

(d) Anchor Installation and Grouting. Anchor installation specified on the Plans shall proceed as detailed in the approved work plan. In addition, the following requirements shall be met:

(1) Anchors shall be installed at the locations and to the lengths indicated on the Plans or as directed by the Engineer during construction. The Engineer may add, eliminate, or relocate anchors to accommodate actual field conditions.

(2) The Contractor shall flush the drill hole of all drill cuttings and debris with compressed air prior to the installation of rock anchor. Holes drilled for which installation is considered by the Engineer to be unacceptable or impractical shall be re-drilled at the Contractor's expense.

(3) The cement grout shall be mixed for a minimum of five minutes in a paddle-type grout mixer and passed through a No. 4 (4.75 mm) sieve before being used. Grout may be pumped or fed by gravity into the tremie pipe or grout tube. Grout containing lumps or that has been in the grout mixer for more than 30 minutes shall not be used. The Contractor shall flush the drill hole of all drill cuttings and debris with compressed air prior to grout installation.

(4) Anchor installation shall be completed with a single stage of grouting that utilizes a fabricated anchor inserted into a prepared borehole. Once in place the anchor will be checked to ensure that there is a level bearing plate surface, and where necessary hand placed grout will be troweled around the borehole. With a level anchor head surface the anchor will be tremie grouted to the surface. If an encapsulated anchor is not used, then two stage grouting will be required.

(5) Grouting of holes shall be performed by placing grout through a tremie tube installed at the bottom of the open hole. The tremie tube may be withdrawn as grouting proceeds, however, grout shall be maintained over the end of the tremie tube at all times.

(6) Grouting, to establish the anchorage, will be completed to establish a bond length sufficient to resist the 1.33 DL or as directed by the Engineer. For grouting, the anchor bar shall be inserted in the hole and the grout placed through a tremie tube to fill the borehole. The Contractor shall observe the grout level for five minutes. If the grout level drops by more than 1 inch in five minutes, the Contractor shall re-fill the hole with grout to the original level. The use of a grout sock will be permitted to limit grout loss.

(7) Following the placement of the grout through a tremie tube and filling the bird's beak annulus between the anchor and the hole with hand-packed grout, the washer and nut will be installed and the anchor loaded to 1.10 DL. The nut shall be tightened with a wrench to lock off the anchor at the 1.10 DL load and the jack shall be removed.

(8) After acceptance of the anchor by the Engineer, the end of the bar shall be cut to its final length as directed by the Engineer. Cutting of the bars with torches will not be permitted. Anchor ends, where cut, shall be painted with a cold galvanizing compound following installation.

(9) The Engineer shall verify that the Contractor is using the approved grout mix on a daily basis. Any deviations from the approved mix will require additional testing.

(e) Grout Testing. Grout testing shall be performed as specified in Subsection 221.04(e).

(f) Tolerances. Tolerances shall be as specified in Subsection 221.04(f).

221.06 SHEAR KEYS.

(a) Material Handling and Storage. Materials shall be handled and stored as specified in Subsection 221.04(a).

(b) Shear Key Installation and Grouting. Shear key installation specified on the Plans shall proceed as detailed in the approved work plan and meet the requirements of Subsection 221.04(d)(2) through Subsection 221.04(d)(6). In addition, the following requirements shall be met:

(1) A minimum of 6 inches of the bar shall stick out from the drill hole. The steel sticking out shall be completely covered by Type III mortar, forming a buttress according to the dimensions shown on the Plans.

(2) The Engineer shall verify that the Contractor is using the approved grout mix on a daily basis. Any deviations from the approved mix will require additional testing.

(c) Grout Testing. Grout testing shall be performed as specified in Subsection 221.04(e).

(d) Tolerances. The shear key bars shall not extend beyond the limits shown in the Plans unless approved otherwise by the Engineer. The bars shall be centered within 1 inch of the center of the drillhole. Individual shear keys shall be positioned no more than one foot from the design spacing shown on the Plans. Bar inclination shall be within ± 3° of that shown on the Plans. Bars that encounter unanticipated obstructions during drilling shall be relocated by the Contractor with the approval of the Engineer. Bars that do not satisfy the specified tolerances due to the Contractor's installation methods shall be replaced to the Engineer's satisfaction at no additional cost to the Agency.

221.07 ROCK DRAINS. Rock drains shall be installed as specified in the Plans and shall proceed as detailed in the approved work plan. In addition, the following requirements shall be met:

(a) Drain inclination shall be within ± 3° of that shown on the Plans.

(b) Drains that encounter obstructions during drilling shall be relocated by the Contractor with the approval of the Engineer.

(c) Drains that do not satisfy the specified tolerances due to the Contractor's installation methods shall be replaced to the Engineer's satisfaction at no additional cost to the Agency.

221.08 ROCK NAILS.

(a) Material Handling and Storage. Materials shall be handled and stored as specified in Subsection 221.04(a).

(b) Rock Nail Installation and Grouting. Nail installation of the slope stabilization nail type specified on the Plans shall proceed as detailed in the approved work plan and meet the requirements of Subsection 221.04(d)(2) through Subsection 221.04(d)(6).

(c) Grout Testing. Grout testing shall be performed as specified in Subsection 221.04(e).

(d) Tolerances. Tolerances shall be as specified in Subsection 221.06(d).

221.09 SHOTCRETE. If a shotcrete is specified on the Plans, the installation procedures shall be as follows:

(a) Material Handling and Storage. Materials shall be delivered, stored, and handled to prevent contamination, segregation, corrosion, or damage.

(b) Surface Preparation.

(1) The shotcrete shall be installed after placement of rock nails and installation of the permanent wall drainage as specified on the Plans.

(2) When geocomposite drain strips are required per the Plans, then the drain strips shall be 12 inches wide and shall be secured to the excavation face with the geotextile side against the ground as specified in the Plans. Drain strips shall be made continuous by using the shingle method of splicing with a 12 inch minimum overlap such that the flow of water is not impeded, or through use of splices supplied by the manufacturer.

(3) The weep drains shall be installed at the locations and to the lengths indicated on the Plans or as directed by the Engineer during construction. Unless specified in the Plans, drill holes shall be no larger than 3 inches in diameter, and the pipe shall extend 1 inch to 3 inches beyond the final slope face. The PVC pipe shall be installed before applying the shotcrete.

(4) The joint between the weep pipe and the geocomposite drain strip, and the discharge end of the weep pipe shall both be sealed to prevent shotcrete intrusion. Damage of the geocomposite drain strip which, in the opinion of the Engineer, may cause interruption in flow shall require installation of additional weep pipes above the damaged section.

(5) The Contractor shall remove all loose material from the surface of the ungrouted zone if any rock anchors, rock dowels, or rock nails for shotcrete are installed within the limits of the shotcrete, prior to shotcreting.

(6) The Contractor shall remove all loose materials and loose dried shotcrete from previous placement operations and from all receiving surfaces by methods acceptable to the Engineer. The removal shall be accomplished in such a manner as not to loosen, crack, or shatter the surfaces to receive the shotcrete. Any surface material that, in the opinion of the Engineer, is so loosened or damaged shall be removed to sufficient depth to provide a base that is suitable to receive the shotcrete. Material that loosens as the shotcrete is applied shall be removed. Shotcrete shall not be placed on frozen surfaces.

(7) Surfaces receiving shotcrete shall be damp but free of standing water.

(c) Delivery and Application.

(1) Wet-mix shotcrete shall be placed within 90 minutes of mixing the cementitious material with the aggregate, unless approved otherwise by the Engineer. Dry-mix shotcrete shall be placed within 45 minutes of mixing.

(2) A clean, dry, oil-free supply of compressed air sufficient for maintaining adequate nozzle velocity for all parts of the work and simultaneous operations of the blow pipe for cleaning away rebound shall be maintained at all times. The equipment shall be capable of delivering the premixed material accurately, uniformly, and continuously through the delivery hose.

(3) The shotcrete shall be applied from the lower part of the work area upwards to prevent accumulation of rebound on uncovered surfaces. Thickness, methods of support, air pressure, and rate of placement of shotcrete shall be controlled to prevent sagging or sloughing of freshly applied shotcrete. Where shotcrete is used to fill the bird's beak, the nozzle shall be positioned into the mouth of the drill hole to completely fill the void. Rebound shall not be worked back into the placement nor shall the rebound be salvaged. Rebound that does not fall clear of the working area shall be removed. The nozzle shall be held at a distance and at an angle approximately perpendicular to the working face so that the rebound will be minimal and compaction will be maximized. The nozzle shall be rotated steadily in a small circular pattern.

(4) Shotcrete placement shall be by the bench gunning method when the thickness of the shotcrete layer is 6 inches or greater. The gunning method shall consist of building up a thick layer of shotcrete from the bottom of the lift and maintaining the top surface at approximately a 45° slope.

(5) Successful pre-production test panels are required prior to starting installation of production shotcrete.

(d) Visual Observations.

(1) A clearly defined pattern of continuous horizontal or vertical ridges or depressions at the reinforcing elements after they are covered will be considered indication of insufficient cover of reinforcement or poor application and probable void. In this case, the work shall be immediately suspended, and the work carefully inspected by the Engineer. The Contractor shall implement and complete corrective measures prior to resuming the shotcrete operations.

(2) The shotcreting procedure may be corrected by adjusting the nozzle distance and orientation perpendicular to the surface, adjusting the water content of the shotcrete mix, or other means acceptable to the Engineer. All overspray and rebound shall be removed from the surface.

(3) Surface defects shall be repaired as soon as possible after initial placement of shotcrete. All shotcrete that lacks uniformity, exhibits segregation, sagging, honeycombing, or lamination, or contains any voids or sand pockets shall be removed and replaced with fresh shotcrete by the Contractor to the satisfaction of the Engineer.

(4) If field inspection or testing, by the Engineer, indicates that any shotcrete produced fails to meet the requirements, the Contractor shall immediately modify procedures, equipment, or systems, as necessary, and as approved by the Engineer, to produce shotcrete meeting specifications. All substandard shotcrete already placed shall be repaired by the Contractor, to the satisfaction of the Engineer, at no additional cost to the Agency. Such repairs may include removal and replacement of all affected materials.

(e) Nail Head Connection Hardware.

(1) For bearing plate connections, the plate shall be wet-set while the shotcrete is plastic to ensure full shotcrete bearing behind the plate. However, the retention nut shall only be hand tightened such that full bearing is achieved without excessively squeezing fresh shotcrete out from under the plate.

(2) For embedded plate connections, the embedment shall be located within the wall such that the proper shotcrete cover is provided as shown on the Plans. In addition, the plate, washer, and nut shall be pulled up flush together by wiring to the reinforcement or other means necessary to ensure adequate contact between these parts.

(f) Finishing and Curing Requirements.

(1) The shotcrete shall be protected from loss of moisture for at least 7 days after placement.

(2) When shotcrete is being protected from low temperatures, curing shall be terminated no sooner than 24 hours after the removal of low temperature protection.

(3) Curing of shotcrete shall commence within one hour of shotcrete application. When the ambient temperature exceeds 80°F, the Contractor shall plan the work such that curing can commence immediately after finishing. The curing shall be completed using water, membrane, or film curing methods in accordance with the following requirements:

a. If water curing is used, the rate of water application shall be regulated to provide complete surface coverage with minimum runoff.

b. Curing compounds shall not be used on any surfaces against which additional shotcrete or other finishing materials are to be bonded unless the surface is sandblasted in a manner acceptable to the Engineer. Membrane curing compounds shall be spray applied as quickly as practical after initial shotcrete set, at a coverage of not less than 40 square feet per gallon.

c. Polyethylene sheeting may be used to supplement water curing on shotcrete that will be covered later with additional shotcrete. The sheeting shall completely cover all surfaces, and have edges overlapped for proper sealing and anchorages.

(g) Weather Limitations.

(1) Shotcrete shall not be applied when ambient, substrate, and material temperatures are below 40°F or above 95°F, or during rainfall events.

(2) Shotcrete shall not be placed in cold weather unless adequately protected when the ambient temperature is below 40°F or when the shotcrete is likely to be subjected to freezing temperatures before reaching a minimum strength of 750 psi. Cold weather protection shall be maintained until the strength of the shotcrete is greater than 750 psi. Cold weather protection shall include heating under tents, blankets, or other means acceptable to the Engineer.

(3) The temperature of the shotcrete, when deposited, shall not be less than 50°F nor more than 80°F. The air in contact with shotcrete surfaces shall be maintained at temperatures above 32°F for a minimum of 7 days.

(4) Shotcrete application shall also be suspended during high winds and heavy rains when in the opinion of the Engineer the quality of the application is not acceptable. Newly placed shotcrete exposed to rain that washes out cement or otherwise makes the shotcrete unacceptable to the Engineer shall be removed and replaced. The Contractor shall provide adequately secured polyethylene sheeting or equivalent when adverse exposure to weather is anticipated.

(h) Testing.

(1) Test Panels. Shotcrete test panels include pre-production test panels and production test panels. Test panels shall meet the following requirements:

a. Panels shall be a minimum size of 30 inches × 30 inches.

b. Panels shall be in the same shooting orientation as the production work.

c. Panels shall be shot at approximately the same pressure as anticipated for the work.

d. Panels shall not be disturbed or moved within the first 24 hours after shooting.

e. Panels shall be field-cured under conditions similar to those anticipated for the work.

f. Shotcreting of test panels shall be performed by qualified personnel in the presence of the Engineer.

(2) Pre-Production Test Panels. Two shotcrete test panels shall be required for pre-production. One pre-production test panel shall be unreinforced, at least 6 inches thick, and used for absorption and compressive strength testing. One pre-production test panel shall be the maximum shotcrete thickness shown on the Plans and shall include the anticipated reinforcing congestion.

(3) Production Test Panels. Unless specified in the Plans, a minimum of one production test panel shall be required for each 50 cubic yards placed, but no fewer than one production test panel daily for each nozzle operator. One production test panel shall be required whenever the nozzle equipment is changed. At least one production test panel shall be unreinforced, at least 6 inches thick, and used for absorption and compressive strength testing. Once per job, the Engineer may require an additional production test panel to test for encapsulation.

(4) Sampling.

a. Pre-production and production test panels shall be cored by the Contractor in the presence of the Engineer.

b. At least nine cores shall be cut from each pre-production test panel and production test panel for compressive strength and absorption testing.

c. Cores shall be taken at a minimum distance from the edge of core to the edge of test panel in accordance with *ASTM C1140* and with a minimum of 1 inch between cores. Cores shall be conditioned accordance with *AASHTO T 24*.

d. Cores shall be at least 4 inches in diameter and shall have a minimum length to diameter ratio of one. An alternate core size may be requested but shall be no less than 3 inches in diameter. When the length of the core is less than twice the diameter, the correction factors given in *ASTM C42* shall be applied to obtain the compressive strength of individual cores.

e. Cores shall be delivered to the Agency's Materials Testing and Certification Section Central Laboratory for testing no more than 24 hours after being taken.

f. Cores for encasement scoring may be taken when the shotcrete has attained strength enough to not be damaged by coring.

g. Cores of at least two reinforcing intersections shall be extracted from the reinforced pre-production test panel.

(i) Testing Acceptance. Pre-production test panels and production test panels shall be approved based on the same criteria.

(1) Three cores shall be tested at 7-days, and three cores shall be tested at 28-days for compressive strength. Three cores shall be tested at 7-days for absorption in accordance with *ASTM C642*. Shotcrete will be accepted based on the 7-day or 28-days strength of cores taken from the panels. The shotcrete strengths may be accepted if the average 7 day compressive strength of each set of three cores extracted from test panels or wall face is equal to or exceeds 85%, with no individual core less than 75%, of the specified 28 day compressive strength in accordance with *ACI 506.2*.

(2) Cores extracted from the reinforced test panel shall demonstrate encapsulation of the reinforcement in accordance with *ACI 506.2* equal to core grade 2 or better.

If a shotcrete section represented by any test panel core is deficient in any of the criteria specified, the Contractor shall propose an alternative repair at no additional cost to the Agency. Repairs may include, but are not limited to, the application of additional shotcrete to the deficient area or removal and replacement of the deficient section.

221.10 METHOD OF MEASUREMENT. The quantity of Rock Slope Stabilization Dowel to be measured for payment will be the number of linear feet of rock dowels installed in the complete and accepted work, as determined by the Engineer, and as shown as the pay limits on the Plans.

The quantity of Rock Slope Stabilization Dowel Testing to be measured for payment will be the number of tests completed and accepted, as determined by the Engineer.

The quantity of Rock Slope Stabilization Anchor to be measured for payment will be the number of linear feet of rock anchors installed in the complete and accepted work, as determined by the Engineer.

The quantity of Rock Slope Stabilization Anchor Testing to be measured for payment will be the number of tests completed and accepted, as determined by the Engineer.

The quantity of Rock Slope Stabilization Shear Keys to be measured for payment will be the number of linear feet of shear keys installed in the complete and accepted work, as determined by the Engineer.

The quantity of Rock Slope Stabilization Drain to be measured for payment will be the number of linear feet of rock drains installed in the complete and accepted work, as determined by the Engineer.

The quantity of Rock Slope Stabilization Nail for Shotcrete to be measured for payment will be the number of linear feet of rock nail installed in the complete and accepted work, as determined by the Engineer.

The quantity of Rock Slope Stabilization Shotcrete to be measured for payment will be the number of cubic yards installed in the complete and accepted work, as determined by the Engineer. Test Panels will not be measured for payment.

219.11 BASIS OF PAYMENT. The accepted quantity of Rock Slope Stabilization Dowel will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, drilling, installing, and grouting the rock dowels and for furnishing all labor, tools, equipment, and incidentals to complete the work.

The accepted quantity of Rock Slope Stabilization Dowel Testing will be paid for at the Contract unit price per each price. Payment will be full compensation for performance testing, obtaining acceptable results for all tests, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Rock Slope Stabilization Anchor will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, drilling, installing, and grouting the rock anchors and for furnishing all labor, tools, equipment, and incidentals to complete the work.

The accepted quantity of Rock Slope Stabilization Anchor Testing will be paid for at the Contract unit price per each price. Payment will be full compensation for performance testing, obtaining acceptable results for all tests, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Rock Slope Stabilization Shear Keys will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, drilling, installing, formwork, and grouting the shear keys and for furnishing all labor, tools, equipment, and incidentals to complete the work.

The accepted quantity of Rock Slope Stabilization Drain will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, drilling and installing the rock anchors and for furnishing all labor, tools, equipment, and incidentals to complete the work.

The accepted quantity of Rock Slope Stabilization Nail for Shotcrete will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, drilling, installing, and grouting the rock nail, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Rock Slope Stabilization Shotcrete will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for furnishing and installing the specified materials for a complete in place shotcrete in accordance with the Contract, including all required submittal and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Test panels will be considered incidental to Rock Slope Stabilization Shotcrete.

Payment for preparing and making required submittals will not be made separately, but will be considered incidental to the work under this section.

Payment will be made under:

Pay Item		Pay Unit
221.1000	Rock Slope Stabilization Dowel	Linear Foot
221.1500	Rock Slope Stabilization Dowel Testing	Each
221.2000	Rock Slope Stabilization Anchor	Linear Foot
221.2500	Rock Slope Stabilization Anchor Testing	Each
221.3000	Rock Slope Stabilization Shear Key	Linear Foot
221.4000	Rock Slope Stabilization Drain	Linear Foot
221.5000	Rock Slope Stabilization Nail	Linear Foot
221.6000	Rock Slope Stabilization Shotcrete	Cubic Yard

SECTION 225 – CONCRETE RETAINING WALL

225.01 DESCRIPTION. This work shall consist of designing, detailing, fabricating, furnishing, and erecting a precast or cast-in-place concrete retaining wall at the locations specified and in conformance with the lines and grades shown on the Plans or as directed by the Engineer.

225.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Granular Backfill for Structures.....704.08
Drainage Aggregate 704.16
Bar Reinforcement.....713.01
Mechanical Splices for Bar Reinforcement 713.02
Welded Wire Reinforcement 713.03
Precast Concrete Retaining Wall Systems.....760.05

Concrete shall meet the requirements of Section 501 for Performance-Based Concrete, Class PCS, unless otherwise specified in the Contract.

Reinforcing steel shall meet the requirements for Level II corrosion resistance unless otherwise specified in the Plans.

225.03 DESIGN REQUIREMENTS. The wall shall be designed and constructed in accordance with the *AASHTO LRFD Bridge Design Specifications*, the Plans, the design criteria, and the geotechnical information specified in the Contract.

Precast and cast-in-place concrete retaining walls shall employ concrete facing. All wall components shall have a minimum design life of 100 years.

225.04 GENERAL REQUIREMENTS. Unless noted otherwise herein, cast-in-place concrete retaining walls shall meet the requirements of Section 501 and Section 507 as applicable.

Precast concrete retaining walls shall meet the requirements of Section 540 and Section 649 as applicable.

When the pay item Retaining Wall, Concrete is included in the Contract, the Contractor may choose to use either a precast or cast-in-place concrete retaining wall at their discretion. The wall shall meet the requirements for the applicable type as noted above.

225.05 SUBMITTALS. Working drawings shall be submitted in accordance with Subsection 105.06. Submittals for precast concrete shall also meet the requirements of Subsection 540.04. The submittal shall include, but not be limited to, all of the following that apply to the particular wall system or type being constructed:

(a) Complete design drawings and design calculations substantiating that the proposed design satisfies the design parameters in the Contract. The wall design drawings and design calculations shall be signed, stamped, and dated by a professional engineer.

(b) A plan view of the wall showing the details within the limit of the retaining wall system and the centerline of any drainage pipe which is behind or passes under or through the wall.

(c) An elevation view of the wall which shall include the elevations at the top of the wall, at all horizontal and vertical break points and at least every 50 feet along the face of the wall, and at all steps in the leveling pads. The elevation view shall also include the designation as to the type of panel or block, the length of soil reinforcing elements, the distance along the face of the wall to where changes in length of the soil reinforcing elements occur, and an indication of the final ground line.

(d) A typical cross section or cross sections showing the existing ground conditions and proposed grades.

(e) All details for foundations and leveling pads, including details for steps in the footings or leveling pads, as well as design maximum and minimum bearing pressures.

(f) All details for the wall system including all dimensions necessary to construct the wall.

(g) Details of the drainage systems or other facilities required to accommodate the system.

(h) The details for connection between the wall and the soil reinforcements.

(i) The details for diverting soil reinforcements around obstructions such as guard rail posts, piles, catch basins, and utilities.

(j) All reinforcing details, including type, strength, locations, and lengths of reinforcement used.

(k) Any general notes required for the construction of the wall.

(l) A listing of the summary of quantities for each wall.

(m) Working drawings shall demonstrate compatibility in how the retaining wall will adjoin adjacent structures designed by others.

(n) Working drawings shall include call-outs indicating the applicable AASHTO or ASTM material grades.

225.06 INSPECTION.

(a) Cast-In-Place Concrete. Cast-in-place concrete will be inspected in accordance with Section 501.

(b) Precast Concrete. Precast concrete will be inspected in accordance with Section 540.

(c) Concrete Finish. No surface voids or bug holes greater than 5/8 inch in diameter and more than 1/4 inch deep will be allowed in the finished exposed surface. Surface voids or bug holes that are less than described shall not exceed 1% of the finished exposed surface with no 6 inch by 6 inch area containing more than 3 surface voids or bug holes. The concrete surface for the front face shall meet the requirements noted in the Plans. Any repairs to the front face shall match the color and finish of the surface and be approved by the Engineer.

225.07 CONSTRUCTION REQUIREMENTS. Foundation soil, leveling pad, and backfill material shall be compacted to not less than 95% of the material's maximum dry density as determined by *AASHTO T 99, Method C*. Field density quality control shall be conducted by the Contractor in accordance with *AASHTO T 310* at a frequency of no less than once per 500 cubic yards.

225.08 METHOD OF MEASUREMENT. The quantity of Retaining Wall, Cast-In-Place Concrete; Retaining Wall, Precast Concrete; and Retaining Wall, Concrete to be measured for payment will be on a lump sum basis in the complete and accepted work.

225.09 BASIS OF PAYMENT. The accepted quantity of Retaining Wall, Cast-In-Place Concrete; Retaining Wall, Precast Concrete; and Retaining Wall, Concrete will be paid for at the Contract lump sum price. Payment will be full compensation for designing, detailing, fabricating, transporting, handling, erecting, and installing the materials specified, including but not limited to the tieback system, geotextile fabric, backfill material, concrete, bar reinforcement and welded steel wire fabric, drainage pipe, drainage aggregate, precast concrete facing panels, precast concrete blocks, soil reinforcements, attachment devices, fasteners, bearing blocks, shims, geomembrane, and expansion material; any excavation, sheeting, bracing, dewatering, and siltation control; preparing and submitting working drawings; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Any grouting work, such as fairing out unevenness between adjacent concrete pieces and filling leveling screw holes, shear keys, transverse anchor recesses, and dowel holes, will be considered incidental to the Contract lump sum price for the applicable Section 225 pay item.

Payment will be made under:

Pay Item		Pay Unit
225.0300	Retaining Wall, Cast-In-Place Concrete	Lump Sum
225.0400	Retaining Wall, Precast Concrete	Lump Sum
225.0500	Retaining Wall, Concrete	Lump Sum

SECTION 227 – MECHANICALLY STABILIZED EARTH RETAINING WALL

227.01 DESCRIPTION. This work shall consist of designing, detailing, fabricating, furnishing, and erecting mechanically stabilized earth (MSE) retaining walls constructed in accordance with these specifications and in conformance with the lines, grades, details, and dimensions shown on the Plans or as directed by the Engineer.

Construction of the MSE retaining wall system shall consist of placement and compaction of select granular backfill, a non-structural leveling pad, precast concrete face panels, and membrane and soil reinforcement elements mechanically connected to each facing panel.

227.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Drainage Aggregate 704.16
Select Backfill for MSE Structures 704.18
Polyvinyl Chloride (PVC) Plastic Pipe 710.05
Bar Reinforcement 713.01
Mechanical Splices for Bar Reinforcement 713.02
Geotextile for Roadbed Separator 720.02
Mechanically Stabilized Earth (MSE) Wall Systems 760.06
Geomembrane Liner 760.07

Precast concrete shall meet the requirements of Section 540.

Reinforcing steel shall meet the requirements for Level II corrosion resistance unless otherwise specified in the Plans.

227.03 DESIGN REQUIREMENTS. The MSE retaining wall system shall be designed and constructed in accordance with the *AASHTO LRFD Bridge Design Specifications*, the Plans, the design criteria, and the geotechnical information specified in the Contract.

The system shall be designed for a design life of 100 years, and any wall reinforcing located above the geomembrane shall have a design life of 125 years, both using the corrosion rates given in the *AASHTO LRFD Bridge Design Specifications* for non-aggressive soil.

All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown on the Plans shall be accounted for in the stability design of the wall.

MSE wall panels shall have a minimum structural thickness of 5 inches and a minimum cover for steel reinforcement of 1-1/2 inches.

The design shall follow the dimensions of the wall envelope and minimum embedment shown on the Plans. Where a wall coping is utilized, the wall face panel shall extend up into the coping the minimum distance specified on the Plans. The top of the face panels may be level or sloped to meet the top of the wall. Cast-in-place concrete will not be an acceptable replacement for panel areas, except for minor grouting of pipe penetrations and leveling required for coping.

Where walls or wall sections intersect with an angle of 130° or less, a special vertical corner element panel shall cover the joint of the panels that abut the corner and allow for independent movement along the abutting panels.

The face panels shall be designed to accommodate differential settlement of 12 inches in 100 feet between the substructure and wall system. The design of the wall system shall include a provision to accommodate settlement of this magnitude. The spacing between adjacent panels shall be designed to be 0.75 inches. Where shown on the Plans, slip joints to accommodate excessive differential settlement shall be included.

227.04 SUBMITTALS. As soon as practical after award of the Contract, the following information shall be prepared and submitted:

(a) Working drawings and design calculations shall be submitted to the Engineer for review and approval in accordance with Subsection 105.06 and shall include the following:

(1) Complete design drawings and calculations substantiating that the proposed design satisfies the design parameters specified in the Contract. Wall design drawings and calculations shall be signed and sealed by a professional engineer employed by the wall system supplier.

(2) Details of revisions or additions to drainage systems or other facilities required to accommodate the wall system.

(3) An elevation view of the wall, which shall include the elevations at the top of the wall, at all horizontal and vertical break points and at least every 50 feet along the face of the wall, and at all steps in the leveling pads, the designation as to the type of panel, the length of soil reinforcing elements. The elevation view shall also include the distance along the face of the wall to where changes in length of the soil reinforcing elements occur, and an indication of the final ground line.

(4) A typical section or cross-sections showing the existing ground conditions and proposed grades, including existing ground elevations that have been verified by the Contractor for each location involving construction wholly or partially in original ground.

(5) General notes pertaining to design criteria and wall construction.

(6) All other necessary details including reinforcement overlap detail.

(7) A listing of the summary of quantities on the elevation sheet for each wall.

(8) The details for diverting soil reinforcements around obstructions such as piles, catch basins, and other utilities.

(9) The details for connection between the concrete panel and the soil reinforcements.

(10) Other information required in the Contract or requested by the Engineer.

(11) Working drawings showing all dimensions necessary to construct the element, all reinforcing steel in the element, the location of soil reinforcing connection devices embedded in the panels, and an indication of the architectural treatment.

(b) All applicable information required in Subsection 540.04.

227.05 MSE WALL PANEL FABRICATION REQUIREMENTS.

(a) Test Panel. A full-size test panel shall be produced and approved by the Agency prior to production of the MSE wall panels. The panel shall be available for review a minimum of 5 working days prior to the start of production. The approved test panel shall be used as a benchmark for the correct color and form liner finish.

(b) Concrete Finish. No surface voids or bug holes greater than 5/8 inch in diameter and more than 1/4 inch deep will be allowed in the finished exposed surface. Surface voids or bug holes that are smaller than the size described shall not exceed 1% of the finished exposed surface with no 6 inch by 6 inch area containing more than 3 surface voids or bug holes. The concrete surface for the front face shall meet requirements as noted on the Plans. Any repairs to the front face shall match the color and finish of the surface and be approved by the Engineer.

The concrete surface for the front face shall have a form liner finish as required on the approved fabrication drawings. The concrete surface on the rear face shall be an unformed flat finish. The concrete panels shall be constructed using colored concrete as specified in the Plans.

(c) Panel Tolerances. All MSE wall panels shall be manufactured within the following tolerances with respect to the dimensions shown on the approved fabrication drawings:

(1) Attachment Device Locations and Alignment. The lateral position of reinforcing element attachment devices shall be within 1 inch. The embedment measured from the back face of the panel shall be 4 inches (+ 1/4 inch, - 1/2 inch).

(2) Panel Dimensions. All panel dimensions shall be within ± 1/4 inch. All hardware embedded in the panel except for attachment devices shall be within ± 1/4 inch.

(3) Panel Squareness. The panel's squareness, as determined by the difference between the two diagonals, shall not exceed 1/2 inch.

(4) Panel Surface Finish. Surface defects on smooth-formed surfaces, measured on a length of 5 feet, shall not exceed 1/4 inch. Surface defects on textured-finished surfaces, measured on a length of 5 feet, shall not exceed 5/16 inch.

(d) Curing. MSE wall panels shall have an approved curing compound applied to the back face of the panel immediately following finishing.

(e) Handling, Storage, and Shipping. MSE wall panels shall be stored and shipped in stacks, front face down. Firm blocking of sufficient thickness to prevent the reinforcement attachments from contacting the adjacent panels shall be used. Lifting inserts shall be installed on the top edge of the MSE wall panels to permit lifting at the project site. Reinforcement connection inserts (tie strips) shall not be used for lifting or handling the panel at the project site.

(f) Panel Acceptance Criteria. MSE wall panels will be accepted for use in wall construction provided the concrete strength meets or exceeds the design compressive strength, the soil reinforcement connection devices and the panel dimensions are within tolerances, and any chipping, cracks, honeycombing, or other defects are repaired to the satisfaction of the Structural Concrete Engineer using methods submitted and approved as specified in Subsection 540.07(g).

The MSE wall panels will be subject to inspection by the Engineer at the time of unloading and once placed in their final position. MSE wall panels that do not meet the requirements of this subsection may be subject to rejection.

227.06 CONSTRUCTION REQUIREMENTS.

(a) Manufacturer's Representative. The Contractor shall make the necessary arrangements with the wall supplier to have a technical representative on the project to supervise the first level of panel placement of the mechanically stabilized earth retaining wall system. The technical representative shall also be required to be on-site or available for consultation any time during wall installation as requested by the Engineer.

(b) Wall Excavation. Excavation shall be performed in accordance with Section 203 or Section 204 as applicable and shall conform with the limits shown on the Plans.

(c) Foundation Preparation. The foundation for the structure shall be graded level for a width equal to or exceeding the length of the soil reinforcements, or as shown on the Plans. The Contractor shall proof roll the foundation using a minimum 5-ton, self-propelled vibratory roller to compact soils disturbed by excavation. Areas exhibiting excess weaving or soft, unsuitable soils shall be excavated and replaced with compacted granular fill. Wet foundation soils shall be proof rolled without vibration. Any foundation soils found to be unsuitable shall be removed and replaced as directed by the Engineer.

At each panel foundation level, an unreinforced concrete leveling pad shall be provided as shown on the Plans. Allowable elevation tolerances are +0.01 feet and -0.02 feet from the design elevation. Prior to placement of the leveling pad, the Agency's Geotechnical Engineer or designated representative shall inspect the foundation soils to evaluate the suitability of the bearing soils.

Leveling pads shall be required to cure a minimum of 24 hours before wall panels are erected on them.

(d) Wall Erection. Precast concrete panels shall be placed vertically with the aid of a crane or other construction equipment capable of handling the anticipated loads. For erection, panels shall be handled by means of lifting devices set into the upper edge of the panels. Panels shall be placed in successive horizontal lifts in the sequence shown on the working drawings as select granular backfill placement proceeds.

The maximum allowable offset in any panel joint shall be 0.75 inches. The overall vertical tolerance of the wall (plumbness from top to bottom) shall not exceed 0.50 inches per 10 feet of wall height.

(e) Placement of Reinforcements. Prior to the first layer of reinforcements, select granular backfill shall be placed and compacted in accordance with Subsection 227.06(f).

Soil reinforcements shall be placed normal to the face of the wall, unless otherwise shown on the working drawings or directed by the Engineer.

If skewing of the soil reinforcements is required due to obstructions in the reinforced fill, or in other cases justified by calculation, the maximum skew angle shall not exceed 15 degrees from the normal position, except in case of acute corners where redundant reinforcements are used, or in other cases justified by calculation.

(f) Backfill Placement. Backfill placement shall closely follow erection of each course of panels. Backfill shall be placed in such a manner as to avoid any damage or disturbance to the wall materials or misalignment of the facing panels. Any wall materials which become damaged or disturbed during backfill placement shall be corrected or removed and replaced at the Contractor's expense, as directed by the Engineer.

Backfill shall be compacted to 95% of the maximum density as determined in accordance with *AASHTO T 99, Method C* or *AASHTO T 99, Method D* (with oversize correction). The optimum moisture content shall be determined in accordance with *AASHTO T 99, Method C* or *AASHTO T 99, Method D* (with oversize correction). The moisture content of the select backfill material prior to and during compaction shall be uniform throughout each layer. Backfill material shall have a placement moisture content less than or equal to the optimum moisture content. Backfill material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniform and acceptable throughout the entire lift. Field density and moisture content quality control shall be conducted by the Contractor in accordance with *AASHTO T 310* at a frequency of no less than once per 500 cubic yards.

The maximum lift thickness after compaction shall not exceed 10 inches, regardless of the vertical spacing between the reinforced soil layers. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density. Prior to placement of the soil reinforcement elements, the backfill elevation, after compaction, shall be equal to or up to 2 inches above the attachment device elevation from a point approximately 12 inches behind the back face of the panels to the free end of the soil reinforcements, unless otherwise shown on the Plans.

Compaction within 3 feet of the back face of the panels shall be achieved by a minimum of three passes of a lightweight mechanical tamper, roller, or vibratory system. The specified lift thickness shall be adjusted as warranted by the type of compaction equipment actually used, but no soil density tests need be taken within this area. Care shall be exercised in the compaction process to avoid misalignment of the panels or damage to the attachment devices. Heavy compaction equipment shall not be used to compact backfill within 3 feet of the wall face.

At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing to direct runoff of rainwater away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

(g) Geomembrane Liner. Field seams shall be made to seal factory fabricated panels of PVC together in the field. Seams shall be formed by lapping the edges of panels a minimum of 6 inches. The contact surfaces of the panels shall be wiped clean to remove all dirt, dust, or other substance. A vinyl-to-vinyl solvent shall be applied to the contact surface in the seam area as recommended by the manufacturer, and the two surfaces pressed together immediately. Any wrinkles shall be smoothed out. Field seams shall have a strength of at least 85% of the specified sheet strength.

All curing compounds and coatings shall be completely removed from the joint area. Joining of the PVC to the back of panel shall be done with an adhesive. Unless otherwise shown on the Plans, the minimum width of concrete to PVC joint shall be 6 inches. In addition, mechanical attachments may be necessary.

Any necessary repairs to the PVC shall be made with the lining material itself and cold applied vinyl to vinyl splicing adhesives. Patches shall be cut so as to cover the area to be repaired by a minimum of 4 inches in all directions. Patches shall be cut with rounded corners. The splicing adhesive shall be applied to the contact surface between the patch and the lining, and the two surfaces pressed together immediately.

(h) Horizontal and Vertical Control. Immediately following the erection of the mechanically stabilized earth retaining wall system, the Contractor shall establish horizontal and vertical survey points at a minimum of three locations across the top and at mid-elevation on the wall with an additional set of points for each 100 feet of wall required to monitor future movements. These points shall be tied into a minimum of two control markers that are sufficiently removed from the wall so as not to be influenced by wall movement. The control shall be located to allow the Agency to gather additional measurements to be made after all construction is complete. A plan with the northings and eastings of all survey points and ties, along with distances and elevations recorded to the nearest 0.001 feet, shall be provided to the Engineer within 48 hours of the completion of the mechanically stabilized earth retaining wall system.

227.07 METHOD OF MEASUREMENT. The quantity of Retaining Wall, Mechanically Stabilized Earth to be measured for payment will be on a lump sum basis in the complete and accepted work.

227.08 BASIS OF PAYMENT. The accepted quantity of Retaining Wall, Mechanically Stabilized Earth will be paid for at the Contract lump sum price. Payment shall include full compensation for designing, detailing, fabricating, furnishing, transporting, erecting, and baseline monitoring the mechanically stabilized earth retaining wall system; for preparing all required submittals; for supervision by the manufacturer's representative; for materials required, including but not limited to, select granular backfill, PVC pipe, drainage aggregate, filter fabric, adhesive, underdrain pipe, concrete facing panels, reinforcing steel, concrete coping, soil reinforcements, attachment devices, fasteners, bearing blocks, shims, joint materials, geomembrane, and geotextiles; for preparing the wall foundation, proof rolling foundation soils, and constructing the concrete leveling pad; all required excavation; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
227.0100 Retaining Wall, Mechanically Stabilized Earth	Lump Sum

SECTION 230 – CONTAMINATED MATERIALS

230.01 DESCRIPTION. This work shall consist of the management and disposal of contaminated soil and groundwater encountered during construction in accordance with these specifications.

230.02 GENERAL REQUIREMENTS. The Contractor shall follow the soil management plans (SMP), corrective action plans (CAP), and other supporting documentation incorporated by reference as part of the Contract. The work shall include identification, handling, sampling, testing, classification, segregation, temporary stockpiling, loading, transportation, disposal, treatment, and final placement of the contaminated materials in accordance with any such referenced plan. The work will also include management, treatment, and disposal when contaminated groundwater is encountered. Initial excavation of the contaminated material shall be performed in accordance with the appropriate excavation item included in the Contract.

The Contractor shall engage the services of an environmental professional (EP), as defined in *ASTM E1527*, to prepare and submit a project operations plan (POP) to the Agency, provide environmental oversight, identify and classify contaminated soils, coordinate with and submit relevant documents to regulatory agencies, obtain any required regulatory permits, including, but not limited to National Pollutant Discharge Elimination System discharge permits or other deviations to the approved SMP or CAP. The EP shall also prepare and submit a project operations completion report (POCR).

230.03 SUBMITTALS. Prior to the commencement of construction, the Contractor's EP shall prepare and submit to the Agency a site-specific POP in accordance with the referenced plans and all other relevant specifications in the Contract.

The POP shall include the name and qualifications of the EP, discuss applicable authorizations, and propose and detail means and methods for meeting applicable regulatory requirements, including the following:

(a) Separating clean soils from contaminated soil encountered during excavation.

(b) Reducing the waste stream for soils that may be reused on site.

(c) Identifying and getting locations approved for stockpiling contaminated soils.

(d) Lining and capping stockpiles to prevent leachate, contaminated runoff, and wind impacts to contaminated soils and waste materials.

(e) Securing stockpiles from public access.

(f) Inspecting and maintaining stockpiles until materials are characterized and properly disposed of or reused.

(g) Dewatering, storing, characterizing, treating, and disposing of contaminated water if encountered during excavation. Disposal of water deemed contaminated shall be in accordance with all applicable federal, state, and local rules and regulations. Contaminated water shall not be discharged to an existing municipal sanitary sewer without permission from the governing municipality.

(h) Meeting all relevant VOSHA and OSHA requirements.

No excavation will be allowed until the POP has been approved by the Engineer.

During the work specified herein, the Contractor's EP shall provide daily field reports documenting the oversight, management, and disposal operations in accordance with approved plans. Daily field reports shall be submitted to the Engineer on the following working day.

Within 30 calendar days of the completion of all excavation, dewatering, and disposal activities, the Contractor's EP shall prepare and submit a POCR to the Agency. The POCR shall include contaminated material shipping and disposal documentation, and all updates and closure documentation required by the Vermont Agency of Natural Resources. In the event that there are hazardous material releases resulting from Contractor activities, the POCR shall also include documentation necessary to support remedial actions taken to address any such releases.

230.04 CONSTRUCTION REQUIREMENTS. The Contractor's EP shall be present on site during active construction any time work specified herein is planned or can reasonably be anticipated. The EP shall oversee contaminated soil and groundwater management, train site workers, and monitor contamination levels of excavated soils in accordance with the POP and as directed by the Engineer. The EP shall also be responsible for preparing material shipping records, hazardous waste manifests, and necessary documents to transport and dispose or recycle stockpiled material. The EP shall also obtain approval from recycling and disposal facilities for recycling or disposal and prepare necessary documents to support remedial actions for hazardous material releases resulting from the Contractor's activities.

The Agency's Hazardous Materials and Waste Coordinator, or their representative, may also monitor the contamination levels of the excavated soils and groundwater for the Engineer and ensure that the Contract conditions and referenced plans are fully followed.

If, during the excavation of contaminated material, the Contractor encounters conditions which differ from those expected, the Contractor shall immediately notify the Engineer. All excavation operations in the contaminated area shall cease until the condition or situation can be evaluated by the Agency's Hazardous Materials and Waste Coordinator and the Contractor's EP.

No additional compensation or allowance for additional Contract time will be made for any delays incurred in executing the soil management plan or corrective action plan.

230.05 METHOD OF MEASUREMENT. The quantity of Disposal of Contaminated Materials (N.A.B.I.) to be measured for payment will be the cost, in dollars, of trucking materials to a disposal facility plus the cost, in dollars, of disposing of the contaminated materials at the disposal facility. Costs will be calculated on a force account basis in accordance with Subsection 109.06. When performed by the Contractor, trucking costs will be calculated in accordance with Subsection 109.06(c) and labor costs will be calculated in accordance with Subsection 109.06(a). When performed by a subcontractor, trucking will be considered subcontracted work in accordance with Subsection 109.06(d). The cost of disposal, as determined from disposal facility receipts, will be considered subcontracted work in accordance with Subsection 109.06(d). Bills of lading or waste manifests, disposal facility receipts, and slips describing the type of trucking equipment and hours of use shall be furnished to the Engineer for each load delivered to a disposal facility.

The quantity of Reuse of Contaminated Materials to be measured for payment will be the number of cubic yards of material stockpiled and reused in the complete and accepted work.

The quantity of the Project Operations Plan and the Project Operations Completion Report will be paid for on a lump sum basis for the complete and accepted work.

The quantity of Environmental Oversight to be measured for payment will be the number of hours of field work as documented in the reviewed and accepted field reports.

When specified to be measured on a lump sum basis, the quantity of Management of Contaminated Groundwater to be measured for payment will be on a lump sum basis for the complete and accepted work.

When specified to be measured by volume, the quantity of Management of Contaminated Groundwater to be measured for payment will be the number of thousand gallons (MGAL) of water managed in the complete and accepted work.

230.06 BASIS OF PAYMENT. Payment for Disposal of Contaminated Materials (N.A.B.I.) will be full compensation for trucking costs, disposal facility tipping fees, and district solid waste fees. Costs for the initial excavation of material will be paid for under the appropriate excavation item included in the Contract.

A value in dollars has been included in the bid proposal for Disposal of Contaminated Materials (N.A.B.I.). This amount will be adjusted to the actual cost of trucking and disposal, after review and approval of trucking slips and paid invoices. No additional payment will be made under this item.

The accepted quantity of Reuse of Contaminated Materials will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for handling, segregating, and installing the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Costs for the initial excavation of materials will be paid for under the appropriate excavation items included in the Contract.

The accepted quantity of Project Operations Plan will be paid for at the Contract lump sum price. Payment will be full compensation for preparing, submitting, and revising, based on Agency comments, a report that meets the requirements set forth in the Contract, and subsequent management of the project site, including protecting stockpiles, decontamination of trucks and equipment, coordination and other activities required to maintain the site in compliance with the POP.

The accepted quantity of Project Operations Completion Report will be paid for at the Contract lump sum price. Payment will be full compensation for completing any required waste profiles for receiving facility acceptance; reviewing manifests and bills of lading for contaminated soils; coordinating and administering documentation and reimbursement submittals; and for providing all labor, management, administration, laboratory analysis, and incidentals necessary to complete the work.

The accepted quantity of Environmental Oversight will be paid for at the Contract unit price per hour. Payment will be full compensation for preparing daily field reports, field screening of excavated soil, collection of all samples, documentation of dewatering and groundwater treatment activities, and for providing all labor, equipment, and supplies necessary to complete the work.

The accepted quantity of Management of Contaminated Groundwater will be paid for at the Contract lump sum price or at the Contract unit price per thousand gallons (MGAL), as applicable. Payment will be full compensation for mobilization, installation, startup, operation, maintenance, monitoring, demobilization, decontamination, and proper disposal of all treatment media and residuals, and for providing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

(a) Partial payments for Project Operations Plan will be made as follows:

(1) The first payment of 50% of the lump sum price will be paid upon acceptance of the Project Operations Plan by the Agency.

(2) The remaining 50% of the lump sum price will be paid when disposal activities are complete or stockpile areas have been closed out, whichever is later.

(b) Partial payments for Management of Contaminated Groundwater paid by the lump sum will be made as follows:

(1) The first payment of 50% of the lump sum price will be paid when the liquid treatment system is permitted, delivered to the site, and made fully operational.

(2) The remaining 50% of the lump sum price will be paid when the liquid treatment system is fully removed from the site and demobilized.

Payment will be made under:

Pay Item		Pay Unit
230.0010	Disposal of Contaminated Materials (N.A.B.I.)	Dollar
230.0020	Reuse of Contaminated Materials	Cubic Yard
230.0030	Project Operations Plan	Lump Sum
230.0040	Project Operations Completion Report	Lump Sum
230.0050	Environmental Oversight	Hour
230.0060	Management of Contaminated Groundwater	Lump Sum
230.0070	Management of Contaminated Groundwater	MGAL

SECTION 240 – TEMPORARY CONSTRUCTION ACCESS

240.01 DESCRIPTION. This work shall consist of constructing temporary construction access roads, temporary causeways, temporary railroad access, and associated work areas for the project site as shown and described on the Plans, and restoring the disturbed areas to their original condition in accordance with the Plans and as directed by the Engineer.

240.02 MATERIALS. Unless otherwise specified in the Contract, the Contractor may use any material or combination of materials that meet the approval of the Engineer.

240.03 GENERAL REQUIREMENTS. Prior to beginning the work covered under this section, the Contractor shall submit to the Engineer site-specific plans, including all construction, erosion prevention and sediment control, and maintenance details, for providing temporary construction access as specified in the Contract. These details shall be developed in accordance with the requirements of Section 653 and will be considered a component of the overall project EPSC Plan.

These plans shall conform to any permits, both state and federal, which have been issued for the project, or the Contractor shall be responsible for obtaining the necessary amendments to those permits.

These plans shall also include limits for project demarcation fence and locations of erosion prevention and sediment control measures in the project areas affected by temporary access road and staging area construction. All work shall be performed within the project demarcation fence limits.

The Contractor shall be responsible for designing and constructing temporary access measures suitable for their means and methods of construction. It shall be incumbent upon the Contractor to determine the level of protection required to safeguard the work, existing facilities, structures, and property. Any damage thereto shall be repaired by the Contractor at no additional expense to the Agency.

Following construction, the temporary access measures shall be removed and the site restored to its original conditions, unless otherwise specified on the Plans.

240.04 METHOD OF MEASUREMENT. The quantity of Temporary Access Road, Temporary Causeway, and Temporary Railroad Access to be measured for payment will be on a lump sum basis for the complete and accepted work.

240.05 BASIS OF PAYMENT. The accepted quantity of Temporary Access Road, Temporary Causeway, and Temporary Railroad Access will be paid for at the Contract lump sum price. Payment will be full compensation for preparing and submitting construction drawings; obtaining all required permits and property owner agreements; designing, constructing, and removing the temporary construction access; performing any necessary excavation and fill; restoring the site to its original condition; and for furnishing all labor, tools, materials, equipment, and incidentals necessary to complete the work.

Partial payments will be made as follows:

(a) An initial payment of 75% of the Contract lump sum price will be made upon satisfactory construction of the temporary construction access.

(b) The remaining 25% of the Contract lump sum price will be paid upon removal of the temporary construction access and restoration of the work area to the satisfaction of the Engineer.

Payment will be made under:

Pay Item		Pay Unit
240.0100	Temporary Access Road	Lump Sum
240.0200	Temporary Causeway	Lump Sum
240.0300	Temporary Railroad Access	Lump Sum

SECTION 248 – GEOTECHNICAL INSTRUMENTATION AND MONITORING

248.01 DESCRIPTION. This work shall consist of furnishing, installing, monitoring, and maintaining instrumentation and equipment, recording data, and reporting results in accordance with these provisions, the Plans, and as directed by the Engineer.

248.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Portland Cement.....701.02
Sand Borrow and Cushion 703.03
Mortar, Type IV .....707.01(e)
Miscellaneous Hardware, Shapes, and Fabricated Materials.....709.01(h)
Nonstructural Lumber.....709.02
Timber Preservative 726.01
Plastic Pipe, Rigid (PVC) 740.02
Steel Pipe, Galvanized 740.04

248.03 GENERAL REQUIREMENTS. All instrumentation and monitoring devices shall be installed at the locations indicated on the Plans or as directed by the Engineer and installed in accordance with the manufacturer's instructions.

Drilling personnel required for instrument installation shall have 3 years of experience in installing geotechnical instrumentation. A qualified geotechnical engineer shall oversee all installation.

All instrumentation locations shall be surveyed, in both location and elevation, prior to and after installation or as directed by the Engineer.

248.04 SUBMITTALS. The Contractor shall submit qualifications and references for the qualified geotechnical engineer and driller. The geotechnical engineer shall submit examples of three projects of similar scope with descriptions of instrumentation and shall include reference information for each.

The Contractor shall submit to the Engineer for approval an installation and monitoring plan provided by the qualified licensed geotechnical engineer. This shall include an installation schedule, instrumentation installation procedures, calibration sheets as required, monitoring frequency, and a complete listing of materials to be used. These shall be submitted in accordance with Subsection 105.06 for fabrication drawings.

248.05 MAINTENANCE. The Contractor shall maintain all geotechnical instrumentation equipment in an acceptable working order for the duration of the project and shall repair or replace any such equipment which fails to function properly.

Any instrumentation that becomes damaged or inoperable through no fault of the Contractor and requires replacement shall be replaced and paid for at the unit price bid for the respective instrumentation.

Any instrumentation that becomes damaged or inoperable as a result of the Contractor's operations shall be replaced by the Contractor at no cost to the Agency.

The Contractor shall monitor and record data as indicated in the installation and monitoring plan or as directed by the Engineer. All data shall be recorded in a format acceptable to the Engineer and shall be provided on a weekly basis at a minimum, or as directed by the Engineer.

248.06 METHOD OF MEASUREMENT. The quantity of Instrumentation and Monitoring Plan to be measured for payment will be lump sum basis for design and modification of an instrumentation and monitoring plan in the complete and accepted work.

The quantity of Slope Inclinometer and Observation Well to be measured for payment will be the number of linear feet of specified casing satisfactorily installed and maintained in the complete and accepted work.

The quantity of Shape Array Instrument; Tiltmeter; Observation Well; Settlement Platform, Type I; Settlement Platform, Type II; Piezometer, Type III; Datalogger; and Pressure Cell to be measured for payment will be the number of instruments installed, monitored, and maintained in the complete and accepted work.

248.07 BASIS OF PAYMENT. The accepted quantity of Instrumentation and Monitoring Plan will be paid for at the Contract lump sum price. Payment will be full compensation for designing, preparing, and submitting the plan, making any necessary modifications during construction, and all incidentals necessary to complete the work.

The accepted quantity of Slope Inclinometer and Observation Well will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and installing all instruments, and for furnishing of all tools, equipment, measuring devices, and incidentals necessary to complete and maintain the instruments.

The accepted quantity Shape Array Instrument; Tiltmeter; Observation Well; Settlement Platform, Type I; Settlement Platform, Type II; Piezometer, Type III; Datalogger; and Pressure Cell will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified; for protecting and maintaining the instruments, for monitoring and recording survey data for each instrument; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Payment will be made only if the instrument remains functional during all phases of construction unless otherwise allowed by the Engineer.

At the completion of the project, the geotechnical instrumentation and appurtenances, including all readout devices, will become the property of the Agency.

Payment will be made under:

Pay Item		Pay Unit
248.5000	Instrumentation and Monitoring Plan	Lump Sum
248.5100	Slope Inclinometer	Linear Foot
248.5200	Observation Well	Linear Foot
248.5300	Shape Array Instrument	Each
248.5400	Tiltmeter	Each
248.5501	Settlement Platform, Type I	Each
248.5502	Settlement Platform, Type II	Each
248.5603	Piezometer, Type III	Each
248.5700	Datalogger	Each
248.5800	Pressure Cell	Each

SECTION 250 – CONSTRUCTION VIBRATION AND CRACK MONITORING

250.01 DESCRIPTION. This work shall consist of conducting construction condition surveys, developing and implementing a construction vibration monitoring plan, installing monitoring equipment, and performing monitoring of construction activities.

250.02 GENERAL REQUIREMENTS. Structures identified in the Contract shall be monitored as specified herein, however, in accordance with Subsection 107.11, the Contractor shall be responsible for all damage caused by their activities, regardless of whether or not the damaged structure or infrastructure was identified as being susceptible to damage in the Contract.

The Contractor shall notify residents and owners of the buildings identified in the Contract of the required monitoring and inform them of the scheduled activities. At a minimum, notification shall include a certified letter. The Contractor shall furnish to the Engineer a list of those contacted and proof of notification.

The Contractor shall maintain a log of all vibration related complaints, contact information for complainant, and actions taken, and shall furnish copies to the Engineer upon request.

250.03 EQUIPMENT. The Contractor shall furnish, maintain, and operate vibration monitoring equipment, such as seismographs and crack displacement monitoring gauges. Seismographs shall be capable of measuring, recording, and producing a hard copy of the frequency and peak particle velocity in three mutually perpendicular components of vibration, the vector sum of these peak particle velocities, and the frequency history of the vibrations. Instruments that only record vector sum measurements are not acceptable. These instruments shall be capable of measuring linear scale (dB-L) sound levels and be capable of continuously recording the peak particle velocity and providing a permanent record of the entire vibration event.

All monitoring equipment shall be powered with rechargeable batteries. Extension geophone and microphone cables may be necessary so that the instruments can be placed within structures if outside temperatures drop below 32°F.

Crack displacement monitoring gages shall be capable of monitoring horizontal and vertical movement with an accuracy of 0.04 inches.

250.04 PERSONNEL PREQUALIFICATION. The Contractor shall provide the services of an independent qualified engineering consultant. The engineering consultant used shall be subject to the approval of the Engineer.

The engineering consultant shall be responsible for the vibration and crack monitoring for construction activities. They shall conduct the construction condition surveys, develop the construction vibration monitoring plan, conduct the deployment and operation of all monitoring equipment, and be available to discuss vibration results at the request of the Agency.

The Contractor shall submit the following information regarding the engineering consultant's qualifications:

(a) Documentation showing that the engineering consultant has directly participated in three projects in the past 5 years where they have successfully developed vibration criteria and monitored construction activities on projects similar to the scope of the current project. The documentation shall contain a description of the projects, the names of the general contractor and the owner, and current contact information of a representative of the construction manager or project owner.

(b) A resume of the engineering consultant showing at least 10 years of experience in seismic monitoring.

The Contractor shall submit this information to the Engineer for review, evaluation, and approval prior to submitting detailed information as required in Subsection 250.06. The Engineer will render a decision within 7 calendar days after receipt of the submission.

250.05 CONSTRUCTION CONDITION SURVEYS. The engineering consultant shall conduct a pre- and post-construction condition survey of any buildings, structures, or utilities identified in the Contract. Additional buildings, structures, or utilities not identified in the Contract may require a survey, as identified by the engineering consultant or as directed by the Engineer. The engineering consultant shall submit the construction condition survey results as outlined in Subsection 250.06.

250.06 SUBMITTALS. The Contractor shall submit to the Engineer, in accordance with Subsection 105.06, the following information for completing the work. The Contractor is entirely responsible for the work associated with these submittals.

(a) Pre-Construction Submittals. The contractor shall submit the following information at least 21 calendar days prior to the start of construction. Construction shall not begin until the submittals have been approved in writing by the Engineer.

(1) Pre-Construction Condition Survey Report. The pre-construction condition survey shall include, but is not limited to:

a. A summary naming the person who performed the survey, including the date and time of the survey.

b. A description of all structures, utilities, and other facilities identified in the Contract and in the judgment of the engineering consultant requiring a pre-construction condition survey. Particular attention shall be given to historic structures, structures in poor condition, structures supported by vibration sensitive materials which could cause settlement or loss of support, and structures which contain sensitive equipment or processes.

c. Location and contact information for the owners and occupants of all facilities contacted and surveyed.

d. Documentation of the aesthetic and structural condition through observations, actual measurements, plan sketches, photographs, digital recordings, and any other data deemed appropriate. Photos and digital recordings shall contain an accurate date stamp.

(2) Construction Vibration and Crack Monitoring Plan. The Contractor shall submit a detailed plan for construction vibration monitoring. This shall include, but is not limited to:

a. A description of proposed construction methods, including amplitude descriptions of each vibration producing activity, and a vibration monitoring plan for each activity.

b. A description of the monitoring equipment intended for use.

c. Certificates of calibration for all monitoring equipment. The records shall show that the monitoring equipment has been calibrated on an approximate 6 month interval.

d. Proposed vibration and crack monitoring limits for each piece of monitoring equipment for each vibration producing activity.

e. Proposed locations of seismographs and crack displacement monitoring gauges. Locations shall be recorded in degrees latitude and longitude and included in a plan view.

f. Baseline monitoring data, recorded for at least 7 calendar days prior to vibration producing activities to establish background conditions.

g. Description of the process which will be used to verify that the monitoring equipment will function as planned before starting work and the process which will be used to verify that the monitoring equipment remains in calibrated working order.

h. Procedures to be implemented if it is determined that the proposed construction activity cannot be reasonably implemented without exceeding vibration limits.

i. Procedures to be implemented if the vibration limit is reached or if damage is observed regardless of vibration limits being exceeded.

j. Examples of all forms used in the Contractor's submissions. Individual forms may require revision for the Agency's approval.

(b) Monitoring Data and Reporting. The engineering consultant shall submit monitoring data daily when vibration producing activities are in progress. This shall include, but is not limited to:

(1) Summary report from each seismograph, including, but not limited to:

a. Instrument and location.

b. Peak particle velocity and frequency of the peak.

c. Peak particle displacement.

d. Peak acceleration.

e. Peak vector sum.

f. Relationship to baseline data collection.

g. Confirmation that the vibration data shows conformation with the vibration limits.

(2) Measurements from crack displacement monitoring gauges.

(3) A dated and signed copy of records of all seismographs and crack gauges readings.

(c) Vibration Exceedance Report. If the vibration limit is reached or exceeded, or there are signs of damage to surrounding buildings and structures, the Contractor shall submit a vibration exceedance reports for approval before vibration producing activities can resume. This report shall include, but it is not limited to:

(1) Cause of the exceedance.

(2) Proposed corrective action for future construction activity.

(3) Proposed corrective action to address any damage that occurred.

(d) Post-Construction Condition Survey Report. The contractor shall submit the following information not more than 21 calendar days after vibration inducing activities are completed. The post-construction condition survey shall include, but is not limited to:

(1) A summary naming the person who performed the survey, including the date and time of the survey.

(2) Location and contact information for the owners and occupants of all facilities surveyed.

(3) Documentation of all facilities surveyed during the post-construction condition survey, including documenting the aesthetic and structural condition through observations, actual measurements, plan sketches, photographs, digital recordings, and any other data deemed appropriate. Photos and digital recordings shall contain an accurate date stamp.

250.07 MONITORING CRITERIA. The engineering consultant shall be responsible for installing monitoring equipment and performing monitoring of background and construction activities.

(a) The engineering consultant shall be responsible for placing the monitoring equipment at locations designated in the construction vibration monitoring plan.

(b) The monitoring vibration measuring equipment shall be calibrated within 6 months of the time of use and operated by properly trained personnel.

(c) Additional monitoring equipment may be required at the discretion of the Engineer and at no cost to the Agency.

(d) In the event that the Contractor chooses to have concurrent vibration producing activities at more than one location, the Contractor shall notify the Engineer prior to the commencement of such activities. The Engineer may require additional monitoring equipment at each location depending on site parameters.

(e) No vibration producing activities may be started until the appropriate monitoring equipment is installed and functioning as witnessed by the Engineer.

(f) The Contractor shall be responsible for monitoring equipment maintenance. If the Contractor does not maintain an amount of monitoring equipment sufficient to monitor the vibration producing activity, the Engineer may direct that all vibration producing activities cease until a sufficient amount of monitoring equipment is present.

(g) The Contractor shall immediately cease work if the approved vibration limit is reached or exceeded. In the event of an exceedance the Engineer shall be notified immediately. In the event of work being stopped, the Contractor shall submit a vibration exceedance report as outlined in Subsection 250.06(c). In order to proceed with any further vibration producing activities, written permission shall be obtained from the Engineer.

(h) The Engineer may, at any time, halt construction if there are signs of damage to surrounding buildings and structures.

250.08 METHOD OF MEASUREMENT. The quantity of Construction Vibration and Crack Monitoring to be measured for payment will be on a lump sum basis in the complete and accepted work.

250.09 BASIS OF PAYMENT. The accepted quantity of Construction Vibration and Crack Monitoring will be paid for at the Contract lump sum price. Payment will be full compensation for developing the construction vibration and crack monitoring plan, performing the construction condition surveys, implementing the plan, including making all submittals, installation of monitoring equipment, recording and submitting daily monitoring reports, making any necessary modifications during construction and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Partial payments will be made as follows:

(a) The first payment of 35% of the Contract unit price will be made once the construction vibration and crack monitoring plan is approved.

(b) The final payment of 65% of the Contract unit price will be made once the post-construction condition survey report is approved.

Payment will be made under:

Pay Item	Pay Unit
250.0100 Construction Vibration and Crack Monitoring	Lump Sum

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DIVISION 300

SUBBASE AND BASE COURSES

SECTION 301 – SUBBASE

301.01 DESCRIPTION. This work shall consist of furnishing and placing one or more courses of approved gravel, crushed gravel, dense graded crushed stone, or other proportioned material on a prepared surface or at other locations.

301.02 MATERIALS. Materials shall meet the requirements of the following subsections:

At the option of the Contractor, unless otherwise specified in the Contract, processed glass aggregate (PGA) meeting the requirements of Subsection 704.20 or recycled concrete aggregate (RCA) meeting the requirements of Subsection 704.21 may be used to partially replace natural aggregate in materials specified to meet the requirements of Subsection 704.04, Subsection 704.05, or Subsection 704.06.

PGA subbase blends shall not contain more than 20% PGA by weight. RCA subbase blends shall not contain more than 25% RCA by weight. In no case shall PGA and RCA be combined in subbase. The final blend shall conform to the specified gradation for the subbase material. The blending process shall be complete to ensure that as thorough a distribution and as uniform a mixture as practicable has been obtained. In-place blending of PGA with other materials will not be permitted.

When specified for use on the project or as directed by the Engineer, RAP subbase shall include milled grindings which have been screened or crushed by the Contractor such that 100% pass the 1-1/2 inch (37.5 mm) sieve prior to blending. The grindings shall be blended in equal proportions (50% by weight) with material meeting the requirements of fine graded crushed gravel for subbase as specified in Table 704.05A.

301.03 GENERAL CONSTRUCTION REQUIREMENTS. The subbase material shall be placed on a prepared surface with an approved spreader box or by use of other approved mechanical spreading equipment. Dumping directly on the subgrade will not be permitted. A bulldozer may be used instead of a spreader box, provided that the subbase material is first placed on the previously laid subbase and then completely removed from the area where it was first deposited.

Should segregation of the subbase occur, the Contractor shall remove and replace the material or rework it until uniform grading is obtained.

If material below subgrade becomes intermixed with the subbase, resulting in an unacceptable product, the mixture shall be removed and replaced with new subbase material.

Frozen material shall not be used in the construction of subbase. Subbase material shall not be deposited on frozen subgrade, and successive layers shall not be placed on material that has frozen.

The maximum compacted layer thickness for all subbase materials is 12 inches. Where the finished depth of the subbase is to be greater than 12 inches, it shall be placed and compacted in two or more layers of approximately equal thickness. In the placement of layers, all joints shall be staggered at least 12 inches.

After each layer of subbase material is placed, it shall be graded to obtain a smooth, even surface as specified in Subsection 301.05. Following grading operations, the subbase shall be thoroughly compacted as specified in Subsection 301.06. If required, water shall be uniformly applied over the subbase materials during compaction in the amount necessary for proper consolidation. Care shall be taken to prevent excessive moisture contents in subbase materials prior to compaction.

Materials containing PGA or RCA shall be compacted in the same manner as materials that do not contain recycled materials. If needed, the Contractor may use material meeting the requirements of Table 704.02C as filler to achieve the design grade when the variation of the surface is less than 1 inch.

When it is necessary to maintain traffic over the subbase, half of the width of the roadway shall be constructed at a time. The portion under construction shall have the subbase material placed, graded, and compacted before opening to traffic. Subsequent traffic damage to the material shall be entirely the Contractor's responsibility. If the subbase loses its shape, the Contractor shall loosen, regrade, and compact as necessary.

When it is necessary to maintain traffic over the subbase, or where construction hauling occurs over the subbase, the upper 2 inches of subbase shall be scarified (to restore permeability in the subbase surface), compacted, and regraded as required, or replaced just prior to the placement of any pavement.

301.04 SPECIFIC CONSTRUCTION REQUIREMENTS.

(a) Subbase of Gravel. Only uniformly graded gravel from the pit shall be used. The Contractor shall manipulate the material in the pit to eliminate non-uniformly graded pockets of material.

(b) Subbase of Crushed Gravel. When stockpiling, care shall be taken to prevent segregation in the pile.

(c) Subbase of Dense Graded Crushed Stone. When stockpiling, care shall be taken to prevent segregation in the pile.

301.05 SURFACE TOLERANCE. The surface of the compacted subbase will be tested by the Engineer at selected locations. The variation of the surface shall at no point exceed 1 inch. This variation shall not be maintained for a distance longer than 50 feet. The required crown and superelevation shall be maintained. All humps or depressions exceeding the specified tolerances shall be corrected by reshaping or removing defective work and replacing it with new material as directed by the Engineer. Any new material used to replace removed material shall meet the applicable gradation in Subsection 301.02.

301.06 COMPACTION. Compaction of each layer shall continue until a density of not less than 95% of the maximum dry density has been achieved.

When 1,000 cubic yards or more of subbase material is to be placed as part of the Contract, the maximum dry density shall be determined by the Contractor in accordance with *AASHTO T 180, Method D,* as modified by the Agency's Materials Testing and Certification Section. Laboratory moisture-density tests shall be performed to ensure a standard error of the mean maximum dry density of less than 1 pcf. This will necessitate at least five, but no more than ten, replications of the test. The Contractor shall provide the Engineer with all test results and calculations for determining the maximum dry density, at least 10 calendar days prior to subbase placement.

The maximum dry density shall be determined after any change in source, regardless of quantity, and confirmed by repetition of the selected test method at a frequency of 1,000 cubic yards when the prescribed standard error can be attained by five or less replicate tests. If more than five replicate tests are required to meet the prescribed standard error, the maximum dry density shall be confirmed at a frequency of every 5,000 cubic yards. The Engineer may reduce this frequency with the approval of the Geotechnical Engineering Manager after the initial two maximum dry density determinations.

When fewer than 1,000 cubic yards of subbase material are to be placed as part of the Contract, the maximum dry density will be determined by the Agency in accordance with *AASHTO T 180, Method D*, as modified by the Agency's Materials Testing and Certification Section.

Field density testing will be performed by the Agency in accordance with *AASHTO T 310* at locations determined by the Engineer. Compaction operations shall proceed such that the target field density as determined in accordance with this subsection is achieved.

301.07 METHOD OF MEASUREMENT. The quantity of Subbase of Gravel; Subbase of Crushed Gravel, Coarse Graded; and Subbase of Crushed Gravel, Fine Graded to be measured for payment will be the number of cubic yards of the type specified for use in the complete and accepted work, as determined by the plan dimensions of the compacted material, including any filler material used to achieve the design grade.

When specified to be paid by weight, the quantity of Subbase of Crushed Gravel, Fine Graded to be measured for payment will be the number of tons of material in place in the complete and accepted work, as determined from the load tickets.

The quantity of Subbase, RAP to be measured for payment will be the number of tons of material in place in the complete and accepted work, as determined from the load tickets.

When subbase material is required for extra depth at bridge approaches, the quantity to be measured for payment will be the number of cubic yards measured in place for this purpose between the lines shown on the Plans.

Materials containing PGA or RCA will be measured in the same manner as subbase materials that do not contain PGA or RCA.

301.08 BASIS OF PAYMENT. The accepted quantity of Subbase of Gravel; Subbase of Crushed Gravel, Coarse Graded; Subbase of Crushed Gravel, Fine Graded; and Subbase, RAP will be paid for at the Contract unit price per cubic yard or ton for the type specified. Payment will be full compensation for furnishing, blending, transporting, testing, placing, grading, and compacting the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

No additional payment will be made for filler material used as a replacement for the specified subbase material.

No payment will be made for the following:

(a) Material forced into or mixed with the subgrade material.

(b) Material placed to a depth greater than shown on the Plans.

(c) Water used to obtain required compaction.

(d) Removal and replacement of subbase material.

(e) Scarifying, recompacting, or regrading of subgrade or subbase layers, when required.

Payment will be made under:

Pay Item		Pay Unit
301.1500	Subbase of Gravel	Cubic Yard
301.2500	Subbase of Crushed Gravel, Coarse Graded	Cubic Yard
301.2600	Subbase of Crushed Gravel, Fine Graded	Cubic Yard
301.2800	Subbase of Crushed Gravel, Fine Graded	Ton
301.3500	Subbase of Dense Graded Crushed Stone	Cubic Yard
301.4000	Subbase, RAP	Ton

SECTION 310 – FULL DEPTH RECLAMATION

310.01 DESCRIPTION. This work shall consist of performing full depth reclamation (FDR) by pulverizing the existing pavement together with underlying base course material, mixing with water, fine grading, and compacting the homogenous base materials to the depth, width, and desired density specified in the Contract.

310.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Water.....745.01

The pulverized material shall consist of the existing pavement blended with underlying subbase material and additional aggregate material and shall conform to the gradation requirements of Table 310.02A.

TABLE 310.02A – FDR GRADATION REQUIREMENTS

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
3 inch (75.0 mm)	100
1-1/2 inch (37.5 mm)	80 – 100
No. 4 (4.75 mm)	30 – 60

310.03 EQUIPMENT.

(a) General Requirements. Any additional equipment used by the Contractor beyond that specified below shall be approved by the Engineer based on its suitability to produce results meeting the specification requirements.

(b) Reclamation. The Contractor shall use a self-propelled, traveling rotary reclaimer or equivalent machine capable of cutting through existing roadway material to depths of up to 16 inches with one pass. The equipment shall be capable of pulverizing the existing pavement, base, and subgrade in-place, and mixing any added materials to the specified depth. The cutting drum shall have the ability to operate at various speeds (rpm), independent of the machine's forward speed, to control oversized material and gradation.

The Contractor shall provide and use equipment that will produce the completed FDR base as specified herein. The Contractor shall maintain all equipment in a satisfactory operating condition. Equipment such as road planers or milling machines designed to mill or shred the existing roadway materials rather than crush or fracture the materials are not allowed as an alternative to the reclaimer.

The reclaimer shall be equipped with a means for the Engineer to continually monitor reclamation depth or, alternately, the QC data shall be immediately available at all times.

The reclaimer drum shall rotate in the opposite direction of the reclaimer tires or as per the manufacturer's recommendation. Additional passes shall be provided as necessary to pulverize the material to meet the gradation as required.

The Contractor shall inspect the condition of the cutting teeth on a daily basis, replace all worn and broken cutting teeth, and keep the cutting drum fully maintained and in good working condition at all times. The inability of the reclaimer to produce the required objectives will subject the equipment to rejection by the Engineer.

(c) Grading. The power grader and any replacement graders shall have grade control automation.

(d) Compaction. The Contractor shall use a vibratory pad-foot roller having a dynamic force of 25 tons for breakdown compaction and shall perform finish rolling using a single steel drum roller of 12 tons to 14 tons. Additional compaction equipment may be used by the Contractor to achieve the desired compaction.

310.04 CONSTRUCTION REQUIREMENTS.

(a) General Requirements. Any manholes, valve covers, or other buried structures shall be protected from damage prior to beginning work. Construction operations shall be sequenced such that the entire roadway width is reclaimed and compacted to the depth specified on the Plans. The length of reclaimed base pulverized shall not exceed the length that can be completely pulverized, mixed, and compacted in the same working day. The compacted material shall provide a stable surface for traffic as directed by the Engineer.

The Contractor shall protect any surface or buried structures (bridges, culverts, slabs, utilities, shallow drainage pipes, etc.) during pulverization, including stopping pulverization and reclamation at these obstructions when required. When approaching any surface or shallow buried structures, the Contractor shall terminate mechanical pulverization or mixing a minimum distance of 2 feet from said structure. The Contractor shall remove the unpulverized material through other means and take care not to damage the structure. The Contractor shall replace the removed material with full depth pulverized material that has been fully mixed. Damage to these surface and buried structures shall be repaired at the expense of the Contractor.

Longitudinal joints between successive reclamation passes shall overlap a minimum of 6 inches. The Contractor shall provide a sufficient number of mixing cycles so that the minimum 6 inch overlap is achieved. The Contractor shall sequence the operations in order to complete all pulverization and mixing activities across the full width of the roadway within 36 hours. Reclaimed sections shall be paved over with bituminous concrete in the same year they were reclaimed.

(b) Geometry and Limits of Pulverization, Reclamation, and Grading. The pulverized material shall extend to the depth and width established in the Plans, or if not specified, the width of existing pavement.

The base material surface shall be finished within a tolerance of ± 1 inch. Any deviation shall not extend for more than 50 feet. The existing crown or superelevation shall be maintained.

(c) Compaction. For compaction of the FDR, the moisture content shall be within the range of the optimum moisture content ± 2%. The Contractor shall monitor the moisture content using a moisture meter or as otherwise approved or directed by the Engineer. If the optimum moisture content is not attained, then the material shall be reworked to bring the moisture content back into specification prior to completing further operations.

The FDR shall be compacted to 95% to 105% of the target maximum density (TMD). If two out of three consecutive density test results are outside of the allowable range, the Contractor will be required to construct a new test section to establish an updated TMD.

If the Engineer determines that the TMD is apparently incorrect, as evidenced by being achieved with little or minimal compactive effort, then the Engineer will require a new control section to establish a new TMD.

(d) Maintenance. The completed and cured FDR may be opened to traffic as approved by the Engineer. The Contractor shall protect and maintain the reclaimed base in good condition until all work is accepted. Required density and moisture content of the finished base shall be maintained until it is paved over. Any imperfections discovered shall be repaired by the Contractor as directed by the Engineer at no additional cost to the Agency. Portions of the FDR damaged by rain shall be reconstructed at the Contractor’s expense.

Dust control shall be conducted on the FDR sections to reduce the production of nuisance dust and reduce the hazard to traffic. When a dust control agent is not specified on the Plans, water or calcium chloride shall be used.

310.05 QUALITY CONTROL.

(a) General Requirements. The Contractor shall perform all process control and quality control sampling and testing, at the minimum frequencies specified in Table 310.05A.

TABLE 310.05A – MINIMUM QUALITY CONTROL FREQUENCIES

Test or Action	Frequency	Test Method
Density	1 per 1,000 feet per lane	*AASHTO T 310* or *ASTM D7830*
Moisture content	3 per day	*AASHTO T 217*, *AASHTO T 255*, *AASHTO T 310*, or *ASTM D7830*
Gradation	1 per day	*AASHTO T 27*

Density testing locations shall be sited at various transverse offsets within the lanes.

The Contractor shall provide the Engineer with written copies of all process control and quality control results by 1:00 p.m. on the next working day, including test locations. The Contractor shall make all test results available to the Engineer onsite and on request.

(b) Control Section. Control sections shall be constructed to establish the target density and moisture content at the beginning of the FDR, and through the project as needed.

The Contractor shall construct a control section to assure the Agency that the Contractor's equipment and procedures are suitable for the work specified and establish the target maximum density and moisture content. The TMD shall be the density determined from buildup, when the density readings show an increase in dry density of less than 1 pcf for the final four roller passes of each roller.

The control section shall be full lane width and a minimum of 500 feet long, or as approved by the Engineer. No further reclaiming shall be performed until all aspects of the control section and the TMD are approved by the Engineer. The Contractor shall use the same equipment for building both the accepted control sections and performing the FDR work on the project unless equipment substitution is approved by the Engineer.

The Engineer may require an additional control section and additional process control sampling to investigate the suitability of substituted or changed equipment.

If the control section does not meet the requirements of this specification, or the target density is not determined from buildup testing, then the Contractor shall modify the procedure and either construct another control section or reconstruct the original control section until suitable results are obtained.

The control section shall be used to determine the optimum moisture content and determine if supplemental aggregate is needed to meet the gradation requirements. Four quarter point samples shall be taken from the initial control section and combined to produce a representative sample. The representative sample shall be tested for gradation using *AASHTO T 27* and optimum moisture content in accordance with *AASHTO T 180, Method C* using a minimum of four moisture contents.

310.06 METHOD OF MEASUREMENT. The quantity of Full Depth Reclamation to be measured for payment will be the number of square yards constructed to the depth specified, complete in place in the accepted work. No allowance will be made for overlapping areas.

If the depth of base to be reclaimed must be adjusted in the field, the first 2 inches of additional or decreased depth will not be paid for directly, but will be considered incidental to the Full Depth Reclamation item. If the change in depth exceeds 2 inches, the number of square yards pulverized at the revised depth will be multiplied by the result of dividing the total depth actually pulverized by the original depth designated on the Plans to create an equivalent number of square yards for which payment will then be made.

310.07 BASIS OF PAYMENT. The accepted quantity of Full Depth Reclamation will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, handling, transporting, and placing the necessary materials; pulverizing; adding, or removing moisture; shaping, placing, and compacting the designated materials; constructing tests strips; conducting tests; maintaining the finished base until it is paved over and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

No additional compensation will be provided for multiple passes of the reclamation equipment and additional shaping, grading, and compacting.

Water used to adjust the moisture content prior to pulverization to achieve compaction of the pulverized material, will not be paid for directly but will be considered incidental to the Full Depth Reclamation item.

Water used for dust control after the reclamation will be incidental to the reclamation pay item.

Calcium chloride used for dust control after the reclamation will be paid for separately under the appropriate Section 609 pay item included in the Contract.

Payment will be made under:

Pay Item	Pay Unit
310.0100 Full Depth Reclamation	Square Yard

SECTION 311 – FULL DEPTH RECLAMATION, CALCIUM CHLORIDE

311.01 DESCRIPTION. This work shall consist of performing full depth reclamation (FDR) by pulverizing the underlying material, mixing with liquid calcium chloride, fine grading, and compacting the homogenous base materials to the depth, width, grade, and desired density specified in the Contract, and capping with a surface application of liquid calcium chloride.

311.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Water.....745.01
Calcium Chloride for Full Depth Reclamation.....746.02

The pulverized material shall consist of the existing pavement blended with underlying subbase material and additional aggregate material and shall conform to the gradation requirements of Table 311.02A.

TABLE 311.02A – FDR GRADATION REQUIREMENTS

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
3 inch (75.0 mm)	100
1-1/2 inch (37.5 mm)	80 – 100
No. 4 (4.75 mm)	30 – 60

311.03 EQUIPMENT.

(a) General Requirements. Any additional equipment used by the Contractor beyond that specified below shall be approved by the Engineer based on its suitability to produce results meeting the specification requirements.

(b) Reclamation. The Contractor shall use a self-propelled, traveling rotary reclaimer mixing unit with liquid injection. The equipment shall be capable of pulverizing the existing pavement, base, and subgrade in-place, and mixing any added materials to the specified depth. The cutting drum shall have the ability to operate at various speeds (rpm), independent of the machine's forward speed, to control oversized material and gradation. The reclaimer shall have a full width spray bar consisting of a positive displacement pump interlocked to the machine speed so that the amount of liquid calcium chloride being added is automatically adjusted with changes in machine speed, up to 5.0 gallons per square yard (± 0.02 gallons per square yard). Individual valves on the spray bar shall be capable of being turned off as necessary to minimize application overlap on subsequent passes. Liquid calcium chloride for stabilization shall only be introduced via the reclaimer and shall not be pre-applied to the road surface in front of the reclaimer.

The Contractor shall provide and use equipment that will produce the completed FDR base as specified herein. The Contractor shall maintain all equipment in a satisfactory operating condition. Equipment such as road planers or cold-milling machines designed to mill or shred the existing roadway materials rather than crush or fracture the materials are not allowed as an alternative to the reclaimer.

The Contractor shall ensure a full and homogeneous distribution of the liquid calcium chloride stabilizing agent. The reclaimer shall be equipped with a means for the Engineer to continually monitor reclamation depth or, alternately, the QC data shall be immediately available at all times.

The reclaimer drum shall rotate in the opposite direction of the reclaimer tires or as per the manufacturer's recommendation. Additional passes shall be provided as necessary to pulverize the material to meet the gradation as required.

The Contractor shall inspect the condition of the cutting teeth on a daily basis, replace all worn and broken cutting teeth, and keep the cutting drum fully maintained and in good working condition at all times. The inability of the reclaimer to produce the required objectives will subject the equipment to rejection by the Engineer.

(c) Grading. The power grader and any replacement graders shall have grade control automation.

(d) Compaction. The Contractor shall use a vibratory pad-foot roller having a dynamic force of 25 tons for breakdown compaction and shall perform finish rolling using a single steel drum roller of 12 tons to 14 tons. Additional compaction equipment may be used by the Contractor to achieve the desired compaction.

(e) Pressure Distributor. The distributor for surface application of the solution shall be capable of applying liquid calcium chloride in accurately measured quantities at any rate between 0.1 gallons to 2.0 gallons per square yard of roadway surface, at any length of spray bar up to 20 feet. The distributor shall be capable of maintaining a uniform rate of distribution of material regardless of change in grade, width, or direction of the road. The distributor shall be equipped with a digital volumetric accumulator capable of measuring gallons applied and distance traveled. The volume and measuring device shall be equipped with a power unit for the pump so that application is by pressure, not gravity. The spray nozzles and pressure system shall provide a sufficient and uniform fan-shaped spray of material throughout the entire length of the spray bar at all times while operating and shall be adjustable laterally and vertically. The spray shall completely cover the roadway surface receiving the treatment.

311.04 CONSTRUCTION REQUIREMENTS.

(a) General Requirements. Any manholes, valve covers, or other buried structures shall be protected from damage prior to beginning work. Construction operations shall be sequenced such that the entire roadway width is reclaimed and compacted to the depth specified on the Plans. The length of reclaimed base pulverized shall not exceed the length that can be completely pulverized, mixed, and compacted in the same working day. The compacted material shall provide a stable surface for traffic as directed by the Engineer.

The Contractor shall protect any surface or buried structures (bridges, culverts, slabs, utilities, shallow drainage pipes, etc.) during pulverization, including stopping pulverization and reclamation at these obstructions when required. When approaching any surface or shallow buried structures, the Contractor shall terminate mechanical pulverization or mixing a minimum distance of 2 feet from said structure. The Contractor shall remove the unpulverized material through other means and take care not to damage the structure. The Contractor shall replace the removed material with stabilized full depth pulverized material that has been fully mixed and treated with the applicable stabilization agent. Damage to these surfaces and buried structures shall be repaired at the expense of the Contractor.

Reclaimed sections shall be paved over with bituminous concrete in the same year they were reclaimed.

(b) Geometry and Limits of Pulverization, Reclamation, and Grading. The pulverized material shall extend to the depth and width established in the Plans, or if not specific the width of existing pavement.

The base material shall be finished within a grade tolerance of ± 1 inch. Any deviation shall not extend for more than 50 feet. The required crown or superelevation shall be maintained.

(c) Stabilization. The stabilizing agent shall be calcium chloride and shall be delivered to the reclaimer and distributed by the reclaimer in such a way as to ensure a uniform distribution across the roadway, at a rate of 0.75 gallons to 0.90 gallons per square yard, with a reclaim depth as shown on the Plans. Following base compaction, shaping, fine grading, and finish compaction and rolling, a final capping of 0.10 gallons to 0.25 gallons per square yard of liquid calcium chloride shall be applied with the pressure distributor to the finished surface. Total calcium chloride application rate from the combined processes shall be targeted at 1.0 gallons per square yard.

The Contractor shall provide a method for verifying that the correct amount of calcium chloride solution is being applied uniformly to the entire depth of the reclaimed layer and shall also provide a means for the Engineer to continually monitor, in real time, the forward speed of the reclaimer. At no time shall the reclaimer have a forward speed greater than 30 feet per minute unless the Contractor otherwise demonstrates that the stabilizer is fully and evenly mixed throughout the full depth of the finished material.

Longitudinal joints between successive reclamation passes shall overlap a minimum of 6 inches. The Contractor shall provide a sufficient number of mixing cycles so that the minimum 6 inch overlap is achieved. The Contractor shall sequence the operations in order to complete all pulverization and mixing activities across the full width of the roadway within 36 hours.

(d) Compaction. For compaction of the FDR, the moisture content shall be within the range of the optimum moisture content ± 2%. The Contractor shall monitor the moisture content using a moisture meter or as otherwise approved or directed by the Engineer. If the optimum moisture content is not attained, then the material shall be reworked to bring the moisture content back into specification prior to completing further operations.

The FDR shall be compacted to 95% to 105% of the target maximum density (TMD). If two out of three consecutive density test results are outside of the allowable range, the Contractor will be required to construct a new test section to establish an updated TMD.

If the Engineer determines that the TMD is apparently incorrect, as evidenced by being achieved with little or minimal compactive effort, then the Engineer will require a new control section to establish a new TMD.

(e) Maintenance. The completed and cured FDR may be opened to traffic as approved by the Engineer. The Contractor shall protect and maintain the reclaimed base in good condition until all work is accepted. Required density and moisture content of the finished base shall be maintained until it is paved over. Any imperfections discovered shall be repaired by the Contractor as directed by the Engineer at no additional cost to the Agency. Portions of the FDR damaged by rain shall be reconstructed at the Contractor’s expense.

Dust control shall be taken on the FDR sections to reduce the production of nuisance dust and reduce the hazard to traffic. When a dust control agent is not specified on the Plans, water or calcium chloride shall be used.

311.05 QUALITY CONTROL.

(a) General Requirements. The Contractor shall perform all process control and quality control sampling and testing, at the minimum frequencies specified in Table 311.05A.

TABLE 311.05A – MINIMUM QUALITY CONTROL FREQUENCIES

Test or Action	Frequency	Test Method
Density	1 per 1,000 feet per lane	*AASHTO T 310* or *ASTM D7830*
Moisture content	3 per day	*AASHTO T 217*, *AASHTO T 255*, *AASHTO T 310*, or *ASTM D7830*
Gradation	1 per day	*AASHTO T 27*

Density testing locations shall be sited at various transverse offsets within the lanes.

Gradation failures shall require the Contractor to take action to adjust the process to achieve compliant material. Additional aggregate added to correct gradation shall meet the requirements of Subsection 704.05(b).

The Contractor shall provide the Engineer with written copies of all process control and quality control results by 1:00 p.m. on the next working day, including test locations. The Contractor shall make all test results available to the Engineer onsite and on request.

(b) Control Section. Control sections shall be constructed to establish the target density and moisture content at the beginning of the FDR, and through the project as needed.

The Contractor shall construct a control section to assure the Engineer that the Contractor's equipment and procedures are suitable for the work specified and establish the target maximum density and moisture content. The TMD shall be the density determined from buildup, when the density readings show an increase in dry density of less than 1 pcf for the final four roller passes of each roller.

The control section shall be full lane width and a minimum of 500 feet long, or as approved by the Engineer. No further recycling shall be performed until all aspects of the control section and the TMD are approved by the Engineer. The Contractor shall use the same equipment for building both the accepted test sections and performing the FDR work on the project unless equipment substitution is approved by the Engineer.

The Engineer may require an additional test section and additional process control sampling to investigate the suitability of substituted or changed equipment.

If the control section does not meet the requirements of this specification, or the target density is not determined from buildup testing, then the Contractor shall modify the procedure and either construct another test section or reconstruct the original test section until suitable results are obtained.

The control section shall be used to determine the optimum moisture content. Four quarter point samples shall be taken from the initial test section and combined to produce a representative sample. This representative sample shall be tested for gradation using *AASHTO T 27* and optimum moisture content in accordance with *AASHTO T 180, Method D* using a minimum of four moisture contents.

The initial control section shall be used to determine if supplemental aggregate is needed to comply with the gradation requirements. Four quarter point samples shall be taken from the initial test section and combined to produce a representative sample and tested for gradation using *AASHTO T 27*.

311.06 METHOD OF MEASUREMENT. The quantity of Full Depth Reclamation, Calcium Chloride to be measured for payment will be the number of square yards constructed to the depth specified, complete in place in the accepted work. No allowance will be made for overlapping areas.

The quantity of Calcium Chloride for FDR, Calcium Chloride to be measured for payment will be the number of gallons used in the completed and accepted work, as determined from the load tickets or other method as approved by the Engineer.

311.07 BASIS OF PAYMENT. The accepted quantity of Full Depth Reclamation, Calcium Chloride will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, handling, transporting, and placing the necessary materials; pulverizing; adding, or removing moisture; shaping, placing, and compacting the designated materials; constructing tests strips; conducting tests; maintaining the finished base until it is paved over and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

No additional compensation will be provided for multiple passes of the reclamation equipment and additional shaping, grading, and compacting.

The accepted quantity of Calcium Chloride for FDR, Calcium Chloride will be paid for at the Contract unit price gallon. Payment will be full compensation for furnishing, handling, and placing the material specified.

Water used to adjust the moisture content prior to pulverization to achieve compaction of the pulverized material, will not be paid for directly but will be considered incidental to reclamation pay item.

Water used for dust control after the reclamation will be incidental to the reclamation pay item.

Calcium chloride used for dust control after the reclamation will be paid for separately under the appropriate Section 609 pay item in the Contract.

Subbase of Crushed Gravel, Fine Graded used to correct gradation or geometric deficiencies will be paid for under the appropriate subbase item included in the Contract.

Payment will be made under:

Pay Item		Pay Unit
311.0100	Full Depth Reclamation, Calcium Chloride	Square Yard
311.5100	Calcium Chloride for FDR, Calcium Chloride	Gallon

SECTION 312 – FULL DEPTH RECLAMATION, EMULSION

312.01 DESCRIPTION. This work shall consist of performing full depth reclamation (FDR) by pulverizing the underlying material, mixing with emulsified asphalt and Portland cement, fine grading, and compacting the homogenous base materials to the depth, width, grade, and desired density specified in the Contract.

312.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Portland Cement.....701.02
Anionic Emulsified Asphalt.....702.02(a)
Cationic Emulsified Asphalt.....702.02(b)
Water.....745.01

Emulsified asphalt for base stabilization shall be type, HFMS-2, HFMS-2h, HFMS-2s, MS-2h, CMS-2h, SS-1h, CSS-1, or CSS-1h as recommended by the Contractor mix design.

The pulverized material shall consist of the existing pavement blended with underlying subbase material and additional aggregate material and shall conform to the gradation requirements of Table 312.02A.

TABLE 312.02A – FDR GRADATION REQUIREMENTS

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
3 inch (75.0 mm)	100
1-1/2 inch (37.5 mm)	80 – 100
No. 4 (4.75 mm)	30 – 60

312.03 EQUIPMENT.

(a) General Requirements. Any additional equipment used by the Contractor beyond that specified below shall be approved by the Engineer based on its suitability to produce results meeting the specification requirements.

(b) Reclamation. The Contractor shall use a self-propelled, traveling rotary reclaimer or equivalent machine capable of cutting through existing roadway material to depths of up to 16 inches with one pass. The equipment shall be capable of pulverizing the existing pavement, base, and subgrade in-place, and mixing any added materials to the specified depth. The cutting drum shall have the ability to operate at various speeds (rpm), independent of the machine's forward speed, to control oversized material and gradation.

The Contractor shall provide and use equipment that will produce the completed FDR-emulsion base as specified herein. In addition, the equipment used shall be capable of automatically metering the emulsion with a variation of not more than ± 2% by weight of the emulsion. Calibration records shall be provided to the Engineer before use of any equipment as requested. The Contractor shall maintain all equipment in a satisfactory operating condition.

The Contractor shall ensure a full and homogeneous distribution of the emulsified asphalt stabilizing agent. In concert with this requirement, the reclaimer shall be equipped with a means for the Engineer to continually monitor reclamation depth or, alternately, the QC data shall be immediately available at all times.

The reclaimer drum shall rotate in the opposite direction of the reclaimer tires or as per the manufacturer's recommendation.

The Contractor shall inspect the condition of the cutting teeth on a daily basis, replace all worn and broken cutting teeth, and keep the cutting drum fully maintained and in good working condition at all times. The inability of the reclaimer to produce the required design objectives will subject the equipment to rejection by the Engineer and require QC plan amendments to address equipment faults.

(c) Compaction. The Contractor shall use a vibratory pad-foot roller having a dynamic force of 25 tons for breakdown compaction and shall perform intermediate rolling using a single steel drum roller of 12 tons to 14 tons. A pneumatic tire roller shall be used for finish rolling to create a close-knit texture. Additional compaction equipment may be used by the Contractor to achieve desired compaction.

312.04 CONSTRUCTION REQUIREMENTS.

(a) General Requirements. For quantity calculation and construction purposes, a Portland cement content of 1.0% was used to estimate the required Portland cement tonnage for this work. Cement has been included in the work to expedite the FDR curing process.

Agency personnel and equipment shall be allowed free and full access to the project site at no additional compensation due the Contractor to allow for any and all sampling required to assess compliance with the provisions of this specification. The Contractor will afford the Agency all traffic control operations and provide means to extract samples as requested to achieve this effort.

The emulsified asphalt and cement contents used in production may vary throughout the project and be adjusted by the Contractor based on the results of QC testing or other variables as identified by the Agency or the Contractor to maintain an optimized finished product.

Any manholes, valve covers, or other buried structures shall be protected from damage prior to beginning work. Construction operations shall be sequenced such that the entire roadway width is reclaimed and compacted to the depth specified on the Plans. The length of reclaimed base pulverized shall not exceed the length that can be completely pulverized, mixed, and compacted in the same working day. The compacted material shall provide a stable surface for traffic as directed by the Engineer.

The Contractor shall protect any surface or buried structures (bridges, culverts, slabs, utilities, shallow drainage pipes, etc.) during pulverization and chemical stabilization, including stopping pulverization and reclamation at these obstructions when required. When approaching any surface or shallow buried structures, the Contractor shall terminate mechanical pulverization or mixing a minimum distance of 2 feet from said structure. The Contractor shall remove the unpulverized material through other means and take care not to damage the structure. The Contractor shall replace the removed material with full depth treated material that has been fully mixed and treated with the applicable chemical. Damage to these surfaces and buried structures will be repaired at the expense of the Contractor.

(b) Design Criteria. The FDR mix design shall meet the design criteria requirements of Table 312.04A.

TABLE 312.04A – DESIGN REQUIREMENTS

Test Method	Criteria
Indirect tensile strength, dry subset, *AASHTO T 283*	40 psi, min.
Ratio of residual asphalt to cement	2.5 to 1, min.

(c) Mix Design. The Contractor shall develop an FDR mix design consisting of blended aggregate, RAP, emulsified asphalt, and Portland cement. To obtain material to develop the mix design, the Contractor shall sample existing pavement to represent the reclaimed aggregates that would be expected to result from the first pass of the reclamation process. A minimum of four samples representative of the quarter points of the entire length of the project shall be taken. The sampling process may occur either before or after milling, however, if it occurs before milling, any alternate means of removing the excess pavement to conduct the simulation shall be approved by the Engineer. The Contractor shall develop and submit a material sampling plan for review and approval by the Agency a minimum of 5 working days prior to obtaining mix design samples. At a minimum, the sampling plan shall include the number of samples, location of samples, and the method of sampling and backfilling.

Additional FDR and subbase blends may be required in design analysis as directed by the Engineer.

AASHTO R 109 shall be the method used to develop a mix design in accordance with *AASHTO M 347*, except only meeting specified design requirements in Table 312.04A. The resultant job mix formula (JMF) shall contain the percent passing each sieve, emulsified asphalt type and content as a percent of total FDR material, cement content as a percent of total FDR material, maximum density, and recommended water content range as a percentage of dry FDR material.

A minimum of 10 working days shall be allowed for evaluation of the submitted mix design. A copy of all test data used in developing the mix design, including graphs, shall be required with the submittal of the mix design.

The Engineer may approve changes in the design's job-mix formula or discontinue use of the design if placement, finishing, or compaction characteristics are determined to be unsatisfactory.

(d) Geometry and Limits of Pulverization, Reclamation, and Grading. The stabilized material shall extend to the Plan depth and width of the roadway and shall not be more than 2 inches narrower nor more than 6 inches wider than the Plan edge of stabilized material. Stabilized material that spreads over the edges and creates a surface crust that is less than the full depth indicated on the Plans is not considered to be full depth emulsified asphalt stabilized material and shall be reclaimed to meet the Plan requirements as directed by the Engineer.

The design depth and line of stabilized material shall be fully homogenous of emulsion stabilizer, shaped, graded, and compacted to within 1 inch of the design depth.

(e) Stabilization. The stabilizing agent shall be emulsified asphalt as specified in the JMF and shall be delivered to the reclaimer and distributed by the reclaimer in such a way as to ensure a uniform distribution across the roadway. The Contractor shall provide a method for verifying that the correct amount of emulsion is being applied uniformly to the entire depth of the reclaimed layer and shall also provide a means for the Engineer to continually monitor, in real time, the forward speed of the reclaimer. At no time shall the reclaimer have a forward speed greater than 30 feet per minute unless the Contractor otherwise demonstrates that the stabilizer is fully and evenly mixed throughout the full depth of the finished FDR material.

Longitudinal joints between successive reclamation passes shall overlap a minimum of 6 inches. The Contractor shall provide a sufficient number of mixing passes so that the minimum 6 inch overlap is achieved. The Contractor shall sequence the operations in order to complete all pulverization and mixing activities across the full width of the roadway within the same work shift. Longitudinal cold joints are not allowed in the emulsified asphalt stabilized base.

(f) Compaction. For compaction of the FDR, the moisture content shall be within the range of the optimum moisture content ± 2%. The Contractor shall monitor the moisture content using a moisture meter or as otherwise approved or directed by the Engineer. If the optimum moisture content is not attained, then the material shall be reworked to bring the moisture content back into specification prior to completing further operations.

The FDR shall be compacted to 95% to 105% of the target maximum density (TMD). If two out of three consecutive density test results are outside of the allowable range, the Contractor will be required to construct a new test section to establish an updated TMD.

If the Engineer determines that the TMD is apparently incorrect, as evidenced by being achieved with little or minimal compactive effort, then the Engineer will require a new control section to establish a new TMD.

(g) Curing and Maintenance. After the FDR has been compacted, traffic, including the Contractor's equipment, shall not be permitted on the pulverized pavement for a minimum of 2 hours unless otherwise approved by the Engineer. Prior to placement of any bituminous overlay, the pulverized pavement shall be allowed to cure until the free moisture is reduced to 2% or less, by total weight of mix in accordance with *AASHTO T 217*. However, the FDR shall be covered by bituminous pavement within 14 calendar days of being mixed and compacted.

The Contractor shall protect and maintain the FDR in good condition until all work is accepted. Such maintenance shall be performed by the Contractor at the Contractor's expense. Maintenance shall include immediate repairs of any defects that may occur. If it is necessary to replace any processed material, the replacement shall be full depth, with vertical cuts, using treated material with strength properties equivalent to the original FDR material. No skin patches will be permitted. Portions of the FDR damaged by rain shall be reconstructed at the Contractor's expense.

Dust control shall be taken on the FDR sections to reduce the production of nuisance dust and reduce the hazard to traffic. When a dust control agent is not specified on the Plans, water or calcium chloride shall be used.

(h) Weather and Seasonal Limitations. Emulsified asphalt stabilization shall not be performed when soil temperatures are expected to be less than 40°F within the next 72 hours or freezing temperatures within 7 calendar days of curing operations unless requested and subsequently authorized in writing by the Engineer. Stabilization shall not occur when rainfall is reasonably expected within 24 hours of emulsion application. The Contractor shall monitor the weather and sequence operations accordingly and provide necessary repairs to work that has been damaged by inclement weather. The Contractor shall not perform stabilization from September 1st to May 15th, inclusive, unless requested in writing and subsequently approved by the Engineer. The quality control program shall adequately address these factors.

312.05 QUALITY CONTROL.

(a) General Requirements. The Contractor shall sample, test, and evaluate the FDR process in accordance with the procedures and minimum frequencies specified in Table 312.05A.

TABLE 312.05A – MINIMUM QUALITY CONTROL FREQUENCIES

Test or Action	Frequency	Test Method
Density	1 per 1,000 feet per lane	*AASHTO T 310* or *ASTM D7830*
Moisture content	3 per day	*AASHTO T 217*, *AASHTO T 255*, *AASHTO T 310*, or *ASTM D7830*
Yield for cement and emulsion	2 per day at even intervals	Tank check
Gradation and asphalt content of final product	1 per day	*AASHTO T 30* (dry), *AASHTO T 164*, or *AASHTO T 308*

Density testing locations shall be sited at various transverse offsets within the lanes.

Gradation failures shall require the Contractor to take action to adjust the process to achieve compliant material. Additional aggregate material added to correct gradation shall meet the requirements of Subsection 704.05(b).

Quality control records shall include all sampling events, testing events, and process changes with accurate time and location data. The Contractor shall submit QC records and summaries to the Engineer by 1:00 p.m. on the next working day. The Contractor shall make all test results, including randomly sampled densities, available to the Engineer onsite and on request.

The Contractor shall cease recycling operations whenever one of the following occurs:

(1) The computed yield of each additive differs from the approved JMF by 10% or more.

(2) The Contractor fails to follow the approved QC plan.

(3) The finished product is visually segregated, unstable, or otherwise defective, as determined by the Engineer.

Recycling operations shall not resume until the Contactor and the Agency agree on the corrective action to be taken.

(b) Quality Control Plan. The Contractor shall submit a quality control plan (QC plan) to the Engineer a minimum of 14 calendar days prior to initiating FDR operations and shall not commence FDR operations until the QC plan is accepted by the Engineer.

The QC plan shall address any items that affect the quality of the recycling process including, but not limited to, the following:

(1) QC Plan Administrator. The QC plan administrator shall be identified in the QC plan and shall list their past experience on FDR projects stabilized with emulsion. They shall:

a. Be a full-time employee of the Contractor or an independent consultant not involved with the acceptance activities of the project.

b. Have a minimum of four years of experience in quality control activities in construction operations.

c. Have full authority to institute actions necessary for successful implementation of the QC plan.

(2) Quality Control Technician. The quality control technicians (QCT) shall be responsible for conducting quality control and inspection activities to implement the QC plan. There may be more than one QCT on a project. They shall:

a. Be a full-time employee of the Contractor or an independent consultant with a minimum of two years of experience in quality control activities in field construction operations.

b. Have completed the requirements for the applicable testing by the Northeast Transportation Training and Certification Program (NETTCP) for Soils and Aggregate Inspector, or an equivalent regional program.

c. Have full authority to institute actions necessary for successful implementation of the QC plan.

(3) Minimum Quality Control Parameters. Minimum quality control parameters are:

a. Make and type of reclaimer.

b. Make and type of rollers and their respective location.

c. Gradation and asphalt content results.

d. Moisture content behind the reclaimer.

e. Emulsion application rate.

f. Water addition rate and distribution.

g. Mixing via drum speed, reclaimer ground speed, and depth.

h. Accurate moisture density curves and targets.

i. Specifics of the testing methods used for density and moisture content.

j. Final density after compaction (both passes).

k. Curing plan.

(c) Control Section. Control sections shall be constructed to establish the TMD and verify moisture content at the beginning of the FDR, and through the project as needed.

The Contractor shall construct a control section to assure the Engineer that the Contractor's equipment and procedures are suitable for the work specified and establish the target maximum density and moisture content. The TMD shall be the density determined from buildup, when the density readings show an increase in dry density of less than 1 pcf for the final four roller passes of each roller.

The control section shall be full lane width and a minimum of 500 feet long, or as approved by the Engineer. No further reclamation shall be performed until all aspects of the control section and the TMD are approved by the Engineer. The Contractor shall use the same equipment for building both the accepted test sections and performing the FDR work on the project unless equipment substitution is approved by the Engineer.

The Engineer may require an additional test section and additional process control sampling to investigate the suitability of substituted or changed equipment.

If the control section does not meet the requirements of this specification, or the target density is not determined from buildup testing, then the Contractor shall modify the procedure and either construct another test section or reconstruct the original test section until suitable results are obtained.

The control section shall be used to verify the optimum moisture content. Four quarter point samples shall be taken from the initial test section and combined to produce a representative sample. This representative sample shall be tested for optimum moisture content in accordance with *AASHTO T 180, Method D* using a minimum of four moisture contents.

The initial control section shall be used to determine if supplemental aggregate is needed to comply with the gradation requirements. Four quarter point samples shall be taken from the initial test section, combined to produce a representative sample, and tested for gradation using *AASHTO T 30*.

The Contractor shall provide the Engineer with written copies of all process control and quality control results by 1:00 p.m. on the next working day, including test locations. The Contractor shall make all test results available to the Engineer onsite and on request.

312.06 METHOD OF MEASUREMENT. The quantity of Full Depth Reclamation, Emulsion to be measured for payment will be the number of square yards constructed to the depth specified, complete in place in the accepted work. No allowance for overlapping areas will be made.

The quantity of Emulsified Asphalt for FDR, Emulsion to be measured for payment will be the number of hundredweight used in the completed and accepted work, as determined from the load tickets or other method as approved by the Engineer.

The quantity of Portland Cement for FDR, Emulsion to be measured for payment will be the number of tons of material in place in the completed and accepted work, as determined from the load tickets or other method as approved by the Engineer.

312.07 BASIS OF PAYMENT. The accepted quantity of Full Depth Reclamation, Emulsion will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, handling, transporting, and placing the necessary materials; pulverizing; adding, or removing moisture; shaping, placing, and compacting the designated materials; constructing tests strips; conducting tests; maintaining the finished base until it is paved over and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

No additional compensation will be provided for multiple passes of the reclamation equipment and additional shaping, grading, and compacting.

Water used to adjust the moisture content prior to pulverization to achieve compaction of the pulverized material, will not be paid for directly but will be considered incidental to the Full Depth Reclamation, Emulsion item.

Water used for dust control after the reclamation will be incidental to the reclamation pay item.

Calcium chloride used for dust control after the reclamation will be paid for separately under the appropriate Section 609 pay item in the Contract.

The accepted quantity of Emulsified Asphalt for FDR, Emulsion will be paid for at the Contract unit price per hundredweight. Payment will be full compensation for furnishing, handling, and placing the material specified.

The accepted quantity of Portland Cement for FDR, Emulsion will be at the Contract unit price per ton. Payment will be full compensation for furnishing, handling, and placing the material specified.

Subbase of Crushed Gravel, Fine Graded used to correct gradation or geometric deficiencies will be paid for under the appropriate subbase item included in the Contract.

Payment will be made under:

Pay Item		Pay Unit
312.0100	Full Depth Reclamation, Emulsion	Square Yard
312.5100	Emulsified Asphalt for FDR, Emulsion	Hundredweight
312.5200	Portland Cement for FDR, Emulsion	Ton

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DIVISION 400

SURFACE COURSES AND PAVEMENT

SECTION 401 – AGGREGATE SURFACE COURSE

401.01 DESCRIPTION. This work shall consist of furnishing and placing a wearing course of approved aggregate on a prepared surface.

401.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Aggregate Surface Course .....704.12(a)
Aggregate Surface Course, Paths and Trails.....704.12(b)

401.03 PLACEMENT. The aggregate shall be placed and properly shaped using equipment that allows the typical cross-section and design grade to be attained. Should aggregate segregation occur, the Contractor shall remove and replace the segregated material or manipulate it until uniform gradation is obtained.

The minimum layer thickness for placement of any aggregate surface material shall be 2 inches after compaction, and the maximum layer thickness shall be 8 inches after compaction. All layers shall be placed and compacted at approximately equal thickness. In the placement of layers, all joints shall be staggered at least 12 inches.

After each layer of surface material is placed, it shall be thoroughly compacted to a uniform density of not less than 95% of the maximum dry density as determined by *AASHTO T 99, Method C*, or to the satisfaction of the Engineer. Suitable and effective equipment, meeting the approval of the Engineer, shall be used to obtain a true and even surface during compaction. All holes or depressions found during the compacting shall be filled with additional material, reworked, and compacted.

If required, water shall be uniformly applied over the aggregate material during compaction in an amount necessary to produce proper consolidation. The aggregate shall be thoroughly compacted by an approved power roller with a minimum weight of 8 tons, by an approved rubber-tired roller, or by other approved methods.

401.04 METHOD OF MEASUREMENT. The quantity of Aggregate Surface Course and Aggregate Surface Course, Paths and Trails to be measured for payment will be the number of cubic yards used in the complete and accepted work, as determined by the Plan dimensions of the compacted material or as ordered by the Engineer. No allowance will be made for material placed to a depth greater than that shown on the Plans unless ordered by the Engineer.

401.05 BASIS OF PAYMENT. The accepted quantity of Aggregate Surface Course and Aggregate Surface Course, Paths and Trails will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for performing the work specified and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Water used for obtaining the required compaction will not be paid for separately but will be considered incidental to the applicable item.

Payment will be made under:

Pay Item	Pay Unit
401.1000 Aggregate Surface Course	Cubic Yard
401.1500 Aggregate Surface Course, Paths and Trails	Cubic Yard

SECTION 402 – AGGREGATE SHOULDERS

402.01 DESCRIPTION. This work shall consist of furnishing, placing, and compacting material for aggregate shoulders on a prepared surface.

402.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Aggregate Shoulders.....704.12(c)
Aggregate Shoulders, RAP.....704.12(d)

402.03 PLACEMENT. Aggregate shoulders shall be placed with equipment capable of placing the material in accordance with the Plans. The Contractor shall demonstrate the proposed placement procedures to the Engineer. If deemed necessary by the Engineer, the procedures shall be adjusted to avoid damage to the wearing course. It shall be the Contractor's responsibility to repair any damage to the wearing course to the satisfaction of the Engineer, at no additional cost to the Agency.

Unless otherwise directed by the Engineer or shown on the Plans, aggregate shoulders shall be placed in one course and shall not be placed until the adjacent wearing course has been completed. The maximum layer thickness for placement of material shall be 8 inches after compaction. When multiple layers are required, all layers shall be placed in approximately equal thicknesses and compacted as directed by the Engineer.

The Contractor shall correct any segregated material, to the satisfaction of the Engineer, at no additional cost to the Agency.

All material shall have a true and even surface as shown in the Plans. All holes or depressions found prior to acceptance of the project shall be filled with additional material, reworked, and compacted as necessary.

A load ticket, indicating truck identification, date and time of delivery, and weight shall be furnished to the Engineer with each load delivered to the project.

402.04 METHOD OF MEASUREMENT. The quantity of Aggregate Shoulders and Aggregate Shoulders, RAP to be measured for payment will be the number of tons used in the complete and accepted work, as determined from load tickets. Partial loads shall be paid for on a prorated basis.

402.05 BASIS OF PAYMENT. The accepted quantity of Aggregate Shoulders and Aggregate Shoulders, RAP will be paid for at the Contract unit price per ton. Payment will be full compensation for performing the work specified and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Water used for obtaining the required compaction will not be paid for separately but will be considered incidental to the Aggregate Shoulders item in the Contract.

Payment will be made under:

Pay Item	Pay Unit
402.1200 Aggregate Shoulders	Ton
402.1300 Aggregate Shoulders, RAP	Ton

SECTION 404 – BITUMINOUS SURFACE TREATMENTS

404.01 DESCRIPTION. This work shall consist of furnishing and applying a bituminous treatment on an approved surface.

404.02 MATERIALS. Materials shall meet the requirements of the following subsections:

404.03 WEATHER LIMITATIONS. Bituminous material shall only be applied when the following conditions prevail.

(a) The ambient air and pavement surface temperature, in the shade and away from artificial heat, meets the minimum requirements specified in Table 404.03A, and the temperatures are rising.

TABLE 404.03A – MINIMUM TEMPERATURES REQUIRED FOR SURFACE TREATMENT

Surface Treatment	Min. Air Temperature	Min. Surface Temperature
Emulsified asphalt tack coat	35°F	35°F
Polymer-modified emulsified asphalt tack coat	50°F	50°F
Emulsified asphalt fog seal	50°F	60°F
Emulsified asphalt seal coat with sand cover	60°F	60°F

(b) The road surface is sufficiently dry.

(c) Weather and other conditions are favorable and expected to remain so until the material has reached the point where adverse weather conditions will not negatively impact the quality.

404.04 EQUIPMENT.

(a) Distributor. Distributors shall be designed, equipped, maintained, and operated such that bituminous material at even heat may be applied uniformly on variable widths up to 24 feet at the specified rate for the item being placed. Distributors shall include a suitable hand spray nozzle and hose, a tachometer, pressure gauges, accurate volume measuring devices or a calibrated tank, a measuring stick, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically.

The distributor shall provide means for obtaining a sample of the emulsified asphalt, and as needed, the lines shall be flushed prior to sampling to ensure there are no residual cleaning solvents in the sample.

With the approval of the Engineer, traveling or stationary plants or other equipment of proven performance may be used by the Contractor instead of the specified equipment.

(b) Aggregate Spreader. Aggregate spreaders shall be mounted on the asphalt distributor and shall have a minimum capacity of 2,000 pounds. The hopper shall have vibratory agitation to facilitate material flow. The aggregate spinners shall be variable speed, capable of distributing aggregate consistently over variable roadway widths in a single pass. All controls shall be cab-mounted and capable of being operated during the application of the asphalt emulsion by the distributor operator.

(c) Self-Priming Paver. Self-priming pavers shall meet the requirements of Section 407.

(d) Transporting Equipment. Tanks for motor transport trucks shall be made of either steel or aluminum with a minimum capacity of 1,500 gallons, insulated, equipped with baffle plates to prevent surging, and equipped with the necessary units to heat the bituminous content in accordance with these specifications. Heating of motor transport truck tanks by distributors to bring the material to the proper temperature will not be permitted. The Contractor shall furnish the necessary heating units for the motor transport trucks and the operators for the heating units.

404.05 PREPARATION OF SURFACES. All surfaces to be treated shall be dry, patched, and free of irregularities in order to provide a reasonably smooth and uniform surface. Any necessary surface preparation, patching, or crack sealing shall be performed in accordance with Section 406 and Section 417.

The Contractor shall clean the surfaces prior to treatment and remove all loose or objectionable material, dust, and debris. All drop inlets, catch basins, and manholes shall be covered prior to application of the treatment and uncovered after application.

404.06 APPLICATION OF BITUMINOUS MATERIALS.

(a) General Requirements. A load ticket shall be supplied for each load of bituminous material such that the weight of actual project usage can be determined.

(b) Emulsified Asphalt Tack Coat. Emulsified asphalt tack coat shall be a grade RS-1, RS-1h, CRS-1, or CRS-1h emulsified asphalt. It shall be applied uniformly and completely to all vertical and horizontal surfaces to be paved by distributors or other methods approved by the Engineer. The application rate shall be as specified in Table 404.06A.

TABLE 404.06A – EMULSIFIED ASPHALT APPLICATION RATE

Surface Type	Application Rate (gal/SY)
New bituminous concrete	0.040 – 0.060
Existing bituminous concrete	0.060 – 0.080
Coarse- or fine-milled surface	0.080 – 0.100
Cold mix	0.060 – 0.080
Portland cement concrete	0.080 – 0.100

The tack coat shall not be applied to more than 50% of the width of the road surface at a time, unless all traffic is detoured, in which case the tack coat may be applied to the full width. The tack coat shall be applied just prior to the placement of the bituminous concrete pavement and shall progress sufficiently ahead of the paving so that the surface to be paved will be broken such that the surface consists of residual asphalt only. Contact surfaces such as curbing, gutters, and manholes shall be coated with a thin, uniform coat of emulsified asphalt immediately before the bituminous concrete mixture is placed against them.

(c) Polymer-Modified Emulsified Asphalt Tack Coat. Polymer-modified emulsified asphalt tack coat shall be a grade CRS-1P emulsified asphalt. It shall be uniformly applied across the entire width to be overlaid by a self-priming paver at the temperature recommended by the self-priming paver manufacturer. The application rate shall be as specified in Table 404.06B.

TABLE 404.06B – POLYMER-MODIFIED EMULSIFIED ASPHALT APPLICATION RATE

BWC Mix Type	Application Rate (gal/SY)
Type A	0.125 – 0.175
Type B	0.165 – 0.215
Type C	0.200 – 0.250

The Contractor shall continuously monitor the application rate, with the Agency verifying the rate on a daily basis using the following formula:

$$R_A = \frac{M_E - M_S}{A}$$

where:

R_A = Polymer-modified emulsified asphalt application rate (gallons/square yard)

M_E = Ending meter reading (gallons)

M_S = Starting meter reading (gallons)

A = Area of bonded wearing course (square yards)

Field adjustments to the specified application rate of polymer-modified emulsified asphalt shall be determined based upon the existing surface condition of the pavement. Adjustments to the specified polymer-modified emulsified asphalt application rate shall be approved by the Engineer.

(d) Emulsified Asphalt Fog Seal. Emulsified asphalt fog seal shall be a grade CSS-1h emulsified asphalt diluted in accordance with Subsection 702.02. It shall be applied in a uniform, continuous spread over the area to be treated by distributors or other methods approved by the Engineer at the temperature recommended by the manufacturer. The application rate shall be as specified in Table 404.06C, or as directed by the Engineer.

TABLE 404.06C – EMULSIFIED ASPHALT FOG SEAL APPLICATION RATE

Surface Type	Application Rate (gal/SY)
All	0.100 – 0.200

The Contractor shall maintain the treated surfaces until the Contract is complete and the work accepted. Holes or irregularities shall be repaired by filling them with material acceptable to the Engineer.

(e) Emulsified Asphalt Seal Coat with Sand Cover Material. Emulsified asphalt seal coat shall be a grade SS-1, SS-1h, CSS-1, or CSS-1h emulsified asphalt diluted in accordance with Subsection 702.02. It shall be applied by distributors in a uniform, continuous spread over the area to be treated at the temperature recommended by the manufacturer. The application rate shall be as specified in Table 404.06D, or as directed by the Engineer.

TABLE 404.06D – EMULSIFIED ASPHALT SEAL COAT APPLICATION RATE

Surface Type	Application Rate (gal/SY)
All	0.100 – 0.140

Sand cover material, meeting the requirements of Subsection 704.11(a) or as approved by the Engineer, shall be applied immediately after the emulsified asphalt, prior to the emulsion breaking or curing, using an aggregate spreader attached to the distributor. The application rate for sand cover material shall be as specified in Table 404.06E, or as directed by the Engineer. The Contractor shall be required to apply additional sand cover material above the prescribed rate in the event excessive emulsified asphalt is applied.

TABLE 404.06E – SAND COVER APPLICATION RATE

Surface Type	Application Rate (lbs/SY)
All	0.350 – 0.650

Following application of the sand cover material, the Contractor shall perform pavement friction testing in accordance with *AASHTO T 242*. The surface shall exhibit a minimum skid resistance value of 35. One test shall be performed each day of production. Tests shall be conducted using the standard ribbed tire as specified by *AASHTO M 261*. Testing equipment shall have been calibrated no more than 3 years before the start of testing. Calibration documents shall be provided to the Engineer prior to testing.

The Contractor shall maintain the treated surfaces until the Contract is complete and the work accepted. Holes or irregularities shall be repaired by filling them with material acceptable to the Engineer.

404.07 TRAFFIC CONTROL. Equipment or traffic will not be allowed on the emulsion treated surface until the emulsion has fully cured and the treatment will not "pick up" under traffic, or as directed by the Engineer.

404.08 PROTECTION OF STRUCTURES, VEHICLES, AND TREES. The Contractor shall use care in applying bituminous material and protecting surfaces of adjacent structures, vehicles, and trees from being spattered with the material. The use of skirting or end panels may be required to control application widths and limit overspray.

404.09 METHOD OF MEASUREMENT. The quantity of Tack Coat, Emulsified Asphalt; Tack Coat, Polymer-Modified Emulsified Asphalt; Fog Seal, Emulsified Asphalt; and Seal Coat, Emulsified Asphalt to be measured for payment will be the number of hundredweight used in the complete and accepted work.

The quantity of Cover Material, Sand to be measured for payment will be the number of pounds used in the complete and accepted work.

404.10 BASIS OF PAYMENT. The accepted quantity of Tack Coat, Emulsified Asphalt; Tack Coat, Polymer-Modified Emulsified Asphalt; Fog Seal, Emulsified Asphalt; and Seal Coat, Emulsified Asphalt will be paid for at the Contract unit price per hundredweight. Payment will be full compensation for cleaning the roadway surface; furnishing, transporting, and placing the emulsified asphalt; and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The quantity of Cover Material, Sand will be paid for at the Contract unit price per pound. Payment will be full compensation for furnishing, hauling, and placing the material specified; performing friction testing and supplying test reports; and for furnishing all labor, tools, testing apparatuses, equipment, and incidentals necessary to complete the work.

Surface preparation, patching, and crack sealing will be paid for separately in accordance with Section 406 and Section 417.

Payment will be made under:

Pay Item		Pay Unit
404.1100	Tack Coat, Emulsified Asphalt	Hundredweight
404.1200	Tack Coat, Polymer-Modified Emulsified Asphalt	Hundredweight
404.3100	Fog Seal, Emulsified Asphalt	Hundredweight
404.5100	Seal Coat, Emulsified Asphalt	Hundredweight
404.8100	Cover Material, Sand	Pound

SECTION 406 – BITUMINOUS CONCRETE PAVEMENT

406.01 DESCRIPTION. This work shall consist of constructing one or more courses of Superpave bituminous concrete pavement on a prepared foundation in accordance with these specifications and in conformance with the lines, grades, thicknesses, and typical cross-sections shown on the Plans or established by the Engineer.

The Agency will accept this work under quality assurance provisions, in accordance with these specifications and the provisions of *AASHTO M 323* except where otherwise noted in Section 702, Section 704, Section 716, and the Agency's *Bituminous Concrete Policy Manual*.

406.02 MATERIALS. Materials shall meet the requirements of the following subsections:

406.03 AGENCY MATERIAL EVALUATION. Material evaluation and acceptance by the Agency will follow the procedures outlined in this subsection for the applicable quality assurance tier and Contract item. Acceptance sampling of bituminous materials by the Agency will be on a statistically random basis in accordance with the specified requirements, and the material will be evaluated for acceptance based on the results of these tests. Contractor quality control samples will not be used to evaluate, accept, reject, or determine pay factors for any material.

Material may be sampled at either the production facility or on the project site and may be tested at either the production facility's qualified laboratory or at the Agency's Materials Testing and Certification Section Central Laboratory.

(a) General Requirements.

(1) Control of the Mixture. The actual mixture produced shall not vary from the job mix formula target values by more than production tolerances specified in Table 406.03A. For the purposes of verification sampling, the tolerances in Table 406.03A will be considered the specification limits for an individual sample. Continued production outside these ranges will be grounds to halt production and revoke the mix design.

TABLE 406.03A – MIXTURE PRODUCTION TOLERANCES FOR ALL QA TIERS

Material Property	Lower Mixture Tolerance	Upper Mixture Tolerance
Coarse aggregate, percent passing the No. 4 (4.75 mm) or larger sieves (dry sieve)	JMF – 6%	JMF + 6%
Fine aggregate, percent passing the No. 8 (2.36 mm) sieve through the No. 100 (0.150 mm) sieve (dry sieve)	JMF – 4%	JMF + 4%
Fines, percent passing the No. 200 (0.075 mm) sieve (dry sieve)	JMF – 1%	JMF + 1%
Mixture temperature [1]	JMF – 20°F	JMF + 20°F
Air voids	JMF – 1.0%	JMF + 1.0%
Dust proportion (Type IS and Type IIS)	0.50	1.20
Dust proportion (Type IIIS, Type IVS, and Type IVSB)	0.50	1.00
Voids in mineral aggregate	JMF – 1.0%	JMF + 1.0%
Asphalt binder content	JMF – 0.4%	JMF + 0.4%

[1] The mixture temperatures shall not exceed 355°F.

(2) Quality Assurance Tiers. The Agency will use a tiered approach to evaluate bituminous concrete material. The applicable QA tier for each mix type will be as specified on the Plans. If not specified on the Plans, the QA tier shall be based on the quantity of each mix type as specified in Table 406.03B. The Contract may specify mix produced under more than one QA tier, based on quantity. Sampling, testing, and evaluation by the Agency for the Contract will be in accordance with the criteria specified for each QA tier.

Bituminous concrete pavement surface preparation and non-paver placed bituminous concrete pavement paid separately are not subject to the requirements of any QA tier.

TABLE 406.03B – QUALITY ASSURANCE TIER BY QUANTITY OF MIX

Quality Assurance Tier	Contract Quantity (Q) of Mix Type (tons)
QA Tier I	$Q \geq 3{,}000$
QA Tier II	$3{,}000 > Q \geq 1{,}500$
QA Tier III	$Q < 1{,}500$

(3) Lots and Sublots. Sampling will be conducted using stratified random sampling on a lot and sublot basis for the applicable QA tiers. Standard lot and sublot sizes are specified for each QA tier and criteria. Adjustments to the lot and sublot size may be made by the Engineer.

If the number of sublots in the final resultant partial lot is greater than or equal to the minimum number specified in the applicable table, then the final resultant partial lot will be processed as a full lot. If the number of sublots is less than the specified minimum, then the final resultant partial lot will be combined with the previous lot. The final sublot of a partial lot will consist of the quantity of material required to complete the partial lot.

(4) Evaluation Methods. Material produced under this specification will be sampled and tested in accordance with the requirements of the applicable QA tier. The Agency will evaluate compliance based on the methods below.

a. Percent Within Limits Method. Detailed documentation on the PWL method is available in the Agency's *Bituminous Concrete Policy Manual*. Properties which are to be evaluated using the PWL method will be sampled once per sublot. The PWL for the lot will then be calculated from those sublot test results to determine if the lot of material is in compliance with the specification requirements.

b. Single Test Departure Method. The single test departure (STD) method is a procedure that uses individual test results to determine the magnitude of departure from the specification limits. Properties which are to be evaluated using the STD method will be sampled once per lot. The test result from that one sample will be evaluated independently of all other samples to determine if the lot of material is in compliance with the specification requirements.

The departure will be calculated using the equation below.

$$D = 1 - |TR - JMF|$$

where:

D = Single test departure of the sample

TR = Sample test result

JMF = Job mix formula target value

c. Average Method. The average method is a procedure for estimating the overall compliance with a specification based on the average value of a property. The average value of the property for the entire lot will be used to evaluate the quality of the material.

(5) Types of Criteria. Every material property identified for each QA tier has been designated as being an acceptance or quality criteria. These criteria will be used by the Agency as described below.

a. Acceptance Criteria. Acceptance criteria will be used to determine the acceptability of an entire lot of material. The material will be evaluated following the completion of the lot. No consideration will be given to results from adjacent lots, and sublots will not be considered independently.

The Engineer will evaluate all designated acceptance criteria separately and determine whether the material is compliant or non-compliant with each criterion.

If the PWL or STD, as applicable, equals or exceeds the rejectable quality level (RQL), the material will be deemed compliant. If the PWL or STD is less than the RQL, the material will be deemed non-compliant.

If the material is compliant with each and every designated acceptance criteria, then the lot will be deemed acceptable material as described in Subsection 406.03(a)(6)a.

If the material is non-compliant with one or more designated acceptance criteria, then the lot will be deemed rejectable material as described in Subsection 406.03(a)(6)b.

b. Quality Criteria. Quality criteria will be used to determine closeness to the desired target of an entire lot of material. This is only applicable to material which has already been accepted based on the designated acceptance criteria. Material will not be accepted or rejected based on quality criteria.

The material will be evaluated following the completion of the lot. The Engineer will calculate pay factors for the material, as described under the appropriate QA tier. These pay factors may be positive, negative, or zero, depending on the quality of the material.

(6) Materials Acceptance. As described in Subsection 406.03(a)(5)a., every lot will be evaluated and deemed to be either acceptable or rejectable material. Acceptable and rejectable material will be dealt with as specified below.

a. Acceptable Material. If a lot of material is deemed compliant with every acceptance criteria, then the entire lot will be accepted by the Agency and paid for at the Contract unit price, unless otherwise directed by the Engineer.

Following acceptance, the Engineer will calculate pay factors for the material, as described under the appropriate QA tier. These pay factors may be positive, negative, or zero, depending on the quality of the material.

b. Rejectable Material. If a lot of material is deemed non-compliant with one or more acceptance criteria, then the entire lot will be rejected by the Agency and shall be removed and replaced with new material at no expense to the Agency, unless otherwise directed by the Engineer. No pay factors will be applied to rejected material. Any such new material will be sampled, tested, and evaluated for acceptance. Should the Engineer allow rejectable material to remain in place, it shall receive no positive pay adjustments.

c. Dispute Resolution. For material deemed rejectable, the Agency's *Quality Assurance Program* will outline the applicable dispute resolution practices. At the time of collecting an acceptance sample, the Contractor may take loose mix replicate samples for the purposes of dispute resolution. Replicate sampling of cores will not be permitted.

(7) Removal of Defective Material by the Contractor. With the approval of the Engineer, the Contractor may elect to remove any defective material and replace it with new material at no expense to the Agency. Any such new material will be sampled, tested, and evaluated for acceptance.

(8) Pay Factors. The pay factors which apply to material produced under each QA tier will be as specified in this section. These pay factors will only be applied to material which has been accepted by the Agency.

(9) Rounding and Reporting of Values. Results from all calculations shall be rounded and reported as specified below:

a. All pay factors will be reported to 0.0001 and all pay adjustments to 0.01. For intermediate calculations used to obtain pay factors and pay adjustments values shall retain the maximum available precision.

b. The use of *ASTM E29* rounding will not be permitted. Instead, when rounding, if the first digit to the right of the number to be rounded is greater than or equal to 5, then the number will be rounded away from zero to the next number with larger magnitude. If the digit to the right of the number to be rounded is less than 5, then the number will remain the same.

For example, for rounding to the nearest one decimal (0.1):

5.35 rounds to 5.4 -5.35 rounds to -5.4

5.34 rounds to 5.3 -5.34 rounds to -5.3

(b) Quality Assurance Tier I. For evaluating mixtures produced under QA Tier I, the criteria specified in Table 406.03D will apply. Lots and sublots will be established as specified in Subsection 406.03(a)(3) and Table 406.03C.

(1) Material Evaluation. Evaluation of the material will follow the procedures described in Subsection 406.03(a)(4), and acceptance will follow the procedures described in Subsection 406.03(a)(5) and Subsection 406.03(a)(6).

At the Engineer's discretion, low production activities, defined as a daily production of 300 tons or less, that would otherwise be evaluated for air voids using the PWL method will be excluded from the PWL lot, and instead evaluated using the STD method with an RQL of -1 and an AQL of 0.

(2) Pay Factors. When they are included in the Contract, the following pay factors will apply to all accepted material in this tier, except as noted below:

a. Mixture Properties Pay Factor (PF_{MP}). This pay factor will be calculated based on air voids.

b. Mat Density Pay Factor (PF_{MD}). This pay factor will not apply to material used for shoulders paved separately, leveling courses, side roads, or drives.

c. Longitudinal Joint Density Pay Factor (PF_{JD}). This pay factor will not apply to material used for leveling courses, side roads, or drives.

d. Pavement Roughness Pay Factor (PF_{PR}). This pay factor only applies to the wearing course.

TABLE 406.03C – QUALITY ASSURANCE TIER I LOT AND SUBLOT SIZES

Property	Lot Size	Max. Sublot Size	Min. No. of Sublots
Air voids	3,000 tons	500 tons	4
Mat density	Daily production for each course	0.5 miles	6
Longitudinal joint density	Entire project for each course	0.5 miles	4
Pavement roughness on limited access highways	Entire project wearing course	N/A	N/A
Pavement roughness on non-limited access highways	Entire project wearing course	N/A	N/A

TABLE 406.03D – QUALITY ASSURANCE TIER I CRITERIA

Property	Evaluation Method	Type of Criteria	LSL	USL	RQL	AQL
Air voids	PWL	Acceptance	JMF – 1.0%	JMF + 1.0%	50%	90%
Mat density	PWL	Acceptance	92%	97%	50%	90%
Longitudinal joint density	PWL	Quality	90%	N/A	N/A	75%
Pavement roughness on limited access highways	Average	Quality	N/A	N/A	N/A	48 in./mile
Pavement roughness on non-limited access highways	Average	Quality	N/A	N/A	N/A	58 in./mile

(c) Quality Assurance Tier II. For evaluating mixtures produced under QA Tier II, the criteria specified in Table 406.03F will apply. Lots and sublots will be established as specified in Subsection 406.03(a)(3) and Table 406.03E.

(1) Material Evaluation. Evaluation of the material will follow the procedures described in Subsection 406.03(a)(4), and acceptance will follow the procedures described in Subsection 406.03(a)(5) and Subsection 406.03(a)(6).

At the Engineer's discretion, low production activities, defined as a daily production of 300 tons or less, that would otherwise be evaluated for air voids using the PWL method will be excluded from the PWL lot, and instead evaluated using the STD method with an RQL of -1 and an AQL of 0.

(2) Pay Factors. When they are included in the Contract, the following pay factors will apply to all accepted material in this tier, except as noted below:

a. Mixture Properties Pay Factor (PF_{MP}). This pay factor will be calculated based on air voids.

b. Mat Density Pay Factor (PF_{MD}). This pay factor will not apply to material used for shoulders paved separately, leveling courses, side roads, or drives.

c. Pavement Roughness Pay Factor (PF_{PR}). This pay factor only applies to the wearing course.

TABLE 406.03E – QUALITY ASSURANCE TIER II LOT AND SUBLOT SIZES

Property	Lot Size	Max. Sublot Size	Min. No. of Sublots
Air voids	Entire project	500 tons	3
Mat density	Entire project for each course	0.1 miles	3
Pavement roughness on limited access highways	Entire project wearing course	N/A	N/A
Pavement roughness on non-limited access highways	Entire project wearing course	N/A	N/A

TABLE 406.03F – QUALITY ASSURANCE TIER II CRITERIA

Property	Evaluation Method	Type of Criteria	LSL	USL	RQL	AQL
Air voids	PWL	Acceptance	JMF – 1.0%	JMF + 1.0%	50%	80%
Mat density	PWL	Acceptance	91%	N/A	50%	80%
Pavement roughness on limited access highways	Average	Quality	N/A	N/A	N/A	48 in./mile
Pavement roughness on non-limited access highways	Average	Quality	N/A	N/A	N/A	58 in./mile

(d) Quality Assurance Tier III. For evaluating mixtures produced under QA Tier III, the criteria specified in Table 406.05H will apply. Lots and sublots will be established as specified in Subsection 406.03(a)(3) and Table 406.03G.

(1) Material Evaluation. Evaluation of the material will follow the procedures described in Subsection 406.03(a)(4), and acceptance will follow the procedures described in Subsection 406.03(a)(5) and Subsection 406.03(a)(6).

(2) Pay Factors. When they are included in the Contract, the following pay factors will apply to all accepted material in this tier, except as noted below:

a. Mixture Properties Pay Factor (PF_{MP}). This pay factor will be calculated based on air voids.

b. Mat Density Pay Factor (PF_{MD}). This pay factor will not apply to material used for leveling courses, side roads, or drives. The Engineer may elect to waive this pay factor for other material at their discretion.

TABLE 406.03G – QUALITY ASSURANCE TIER III LOT AND SUBLOT SIZES

Property	Lot Size	Min. No. of Sublots
Air voids	500 tons	N/A
Mat density	Entire project for each course	4

TABLE 406.03H – QUALITY ASSURANCE TIER III CRITERIA

Property	Evaluation Method	Type of Criteria	LSL	USL	RQL	AQL
Air voids	STD	Acceptance	N/A	N/A	-1	0
Mat density	PWL	Acceptance	91%	N/A	50%	80%

406.04 CONTRACTOR QUALITY CONTROL. The Contractor shall be responsible for maintaining control of the mix production process. The mix production methods and technologies shall generally be at the Contractor's discretion, but will be limited to proven, Agency and industry accepted practice. Upon approval of the Engineer and at no additional cost to the Agency, the Contractor may use innovative equipment or techniques not included in the Specifications to produce or monitor the production or placement of the mixture.

(a) Control of Mixtures. For all mixtures and all QA tiers, the plant shall be operated so that no intentional deviations are made from the job mix formula. The Contractor shall provide quality control adequate to produce work of acceptable quality. Continual production of non-conforming work at a reduced price, in lieu of making adjustments to bring work into conformance, will not be allowed.

The Contractor shall provide process control adequate to produce work of acceptable quality. At a minimum, the Contractor shall perform sampling and testing at the frequencies specified in Table 406.04A, as applicable for the mixture type. The Engineer will not sample or test for process control or assist in controlling the Contractor's production operations.

Control over production shall follow the control limits established for the mix design for quality control samples. A single result outside the control limit will necessitate the Contractor take action to control the process. Two out of three values in row that exceed the control limits will necessitate the Contractor suspend production, as it is not in control. After suspension, a passing quality control test from a trial drop shall be used to show the mix has been returned to in control, and production may resume. Failure or inaction by the Contractor to maintain control over the mix production will result in mix design suspension.

TABLE 406.04A – QUALITY CONTROL SAMPLING AND TESTING CRITERIA

Parameter	Test Method	Minimum Frequency (Select the Least Frequent)
Mixture gradation	*AASHTO T 30, AASHTO T 308*	1 per 500 tons
Mixture temperature	Verified thermometer	1 per 250 tons at plant (truck)
Mixture volumetrics (air voids, VMA, and dust proportion)	*AASHTO T 269, AASHTO T 166, AASHTO T 209*	1 per 500 tons
Asphalt binder content	*AASHTO T 308*	1 per 500 tons
Cold feed gradation	*AASHTO T 27*	1 per day
Cold feed percentage fractured face [1]	*AASHTO T 335*	1st day of paving, 1 per week or 5,000 tons
Cold feed flat and elongated particles [2]	*ASTM D4791*	1 per month
Fine and coarse aggregate moisture content [3]	*AASHTO T 255*	2 per day
Ram moisture content	*AASHTO T 255*	2 per day
Fine aggregate, coarse aggregate, and RAM specific gravities [4]	*AASHTO T 84, AASHTO T 85*	1st day of paving, 1 per two weeks or 5,000 tons
Stripping [5]	*ASTM D3625*	1 per week

[1] Fractured face for crushed gravel sources only.

[2] Flat and elongated percentage for all material retained on or above the No. 4 (4.75 mm) sieve.

[3] For drum-mix and continuous mixing plants only.

[4] New values will be required when the absorbed asphalt value is either zero or negative, or when requested by the Engineer.

[5] Stripping testing for stripping prone aggregates only. Testing will be witnessed by Agency staff.

In addition to the control limits referenced above, the Contractor shall cease production operations whenever one or more of the following occurs:

(1) The Contractor fails to follow the approved QC plan.

(2) If the flat and elongated particles value exceeds 10% when measured by *ASTM D4791*.

(3) If there is any visible damage to the aggregate due to over-densification, except on variable depth shim courses.

The Contractor shall immediately notify the Agency in writing as to the reason for a shutdown, as well as the proposed corrective action. The Agency will consider the corrective action successful if the result of the trial drop quality control test for the failing property is in conformance with the applicable requirements defined above. The Agency will consider the corrective action unsuccessful if the result of the trial drop quality control test is not in conformance with the applicable requirements specified above. If the corrective action is unsuccessful, the Contractor shall cease production and submit a new corrective action plan.

(b) Contractor Quality Control Plan. For material produced and paved under all QA tiers, the Contractor shall provide, maintain, and operate in accordance with a quality control plan for the plant and the field, hereafter referred to as the plant QC plan and field QC plan, to ensure the production of material that meets the Contract requirements. The Contractor shall develop and submit program-wide QC plans annually in advance of the paving season, to document the QC practices, personnel, facilities, and equipment to be used by the Contractor. Additionally, the Contractor shall submit project-specific supplements to both the plant and field QC plans to provide specific details applicable to each project. No paving shall occur until both QC plans and their supplements have been approved for the project. Project supplements to the QC plans shall be submitted at least 10 working days before the start of paving on the project.

(1) Plant QC Plan. Bituminous concrete mixture plants shall submit a program-wide plant QC plan to cover all mix production, as detailed in the Agency's *Bituminous Concrete Policy Manual*. A project-specific supplement shall be submitted to apply the plant QC plan to the project and provide specific details, including, but not limited to, the mix designs to be used, the use of silos, changes in personnel, and other project-specific requirements.

(2) Field QC Plan. The Contractor shall submit a comprehensive program-wide field QC plan to cover paving practices in the field, as detailed in the Agency's *Bituminous Concrete Policy Manual*. A project-specific supplement shall be submitted to apply the field QC plan to the project and provide specific details, including, but not limited to, paving personnel and equipment identification, QC personnel, mixing, loading, transportation, intended paving sequence, and other project-specific requirements.

(3) Non-Compliance with the QC Plans. The Contractor shall comply with the approved QC plans and shall take all other steps necessary to ensure a high-quality product. Failure of the Contractor to comply with the approved QC plans may result in the Agency ordering the Contractor to cease production or paving, revoking approval of the QC plan, or taking other actions as necessary.

406.05 EQUIPMENT.

(a) Hauling Equipment. To prevent the mixture from adhering to the beds, trucks used for hauling bituminous mixture shall have tight, clean, and smooth metal beds which have been thinly coated with a bond release agent. Petroleum-based products will not be permitted. Each truck shall have a cover of canvas or other suitable material of sufficient size to extend over all sides of the haul vehicle to properly protect the mix from the weather. When necessary, to ensure placement of material at the specified temperature, truck beds shall be insulated and covers shall be securely fastened.

The trucks used for hauling bituminous mixture shall be compatible with the equipment used for placing the bituminous mixture.

Trucks shall not be cleaned or emptied on surfaces to be paved.

(b) Placing Equipment. The bituminous concrete paver shall be a self-propelled unit with an activated screed or strike-off assembly capable of being heated if necessary and capable of spreading the mixture without segregation for the widths and thicknesses required. The screed shall be adjustable to provide the desired cross-sectional shape.

Pavers shall be in good mechanical condition, equipped with all necessary attachments, and designed to operate electronically for controlling the grade of the finished surface. Additionally, pavers shall be equipped such that, upon extension of the screed by 24 inches or more, auger extensions shall be used, as directed by the Engineer. The adjustments and attachments of the paver shall be checked and approved by the Engineer before placement of bituminous material.

Bituminous concrete pavers shall be equipped with a sloped plate to produce a tapered or notched tapered edge at longitudinal joints. The sloped plate shall produce a tapered or notched tapered edge having a face slope of 1:3 (V:H) or flatter. The plate shall be able to accommodate compacted mat thicknesses from 1-1/4 inches to 4 inches. The bottom of the sloped plate shall be mounted 3/8 inch to 1/2 inch above the existing pavement.

Joint heaters, if used, shall be equipped with automated controls which will shut off the burners when the paving machine stops and reignite them when the paver begins moving forward. The joint heater shall heat the entire area of the previously placed wedge to the required temperature. Heating to the point of 200°F or higher shall immediately precede placement of the bituminous material.

(c) Compaction Equipment. Rollers shall be in good mechanical condition, capable of reversing without backlash, and operated at speeds slow enough to avoid displacement of the bituminous mixture. The weight of the rollers shall be sufficient to compact the mixture to the required density without crushing the aggregate. Rollers shall be equipped with tanks and sprinkling bars for wetting the rollers or tires.

Pneumatic-tired rollers shall be equipped with appropriate skirts and shall be preheated prior to use in order to avoid picking. The Contractor shall repair and remove all picked material from the surface.

Vibratory rollers shall have separate controls for energy and propulsion. They shall be equipped with automatic cutoffs that stop the vibration prior to the roller stopping or reversing its direction of travel. The Contractor assumes full responsibility for, and shall repair at their expense, all damage which may occur to highway components or adjacent property if vibratory compaction equipment is used.

406.06 TRAFFIC CONTROL. Traffic shall be maintained in accordance with Subsection 104.04 and Section 641. Whenever traffic must be maintained during paving operations, uniformed traffic officers or flaggers in accordance with Section 630 shall be stationed at each end of the section being paved and at such other locations as may be required by the Engineer.

406.07 WEATHER AND SEASONAL LIMITATIONS. Bituminous material shall not be placed on a wet or frozen surface, or when weather or other conditions would prevent the proper handling, finishing, or compacting of the material, unless otherwise approved by the Engineer.

(a) Temperature Limitations. Bituminous material shall not be placed unless both the ambient air temperature, and the temperature of the existing surface at the paving site in the shade and away from artificial heat, are greater than that specified in Table 406.07A.

TABLE 406.07A – MINIMUM TEMPERATURES REQUIRED FOR PAVING

Compacted Lift Thickness (T)	Min. Temp. for Mixes without WMA Technologies	Min. Temp. for Mixes with WMA Technologies
T ≥ 1.25 inches	40°F	35°F
T < 1.25 inches	50°F	35°F

(b) Seasonal Limitations. For the purpose of paving operations, including placement of temporary pavements, the year shall be divided into in-season and extended season paving. The dates of these seasons shall be as defined in Table 406.07B.

TABLE 406.07B – IN-SEASON AND EXTENDED-SEASON PAVING DATES

Type of Pavement Course	In-Season Paving Dates (Inclusive of End Dates)	Extended Season Paving Dates (Inclusive of End Dates)
Temporary, leveling, bottom, or intermediate	May 1st to October 31st	November 1st to April 30th
Wearing	May 16th to October 15th	October 16th to May 15th

(c) Extended-Season Paving Plan. Should paving operations be scheduled during the extended season, the Contractor shall submit an extended season paving plan 14 calendar days prior to paving within the extended season. Paving within the extended season shall not commence until the Engineer has approved the plan. The Contractor shall operate in accordance with the plan in order to ensure that the product meets the Contract requirements.

If the Contractor fails to follow the extended season paving plan, paving operations shall cease, and the Contractor shall modify operations to comply with the extended season paving plan. All process modifications shall be communicated to the Engineer. Paving operations shall only resume once the Engineer has approved all modifications.

An extended season pre-paving meeting shall be conducted at least 5 calendar days prior to paving within the extended season, and shall include the Agency, Contractor, producer, and other stakeholders as necessary. The extended season paving plan shall include, but not be limited to, the following:

(1) General Requirements.

a. Minimum mixing and delivery mixture temperatures. Details on the use of WMA technologies or other additives to enhance workability shall be provided.

b. Calculations providing a balanced paving operation. The anticipated paver speed shall be specified.

c. A plan for an enhanced rolling pattern. The enhanced rolling pattern shall be established by a QC technician during the first shift of paving within the extended season.

d. Methods for determining the time available for compaction. The time available shall be determined and reported to the Engineer on a daily basis to confirm that compaction has been completed within the time available.

e. The sequence of paving for remaining placement.

f. A description of the level of staffing and additional equipment necessary to ensure paving and rolling operations can proceed without delay and achieve the desired compaction in a shorter timeframe.

(2) Schedule of Extended-Season Items.

a. The scope of remaining paving, including number of shifts and project limits to be completed.

b. Information about the application of retroreflective pavement markings. Retroreflective pavement markings shall be monitored and maintained throughout the extended season.

c. A schedule of adjacent work items to be completed.

406.08 CONDITIONING OF EXISTING SURFACE. All surfaces shall be cleaned and sprayed with an emulsified asphalt tack coat in accordance with Subsection 404.06(b) before placing of any bituminous mixture, unless otherwise ordered by the Engineer.

Prior to paving any mainline or drive surfaces, the existing bituminous concrete pavement surface shall be prepared as shown on the Plans and as directed by the Engineer. Bituminous concrete pavement surface preparation shall consist of performing all necessary surface preparation, including pothole repairs, raveling repairs, and other repairs directed by the Engineer prior to placing the final surface treatment.

Grass growing adjacent to pavement or through cracks in the pavement which may hinder the placement of new bituminous concrete shall be removed by the Contractor as directed by the Engineer.

Where deficiencies in any full depth reclamation, recycled bituminous pavement, or subbase exist, bituminous concrete mixtures approved by the Engineer shall be used to correct them.

Where bituminous concrete pavement is used to resurface existing pavements and the existing pavement contains irregularities, depressions, or waves, such deficiencies shall be eliminated using extra bituminous material for spot leveling to bring the existing pavement to uniform section and grade before placing of the required courses of bituminous concrete.

406.09 PLACING AND FINISHING.

(a) General Requirements. The bituminous mixture shall be placed and finished with the specified equipment, shall be struck off in a uniform layer to the full width required and of such depth that each course, when compacted, shall have the required thickness, and shall conform to the grade and elevation specified. The finished surface shall be of uniform texture and evenness and shall not show tearing, shoving, or pulling of the mixture.

In areas where irregularities or unavoidable obstacles make the use of mechanical placing and finishing equipment impracticable, the mixture shall be spread, raked, luted, and compacted by hand methods.

At the time of placement, the bituminous mixture shall be within 10°F of the compaction temperature for the approved mix design. No traffic will be permitted on placed material until the material has been thoroughly compacted and has cooled to 140°F unless otherwise authorized by the Engineer. The use of water to cool the pavement will not be permitted.

The Contractor shall protect all exposed surfaces and objects which are not to be treated from damage during all phases of the paving operation.

All material shall be produced early enough in the work day such that the completion of placing and compaction of the mixture will occur during daylight hours, unless night work is allowed for the project.

Mainline temporary transverse tapers shall have a minimum slope rate of 1 inch per 5 feet for speeds of 40 mph and lower, and a minimum slope rate of 1 inch per 10 feet for speeds greater than 40 mph.

A load ticket shall accompany each vehicle supplying bituminous concrete and shall be made available to the Engineer prior to placement of the mixture.

(b) Driveways and Side Road Intersections. Suitable temporary aprons or fillets shall be constructed at side road intersections and driveways as directed by the Engineer within 24 hours of adjacent mainline paving. Reasonable access to and from the mainline mat shall be maintained at all times.

Permanent drive construction shall consist of placing one or more courses of bituminous concrete material on a prepared foundation in conformance with the Plans, or as directed by the Engineer.

Placement of bituminous concrete material for driveways and side roads may be done with mechanical or hand methods as specified on the Plans and as directed by the Engineer.

All vegetation and soft, yielding, or unsuitable material shall be excavated and replaced with properly compacted material meeting the requirements of Section 301 for Subbase of Crushed Gravel, Fine Graded. Crushed RAP generated from the project may be substituted for Subbase of Crushed Gravel, Fine Graded.

For drives constructed via hand method, the existing edge of pavement shall be saw-cut or trimmed by mechanical means to provide a vertical edge for placing bituminous concrete material. Emulsified asphalt shall be applied as specified in Subsection 404.06(b).

If cross slope allows, as determined by the Engineer, existing paved drives shall be milled across the entire drive width to the depth of the wearing course, not to exceed 2 inches. Unless the drive is to be paved that work day, all vertical milled edges shall have temporary fillets placed the same work day as milling takes place.

(c) Compaction. Leveling courses shall be compacted using a self-propelled pneumatic tired roller for intermediate rolling, unless otherwise permitted in writing by the Engineer.

Tandem paving operations shall have an independent rolling train for each paver sufficient to achieve compaction requirements.

When bituminous concrete pavement is to be placed on a bridge deck having a waterproofing membrane, a rubber-tired or rubber-tracked paver shall be used to place the intermediate course of pavement. Rollers shall operate in static mode when compacting bridge deck pavements.

Non-paver placed bituminous concrete pavement shall be rolled with a minimum 1-ton mechanical roller with steel drums, or approved equal, until compacted to the satisfaction of the Engineer.

To prevent adhesion of the mixture to the rollers, the rollers shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid and petroleum products will not be permitted. If rolling causes undue displacement, cracking, tearing, or shoving, no further material will be produced for or placed on the project until a corrective action plan is proposed by the Contractor and accepted by the Engineer.

For places not accessible to the rollers, the mixture shall be thoroughly compacted with hand tampers, smoothing irons, or mechanical tampers coated with a non-petroleum based bond release agent.

During paving, the Contractor shall take daily process control cores at locations approved by the Engineer to verify the effectiveness of the proposed rolling pattern and correlate density gauge equipment. The Contractor shall fill the core holes, at their expense, with hot bituminous concrete pavement at a temperature of at least 200°F on the same work day that the cores are taken. Pending results of the investigative cores, necessary adjustments to the proposed rolling pattern and equipment shall be made by the Contractor to achieve densities to the satisfaction of the Engineer. In the absence of a Mat Density Pay Adjustment on any project, this provision will be the sole criterion governing compaction requirements. The Contractor shall provide the Engineer with all compaction QC records in a format acceptable to the Engineer at the conclusion of each day's paving operations.

(d) Joints. All paving operations shall be conducted such that, to the extent possible, the full width of a travel lane will be paved in a single pass. Longitudinal construction joints within any travel lane will not be permitted. Screed extension to cover adjacent shoulders concurrent with any travel lane will be permitted considering the requirement for auger extensions.

Joints between old and new pavements, or between each successive day's work, shall have a thorough and continuous bond between the old and new mixtures. Whenever the placement process is interrupted long enough for the mixture to attain its initial stability, the paver shall be removed from the mat and a transverse butt joint constructed.

Transverse butt joints shall be formed by cutting the pavement in a vertical plane, at a location approved by the Engineer, where the pavement has a true surface as determined using a straightedge at least 16 feet long. Otherwise, the transverse butt joint may be formed by trimming using mechanical means such that the full design depth of bituminous material is present at the trimmed joint. The transverse joint shall be thoroughly coated with emulsified asphalt just prior to depositing the new paving mixture.

When constructing transverse tapered joints, care shall be taken in raking out and discarding the coarser aggregate at the low end of the taper, and in rolling the taper. The taper area shall be thoroughly coated with emulsified asphalt just prior to the resumption of paving operations. As the paver places new mixture on the taper area, placement shall proceed such that an evenly graduated deposit of mixture will complement the previously made taper. Shovels may be used to add additional mixture if necessary. The joint shall be smoothed with a rake and properly rolled, with coarse material discarded.

Transverse joints shall not be constructed within 12 inches of transverse joints constructed in lower courses.

Longitudinal joints that have become cold shall be coated with emulsified asphalt before the adjacent mat is placed. If directed by the Engineer, such joints shall be cut back to a clean vertical edge prior to coating with the emulsion. Unless otherwise directed by the Engineer, longitudinal joints shall be offset at least 6 inches from any joint in the lower courses of pavement.

Wherever possible, the Contractor shall locate the joints such that, when the final pavement markings are placed, there will be a 2-inch offset between the pavement markings and parallel joints. The Contractor shall conduct paving operations such that the paving joint between the travel lane and adjacent shoulder will be outside of all longitudinal pavement markings.

(e) Surface Tolerance. The finished surface will be tested by the Engineer using a straightedge at least 16 feet in length at selected locations parallel with the centerline. Any variations exceeding 1/8 inch between any two contact points shall be satisfactorily eliminated. A straightedge at least 10 feet in length may be used on a vertical curve. The straightedges shall be provided by the Contractor in accordance with Subsection 631.04.

(f) Work Adjacent to the Pavement. When the Contractor proposes to perform work adjacent to the pavement (e.g. guardrail installation) after the wearing course has been placed, they shall submit a pavement protection plan. This plan shall be submitted at least 7 calendar days prior to performing any work adjacent to the pavement, and work shall not commence until the Engineer has approved the plan.

The plan shall outline methods of protecting the pavement during each proposed operation, as well as procedures for remediation of any damage that may occur. At a minimum, the repair shall be the full depth of the wearing course, but shall extend beyond that to the depth of the damage as needed. All repairs shall be performed in accordance with the applicable requirements of this section.

Spot patching will not be allowed as a method of remediation for repeated damage, and adjacent work that causes frequent or repeated damage will not be allowed to continue. Areas of repeated damage shall be repaved for the full lane width and for a minimum length of 250 feet, unless otherwise directed by the Engineer.

If the pavement is damaged, the Contractor shall immediately perform repairs as outlined in the pavement protection plan at no cost to the Agency. When the Pavement Roughness Pay Adjustment is included in the Contract, repaired areas will not be excluded from analysis.

406.10 MIXTURE PROPERTIES PAY ADJUSTMENT. The Mixture Properties Pay Adjustment will be based on the Mixture Properties Pay Factor calculated using the applicable equations specified below.

(a) Mixture Properties Pay Factor Determination for QA Tier I. For QA Tier I, the Mixture Properties Pay Factor will be calculated based on the PWL or STD for air voids using the equations below.

(1) Percent Within Limits Evaluation.

For $90\% \leq PWL_{AV} \leq 100\%$

$$PF_{MP} = 0.0020\ PWL_{AV} - 0.1800$$

For $70\% \leq PWL_{AV} < 90\%$

$$PF_{MP} = 0.0025\ PWL_{AV} - 0.2250$$

For $50\% \leq PWL_{AV} < 70\%$

$$PF_{MP} = 0.0075\ PWL_{AV} - 0.5750$$

where:

PWL_{AV} = Total percent within specification limits for air voids

PF_{MP} = Mixture Properties Pay Factor

(2) Single Test Departure Evaluation.

For $D_{AV} \geq 0$

$$PF_{MP} = 0$$

For -1 ≤ D_{AV} < 0

$$PF_{MP} = 0.1000\ D_{AV}$$

where:

D_{AV} = Single test departure for air voids

PF_{MP} = Mixture Properties Pay Factor

(b) Mixture Properties Pay Factor Determination for QA Tier II. For QA Tier II, the Mixture Properties Pay Factor will be calculated based on the PWL or STD for air voids using the equations below.

(1) Percent Within Limits Evaluation.

For 90% ≤ PWL_{AV} ≤ 100%

$$PF_{MP} = 0.0020\ PWL_{AV} - 0.1800$$

For 80% ≤ PWL_{AV} < 90%

$$PF_{MP} = 0$$

For 50% ≤ PWL_{AV} < 80%

$$PF_{MP} = 0.0067\ PWL_{AV} - 0.5336$$

where:

PWL_{AV} = Total percent within specification limits for air voids

PF_{MP} = Mixture Properties Pay Factor

(2) Single Test Departure Evaluation.

For $D_{AV} \geq 0$

$$PF_{MP} = 0$$

For $-1 \leq D_{AV} < 0$

$$PF_{MP} = 0.1000\ D_{AV}$$

where:

D_{AV} = Single test departure for air voids

PF_{MP} = Mixture Properties Pay Factor

(c) Mixture Properties Pay Factor Determination for QA Tier III. For QA Tier III, the Mixture Properties Pay Factor will be calculated based on the single test departure for air voids using the equations below.

For $D_{AV} \geq 0$

$$PF_{MP} = 0$$

For $-1 \leq D_{AV} < 0$

$$PF_{MP} = 0.1000\ D_{AV}$$

where:

D_{AV} = Single test departure for air voids

PF_{MP} = Mixture Properties Pay Factor

(d) Mixture Properties Pay Adjustment Determination. The Mixture Properties Pay Adjustment will be calculated using the equation below.

$$PA_{MP} = PF_{MP} \times Q \times B$$

where:

PA_{MP} = Mixture Properties Pay Adjustment (dollars)

PF_{MP} = Mixture Properties Pay Factor

Q = Quantity of material (tons)

B = Contract bid price (dollars/ton)

The quantity of material (Q) will be the number of tons compacted in place for each lot. This quantity will include all material used for shoulders, leveling courses, side roads, drives, and any other miscellaneous mix.

406.11 MAT DENSITY PAY ADJUSTMENT.

(a) Mat Density Analysis Procedure. Each course of bituminous concrete pavement, excluding leveling courses, placed on projects that contain the pay item for Mat Density Pay Adjustment will be analyzed for density according to the procedures specified in this subsection and the requirements of Subsection 406.03 for the applicable QA tier. If the Agency elects to not take cores of any lot of material, the Mat Density Pay Factor (PF_{MD}) for that lot will be set equal to zero.

Acceptance testing will be conducted by Agency personnel using cores provided by the Contractor in accordance with the coring protocol below.

(b) Coring Protocol.

(1) Selecting Core Locations. Original core sampling locations will be determined by the Engineer and will be restricted to travel lanes only. Cores will not be taken within 6 inches of a longitudinal joint or within 50 feet of a transverse joint, except on bridges. Bridge decks or approaches will not be cored within 10 feet of a bridge joint or transverse joint, and bridges less than or equal to 20 feet in length will not be cored. Independent shoulder and mat area core sampling locations may be selected by the Engineer to afford verification as specified in Subsection 406.11(c).

Original core sampling locations will be selected by the Engineer in accordance with *ASTM D3665* within 2 working days of the bituminous mixture being placed. The Contractor will be advised in writing of the selected sampling locations.

The Contractor may challenge whether any specific original sample location is representative of any specific lot by notifying the Engineer. This notification shall be made immediately upon the core locations being selected and conveyed to the Contractor, and prior to extracting the cores, and shall be further documented in any Contractor job records citing just reasoning for recommending a reselection of original sample locations.

Upon receipt by the Engineer of a written challenge from the Contractor, the Engineer will evaluate it within 1 working day and notify the Contractor in writing of either acceptance or rejection of the challenge. Rejection of a challenge will result in the Engineer using the original core sampling locations for the determination of density data in any compaction pay factor calculations. Acceptance of a challenge will result in the Engineer selecting alternate core sampling locations for those challenged samples.

Alternate core sampling locations will be selected by the Engineer by generating new random numbers to determine both new longitudinal and transverse coordinates within the sublot in question. The alternate core sampling locations will not be subject to further challenge and will be used for the determination of density data in any compaction pay factor calculations. The Contractor will be notified in writing of the final core sampling locations.

(2) Taking and Delivering Cores. Core samples 6-inches in diameter shall be taken within one working day of the final selection of the core sampling locations. The Contractor shall extract cores in the presence of the Engineer and shall deliver the samples to the Engineer, in a suitable container provided by the Contractor, on the same work day the samples are taken. As necessary, the Contractor shall mark the cores for saw-cutting in the presence of the Engineer for verification of cut locations. The Engineer will identify and record the core samples. Agency personnel will process the core samples within 10 working days and will relay the test results to both the Engineer and the Contractor.

Physical core samples will be retained for a period of 2 working days from the time that the density test results are relayed to the Engineer and Contractor. In addition, any subsequently retested or re-cored samples, as defined in Subsection 406.11(c), will be retained to the point of fully satisfying the requirements of Subsection 406.11(c).

Any cores not delivered in a suitable container will be rejected and new cores taken at the Contractor's expense. The Contractor shall fill the core holes, at their expense, with hot bituminous concrete pavement at a temperature of at least 200°F on the same work day that the cores are taken. Failure to comply with these provisions may result in payment being withheld for the representative lot of bituminous material.

(3) Calculating Mat Density. The density of each core will be calculated using the following formula.

$$D = 100 \times \frac{G_{mb}}{G_{mm}}$$

where:

D = Density (percent of maximum)

G_{mb} = Bulk specific gravity of compacted mixture

G_{mm} = Maximum specific gravity of the uncompacted mixture

Bulk specific gravity will be determined in accordance with *AASHTO T 166, Method A*, and maximum specific gravity will be determined in accordance with *AASHTO T 209*, from Agency acceptance tests. Should the sample absorb more than 2% of water by volume when tested with *AASHTO T 166*, it will be retested in accordance with *AASHTO T 331*, and the retested result will replace the original outlier sample results. Should the sample be considered an outlier in accordance with *ASTM E178, Table 1* at a 5% significance level, it will be retested in accordance with *AASHTO T 331*, and the retested result will replace the original outlier sample results.

(c) Core Result Verification. For any individual core considered to be an outlier, as determined in accordance with *ASTM E178, Table 1* at a 5% significance level, the Contractor or Agency may elect to re-core, to verify the original core result. The re-coring location shall be at the same transverse offset as the original location and shall be offset longitudinally forward 18 inches from the original location. The re-cored sample test result will replace the original core result and shall not cause any other core test result to become an outlier core subject to core result verification.

(d) Mat Density Pay Factor Determination for QA Tier I. For QA Tier I, the Mat Density Pay Factor for each lot of bituminous concrete pavement will be determined using the equations below.

For 90% ≤ PWL_{MD} ≤ 100%

$$PF_{MD} = 0.0030\ PWL_{MD} - 0.2700$$

For 70% ≤ PWL_{MD} < 90%

$$PF_{MD} = 0.0050\ PWL_{MD} - 0.4500$$

For 50% ≤ PWL_{MD} < 70%

$$PF_{MD} = 0.0100\ PWL_{MD} - 0.8000$$

where:

PWL_{MD} = Total percent within specification limits for mat density

PF_{MD} = Mat Density Pay Factor

(e) Mat Density Pay Factor Determination for QA Tier II and QA Tier III. For QA Tier II and QA Tier III, the Mat Density Pay Factor for each lot of bituminous concrete pavement will be determined using the equations below.

For 80% ≤ PWL_{MD} ≤ 100%

$$PF_{MD} = 0.00150\ PWL_{MD} - 0.1200$$

For 50% ≤ PWL_{MD} < 80%

$$PF_{MD} = 0.0050\ PWL_{MD} - 0.4000$$

where:

PWL_{MD} = Total percent within specification limits for mat density

PF_{MD} = Mat Density Pay Factor

(f) Mat Density Pay Adjustment Determination. The Mat Density Pay Adjustment will be calculated using the following equation.

$$PA_{MD} = PF_{MD} \times Q \times B$$

where:

PA_{MD} = Mat Density Pay Adjustment (dollars)

PF_{MD} = Mat Density Pay Factor

Q = Quantity of material (tons)

B = Contract bid price (dollars/ton)

The quantity of material (Q) will be the number of tons compacted in place for each lot. This quantity will exclude all material used for shoulders paved separately from mainline, leveling courses, side roads, and drives.

406.12 LONGITUDINAL JOINT DENSITY PAY ADJUSTMENT.

(a) General Requirements. For each course of bituminous concrete pavement, excluding leveling courses, placed on projects that contain the pay item for Longitudinal Density Pay Adjustment, the longitudinal joints will be analyzed for density according to the procedures specified in this subsection and the requirements of Subsection 406.03 for the applicable QA tier. If the Agency elects to not take cores of any portion of the material, that material will be excluded from the lot and not subject to the Longitudinal Joint Density Pay Factor (PF_{JD}).

Acceptance testing will be conducted by Agency personnel using cores provided by the Contractor in accordance with the coring protocol below.

(b) Coring Protocol.

(1) Selecting Core Locations. Core sampling locations will be determined by the Engineer. Joint core samples shall be taken between any adjacent travel lanes and between any travel lane and shoulder, provided that the shoulder material was placed as a separate construction operation. Cores will not be taken within 50 feet of a transverse joint, except on bridges. Bridge decks or approaches will not be cored within 10 feet of a bridge joint or transverse joint, and bridges less than or equal to 20 feet in length will not be cored.

Sampling locations will be selected using a stratified random sampling procedure in the longitudinal direction. The total project joint length will be subdivided into segments of the length specified for the applicable QA tier, and one sample (core) taken from each segment. The sampling location within each segment will be determined using *ASTM D3665*. For a longitudinal butt joint, the transverse location of the sample shall be centered on the visible surface joint line. For a tapered joint, the transverse location of the sample shall be offset from the visible surface joint line by approximately 50% of the taper width as directed by the Engineer.

Each individual core shall be a separate sample. Once selected according to the procedures above, core locations will become final and not subject to revision, nor will any core sample be subject to the provisions specified in Subsection 406.11(c).

(2) Taking and Delivering Cores. Core samples 6-inches in diameter shall be taken within one working day of the final selection of the core sampling locations. The Contractor shall extract cores in the presence of the Engineer and shall deliver the samples to the Engineer, in a suitable container provided by the Contractor, on the same work day the samples are taken. As necessary, the Contractor shall mark the cores for saw-cutting in the presence of the Engineer for verification of cut locations. The Engineer will identify and record the core samples. Agency personnel will process the core samples within 10 working days and will relay the test results to both the Engineer and the Contractor.

Any cores not delivered in a suitable container will be rejected and new cores taken at the Contractor's expense. The Contractor shall fill the core holes, at their expense, with hot bituminous concrete pavement at a temperature of at least 200°F on the same work day that the cores are taken. Failure to comply with these provisions may result in payment being withheld.

(3) Calculating Joint Density. The density of each core will be calculated using the following formula.

$$D = 100 \times \frac{G_{mb}}{G_{mma}}$$

where:

D = Density (percent of maximum)

G_{mb} = Bulk specific gravity of compacted mixture

G_{mma} = Average of the two maximum specific gravities for the mixture placed on both sides of the joint

Bulk specific gravity will be determined in accordance with *AASHTO T 166, Method A*, and maximum specific gravity will be determined in accordance with *AASHTO T 209*, from Agency acceptance tests. Should the sample absorb more than 2% of water by volume when tested with *AASHTO T 166*, it will be retested in accordance with *AASHTO T 331*, and the retested result will replace the original outlier sample results.

(c) Longitudinal Joint Density Pay Factor Determination for QA Tier I. For QA Tier I the Longitudinal Joint Density Pay Factor for each lot of bituminous concrete pavement will be determined using the equation below.

For $0\% \leq PWL_{JD} \leq 100\%$

$$PF_{JD} = 0.0012\, PWL_{JD} - 0.0900$$

where:

PWL_{JD} = Total percent within specification limits for longitudinal joint density

PF_{JD} = Longitudinal Joint Density Pay Factor

(d) Longitudinal Joint Density Pay Adjustment Determination. The Longitudinal Joint Density Pay Adjustment will be calculated using the following equation.

$$PA_{JD} = PF_{JD} \times Q \times B$$

where:

PA_{JD} = Longitudinal Joint Density Pay Adjustment (dollars)

PF_{JD} = Longitudinal Joint Density Pay Factor

Q = Quantity of material (tons)

B = Contract bid price (dollars/ton)

The quantity of material (Q) will be the number of tons compacted in place for each pavement course. This quantity will include material used for shoulders, but will exclude all material used for leveling courses, side roads, and drives.

406.13 PAVEMENT ROUGHNESS PAY ADJUSTMENT. When the project contains the pay item for Pavement Roughness Pay Adjustment, the Agency will measure the surface roughness of the wearing course with a road surface profiler (RSP) in accordance with *AASHTO R 43*. Results from the RSP will be reported in terms of the Mean Roughness Index (MRI) in inches per mile. MRI is the International Roughness Index (IRI) averaged across the right and left wheel path. The MRI value will be analyzed for pavement roughness according to the procedures in this subsection and the requirements of Subsection 406.03 for the applicable QA tier.

Prior to the highway being surface tested, all Contract items shall be complete such that the project could be deemed substantially complete, unless otherwise directed by the Engineer, including, but not limited to, all guardrail, bridge joints, and permanent pavement markings installed, including all side road markings. There shall not be lane closures or equipment present that would impede highway travel. At the time of testing, the highway surface shall be dry and free of snow, ice, and loose debris, and the ambient air temperature shall be a minimum of 40°F.

The Engineer may elect to waive surface testing for some or all of the project due to unfavorable weather conditions or other considerations. If the Engineer elects to waive surface testing for some or all of the project, that portion of the project will be eliminated from the calculations and not subject to the Pavement Roughness Pay Factor (PF_{PR}).

For undivided highways, the surface will be tested by Agency personnel traveling once in each direction. If the route contains truck lanes or passing lanes, only the rightmost lane will be tested in any given direction. The MRI value used to determine the Pavement Roughness Pay Factor will be the average calculated based upon travel in both directions.

For divided highways, the surface of both the travel and passing lanes will be tested. If only one barrel of the highway is paved as part of the project, the MRI value used to determine the Pavement Roughness Pay Factor will be the average calculated based on travel in all lanes of that barrel. If both barrels of the highway are paved as part of the project, the MRI value used to determine the Pavement Roughness Pay Factor will be the average calculated based on travel in all lanes of both barrels.

For both undivided and divided highways, the roughness associated with any anomalous features beyond the control of the Contractor, such as mechanical bridge joints, utility structures, or construction joints with existing pavement will be eliminated from the calculations. Areas that were repaired due to damage caused by the Contractor will not be eliminated from the calculations.

(a) Pavement Roughness Pay Factor Determination for QA Tier I and QA Tier II. For QA Tier I and QA Tier II, the Pavement Roughness Pay Factor will be determined based on the average MRI value using the following equations.

For non-limited access highways

$$PF_{PR} = -0.0029\ MRI_A + 0.1682$$

For limited access highways

$$PF_{PR} = -0.0029\ MRI_A\ + 0.1392$$

where:

MRI_A = Average mean roughness index

PF_{PR} = Pavement Roughness Pay Factor

(b) Pavement Roughness Pay Adjustment Determination. The Pavement Roughness Pay Adjustment will be calculated using the following equation.

$$PA_{PR} = PF_{PR}\ \times\ Q\ \times\ B$$

where:

PA_{PR} = Pavement Roughness Pay Adjustment (dollars)

PF_{PR} = Pavement Roughness Pay Factor

Q = Quantity of material (tons)

B = Contract bid price (dollars/ton)

The quantity of material (Q) will be the number of tons of wearing course compacted in place on the entire project. This quantity will exclude all material used for shoulders paved separately, side roads, drives, limited-access highway on- and off-ramps, and courses other than the wearing course.

406.14 METHOD OF MEASUREMENT. The quantity of Bituminous Concrete Pavement of the type and QA tier specified to be measured for payment will be the number of tons of mixture complete in-place in the accepted work as determined from the weigh tickets.

The quantity of Bituminous Concrete Pavement, Surface Preparation of the type specified to be measured for payment will be the number of tons of material complete in-place in the accepted work as determined from the weigh tickets.

The quantity of Bituminous Concrete Pavement, Non-Paver Placed of the type specified to be measured for payment will be the number of square yards complete in-place in the accepted work. Measurement will only include that bituminous concrete pavement not placed with a paver. Bituminous concrete material placed with a paver will be excluded.

The quantity of all applicable Pay Adjustments will be the number of dollars calculated according to the appropriate subsection.

406.15 BASIS OF PAYMENT. The accepted quantity of Bituminous Concrete Pavement of the type and QA tier specified will be paid for at the Contract unit price per ton. Payment will be full compensation for furnishing, mixing, hauling, and placing the material specified, including hand placement when payment is not otherwise provided for in the Contract, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Bituminous Concrete Pavement, Surface Preparation of the type specified will be paid for at the Contract unit price per ton. Payment will be full compensation for furnishing, mixing, hauling, and placing the materials specified, including emulsified asphalt, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Bituminous Concrete Pavement, Non-Paver Placed of the type specified will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, mixing, hauling, and placing the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. The costs of excavation, subbase material, milling, emulsified asphalt, cleaning existing paved surfaces, and filling joints, cracks, and holes will not be paid for directly, but will be considered incidental to Bituminous Concrete Pavement, Non-Paver Placed.

The quantity of all Pay Adjustments will be debited or credited against the Contract dollar amounts for those items.

The costs of furnishing testing facilities and supplies at the plant will be considered included in the Contract unit price of Bituminous Concrete Pavement. The costs of obtaining, furnishing, transporting, and providing the straightedges required by Subsection 406.09 will be paid for under the appropriate Section 631 pay item included in the Contract.

All costs associated with obtaining samples for acceptance testing, including taking cores and filling the core holes, will be incidental to the cost of the pay item being sampled. The cost of uniformed traffic officers and flaggers used while taking cores for acceptance testing and filling the core holes will be paid for under the appropriate Section 630 Contract item.

When not specified as items in the Contract, the costs of sweeping and cleaning existing paved surfaces and tacking of utility structures, curbing, gutters, and other contact surfaces will not be paid for directly but will be incidental to the appropriate Bituminous Concrete Pavement pay item.

Bituminous concrete mixtures approved by the Engineer for use in correcting deficiencies in any full depth reclamation, recycled bituminous pavement, or subbase constructed as part of the Contract will not be paid for as Bituminous Concrete Pavement but will be incidental to the Contract item being corrected.

Payment will be made under:

Pay Item		Pay Unit
406.0110	Bituminous Concrete Pavement, Type IS, QA Tier I	Ton
406.0120	Bituminous Concrete Pavement, Type IS, QA Tier II	Ton
406.0130	Bituminous Concrete Pavement, Type IS, QA Tier III	Ton
406.0210	Bituminous Concrete Pavement, Type IIS, QA Tier I	Ton
406.0220	Bituminous Concrete Pavement, Type IIS, QA Tier II	Ton
406.0230	Bituminous Concrete Pavement, Type IIS, QA Tier III	Ton
406.0310	Bituminous Concrete Pavement, Type IIIS, QA Tier I	Ton
406.0320	Bituminous Concrete Pavement, Type IIIS, QA Tier II	Ton
406.0330	Bituminous Concrete Pavement, Type IIIS, QA Tier III	Ton
406.0410	Bituminous Concrete Pavement, Type IVS, QA Tier I	Ton
406.0420	Bituminous Concrete Pavement, Type IVS, QA Tier II	Ton
406.0430	Bituminous Concrete Pavement, Type IVS, QA Tier III	Ton
406.1410	Bituminous Concrete Pavement, Type IVSB, QA Tier I	Ton
406.1420	Bituminous Concrete Pavement, Type IVSB, QA Tier II	Ton
406.1430	Bituminous Concrete Pavement, Type IVSB, QA Tier III	Ton
406.2400	Bituminous Concrete Pavement, Surface Preparation, Type IVS	Ton
406.3400	Bituminous Concrete Pavement, Non-Paver Placed, Type IVS	Square Yard
406.9100	Pay Adjustment, BCP, Mixture Properties (N.A.B.I.)	Dollar
406.9200	Pay Adjustment, BCP, Mat Density (N.A.B.I.)	Dollar
406.9300	Pay Adjustment, BCP, Longitudinal Joint Density (N.A.B.I.)	Dollar
406.9400	Pay Adjustment, BCP, Pavement Roughness (N.A.B.I.)	Dollar

SECTION 407 – BONDED WEARING COURSE

407.01 DESCRIPTION. This work shall consist of applying a bonded wearing course pavement. This work shall be performed in conformance with the lines, grades, thicknesses, and typical cross-sections shown on the Plans or established by the Engineer.

407.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Performance-Graded Asphalt Binder.....702.01
Polymer-Modified Emulsified Asphalt.....702.02(c)
Anti-Strip Additives.....702.04
Aggregate for Bituminous Concrete Mixtures.....704.10
General Bituminous Concrete Mixture Design Requirements .....716.02(a)
Bonded Wearing Course Mixtures.....716.02(c)
Bituminous Mixing Plant and Laboratory 716.03
Preparing and Mixing Bituminous Concrete Mixtures.....716.04

407.03 AGENCY MATERIAL EVALUATION. Bonded wearing course will be sampled and tested on a statistically random basis for both quality control and acceptance in accordance with the specified requirements, and the material quality will be evaluated based on the results of these tests.

The actual mixture produced shall not vary from the job mix formula target values by more than production tolerances specified in Table 407.03A. For the purposes of verification sampling, the tolerances given in Table 407.03A will be considered the specification limits for an individual sample. Continued production outside these ranges will be grounds to halt production and rescind the mix design.

TABLE 407.03A – MIXTURE PRODUCTION TOLERANCES

Material Property	Lower Mixture Tolerance	Upper Mixture Tolerance
Aggregate, percent passing the 3/8 inch (9.50 mm) or larger sieves (dry sieve)	JMF – 4%	JMF + 4%
Aggregate, percent passing the No. 4 (4.75 mm) sieve through the No. 16 (1.18 mm) sieves (dry sieve)	JMF – 3%	JMF + 3%
Aggregate, percent passing the No. 30 (0.600 mm) sieve through the No. 100 (0.150 mm) sieves (dry sieve)	JMF – 2%	JMF + 2%
Fines, percent passing the No. 200 (0.075 mm) sieve (dry sieve)	JMF – 1.5%	JMF + 1.5%
Mixture temperature [1]	JMF – 20°F	JMF + 20°F
Asphalt binder content	JMF – 0.4%	JMF + 0.4%

[1] The mixture temperatures shall not exceed 355°F.

Material may be sampled at either the production facility or on the project site and may be tested at either the production facility's qualified lab, or at the Agency's Materials Testing and Certification Section Central Laboratory.

(a) Lots and Sublots. The entire quantity of a single mix design of bonded wearing course will constitute a lot. Sublots for quality control shall be a maximum of 500 tons. For acceptance, a sublot will be 1,000 tons. Samples will be taken once per sublot. Agency sublot size may be adjusted by the Engineer to sample more frequently for material quality issues.

(b) Evaluation Method. The percent within limits (PWL) method will be used to determine the quality of the material produced based on the specification limits listed in Table 407.03A. This PWL will be used to determine a pay factor for the material but will not be used to accept or reject the material. Detailed documentation on the PWL method is available in the Agency's *Bituminous Concrete Policy Manual*. If mix design JMF changes cause there to be multiple lots, the quantity weight average PWL will be used to determine the project pay factor.

(c) Quality Characteristics. Type A bonded wearing course will be evaluated using the No. 4 (4.75 mm), No. 8 (2.36 mm), No. 50 (0.300 mm), and No. 200 (0.075 mm) sieves, and asphalt binder content. Type B and Type C bonded wearing course will be evaluated using the 3/8 inch (9.50 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 50 (0.300 mm), and No. 200 (0.075 mm) sieves, and asphalt binder content.

(d) Pay Factor. A composite weighted pay factor combining the PWL of each quality characteristic will be calculated to account for the overall quality of the lot. If mix design JMF changes cause there to be multiple lots, a quantity weight average PWL will be used to determine the project pay factor.

407.04 CONTRACTOR QUALITY CONTROL.

(a) Control of Mixture. The Contractor shall be responsible for maintaining control of the mix production process. The mix production methods and technologies shall generally be at the Contractor's discretion, but will be limited to proven, Agency and industry accepted practice. Upon approval of the Engineer and at no additional cost to the Agency, the Contractor may use innovative equipment or techniques not included in the specifications to produce or monitor the production or placement of the mixture.

The plant shall be operated so that no intentional deviations are made from the approved job mix formula. The continual production of non-conforming work at a reduced price, in lieu of making adjustments to bring work into conformance, will not be allowed. The Contractor shall provide process control adequate to produce work of acceptable quality. At a minimum, the Contractor shall perform sampling and testing at the frequencies specified in Table 407.04A as applicable for the mixture type, and shall calculate the cumulative weighted PWL using the equation specified in Subsection 407.06(a)(1) after each quality control sublot. The Engineer will not sample or test for process control or assist in controlling the Contractor's production operations.

TABLE 407.04A – QUALITY CONTROL TESTING AND SAMPLING CRITERIA

Parameter	Test Method	Minimum Frequency (Select the Least Frequent)
Mixture gradation	*AASHTO T 30, AASHTO T 308*	1 per 500 tons
Mixture temperature	Verified thermometer	1 per 250 tons at plant (truck)
Asphalt binder content	*AASHTO T 308*	1 per 500 tons
Cold feed gradation	*AASHTO T 27*	1 per day
Cold feed percentage fractured face [1]	*AASHTO T 335*	1st day of paving, 1 per week or 5,000 tons
Cold feed flat and elongated particles [2]	*ASTM D4791*	1 per month
Fine and coarse aggregate moisture content [3]	*AASHTO T 255*	2 per day
Stripping [4]	*ASTM D3625*	1 per week

[1] Fractured faces for crushed gravel sources only.

[2] Flat and elongated percentage for all material retained on or above the No. 4 (4.75 mm) sieve.

[3] For drum-mix and continuous mixing plants only.

[4] Stripping testing for stripping prone aggregates only. Testing will be witnessed by Agency staff.

Control over production shall follow the control limits established for the mix design for quality control samples. A single result outside the control limit will necessitate the Contractor take action to return production to in control. Production shall be suspended if two out of three values in row exceed the control limits, or if the quality control cumulative weighted PWL falls below 60%.

After suspension, a passing quality control test from a trial drop shall be used to show the mix has been returned to in control, and production may resume. Following a PWL suspension, three tests will be conducted before reevaluating for suspension of production based on the total project PWL, however, production shall be suspended if two out of those three tests exceed the control limits. Failure or inaction by the Contractor to maintain control over the mix production will result in mix design suspension.

(b) Contractor Quality Control Plan. The Contractor shall provide, maintain, and operate in accordance with a quality control plan for the plant and the field, hereafter referred to as the plant QC plan and field QC plan, to ensure the production of material that meets the Contract requirements. The Contractor shall develop and submit program-wide QC plans annually in advance of the paving season, to document the QC practices, personnel, facilities, and equipment to be used by the Contractor. Additionally, the Contractor shall submit project-specific supplements to both the plant and field QC plans to provide specific details applicable to each project. No paving shall occur until both QC plans and their supplements have been approved for the project. Project supplements to the QC plans shall be submitted at least 10 working days before the start of paving on the project.

(1) Plant QC Plan. Bituminous concrete mixture plants shall submit a program wide plant QC plan to cover all mix production, as detailed in the Agency's *Bituminous Concrete Policy Manual*. A project-specific supplement shall be submitted to apply the plant QC plan to the project and provide specific details, including, but not limited to, the mix designs to be used, the use of silos, changes in personnel, and other project specific requirements.

(2) Field QC Plan. The Contractor shall submit a comprehensive field QC plan to cover paving practices in the field, as detailed in the Agency's *Bituminous Concrete Policy Manual*. A project-specific supplement shall be submitted to apply the field QC plan to the project and provide specific details, including, but not limited to, paving personnel and equipment identification, QC personnel, mixing, loading, transportation, intended paving sequence, emulsion application procedure and rate, and other project-specific requirements.

(3) Non-Compliance with the QC Plans. The Contractor shall comply with the approved QC plans and shall take all other steps necessary to ensure a high-quality product. Failure of the Contractor to comply with the approved QC plans may result in the Agency ordering the Contractor to cease production or paving, revoking approval of the QC plan, or taking other actions as necessary.

407.05 CONSTRUCTION REQUIREMENTS

(a) Equipment.

(1) Hauling Equipment. To prevent the mixture from adhering to the beds, trucks used for hauling bituminous mixture shall have tight, clean, and smooth metal beds which have been thinly coated with a bond release agent. Petroleum-based products will not be permitted. Each truck shall have a cover of canvas or other suitable material of sufficient size to extend over all sides of the haul vehicle to properly protect the mix from the weather. Covers shall be securely fastened to ensure placement of the material at the specified temperature.

The trucks used for hauling bituminous mixture shall be compatible with the equipment used for placing the bituminous mixture.

Trucks shall not to be cleaned or emptied on surfaces to be paved.

(2) Placing Equipment. The Contractor shall use a self-priming paver as approved by the Engineer. The self-priming paver shall be capable of spraying the polymer-modified emulsified asphalt, applying the bonded wearing course, and smoothing the surface of the mat in one pass at a rate of at least 35 feet per minute.

The paver shall provide means for obtaining a sample of the emulsified asphalt, and as needed, the lines shall be flushed prior to sampling to ensure there are no residual cleaning solvents in the sample.

The self-priming paver shall be equipped with a receiving hopper, feed conveyor, emulsion storage tank, metered high-pressure emulsion spray bar calibrated per the manufacturer's recommendations, and a variable width, heated, ironing-type screed. The screed shall have the ability to be crowned at the center both positively and negatively and have vertically adjustable extensions to accommodate the desired pavement profile.

(3) Compaction Equipment. The Contractor shall use steel-wheeled double-drum rollers weighing at least 10 tons, equipped with functioning water systems and scrapers to prevent material from adhering to the roller drums.

(b) Weather And Seasonal Limitations. Bonded wearing course shall not be placed unless both the ambient air temperature and the temperature of the existing surface at the paving site, in the shade and away from artificial heat, are greater than 50°F.

Bonded wearing course shall not be placed on a wet or frozen surface, or when weather or other conditions would prevent the proper handling, finishing, or compacting of the material, unless otherwise approved by the Engineer.

Placement of bonded wearing course shall not occur between September 16th and May 15th, inclusive.

(c) Preparation of Surfaces. The existing bituminous concrete pavement surface shall be prepared as shown on the Plans and as directed by the Engineer prior to applying the polymer-modified emulsified asphalt. This shall include patching, pothole repairs, raveling repairs, crack sealing, and other repairs directed by the Engineer and performed in accordance with Subsection 406.08 and Subsection 417.05(c). Surface preparation material shall be a bituminous material or mixture approved by the Engineer or as otherwise specified.

The surface of the area to be overlaid shall be thoroughly cleaned and free of dirt, oil, debris, other foreign materials, and standing water.

All utility structures within the area to be paved shall be covered with material approved by the Engineer and referenced for location and adjustment, if necessary, after paving.

(d) Placing and Finishing.

(1) Polymer-Modified Emulsified Asphalt. Polymer-modified emulsified asphalt shall be applied in accordance with Subsection 404.06(c).

Production of bonded wearing course shall be suspended if the actual application rate of the polymer-modified emulsified asphalt is outside of the required application rate range specified in Subsection 404.06(c).

(2) Bonded Wearing Course. Equipment shall not come in contact with the polymer-modified emulsified asphalt before the bonded wearing course is applied. Immediately after the polymer-modified emulsified asphalt has been applied, the bonded wearing course shall be placed across the full width of the emulsion within the temperature range specified on the approved mix design.

A load ticket shall accompany each vehicle supplying bonded wearing course. One legible copy of the load ticket shall be made available to the Engineer prior to placement of the mixture.

(3) Finishing. Finishing shall begin immediately after application of the bonded wearing course using a minimum of two static passes. Vibratory equipment shall not be used unless otherwise approved by the Engineer. The rollers shall not stop on the freshly placed bonded wearing course. The Contractor shall use an adequate number of rollers to complete finishing before the pavement temperature falls below 185°F.

Once finished, traffic will not be permitted on placed material until the material has cooled to 140°F, unless otherwise authorized by the Engineer.

407.06 MIXTURE PROPERTIES PAY ADJUSTMENT. The Mixture Properties Pay Adjustment will be based on the Mixture Properties Pay Factor calculated using the equations specified below.

(a) Mixture Properties Pay Factor Determination. For bonded wearing course, the Mixture Properties Pay Factor will be calculated based on the weighted PWL for gradation and asphalt binder content.

(1) Weighted PWL. The weighted PWL for gradation and asphalt binder content will be calculated using the equation below.

For Type A

$$PWL_W = 0.20(PWL_{\#4} + PWL_{\#8} + PWL_{\#50} + PWL_{\#200} + PWL_A)$$

For Type B and Type C

$$PWL_W = 0.15(PWL_{3/8} + PWL_{\#4} + PWL_{\#8} + PWL_{\#50}) + 0.20(PWL_{\#200} + PWL_A)$$

where:

PWL_W = Weighted percent within specification limits

$PWL_{3/8}$ = Percent within specification limits for the 3/8 inch (9.5mm) sieve

$PWL_{\#4}$ = Percent within specification limits for the No. 4 (4.75 mm) sieve

$PWL_{\#8}$ = Percent within specification limits for the No. 8 (2.36 mm) sieve

$PWL_{\#50}$ = Percent within specification limits for the No. 50 (0.300 mm) sieve

$PWL_{\#200}$ = Percent within specification limits for the No. 200 (0.075 mm) sieve

PWL_A = Percent within specification limits for asphalt binder content

(2) Mixture Properties Pay Factor. Once the weighted PWL for gradation has been determined, the Mixture Properties Pay Factor will be calculated using the formulas below.

For 85% ≤ PWL_W ≤ 100%

$$PF_{MP} = 0.00067\ PWL_W - 0.05700$$

For 50% ≤ PWL_W < 85%

$$PF_{MP} = 0.00286\ PWL_W - 0.24310$$

For PWL_W < 50%

$$PF_{MP} = 0.00800\ PWL_W - 0.50000$$

where:

PWL_W = Weighted percent within specification limits

PF_{MP} = Mixture Properties Pay Factor

(b) Mixture Properties Pay Adjustment Determination. The Mixture Properties Pay Adjustment will be calculated using the equation below.

$$PA_{MP} = PF_{MP} \times Q \times B$$

where:

PA_{MP} = Mixture Properties Pay Adjustment (dollars)

PF_{MP} = Mixture Properties Pay Factor

Q = Quantity of material (square yards)

B = Contract bid price (dollars/square yard)

The quantity of material (Q) will be the number of square yards compacted in place for each lot. This quantity will include material used for shoulders.

407.07 METHOD OF MEASUREMENT. The quantity of Bonded Wearing Course of the type specified to be measured for payment will be the number of square yards of mixture complete in-place in the accepted work.

The quantity of all applicable Pay Adjustments will be calculated according to the appropriate subsection.

407.08 BASIS OF PAYMENT. The accepted quantity of Bonded Wearing Course of the type specified will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, mixing, hauling, and placing the material specified, and for furnishing all labor, materials, and equipment necessary to complete the work.

The costs of furnishing testing facilities and supplies at the plant will be considered included in the Contract unit price for Bonded Wearing Course.

Surface preparation, patching, and crack sealing will be paid for separately in accordance with Section 406 and Section 417.

The quantity of all Pay Adjustments will be debited or credited against the Contract dollar amounts for those items.

Payment will be made under:

Pay Item		Pay Unit
407.0100	Bonded Wearing Course, Type A	Square Yard
407.0200	Bonded Wearing Course, Type B	Square Yard
407.0300	Bonded Wearing Course, Type C	Square Yard
407.9100	Pay Adjustment, BWC, Mixture Properties (N.A.B.I.)	Dollar

SECTION 410 – MATERIAL TRANSFER VEHICLE

410.01 DESCRIPTION. This work shall consist of furnishing and using an approved material transfer vehicle (MTV) in bituminous concrete paving operations.

410.02 CONSTRUCTION REQUIREMENTS. An approved MTV shall be used to transfer the bituminous material from the hauling equipment to the paver. The MTV shall operate independently from the paver and shall be a commercially manufactured unit specifically designed for the transfer of mix from the hauling equipment to the paver without depositing the mix on the roadway surface.

The MTV or separate hopper shall be designed such that the deposited mix is remixed prior to placement on the roadway. The minimum storage capacity of the MTV, not including any separate hopper, shall be 12 tons. The MTV shall be capable of swinging or offsetting the material transfer delivery system to side discharge into the paver. If the MTV and associated actions do not effectively eliminate mat segregation as determined by the Engineer, the Engineer may require a hopper insert with remixing capabilities or other measures. When the MTV traverses a bridge that is not a buried structure, it shall be as near to empty as possible and shall not exceed 5 mph while on any structure.

410.03 METHOD OF MEASUREMENT. The quantity of Material Transfer Vehicle to be measured for payment will be the number of tons of bituminous pavement transferred by the MTV to the paver in the completed and accepted work, as determined by the weigh slips.

410.04 BASIS OF PAYMENT. The accepted quantity of Material Transfer Vehicle will be paid for at the Contract unit price per ton. Payment will be full compensation for the equipment as specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
410.1000 Material Transfer Vehicle	Ton

SECTION 413 – HOT IN-PLACE RECYCLING

413.01 DESCRIPTION. This work shall consist of hot in-place recycling (HIR) of the existing pavement surface, including heating the pavement surface using specialized equipment causing the asphalt to soften, scarifying the softened pavement surface in a continuous process to the depth specified in the Plans, mixing the scarified asphalt pavement with a recycling agent that rejuvenates the asphalt, and placing and compacting the mix back onto the roadway.

Excess recycled material not used in the HIR process will become the property and responsibility of the Contractor.

413.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Hot Recycling Agents 702.05

The HIR mixture shall be free of any materials not generally considered to be asphalt pavement.

413.03 EQUIPMENT.

(a) General Requirements. The recycling equipment shall be capable of milling the existing roadway, sizing the resulting RAP, and mixing the RAP with the recycling agent and any additives stipulated in the mix design. The equipment used shall be capable of placing the recycled pavement mixture to the requirements provided herein and to the lines and grades shown on the Plans. Any additional equipment used by the Contractor beyond that specified below shall be approved by the Engineer based on its suitability to produce results meeting the specification requirements.

(b) Heating Unit. The heating unit shall generate sufficient heat to soften the asphalt pavement to the depth required. Care shall be taken not to overheat the existing pavement thereby softening the underlying asphalt pavement not to be scarified. The burner assembly shall be adjustable to heat between 8 feet and 14 feet in width. The entire heating unit shall be enclosed and vented to contain the heat and prevent damage to adjacent properties and landscape. In cooler temperatures, an additional heating unit may be required.

(c) Heater Scarification Train. This equipment shall be a self-contained machine designed to reprocess only the upper layers of the existing pavement. The heater scarification train shall be self-propelled and capable of operating at speeds of 16 feet to 50 feet per minute while uniformly heating and scarifying the existing pavement to a minimum depth of one inch. Listed below are the various units that are part of the heater scarification train.

(1) Scarifying Unit. The scarifying unit shall contain at least two rows of spring-loaded tines that are adjustable in one inch increments to scarify a width of 14 feet. This unit shall also be able to conform to the pavement contours to ensure a uniform penetration from the tines and prevent damage to utility structures.

(2) Spray Unit. A rejuvenator shall be applied to the material during the scarifying process. The size of the nozzles located on the spray bar and pump shall be selected based upon the rate of application rate and the forward speed of the heater scarification unit. The spray unit shall be equipped with an electronic digital measuring system, which shall be capable of maintaining the required application rate of the recycling agent with a tolerance of ± 5% for the mix design.

The electronic digital measuring system shall continuously verify and display the application rate of recycling agent and cumulative total with respect to the volume of scarified material for the road surface. The Contractor shall calibrate the electronic digital measuring system in the presence of the Engineer. Approved calibrations shall be done for each project. Work shall not progress until the calibration has been completed and verified.

(d) Remixer Unit. Immediately following the application of the rejuvenating agent, the Contractor shall thoroughly mix the agent with the scarified material to the required depth. This process may be completed with the use of a dual drum enclosed auger or mill head in a manner to perform proper and continuous blending. The remixer unit shall be an integral part of the scarifying machine and shall be located between the spray unit, which applies the recycling agent, and the screed. This unit shall be operated hydraulically, able to work at variable speeds from 0 rpm to 120 rpm, and shall be adjustable from 8 feet to 14 feet wide. In addition, this unit shall be able to break in the center to allow for quarter point and crown control.

(e) Screed Unit. The hot scarified material shall be uniformly distributed to the desired longitudinal and transverse section by the use of an attached heated, augured vibratory screed. The temperature of the hot scarified material shall be maintained between a minimum of 275°F and a maximum of 330°F. The screed shall be equipped with an adjustable crown control and each end of the screed shall have hand wheel adjusting screws for providing the desired longitudinal grade and transverse slope.

(f) Rollers. Rollers shall be in good mechanical condition, capable of reversing without backlash, and operated at speeds slow enough to avoid displacement of the bituminous mixture. The weight of the rollers shall be sufficient to compact the mixture to the required density without crushing the aggregate. Rollers shall be equipped with tanks and spray bars for wetting the rolls or tires.

Pneumatic-tired rollers shall be equipped with appropriate skirts at all times and be preheated prior to use in order to avoid picking. The Contractor shall remove all picked material from the surface.

Vibratory rollers shall have separate controls for energy and propulsion. They shall be equipped with automatic cutoffs that stop the vibration prior to the roller stopping or reversing its direction of travel.

413.04 CONSTRUCTION REQUIREMENTS.

(a) General Requirements. Agency personnel and equipment shall be allowed free and full access to the project site at no additional compensation due the Contractor to allow for any and all sampling required to assess compliance with the provisions of this specification. The Contractor shall afford the Agency all traffic control operations and provide means to extract samples as requested to achieve this effort.

The recycling agent content used in production may vary throughout the project and be adjusted by the Contractor based on the results of QC testing or other variables with the approval of the Engineer, to maintain an optimized finished product.

(b) Design Criteria. The HIR shall increase the average penetration value of the mixture by at least 30% over the original penetration, while not exceeding 100 microns, when tested in accordance with *AASHTO T 49*.

(c) Mix Design. The Contractor shall develop an HIR mix design consisting of RAP and hot recycling agent. To obtain material to conduct mix designing, the Contractor shall sample existing pavement to represent the recycled aggregates. A minimum of six core samples representative of the project shall be taken. The Contractor shall develop and submit a material sampling plan for review and approval by the Agency a minimum of 5 working days prior to obtaining HIR mix design samples. At a minimum, the sampling plan shall include the number of samples, location of samples, and the method of sampling and backfilling.

The mix design process shall include recovery of the asphalt binder from the RAP for penetration testing, dosing with recycling agent, and testing to determine the percent improvement of penetration.

The mix design shall provide the type and recommended dosage rate of the recycling agent.

(d) Cleaning. The existing pavement and shoulder to be recycled shall be cleaned by using mechanical sweepers, hand brooms, or other effective means until the surface is free of all material which might interfere with the scarification process.

(e) Heater Scarification. The heating unit shall be operated in such a manner as to prevent damage to adjacent property and vegetation. All heat-damaged areas shall be repaired immediately to the satisfaction of the Engineer and at no additional cost to the Agency.

The speed of the equipment shall be controlled to ensure that the recycled pavement is properly mixed, and uniformly distributed to the proper thickness, slope, and crown shown in the Plans. Extra care shall be taken in controlling heater scarification equipment to prevent segregation of the recycled mix at the start and end of paving production as well as at any locations where the heater scarification train needs to stop and restart.

The hot in-place pavement shall be constructed to conform to the depth requirements and tolerances shown in the Plans. The width of each pass shall be controlled to provide proper placement of longitudinal joints, including a 3 inch overlap onto adjacent lane passes.

Recycling agent shall be added uniformly to the scarified pavement at the predetermined application rate to produce a homogenous recycled mix.

The temperature of the scarified mixture shall be maintained between 275°F and 330°F prior to initial compaction.

In areas having catch basins or manholes that are not accessible to scarifying equipment, the Engineer will determine if they require repair. Pavement surfaces that are in good condition and are less than one square yard in size do not require repair. Areas that are greater than one square yard in size or with cracks or spalls shall be repaired with bituminous concrete pavement, as approved by the Engineer.

(f) Compaction. The CIR shall be compacted to 98% to 102% of the target maximum density (TMD). If two out of three consecutive density test results are outside of the allowable range, the Contractor will be required to construct a new test section to establish an updated TMD.

If the Engineer determines that the TMD is apparently incorrect, as evidenced by being achieved with little or minimal compactive effort, then the Engineer will require a new test section to establish a new TMD.

(g) Surface Tolerance. The surface will be tested by the Engineer using a straightedge at least 12 feet in length at selected locations parallel with the centerline. Any variations exceeding 1/8 inch between any two contact points shall be eliminated. A straightedge at least 10 feet in length may be used on a vertical curve. The straightedges shall be provided by the Contractor in accordance with Subsection 631.04.

(h) Curing and Stability. The HIR may be opened to traffic after achieving the target density and after the material is determined to be stable by the Engineer.

The required density shall be achieved and maintained until a wearing course pavement has been placed. Any additional compaction effort or repair of imperfections in the HIR material shall be performed as directed by the Engineer at no additional cost to the Agency.

(i) Weather and Seasonal Limitations. Hot in-place activities shall only be performed between the dates of May 16th and October 15th, inclusive. In addition, hot in-place activities shall only occur when the following conditions are met:

(1) The atmospheric and road surface temperature, as measured by a thermometer placed in the shade at the recycling location, is at least 50°F and rising.

(2) There is no standing water on the surface to be recycled.

413.05 QUALITY CONTROL.

(a) General Requirements. The Contractor shall be responsible for performing all process control and quality control sampling and testing and operate in accordance with an approved QC plan. Prior to performing any HIR production, the Engineer or the Contractor may request a pre-recycle conference to discuss the recycling schedule.

The Contractor shall sample, test, and evaluate the HIR process in accordance with the procedures and minimum frequencies specified in Table 413.05A.

TABLE 413.05A – MINIMUM QUALITY CONTROL FREQUENCIES

Test or Action	Frequency	Test Method
Density	1 per 1,000 feet per lane	*AASHTO T 355* or *AASHTO T 343*
Air temperature	4 per day at even intervals	Verified thermometer
Surface temperature	At beginning and end of each day's operation	Verified thermometer
Yield of recycling agent	2 per day at even intervals	Tank check
Penetration of recovered binder of mix	1 per mile per lane	*AASHTO T 49*

Density testing shall be the average of three points across the lane (transverse) for each testing location.

Quality control records shall include all sampling events, testing events, and process changes with accurate time and location data. The Contractor shall submit QC records and summaries to the Engineer by 1:00 p.m. on the next working day. The Contractor shall make all test results, including randomly sampled densities, available to the Engineer onsite and on request.

The Contractor shall cease recycling operations whenever one of the following occurs:

(1) The submitted QC plan is not followed.

(2) Density between 98% to 102% of TMD is not being achieved following corrective action.

(3) The finished product is visually defective.

(4) The computed rejuvenator yield differs from the mix design value by more than 10%.

(5) The QC penetration values are less than 30% greater than the average original penetration values in the mix design.

(6) The QC penetration values exceed 100 microns.

(7) The recycled layer depth varies more than 1/4 inch across the width of the mat when checked behind the screed prior to compaction.

Recycling operations shall not resume until the Contactor and the Agency agree on the corrective action to be taken.

(b) Quality Control Plan. The Contractor shall submit a quality control plan (QC plan) to the Engineer a minimum of 14 calendar days prior to initiating HIR operations and shall not commence HIR operations until the QC plan is accepted by the Engineer.

The QC plan shall address any items that affect the quality of the recycling process including, but not limited to, the following:

(1) QC Plan Administrator. The QC plan administrator shall be identified in the QC Plan and shall list their past experience on HIR projects. They shall:

a. Be a full-time employee of the Contractor or an independent consultant not involved with the acceptance activities of the project.

b. Have a minimum of four years of experience in quality control activities in construction operations.

c. Have full authority to institute actions necessary for successful implementation of the QC Plan.

(2) Quality Control Technician. The quality control technicians (QCT)shall be responsible for conducting quality control and inspection activities to implement the QC plan. There may be more than one QCT on a project. They shall:

a. Be a full-time employee of the Contractor or an independent consultant with a minimum of two years of experience in quality control activities in field construction operations.

b. Have completed the requirements for the applicable testing by the Northeast Transportation Training and Certification Program (NETTCP) for Soils and Aggregate Inspector, or an equivalent regional program.

c. Have full authority to institute actions necessary for successful implementation of the QC Plan.

(3) Recycling Supervisor. The recycling supervisor shall be responsible for conducting controlling the recycling process, quality control and inspection activities to implement the QC plan. They shall:

a. Be a full-time employee of the Contractor or an independent consultant with a minimum of two years of experience in quality control activities in field construction operations.

b. Have full authority to institute actions necessary for successful implementation of the QC plan.

(4) Minimum Quality Control Parameters. Minimum quality control parameters are:

a. Make and type of all hot in-place equipment to be used on the project.

b. Description of heating system (radiant or direct burner), including the heating equivalency.

c. The mixing system, including any drum speeds, operation, time, type, spacing, and configuration.

d. Project specific hot in-place mix design.

e. Proposed method for reducing or eliminating damage to adjacent property and landscape.

f. Make and type of rollers, including weight, weight per inch of drum, and average contact pressure for pneumatic tired rollers.

g. Proposed roller patterns to achieve density.

h. Density testing plan.

i. Recycling operations, including recycling speed and methods to ensure that the required treatment depth is obtained and that segregation is minimized.

j. Methods for protecting the finished product from damage and procedures for any necessary corrective action or repair.

k. Methods of grade checks.

l. Examples of quality control forms.

m. Confirmation that all testing will be performed in accordance with AASHTO or other applicable procedures.

(c) Control Section. Control sections shall be constructed to establish the TMD at the beginning of the HIR, and through the project as needed.

The Contractor shall construct a control section to assure the Engineer that the Contractor's equipment and procedures are suitable for the work specified and establish the target maximum density. The rolling pattern shall be determined from buildup, when the density readings show an increase in dry density of less than 1 pcf for the final four roller passes of each roller.

The average of a minimum of 10 tests taken throughout the control section after the buildup is complete shall be used to determine the TMD. If Agency personnel are available, their values shall be included in the average, or used to establish the density gauge offsets, as directed by the Engineer.

The control section shall be full lane width and a minimum of 500 feet long, or as approved by the Engineer. No further recycling shall be performed until all aspects of the control section and the TMD are approved by the Engineer. The Contractor shall use the same equipment for building both the accepted test sections and performing the HIR work on the project unless equipment substitution is approved by the Engineer.

The Engineer may require an additional test section and additional process control sampling to investigate the suitability of substituted or changed equipment.

If the control section does not meet the requirements of this specification, or the target density is not determined from buildup testing, then the Contractor shall modify the procedure and either construct another test section or reconstruct the original test section until suitable results are obtained.

The Contractor shall provide the Engineer with written copies of all process control and quality control results from the control section by 1:00 p.m. on the next working day, including test locations. The Contractor shall make all test results available to the Engineer onsite and on request.

413.06 METHOD OF MEASUREMENT. The quantity of Hot In-Place Recycling to be measured for payment will be the number of square yards of existing pavement which has been recycled in an acceptable manner as determined by actual surface measurements of the lengths and widths of the recycled area as shown on the Plans or as directed by the Engineer. No additional compensation will be made for overlapping areas.

Areas where the scarifying equipment cannot be used and that are repaired with bituminous concrete pavement, such as catch basins or manholes, will be measured for payment as square yards of Hot In-Place Recycling.

413.07 BASIS OF PAYMENT. The accepted quantity of Hot In-Place Recycling will be paid for at the Contract unit price per square yard. Payment will be full compensation for cleaning debris from the existing pavement; providing the recycling agent; heating and scarifying, mixing, paving, compacting, coring, and testing the recycled materials; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Furnishing and incorporating the recycling agent will not be paid for separately but will be included in the unit price bid for Hot-In-Place Recycling.

Payment will be made under:

Pay Item	Pay Unit
413.0100 Hot In-Place Recycling	Square Yard

SECTION 414 – COLD IN-PLACE RECYCLING

414.01 DESCRIPTION. This work shall consist of cold in-place recycling (CIR) of the existing pavement surface, including milling bituminous pavement from the existing roadway, crushing or screening the existing bituminous pavement if needed, the addition of asphalt emulsion or foamed asphalt binder, Portland cement, and virgin aggregate, and mixing and repaving of the material to the depths, lines, and grades shown on the Plans.

Excess recycled material not used in the CIR process will become the property and responsibility of the Contractor.

414.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Portland Cement.....701.02
Performance-Graded Asphalt Binder.....702.01
Anionic Emulsified Asphalt.....702.02(a)
Cationic Emulsified Asphalt.....702.02(b)
Aggregate for Bituminous Concrete Mixtures.....704.10
Recycled Asphalt Pavement .....704.22(a)
Water.....745.01

Emulsified asphalt for CIR, when used, shall be type HFMS-2, HFMS-2h, HFMS-2s, CSS-1, CSS-1h, MS-2h, or as recommended by the Contractor as a result of the design criteria of this specification and approved by the Engineer.

Foamed asphalt binder for CIR, when used, shall be unmodified and grade 58S-28, unless otherwise specified in the Contract.

The CIR shall meet the gradation requirements of Table 414.02A for extracted aggregate (*AASHTO T 30*, dry) taken from the pulverized material.

TABLE 414.02A – EXTRACTED AGGREGATE GRADATION

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1-1/2 inch (37.5 mm)	100
1 inch (25.0 mm)	90 – 100
No. 4 (4.75 mm)	30 – 70
No. 200 (0.075 mm)	0 – 12

The CIR shall be free of any materials not generally considered to be asphalt pavement. If the processed material does not meet the gradation requirements as specified, additional virgin aggregates shall be added at a rate such that the blended mixture conforms to the gradation requirements specified in Table 414.02A. Additional virgin aggregate shall meet the requirements of Subsection 704.10(a) and Subsection 704.10(b), except that sand equivalent is not required.

414.03 EQUIPMENT.

(a) General Requirements. The recycling equipment shall be capable of milling the existing roadway, sizing the resulting RAP, and mixing the RAP with the recycling agent and any additives stipulated in the mix design. The recycling equipment shall be capable of meeting the specified sizing requirements with either the milling process or with additional sizing equipment. The recycling equipment shall be capable of producing a homogeneous recycled pavement mixture by mixing the RAP with the recycling agent, water, and any other additives, either in the milling machine housing or in an additional mixing chamber. The equipment used shall be capable of placing the recycled pavement mixture to the requirements provided herein and to the lines and grades shown on the Plans. Any additional equipment used by the Contractor beyond that specified below shall be approved by the Engineer based on its suitability to produce results meeting the specification requirements.

For foamed asphalt applications, the equipment must accurately foam bituminous material, uniformly add specified water, and provide samples of the foamed bituminous material through a sampling nozzle.

(b) Spreading of Dry Cement. Dry cement shall be spread on the existing asphalt pavement surface ahead of the milling machine using either a cyclone or screw type calibrated spreader truck built to provide a consistent, accurate and uniform distribution of material. The equipment must apply the additive within a tolerance of ± 10% of the specified rate.

(c) Spreading of Corrective Aggregate. Corrective aggregate shall be spread in consistent and uniform windrows using belly dump trucks or tailgated trucks with end dumps and spread to a uniform thickness with a motor grader or mechanical spreader in front of the milling machine.

(d) Mainline Milling Machine. The Contractor shall furnish a self-propelled machine capable of milling the existing bituminous pavement to the depth shown on the Plans. The machine shall be equipped with standard automatic depth controls and must maintain a constant cutting depth and width. The primary cutting drum shall be a sufficient width to recycle the full lane in one pass. The machine shall be capable of producing the size of material required or additional crushing or screening shall be used. A smaller milling machine may be used to mill shoulders and miscellaneous areas ahead of the primary milling machine to increase the recycled width.

(e) Portable Mixing Unit. The unit shall be capable of producing a uniform, thoroughly mixed, cold mixed asphalt product.

The material feed system to the mixing unit shall be equipped with a computer-controlled weigh bridge that will determine the mass of recycled material being deposited into the mixing unit prior to the addition of the emulsified or foamed asphalt. The scales shall be calibrated to the manufacturer's tolerance at the start of the Contract.

This mixing unit shall be of a dual shaft pugmill design, equipped with a metering device which will continuously meter and maintain the amount of emulsified or foamed asphalt being added to the process to a tolerance of ± 0.25% of the total, by weight.

The asphalt control unit shall be equipped with a flow meter and a total delivery meter. A positive displacement pump capable of accurately metering the required quantity of asphalt down to a rate of 4 gallons per minute into the recycled material is required.

The pump shall be equipped with a positive interlock system that will shut off automatically when material is not present in the mixing chamber.

The unit shall be designed to either deposit the mixed product onto the roadway in a sized windrow or be capable of depositing the product directly into a paver hopper.

If a foamed asphalt recycling agent is used, the system shall be equipped with a heating system capable of maintaining the temperature of asphalt flow components to maintain the required expansion ratio and half-life. The asphalt binder injection system shall contain an independent pumping system and spray bar to regulate the application of foamed asphalt separate from the water used to increase moisture content for compaction. The additive system shall be computer controlled and the rate of addition of water into the hot asphalt binder shall be automatically kept at a constant percent by weight of asphalt binder. An inspection or test nozzle shall be fitted at one end of the spray bar to produce a representative sample of foamed asphalt binder.

(f) Tankers. Tankers used to supply the recycling machine with bitumen shall have a capacity of at least 2,500 gallons. No leaking tankers will be permitted on the job site. In addition, each tanker shall be equipped with the following:

(1) A thermometer to show the temperature of the contents in the bottom third of the tank.

(2) Insulation to retain heat.

(3) A calibrated dipstick marked at intervals of no more than 25 gallons, for measuring the contents of the tank.

(g) Placing Equipment. Placing of the CIR shall be accomplished with a self-propelled bituminous paver. The CIR material shall be spread without segregation to the lines and grades shown on the Plans or as directed by the Engineer. The screed shall be controlled by electronic grade and cross-slope control. If a pick-up machine is used to feed a windrow of the bituminous material into the paver hopper, the pick-up machine shall be capable of picking up the entire windrow down to the underlying materials.

(h) Compaction Equipment. The number, mass, and type of rollers shall be sufficient to obtain the required uniform density, full depth, while the mixture is in a workable condition. A rubber-tired roller shall perform the initial rolling after the emulsion initially breaks (indicated by color change from brown to black). At a minimum, the following rollers shall be used:

(1) At least one double drum vibratory roller with a minimum weight of 10 tons.

(2) At least one pneumatic-tired roller with a minimum weight of 22 tons.

Rollers shall have a width of not less than 65 inches. Tires on pneumatic rollers shall be evenly inflated and matched in size and profile so as to maximize compactive effort.

414.04 CONSTRUCTION REQUIREMENTS.

(a) General Requirements. For quantity calculation and construction purposes, a Portland cement content of 1.0% was used to estimate the required Portland cement tonnage for this work.

Agency personnel and equipment shall be allowed free and full access to the project site at no additional compensation due the Contractor to allow for any and all sampling required to assess compliance with the provisions of this specification. The Contractor will afford the Agency all traffic control operations and provide means to extract samples as requested to achieve this effort.

The residual asphalt and cement content used in production may vary throughout the project and be adjusted by the Contractor based on the results of QC testing or other variables as identified by the Agency or the Contractor to maintain an optimized finished product.

Emulsion or foamed asphalt binder, water, processed bituminous pavement, virgin aggregate, and Portland cement shall be added in the proportions necessary to meet mix design requirements and verified by tank checks performed in accordance with the minimum quality control frequencies.

(b) Design Criteria. The CIR shall meet the design criteria requirements of Table 414.04A, Table 414.04B, or Table 414.04C, as applicable for the type of asphalt being used.

TABLE 414.04A – EMULSIFIED ASPHALT USING THE MARSHALL STABILITY TEST

Criteria	Test Method	Requirement
Ratio of residual asphalt to cement	--	3 to 1, min.
Stability value, dry subset	*AASHTO T 245*	1,500 lbf, min.
Retained stability, wet/dry subsets	*AASHTO T 245*	0.70, min.

TABLE 414.04B – EMULSIFIED ASPHALT USING THE INDIRECT TENSILE STRENGTH TEST

Criteria	Test Method	Requirement
Ratio of residual asphalt to cement	--	3 to 1, min.
Indirect tensile strength, dry subset	*AASHTO T 283*	45 psi, min.
Tensile strength ratio	*AASHTO T 283*	0.70, min.

TABLE 414.04C – FOAMED ASPHALT

Criteria	Test Method	Requirement
Ratio of residual asphalt to cement	--	3 to 1, min.
Foamed asphalt expansion ratio	--	8 times, min.
Foamed asphalt half-life	--	6.0 sec., min.
Indirect tensile strength, dry subset	*AASHTO T 283*	45 psi, min.
Tensile strength ratio	*AASHTO T 283*	0.70, min.

(c) Mix Design. The Contractor shall develop a CIR mix design consisting of RAP, emulsified asphalt or foamed asphalt, Portland cement, and blended aggregate if appropriate. To obtain material to conduct mix designing, the Contractor shall sample existing pavement to represent the recycled aggregates that would be expected to result from the milling process. A minimum of four samples representative of the quarter points of the entire length of the project shall be taken. The Contractor shall develop and submit a material sampling plan for review and approval by the Agency a minimum of 5 working days prior to obtaining CIR mix design samples. At a minimum, the sampling plan shall include the number of samples, location of samples, and the method of sampling and backfilling. The mix design shall also consider shoulder areas to be widened beyond existing edge of pavement such that the recycled bituminous pavement is full width to the lines and grades shown in the Plans.

When emulsified asphalt is used, *AASHTO PP 86* shall be the method used to develop a mix design in accordance with *AASHTO MP 31*, except only meeting the specified design requirements in Table 414.04A or Table 414.04B, as applicable. The job mix formula (JMF) shall contain the percent passing each sieve, emulsified asphalt type and content as a percent of total CIR material, and cement content as a percent of total CIR material.

When foamed asphalt is used, *AASHTO PP 94* shall be the method used to develop a mix design in accordance with *AASHTO MP 38*, except only meeting the specified mix design requirements in Table 414.04C. The job mix formula shall contain the percent passing each sieve, foamed asphalt content as a percent of total CIR material, and cement content as a percent of total CIR material.

A minimum of 10 working days shall be allowed for evaluation of the submitted mix design. A copy of all test data used in developing the mix design, including graphs, shall be submitted with the mix design.

The established job-mix formula is valid until a change is made in aggregate source, cement content, or emulsion source. No change in the job-mix formula may be made without the written approval of the Engineer.

The Engineer may approve changes in the design's job-mix formula or discontinue use of the design if placement, finishing, or compaction characteristics are determined to be unsatisfactory.

(d) Removal of Existing Pavement. The existing pavement surface, including cracks, shall be visibly free from all foreign matter before recycling commences. The Contractor shall be responsible for removing any deleterious materials or crack sealants which may interfere with the CIR process.

In areas of shoulder widening, if milling is conducted prior to CIR, and subgrade or native soils are encountered, the removed material shall be considered waste and removed from the project using the appropriate pay item for excavation.

If the shoulders or miscellaneous areas are milled in advance of CIR to increase the recycled width, the material will be deposited in advance of the CIR to be incorporated into the recycling.

If during the CIR process, the milling head is regularly breaking through to the subbase soils, the process shall be adjusted in consultation with the engineer.

If more than 5% of the recycled material is screened off as waste, the Contractor will be required to change the process to reduce the amount of oversized material being screened off as waste, with the approval of the Engineer.

(e) Placing. The mix shall be paved full width, including shoulders where paved shoulders existed or where the shoulders are widened, to the specified grade and slope. The bituminous mixture shall be placed and finished with the specified equipment, shall be struck off in a uniform layer to the full width required and of such depth that each course, when compacted, shall have the required thickness, and shall conform to the grade and elevation specified. The finished surface shall be of uniform texture and evenness and shall not show tearing, shoving, or pulling of the mixture.

In areas where irregularities or unavoidable obstacles make the use of mechanical placing and finishing equipment impracticable, the mixture shall be spread, raked, luted, and compacted by hand methods.

Longitudinal joints between successive reclamation passes shall overlap. The Contractor shall provide a sufficient number of mixing passes so that overlap is achieved. The Contractor shall sequence the operations in order to complete all recycling and paving activities across the full width of the roadway within the same work shift. Longitudinal cold joints are not allowed in the emulsified asphalt stabilized base.

(f) Compaction. Compaction shall be performed while the emulsion or foamed asphalt is in a workable state. The CIR material shall be finished within a grade tolerance of ± 1/2 inch, provided that this deviation is not maintained for a distance longer than 50 feet, and provided that the required crown or superelevation is maintained.

Deviations in the finished surface shall not exceed ± 3/8 inch in any direction using a 10 foot minimum straight edge. Any repairs required to correct surface deviations are at the Contractor's expense using Agency approved material and methods.

The CIR shall be compacted to 98% to 102% of the target maximum density (TMD). If two out of three consecutive density test results are outside of the allowable range, the Contractor will be required to construct a new test section to establish an updated TMD.

If the Engineer determines that the TMD is apparently incorrect, as evidenced be being achieved with little or minimal compactive effort, then the Engineer will require a new test section to establish a new TMD.

(g) Curing and Stability. The CIR may be opened to traffic after achieving the target density and after the material is determined to be stable by the Engineer.

Hot mixed bituminous concrete pavements shall not be placed until the CIR material has been allowed to cure and the free moisture content is reduced to a maximum of 1.5% every 1,000 feet per lane or as directed by the Engineer.

The Engineer may waive the 1.5% free moisture content in such cases that the CIR has been open to a cure period of 14 days or more.

The required density shall be achieved and maintained until a wearing course pavement has been placed. Any additional compaction effort or repair of imperfections in the CIR material shall be performed as directed by the Engineer at no additional cost to the Agency. As an alternative for the purpose of protecting the CIR from damage due to traffic, the Engineer may approve the use of an emulsified asphalt fog seal after the placement of the CIR and prior to the placement of any hot mix bituminous pavement.

(h) Weather and Seasonal Limitations. CIR shall not be performed when the ambient air temperature is below 50°F, when the overnight temperatures are expected to be below 50°F, when the temperature of the existing roadway surface is below 50°F, when the weather is foggy or rainy, or when weather conditions or predicted weather conditions are such that proper mixing, spreading, and compacting of the recycled material cannot be accomplished.

The placement of CIR shall not be performed prior to May 1st or after September 15th.

When it is in the public interest for servicing traffic, the Engineer may adjust the ambient air or existing roadway surface temperature requirements or extend the dates of the recycling season.

414.05 QUALITY CONTROL.

(a) General Requirements. The Contractor shall be responsible for performing all process control and quality control sampling and testing and operate in accordance with an approved QC plan. Prior to performing any CIR production, the Engineer or the Contractor may request a pre-recycle conference to discuss the recycling schedule.

The Contractor shall sample, test, and evaluate the CIR process in accordance with the procedures and minimum frequencies specified in Table 414.05A.

TABLE 414.05A – MINIMUM QUALITY CONTROL FREQUENCIES

Test or Action	Frequency	Test Method
Density	1 per 1,000 feet per lane	*AASHTO T 355* or *AASHTO T 343*
Air temperature	4 per day at even intervals	Verified thermometer
Surface temperature	At beginning and end of each day's operation	Verified thermometer
Yield for cement and emulsion	2 per day at even intervals	Tank check
RAP moisture	1 per day	*AASHTO T 217* or *AASHTO T 255*
Aggregate moisture	1 per day	*AASHTO T 217* or *AASHTO T 255*
In-place moisture content	3 per day	*AASHTO T 217*, *AASHTO T 255*, *AASHTO T 310*, or *ASTM D7830*
Gradation and asphalt content of final product	1 per day	*AASHTO T 30* (dry), *AASHTO T 164*, or *AASHTO T 308*

Density testing shall be the average of three points across the lane (transverse) for each testing location.

Gradation failures shall require the Contractor to take action to adjust the process to achieve compliant material. Additional virgin aggregate added to correct gradation shall meet the requirements of Subsection 704.10(a) and Subsection 704.10(b), except that sand equivalent is not required.

Quality control records shall include all sampling events, testing events, and process changes with accurate time and location data. The Contractor shall submit QC records and summaries to the Engineer by 1:00 p.m. on the next working day. The Contractor shall make all test results, including randomly sampled densities, available to the Engineer onsite and on request.

The Contractor shall cease recycling operations whenever one of the following occurs:

(1) The computed yield of each additive differs from the approved JMF by 10% or more.

(2) The Contractor fails to follow the approved QC plan.

(3) The finished product is visually segregated, unstable, or otherwise defective, as determined by the Engineer.

Recycling operations shall not resume until the Contactor and the Agency agree on the corrective action to be taken.

(b) Quality Control Plan. The Contractor shall submit a quality control plan (QC plan) to the Engineer a minimum of 14 calendar days prior to initiating CIR operations and shall not commence CIR operations until the QC plan is accepted by the Engineer.

The QC plan shall address any items that affect the quality of the recycling process including, but not limited to, the following:

(1) QC Plan Administrator. The QC plan administrator shall be identified in the QC plan and shall list their past experience on CIR projects. They shall:

a. Be a full-time employee of the Contractor or an independent consultant not involved with the acceptance activities of the project.

b. Have a minimum of four years of experience in quality control activities in construction operations.

c. Have full authority to institute actions necessary for successful implementation of the QC plan.

(2) Quality Control Technician. The quality control technicians (QCT) shall be responsible for conducting quality control and inspection activities to implement the QC plan. There may be more than one QCT on a project. They shall:

a. Be a full-time employee of the Contractor or an independent consultant with a minimum of two years of experience in quality control activities in field construction operations.

b. Have completed the requirements for the applicable testing by the Northeast Transportation Training and Certification Program (NETTCP) for Soils and Aggregate Inspector, or an equivalent regional program.

c. Have full authority to institute actions necessary for successful implementation of the QC plan.

(3) Minimum Quality Control Parameters. Minimum quality control parameters are:

a. Methods to adhere to the JMF.

b. Mixing details, pugmill type, production rates, and material processing.

c. Make and type of pavers.

d. Make, type, of rollers, and their respective location within the paving train.

e. Process control testing and quality control testing. Daily QC testing results shall be submitted to the Engineer as requested and copies of all project QC testing shall be submitted on such dates that a biweekly estimate from the Agency is intended to be processed.

f. Laydown operations, including procedures for mix design modification, avoiding recycling and curing in inclement weather, avoiding damage from haul trucks, material yield monitoring, methods to ensure that segregation is minimized, longitudinal joint construction, procedures to determine the maximum rolling and placing speeds based on field quality control, and achieving the best possible smoothness.

g. Methods for protecting the finished product from damage and procedures for any necessary corrective action.

h. Methods of grade checks.

i. Examples of QC plan and logbook forms.

j. Methods for calibration or verification of density gauge.

k. Stockpile management procedures.

(c) Control Section. Control sections shall be constructed to establish the TMD at the beginning of the CIR, and through the project as needed.

The Contractor shall construct a control section to assure the Engineer that the Contractor's equipment and procedures are suitable for the work specified and establish the target maximum density and moisture content. The rolling pattern shall be determined from buildup, when the density readings show an increase in dry density of less than 1 pcf for the final four roller passes of each roller.

The average of a minimum of 10 tests taken throughout the control section after the buildup is complete shall be used to determine the TMD. If Agency personnel are available, their values shall be included in the average, or used to establish the density gauge offsets, as directed by the Engineer.

The control section shall be full lane width and a minimum of 500 feet long, or as approved by the Engineer. No further recycling shall be performed until all aspects of the control section and the TMD are approved by the Engineer. The Contractor shall use the same equipment for building both the accepted test sections and performing the CIR work on the project unless equipment substitution is approved by the Engineer.

The Engineer may require an additional test section and additional process control sampling to investigate the suitability of substituted or changed equipment.

If the control section does not meet the requirements of this specification, or the target density is not determined from buildup testing, then the Contractor shall modify the procedure and either construct another test section or reconstruct the original test section until suitable results are obtained.

414.06 METHOD OF MEASUREMENT. The quantity of Cold In-Place Recycling to be measured for payment will be the number of square yards of existing pavement which has been recycled in an acceptable manner as determined by actual surface measurements of the lengths and widths of the recycled area as shown on the Plans or as directed by the Engineer. No additional compensation will be made for overlapping areas.

The quantity of Aggregate for CIR to be measured for payment will be the number of tons used in the complete and accepted work.

The quantity of Portland Cement for CIR to be measured for payment will be the number of tons of material in place in the complete and accepted work, as determined from the load tickets or other method as approved by the Engineer.

The quantity of Emulsified Asphalt for CIR and Foamed Asphalt for CIR to be measured for payment will be the number of hundredweight used in the completed and accepted work.

414.07 BASIS OF PAYMENT. The accepted quantity of Cold In-Place Recycling will be paid for at the Contract unit price per square yard. Payment will be full compensation for performing the work specified including removal of deleterious material and crack sealant, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work. Any additional RAP material, not generated from the project, required to meet the project volume of Cold In-Place Recycling will not be paid for separately but will be considered incidental to Cold In-Place Recycling.

Any mainline milling prior to the CIR process will be paid for under the appropriate Section 210 pay item included in the Contract.

The accepted quantity of Aggregate for CIR will be paid for at the Contract unit price per ton. Payment will be full compensation for furnishing and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment for the furnishing of emulsified asphalt fog seal will be made under the appropriate Section 404 pay item in the Contract.

The accepted quantity of Portland Cement for CIR will be paid for at the Contract unit price per ton. Payment will be full compensation for furnishing and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Emulsified Asphalt for CIR and Foamed Asphalt for CIR will be paid for at the Contract unit price per hundredweight for the specified material applied. Payment will be full compensation for furnishing, transporting, and placing the material and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
414.0200	Cold In-Place Recycling, 2 Inch Depth	Square Yard
414.0250	Cold In-Place Recycling, 2.5 Inch Depth	Square Yard
414.0300	Cold In-Place Recycling, 3 Inch Depth	Square Yard
414.0350	Cold In-Place Recycling, 3.5 Inch Depth	Square Yard
414.0400	Cold In-Place Recycling, 4 Inch Depth	Square Yard
414.0450	Cold In-Place Recycling, 4.5 Inch Depth	Square Yard
414.0500	Cold In-Place Recycling, 5 Inch Depth	Square Yard
414.5100	Aggregate for CIR	Ton
414.5200	Portland Cement for CIR	Ton
414.5300	Emulsified Asphalt for CIR	Hundredweight
414.5400	Foamed Asphalt for CIR	Hundredweight

SECTION 415 – COLD CENTRAL PLANT RECYCLING

415.01 DESCRIPTION. This work shall consist of cold central plant recycling (CCPR) of the existing pavement surface, including generating RAP material from the project or other sources, adding additional asphalt emulsion or foamed asphalt binder, Portland cement, virgin aggregate, and mixing and repaving of the material to the depths, lines, and grades shown on the Plans.

Excess recycled material not used in the CCPR process will become the property and responsibility of the Contractor.

415.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Emulsified asphalt for CCPR, when used, shall be type HFMS-2, HFMS-2h, HFMS-2s, CSS-1, CSS-1h, MS-2h, or as recommended by the Contractor as a result of the design criteria of this specification and approved by the Engineer.

Foamed asphalt binder for CCPR, when used, shall be unmodified and grade 58S-28, unless otherwise specified in the Contract.

The CCPR shall meet the gradation requirements of Table 415.02A for extracted aggregate (*AASHTO T 30*, dry) taken from the pulverized material.

TABLE 415.02A – EXTRACTED AGGREGATE GRADATION

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1-1/2 inch (37.5 mm)	100
1 inch (25.0 mm)	90 – 100
No. 4 (4.75 mm)	30 – 70
No. 200 (0.075 mm)	0 – 12

The CCPR shall be free of any materials not generally considered to be asphalt pavement. If the processed material does not meet the gradation requirements as specified, additional virgin aggregates shall be added at a rate such that the blended mixture conforms to the gradation requirements specified in Table 415.02A. Additional virgin aggregate shall meet the requirements of Subsection 704.10(a) and Subsection 704.10(b), except that sand equivalent is not required.

415.03 EQUIPMENT.

(a) General Requirements. The Contractor shall furnish equipment which is capable of mixing, crushing, or screening the processed bituminous material and any virgin material, foamed asphalt or emulsion, and Portland cement into a homogeneous mixture. The mixing equipment shall be equipped with belt scales to accurately proportion the additives, adjusted by the moisture content of the processed RAP and aggregate. The belt scale shall be verified for accuracy at each new location prior to mix production and shall be verified during production at the request of the Engineer. The method of depositing the mixed material shall be such that segregation does not occur. Any additional equipment used by the Contractor beyond that specified below shall be approved by the Engineer based on its suitability to produce results meeting the specification requirements.

Hauling equipment used for hauling the mixture shall meet the requirements of Subsection 406.05(a).

Pavers shall meet the requirements of Subsection 406.05(b).

(b) Compaction Equipment. The number, mass, and type of rollers shall be sufficient to obtain the required uniform density, full depth, while the mixture is in a workable condition. A pneumatic-tired roller shall perform the initial rolling after the emulsion initially breaks (indicated by color change from brown to black). At a minimum, the following rollers shall be used:

(1) At least one double drum vibratory roller with a minimum weight of 10 tons.

(2) At least one pneumatic-tired roller with a minimum weight of 22 tons.

Rollers shall have a width of not less than 65 inches. Tires on pneumatic rollers shall be evenly inflated and matched in size and profile so as to maximize compactive effort.

415.04 CONSTRUCTION REQUIREMENTS.

(a) General Requirements. For quantity calculation and construction purposes, a Portland cement content of 1.0% was used to estimate the required Portland cement tonnage for this work.

Agency personnel and equipment shall be allowed free and full access to the project site at no additional compensation due the Contractor to allow for any and all sampling required to assess compliance with the provisions of this specification. The Contractor will afford the Agency all traffic control operations and provide means to extract samples as requested to achieve this effort.

The residual asphalt and cement content used in production may vary throughout the project and be adjusted by the Contractor based on the results of QC testing or other variables as identified by the Agency or the Contractor to maintain an optimized finished product.

Emulsion or foamed asphalt binder, water, processed bituminous pavement, virgin aggregate, and Portland cement shall be added in the proportions necessary to meet mix design requirements and verified by tank checks performed in accordance with the minimum quality control frequencies. Portland cement may be introduced in dry form or as a cement slurry.

(b) Design Criteria. The CCPR shall meet the design criteria requirements of Table 415.04A, Table 415.04B, or Table 415.04C, as applicable for the type of asphalt being used.

TABLE 415.04A – EMULSIFIED ASPHALT USING THE MARSHALL STABILITY TEST

Criteria	Test Method	Requirement
Ratio of residual asphalt to cement	--	3 to 1, min.
Stability value, dry subset	*AASHTO T 245*	1,500 lbf, min.
Retained stability, wet/dry subsets	*AASHTO T 245*	0.70, min.

TABLE 415.04B – EMULSIFIED ASPHALT USING THE INDIRECT TENSILE STRENGTH TEST

Criteria	Test Method	Requirement
Ratio of residual asphalt to cement	--	3 to 1, min.
Indirect tensile strength, dry subset	*AASHTO T 283*	45 psi, min.
Tensile strength ratio	*AASHTO T 283*	0.70, min.

TABLE 415.04C – FOAMED ASPHALT

Criteria	Test Method	Requirement
Ratio of residual asphalt to cement	--	3 to 1, min.
Foamed asphalt expansion ratio	--	8 times, min.
Foamed asphalt half-life	--	6.0 sec., min.
Indirect tensile strength, dry subset	*AASHTO T 283*	45 psi, min.
Tensile strength ratio	*AASHTO T 283*	0.70, min.

(c) Mix Design. The Contractor shall develop a CCPR mix design consisting of RAP, emulsified asphalt or foamed asphalt, Portland cement, and blended aggregate if appropriate. To obtain material to conduct mix designing, the Contractor shall sample existing pavement to represent the recycled aggregates that would be expected to result from the milling process. A minimum of four samples representative of the quarter points of the entire length of the project shall be taken. If stockpiled RAP is to be used, the stockpile will be sampled from 4 locations and combined to generate a representative sample. The Contractor shall develop and submit a material sampling plan for review and approval by the Agency a minimum of 5 working days prior to obtaining CCPR mix design samples. At a minimum, the sampling plan shall include the number of samples, location of samples, and the method of sampling and backfilling. The mix design shall also consider shoulder areas to be widened beyond existing edge of pavement such that the recycled bituminous pavement is full width to the lines and grades shown in the Plans.

When emulsified asphalt is used, *AASHTO PP 86* shall be the method used to develop a mix design in accordance with *AASHTO MP 31*, except only meeting the specified design requirements in Table 415.04A or Table 415.04B, as applicable. The job mix formula (JMF) shall contain the percent passing each sieve, emulsified asphalt type and content as a percent of total CCPR material, and cement content as a percent of total CCPR material.

When foamed asphalt is used, *AASHTO PP 94* shall be the method used to develop a mix design in accordance with *AASHTO MP 38*, except only meeting the specified mix design requirements in Table 415.04C. The job mix formula shall contain the percent passing each sieve, foamed asphalt content as a percent of total CCPR material, and cement content as a percent of total CCPR material.

A minimum of 10 working days shall be allowed for evaluation of the submitted mix design. A copy of all test data used in developing the mix design, including graphs, shall be submitted with the mix design.

The established job-mix formula is valid until a change is made in aggregate source, cement content, or emulsion source. No change in the job-mix formula may be made without the written approval of the Engineer.

The Engineer may approve changes in the design's job-mix formula or discontinue use of the design if placement, finishing, or compaction characteristics are determined to be unsatisfactory.

(d) Placing. The mix shall be paved full width, including shoulders where paved shoulders existed or where the shoulders are widened, to the specified grade and slope. The bituminous mixture shall be placed and finished with the specified equipment, shall be struck off in a uniform layer to the full width required and of such depth that each course, when compacted, shall have the required thickness, and shall conform to the grade and elevation specified. The finished surface shall be of uniform texture and evenness and shall not show tearing, shoving, or pulling of the mixture.

In areas where irregularities or unavoidable obstacles make the use of mechanical placing and finishing equipment impracticable, the mixture shall be spread, raked, luted, and compacted by hand methods.

(e) Compaction. Compaction shall be performed while the emulsion or foamed asphalt is in a workable state. The CCPR material shall be finished within a grade tolerance of ± 1/2 inch, provided that this deviation is not maintained for a distance longer than 50 feet, and provided that the required crown or superelevation is maintained.

Deviations in the finished surface shall not exceed ± 3/8 inch in any direction using a 10 foot minimum straight edge. Any repairs required to correct surface deviations are at the Contractor's expense using Agency approved material and methods.

The CCPR shall be compacted to 98% to 102% of the target maximum density (TMD). If two out of three consecutive density test results are outside of the allowable range, the Contractor will be required to construct a new test section to establish an updated TMD.

If the Engineer determines that the TMD is apparently incorrect, as evidenced be being achieved with little or minimal compactive effort, then the Engineer will require a new test section to establish a new TMD.

(f) Curing and Stability. The CCPR may be opened to traffic after achieving the target density and after the material is determined to be stable by the Engineer.

Hot mixed bituminous concrete pavements shall not be placed until the CCPR material has been allowed to cure and the free moisture content is reduced to a maximum of 1.5% every 1,000 feet per lane or as directed by the Engineer.

The Engineer may waive the 1.5% free moisture content in such cases that the CCPR has been open to a cure period of 14 days or more.

The required density shall be achieved and maintained until a wearing course pavement has been placed. Any additional compaction effort or repair of imperfections in the CCPR material shall be performed as directed by the Engineer at no additional cost to the Agency. As an alternative for the purpose of protecting the CCPR from damage due to traffic, the Engineer may approve the use of an emulsified asphalt fog seal after the placement of the CCPR and prior to the placement of any hot mix bituminous pavement.

(g) Weather and Seasonal Limitations. CCPR shall not be performed when the ambient air temperature is below 50°F, when the overnight temperatures are expected to be below 50°F, when the temperature of the existing roadway surface is below 50°F, when the weather is foggy or rainy, or when weather conditions or predicted weather conditions are such that proper mixing, spreading, and compacting of the recycled material cannot be accomplished.

The placement of CCPR shall not be performed prior to May 1st or after September 15th.

When it is in the public interest for servicing traffic, the Engineer may adjust the ambient air or existing roadway surface temperature requirements or extend the dates of the recycling season.

415.05 QUALITY CONTROL.

(a) General Requirements. The Contractor shall be responsible for performing all process control and quality control sampling and testing and operate in accordance with an approved QC plan. Prior to performing any CCPR production, the Engineer or the Contractor may request a pre-recycle conference to discuss the recycling schedule.

The Contractor shall sample, test, and evaluate the CCPR process in accordance with the procedures and minimum frequencies specified in Table 415.05A.

TABLE 415.05A – MINIMUM QUALITY CONTROL FREQUENCIES

Test or Action	Frequency	Test Method
Density	1 per 1,000 feet per lane	*AASHTO T 355* or *ASTM D2950*
Air temperature	4 per day at even intervals	Verified thermometer
Surface temperature	At beginning and end of each day's operation	Verified thermometer
Yield for cement and emulsion	2 per day at even intervals	Tank check
RAP moisture	1 per day	*AASHTO T 217* or *AASHTO T 255*
Aggregate moisture	1 per day	*AASHTO T 217* or *AASHTO T 255*
In-place moisture content	3 per day	*AASHTO T 217*, *AASHTO T 255*, *AASHTO T 310*, or *ASTM D7830*
Gradation and asphalt content of final product	1 per day	*AASHTO T 30* (dry), *AASHTO T 164*, or *AASHTO T 308*

Density testing shall be the average of three points across the lane (transverse) for each testing location.

Gradation failures shall require the Contractor to take action to adjust the process to achieve compliant material. Additional virgin aggregate added to correct gradation shall meet the requirements of Subsection 704.10(a) and Subsection 704.10(b), except that sand equivalent is not required.

Quality control records shall include all sampling events, testing events, and process changes with accurate time and location data. The Contractor shall submit QC records and summaries to the Engineer by 1:00 p.m. on the next working day. The Contractor shall make all test results, including randomly sampled densities, available to the Engineer onsite and on request.

The Contractor shall cease recycling operations whenever one of the following occurs:

(1) The computed yield of each additive differs from the approved JMF by 10% or more.

(2) The Contractor fails to follow the approved QC plan.

(3) The finished product is visually segregated, unstable, or otherwise defective, as determined by the Engineer.

Recycling operations shall not resume until the Contactor and the Agency agree on the corrective action to be taken.

(b) Quality Control Plan. The Contractor shall submit a quality control plan (QC plan) to the Engineer a minimum of 14 calendar days prior to initiating CCPR operations and shall not commence CCPR operations until the QC plan is accepted by the Engineer.

The QC plan shall address any items that affect the quality of the recycling process including, but not limited to, the following:

(1) QC Plan Administrator. The QC plan administrator shall be identified in the QC plan and shall list their past experience on CCPR projects. They shall:

a. Be a full-time employee of the Contractor or an independent consultant not involved with the acceptance activities of the project.

b. Have a minimum of four years of experience in quality control activities in construction operations.

c. Have full authority to institute actions necessary for successful implementation of the QC plan.

(2) Quality Control Technician. The quality control technicians (QCT) shall be responsible for conducting quality control and inspection activities to implement the QC plan. There may be more than one QCT on a project. They shall:

a. Be a full-time employee of the Contractor or an independent consultant with a minimum of two years of experience in quality control activities in field construction operations.

b. Have completed the requirements for the applicable testing by the Northeast Transportation Training and Certification Program (NETTCP) for Soils and Aggregate Inspector, or an equivalent regional program.

c. Have full authority to institute actions necessary for successful implementation of the QC plan.

(3) Recycling Supervisor. The recycling supervisor shall be responsible for conducting controlling the recycling process, quality control and inspection activities at the mixing plant to implement the QC plan. They shall:

a. Be a full-time employee of the Contractor or an independent consultant with a minimum of two years of experience in quality control activities in field construction operations.

b. Have full authority to institute actions necessary for successful implementation of the QC plan.

(4) Minimum Quality Control Parameters. Minimum quality control parameters are:

a. Methods to adhere to the JMF.

b. Mixing details, pugmill type, production rates, and material processing.

c. Make and type of pavers.

d. Make, type, of rollers, and their respective location within the paving train.

e. Process control testing and quality control testing. Daily QC testing results shall be submitted to the Engineer as requested and copies of all project QC testing shall be submitted on such dates that a biweekly estimate from the Agency is intended to be processed.

f. Transportation, including the process for ensuring that truck bodies are clean and free of debris or contamination that could adversely affect the finished product, and the type of release agent used (if required).

g. Laydown operations, including procedures for mix design modification, avoiding recycling and curing in inclement weather, avoiding damage from haul trucks, material yield monitoring, methods to ensure that segregation is minimized, longitudinal joint construction, procedures to determine the maximum rolling and placing speeds based on field quality control, and achieving the best possible smoothness.

h. Methods for protecting the finished product from damage and procedures for any necessary corrective action.

i. Methods of grade checks.

j. Examples of QC plan and logbook forms.

k. Methods for calibration or verification of density gauge.

l. Stockpile management procedures.

(c) Control Section. Control sections shall be constructed to establish the TMD at the beginning of the CCPR, and through the project as needed.

The Contractor shall construct a control section to assure the Engineer that the Contractor's equipment and procedures are suitable for the work specified and establish the target maximum density and moisture content. The rolling pattern shall be determined from buildup, when the density readings show an increase in dry density of less than 1 pcf for the final four roller passes of each roller.

The average of a minimum of 10 tests taken throughout the control section after the buildup is complete shall be used to determine the TMD. If agency personnel are available, their values shall be included in the average, or used to establish the density gauge offsets, as directed by the Engineer.

The control section shall be full lane width and a minimum of 500 feet long, or as approved by the Engineer. No further recycling shall be performed until all aspects of the control section and the TMD are approved by the Engineer. The Contractor shall use the same equipment for building both the accepted test sections and performing the CCPR work on the project unless equipment substitution is approved by the Engineer.

The Engineer may require an additional test section and additional process control sampling to investigate the suitability of substituted or changed equipment.

If the control section does not meet the requirements of this specification, or the target density is not determined from buildup testing, then the Contractor shall modify the procedure and either construct another test section or reconstruct the original test section until suitable results are obtained.

415.06 METHOD OF MEASUREMENT. The quantity of Cold Central Plant Recycling of the depth specified to be measured for payment will be the number of square yards of existing pavement which has been recycled in an acceptable manner as determined by actual surface measurements of the lengths and widths of the recycled area as shown on the Plans or as directed by the Engineer. No additional compensation will be made for overlapping areas.

The quantity of Aggregate for CCPR to be measured for payment will be the number of tons used in the complete and accepted work.

The quantity of Portland Cement for CCPR to be measured for payment will be the number of tons of material in place in the complete and accepted work, as determined from the load tickets or other method as approved by the Engineer.

The quantity of Emulsified Asphalt for CCPR and Foamed Asphalt for CCPR to be measured for payment will be the number of hundredweight used in the completed and accepted work.

415.07 BASIS OF PAYMENT. The accepted quantity of Cold Central Plant Recycling of the depth specified will be paid for at the Contract unit price per square yard. Payment will be full compensation for performing the work specified and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work. Any additional RAP material, not generated from the project, required to meet the project volume of Cold Central Plant Recycling will not be paid for separately but will be considered incidental to Cold Central Plant Recycling.

The accepted quantity of Aggregate for CCPR will be paid for at the Contract unit price per ton. Payment will be full compensation for furnishing and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment for the furnishing of emulsified asphalt fog seal will be made under the appropriate Section 404 pay item in the Contract.

The accepted quantity of Portland Cement for CCPR will be paid for at the Contract unit price per ton. Payment will be full compensation for furnishing and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Emulsified Asphalt for CCPR and Foamed Asphalt for CCPR will be paid for at the Contract unit price per hundredweight for the specified material applied. Payment will be full compensation for furnishing, transporting, and placing the material and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
415.0200	Cold Central Plant Recycling, 2 Inch Depth	Square Yard
415.0250	Cold Central Plant Recycling, 2.5 Inch Depth	Square Yard
415.0300	Cold Central Plant Recycling, 3 Inch Depth	Square Yard
415.0350	Cold Central Plant Recycling, 3.5 Inch Depth	Square Yard
415.0400	Cold Central Plant Recycling, 4 Inch Depth	Square Yard
415.0450	Cold Central Plant Recycling, 4.5 Inch Depth	Square Yard
415.0500	Cold Central Plant Recycling, 5 Inch Depth	Square Yard
415.5100	Aggregate for CCPR	Ton
415.5200	Portland Cement for CCPR	Ton
415.5300	Emulsified Asphalt for CCPR	Hundredweight
415.5400	Foamed Asphalt for CCPR	Hundredweight

SECTION 417 – BITUMINOUS CRACK SEALING

417.01 DESCRIPTION. This work shall consist of furnishing and placing crack-sealing material in the cracks of existing bituminous concrete pavement.

417.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Joint Sealer, Hot Poured .....707.02(a)

The Contractor shall provide the Engineer with a copy of the material manufacturer's recommendations pertaining to heating, application, and reheating prior to the beginning of operations or the changing of materials.

417.03 EQUIPMENT. Equipment shall meet the approval of the Engineer and shall always be maintained in working condition.

(a) Air Compressor. Air compressors shall be portable and capable of furnishing at least 100 cubic feet of air per minute with a minimum pressure of 90 psi at the nozzle. The compressor shall be equipped with traps that will keep the compressed air free of any oil or water.

(b) Hand Tools. Hand tools shall consist of brooms, shovels, metal bars with chisel-shaped ends, squeegees, and any other tools which may be required to accomplish the work.

(c) Melting Kettle. The melting kettle shall be a double boiler, indirect-fired portable type. The space between the inner and outer shells shall be filled with a suitable heat transfer oil or substitute having a flash point of not less than 531°F. The kettle shall be equipped with a satisfactory means of agitating the joint sealer. This may be accomplished by continuous stirring with mechanically operated paddles or by a continuous circulating gear pump attached to the heating unit.

The melting kettle shall be equipped with a thermostatic control calibrated between 200°F and 550°F. The kettle shall be mounted on rubber tires and be equipped with a metal shield beneath the firebox to protect the pavement.

(d) Application Wand. The application wand shall apply a controlled flow of material via an insulated or heated hose. The nozzle shall distribute the material as called for on the Plans or this specification. The Contractor shall backflush the hose and applicator wand any time the application of sealant has been delayed for a period greater than 15 minutes. A pressure regulator shall be provided to regulate pressure at the nozzle. A bypass line into the holding tank is required for use when the nozzle is shut off.

(e) Router. Equipment for preparing cracks shall be a rotary-impact type cutter or a diamond-blade crack saw which will provide a reservoir of the dimensions specified on the Plans.

(f) Hot-Air Lance. Equipment for blowing clean and drying cracks and joints shall be a propane gas and compressed air burner operating at a temperature of 3,000°F and at a velocity of 3,000 feet per second.

417.04 TEMPERATURE LIMITATIONS. The ambient air temperature shall be in the range of 40°F to 104°F, inclusive, and the pavement temperature shall be in the range of 50°F to 140°F, inclusive. The relative humidity shall be less than 80%. The Contractor shall provide the Engineer with a sling psychrometer to measure the humidity.

When it is in the public interest, the Engineer may adjust the specified temperature or humidity requirements.

417.05 PREPARATION.

(a) General Requirements. Care shall be taken in the preparation of all cracks to receive sealant material. All cracks shall be clean, dry, and heated to ensure optimal bonding of the sealant material to the existing pavement.

(b) Bituminous Crack Sealing. All routed cracks shall be filled with sealant on the same work day as directed by the Engineer.

Cracks of 1/8 inch to 3/4 inch in width shall be shaped into a square cross-section of approximately 3/4 inch in width by 3/4 inch in depth using a router or crack saw. All cracks to be sealed shall be routed or saw-cut. All material removed from the cracks shall be immediately removed from the pavement. Cracks greater than 3/4 inch in width shall only be prepared and sealed at the direction of the Engineer.

Following crack routing or saw-cutting, the entire pavement area shall be cleaned using a power broom or blower device. Special care must be exercised in urban areas to ensure that the pavement area is cleaned after the crack sealing operation and to minimize the creation of dust in the cleaning process. Immediately prior to the application of the sealer material, all cracks shall be cleared of loose pavement, vegetation, sand, dust, and any other debris using the hot-air lance.

The full length of the cracks shall be heated with the hot-air lance to improve bonding of the sealant and pavement. Care shall be taken not to burn or char the pavement. Any charred pavement shall be cut out and removed and the crack prepared and resealed.

Areas of high density cracking indicating a structural failure should not be prepared for sealing as directed by the Engineer.

(c) Bituminous Crack Sealing, "Blow and Go" Method. Bituminous crack sealing using the "blow and go" method shall be performed in accordance with Subsection 417.05(b), with the exception that no routing or saw-cutting will be required prior to cleaning and sealing the crack.

417.06 PLACING OF SEALER. The joint sealer material shall be heated and applied at the temperature specified by the manufacturer and approved by the Engineer. Any material that has been heated above the manufacturer's specification shall not be used. Material that is reheated or held at temperature for an extended period of time may be used as allowed by the manufacturer's specification and approved by the Engineer.

The Contractor shall provide the Engineer with a suitable device for verifying the sealant temperature in the kettle and at the application site. The sealant application temperature shall not be lowered below the manufacturer's recommended temperature to address pooling problems at the end of the rout. This problem shall be addressed by using sealant material with appropriate flow characteristics to prevent pooling.

All routed cracks shall be fully filled with joint sealer material. A strike-off device may be used to facilitate placement of the material provided it has a maximum width of 1-1/2 inches. The distance between the applicator and the strike-off device should be less than three feet, but in no case shall it be greater than six feet.

The joint sealer material shall be struck off such that only a thin film band 1/16 inch thick or less is left on the pavement. Optimally, the pavement aggregate should be visible through the thin film band.

Any over application or spills shall be removed to the satisfaction of the Engineer. Any sealed areas with damaged or contaminated sealer or visible voids shall be removed, prepared, and resealed. Any filled areas that have sunk below the surface more than 1/16 inch shall be repaired by applying additional material.

The sealant material shall be applied while the cracks or joints are still hot from the hot-air lance preparation. The time delay between the hot air lance treatment and the application of the sealant should be less than two minutes, but in no case greater than five minutes. Any loose material on the surface or in the crack that may contaminate the joint sealer or impede bonding of the sealant to the pavement is to be removed by hand tools prior to crack sealing. No crack sealing material shall be applied in a crack that is wet or where frost, snow, or ice is present.

No vehicles or equipment should be allowed on the newly placed sealant material until it has cooled as specified by the manufacturer. If the pavement must be reopened to traffic prior to air cooling, the cooling process may be accelerated with water or other coolant as specified by the manufacturer and approved by the Engineer. As a last resort, sealant may be protected against tire pick-up by dusting with fine sand, mineral dust, or similar material as approved by the Engineer.

Any procedure used to accelerate cooling time must be approved by the Engineer and follow the manufacturer's application specifications.

417.07 METHOD OF MEASUREMENT. The quantities of Bituminous Crack Sealing and Bituminous Crack Sealing, "Blow and Go" Method to be measured for payment will be the number of pounds of joint sealer complete and in-place in the accepted work.

417.08 BASIS OF PAYMENT. The accepted quantities of Bituminous Crack Sealing and Bituminous Crack Sealing, "Blow and Go" Method will be paid for at the Contract unit price per pound. Payment shall be full compensation for handling and placing the sealant material, including the cleaning and preparation of cracks, the removal and disposal of all bituminous grindings, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Costs for all material and labor for dusting or cooling shall not be paid for directly but shall be considered incidental to the applicable crack sealing pay item.

Payment will be made under:

Pay Item	Pay Unit
417.1000 Bituminous Crack Sealing	Pound
417.2000 Bituminous Crack Sealing, "Blow and Go" Method	Pound

SECTION 418 – ASPHALTIC APPROACH MATERIAL

418.01 DESCRIPTION. This work shall consist of furnishing and installing asphaltic approach material at the transition between bituminous concrete pavement and Portland cement concrete, steel, or other materials.

418.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Asphaltic Plug Joint Binder 707.15

418.03 INSTALLATION. Asphaltic approach material shall be installed at the locations and to the depth and configuration shown in the Plans and as directed by the Engineer.

418.04 METHOD OF MEASUREMENT. The quantity of Asphaltic Approach Material to be measured for payment will be the number of square feet used in the complete and accepted work.

418.05 BASIS OF PAYMENT. The accepted quantity of Asphaltic Approach Material will be paid for at the Contract unit price per square foot. Payment will be full compensation for detailing, furnishing, handling, transporting, and placing the material specified, including surface preparation, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Tack, prime, or seal coats of bituminous material required for the installation of asphaltic approach material will not be paid for separately but will be considered incidental to the Contract unit price for Asphaltic Approach Material.

Removal of any existing asphaltic, bituminous, or Portland cement concrete materials to allow for the installation of asphaltic approach material will not be paid for separately but will be considered incidental to the Contract unit price for Asphaltic Approach Material.

Payment will be made under:

Pay Item	Pay Unit
418.1000 Asphaltic Approach Material	Square Foot

DIVISION 500

STRUCTURES

SECTION 501 – PERFORMANCE-BASED STRUCTURAL CONCRETE

501.01 DESCRIPTION. This work shall consist of designing, furnishing, and placing performance-based Portland cement concrete for structures and incidental construction.

The Portland cement concrete may consist of a homogeneous mixture of cement, fine aggregate, coarse aggregate, water, admixtures, and pozzolans, proportioned and mixed according to these specifications.

501.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Normal weight coarse aggregate for superstructures shall be conditioned so that the total moisture percentage shall be the absorption percentage plus, at a minimum, 0.25% free moisture for the aggregate.

501.03 CLASSIFICATION AND PROPORTIONING. Concrete shall meet the requirements specified in Table 501.03A and shall be used as shown on the Plans.

TABLE 501.03A – PERFORMANCE-BASED CONCRETE CLASSES AND PROPERTIES

Concrete Class [1]	Min. 56-Day Comp. Strength (psi) [2]	Max. W/CM Ratio [3]	Max. VSI [4]	Slump/ Spread Limit	Freeze/Thaw Durability [5]		Air Content Limits [6]	Max. Free Shrinkage	Max. 56-Day Surface Resistivity [7]
					Min. Durability Factor	Max. Air Void Spacing Factor (in.)			
PCD	4,000	TBD	--	N/A [8]	80	0.008	TBD	0.032%	Low
PCS	3,500	TBD	--	N/A [8]	80	0.008	TBD	0.042%	Low
SCC	4,000	TBD	1	TBD [9]	80	0.008	TBD	TBD [10]	Low

[1] PCD = Performance Concrete, Deck

PCS = Performance Concrete, Substructure

SCC = Self-Consolidating Concrete

[2] The concrete may be accepted if the design compressive strength from standard cured cylinders has been obtained at 28 days. Any 56 day acceptance cylinders shall be tested regardless of the results of earlier tests.

[3] The maximum W/CM ratio shall be determined by the Contractor as established by mix qualification testing. During production, the W/CM ratio shall be less than or equal to the W/CM ratio from the approved qualification mix. See Subsection 501.03(b). The W/CM ratio shall be rounded to two decimal places in accordance with *ASTM E29*.

[4] Visual stability index (VSI) as determined in accordance with *ASTM C1611*.

[5] The freeze/thaw durability of the proposed mix design may be established by providing mix qualification testing demonstrating conformance with either of the two requirements. Testing shall meet the requirements of either *AASHTO T 161, Procedure A*, or *ASTM C457*, as applicable. See Subsection 501.03(b)(2).

[6] The minimum air content shall be determined by the Contractor as established by mix qualification testing. During production, the air content shall be greater than or equal to the air content from the approved qualification mix. See Subsection 501.03(b)(2).

[7] The Contractor shall determine the surface resistivity in accordance with Subsection 501.03(b)(4).

[8] The mix shall not exhibit segregation. If the mix does exhibit segregation, the load shall be rejected. If the spread is equal to or exceeds 20 inches, the mix shall be classified as Class SCC concrete.

[9] The Contractor shall determine the spread limits in accordance with Subsection 501.03(b)(5). The spread shall be maintained within the determined spread limits for the placement. The mix shall not exhibit segregation. If the mix does exhibit segregation or exceeds the upper spread limit, the load shall be rejected. and subsequent loads shall be tested by the Contractor until the mix meets the allowable limits. The Engineer may perform a J-ring test at the time of placement if blocking is a concern.

[10] The Contractor shall determine the free shrinkage in accordance with Subsection 501.03(b)(1). Class SCC concrete will be allowed for use in superstructure elements if the free shrinkage meets the requirements for Class PCD. Class SCC concrete will be allowed for use in substructure elements if the free shrinkage meets the requirements for Class PCS.

If a nominal maximum aggregate size is not specified, the Contractor shall determine the nominal maximum aggregate size using guidance from *ACI 211.1*. In no case shall the maximum aggregate size exceed 1/5 of the narrowest dimension between sides of the forms, 1/3 the depth of slabs, or 3/4 of the minimum clear spacing between individual reinforcing bars, bundles of bars, or pre-tensioning strands unless approved by the Engineer.

The Contractor may use industry methods to develop gradations not specified in Section 704 that are better optimized to satisfy the required concrete performance characteristics. If the Contractor is using a combined gradation, they shall provide the method or methods of how they will monitor gradation, the limits of the gradation ranges, and the frequency of monitoring.

Lightweight fine aggregate may be used to replace up to 30% of the volume of normal weight sand. The gradation of the lightweight fine aggregate shall conform to the requirements of *AASHTO M 195*. The lightweight fine aggregate shall be conditioned for enough time to fully saturate the material.

The stockpile shall be constructed so that the moisture content is uniform throughout the pile. The stockpile will be allowed to drain 12 hours to 15 hours immediately prior to use, unless an alternate procedure is approved by the Structural Concrete Engineer. The Contractor shall state the method, duration and procedure used to confirm that the material is at or above its saturated surface dry (SSD) value, by weight, throughout the pile.

The use of chlorides or admixtures containing chlorides is prohibited. All admixtures will be considered incidental to the work and included in the Contract unit price of the concrete.

The concrete materials may be proportioned using the absolute volumes method in accordance with the specified requirements. The volumetric proportioning method, such as that outlined in *ACI 211.1* or other approved volumetric proportioning methods, shall be employed in the mix design.

Prior to placing concrete on the project (or prior to the trial pour or the pre-placement meeting, whichever occurs first), the Contractor shall submit for approval the single mix design formula that satisfies all mix design qualification requirements and testing for the class of concrete specified. The mix designs shall be submitted to the Structural Concrete Engineer at the Agency's Materials Testing and Certification Section Central Laboratory. The Structural Concrete Engineer may require a minimum of 8 weeks for testing, review, and approval of new mix designs. No class of concrete shall be placed on a project, including the trial pour, until the mix design is approved.

If the proposed performance concrete mix design fails to meet the qualification requirements, the Contractor shall submit a revised mix design formula in writing to address the mix qualification deficiencies of the original failed mix design.

Review of the revised mix design formula by the Structural Concrete Engineer will be completed within 14 calendar days. Upon approval of the revised mix design formula by the Structural Concrete Engineer, testing of the revised mix design may commence. Testing of the revised mix design formula shall be completed within 6 months of the revised mix design formula approval.

Until the testing of the revised mix design formula is completed and approved, the Structural Concrete Engineer will specify the use of an alternative, prescriptive mix design formula for the application in question, including appropriate acceptance requirements for the prescriptive alternative mix.

(a) Mix Design Information. The mix design shall contain the following information:

(1) Class of concrete.

(2) Type of mix, conventional or self-consolidating concrete (SCC).

(3) Saturated surface dry or dry weights (specify which).

(4) Aggregate types, sources, specific gravities, and absorption values.

(5) 56 day design compressive strength, psi.

(6) Cementitious content and the amount of each, pounds per cubic yard.

(7) Air content lower limit, percent.

(8) 56 day surface resistivity value.

(9) Determined spread lower limit and upper limit for SCC.

(10) Maximum water/cementitious materials (W/CM) ratio.

(11) Volumetric quantities of each material in the mix design.

(12) Design unit weight of the mix.

(13) Chemical admixture types, brand names, and dosages.

Concrete test mixes shall be used to obtain the test results where applicable. All wet testing shall be done by personnel with current ACI Concrete Field Testing Technician Grade I certifications. All other tests shall be performed by a laboratory that is accredited by AASHTO re:source or the Concrete and Cement Reference Laboratory (CCRL) in the particular test method, or as allowed by the Engineer. All test reports pertaining to the qualification testing shall be date traceable to concrete test batches whether produced at a concrete producer's facility or an independent laboratory facility. All qualification batches shall have weight tickets and fresh concrete property test results included.

(b) Mix Qualification Tests. The following mix qualification tests shall be performed. Sampling shall be performed in accordance with *AASHTO R 60* on a qualification batch of concrete that is a minimum of 3 cubic yards. Specimens for tests to determine freeze-thaw durability, strength, surface resistivity, and SCC spread limits shall be made from the qualification batch. The qualification batch shall also be tested for air content (*AASHTO T 152*), concrete temperature (*ASTM C1064*), and unit weight *(AASHTO T 121)*. The air content value and the water/ cementitious materials ratio of the material used to pass the mix qualification tests shall become the minimum air content value and the maximum water/cementitious materials ratio allowed during production.

The free shrinkage specimens may be obtained from the qualification batch, except the Contractor will be required to submit a plan on how they will comply with *AASHTO T 160, Section 10*, which shall be approved by the Structural Concrete Engineer prior to the beginning of qualification testing.

(1) The Contractor shall provide test results that establish the shrinkage tendency of the concrete. The free shrinkage rate of the concrete shall be tested per the requirements of *AASHTO T 160*. The cross-section of the prism shall be 4 inches × 4 inches. The requirements of *AASHTO T 160, Section 11.1.2* shall be followed for storage and measurements, and all specified test age results shall be submitted. Specimen testing may be terminated after 28 days of drying.

Testing shall be performed by a laboratory accredited in the specific test method. Concrete produced by the testing laboratory to make the specimens shall have an air content equal to the Contractors proposed minimum air content with a tolerance of + 1%. The air content value from laboratory produced concrete used for this testing will not be considered in determination of the minimum air content value allowed during production.

(2) The Contractor shall provide test results that establish the freeze-thaw durability of the concrete. At the Contractor's choice, either *AASHTO T 161* or *ASTM C457* may be used to demonstrate freeze/thaw durability meeting the specification requirements.

The durability factor shall be tested in accordance with *AASHTO T 161, Procedure A.*

The air void spacing factor shall be tested in accordance with *ASTM C457*. The Contractor shall make a minimum of two concrete cylinders per *AASHTO R 100* and report the average air-void spacing factor obtained from testing these two specimens. The cylinders shall be cured for a minimum of 5 days prior to being tested according to the requirements of *ASTM C457*.

The air content of the qualification batch that passes the chosen freeze-thaw durability testing shall become the minimum air content allowed in production. This shall also become the minimum air content allowed for all subsequent mix qualification testing, unless otherwise stated.

(3) The compressive strength of the concrete shall be measured based on the requirements of *AASHTO T 22* for 28 day and 56 day standard cured cylinders.

(4) The surface resistivity of the test mix shall be measured at 56 days based on the requirements of *AASHTO T 358*. Results shall be categorized as Low, Very Low, or Negligible in accordance with *AASHTO T 358, Table 1*. The surface resistivity may be accepted prior to 56 days if the results meet these requirements. The 56 day test results shall be completed and submitted regardless of the results of earlier tests.

(5) The Contractor shall determine the lower and upper spread limit for Class SCC concrete. *ASTM C1621* shall be performed at the proposed upper and lower spread limits. Each spread limit shall not exceed a blocking assessment of "Minimal to Noticeable Blocking". The slump cone shall be filled in accordance with *ASTM C1621, Procedure B.* At both the upper and lower limits, the visual stability index (VSI) shall not be greater than 1.

(c) Alkali-Silica Reactivity. The alkali-silica reactivity (ASR) of each type of aggregate shall be measured separately based on the requirements of *AASHTO T 303* or *ASTM C1260*. If one or more of the aggregates exceeds 0.10% expansion, then the aggregate shall be tested again according to the requirements of *ASTM C1567* or *CRD-C 662*.

The Contractor may elect to go directly to *ASTM C1567*, or *CRD-C 662* if using lithium nitrate, if they suspect that the aggregate may exceed the 0.10% expansion if tested by *AASHTO T 303* or *ASTM C1260*.

If a lithium nitrate admixture will be used, no matter the cementitious materials combination, each aggregate will be tested by *CRD-C 662*. *CRD-C 662, Section 9* shall be replaced using *ASTM C1567, Section 9*.

The aggregates shall not exceed 0.10% expansion when tested by any of the four allowable test methods.

Testing shall be performed by a laboratory accredited in the *ASTM C1260*, *ASTM C1567*, or *AASHTO T303* test method.

Test results shall be submitted with the mix design.

(d) Mix Design Approval and Changes. After the mix design furnished by the Contractor has been reviewed and approved by the Structural Concrete Engineer, no changes to the mix design shall be allowed except as defined in Table 501.03B. Following an approved change in accordance with Table 501.03B, the Contractor may still revert to the original approved mix design formulation. If a source change is requested due to a change in product or material name that does not include any significant change in product formulation or material characteristic, and this is substantiated by the product or material supplier in writing, re-testing is not required.

TABLE 501.03B – ALLOWABLE MIX DESIGN CHANGES FOR ALL MIX TYPES

Previously Approved Component or Property Being Changed	Mix Design Resubmittal Requirements [1]	No. of Changes Allowed
Cement source	If the alkali content (Na and K) of the new source is greater than that of the original source, and the original result from Subsection 501.03(c) was greater than 0.08% expansion, then updated ASR testing is required. Otherwise, no qualification testing is required.	Unlimited
Cement proportioning (± 5% by volume)	No qualification testing required	One
Aggregate proportioning (± 10% by volume)	No qualification testing required	One
Aggregate source	ASR testing and gradation check by original Contractor method	One
Slag source	If same grade is used, no qualification testing required	Unlimited
Silica fume source	No qualification testing required	Unlimited
Fly ash source	If either the calcium (CaO) or the alkali (Na and K) content of the new source is greater than that of the original source, and the original result from Subsection 501.03(c) was greater than 0.08% expansion, then updated ASR testing is required. Otherwise, no qualification testing is required.	Unlimited
Air-entraining admixture source (Subsection 725.02(b))	Resubmittal of freeze/thaw durability qualification testing	Unlimited
Shrinkage reducing admixture source (Subsection 725.02(k))	Resubmittal of shrinkage qualification testing	Unlimited
Corrosion inhibiting admixture source (Subsection 725.02(k))	Resubmittal of shrinkage qualification testing. If shrinkage qualification testing of the original mix design is greater than 70% of shrinkage limit, then updated shrinkage testing is required.	Unlimited
Latex admixture source (Subsection 725.02(d))	Resubmittal of surface resistivity testing	Unlimited
Accelerating admixture dosage increase (Subsection 725.02(i), Subsection 725.02(j))	Resubmittal of shrinkage qualification testing	Unlimited
Accelerating admixture source (Subsection 725.02(i), Subsection 725.02(j))	No qualification testing required	Unlimited
ASR mitigating admixture source and dosage decrease (Subsection 725.02(k))	Resubmittal of ASR qualification testing	Unlimited
All other admixture source and dosage changes (Subsection 725.02)	No qualification testing required	Unlimited

[1] All changes will require administrative submittal to establish proposed changes. Where required, resubmittal testing shall be completed using the same material sources and proportions from the original approved mix design.

No new materials shall be incorporated without prior written approval of the Engineer. In no case shall concrete from more than one mix design be permitted to be used during the same pour without prior written approval of the Engineer.

The approved mix design will be allowed consecutive re-approval if no material proportioning or material sources have changed from the previous year's approved mix design and the mix design is submitted with updated aggregate properties and volumes adjusted accordingly. The aggregate properties shall be tested annually. Aggregate property values will be valid for 14 months from the date tested. The properties to be tested include, but are not limited to, specific gravity and absorption.

The mix design shall be accompanied by the previously completed and accepted mix qualification test data and any applicable updated test information. The submittal shall also include all applicable quality control test results and all requests for variance from the material requirements of these specifications.

501.04 BATCHING.

(a) General Requirements. Measuring and batching of materials shall be performed at an approved batch plant. Batch plants shall have an inspection completed prior to the first concrete placement on an Agency project if it has been more than 12 calendar months since the last inspection. Requests for inspection and required documentation shall be received by the Agency's Materials Testing and Certification Section a minimum of 21 calendar days prior to the date of the requested inspection.

All deficiencies shall be corrected and verified a minimum of 5 calendar days prior to the first concrete placement for any Agency project. The batch plant shall meet the requirements of *AASHTO M 157*, except as modified in these specifications, and shall always be maintained in good repair. The batch plant shall be subject to periodic inspections by authorized representatives of the Agency. The batch plant shall have approved methods of storing, measuring, and dispensing approved admixtures.

All concrete batch plants offered for Agency approval shall be equipped for semi-automatic batching and proportioning of all cementitious material, aggregates, water, and for the automatic insertion of admixtures. The plants shall be equipped to automatically and accurately record and report batch weights.

Proper facilities shall be provided for the Engineer to inspect ingredients and processes used in the batching and delivery of the concrete. The Contractor shall, without charge, afford the Engineer all reasonable facilities for securing samples to determine whether the concrete is being furnished in accordance with these specifications. In the batch room area, the producer shall provide the inspector with a 24 inch × 18 inch horizontal working surface, at a sufficient working height, with a seat and an adequate view of the batching controls, display, and power supply.

The Contractor shall give the Engineer 24-hours' notice of intent to place concrete. Failure to give notice which causes postponement of placing operations shall not be reason for determining an extension of Contract time per the requirements of Subsection 108.11.

(b) Batch Weight Tickets. Batch weight tickets shall include the following information:

(1) Approved mix design identification number

(2) Weight of all aggregates

(3) Weight of cementitious material

(4) Quantity of admixtures by type

(5) Quantity of water batched

(6) Aggregate moistures

(7) Total water to cementitious ratio

Materials on the batch weight ticket shall be identified by type. All batch weight ticket information shall be provided in English units. All materials added to the concrete batch shall be added to the batch weight ticket prior to delivery.

(c) Semiautomatic Batch Plants. When actuated by a starting mechanism, the semiautomatic batch controller shall start the weighing operation of the materials and stop the flow automatically when the designated weight has been reached. It shall be interlocked to ensure that the discharge mechanism cannot be opened until the weight is within the tolerance specified in Subsection 501.04(f).

Water and admixtures may be batched in a weigh batcher or by volume in a volumetric device. When actuated, volumetric controls shall start the measuring operation and stop the flow automatically when the designated volume has been reached.

(d) Testing Laboratory. The Contractor shall provide a weatherproof building or room at the plant site for the use of Agency personnel as a testing laboratory. The Contractor shall attain and maintain a qualified laboratory status in accordance with the current edition of the Agency's *Qualified Laboratory Program*. Failure to comply with this program may result in suspension of material production for Agency projects.

The testing laboratory shall have a minimum gross internal area of 150 square feet with a layout providing a minimum internal width of 7 feet, in which to house and use the equipment specified. Should the Contractor elect to provide additional equipment relevant to testing of Portland cement concrete and materials, the gross inside floor area of the laboratory shall be increased in proportion to the area required to house and operate the additional equipment. If the additional equipment is to be operated on a bench, the length of bench sections shall also be proportionally increased.

Adequate ventilation, lighting, heating, and any necessary electrical or gas connections shall be provided. Proper sanitary toilet facilities with a lavatory shall be available for use by Agency personnel at the plant site. Dedicated private telephone and internet services shall be provided to the laboratory in accordance with Subsection 631.02(a)(4), except that selection of the service by the Engineer is not required.

The laboratory shall be equipped with the following items and equipment:

1 Standard office desk, with lockable drawers or a separate lockable two-drawer file cabinet and chair

1 Agency *Qualified Laboratory Binder* with producer equipment calibration data

1 Set of bench sections at least 2 feet wide providing a minimum of 28 square feet of working area with under-counter shelving

1 Standard laboratory stool

1 Electronic calculator with eight digit capacity

1 Standard laboratory sink and faucet provided with an adequate supply of water meeting the requirements of Subsection 745.01. The sink shall drain to the outside of the laboratory.

1 Bench brush

1 Floor brush

1 Motorized 8-inch sieve shaker with an adjustable timer. The shaker's operation shall be conducted by means of lateral and vertical motion of the sieve accompanied by jarring action with the following 8-inch diameter sieves: 3/8 inch (9.50 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (0.600 mm), No. 50 (0.300 mm), No. 100 (0.150 mm), plus pan and cover.

1 Mechanical aggregate shaker with an adjustable timer, a 1 cubic foot capacity, together with the following screens: 1-3/4 inch (43.0 mm), 1-1/2 inch (37.5 mm), 1 inch (25. 0 mm), 3/4 inch (19.0 mm), 1/2 inch (12.5 mm), 3/8 inch (9.50 mm), 1/4 inch (6.30 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), and pan. The aggregate shaker may be placed in a separate enclosed area or be shielded for dust and sound control. When the aggregate shaker is placed in a separate enclosed area, there shall be a minimum of 5 feet of clear space measured from the front frame of the aggregate shaker outward, as well as a bench section measuring approximately 36 inches high, 24 inches deep, and 50 inches long located adjacent to the aggregate shaker. The area shall be well lit and ventilated.

1 Square pointed shovel

5 Five gallon plastic buckets, with handles

1 Electronic balance with a minimum capacity of 50 pounds and accurate to 0.0002 pounds. If separate fine and coarse aggregate scales are to be used, the fine aggregate scale shall meet the requirements of *AASHTO M 231, Table 2*, Class G2 with a minimum capacity of 1.75 pounds and readable to 0.0002 pounds. The coarse aggregate scale shall meet the requirements of *AASHTO M 231, Table 2*, Class G5 with a minimum capacity of 50 pounds and readable to 0.002 pounds.

1 Set of standard masses (weights) to use for verifying the accuracy of the electronic balance

2 Double-burner hot plates with variable temperature controls

3 Metal pans with a nominal size of 9 inches × 9 inches × 2 inches

5 Metal pans with a nominal size of 9 inches × 13 inches × 2 inches

1 Sample splitter with a 2-1/2-inch chute

1 10-inch blunted trowel

1 4 foot × 4 foot minimum heavy canvas for quartering samples

1 Brass wire-bristle brush

1 Pair of heat-resistant gloves (500°F, short-contact)

2 1-1/2 inch soft bristle paint brushes

Acceptable substitutes for these items and equipment may be made with the approval of the Structural Concrete Engineer.

Batching operations shall not begin until the testing laboratory has been approved as being in compliance with these specifications and all equipment and equipment calibration requirements of the Agency's *Quality Assurance Program* and *Qualified Laboratory Program* documents. Removal of any equipment, except upon written request and with the written approval of the Structural Concrete Engineer, will revoke any prior approvals or qualifications and require the termination of batching operations.

The building or room designated as a testing laboratory shall be maintained in a clean condition by the producer and kept free of all articles not necessary for the testing of materials. Cleaning supplies shall be furnished by the Contractor.

(e) Bins and Scales. The batch plant shall include bins, weighing hoppers, and scales with adequate separate compartments for fine aggregate and for each required separate size of coarse aggregate. If cement is used in bulk, a bin, hopper, and scale for cement shall be included. Each compartment shall be designed to discharge efficiently and freely into the weighing hopper or hoppers. Means of control shall be provided so that when required, the material may be added slowly in minute quantities and shut off with precision.

Hoppers shall be constructed to eliminate accumulations of tare materials and to discharge fully without jarring the scales. Partitions between compartments shall be configured to prevent spilling under any working condition. All batch plant structures shall be properly leveled and maintained in that condition within the tolerance required by the design of the weighing mechanism.

The scales for determining the mass (weight) of aggregate, water and cementitious material shall be comprised of a suitable system of levers or load cells. The levers or load cells shall determine the mass (weight) consistently within 0.5% under operating conditions, with loads indicated either by means of a beam with balance indicator, a full-reading dial, or a digital read-out or display.

Adequate means for checking the accuracy of the scales shall be provided by the Contractor either using 50 pound weights or by other methods approved by the Structural Concrete Engineer. Weights shall be certified annually by the Weights and Measures Section of the Vermont Agency of Agriculture, Food, and Markets. All exposed fulcrums, clevises, and similar working parts of scales shall be kept clean.

When beam-type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. Poises shall be designed to be locked in any position to prevent unauthorized change of position. All measuring and weighing indicating devices shall be in full view of the operator while charging the hopper and the operator shall have convenient access to all controls.

The scales shall be serviced and their accuracy verified annually by a hopper-scale service person licensed by the Weights and Measures Section. For Vermont plants, an inspector representing the Weights and Measures Section shall witness all testing conducted by the service person and will attach a seal to each hopper scale, provided it meets the current specifications, tolerances, and regulations adopted by the Weights and Measures Section. Standard test weights used to determine the accuracy of hopper scales shall be certified yearly by the Weights and Measures Section in accordance with their established standards.

The ready-mixed concrete producer shall hire a licensed hopper scale service person for annual checking and service of scales. In addition, Vermont producers shall schedule an inspection with the Weights and Measures Section between February 16th and April 30th of each year, inclusive. After April 30th, Vermont plants without current seals affixed to the hopper scales will not be permitted to supply concrete to Agency projects, unless otherwise directed by the Engineer or until the seals are affixed.

Out-of-state concrete producers shall observe all annual hopper scale weighing and seal requirements of their respective states.

(f) Production Tolerances for Batching. For weighed ingredients, the accuracy of batching is determined by a comparison between the desired weight and the actual scale reading. For volumetric measurement of water and admixtures, accuracy is determined by checking the quantity either by weight on a scale or by volume in a calibrated container.

Admixture-dispensing systems shall, at a minimum, be annually calibrated by an admixture distributor representative. The admixture distributor representative shall check at least two volumes, with a check done at approximately 15% of the minimum and at 15% of the maximum manufacturer's recommended dosage range, or other targets as approved by the Structural Concrete Engineer.

Batching shall be conducted to accurately measure the desired quantities of materials within the tolerances specified in Table 501.04A.

TABLE 501.04A – CONCRETE PRODUCTION TOLERANCES FOR BATCHING

Material	Tolerance
Cement	± 1%
Water	± 1%
Aggregates	± 2%
Chemical admixtures	± 3%
Mineral admixtures	+ 10%, - 1%

(g) Storage and Proportioning of Materials.

(1) Portland Cement. Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed.

All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be properly sealed and vented to preclude dusting during operation. Facilities shall be provided for the sampling of cement at the batch plant, either from the storage silo or from the weighing hopper. The sampling device shall provide a sample that represents the true nature of the material being used. This device shall be a permanent installation located to allow for safe and easy access.

(2) Water. Water may be measured either by volume or by weight. When measurement is by meter, the water meter shall be so located that the measurements will not be affected by variable pressures and temperatures in the water supply line.

Measuring tanks shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tanks.

All water metering methods shall be verified and calibrated on an annual basis or at any time there is a question of accuracy. All water added to the concrete at any point shall be through an approved metering method.

(3) Aggregates. Aggregate stockpiles shall be formed on hard, well-drained areas that prevent contamination from underlying material and accumulation of excessive moisture.

Aggregates from different sources or of different gradations shall not be stockpiled together. Only rubber-tired equipment shall be permitted to operate on aggregate stockpiles.

Stockpiles shall be constructed as follows:

a. If the stockpile is to be made using mechanical equipment (front end loader, clam bucket, rock ladder, radial stacker, or other approved equipment), the stockpile shall be made in such a manner that segregation is kept to a minimum.

b. If the stockpile is to be made by dumping from trucks in multiple layers, each layer shall be approximately 4 feet in depth. Each layer shall be completely in place before commencing the next layer. Care shall be taken that successive layers do not cone down over the previous layer.

c. No equipment shall be used to haul aggregate over the stockpiled material except to deposit the material for the layer being placed. It shall be the responsibility of the Contractor to ensure that the aggregate is kept free from deleterious material or degradation.

Stockpiles shall be maintained in such a manner that twice the anticipated aggregate requirement for any Agency project placements will be on hand and available for sampling and testing at least 48 hours before mixing operations for the placements are scheduled to begin. The Engineer may modify this requirement when special aggregates are required.

Aggregates shall be handled from stockpiles or other sources to the batch plant in such a manner as to secure a uniform grading of the material. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates, except lightweight coarse aggregate, produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. In case the aggregates have a high or non-uniform moisture content, a storage or stockpile period longer than 12 hours may be required by the Engineer.

Stockpiles being watered per the specifications or allowed through producer QC procedures shall be watered for a sufficient time to ensure consistent moisture throughout the stockpile. Aggregate stockpiles being watered shall be loaded in the bin within 1 hour of being batched.

The Contractor shall conduct moisture content tests within 1.5 hours of the anticipated concrete batching time. If there is a visual difference in aggregate moisture appearance, aggregate moisture content will be tested again and new moisture test results shall be obtained and used as soon as possible. Material that has been stored in a storage bin for more than 10 hours shall be retested for moisture content. A minimum of one cubic yard of aggregate will be removed from the bottom of the storage bin and discarded. A minimum of one cubic yard of aggregate will then be removed and a moisture content sample taken.

Plants that employ moisture probes shall have them calibrated and verified a minimum of 24 hours prior to batching or as directed by the Structural Concrete Engineer. The procedure for checking the meter will be to run aggregate over the probe and then collect a portion of the aggregate on which to perform a moisture content test. If the difference between the meter and the tested moisture content is greater than 0.5%, then the meter shall be calibrated.

d. Lightweight coarse aggregate stockpiles shall be presoaked for a minimum period of time to ensure that the aggregate is completely saturated surface dry or greater immediately prior to use as indicated by moisture testing. Soaking shall be accomplished by continuous sprinkling or other suitable means that will provide a uniform moisture content throughout the stockpile. The stockpile shall be allowed to drain for 12 hours to 15 hours immediately prior to use.

(4) Admixtures. The Contractor shall follow an approved procedure for adding the necessary amounts of admixtures to each batch. Admixtures shall be dispensed in such a manner that will ensure uniform distribution of the material throughout the batch within the required mixing period. Except as specified herein, all admixtures shall be added to the batch at the plant, unless otherwise authorized by the Structural Concrete Engineer.

Chemical admixture containers, metering equipment, and scales shall be calibrated annually by a qualified admixture distributor representative. Admixture calibration and verification shall be done at 15% of the high, at approximately the middle, and at 15% of the low recommended ranges for the admixture being dispensed by the system. The calibration and verification shall be done in the presence of an Agency representative when requested by the Agency.

All dispensers shall include visual inspection aids such as graduated transparent cylinders. A separate dispenser shall be provided for each liquid admixture. If the dispensing system does not provide visual inspection aids, then periodic verification tests shall be done at a frequency satisfactory to the Structural Concrete Engineer. Calibration and verification records shall be kept at the production facility for a minimum of one year. The producer shall perform the calibration and verification of the metering systems when requested.

Storage and dispensing systems for liquid admixtures shall be equipped to allow thorough circulation and agitation of all liquid in the system. This shall be required prior to the first batching of concrete for Agency projects in any calendar year and periodically thereafter at intervals not to exceed 60 calendar days for the duration of the period the plant is supplying concrete for Agency projects.

If the plant has received a delivery of at least 25% of the volume of the storage container, this will be considered as a method of circulation or agitation. If the circulation method is used, the admixture shall be circulated until a complete exchange of admixture is achieved. If an agitation method is used, the method shall be subject to approval by the Structural Concrete Engineer. If an admixture does not need agitation, then the admixture manufacturer shall submit a written statement annually indicating that agitation is not required.

Storage and dispensing systems for liquid admixtures shall be maintained within the manufacturer's stated temperature and environmental conditions.

It shall be the responsibility of the Contractor to use the quantity of Agency-approved admixtures needed to obtain concrete meeting the requirements of the Contract. All admixtures shall be approved by the Structural Concrete Engineer prior to incorporation into the mix.

a. Air-entraining admixtures shall be used as required to obtain the specified air content.

b. The dosages of water-reducing, retarding, and water-reducing and retarding admixtures, accelerators and specialty admixtures shall be in the recommended range as stated by the manufacturer, unless otherwise approved by the manufacturer.

(5) Fly Ash or GGBFS. Fly ash or GGBFS shall be stored at the batch plant in separate storage or holding bins or other approved holding containers and shall be protected from rain and moisture.

501.05 MIXING AND DELIVERY.

(a) General Requirements. Concrete may be mixed at the site of construction, at a central point, or wholly or in part in transit mixers. The production of concrete shall meet the requirements of *AASHTO M 157* with the following additional requirements:

(1) All concrete shall reach its final position in the forms no more than 1.5 hours after the cement has been added to the water. When an approved admixture to slow or temporarily halt the hydration process of the cement is used, this time limit will be extended to 2 hours, provided the mix has adequate workability. Prior to discharge, the Contractor shall perform concrete temperature testing on every load of concrete which will be deposited after the 1.5 hour time limit, as defined above, to verify the concrete temperature is within the limits defined by Subsection 501.07.

A time limit greater than 2 hours may be approved if the request is made a minimum of 3 working days prior to the placement and all quality control test results are within specification immediately prior to placement. The request to extend the time limit beyond 2 hours shall include the requested time limit and required admixture dosages. Acceptance testing will be performed by the Engineer, concrete will not be accepted on the basis of quality control tests performed by the Contractor.

Concrete shall not have water added once discharging has begun. Admixtures may be adjusted as required by the producer before discharge has begun. Admixtures to slow or temporarily halt the hydration process of the cement shall only be added at the production facility.

If, in the opinion of the Engineer, any concrete appears to have visually changed from previously placed concrete, the Contractor shall perform quality control tests to confirm the concrete conforms to the specifications.

(2) To obtain the required concrete characteristics, a representative from the concrete producer shall be present on the project to determine the final admixture dosage and water addition for each load of concrete. The dosage shall be applied by means of a dispenser, or by other means of accurately measuring volume as approved by the Engineer. The Contractor shall provide QC concrete testing personnel, with current ACI Concrete Field Testing Technician Grade I Certification, to confirm the concrete is within specifications for the required work.

(3) Addition of water or admixtures at the project site shall be communicated to field inspection personnel. If additional mixing water, admixtures, or other additions are required, a minimum of 30 revolutions of the mixer drum at mixing speed shall be required before discharge of any concrete. If water is added in excess of the specified maximum W/CM ratio, the concrete shall not be used.

(4) The Engineer may require the Contractor to perform uniformity tests on a transit mixer or agitator, in accordance with *AASHTO M 157* and reported except as modified below. Two samples shall be taken. The first sample shall be taken after 15% of the load volume has been discharged, and the second prior to 85% of the load volume being discharged.

Slump and air content tests shall be performed on each sample. The maximum difference in air content between the two samples shall be 1%. For concretes with a specified slump of 4 inches or less, the maximum difference between the two samples shall be 1 inch. For concretes with a specified slump greater than 4 inches, the maximum difference shall be 1-1/2 inches. If both conditions are not met, then the Contractor will be required to either modify the mixing procedure or batching sequence, or that transit mixer or agitator will not be allowed to deliver concrete to the project. The Contractor will be required to perform uniformity tests to confirm the changes have satisfactory results.

(5) Each load of concrete delivered to the job site shall be accompanied by a batch weight ticket meeting the requirements of Subsection 501.04(b).

(6) The Contractor shall provide direct communication service from the site of the work to the batch plant that shall be available to the Engineer at all times during concrete operations. The cost of this service will be considered incidental to the work.

(7) All concrete shall be discharged into the forms before 300 revolutions of the drum or blades, not including initial mixing revolutions. The total allowed number of revolutions may be increased as directed by the Engineer.

Mortar shall be mixed in an approved mixer at the site of placement or in transit mixers when approved by the Engineer. The Engineer will withdraw approval for use of transit mixers, if necessary, to ensure a quality product or if the rate of delivery cannot be coordinated with finishing requirements.

(b) Stationary Mixers. When a stationary mixer is used for the complete mixing of the concrete, the mixing time for mixers that have a capacity of 10 cubic yards or less shall be not less than 90 seconds. For mixers that have a capacity of more than 10 cubic yards, the mixing time shall be determined by the concrete producer.

The time is valid provided that mixer efficiency tests prove the concrete is satisfactory for uniformity and strength. The plant shall be equipped with a timing device that will not permit the batch to be discharged before the predetermined mixing time has elapsed. Vehicles used in hauling shall comply with the requirements of Subsection 501.05(c).

(c) Transit Mixers. Transit mixers and agitators shall be subject to periodic inspections by an authorized representative of the Agency. Such equipment shall bear a currently dated inspection sticker supplied by the Agency indicating that the transit mixer or agitator conforms to the Agency's requirements.

For the purpose of this specification, the term agitator shall be interpreted to mean a vehicle with a drum that is not used to perform the initial mixing of the concrete but is used to transport the concrete and mix the concrete prior to discharge.

Transit mixers shall be equipped with a water-measuring tank with a visible sight gauge for use when the water for the batch is supplied from the transit mixer tank. The gauge shall be clean and legibly graduated. Measuring tanks shall be provided with outside drain valves or other means to check their calibration. These should be easily opened for checking at any time.

Electrically actuated revolution counters shall be required on all transit mixers except on mixers charged at central mix plants and used as agitator trucks only.

All mechanical details of the mixer or agitator such as water measuring and discharge apparatus, condition of the blades, speed of rotation of the drum, general mechanical condition of the unit and clearance of the drum shall be checked before a further attempt to use the unit will be permitted.

Mixers and agitators shall be kept free from accumulation of hardened concrete or mortar. The mixing blades shall be rebuilt or replaced when any part or section is worn 3/4 of an inch or more below the original height of the manufacturer's design. A copy of the manufacturer's design, showing the dimensions and arrangements of blades shall be available to the Engineer at the plant at all times.

Concrete containing silica fume shall be mixed in accordance with the appropriate situation:

(1) When silica fume is added to the batch by bags or in bulk from a silo, each batch of concrete shall be mixed for not less than 125 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as the mixing speed. The mixing and agitating speeds shall be found on the metal plate on the mixer.

(2) When silica fume is blended with cement or a combination of cement and mineral admixture at the cement plant prior to being delivered to the concrete plant, each batch of concrete shall be mixed for not less than 70 nor more than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as the mixing speed. The mixing and agitating speeds shall be found on the metal plate on the mixer. If inconsistent test results are obtained, or the batch of concrete appears not to be completely mixed, the mixing revolutions shall be extended as necessary.

When a transit mixer or agitator is used for transporting concrete, mixing during transport shall be continuous and at two to six rotations per minute or as designated by the manufacturer of the equipment as agitating speed. Failure to do so will be cause for rejection of the concrete.

Transit mixers and agitators assigned to a project shall not be used for other purposes until the desired work is completed at the site and shall arrive at the project within the cycle that anticipated placement conditions dictate. The interval between loads shall be controlled such that concrete in place shall not become partially hardened prior to placing succeeding batches. The plant capacity and transportation facilities shall be sufficient to ensure continuous delivery at the rate required.

Before discharging concrete from a transit mixer that has been operating at agitating speed, the drum or blades shall be rotated approximately one minute at mixing speed. The same procedure shall apply to agitators.

Upon discharge of the concrete from the drum, a sufficient amount of water shall be charged into the drum to properly cleanse the drum. This water shall not be used as a part of the next succeeding batch but shall be discharged from the drum prior to the charging of the drum with the concrete ingredients. The drum shall be completely emptied before receiving materials for the succeeding batch. Re-tempering of concrete or mortar that has partially hardened, by remixing with or without additional materials, shall not be permitted.

501.06 QUALITY CONTROL. The Contractor shall provide assistance, equipment, materials, and curing for field sampling and testing as required by the Engineer. All costs shall be included in the Contract unit prices under Section 631. The Engineer shall perform all acceptance sampling and testing in accordance with the Agency's *Quality Assurance Program*. The Contractor shall perform all on-site quality control (QC) sampling and testing. The person performing the QC sampling and testing shall have, as a minimum, current ACI Concrete Field Testing Technician Grade I Certification.

(a) Trial Pour. When concrete will be used for a deck or overlay, or when deemed necessary by the Engineer, the Engineer may require the Contractor to construct a slab to be used for the trial pour. The purpose of the trial pour is to ensure that the mix can be placed and finished in accordance with these specifications. The concrete slab shall be 10 feet × 10 feet × 9 inches thick, unless otherwise directed by the Engineer.

If the concrete is intended to be placed by pump, the trial pour concrete shall be placed by pump. The pump will be set up in the configuration that best represents the most difficult pumping condition. The wet concrete properties will be checked at the point of placement. The Contractor will demonstrate that they can provide an acceptable finish to the concrete for the element to be completed. The Contractor will need to bull float a minimum of 50% of the surface area of the slab and hand finish the curb areas in the same manner as anticipated during the production pour.

The Contractor may elect to construct the slab so that the same screed equipment and same finishing method can be used as anticipated for the production pour. In this case the Contractor will not be required to bull float a minimum percentage of surface area unless that will be included in their process for finishing the concrete deck surface during the deck pour. The test slab will become the property of the Contractor and removed from the project after completion of the trial pour.

Concrete production activities shall be closely monitored to ensure that no deviations are made from the approved mix design. If test results indicate a failure to obtain the characteristics as specified in Table 501.03A, the Engineer may reject the material. The Contractor will be responsible for proposing solutions which could include changes to the mix design and will require testing be done with no extra payment. The modified mix design shall not be used until successful test results are obtained during a trial pour that is representative of the anticipated pour conditions.

(b) Sampling. Sampling for tests shall be taken in accordance with the requirements of *AASHTO R 60* or other procedures approved by the Agency. Sampling will be done at the point of placement or as close to it as practical.

(1) Changes. Any time that there is a change in admixture dosage outside of the allowable tolerances, whether modified at the batch plant or at the site, additional QC sampling and testing shall be performed on the modified load prior to incorporating the concrete into the work.

(2) Beginning of Load Sampling. Beginning of load sampling is sampling for QC testing purposes that is taken before 15% of the load has been discharged. Beginning of load sampling shall be performed as required by the Engineer, or as needed to ensure that the concrete meets the Contract requirements at the point of placement. The QC personnel shall monitor the placement operation and adjust the mix accordingly to ensure that the material being incorporated into the work meets Contract requirements.

(c) Slump Tests. Slump tests shall be made in accordance with *AASHTO T 119*.

(d) Spread Tests. Spread tests for Class SCC concrete shall be performed in accordance with *ASTM C1611, Procedure B*. The concrete inside the cone shall not be tamped.

(e) Visual Stability Index (VSI) Tests. VSI tests for Class SCC concrete shall be performed in accordance with *ASTM C1611, Appendix X.1* and shall be performed on each completed spread test.

(f) Air Content Tests. Air content tests shall be made in accordance with the pressure method specified in *AASHTO T 152*.

For Class SCC concrete, the specimens shall be fabricated in accordance with *ASTM C1758.*

(g) Compressive Strength Tests.

(1) General Requirements. The number of compressive strength tests performed for acceptance will be as specified in the *Materials Sampling Manual*. The Engineer may order additional tests as deemed necessary.

Compressive test cylinders shall be made in accordance with the requirements of *AASHTO R 100* and tested for compressive strength in accordance with the requirements of *AASHTO T 22*.

For Class SCC concrete, the specimens shall be fabricated in accordance with *ASTM C1758.*

(2) Categories of Testing.

a. Acceptance Testing. Acceptance testing uses specimens to determine the compliance with requirements for the project. All test cylinders used for quality acceptance testing shall be stored in an approved curing box until they are shipped to the Agency's Materials Testing and Certification Section Central Laboratory.

b. Job Control Testing. Job control testing uses specimens to determine whether adequate curing procedures are being followed and for early form removal or early loading of structure.

1. All job control specimens shall be stored on the structure and shall receive the same curing and protection from the elements as the concrete that they represent up until 24 hours before anticipated testing of specimens.

2. The maturity method may be used as an alternative to compressive strength testing for estimating the concrete strength. The procedures of *ASTM C1074* shall be followed for the maturity method except as noted below:

   i. For *ASTM C1074, Section 8.1* there shall be a minimum of 17 cylinders cast. Two of the 17 shall have temperature sensors embedded in them to be used for monitoring.

   ii. For *ASTM C1074, Section 8.4* there shall be 3 cylinders tested for each test age.

   iii. For *ASTM C1074, Section 8.4* for rapid set concrete mixes the test ages shall be 12 hours, 1 day, 2 days, 7 days, and 28 days. The Contractor may adjust or add test ages if approved by the Engineer.

   All temperature measuring devices shall be verified or calibrated on a 12 month basis or sooner if there are questions about their accuracy. The devices shall have an accuracy of $\pm 2^{o}$ F.

   At least two temperature sensors shall be embedded each day in each pour. One sensor shall be placed where maturity is expected to develop the slowest at, or near, an exposed outer edge, and a second sensor shall be placed in the concrete poured from the last load of the day. Sensors shall be placed 2 inches to 4 inches from any existing concrete or an exposed outer edge. The temperature sensing end of the monitor shall not be placed in direct contact with reinforcing materials or other elements that will protrude through the surface of the concrete. The Contractor shall submit the proposed locations to the Engineer for review and approval.

c. Specimen Curing Requirements. Specimen curing requirements shall be as stated in the specifications or as directed by the Engineer. If not specifically stated, the curing shall be as specified in Table 501.06A.

TABLE 501.06A – CONCRETE SPECIMEN CURING REQUIREMENTS

Testing Category	Number of Specimens	Curing Location
Acceptance	See the *Materials Sampling Manual*	Curing box
Job control	2 per test	On structure

(h) Concrete Temperature. Concrete temperature tests shall be conducted in accordance with the requirements of *ASTM C1064*.

501.07 WEATHER AND TEMPERATURE LIMITATIONS. The temperature of the concrete just prior to placement in the forms shall not be less than 50°F nor more than 85°F. Aggregates and water shall be heated or cooled as necessary to produce concrete within these temperature limits.

Placement and curing procedures shall be approved by the Engineer prior to actual placement.

(a) Hot Weather Concrete. Placement of concrete during hot weather may be limited by the Engineer based on an assessment of temperature, humidity, wind velocity, and sun radiation conditions. No concrete shall be placed when the ambient air temperature is, or is expected to be, above 90°F.

(b) Cold Weather Concrete.

(1) General Requirements. Cold weather concrete will be any concrete placed or cured when the ambient air temperature is expected to be below freezing at any point or below 40°F for a continuous 8-hour period. No concrete shall be placed when the ambient air temperature is lower than 10°F except by written permission of the Engineer. A cold weather concrete plan shall be submitted to the Engineer for their review and acceptance before any cold weather concrete is placed.

When placing cold weather concrete, the Contractor shall have adequate equipment for heating and protecting the materials and freshly placed concrete meeting the approval of the Engineer. This equipment shall be on the job and ready to deploy prior to the commencement of concrete placing operations.

No concrete shall be placed in any superstructure or thin section under cold weather conditions.

(2) Heating of Materials. The heating equipment deployed for cold weather concrete placement shall be capable of heating the materials uniformly. Aggregates shall not be heated to a temperature exceeding 150°F. If water is heated to a temperature exceeding 140°F, the water shall be mixed with the aggregate before the cementitious material is added.

The materials shall be heated in such a manner, for such a period of time, and in such quantity, as to produce concrete having a uniform temperature within the specified temperature range at the time of placement. Materials containing frost or frozen lumps shall not be used.

Stockpiled aggregates may be heated using dry heat or steam. Aggregates shall not be heated directly by gas or oil flame, or on sheet metal over a fire. When aggregates are heated in bins, steam-coil or water-coil heating, or other methods that will not be detrimental to the aggregates, may be used.

(3) Antifreeze Compounds. Salts, chemicals, or other foreign materials shall not be used in the mix to lower the freezing point of the concrete.

(4) Preparation of Forms. Before placing concrete, any ice, snow, or frost shall be completely removed from the forms.

Concrete shall not be placed on any surface or in any forms that are frozen, have surface temperatures below 32°F, or that contain frozen materials. The frozen surface or forms shall be completely thawed the day before the placement of the concrete and shall be kept continuously thawed until the concrete is poured. The temperature difference between forms or substrate and the plastic concrete shall not exceed 40°F.

(5) Housing. The Contractor shall furnish sufficient canvas with a supporting framework or other suitable type of housing to fully enclose and protect the structure when placing and curing cold weather concrete. The sidewalls and roofing of the protective housing shall be completely built before the placing of any concrete.

The protective housing shall be constructed independently of the forms and bracing and with adequate space to allow for form removal and the initial finishing of the concrete as required during the heating period. Joists shall be located to suitably support the housing roof with no sagging. The protective enclosure shall be heated to the proper temperature before placing any concrete.

When the temperature readings taken on or in the concrete indicate the temperature of the concrete may fall below 50°F, the Contractor shall, without exposing the concrete, immediately build the necessary enclosures around the area involved and supply heat to ensure curing conditions as specified in Subsection 501.15. The enclosure shall be removed when directed by the Engineer.

(6) Heating the Enclosure. The enclosure shall be heated in such a manner that the temperature of the concrete and the enclosed air shall be kept above 50°F, and not more than 40°F above the internal concrete temperature, for the designated curing period. During this time, the concrete shall be kept continuously wet to provide proper curing. The internal concrete temperature shall not exceed 160°F. After the curing period, the temperature shall be gradually lowered to that of the surrounding atmosphere, taking at least 48 hours for the transition but at no time exceeding a 1°F change per hour.

When dry heat is used, a means of maintaining atmospheric moisture shall be supplied. The Contractor shall also maintain adequate fire protection and shall provide personnel to keep the heating units in continuous operation. When concrete placement operations are in locations where water levels may fluctuate, the supports for heating equipment shall be built so that the heating equipment can be raised, and steam lines shall be placed above the probable high water level.

The enclosure shall be well-ventilated to avoid accumulation of carbon dioxide and carbon monoxide.

When using a hydronic heating system with heat-transfer fluid that circulates through a series of hoses, the heat-transfer hoses shall be laid on top of the vapor barrier, usually plastic sheeting, then covered with approved insulating materials or by other approved methods for retaining heat.

(7) Temperature Records. The Contractor shall provide an automatic temperature recorder to continuously record concrete curing temperatures and ambient air temperatures for the entire curing period. Recording thermometers shall be capable of measuring and recording temperatures within the range of 0°F to 200°F with maximum graduations of 5°F.

Temperature sensors shall be carefully placed within the curing enclosure or in the concrete to ensure that temperatures are measured at typical locations. Concrete temperature sensors shall be embedded between 2 inches and 3 inches into the concrete or as directed by the Engineer. The recorder’s accuracy shall be certified once every 12 months, with the certificate displayed with each recorder. The Engineer may make random checks of each recorder.

On each recorder chart or file, the Contractor shall indicate the location of the representative concrete, the placement date, and start and finish times of the temperature record. At the completion of the curing period, the recorder charts shall be submitted to the Engineer.

A thermometer shall be provided that is capable of displaying the current ambient temperature with a maximum gradation of 1°F. The inspector will use the thermometer to take periodic temperature measurements of the enclosure at varying locations.

The Contractor shall provide a hand-held infrared thermometer capable of taking no-contact measurements that is accurate within plus or minus 2% of the reading. The thermometer's accuracy shall be certified once every 12 months, with the certificate provided with each thermometer.

When the Contractor places concrete at more than one location within the specified curing period or if the Engineer determines that monitoring of a single pour is necessary in multiple locations, additional monitoring and recording equipment shall be furnished to provide temperature records at each location.

501.08 FORMS. The Contractor shall be responsible for, and shall make good, any injury arising from inadequate forms. The Engineer shall be provided with the opportunity to inspect all forms prior to concrete placement.

Unless the Plans specifically allow for the use of stay-in-place forms, such forms shall not be used in the construction of any superstructure or bridge deck. Stay-in-place forms will only be allowed as approved by the Engineer.

(a) Falsework. In general, falsework that cannot be founded upon a solid footing shall be supported by falsework piling. The Engineer may require the Contractor to employ screw jacks or hardwood wedges to correct any deflections or settlement, however slight, occurring in the falsework.

(b) Construction. Forms shall be mortar-tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations, including vibration. Forms shall be constructed and maintained to prevent the opening of joints due to shrinkage of the lumber. Sealers and caulking as approved by the Engineer shall be used where forms abut structural steel members, such as top flanges of beams and girders.

To ensure their easy removal, forms shall be filleted and chamfered at all sharp corners, unless otherwise shown on the Plans or directed by the Engineer, and shall be given a bevel or draft in the case of all projections, such as girders and copings.

Falsework and forms for slabs, beams, and girders shall be constructed to provide the camber shown on the Plans or ordered by the Engineer.

Falsework and forms for Class SCC concrete construction shall be designed with consideration given to concrete placement rates, mix temperature, additives, and placement procedures that affect hydrostatic pressure of the concrete. Forms shall be water-tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations, including vibration.

(c) Form Lumber. All face form lumber for exposed surfaces shall be concrete form exterior grade plywood, not less than five ply and with a minimum thickness of 3/4 inch. In computing stud spacing, plywood shall be considered 1 inch lumber, provided that the grain of three of the plies runs perpendicular to the studs.

Form lumber for unexposed surfaces may be dressed tongue-and-groove, dressed shiplap, or square-edge surfaced four sides of uniform width and thickness, with a minimum thickness, after finishing, of 3/4 inch.

All form lumber shall be sound and free from loose or rotten knots, knotholes, checks, splits, or wanes showing on the surface that will be in contact with the concrete. Used face form lumber, having defects or patches which may produce work inferior to that resulting from new material, shall not be used.

Other form materials may be used with the permission of the Engineer.

(d) Form Ties. Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 1 inch from the face without injury to the concrete. Wire ties shall be used only in locations where they will not extend through surfaces exposed in the finished work and then only when authorized by the Engineer.

Unless otherwise specified, cavities shall be filled with a product that meets the requirements of Subsection 780.01. The manufacturer's recommendations shall be followed for surface preparation, mixing, application, and curing.

(e) Surface Treatment. All forms shall be treated with commercial form oil prior to placing reinforcement, and wood forms shall be saturated with water immediately before placing the concrete. Any material that will adhere to or discolor the concrete shall not be used.

(f) Metal Forms. The specifications for wood forms regarding design, mortar-tightness, filleted and chamfered corners, beveled projections, bracing, alignment, removal, reuse, and oiling also apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape throughout the concrete placement operations.

All bolt and rivet heads shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms that do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease, or other foreign matter.

(g) Removal of Forms.

(1) Deck Superstructure. The forms, or their supports, for any portion of a structure shall not be removed before the end of the cure period for the deck specified in Table 501.15A. Forms under beams or floor slabs may be removed upon approval of the Engineer after the concrete attains 85% of the minimum compressive strength as specified in Table 501.03A, but not prior to the end of the cure period specified in Table 501.15A.

(2) Substructure. The forms, or their supports, for any portion of a substructure shall not be removed before the end of the cure period specified in Table 501.15A unless otherwise approved by the Engineer. Removal of forms prior to the end of the cure period will only be allowed if a vertical surface curing plan has been approved by the Engineer. Forms under arches, pier caps, or other special design conditions may be removed upon approval of the Engineer after the concrete attains 85% of the minimum compressive strength as specified in Table 501.03A, but not prior to the end of the cure period specified in Table 501.15A.

Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and their supports shall not be removed without approval of the Engineer. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take up the stresses due to its own dead load.

(h) Stay-In-Place Corrugated Metal Forms (SIPCMF) for Superstructure Deck Slabs.

(1) General Requirements. When SIPCMF are allowed, their use for superstructure deck slab construction shall be subject to the following requirements:

a. Fascia overhangs shall be formed with removable forms that leave the resulting concrete with a flat-surfaced finish.

b. Bays that are constructed in stages such that a longitudinal joint is required shall be made with removable forms.

c. Form flutes (or valleys) shall be filled with closed cell foam, or approved equal, to maintain the deck thicknesses shown on the Plans.

(2) Design Requirements. The following requirements shall govern the design of SIPCMF:

a. The design span shall be the clear span of the form plus 2 inches, measured parallel to the form flute (also referred to as the form valley).

b. The design load shall be the sum of the weight of forms, bar reinforcement, plastic concrete, and 55 pounds per square foot for construction loads.

c. The unit working stress shall not exceed 75% of the specified minimum yield strength of the material.

d. The dead load deflection shall not exceed 1/180 times the form span length or 1/2 inch, whichever is less.

e. Physical design properties shall be computed with the requirements of the AISI *North American Specification for the Design of Cold-Formed Steel Structural Members*.

(3) Construction Requirements. The following construction requirements shall apply to the use of SIPCMF:

a. Construction Drawings. The Contractor shall submit construction drawings for SIPCMF in accordance with the requirements of Subsection 105.06. These drawings shall contain the following information as a minimum:

1. The name of the SIPCMF supplier.

2. A layout showing the compression and tension region of each beam or girder.

3. The method of SIPCMF attachment for the compression and tension regions.

4. The geometric properties of each type of panel being used.

5. The number, location, and type of panels being used within each girder bay.

6. Panel laps, considering the direction of concrete pours.

7. The specifications for the material used to fill the flutes.

8. Any other material data, erection information, or miscellaneous notes that may be required.

b. Handling and Installation. Care and protection shall be given the metal form sheets, supports, and accessory items during handling, shipping, and storage. During loading, hoisting, and unloading operations, extra precautions and care shall be taken to prevent damage to ends, corners, and edges of form sheets, supports, and accessory items.

If the form units and accessories are to be stored prior to installation, they shall not be placed in contact with the ground and shall be adequately covered or protected to keep them dry.

Form supports shall be placed in direct contact with the flange of the beam, girder, stringer, or floor beam. All attachments shall be made by permissible welds, bolts, clips, or other approved means. The welding of form supports to steel not considered weldable or to portions of flanges subject to tensile stresses shall not be permitted. Welds and welding shall be in accordance with the requirements of Subsection 506.10, with the exception that a 1/8-inch fillet weld will be permitted.

Form sheets shall not be permitted to rest directly on the flanges. They shall be securely fastened to form supports by self-tapping screws and shall have a minimum bearing length of 1 inch at each end. Transverse construction joints shall be located at the bottom of a valley. A 1/4 inch diameter weep hole shall be drilled at the lower end of each flute or valley.

Screed and pouring runway supports shall not be located directly on the form sheets, form supports, or reinforcing steel. No loose sheets or miscellaneous hardware shall be left on the structural slab at the end of the working day.

The corrugated metal sheets shall be fabricated for the placement sequence used, with the joints between sections of sheets overlapped or securely fastened to eliminate differential deflections. Any exposed form metal where galvanizing has been damaged shall be cleaned and repaired to the satisfaction of the Engineer.

(4) Inspection Procedures. The following three-step inspection procedure will be used to check the soundness of the concrete deck against the SIPCMF.

a. Step 1. Not less than two days after completion of a concrete structural slab pour, but prior to the next slab pour, one panel of the SIPCMF shall be removed from the most recently completed pour of each span, at a location selected by the Engineer, to provide visual evidence that the concrete mix or the construction procedures are obtaining the desired results.

If the concrete mix or the construction procedures are varied significantly within a pour, such as a change in the extent of vibration or change in the workability of the mix, another section of forming shall be removed to verify that the new procedures are yielding desirable results.

b. Step 2. After the concrete has attained 85% of the specified design strength, the Engineer will spot-check the underside areas of the steel forms by sounding with a suitable weight hammer. If honeycomb or voided areas are detected, the SIPCMF at that location shall be removed for a visual inspection.

c. Step 3. A minimum of 2% of the total SIPCMF area shall be removed for visual inspection of the concrete surface. The amount of sounding and form removal may be moderated, at the Engineer's discretion, after a substantial amount of the slab has been constructed and inspected, if the Contractor's methods of construction and results of the inspections as outlined above indicate that sound concrete is being obtained throughout the slab.

If, after removing a section of form, the concrete is found to be defective, additional panels shall be removed as directed by the Engineer. All defective concrete shall be repaired to match the adjacent concrete in section and color to the satisfaction of the Engineer.

The Contractor shall provide all facilities required for the safe, suitable, and convenient means of access to the forms for the Engineer's inspection procedures.

The form sections shall be removed by a metal saw or air-carbon-arc gouging with minimum damage to the concrete. Cuts shall only be sufficiently deep to sever the form. Any other method of removal shall be submitted to the Engineer for approval. Cuts parallel to the corrugations in the forms shall be located on the sloping surface midway between a crest and valley. Cuts parallel to the supporting beams or girders shall be made through the supporting angles taking care not to damage the structural steel beams or girders.

The Contractor will not be required to replace the forms which have been removed.

501.09 PLACING CONCRETE.

(a) Workforce. The Contractor shall always have sufficient skilled personnel during the concreting operations to properly place, consolidate, and finish the concrete. If, in the opinion of the Engineer, the Contractor does not have sufficient skilled personnel to handle the concrete properly, the Engineer may postpone the start of the concreting operations until the Contractor has remedied this situation.

(b) Pre-Placement Meeting. For deck pours, or as required by the Engineer, a pre-placement meeting shall be scheduled by the Contractor to take place at least 7 calendar days before concrete placement, and prior to the trial pour, if required. Attendees at the pre-placement meeting shall include, but not be limited to, the Contractor's project superintendent, the Engineer, the Structural Concrete Engineer, and the concrete producer.

The Contractor shall provide a placement plan that addresses, but is not limited to, the following topics:

(1) Time of concrete placement and amount

(2) Batch plant testing

(3) Delivery of concrete

(4) Method of concrete placement on the deck

(5) Consolidation and finishing of concrete

(6) QC testing of the plastic concrete

(7) Protection of the concrete from evaporation

(8) Curing of the concrete

(9) How to avoid long delays for balance loads

(10) Screed, work bridge, and rail set-up

(11) Dry run schedule

(12) Contingency plans for long delays, break downs, weather events and other potential problems

(13) Crew size and responsibilities

(14) Available equipment

(15) Project layout, including locations for all pumps, cranes, testing, cleanouts, staging, etc.

(c) Placement Limitations. All concrete shall be placed in daylight, unless otherwise authorized in writing by the Engineer. Authorization to place concrete at any other time shall not be given unless an adequate lighting system is provided prior to beginning the concrete placement operations.

Concrete shall not be placed under adverse environmental conditions that the Engineer determines will interfere with acceptable placement or finishing operations.

Concrete shall not be placed until the depth and character of the foundation, the apparent adequacy of the forms and falsework, and the placing of the reinforcing steel have been approved by the Engineer. The interior of the forms shall be clean of all debris before concrete is placed.

The Contractor shall submit to the Engineer a schedule of batching, delivery, and placement prior to the beginning of the concreting operations. The Contractor shall comply with the requirements of Subsection 501.05.

For deck pours, the Contractor shall submit the required retarder schedule to the Engineer a minimum of 3 working days in advance of the placement. The retarder schedule shall demonstrate how the Contractor will ensure that concrete will remain plastic until the deck is fully placed. The retarder schedule shall include considerations for the maximum time between batching and discharge, duration of the pour, weather, possible delays, and any other factors that may impact the time to initial set.

Equipment and tools necessary for handling materials and performing all parts of the work shall meet the approval of the Engineer as to design, capacity, and mechanical condition and shall be on the site before the work is started. Any equipment, in the judgment of the Engineer, that proves inadequate to obtain results prescribed shall be improved or new equipment substituted or added.

The Engineer may suspend the pour or reject the pour if the Contractor deviates from the accepted pour plan which will also include unacceptable delivery rates. The Contractor will not be allowed compensation due to the pour being suspended or rejected due to the Contractor deviating from the accepted pour plan or uncontrolled delivery rates.

For simple spans, concrete shall be deposited by beginning at the lower end of the span and working toward the upper end. For continuous spans, where required by design considerations, the concrete placing sequence shall be as shown on the Plans.

Concrete shall not be deposited in the forms more than 4 feet from its final position.

The dropping of unconfined concrete more than 5 feet will not be permitted.

Concrete shall not be deposited in running water.

The rate of placing the concrete shall be so regulated that no excessive stresses are placed on the forms. Concrete in all decks shall be placed in one continuous operation, unless otherwise specified.

Concrete shall be placed in continuous horizontal layers, the thickness of which shall not exceed 18 inches, unless otherwise directed by the Engineer. Each succeeding layer shall be placed before the underlying layer has taken initial set and shall be consolidated in a manner that will eliminate any line of separation between the layers. When it is necessary, due to any emergency, to place less than a complete horizontal layer at one operation, such layer shall terminate in a vertical bulkhead.

After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or straining the ends of projecting reinforcing bars.

(d) Placement of Overlays. For a period of at least 24 hours before the placement of overlay material, the prepared surface shall be flooded with water. After removal of all free water, the overlay material shall be deposited on the damp surface and manipulated to coat the horizontal and vertical surfaces to be covered. The rate of progress shall be controlled to prevent the drying of previously deposited materials.

(e) Use of Chutes. Chutes, troughs, and pipes used in placing concrete shall be arranged to avoid segregation of the materials and the displacement of the reinforcement and shall be approved by the Engineer. Aluminum chutes, troughs, or pipes will not be permitted.

All chutes, troughs, and pipes shall be kept clean and free of hardened concrete by thoroughly flushing with water after each run. Open troughs or chutes shall be either made of metal or be metal-lined and shall extend as nearly as possible to the point of deposit. When the discharge must be intermittent, a hopper or other device for regulating the discharge shall be provided.

Dropping of unconfined concrete more than 5 feet or depositing a large quantity at any point and running or working it along the forms will not be permitted.

(f) Use of Vibrators. Unless otherwise specified, the concrete shall be consolidated with mechanical vibrators, of an approved type and design, operating within the concrete. When required, vibrating may be supplemented by hand-spading with suitable tools to ensure proper and adequate consolidation.

Vibrators shall be manipulated to work the concrete thoroughly around the reinforcement and imbedded fixtures and into corners and angles of the forms to produce surfaces free of imperfections. Vibrators shall not be used to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish consolidation but shall not be prolonged to the point where segregation occurs.

Vibrators shall have non-metallic or rubber-coated heads. Vibrating machines shall at no time be left running unattended in the concrete.

When it is necessary due to an emergency to discontinue the placing of a monolithic section, the use of vibrators shall cease. Vibrators shall not again be used until a sufficient depth of fresh concrete is placed to prevent any possibility of the effect of vibration on the concrete already in place and in no case shall this depth be less than 2 feet.

The number of vibrators used shall be ample to consolidate the incoming concrete immediately after it is deposited in the form. The Contractor shall have at least one spare vibrator in serviceable condition at the site of the structure in which more than 25 cubic yards of concrete are to be placed.

The vibrators shall be capable of transmitting vibration to the concrete at frequencies of not less than 4,500 impulses per minute under load. The vibration shall be of sufficient intensity and duration to cause plasticity, settlement, and complete consolidation of the concrete without causing segregation. The vibrator shall visibly affect a mass of concrete of 2-inch slump over a radius of at least 18 inches.

Unless otherwise specified, Class SCC concrete shall not be consolidated with mechanical vibrators. If the Engineer requests the use of a vibrator, it shall be of an approved type and design, operating within the concrete. To avoid segregation of the concrete, it shall be used as little as possible.

(g) Blasting Operations. All blasting operations within 200 feet of any concrete work shall be completed prior to the placement of the concrete. Regardless of the above limitation on blasting operations, the Contractor shall be responsible for any damage resulting from blasting operations.

501.10 DEPOSITING CONCRETE UNDER WATER.

(a) General Requirements. Concrete shall not be deposited under water except as specified by the Contract or upon approval of the Engineer. Class SCC concrete shall be used for all underwater concrete, unless otherwise approved by the Engineer. An anti-washout admixture shall be added to the mix design for all underwater concrete. Underwater concrete with an anti-washout admixture shall have a minimum air content of 3%. The anti-washout admixture may cause a delay in set times.

The anti-washout admixture is not required to be included in mix qualification testing. If the anti-washout admixture is not included in the mix design for qualification testing, an administrative submittal with the addition of the anti-washout admixture to an approved mix design shall be submitted in accordance with Subsection 501.03.

(b) Placement. When placing concrete underwater, the Contractor shall use a tremie or an alternate method of conveyance, approved by the Engineer, which minimizes the mixing of fresh concrete and water. A tremie shall have a hopper at the top that empties into a watertight tube at least 10 inches in diameter.

The discharge end of the tube on the tremie shall include a device to seal out water while the tube is first filled with concrete. An inflatable ball will not be permitted. The device shall keep its shape and float without danger of deflation.

The placement shall be continuous to the elevations shown on the Plans and the resulting concrete shall be monolithic and homogeneous.

Concrete shall not be deposited in water that has a temperature of 35°F or less. When the water temperature is between 35°F and 40°F, the mixing water, the aggregates, or both shall be heated as specified in Subsection 501.07(b).

A tremie shall be constructed of heavy-gauge steel pipe and consist of watertight joints between the tremie sections with a diameter of not less than 10 inches. The tremie hopper shall have a capacity of at least 1/2 cubic yard. When a batch is dumped into the hopper, the flow of the concrete shall be induced by slightly raising the discharge tube, always keeping it in the concrete.

Tubes shall be kept continuously submerged in concrete during discharge. The depth that the tube is submerged in concrete and the height of the concrete in the tube shall be sufficient to prevent water from entering the tube. The Contractor shall continuously monitor the difference in elevation between the top of the concrete and the end of the discharge tube.

Horizontal movement of discharge tubes through the concrete will not be allowed.

For minor quantities, at the sole discretion of the Engineer, a direct pumping method may be approved. If a direct pumping method is to be implemented, the pipe discharging the concrete shall consist of heavy-gauge steel sections. The Contractor shall demonstrate the ability to pump the concrete without the pump line surging or otherwise moving in the water as concrete is being pumped.

Cylinders cured as field cure shall be cured at the same temperature as the water covering the concrete.

501.11 PUMPING. Where concrete is conveyed and placed by mechanically-applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. The pump shall be capable of pumping concrete within the specified slump limits. The use of aluminum pipe as a conveyance for the concrete will not be permitted.

The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. The equipment shall be arranged so that no resulting vibrations may damage freshly placed concrete.

501.12 CONSTRUCTION JOINTS.

(a) Construction Joint Locations. Joints shall be formed at the location shown on the Plans. Any variation or new location of joints shall require written permission of the Engineer. Feather edges at construction joints will not be permitted. Joints shall be formed with inset formwork so that each layer of concrete will have a thickness of not less than 6 inches.

(b) Joining Fresh Concrete to Previously Set Concrete. When joining fresh concrete to concrete that has hardened, the surface of the set concrete shall be roughened in such a manner that will not leave loosened particles or damaged concrete at the surface and shall be thoroughly cleaned of all laitance, loose, and foreign material. Immediately prior to the placing of the new concrete, the surface shall be saturated with water.

When shown on the Plans or ordered by the Engineer, the surface shall be thoroughly coated with a very thin coating of mortar, neat cement grout, or epoxy bonding system and all forms drawn tight against the face of the concrete. This coating shall not be allowed to dry out before being covered with fresh concrete.

(c) Filled Construction Joints. Filled construction joints shall contain a pre-formed cork joint filler or other pre-formed joint filler that may be shown in the Contract. Joint filler shall be cut to fit exactly and shall completely fill the space that is shown on the Plans. Where a pour grade or caulking grade filler is indicated to be used in the joints, that portion of the joint to be filled shall be formed with a separate material (other than the pre-formed joint filler) that can easily be removed prior to placement of the above indicated filler.

(d) Water Stops. Approved water stops shall be placed at locations shown on the Plans. They shall form continuous watertight joints.

(e) Bond Breakers. Bond breakers shall be asphalt-treated felt or pipe insulation, as shown on the Plans.

501.13 EXPANSION JOINTS. All expansion joints shall be constructed according to the details shown on the Plans.

(a) Filled Compression and Expansion Joints. Filled compression and expansion joints shall be made with a pre-formed self-expanding cork joint filler or other pre-formed joint filler that may be shown in the Contract. Joint filler shall be cut to fit exactly and shall completely fill the space that is shown on the Plans. Where a pour grade or caulking grade filler is indicated to be used in the joint, that portion of the joint to be filled shall be formed with a separate material (other than the expansion joint filler) that can easily be removed prior to placement of the above indicated filler.

(b) Special Types of Expansion Joints. Special types of expansion joints may be used when shown on the Plans or ordered by the Engineer.

501.14 CONCRETE FINISHING.

(a) Formed Concrete. Unless otherwise specified, all concrete surfaces shall be given a dressed finish. Other finish classes may be shown on the Plans for designated surfaces.

(1) Dressed Finish. All fins and irregular projections shall be removed from all surfaces except from those that are not to be exposed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other minor defects shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a product that meets the requirements of Subsection 780.01. The manufacturer's recommendations shall be followed for surface preparation, mixing, application, and curing.

All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint shall be left exposed to its full length with clean and true edges.

Areas that contain minor defects shall be repaired to the satisfaction of the Engineer. Minor defects are defined as the intermittent presence of holes, honeycombing, chips, or spalls, which are 6 inches or less in the longest dimension, and that do not penetrate deeper than 1 inch into the concrete. Surface voids or bugholes that are less than 1/4 inch in diameter and less than 1/8 inch deep need not be repaired.

Major defects are anything beyond the scope of minor as described above. The Contractor shall submit a corrective action proposal to the Engineer for all major defects.

(2) Aesthetic Finish. In addition to the requirements for a dressed finish, the following work shall be performed when an aesthetic finish is specified.

On all exposed surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other minor defects shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a mortar composed of the same cement and fine aggregate and mixed in the same proportions used in the concrete being finished, unless otherwise directed by the Engineer. Mortar used in pointing shall be not more than 1 hour old. The mortar patches shall be cured for a minimum of 72 hours in accordance with Subsection 501.15.

(b) Float Finish. This finish for horizontal surfaces shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be smoothed with a magnesium float.

Immediately after float finishing, the surface shall be given a broom finish, burlap drag finish, or left smooth as determined by the Engineer.

(c) Bridge Seats. Surfaces of bridge seats under bearing devices shall be level. The entire bridge seat surface shall be smoothed with a magnesium float.

(d) Finishing Bridge Decks and Overlays.

(1) General Requirements. The Contractor shall follow the procedures and details for placing the deck in accordance with the pre-placement meeting. The procedure shall provide for adequate labor, equipment, and material supply to complete placement of concrete on the entire deck, or specified portion thereof.

If, during the placement, unforeseen circumstances delay the progression of the pour to a point where the concrete begins to lose plasticity, the Contractor shall be prepared to place a bulkhead, as directed by the Engineer.

If at any time the screed machine does not advance in a 15-minute period due to delayed concrete delivery, mechanical breakdown, or other problem, the Contractor shall immediately cover concrete that is under the screed machine past the leading edge of the concrete with wet burlap. Just before concrete placement is to begin, the burlap shall be removed, the screed machine will be moved back, fresh concrete will be added to the area that was directly under the screed to the leading edge, and the area will be vibrated again. The screed machine may then be advanced forward to continue the placement.

Approval of their methods and equipment does not relieve the Contractor of full responsibility for obtaining the required surface finish.

Prior to texturing, the finished concrete surface shall be examined by the Contractor. Surface irregularities greater than 1/8 inch in 10 feet in either the longitudinal or the transverse direction shall be corrected in a manner acceptable to the Engineer. When a bituminous concrete surface is to be placed on a bridge deck, the deviation shall not be greater than 1/4 inch. When a sheet membrane is being applied, sharp ridges shall not be allowed. Thin mortar or laitance, which may have accumulated ahead of the finishing machine screed, shall be removed from the work site. These materials shall not be used to fill depressions.

If the bridge deck concrete does not meet the above smoothness requirements, the Contractor shall remove high spots up to 1/2-inch high by means of grinding. Any other corrections shall be made only with the written approval of the Engineer. The use of bush hammers will not be allowed. No concrete shall be removed that will result in a concrete slab thickness less than that shown on the Plans.

Any deck that cannot be corrected by a method satisfactory to the Engineer shall be removed and replaced at the Contractor's expense.

Sidewalks shall receive their final finish with a fine bristled broom.

(2) Turf Drag. When specified on the Plans, the surface shall be given a suitable texture with an artificial turf drag made of molded polyethylene or other material or method that will provide an acceptable finish. The selection of turf drag or other method should be capable of producing a surface texture with a horizontal peak-to-peak distance ranging from 0.02 inch to less than or equal to 0.25 inch and having a peak-to-peak amplitude of 0.005 inch to 0.8 inch. A turf drag material or other acceptable method that will minimize tearing and rolling of coarse aggregate from the surface shall be used.

The Contractor shall apply the finish texture in a transverse direction using hand methods. Other directions may be allowed with the approval of the Engineer. All texturing shall be performed from a work bridge immediately following the finishing operations and prior to curing operations. A second work bridge will be required for curing purposes unless a method using a single work bridge has been approved by the Engineer.

One pass of the turf drag over the finished area is desired. The drag shall leave a seamless strip between passes. The finish texture resulting from the drag shall stop within 15 inches of the curb face, rail anchor bolts, or edge of deck. Any buildup of concrete at the beginning or end of the pass shall be hand troweled to provide an even transition.

The drag shall produce a transverse, skid-resistant micro-texture acceptable to the Engineer, but shall not tear the surface. If the drag is not producing an acceptable micro-texture, the Contractor shall adjust the means and methods until an acceptable micro-texture is achieved.

The Contractor shall check the drag material before the deck pour and from time-to-time during finishing for tears, worn surface, or hardened concrete. The Contractor shall clean or replace the drag as often as necessary to maintain a well-defined micro-texture.

The turf drag or other acceptable methods shall not be applied when the surface is so wet or plastic that the ridges formed flow back into the valleys when the drag has passed, nor shall dragging be delayed until the concrete is so hard that sharp ridges cannot be formed by the drag. Fogging or similar methods shall be deployed to ensure that the surface does not dry prematurely.

If the 10-minute maximum, as specified in Subsection 501.15(c), for applying the wet cure cannot be met, then fogging of the area shall be performed in a manner that keeps the relative humidity above the evaporation rate of the concrete surface, but not so excessive that water begins to collect on the surface prior to texturing or other surface manipulating procedures.

(3) Finishing Machine Rail Supports. Finishing machine rail supports shall be of substantial construction and accurately set so that the finished deck surface will conform to the profile and transverse sections shown in the Plans. Finishing machine rail supports shall be placed and adjusted to properly provide for the deflection of forms, falsework, and structural supporting members which will occur during the placement of the concrete.

The finishing machine rail supports shall be spaced at a maximum of 2 feet on center and of sufficient design as to secure the rail to prevent it from falling off the support. The screed rails shall be configured to allow the screed machine and work bridges to be fully functional over the entire deck area.

Sufficient screed rails shall be provided so that all rails necessary for any one continuous pour may be preset and graded before the start of concreting operations. The removal of screed rails and exposed chairs shall be accomplished without walking in the fresh concrete and while the concrete is still plastic.

The Contractor shall furnish a work bridge or bridges of an approved type, capable of spanning the entire width of the deck without deflection to the concrete slab surface.

(4) Finishing. After the concrete has been placed, it shall be struck off by a finishing machine and the operation shall be repeated as necessary to produce a uniformly consolidated, dense, smooth surface. The final passage of the finishing machine shall result in a uniform surface at the required grade and slope over its entire area.

Finishing machines shall be kept in true adjustment. Machines shall not be used until the proper adjustments have been made and the adjustments have been checked and approved by the Engineer.

Sufficient time shall be provided prior to beginning concreting operations for the finishing machine to be operated over the full length of the bridge deck segment to be placed. This test run shall be made with the screed adjusted to its finishing position. While operating the finishing machine in this test, the screed rails shall be checked for deflection and proper adjustment, the cover on slab reinforcement shall be measured, and the controlling dimensions of slab reinforcement and forms shall be checked.

After the concrete is placed, it shall be struck off by one of the following methods:

a. A self-propelled concrete finishing machine may be deployed, supported on suitable rails, and equipped with adjustable strike-off and finishing roller screeds capable of producing the required finish surface for the full width of the bridge from face-to-face of curbs.

b. An approved mechanical vibrating screed, capable of exerting a force of at least 12 pounds per linear foot and generating at least 6,500 vibrations per minute when checked by a vibration reed-type tester, may be deployed. The vibrating screed shall provide a uniform finish throughout its entire length and shall be properly adjusted so as not to drive the aggregate more than 1/4 inch below the surface.

The concrete finishing machine, or screed, shall be oriented perpendicular to centerline of the bridge. Screed supports shall extend beyond the end of the deck as needed to ensure that the finishing machine can operate over the full length of the bridge deck segment to be placed. The finishing machine or screed shall not be operated on a skew unless the Contractor is able to demonstrate by calculation that the design deck thickness and cross slopes can be maintained throughout the full length of the segment placed.

In areas that are inaccessible to finishing machines, an approved manual vibratory-equipped power screed with an approved grade-control method may be used with approval from the Engineer. Smoothness shall be checked as specified in Subsection 501.14(d)(1) to ensure a smooth ride and seamless transition to the finishing machine's finished area. If manual vibratory-equipped power screeds are used, then initial vibration of the concrete for consolidation in those areas shall be of the minimal duration possible to avoid over-vibration and loss of air entraining of the surface concrete in these areas.

Hand finishing will be allowed only in areas inaccessible to finishing machines or manually driven vibratory-equipped power screeds. Hand screeds or bull floats shall be magnesium and at least 10 inches in width. Care shall be taken not to overwork the concrete surface during any finishing operation. Smoothness shall be checked as specified in Subsection 501.14(d)(1) to ensure a smooth ride and seamless transition to the finishing machine's finished area.

501.15 CURING CONCRETE.

(a) General Requirements. Water for use in curing concrete shall conform to the requirements of Subsection 745.01. The effective cure time shall be only the time that the concrete has been maintained in a wet condition with the concrete surface temperature above 50°F. If the concrete is not maintained in a wet condition or the concrete surface temperature drops below 50°F, it shall not be counted as effective cure time. The cure period will be extended 4 hours for every 1 hour the concrete is below 50°F, beginning when the concrete temperature is raised to or exceeds the minimum curing temperature.

Regardless of the curing medium specified, the entire surface of the newly placed concrete shall be kept damp. This shall be achieved by applying water with a nozzle that atomizes the flow so that a mist and not a spray is formed. The moisture shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate in a quantity sufficient to cause a flow or washing of the surface.

The atomized flow shall be applied continuously until the surfaces can be covered by the specified curing mediums. For bridge barriers, curbs, and sidewalks the curing method shall be applied within 15 minutes of the completion of the finishing process.

Concrete components shall be cured for the times specified in Table 501.15A.

TABLE 501.15A – CURING TIMES FOR CONCRETE COMPONENTS

Type of Construction	Curing Methods	Effective Cure Time (Days)
Substructure	Subsection 501.15(b)(1), (2), (3), (5), (7), and (8)	7
Superstructure	Subsection 501.15(b)(2) and (8)	7 [1]
Retaining walls	Subsection 501.15(b)(1), (2), (5), (6), and (8)	7
Headwalls	Subsection 501.15(b)(1), (2), (5), (6), and (8)	7
Sidewalks, curbs, and gutters	Subsection 501.15(b)(2) and (8)	7

[1] There shall be no activity on the superstructure during the cure period.

(b) Curing Methods. All exposed surfaces of newly placed concrete shall be cured by one of the following specified methods:

(1) Water Curing. Curing with water shall be performed by continuously sprinkling or flooding all exposed surfaces with water for the entire required curing period.

(2) Burlap Curing. The entire exposed surface of the concrete shall be covered with two layers of approved burlap that has been pre-soaked with water. The burlap shall then be covered with a lapped layer of white polyethylene sheeting. Once the concrete superstructure has hardened sufficiently, a stream of water, applied with a soaker hose or similar device, shall be run continuously under the polyethylene sheeting until the cure period is complete.

(3) Sand Cover. The entire exposed surface of the concrete shall be covered with at least 3 inches of approved sand that shall be kept wet for the entire curing period.

(4) White Polyethylene Sheeting. The entire exposed surface of the concrete shall be covered with a blanket of white polyethylene sheeting, maintained and fastened to provide a nearly airtight condition in contact with the surface where possible. If, in the opinion of the Engineer, this cover is not adequately provided or maintained to ensure the proper conditions for the concrete cure, then the white polyethylene sheeting cure shall be terminated and another method substituted.

(5) White Burlap-Polyethylene Sheeting. The entire exposed surface of the concrete shall be covered with a blanket of white burlap-polyethylene sheeting. The burlap shall be thoroughly dampened prior to placing and shall be placed next to the concrete. All joints shall be lapped a minimum of 18 inches. The burlap shall be kept damp throughout the curing period.

(6) Membrane-Forming Curing Compounds. White-pigmented or fugitive-dye membrane-forming curing compounds may be used for curing concrete in minor drainage structures. All other uses of curing compounds shall be approved in writing by the Engineer. Only membrane-forming curing compounds approved by the Agency's Materials Testing and Certification Section shall be used.

When membrane curing is used, the exposed concrete shall be thoroughly sealed immediately after the free water has left the surface. The concrete inside the forms shall be sealed immediately after the forms are removed and necessary finishing has been done.

The solution shall be applied in one or two separate applications. If the solution is applied in two increments, the second application shall follow the first application within 30 minutes. Satisfactory equipment shall be provided, together with means to properly control and ensure the direct application of the curing solution to the concrete surface to result in a uniform coverage of the surface area at the rate of 1 gallon of solution for every 150 square feet.

If rain falls on the newly coated concrete before the film has dried sufficiently to resist damage, or if the film is damaged in any other manner, a new coat of the solution shall be applied to the affected portions equal in curing value to that specified above.

Should the surface be subject to continuous injury or the use of curing compound results in a streaked or blotchy appearance, the method shall be stopped and water curing applied.

(7) White Polyethylene Sheeting with Sand Cover. This method may be used only when approved by the Engineer and shall conform to the requirements of Subsection 501.15(b)(4). The airtight condition shall be obtained by the addition of a uniform sand cover with a minimum depth of 2 inches.

(8) Pre-Dampened Cotton Mats. The entire exposed surface of the concrete shall be covered with a blanket of cotton mats that has been pre-dampened with water. The mats shall be maintained in a damp condition until the curing period is complete.

If, in the opinion of the Engineer, the Contractor's curing procedure is not producing an adequate cure, the Engineer may direct a change in the cure method at no additional cost to the Agency.

(c) Bridge Decks. For bridge decks, the curing method shall promptly follow the screed machine, within a maximum lag time of 10 minutes and without interruption. If this lag time cannot be met, then fogging of the area shall be performed in a manner that keeps the relative humidity above the evaporation rate of the concrete surface, but not so excessive that water begins to collect on the surface prior to texturing or other surface manipulating procedures.

501.16 LOADING OF CONCRETE. After the concrete has been placed and the finishing operations concluded, it shall not be walked on or disturbed in any manner, including removal of forms, for a minimum period of 18 hours. If retarder is used as an admixture, this minimum period may be extended as directed by the Engineer.

(a) Substructure. No backfill material shall be placed against a newly completed structure unless the concrete cure is maintained in accordance with Table 501.15A, and until the field cured test cylinders have attained 85% of the compressive strength specified in Table 501.03A. However, the Contractor may erect forms for subsequent concrete placement on footings after 18 hours have elapsed from the time that the footing placement was completed, provided the concrete has sufficient strength to allow it to be worked on without damage, and proper cure is maintained.

Static loads, such as forms, reinforcing steel, or other materials necessary for construction, may be placed on any concrete after it has been in place 72 hours, or a compressive strength of 1,800 psi has been obtained, provided proper curing is maintained. Superimposed loads from subsequent concrete pours will not be allowed on any substructure unit or section in place until the field cured test cylinders have attained 85% of the compressive strength specified in Table 501.03A and provided curing of the supporting section is maintained in accordance with Table 501.15A.

(b) Superstructure. Static loads, such as forms, granite curbing, cast-in-place concrete curb, and other materials necessary for deck construction, shall not be placed on deck concrete until the effective cure time specified in Table 501.15A is complete and the field-cured test cylinders for this concrete have attained 85% of the compressive strength specified in Table 501.03A.

The Contractor shall keep bridge floors free of all motor vehicles, transit mixers, and heavy construction equipment until the curing period is satisfactorily completed, the field-cured test cylinders for the bridge floor concrete have attained the compressive strength specified in Table 501.03A, and the field-cured test cylinders for the curb concrete or bridge rail concrete, as applicable, have attained 85% of the compressive strength specified in Table 501.03A.

(c) Vertical Joints. Concrete shall not be placed against a vertical construction joint until the previously placed concrete has been in place a minimum of 72 hours.

501.17 METHOD OF MEASUREMENT. The quantity of Performance-Based Concrete, Class PCD; Performance-Based Concrete, Class PCS; and Performance-Based Concrete, Class SCC to be measured for payment will be the number of cubic yards of the class of concrete specified in the complete and accepted work, as determined by the prismoidal method using dimensions shown on the Plans or as directed by the Engineer.

The quantity of concrete shall exclude the volume of steel or other stay-in-place forms and form filling materials. No deductions will be made for the volume of concrete displaced by steel reinforcement, structural steel, expansion joint material, scuppers, weep holes, conduits, tops of piles, scoring, chamfers or corners, inset panels of 1-1/2 inches or less in depth, or any pipe less than 8 inches in diameter.

If a trial pour is performed at the request of the Engineer, the quantity of concrete to be measured for payment will be the number of cubic yards of the class of concrete specified for the trial pour, as determined by the prismoidal method using dimensions specified in the Contract or as directed by the Engineer.

501.18 BASIS OF PAYMENT. The accepted quantity of Performance-Based Concrete, Class PCD; Performance-Based Concrete, Class PCS; and Performance-Based Concrete, Class SCC will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for performing the work specified, including designing the mix, performance of trial pours, and satisfactory finishing and curing. Payment will also be full compensation for furnishing all forms, materials, including joint filler and bond breaker, labor, tools, admixtures, and equipment, including automatic temperature recording units, trial batches, and incidentals necessary to complete the work.

The cost of heating materials and protecting the concrete against cold weather, and any additional cost for cement, will not be paid for separately but will be considered incidental to the Contract unit prices for the applicable concrete pay items.

The cost of furnishing testing facilities and supplies at the batch plant and the setting of inserts, benchmarks, and bridge plaques furnished by the Agency will not be paid for separately but will be considered incidental to the Contract unit prices for the applicable concrete item.

Costs for all materials, labor, and incidentals for steel or other stay-in-place forms and form filling materials will not be paid for separately but will be considered incidental to the Contract unit prices for the applicable concrete item.

Payment will be made under:

Pay Item	Pay Unit
501.3700 Performance-Based Concrete, Class PCD	Cubic Yard
501.3800 Performance-Based Concrete, Class PCS	Cubic Yard
501.3900 Performance-Based Concrete, Class SCC	Cubic Yard

SECTION 502 – SHORING SUPERSTRUCTURES

502.01 DESCRIPTION. This work shall consist of furnishing the necessary shoring, or vertically jacking of any structure or bearing to a position immediately above its present location, holding it in position during any construction process, lowering it to its supports, removing all shoring or falsework, and cleaning up the site.

502.02 CONSTRUCTION DRAWINGS. Construction drawings shall be submitted in accordance with the requirements of Subsection 105.06. The Contractor shall submit the drawings and associated calculations, procedures, and details a minimum of 28 days prior to the anticipated start of work.

502.03 CONSTRUCTION REQUIREMENTS. Associated details, procedures, and calculations for shoring and jacking shall conform to the requirements of the *AASHTO LRFD Bridge Design Specifications* and *AASHTO LRFD Bridge Construction Specifications*.

The Contractor shall be responsible for the strength, capacity, and performance of the construction methods employed.

When components or materials that are not otherwise specified for removal are removed from the structure during shoring operations and the components or materials are to be re-installed in the construction, the components or materials shall be carefully removed and salvaged by the Contractor.

Components or materials to be retained and re-installed shall be stored at the location specified in the Contract or as directed by the Engineer.

The Contractor shall take every precaution necessary to prevent damage to remaining components or materials and those to be retained for re-installation. Damage to remaining structure components or materials and to those to be re-installed shall be repaired or replaced by the Contractor both to the satisfaction of the Engineer and at no additional cost to the Agency.

502.04 METHOD OF MEASUREMENT. The quantity of Shoring Superstructure to be measured for payment will be on a lump sum basis for each location in the complete and accepted work specified in the Contract or ordered by the Engineer.

Unless otherwise specified in the Contract, all work for removing, salvaging, stockpiling, and re-installing existing structure components or materials during the Contractor’s shoring operations will not be measured for payment but will be considered incidental to Shoring Superstructure.

The quantity of Shoring Superstructure Bearings to be measured for payment will be on a unit basis for each bearing shored in the complete and accepted work as specified by the Contract or ordered by the Engineer.

502.05 BASIS OF PAYMENT. The accepted quantity of Shoring Superstructure will be paid for each location specified at the Contract lump sum price. Payment will be full compensation for preparing and submitting construction drawings, details, procedures, and calculations as specified, performing the work specified including assuming all liability for the structure being shored and for furnishing all labor, tools, equipment, materials, and incidentals necessary to complete the work.

The accepted quantity of Shoring Superstructure Bearings will be paid for at the Contract unit price for each. Payment will be full compensation for preparing and submitting construction drawings, details, procedures, and calculations as specified, performing the work specified including assuming all liability for the structure being shored and for furnishing all labor, tools, equipment, materials, and incidentals necessary to complete the work.

Partial payments for these items will be made as follows:

(a) When the structure or bearing has been jacked and blocked onto its temporary position, a payment of 75% of the Contract unit price will be made.

(b) The remaining 25% of the Contract unit price will be paid when all shoring or falsework has been removed and the site cleaned up.

Payment will be made under:

Pay Item	Pay Unit
502.1000 Shoring Superstructure	Lump Sum
502.1100 Shoring Superstructure Bearings	Each

SECTION 503 – DRILLED SHAFTS

503.01 DESCRIPTION. This work shall consist of mobilizing and furnishing all materials, equipment, labor, and services necessary to construct drilled shafts in accordance with these provisions, the Plans, Section 506, Section 507, Section 541, and as directed by the Engineer.

503.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Mortar, Type IV .....707.01(e)
Bar Reinforcement 713.01
Steel Casing for Drilled Shafts 730.03
Water 745.01

Concrete shall conform to the requirements of Section 541 for Concrete, Class SCC, with the exceptions that the maximum aggregate size shall be 1/2 inch, the 56 day surface resistivity test is not required, and an anti-washout admixture shall not be used for underwater concrete. Additionally, concrete shall have a blocking assessment of "No Visible Blocking" during a period equal to the anticipated pour period plus 2 hours, as determined in accordance with *ASTM C1621*.

Temporary steel pipe piles shall be smooth walled structural steel.

Centralizers for bar reinforcement shall be constructed of a non-corrosive material that is compatible with and as durable as the shaft concrete.

Water shall have a pH conforming to the slurry requirements listed herein.

(a) Mineral Slurry. Mineral (bentonite) slurry shall remain in suspension with sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. The slurry percentage and specific gravity used to make the suspension shall be sufficient to maintain the stability of the excavation and allow proper concrete placement.

The acceptable ranges of values for mineral slurry are specified in Table 503.02A.

TABLE 503.02A – RANGE OF VALUES FOR MINERAL SLURRY AT 68ºF

Property	Test	Requirement
Density (lbs/ft^3)	Mud weight (density) (*API RP 13B-1, Section 1*)	64.3 – 72.0 [1]
Viscosity (sec./quart)	Marsh funnel and cup (*API RP 13B-1, Section 2.2*)	28 – 50
pH	Glass electrode, pH meter, or pH paper	8.0 – 11.0
Sand content immediately prior to placing concrete	Sand content test (*API RP 13B-1, Section 5*)	4.0% max.

[1] Unit weights stated are exclusive of weighting agents that may be proposed by the Contractor with the agreement of the slurry manufacturer's representative and the Agency.

Mineral slurry shall be de-sanded so that the sand content does not exceed 4% (by volume) measured 1 foot from bottom of shaft prior to concrete placement. All referenced tests shall be conducted by the Contractor with results presented to the Engineer. All necessary equipment and materials shall be provided by the Contractor.

(b) Polymer Slurry. Polymer slurry shall have sufficient viscosity and gel characteristics to stabilize the excavation and to transport excavated material to a suitable screening system. Polymer slurry (vinyl (dry) or natural polymers) shall be made from partially hydrolyzed polyacrylamide polymer (PHPA) (emulsified). The polymer slurry product shall be approved for use by the Agency.

Slurry properties at the time of mixing and at the time of concreting shall be in conformance with the written recommendations of the manufacturer. The use of a blended mineral-polymer slurry is not permitted.

The acceptable ranges of values for polymer slurry are specified in Table 503.02B.

TABLE 503.02B – RANGE OF VALUES FOR POLYMER SLURRY AT 68 ºF

Property	Test	Requirement
Density (lbs/ft^3)	Mud weight (density) (*API RP 13B-1*, *Section 1*)	64 max. [1]
Viscosity (sec./quart)	Marsh funnel and cup (*API RP 13B-1*, *Section 2.2*)	32 – 135
pH	Glass electrode, pH meter or pH paper	8.0 – 11.5
Sand content immediately prior to placing concrete	Sand content test (*API RP 13B-1*, *Section 5*)	1.0% max.

[1] Unit weights stated are exclusive of weighting agents that may be proposed by the Contractor with the agreement of the slurry manufacturer's representative and the Agency.

Polymer slurry shall be de-sanded so that the sand content is less than 1% (by volume) prior to concrete placement. All referenced tests shall be conducted by the Contractor with results presented to the Engineer. All necessary equipment and materials shall be provided by the Contractor.

503.03 PREQUALIFICATION.

(a) Drilled Shaft Contractor. The Contractor shall submit proof and details of the following:

(1) Three projects in the past five years where the Contractor or subcontractor performing the work has successfully installed drilled shafts of similar diameter, length, and difficulty as shown on the Plans, and a minimum of one project requiring similar on-site topographical and geotechnical conditions to those described in the Plans.

(2) The on-site superintendent shall have a minimum of two years of experience in supervising construction of drilled shaft foundations of similar size (diameter and depth) and difficulty to those shown on the Plans, and in similar geotechnical conditions to those described in the Contract. The work experience shall be direct supervisory responsibility for the on-site drilled shaft construction operations. Project management level positions indirectly supervising on-site drilled shaft construction operations will not be considered acceptable for this experience requirement.

(3) The drill rig operators shall have had a minimum of one year of experience installing drilled shafts with similar diameters and lengths, and in similar conditions.

Details describing the equipment and methods used, difficulties encountered and how they were overcome, and the results of any testing performed, shall be included. For each project cited, the name and telephone number of someone who can be contacted as a reference shall be included.

(b) Drilled Shaft Integrity Testing Firm. The Contractor shall submit the name of the drilled shaft integrity testing firm, and the names of the personnel who will conduct nondestructive QA testing and analysis of the drilled shafts. The testing firm and the testing personnel shall meet the following minimum qualifications:

(1) The testing firm shall have performed nondestructive tests on a minimum of two drilled shaft projects in the last two years.

(2) Personnel conducting the tests, performing the analysis, and preparing the report shall have a minimum of two years of experience in drilled shaft nondestructive testing and interpretation.

(3) The experience requirements for the firm and personnel shall be consistent with the testing methods the Contractor has selected for nondestructive testing of drilled shafts.

(4) Personnel supervising collection of the data and preparing test reports shall be a professional engineer.

The Contractor shall submit this information to the Engineer for review, evaluation, and approval prior to submitting detailed information as required under Subsection 503.04. The Engineer will render a decision within 7 calendar days after receipt of the submission. The Contractor or subcontractor will not be permitted to install drilled shafts without this approval.

The Engineer may suspend the drilled shaft construction if the Contractor substitutes unapproved field personnel without prior approval by the Engineer. The Contractor shall be fully liable for the additional costs resulting from the suspension of work and no adjustments in Contract time resulting from such suspension of work will be allowed.

503.04 SUBMITTALS. All approvals are subject to satisfactory field performance. Approval of a submittal does not relieve the Contractor or its subcontractor of their responsibilities to satisfactorily complete the work detailed in the Contract. If the approved submittal procedures do not produce satisfactory field performance, the Contractor will be responsible for submitting revised procedures. No further drilled shaft work will be allowed until the revised procedures have been approved.

(a) Drilled Shaft Installation Plan. The Contractor shall submit a drilled shaft installation plan that documents the proposed procedures and equipment for installing drilled shafts. The submittal shall include, but not be limited to, the following information:

(1) Proposed equipment for drilled shaft installation. This shall include a narrative describing equipment suitability to the anticipated site and subsurface conditions, including a project history of the drilling equipment demonstrating the successful use of the equipment on shafts of equal or greater size in similar subsurface conditions. A list describing the type of equipment to be used, including drill rigs, cranes, drilling tools, casing installation equipment, final cleaning equipment, de-sanding equipment, slurry pumps, bailing buckets, tanks, sampling equipment, tremies or concrete pumps, and any other equipment necessary for drilled shaft installation shall also be included.

(2) Drawings and details showing the proposed sequence of drilled shaft installation. The drawings shall include the sequence for each shaft, the overall construction sequence, areas that are planned to be used for staging, and detailed drawings of all over-water equipment for drilled shaft installation including containment measures to prevent drilling spoils from entering the water.

(3) Where a casing is proposed or required, detailed procedures for permanent casing installation and temporary casing installation and removal shall be provided. This shall include casing dimensions, material, and splice details. Welding procedures shall be submitted in accordance with Subsection 506.10 for permanent casing splices.

(4) Details of shaft excavation methods, including proposed drilling methods, methods for removal of sediment from the shaft bottom, and procedures for control, removal, and disposal of spoils. This shall include details of proposed methods to clean the shaft after initial excavation and details of proposed methods to check shaft bottom cleanliness.

(5) Details of the methods to be used to ensure drilled shaft hole stability (e.g. prevention of caving, bottom heave, etc., using temporary casing, slurry, or other means) during excavation and concrete placement. The details shall include a review of method suitability to the anticipated site and subsurface geotechnical conditions.

(6) Details of equipment and procedures for obstruction removal, including the types of chisels and grabs.

(7) Verification methods of final shaft dimensions and verticality. Include details of proposed corrective measures to be implemented as necessary.

(8) Description of equipment and methods to be used for drilled shaft inspection. The inspection program shall be thorough enough to assure the Engineer that each drilled shaft meets the requirements of these provisions.

(9) Description of equipment and methods to be used for drilled shaft integrity testing.

(10) Fabrication drawings in accordance with the requirements of Subsection 105.06 for the steel reinforcement cage including bar count, bend schedule, dimensions, splices, and bracing.

(11) Description of the type of feet and centralizers to be used to support the reinforcing steel cage in the drilled shaft.

(12) Construction drawings in accordance with the requirements of Subsection 105.06 for the methods and sequence of steel reinforcement cage erection, the temporary support, and the equipment to be used for erection. The erection plan shall identify specific lifting points on the cage and demonstrate that all of the erection equipment has adequate capacity for the work to be performed.

(13) Approved concrete mix design and the results of the blocking assessment test performed in accordance with Subsection 503.02.

(14) Details, methods, and procedures for concrete placement. This shall include concrete batching, delivery to the site, how concrete acceptance samples will be collected, quality control testing, proposed location for concrete acceptance testing, proposed operational procedures for concrete pump, initial tremie pipe insertion, raising tremie pipe during concrete placement, reinsertion of a tremie pipe if required, method to accurately monitor the volume of concrete being placed at all times during the placement, removal of waste concrete, and provisions to prepare the completed shaft top at its final shaft top elevation.

(15) Method used to fill or eliminate all voids between the plan shaft diameter and excavated shaft diameter, or between the shaft casing and surrounding soil, where permanent casing is specified.

(16) If slurry is used to construct the shafts, the submittal shall include the following:

a. The name and contact information of the slurry manufacturer’s technical representative assigned to the project.

b. The names of the Contractor's personnel assigned to the project and trained by the slurry manufacturer's technical representative in the proper use of the slurry. The submittal shall include a signed training certification letter from the slurry manufacturer for each individual, including the date of the training.

c. Detailed procedures for mixing, using, maintaining, and disposing of the slurry. A detailed mix design (including all additives and their specific purpose in the slurry mix), and a narrative describing its suitability to the anticipated subsurface geotechnical conditions, shall also be provided for the proposed slurry.

d. Detailed plan for quality control of the proposed slurry, including tests to be performed, test methods to be used, and minimum or maximum property requirements which must be met to ensure that the slurry functions as intended, considering the anticipated subsurface conditions and shaft construction methods, in accordance with the slurry manufacturer's recommendations and these specifications.

e. Description and details of the slurry sampling tool to be used. Tool shall be capable of taking a slurry sample at a specific depth, without being contaminated by slurry from another depth.

f. An alternate procedure to be used which will secure the shaft in the event of slurry loss or loss of slurry stabilization properties.

The Agency will review the submittal for compliance with the requirements of the Contract. If the drawings or procedures have misinterpreted the Plans or specifications, the submittal will be returned as rejected. The submittal shall not be marked as approved or approved as noted until all of the required information has been received and reviewed.

Once a complete submittal has been received, the Agency shall be allowed 21 calendar days for the initial review period and 14 calendar days for the review of each subsequent resubmittal.

The Contractor will not be permitted to install drilled shafts until the drilled shaft installation plan has been marked as approved or approved as noted by the Agency. The Contractor or fabricator shall assume all risk for materials ordered or work performed prior to written notification by the Agency. After the drilled shaft installation plan has been marked approved or approved as noted, no changes shall be made without the written approval of the Agency.

(b) Drilled Shaft As-Built Location Data. Actual drilled shaft location data shall be submitted to the Engineer within 1 working day after a drilled shaft is installed. The submittal shall include the following information:

(1) Drilled shaft location.

(2) Elevation of top of drilled shaft measured to the nearest 1/2 inch.

(3) Deviation from design plan location measured to the nearest 1/4 inch.

(4) Plumbness (deviation from vertical) as determined along the entire length of the shaft where required.

(c) Drilled Shaft As-Built Plan. Within 10 calendar days after the completion of installation of all drilled shafts, and before removing the drilled shaft installation equipment from the site, the Contractor shall provide the Engineer with a plan showing the as-installed location of all drilled shafts installed to the tolerances specified in the Contract.

503.05 CONSTRUCTION TOLERANCES. In-place tolerances for drilled shafts shall be as follows:

(a) The top of the shaft shall not vary horizontally from the location shown on the Plans by more than 3 inches for shafts supporting a single column less than 5 feet in diameter and otherwise by no more than 6 inches.

(b) The allowable tolerance from the required verticality is 2% for shafts socketed in rock and 1.5% for shafts that are not socketed in rock. This tolerance applies for the total length of shaft.

(c) The top of shaft elevation shall be within 1 inch above or 3 inches below the elevation shown in the Plans.

(d) Reinforcing steel projection elevation tolerance, after all shaft concrete has been placed, is ± 2 inches from the projection elevation shown in the Plans.

Drilled shaft excavations and completed shafts not constructed within the required tolerances are unacceptable. The Contractor shall submit written correction procedures to the Engineer for approval prior to correcting the deficiencies. The Contractor is responsible for correcting all unacceptable shaft excavations and completed shafts to the satisfaction of the Engineer at no cost to the Agency and without extension of the Contract completion date.

503.06 DRILLED SHAFT PRE-CONSTRUCTION MEETING. A drilled shaft pre-construction meeting shall be held after the approval of the drilled shaft installation plan, but prior to commencing construction of the drilled shafts. The purpose of the meeting will be to review all aspects of the drilled shaft construction and testing and to facilitate coordination between all parties involved.

Individuals attending the meeting representing the Agency shall include the Engineer, the Project Manager, the design engineer, the Structural Concrete Engineer, and the Geotechnical Engineering Manager.

Individuals attending the meeting representing the Contractor and subcontractor shall include the project superintendent and all foremen in charge of excavating the shaft, placing casing and slurry, placing reinforcing steel, and placing the concrete. A representative from the concrete producer shall also attend the meeting. If slurry is to be used, the slurry manufacturer shall be available by phone for technical assistance during this meeting. All parties shall be notified a minimum of 7 calendar days in advance of the meeting date.

If the Contractor proposes a significant revision of the approved shaft installation narrative, as determined by the Engineer, an additional conference shall be held before any additional shaft construction operations are performed.

503.07 CONSTRUCTION REQUIREMENTS.

(a) Casing. Welding for casings shall conform to the requirements of Subsection 506.10. The shaft casing shall be watertight and clean prior to being placed in the excavation and shall be installed or removed without disturbing the surrounding soil. Casings shall have inside diameters not less than the indicated shaft sizes and not more than 6 inches greater than the indicated shaft sizes.

Permanent casing shall be of ample strength to resist damage and deformation from transportation and handling, installation stresses, and all pressures and forces acting on the casing. It is the Contractor's responsibility to determine the final wall thickness necessary to meet these requirements. No appurtenances, reinforcement, or holes shall be added to the casings without approval of the Engineer.

Temporary casing shall be of ample strength to resist damage and deformation from transportation and handling, installation and extraction stresses, and all pressures and forces acting on the casing. The casing shall be capable of being removed without deforming and causing damage to the completed shaft, and without disturbing the surrounding soil.

(b) Production Shaft Installation Sequencing and Scheduling.

(1) Drilling, installation of reinforcing steel, and concreting shall be scheduled so that each drilled shaft is poured immediately after drilling is complete, the shaft is inspected and accepted by the Engineer, and reinforcing steel placed and accepted.

(2) The Contractor will not be permitted to schedule a concrete pour until it is demonstrated that the Contractor can achieve the required bottom of hole cleanliness to the satisfaction of the Engineer.

(3) Vibration or excessive wheel loads will not be allowed within the immediate vicinity of any drilled shaft. A stable shaft excavation shall be maintained at all times.

(c) Drilling and Excavation. The Contractor shall perform the excavations required for the shafts, through whatever materials are encountered, to the dimensions and elevations shown in the Plans or otherwise required by the Contract. The Contractor shall extend the drilled shaft base elevations when the Engineer determines that the material encountered during the excavation is unsuitable or differs from that anticipated in the design of the drilled shaft. The Contractor's methods and equipment shall be suitable for the intended purpose and materials encountered.

Pre-excavation, using appropriate sediment and turbidity controls when in or near waters of the state, may be needed to advance past shallow obstructions before installing casing.

(d) Obstructions. Obstructions may include man-made or man-placed materials and natural materials, including, but not limited to, logs, boulders encountered outside the strata identified on the boring logs, and man-made objects that in the judgment of the Engineer cannot be removed using conventional tools such as conventional augers, drilling buckets, or underreaming tools or reverse circulation drilling (if this is used as the primary drilling method). Reasonable effort shall include operating approved equipment at maximum power, torque, and down thrust for a period of at least 15 minutes with minimal forward movement. Surface and subsurface obstructions at drilled shaft locations shall be removed by the Contractor. Drilling tools that are lost in the excavation shall not be considered obstructions and shall be promptly removed by the Contractor without compensation.

When suspected obstructions are encountered, the Contractor shall notify the Engineer and recommend a course of action to advance the drill hole in an expedient manner. The Engineer will determine if an obstruction has been encountered.

(e) Slurry. The drilled shafts may be advanced using a controlled slurry or water to maintain the excavation. Slurry cannot be made from native materials, or material from the excavation. The level of slurry shall be maintained at a height sufficient to prevent caving of the hole. The slurry head shall remain above the piezometric head of the groundwater at all times during installation and cleaning out.

The slurry shall be pre-mixed, and adequate time for hydration shall be allowed prior to introduction into the shaft excavation. Adequate slurry tanks shall be provided when specified or when required by the Engineer. Mixing of the slurry shall not occur in the hole for the drilled shaft. Slurry pits will not be allowed without written permission from the Engineer.

Adequate de-sanding equipment shall be provided where required for slurry operations. Appropriate steps shall be taken to prevent slurry from setting up in the shaft excavation, such as agitation, circulation, and adjusting the properties of the slurry. Bentonitic slurry shall not sit unagitated for more than 4 hours.

If the unagitated bentonitic slurry is in the hole for more than 4 hours, or if caking develops, the sides shall be scraped to remove the filter cake before proceeding with the excavation.

The properties of the pre-mixed slurry shall be checked as slurry is introduced and periodically thereafter. Control tests shall be performed on the slurry to determine density, viscosity, and pH before and during shaft excavation to establish a consistent working pattern.

Immediately prior to placing shaft concrete, slurry samples shall be taken from the bottom and 10 feet from the bottom of the drilled shaft excavation using an approved slurry sampling tool. Any heavily contaminated slurry and spoil that has accumulated at the bottom of the shaft shall be removed. The slurry shall be within the specification requirements immediately before concrete placement.

If slurry is used, the slurry manufacturer’s technical representative shall:

(1) Provide technical assistance for the use of the slurry.

(2) Be at the site prior to introduction of the slurry into a drilled hole.

(3) Remain at the site during the construction and completion of a minimum of one shaft to adjust the slurry mix to the specific site conditions.

(f) Rock Socketing. If shafts are intended to be socketed into rock per the Plans, minimum rock socket lengths shall be as shown on the Plans. The top of rock socket elevation shown on the Plans has been estimated based on test borings and survey. The actual top of rock socket may vary in the field based on observations made by the Geotechnical Engineering Manager during drilling. The rock socket shall begin beneath any weathered or highly fractured rock encountered.

(g) Excavation Inspection. The Contractor shall provide equipment for checking the dimensions and alignment of each shaft excavation (moving drilling equipment against the sidewalls, weighted tapes, or other means approved by the Engineer). Electronic measuring equipment may be used but is not required. The Contractor shall determine the dimensions and alignment under the direction of the Engineer. The Contractor shall measure the final shaft depth after cleaning. Unless otherwise stated in the Plans, a minimum of 50% of the base of each shaft shall have less than 1 inch of sediment. Debris at any place on the base of the shaft shall not exceed 2 inches.

(h) Reinforcing Steel. Bar reinforcement shall be installed in accordance with Section 507. Ties shall be installed at every intersection between vertical and horizontal (or spiral) reinforcing. Centralizers shall be installed at the bottom and along the axial length of the steel reinforcing at sufficient spacing to maintain proper concrete cover. The longitudinal spacing shall not exceed 10 feet. A minimum of four centralizers shall be placed at each longitudinal spacing and shall be spaced no greater than 4 feet and equally spaced around the shaft circumference.

(i) Placing Concrete. Concrete placement shall commence as soon as possible after completion of drilled shaft excavation by the Contractor and inspection by the Engineer. Concrete placement shall continue in one operation to the top of the shaft, or as shown in the Plans.

Concrete shall be placed underwater by use of a concrete pump or tremie. A tremie shall have a hopper at the top that empties into a tube at least 10 inches in diameter constructed of heavy-gauge steel pipe with watertight joints. If a pump is used, a watertight tube with a minimum diameter of 4 inches constructed of heavy-gauge steel pipe with watertight joints shall be used.

Throughout the underwater concrete placement operation, the discharge end of the tube shall remain submerged in the concrete at least 5 feet until the work is completed, resulting in a seamless, uniform shaft. If at any time during the concrete pour the end of the tube is removed from the fluid concrete and discharges above the rising concrete level, a measurement will be made to determine the elevation and the shaft will be considered defective. The Contractor shall take appropriate and immediate action to correct the deficiency.

The Contractor’s construction operations in the vicinity of a drilled shaft excavation with freshly placed concrete and curing concrete are subject to the following restrictions:

(1) The Contractor shall not drive piling or advance drilled shaft casing in a 100 foot radius of a drilled shaft within 72 hours after the conclusion of placing concrete.

(2) During the time period between six hours before concrete placement operations and 7 calendar days after completing concrete placement operations, the Contractor shall not place and advance a casing, or perform drilling, within four shaft diameters of the centerline of the shaft.

(j) Shaft Top Preparation.

(1) The top-most concrete placed in the shaft shall be considered waste concrete and shall be removed by one of the following methods:

a. Pumped upward to a level a minimum of 24 inches clear distance above the Plan shaft top level and allowed to cure in place for removal later.

b. Placed a minimum of 24 inches above the Plan shaft top level via tremie, the casing dewatered prior to initial concrete set, and waste concrete removed in the dry by methods approved by the Engineer. The Contractor shall submit calculations demonstrating that the concrete in the shaft at the time of dewatering provides a minimum factor of safety against uplift of 1.25.

c. Pushed upward and ejected completely out of the top of the casing and wasted as final concrete is placed. Waste concrete shall be allowed to evenly overflow the full top circumference of the casing and may not channel or bleed off by notches or holes cut in the casing top. Any fresh concrete in the casing at a level above the Plan shaft top level after ejecting all waste concrete may be dipped or pumped out to the Plan shaft top elevation while still plastic by methods and equipment approved by the Engineer, or allowed to cure in place for removal later. If fresh concrete will be removed to the Plan shaft top elevation while still plastic, the Contractor shall submit calculations demonstrating that the concrete in the shaft at the time of fresh concrete removal provides a minimum factor of safety against uplift of 1.25.

Waste concrete shall be considered to be the top 24 inches of initial concrete placed, plus the height of any additional volume of waste concrete deposited in the shaft where concrete placement was halted and restarted, plus any additional amount necessary to produce full strength, non-segregated concrete at the Plan shaft top level.

(2) Final shaft top preparation may commence only once the drilled shaft concrete obtains an average unconfined compressive strength of 2,500 psi or, in lieu of concrete strength testing, beginning 7 calendar days after completion of concrete placement. Final top preparation steps shall consist of:

a. Cutting off any extra casing above the top of casing elevation.

b. Removing any cured over pour concrete to the Plan shaft top elevation by approved methods.

c. Dressing the final shaft top surface.

d. Verification by the Engineer that the exposed concrete consists of full-strength concrete without any signs of segregation or contamination.

e. Approved non-destructive strength testing by the Contractor where required by the Engineer to verify that concrete has full design strength.

f. Removal of additional concrete below the Plan shaft top level as necessary to reach full-strength, non-segregated concrete.

(k) Temporary Casing Removal. All temporary casing shall be removed unless otherwise approved by the Engineer. The Contractor may submit a request to the Engineer to leave some or all temporary casing in place. The Agency reserves the right to reject any and all proposals.

503.08 RECORDS. The Contractor shall keep a record, independent of that which may be kept by the Engineer, of all pertinent data relative to the installation of the drilled shaft. This record shall be available for the Engineer's inspection until the completion of the project, and a copy shall be transmitted to the Engineer within 3 calendar days of the completion of each shaft. For each shaft, this record shall include:

(a) Shaft location and dates of installation.

(b) Excavation log containing information such as the description and approximate top and bottom elevation of each soil or rock material encountered during shaft excavation, and any obstruction encountered.

(c) Slurry data.

(d) Total length of each shaft.

(e) Plumbness of shaft.

(f) Placement and condition of reinforcing cage.

(g) The time, method, and duration of the concrete placement.

(h) A log of the ambient and concrete temperatures at the time of placement.

(i) A comparison of the computed volume of the excavation (theoretical) with the volume of concrete placed (actual) and a plot of depth versus volume.

503.09 INTEGRITY TESTING. Drilled shaft integrity testing and analysis shall be conducted on all completed drilled shafts. The testing and analysis shall be performed by an integrity testing firm retained by the Contractor. The final test report shall be stamped and signed by a professional engineer and submitted to the Engineer for approval. When not otherwise specified in the Contract, the Contractor shall perform integrity testing in accordance with one of the following methods:

(a) Cross-Hole Sonic Log (CSL) Testing. CSL is a down-hole ultrasonic test method used to evaluate the condition of the concrete within drilled shafts. The test shall meet *ASTM D6760* requirements as modified herein.

The Contractor shall install access tubes for CSL testing in the drilled shafts to permit access for the CSL test probes. One tube per 1.0 foot of shaft diameter, rounding up to the nearest whole number of tubes, (e.g. 8 tubes for an 8 foot diameter shaft) shall be installed.

Access tubes for CSL testing shall be steel pipes with a minimum wall thickness of 0.145 inches and an inside diameter of at least 1-1/2 inches. The access tubes shall have a round, regular inside diameter free of defects and obstructions, including all pipe joints, in order to permit the free, unobstructed passage of 1.3 inch maximum diameter source and receiver probes used for the CSL tests. The Contractor shall securely attach the access tubes to the interior of the reinforcement cage for the shaft. The access tubes shall be equally spaced around the shaft, inside the spiral or hoop reinforcement and midway between adjacent vertical reinforcement. The access tubes shall be placed 2 inches clear of the vertical reinforcement. If these minimums cannot be met due to close spacing of the vertical reinforcement, then the access tubes shall be bundled with the vertical reinforcement.

The access tubes shall be installed in straight alignment and as near to parallel to the vertical axis of the reinforcement cage as possible. The tubes shall be secured, such that the tubes stay in position during reinforcement cage and concrete placement. The tubes shall extend from 6 inches above the shaft bottoms to a minimum of 2 feet above the top of the shaft. The tubes shall not be allowed to rest on the bottom of the drilled shaft excavation.

The access tubes shall be watertight and free from corrosion with clean internal and external faces to ensure a good bond between the concrete and the access tubes. The access tubes shall be fitted with watertight caps on the bottom and the top. Splice joints in the access tubes, if required to achieve full-length access tubes, shall be watertight. The Contractor shall clear the access tubes of all debris and extraneous materials prior to installing the access tubes. The access tubes shall be full of clean water prior to concrete placement. The caps shall be sealed to prevent debris from entering the pipes after the water is placed.

Testing shall be performed after the shaft concrete has cured for a minimum of 72 hours. Additional curing time prior to testing may be required if the shaft concrete contains admixtures, such as set retarding admixture or water reducing admixture. The additional curing time prior to testing required under these circumstances shall not be grounds for additional compensation or an extension of time. All CSL testing shall be completed within 7 calendar days of concrete placement.

After placing the shaft concrete and before beginning CSL testing of a shaft, the Contractor shall inspect the access tubes. Each access tube that the test probe cannot pass through shall be replaced, at the Contractor's expense, with a 2 inch diameter hole cored through the concrete for the entire length of the shaft. Unless directed otherwise by the Engineer, cored holes shall be located approximately 6 inches inside the reinforcement and shall not damage the shaft reinforcement. Descriptions of inclusions and voids in cored holes shall be logged and a copy of the log shall be submitted to the Engineer.

Any anomalies indicated by longer pulse arrival times and significantly lower energy signals shall be reported to the Engineer and further tests shall be conducted as required to evaluate the extent of possible defects. A written report shall be submitted within 5 working days of the completion of testing. The CSL testing and analysis results shall be presented to the Engineer in a report according to *ASTM D6760* requirements. A CSL log for each tube pair tested shall be presented with any defect zones identified on the logs. When required, 3D tomographic analysis shall be performed using all offset data, and color coded 3D tomographic images shall be included in the report.

Findings from cored holes shall be preserved, identified as to location, and made available for inspection by the Engineer.

Care shall be exercised in the removal of caps or plugs from the pipes after installation so as not to apply excess torque, hammering, or other stresses which could break the bond between the tubes and the concrete.

Upon completion of CSL testing and acceptance of the shaft by the Engineer, all water shall be removed from the access tubes and any cored holes. The access tubes and cored holes shall be filled using grout tubes that extend to the bottom of the access tube or cored hole or into the grout already placed. The grout used to fill access tubes and cored holes shall have strength properties equivalent to or better than those of the drilled shaft concrete and be approved by the Engineer. The access tubes and cored holes in a particular shaft shall not be filled with grout until all testing is completed and the shaft has been accepted by the Engineer.

(b) Thermal Integrity Profiling (TIP) Testing. TIP testing records the heat generated by the curing cement to assess the quality of the drilled shaft. The test shall meet *ASTM D7949, Method B* requirements as modified herein.

TIP equipment shall include a computer-based TIP data acquisition system that automatically collects data at user defined time intervals to monitor and download temperature versus time after casting. Wires shall be furnished with built-in sensors as recommended by the drilled shaft integrity testing firm.

Drilled shafts with TIP testing shall have the number of wires equal to the greater of 4 or the nearest whole integer value, rounded up, of the diameter of the drilled shaft measured in feet. Thermal wire cables shall be installed evenly in each drilled shaft by the integrity testing firm.

The thermal wire cables shall be aligned with the longitudinal reinforcement of the drilled shaft and wire slack shall be minimized. The thermal wire cables shall be tied to the longitudinal reinforcement at maximum 3-foot intervals.

Thermal wire cables shall be connected to a thermal access port (TAP) prior to concrete placement. The position and serial number of each thermal wire cable in the drilled shaft shall be recorded. TIP data collection shall begin immediately prior to the start of concrete placement and extend a minimum duration of 30 hours, or as recommended by the integrity testing firm and accepted by the Engineer The timing interval and duration may be revised by the integrity testing firm or the Engineer as the project conditions require.

Potential local anomalies shall be reported immediately to the Engineer, as indicated by locally low temperatures relative to the average temperature at that depth, or by average temperatures significantly lower than the average temperatures at other depths.

A written report shall be submitted within 5 working days of the completion of testing. The TIP testing and analysis results shall be presented to the Engineer in a report according to *ASTM D7949* requirements. The following information shall also be provided:

(1) Graphical displays of all temperature measurements versus depth with top and bottom of shaft adjustments made per the manufacturer's recommendations, so that temperature plots are adjusted for end effects.

(2) Indication of unusual temperatures, particularly significantly cooler local deviations of the average at any depth from the overall average over the entire length.

(3) The overall average radius computed from the actual total concrete volume installed and the estimated radius and shape of each shaft along its depth, as calculated comparing the temperature at each depth to the overall average temperature.

(4) All possible anomalies indicated in graphical displays and a summary of all possible anomalies, including a characterization and evaluation of the anomaly.

The Contractor shall not commence concrete operations in subsequent shaft excavations until the integrity test report has been submitted for the previously completed shaft and the Engineer has given approval. This requirement may be waived at the discretion of the Engineer.

503.10 ACCEPTANCE OF DRILLED SHAFTS. The Engineer will determine final acceptance of each shaft and will provide a response to the Contractor within 7 calendar days after receipt of the final integrity test report.

Unacceptable drilled shafts are drilled shafts that are rejected by the Engineer due to damage, failure to advance through obstructions, mis-location, misalignment, failure to install the drilled shaft to the proper bearing stratum, or the results of the shaft integrity testing indicate defects. Rejection of a shaft based on the shaft integrity testing shall require conclusive evidence that a defect exists in the shaft. If the shaft integrity test results are complex or inconclusive, the Engineer may require additional testing to confirm the location of the defect.

For all shafts determined to be unacceptable, the Contractor shall submit a remedial action plan to the Engineer for approval. If the remedial action plan requires any modifications to the dimensions of the shafts detailed in the Plans, they shall be supported by calculations and working drawings. All remedial correction procedures and designs shall be stamped and signed by a professional engineer and submitted to the Engineer for approval. The Contractor shall not begin repair operations until receiving the Engineer's approval of the remedial action plan.

If the Engineer determines that the concrete placed is structurally inadequate, that shaft will be rejected. The placement of concrete shall be suspended until the Contractor submits to the Engineer written changes to the methods of shaft construction needed to prevent future structurally inadequate shafts and receives the Engineer's written approval of the submittal.

At the Engineer's direction, a core hole (standard NX size rock core) shall be drilled in any questionable quality shaft (as determined from shaft integrity testing and analysis or by observation of the Engineer) to explore the shaft condition.

Prior to beginning coring, the Contractor shall submit to the Engineer the method and equipment used to drill and remove cores from shaft concrete. The Engineer shall issue written approval before the coring work can be started. The coring method and equipment shall provide for complete core recovery and shall minimize abrasion and erosion of the core.

If a defect is confirmed, the Contractor shall pay for all coring costs. If no defect is encountered, the Agency will pay for all coring costs as extra work and, if the shaft construction is on the critical path of the Contractor's schedule, compensation for the delay will be granted by an appropriate time extension.

Materials and work necessary, including engineering analysis and redesign, to effect corrections for shaft defects shall be furnished to the Engineer's satisfaction at no additional cost to the Agency.

503.11 METHOD OF MEASUREMENT. The quantities of Drilled Shaft in Earth and Drilled Shaft in Rock of the size specified to be measured for payment will be the number of linear feet of drilled shaft placed in the complete and accepted work (except where measurement is made for Drilled Shaft Obstruction Drilling and Removal as specified below) measured to the nearest 0.1 foot from the Plan top of concrete shaft elevation to the bottom of shaft. Measurement will be taken at the cross-sectional center of the shaft.

The quantity of Drilled Shaft Obstruction Drilling and Removal to be measured for payment will be the number of linear feet performed in the complete and accepted work, over the depth range in which obstructions are encountered, measured to the nearest 0.1 feet as determined by the Engineer. No measurement for Drilled Shaft in Earth or Drilled Shaft in Rock will be made within the limits of Drilled Shaft Obstruction Drilling and Removal.

The quantity of Mobilization of Drilled Shaft Equipment to be measured for payment will be on a lump sum basis in the complete and accepted work.

503.12 BASIS OF PAYMENT. The accepted quantities of Drilled Shaft in Earth and Drilled Shaft in Rock will be paid for at the Contract unit per price linear foot. Payment will be full compensation for excavation, dewatering, temporary or permanent casing, slurry, concrete, reinforcing steel, integrity testing, and grouting CSL tubes, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Drilled Shaft Obstruction Drilling and Removal will be paid for at the Contract unit price per linear foot. Payment will be full compensation for performing the work of overcoming encountered obstructions and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Mobilization of Drilled Shaft Equipment will be paid for at the Contract lump sum price. Payment will be full compensation for mobilization, remobilization, and demobilization of drilled shaft equipment from the project including the erecting, dismantling, and all incidental tasks necessary to complete the work, and the furnishing of all supervision, equipment, labor, tools, and incidentals necessary to complete the work.

Partial payments for Mobilization of Drilled Shaft Equipment will be made as follows:

(a) When drilling equipment has been set up and drilling operations start, 75% of the Contract lump sum price will be paid.

(b) The remaining 25% of the Contract lump sum price will be paid when the drilling operations are complete and the equipment has been removed from the site.

Costs associated with providing all submittals required as part of the work, and any necessary modifications thereto, will be considered incidental to the Contract items in this section.

Payment will be made under:

Pay Item		Pay Unit
503.1000	Drilled Shaft in Earth	Linear Foot
503.1500	Drilled Shaft in Rock	Linear Foot
503.2000	Drilled Shaft Obstruction Drilling and Removal	Linear Foot
503.2500	Mobilization of Drilled Shaft Equipment	Lump Sum

SECTION 504 – FURNISHING EQUIPMENT FOR DRIVING PILING

504.01 DESCRIPTION. This work shall consist of furnishing the equipment required to drive piles.

504.02 EQUIPMENT.

(a) General Requirements. The Contractor shall obtain a copy of the *Pile and Driving Equipment Data Form* from the Engineer. The Contractor shall complete this form in its entirety and shall submit copies to the geotechnical consultant employed by the Contractor when load tests are required, and to the Engineer so that a wave equation analysis may be performed.

At least 14 calendar days prior to the beginning of any pile driving, the Contractor shall furnish, for the Engineer's acceptance, specifications and applicable information to verify the capacity and capability of the proposed pile driving hammer. No test piles or production piles shall be driven prior to this acceptance. During the pile driving operations, no changes to the accepted equipment will be permitted without the Engineer's permission.

(b) Hammers. The type of hammer or driver shall be adequate in size to develop sufficient energy to drive the type and length of pile specified to the maximum ultimate pile capacity or nominal axial pile resistance shown on the Plans.

Each hammer shall be equipped with an anvil or clamp suitable for transmitting the driving force to the pile. The valve mechanism and the other parts of the air or diesel hammer shall be maintained in first class condition to ensure that the length of stroke for a single-acting hammer and the design number of blows per minute for a double-acting hammer will be obtained.

The drive head shall be axially aligned with the hammer and pile and shall be guided by leads and not be free-swinging. It shall fit around the pile head in such a manner as to prevent transfer of torsional forces during driving while maintaining proper alignment of the hammer and pile.

The pile driving equipment shall not induce a compressive stress greater than 90% of the yield stress of the pile material. In addition, the pile driving equipment shall be capable of driving the pile to the required ultimate capacity at a blow count of between 3 blows and 15 blows per inch as indicated by the wave equation analysis program (WEAP).

(c) Leads and Bracing. The Contractor shall locate and brace each pile so that upon driving, its final position and alignment will be as specified and as shown on the Plans. The selection of leads or form of bracing shall be adequate to align and restrain the piling during placement. If the leads or bracing are not adequate to place the piling to within the specified tolerance, the Contractor shall modify the leads or system of bracing until it obtains results acceptable to the Engineer.

(d) Hammer Cushion. All impact pile driving equipment except gravity hammers shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure uniform driving behavior. Hammer cushions shall be made of durable manufactured materials, such as Micarta, provided in accordance with the hammer manufacturer's guidelines. Wood, wire rope, or asbestos hammer cushions will not be permitted. A striker plate, as recommended by the hammer manufacturer, shall be placed on the hammer cushion to ensure uniform compression of the cushion material.

The hammer cushion shall be inspected in the presence of the Engineer prior to beginning pile driving at each substructure unit or after each 100 hours of pile driving, whichever is less. Hammer cushions shall be replaced when either damaged or worn to 75% of their original thickness.

(e) Saximeter. The Contractor shall provide a Saximeter or equivalent device to assist the inspector in collecting data to monitor the blow count (for all hammer types), the stroke (for open-end diesel hammers only), or the kinetic energy (if the hammer is equipped with proximity switches for measuring impact velocity). The Saximeter shall be completely charged and in sound working order prior to Agency use and shall be available for the duration of the pile driving operation. Pile driving operations shall not be conducted without the use of a Saximeter.

The Saximeter shall perform the following functions:

(1) Detect hammer blows automatically using sound recognition circuits, or manually with a keypad.

(2) Automatically count blows and determine the blows per minute (BPM) for all impact hammers.

(3) Calculate the stroke for open-end diesel hammers.

(4) Store blow count, penetration, average stroke, or BPM data in memory.

(5) Permit viewing of results on built-in screen.

(6) Permit data transfer to computers or printers.

For hammers equipped with proximity switches, the Saximeter shall be deployed to acquire hammer impact velocity data by communicating with a transmitter mounted on the hammer and use this information to calculate the hammer's kinetic energy.

The Saximeter shall operate on rechargeable batteries, with the batteries and charger supplied by the Contractor.

(f) Other Equipment. Other equipment required and not specified in this section shall be suitable for the use intended and shall be approved by the Engineer.

504.03 GENERAL REQUIREMENTS. The type and size of the equipment for driving piling shall be accepted by the Engineer prior to being moved onto the project. Unsatisfactory equipment shall be removed from the site and replaced with satisfactory equipment when directed by the Engineer.

504.04 METHOD OF MEASUREMENT. The quantity of Furnishing Equipment for Driving Piling to be measured for payment will be on a lump sum basis for furnishing the equipment to drive all piles required on the project.

504.05 BASIS OF PAYMENT. The accepted quantity of Furnishing Equipment for Driving Piling will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing and mobilizing the required equipment to the project and demobilizing equipment from the project, including the erecting, dismantling, and all incidentals necessary to complete the work.

The cost of all labor and materials, including operation and maintenance of the equipment for driving piles when used in connection with the driving of piles, except for the costs specified in this subsection, will be included in the Contract unit prices for the types of piles being driven.

Partial payments will be made as follows:

(a) When the equipment for driving piles has been set up and driving operations have started, a payment of 50% of the Contract lump sum price will be made.

(b) The remaining 50% of the Contract lump sum price will be paid when pile-driving operations are complete and the equipment has been removed from the site.

Payment will be made under:

Pay Item	Pay Unit
504.1000 Furnishing Equipment for Driving Piling	Lump Sum

SECTION 505 – PILING

505.01 DESCRIPTION. This work shall consist of furnishing and driving piles of the size and type specified, making field splices and performing pile load tests.

505.02 MATERIALS. Materials shall meet the requirements of the following subsections:

505.03 FURNISHING PILING.

(a) General Requirements. Piling shall be of the type and size shown on the Plans. The lengths shown for a structure are for estimating purposes only, unless otherwise specified.

(b) Steel Piling. Steel piling up to and including 20 feet in length shall be furnished in one un-welded piece. Steel piling over 20 feet in length shall be furnished with not more than the number of splices specified in Table 505.05A.

(c) Permanent Steel Sheet Piling. The length, type, and classification of permanent steel sheet piling shall be as shown on the Plans.

505.04 DRIVING PILING.

(a) General Requirements. Piles shall not be driven until approved mill test reports have been received and it has been verified that they correspond to the heat or lot numbers marked on the piles.

Piling other than sheet piling shall not be driven until the excavation has been made to the elevation shown for the bottom of the footing. In embankment areas, the fill shall be completed to the bottom of the footing elevation prior to driving any piles. Any material forced up between the piles shall be removed at the Contractor's expense to the correct elevation before concrete for the foundation is placed.

Driving shall be done in a manner that will not damage or overstress the piles.

All piling shall be driven to the required maximum ultimate axial pile capacity or nominal axial pile resistance and to the penetration depth as shown on the Plans. Under no condition shall the required maximum ultimate axial pile capacity or nominal axial pile resistance be less than that shown on the Plans except upon written approval of the Engineer.

When the Contractor proposes to use a vibratory or sonic method for driving piling, the Engineer reserves the right to require the Contractor to demonstrate that such methods are capable of driving the piles to the penetration and resistance shown on the Plans. Acceptance of this method shall be based on load tests on one or more piles driven by sonic or vibratory methods or verification of required maximum ultimate axial pile capacity or nominal axial pile resistance of one or more piles with an air, or diesel hammer. Verification of required maximum ultimate axial pile capacity or nominal axial pile resistance of sonic or vibratory driven piles shall be at the Contractor's expense.

Piling shall not be driven within 75 feet of any concrete footings or structures that have not cured for at least 72 hours or attained a compressive strength of 1,800 psi.

The placing of concrete and the driving of piles shall be scheduled so that fresh concrete and setting concrete will not be damaged by the pile driving.

Piles pushed up by driving adjacent piles or by any other cause shall be re-driven to the required maximum ultimate axial pile capacity or nominal axial pile resistance and to the required penetration depth as shown on the Plans.

Any pile damaged during installation, driven out of its proper location, or driven below the elevation shown on the Plans or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer:

(1) Withdrawing and replacing the damaged pile with a new and, if necessary, longer pile.

(2) Driving a second pile adjacent to the damaged pile.

(3) Splicing the damaged pile or extending the footing to properly enclose the pile. This will not be allowed for a substructure unit containing only a single row of piles.

(b) Tolerances. The piling after driving shall not vary more than 1/4 inch per foot from vertical or the specified batter. The Engineer may require that driving be stopped in order to check the pile for plumbness. Pulling or pushing laterally on piles to correct out-of-plumb errors, or splicing a section that meets the tolerances for plumb in this section on an out-of-plumb section will not be permitted.

The tops of foundation piling after driving shall not vary from the position shown on the Plans by more than 6 inches and shall have a minimum of 6 inches of concrete encasement.

The rotation about the vertical axis of the pile shall not vary by more than 5° from that shown on the Plans.

The Contractor shall demonstrate how the tolerances will be met to the satisfaction of the Engineer prior to driving. If the verticality, location, or rotation tolerances specified herein are exceeded, the extent of corrective measures will be evaluated by the Engineer. If, in the judgment of the Engineer, corrective measures are necessary, suitable measures shall be designed and constructed by the Contractor. The Contractor shall bear all costs, including delays, associated with the corrective action.

(c) Pile Load Tests. Pile load tests, when required, shall be performed prior to driving any production piles. When not driven as a permanent production pile, the test pile shall be driven near the substructure footing, at a location acceptable to the Engineer.

When pile load tests are required, the Contractor shall provide the services of a geotechnical consulting firm for dynamic testing of the test piles.

A dynamic load test pile may be used and paid for as a permanent production pile if it meets all of the following requirements:

(1) After testing is completed, the test pile meets all of the requirements for a permanent production pile (i.e. it is driven to the required maximum ultimate axial pile capacity or nominal axial pile resistance and to the required penetration depth as shown on the Plans).

(2) The test pile is driven at the correct location and with the correct batter and has not failed under test loading, is not damaged, and does not exceed maximum number of splices, etc.

(3) The use of the test pile as a permanent production pile is approved by the Engineer.

(d) Determination of the Maximum Ultimate Axial Pile Capacity or Nominal Axial Pile Resistance. These values shall be determined by dynamic loading tests, wave equation analysis, or a combination thereof, as follows:

(1) Dynamic Load Test. Dynamic monitoring of the test piles shall be conducted by the Contractor’s geotechnical consultant and results will be used by the Engineer to verify that the required maximum ultimate axial pile capacity or nominal axial pile resistance has been met.

In addition to equipment and services to dynamically monitor the pile driving, the Contractor's geotechnical consultant shall perform wave equation analyses (WEAP) as necessary to determine the suitability of the pile driving equipment proposed by the Contractor and to determine the preliminary driving criteria for testing. The geotechnical consultant shall submit copies of the wave equation analysis a minimum of 14 calendar days prior to the beginning of any pile driving. Also, the geotechnical consultant shall perform a laboratory case pile wave analysis (CAPWAP) for each test pile to verify the field results.

The geotechnical consultant shall provide a preliminary and final written report including all data collected and the results of both the WEAP and CAPWAP for each test pile in accordance with the requirements of *ASTM D4945*. The preliminary report shall be presented to the Engineer, when required, and the final report shall be submitted following completion of all load tests.

The effective capacity of battered piles shall be reduced by multiplying by the factors specified in Table 505.04A.

TABLE 505.04A – EFFECTIVE CAPACITY FACTORS FOR BATTERED PILES

Batter	Factor
1 to 12	0.99
2 to 12	0.97
3 to 12	0.95
4 to 12	0.92

As a guide, a pile may be considered driven to refusal when the driving resistance is 15 blows per 1 inch or 10 blows per 1/2 inch, but only when the hammer stroke is equal to or above the required stroke as specified in the wave equation analysis. This refusal value may be adjusted by the Engineer according to the results of the dynamic pile monitoring.

The Contractor's driving operations shall be monitored with a pile driving analyzer supplied and operated by the Contractor's geotechnical consultant during the installation and re-striking of the test piles. Dynamic pile load tests shall be performed on the test pile prior to driving production piles at any substructure. Production pile driving procedures may be adjusted based on the results from the pile driving analyzer.

Dynamic monitoring shall be performed in accordance with the requirements of *ASTM D4945* with equipment capable of determining the maximum force, velocity, and transmitted energy as well as the ultimate static bearing capacity computed by the case method for each pile tested. Gauges shall be attached to the pile approximately 3 feet below the pile head and connected with a cable to recording instruments on the ground, away from the pile. The gauge system shall include two accelerometers, two strain transducers, and a junction box. Dynamic monitoring shall be performed with the assistance of the Contractor, as specified in this subsection.

The Contractor may be required by the Engineer to modify the test pile driving operation based on the results from the pile driving analyzer.

The geotechnical consultant shall furnish the pile driving analyzer and supplemental equipment specified in these specifications. All test piles shall be monitored using the pile driving analyzer. The Contractor shall make the test piles available for drilling and tapping holes prior to driving. The geotechnical consultant shall furnish equipment, materials, and labor necessary for drilling and tapping holes in the test piles for attaching the monitoring instruments.

The Contractor shall provide the following support, items, and equipment:

a. Access. The Contractor shall provide the geotechnical consultant's personnel safe and reasonable means of access to the pile head for attaching transducers. A platform having a minimum size of 4 feet × 4 feet shall be equipped so that it may be raised to the top of the pile while the pile is located in the leads.

b. Power Source. The Contractor shall furnish an electric power source for the pile driving analyzer. If a field generator is used as the power source, it shall be equipped with functioning meters for monitoring voltage and frequency levels. Single-phase electricity, 10 amps, 120 volts AC, with a line frequency of 60 Hz shall be provided.

   Dynamic measurements shall be taken by the geotechnical consultant during full length driving of all test piles and during all re-striking of the test piles. The stresses in the piles shall be monitored to ensure that the driving stresses do not exceed 90% of the yield stress of the pile. The Contractor shall reduce the energy transmitted to the pile by using cushions or reducing the energy of the hammer to maintain the above criteria.

The Contractor shall assist in preparing the piles to be monitored with the necessary gauge attachments on opposite sides of the pile. The gauges shall be attached by drilling and threading appropriately sized holes. The estimated time for performing the above tasks is approximately 30 minutes per section of pile driven. The geotechnical consultant shall do the drilling and tapping of holes in each section to be driven. The Contractor shall assist in moving and giving access to the piles. All drilling and tapping of holes shall be done on the ground.

After the gauge attachments are prepared and all gauges and cables are removed from the pile segment, the Contractor shall lift and spot the pile according to normal procedures. The pile shall be made available for the installation of gauges after placing the pile in the leads. The Contractor shall then send one person up to the pile head to assist the geotechnical consultant in attachment of the gauges. The time required to ascend, complete the attachments, and then descend is estimated to be approximately one hour.

Pile driving during monitoring is typical of conventional driving. The cable from the gauges hangs freely down along the pile and to the monitoring equipment. The geotechnical consultant may temporarily stop the pile driving during the monitoring to review the data or change gauges or other equipment. The Contractor shall assist and cooperate with the geotechnical consultant as required during dynamic monitoring. Delays to pile driving due to dynamic monitoring after pile driving has begun should not exceed more than one hour per pile.

When the level of the gauges approaches the ground, the driving shall be halted to remove the gauges from the pile. The time required for removal of gauges is estimated to be about 30 minutes. If additional driving is required, the Contractor shall complete the pile splice and shall repeat the process of attaching gauges at the top of the next segment. The gauges shall be attached prior to continuation of driving.

Re-striking of all test piles is required. The minimum time between the end of initial driving and re-striking shall be 24 hours. Prior to re-striking the test piles, the dynamic testing gauges shall be reattached to the pile and the pile hammer shall be warmed up by striking at least 20 blows on another pile. Re-striking shall consist of either 2 inches of penetration or 30 hammer blows, whichever occurs first.

(2) Wave Equation Analysis. When load tests are not specified, the Engineer will verify the required maximum ultimate axial pile capacity or nominal axial pile resistance based on the Agency's wave equation analysis.

(e) Steel Sheet Piling. Permanent sheet piling shall be left in place as part of the finished structure.

(f) Steel Piling. Unless otherwise specified, the driving point of all piling, including test piling, shall be reinforced. Point reinforcement may be either a commercially fabricated weldment or a casting designed to protect the end of the pile during driving or for seating the pile on bedrock. Point reinforcement details shall conform to the Contract requirements and shall be approved by the Engineer.

Requirements for commercially fabricated weldments are:

(1) Point reinforcement cut sheets and welding procedures shall be submitted for approval in accordance with the requirements in Subsection 105.06.

(2) Weldments shall be fabricated so that the direction of rolling of weldment plates is in the same direction as the axis of the pile.

Pile flanges shall be welded to the outside faces of a pile point with a continuous bevel groove weld. The depth of the groove weld shall be at least 50% of the pile flange thickness but in no case less than 5/16 inch.

The minimum thickness of the cutting edge of the point shall be 1 inch or 150% of the flange thickness of the pile, whichever is greater.

When the Contract requires the piles to be driven to point bearing on bedrock, the bedrock bearing surface of the point shall have at least five cutting wedges, a minimum of one centered along the strong axis of the web and one on each corner of the flanges.

505.05 SPLICES.

(a) Splices for Steel Piling. Splices shall be made in accordance with details shown on the Plans at the locations approved by the Engineer. The maximum allowable number of splices are shown in Table 505.05A.

TABLE 505.05A – ALLOWABLE NUMBER OF SPLICES FOR STEEL PILING

Length (L) of Steel Piling (feet)	Maximum Number of Splices Allowed
$20 < L \leq 60$	1
$60 < L \leq 120$	3
$120 < L \leq 180$	5

All piles to be spliced shall be cut square and even, and the flanges shall be beveled in accordance with approved welding procedures. Webs shall be cut so that full bearing is obtained between the two surfaces. The splice shall be made in such a manner that the spliced pile shall be straight and true.

Welds shall be continuous and develop the full strength of the parts being welded.

When a substructure unit contains only a single row of piles, only one pile splice shall be allowed in the top 20 feet of that substructure unit, measured from the bottom of the pile cap.

(b) Splices for Steel Sheet Piling. Splices for steel sheet piling will not be permitted unless authorized in writing by the Engineer.

505.06 WELDING. Welding shall conform to the requirements of Subsection 506.10.

505.07 CUTTING OF PILING. Piling shall be cut to the elevations shown on the Plans or as ordered by the Engineer. Cut-offs shall remain the property of the Contractor.

505.08 METHOD OF MEASUREMENT. The quantities to be measured for payment will be measured as follows:

(a) Piling.

(1) Steel Piling. Steel Piling will be the total number of linear feet for each pile driven, accepted, and left in place, measured to the nearest linear foot.

If a test pile is driven within foundation limits and subsequently accepted as permanent foundation piling, measurement for payment as Steel Piling will be made for the test pile.

If a test pile is driven outside of foundation limits, no measurement for payment as Steel Piling will be made for the test pile

(2) Permanent Steel Sheet Piling. Permanent Steel Sheet Piling will be the total number of square feet of Permanent Steel Sheet Piling driven, accepted, and left in place after cut-off.

(b) Dynamic Pile Loading Tests. Dynamic Pile Loading Tests will be measured in units of one for each load tested pile. Any necessary retests shall be at the Contractor’s expense.

505.09 BASIS OF PAYMENT. The accepted quantities of piling will be paid for at the Contract unit prices as follows:

(a) Steel Piling. Steel Piling of the size specified will be paid for at the Contract unit price per linear foot.

(b) Permanent Steel Sheet Piling. Permanent Steel Sheet Piling of the type specified will be paid for at the Contract unit price per square foot.

Payment for the above specified items will be full compensation for furnishing, transporting, storing, handling, and placing the material specified, including metal collars, metal shoes, reinforcing material for ends of steel piling, reinforcing steel, splices, wales, and braces for steel sheet piling, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Dynamic Pile Loading Test will be paid for at the Contract unit price for each. Payment will also be full compensation for providing, cooperating with, and assisting the geotechnical consultant in the performance of dynamic testing, for providing dynamic testing equipment, and for re-striking the test pile. Payment will be full compensation for cutting off the test pile at the elevation directed by the Engineer, for preparing and submitting geotechnical reports, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment for furnishing and driving test piling driven outside of foundation limits will be included in the unit price bid for Dynamic Pile Loading Test.

Payment will be made under:

Pay Item		Pay Unit
505.1000	Steel Piling, HP 10 × 42	Linear Foot
505.1200	Steel Piling, HP 10 × 57	Linear Foot
505.1500	Steel Piling, HP 12 × 53	Linear Foot
505.1550	Steel Piling, HP 12 × 63	Linear Foot
505.1600	Steel Piling, HP 12 × 74	Linear Foot
505.1650	Steel Piling, HP 12 × 84	Linear Foot
505.1700	Steel Piling, HP 14 × 73	Linear Foot
505.1800	Steel Piling, HP 14 × 89	Linear Foot
505.1900	Steel Piling, HP 14 × 102	Linear Foot
505.2000	Steel Piling, HP 14 × 117	Linear Foot
505.3500	Permanent Steel Sheet Piling	Square Foot
505.4500	Dynamic Pile Loading Test	Each

SECTION 506 – STRUCTURAL STEEL

506.01 DESCRIPTION. This work shall consist of furnishing, erecting, and, when specified, coating fabricated metal structures and structural components.

506.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Unless otherwise specified in the Contract, all steel shall be high-strength low-alloy structural steel conforming to the requirements of *AASHTO M 270,* Grade 345W (Grade 50W).

All materials shall conform to the prescribed AASHTO or ASTM specifications and no substitutions will be allowed.

506.03 GENERAL FABRICATION REQUIREMENTS. Except as modified below, fabrication shall be performed in accordance with the applicable AASHTO design code, *ANSI/AASHTO/AWS D1.5* (hereinafter designated as *AWS D1.5*), and interim specifications in effect on the date of Contract advertisement. Unless otherwise indicated in the Contract, the applicable AASHTO design code shall be the *AASHTO LRFD Bridge Design Specifications*.

Structural steel furnished under this section shall be fabricated in a plant having an AISC Certified Bridge Fabricator – Advanced (ABR), or Intermediate (IBR) certification, and in a plant listed as a Category 1 fabricator on the Agency's *Pre-Qualified Fabricator List* prior to Contract execution. Structural steel components such as bridge rail, bridge joints, bridge bearings, overhead sign structures, and components for the repair of superstructures consisting of only cutting and drilling (no welding) which are fabricated under this section may be fabricated in a plant that does not have an ABR or IBR certification, provided that the fabrication plant has either an AISC Certified Bridge Fabricator – Simple (SBR) certification or an AISC Bridge Component QMS certification, and is listed as a Category 2 fabricator on the Agency's *Pre-Qualified Fabricator List* prior to Contract execution.

Minor steel components, including, but not limited to, downspouts, scuppers, and pedestrian hand railings may be fabricated in a plant that does not have an AISC certification, provided that the fabrication plant is approved in writing by the Structural Steel Fabrication Engineer prior to Contract execution. All plants without certification shall have an organization, operation, and equipment capable of producing a product equal to a certified plant. These plants will be reviewed on a case-by-case basis.

Structural steel that is to be painted or metalized under this section shall be coated in a plant having an AISC Sophisticated Paint Endorsement – Enclosed or SSPC-QP 3 – Enclosed Shop certification and which is listed as a Category 3 fabricator for the applicable coating on the Agency's *Pre-Qualified Fabricator List* prior to Contract execution. Structural steel that is to be galvanized or powder coated under this section shall also be coated in a plant listed as a Category 3 fabricator for the applicable coating on the Agency's *Pre-Qualified Fabricator List* prior to Contract execution.

The Agency's *Pre-Qualified Fabricator List* can be found on the Agency's website. It is the responsibility of the fabricator to verify that they are on the list prior to bidding on work. It shall be known that being included on the list does not waive any certification requirements that are required for performing the intended work. Any fabricator who has been pre-qualified but does not perform any work for the Agency for a period of 5 years will be automatically removed from the list without notice. It is the fabricator's responsibility to re-apply if they desire to be included on the list again.

When certified fabrication or coating plants are required, the plant shall maintain certified status throughout the duration of the work under the Contract.

The Agency reserves the right for the Structural Steel Fabrication Engineer to give written notification to any fabricator (regardless of certification level or status) restricting the types of items that they are approved to fabricate, up to and including restricting all structural steel fabrication for the Agency. Causes for such restrictions shall include concerns of quality, production, accountability, or any other cause that is deemed justifiable by the Agency.

The fabricator shall demonstrate full capability for fabricating materials meeting the requirements of the Contract. Failure to meet Contract requirements will result in rejection of the material being fabricated and the termination of the ability to fabricate material for the Agency.

Prior to performing any work under this section, the fabricator shall have received approval for all fabrication drawings, welding procedures, and any special Contract requirements and have notified the Agency's Structural Steel Fabrication Engineer in writing at least 10 working days in advance of fabrication. The Contractor shall bear full responsibility and costs for all materials ordered, raw materials stockpiled, or for work performed prior to approval of the fabrication drawings or written authorization from the State Bridge Engineer.

Except as noted in this subsection, all work shall be performed by the fabricator indicated on the approved fabrication drawings, unless otherwise authorized in writing by the Structural Steel Fabrication Engineer. For coatings, if the fabricator intends to use a subcontractor, it shall be clearly outlined on the fabrication drawings to be submitted for review. At a minimum, the provided information shall include the subcontractor's name and address; the name, phone number, and e-mail address of the quality control contact; and an acknowledgement of the Agency quality assurance inspection requirements which apply to the subcontractor.

If the fabricator wishes to request the use of a subcontractor for material processing (e.g. cutting, drilling, bending, rolling, punching, machining, etc.), they shall include this information on the shop drawings that are submitted for review or they shall submit a set of the previously approved shop drawings to the Agency for review, with the requested changes and required information clearly marked and indicated (e.g. by making all additional notes red). At a minimum, the submittal shall include the subcontractor's name and address; the name, phone numbers and e-mail address of the quality control contact; an acknowledgement of the Agency quality assurance inspection requirements which apply to the subcontractor; and clear information on the extent and limits of work to be performed by the subcontractor.

Requests will be evaluated on a case-by-case basis and may be rejected by the Agency for any reason. Use of a subcontractor does not relieve the fabricator of any responsibilities or quality control requirements specified by the Contract.

All steel fabrication plants shall satisfy the following minimum requirements:

(a) Reference Materials. The plant shall have a library containing the latest editions of the following publications:

(1) *AWS A5.1, AWS A5.5, AWS A5.17, AWS A5.18, AWS A5.20, AWS A5.23, AWS A5.28, AWS A5.29, AWS C2.18, AWS C2.23, AWS D1.1, AWS D1.2, AWS D1.3, AWS D1.4,* and *AWS D1.5*

(2) *AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Part I* and *Part II*

(3) *AISC Steel Construction Manual* and *Detailing for Steel Construction*

(4) Vermont Agency of Transportation *Standard Specifications for Construction*

(5) *AASHTO LRFD Bridge Design Specif*ications

(6) *AASHTO LRFD Bridge Construction Specifications*

(7) *AREMA*, when applicable

(8) *ASNT SNT-TC-1A*

(9) *SSPC Steel Structures Painting Manual, Volume 1* and *Volume 2*

(10) *AASHTO/NSBA G1.1*

In addition to the above, access to the latest editions of any applicable ASTM standards is required.

(b) Files. The fabricator shall maintain an organized file containing the following records:

(1) Records of material purchased

(2) Inventory of material in stock

(3) Certification records of all material and welding supplies

(c) Personnel. Fabrication personnel shall meet the following minimum requirements:

(1) Inspectors. Quality control inspectors shall be onsite full-time during any hot work (e.g. burning, heating, welding, etc.), as well during as any operations that may affect the quality of the coating system.

a. Fabrication Inspectors. The fabricator's representative responsible for fabrication inspection, testing and quality matters shall be qualified and certified in accordance with the provisions of *AWS QC 1*.

b. Coating Inspectors. The fabricator's coatings quality control manager shall possess a minimum classification as a NACE Coating Inspector Level 2 – Certified, SSPC Bridge Coatings Inspector (BCI) Level 2, or SSPC Protective Coatings Inspector (PCI) Level 2. The coatings quality control inspector shall possess a minimum classification as a NACE Coating Inspector Level 1 – Certified, SSPC Bridge Coatings Inspector (BCI) Level 1, or SSPC Protective Coatings Inspector (PCI) Level 1.

(2) Welders. Welders shall be certified for each process and position of prequalified joints in the approved welding procedures, including tacking, in accordance with the requirements of *AWS D1.5* for all structural bridge items and *AWS D1.1* for items not covered in *AWS D1.5*.

(d) Material Fabrication Facilities.

(1) All fabrication shall be performed in an enclosed permanent structure, unless otherwise approved by the Structural Steel Fabrication Engineer.

To meet minimum requirements, a plant shall have the following facilities:

a. Dry storage for manual electrodes and fluxes

b. Ovens with proper temperature ranges for drying electrodes and fluxes

c. Calibrated tools, gauges, tapes, and instruments

d. Suitable preheating equipment and means for measuring preheat temperatures

e. DC and AC manual shielded metal arc welding equipment capable of an output of at least 500 amps

f. Mechanically guided burning equipment

g. Machine shop facilities sufficient to perform the work specified

h. Facilities and equipment for applying shop paint to perform the work specified

i. Blast cleaning equipment suitable for preparing a surface meeting the requirements of Subsection 506.14

j. Suitable storage for materials and finished products

(2) A plant engaged in fabrication of plate girders, rolled beams, and other main member components requiring continuous welds over 2 feet in length shall also have the following equipment:

a. Automatic arc equipment

b. Semiautomatic arc equipment

c. Stud-welding equipment capable of installing a 7/8-inch diameter stud, when applicable

d. Equipment suitable for heat curving or heat cambering

e. Hydraulic jacking equipment suitable for aligning and positioning structural components

(3) Adequate office facilities and equipment for the Agency's quality assurance inspector shall be separate from the quality control facilities and shall include the following items:

a. A standard office desk with drawers, locks, and keys

b. Adjustable office chair

c. Telephone

d. Plan rack and file cabinet with lock and keys

e. The following tools shall be available for the inspector's use:

1. Weld gauges

2. Micrometer

3. Dry and wet film paint gauge

4. 10-foot steel measuring tape

5. 100-foot steel measuring tape

6. 6-foot straightedge

7. Temperature and marking crayons

8. Ambient air thermometer

9. 2-foot level

10. 2-foot carpenter's square

The Structural Steel Fabrication Engineer reserves the right to reject inadequate office facilities and require suitable alternatives.

(e) Testing Equipment. When code requirements necessitate nondestructive testing for quality control or quality assurance, the fabricator shall have available the necessary nondestructive testing equipment for material or weld inspection (such as magnetic particle, radiograph, ultrasonic, or dye penetrant) or employ an outside inspection firm to fulfill the necessary nondestructive test requirements of the code. Nondestructive tests shall be performed in accordance with the applicable code in effect on the date of Contract advertisement.

506.04 DRAWINGS AND PROCEDURES.

(a) General Requirements. As soon as practical after Contract execution, the fabricator shall prepare fabrication drawings in accordance with the requirements of Subsection 105.06. Drawings, details, and welding procedures shall be submitted as a complete package for each structure.

The Agency will review fabrication drawings, details, and procedures for their compliance with the Contract. The Agency will refer to the requirements of *AASHTO/NSBA G1.1*, *Section 4* and use them as the basis for the review of structural steel fabrication drawings.

The Agency assumes no responsibility for dimensions and other information calculated by the fabricator. The fabricator is responsible for the fit of all components. If errors occur that cause problems during erection, the Contractor is responsible for making acceptable corrections.

The Agency is responsible for all principal dimensions and material properties contained in the Contract. The fabricator and Contractor are responsible for bringing to the Agency's attention any errors or discrepancies they discover.

The fabricator is responsible for dimensioning members and ordering material to compensate for weld shrinkage, distortion, elastic deformation, sweep, slope, machining, waste from cutting, and other incidentals that are affected by the fabrication process.

(b) Details. Details not shown on the Plans that are necessary for completing the fabrication drawings shall be developed by the fabricator.

The fabrication drawings shall provide a material list on each sheet for tabulating the number of pieces, piece marks, description, dimensions, type of material, and weight of each piece. When the Contract item pay unit is on a per pound basis, the weight of each piece shall be extended and summarized for each sheet as specified in Subsection 506.22. Weight extensions (extended weights) shall be submitted to the Agency upon completion of fabrication.

All welds shown on the fabrication drawings shall identify, by symbol, the applicable procedures and appropriate nondestructive testing requirements. A separate symbol shall be used to identify each approved welding procedure.

(c) Welding Procedures. Detailed welding procedures shall be prepared in accordance with the provisions of the applicable AWS, ANSI, and AASHTO code revisions and submitted in accordance with the following:

(1) All procedures shall be prequalified. Procedure qualification test records shall be submitted along with each procedure. Heat input values during welding shall be shown for each procedure (except for SMAW procedures). All weld procedure sheets shall identify the project name, number, structure, and procedure qualification record or fillet weld soundness test.

(2) Procedure qualification test records and welding procedure specifications shall be presented in a format similar to example forms as shown in *AWS D1.5* and *AWS D1.1* as applicable.

(3) Details of welded joints shall conform to the standard joint details per *AWS D1.5* (or *AWS D1.1* as applicable) unless otherwise approved by the Structural Steel Fabrication Engineer.

(d) Revisions. Adjacent to or incorporated with the title box of each sheet shall be a revision record box including provision for the date of revision, symbol of revision number, revision made by, and description of each revision. As changes or revisions are made to previously approved sheets, the appropriate information shall be recorded, a revision number symbol placed adjacent to the appropriate detail, and the sheet resubmitted for approval. It is the fabricator's responsibility to transfer all as noted corrections to the originals.

Revisions of welding procedures shall also be resubmitted as they occur.

(e) Approval of Procedures. All weld procedures, heat corrective procedures, coatings procedures, and any other procedures that are required to be submitted for approval, and are being used in production, shall bear an Agency approved or approved as noted stamp.

506.05 QUALITY ACCEPTANCE. Quality acceptance is inspection of fabrication by the Agency or the Agency's representative (quality assurance inspector), to verify compliance with these specifications. Acceptance of materials, test results, or completed fabricated items by the quality assurance inspector or Structural Steel Fabrication Engineer does not relieve the fabricator of any responsibility to meet Contract requirements and specifications. The Contractor shall refer to the Agency's *Quality Assurance Manual for Metal Fabrication* for more information.

(a) Scope of Work. Inspection will include the examination of materials, processes, quality of work, reports, and test results; the performance of tests specified; the evaluation of reports and tests; the approval, disapproval, or rejection of materials, processes, quality of work, reports, and test results; or other work specified or directed by the Engineer.

(b) Control of Work. The quality assurance inspector is a representative of the Engineer and will perform all the duties assigned and delegated to the Engineer in Section 105 as they pertain to the Contract except for measuring quantities of materials and payment thereof. The inspector will witness, interpret, and accept or reject all testing.

Inspection of the work will conform to the requirements of the applicable AWS, ANSI, and AASHTO codes and specifications referenced in the Contract.

(c) Tools and Equipment. Quality assurance inspectors are expected to furnish their own personal safety equipment. They may make use of any tools the fabricator is required to make available, however, the fabricator is responsible for verifying that the equipment is properly calibrated and in working order.

506.06 QUALITY CONTROL.

(a) General Requirements. Quality control is the inspection, testing, and management of quality matters necessary for producing a product that conforms to the requirements of the Contract. The fabricator is responsible for quality control.

The fabricator is responsible for performing all nondestructive tests required by the Contract and any nondestructive tests necessary to determine the extent of metallurgical defects discovered in the base metal.

(b) Qualifications of Inspectors. Inspectors shall meet the requirements of Subsection 506.03(c).

(c) Nondestructive Testing. The fabricator shall notify the Agency sufficiently in advance of any scheduled nondestructive testing so that all tests can be witnessed by an Agency quality assurance inspector. Nondestructive tests shall be performed in accordance with the requirements of *AWS D1.5*.

Personnel performing and interpreting nondestructive tests (radiographic (RT), magnetic particle (MT), ultrasonic (UT), and dye penetrant (PT)) shall be NDT certified for Level II qualification in accordance with *ASNT SNT-TC-1A*.

(d) Ultrasonic Testing. Ultrasonic testing will not be permitted as a substitute for radiographic testing. However, ultrasonic testing may be used by the fabricator to determine the extent of discontinuities, laminations, and inclusions discovered in any weld or base metal.

(e) Testing of Overhead Traffic Sign Structures, Mast Arms, and Strain Poles. Nondestructive testing of overhead traffic sign structures, mast arms, and strain poles shall be in accordance with the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* as well as the following:

(1) Fillet Welds. If any fillet welds examined require a welded repair, an additional 10% of the original lot shall be examined using MT. If any welds in the second 10% require a welded repair, all welds in that production lot shall be tested using MT.

(2) Partial Joint Penetration (PJP) Welds. If any PJP welds examined require a welded repair, all remaining PJP welds in that production lot shall be tested using MT.

For the purposes of this subsection, a production lot shall be defined as a day's production on any given project.

506.07 MATERIAL IDENTIFICATION.

(a) Material Traceability. The origin of each piece of material to be incorporated in a product shall be clearly identified at all times during the fabrication of the product. If fabrication operations could obliterate the identity, the fabricator may use a low stress die stamp placed in an area not exposed on the finished structure. The die stamp character size shall be a minimum of 1/8 inch and a maximum of 1/4 inch. Nonmetallic materials shall be identified to the satisfaction of the Engineer.

When requested, the Contractor shall furnish an affidavit certifying that throughout the fabrication operation identification of the steel has been maintained in accordance with this specification.

When a steel stamp identification is used at a tension joint transition, the impression shall be placed on the thicker of the members.

506.08 BASE METAL REQUIREMENTS. When backing bars, extension bars, and runoff plates are part of a welding process, the material used shall be of the same chemistry as the base metal.

Discontinuities, laminations, inclusions, or other anomalies discovered in the base metal during the manufacturing process shall be individually evaluated. The Agency may require nondestructive testing to determine the extent of the defect. Repair procedures or replacement will be approved on an individual case basis.

Rolled beams shall be ordered from the mill without camber, unless pre-approved in writing by the State Bridge Engineer.

Main members are defined as compression members, tension members, and members subject to reversals of stress, including stringers, girders, cover plates, rigid frames, floor beams, gusset plates, and curved girder cross frames. Other members may be indicated in the Contract as main members.

Material for main members shall be ordered and prepared so that the direction of rolling is parallel to the stress in the member, in accordance with the requirements of *AASHTO LRFD Bridge Construction Specifications, Section 11.4.3.1*. Charpy V-notch (CVN) testing shall be performed as required in Subsection 714.01.

Members identified as fracture critical shall be subject to additional base metal requirements as specified in Subsection 506.11.

506.09 PREPARATION OF BASE METAL. Material flame cuts by any thermal cutting process shall be made with an approved mechanically-guided torch.

The fabricator shall use preheating, post-heating, or control of the cutting process to ensure that flame-cut edges of main members of structural steel are not flame-hardened. Flame-cut edges that will not be included in a permanent weld shall have a Rockwell hardness value not greater than C30.

When pieces are to be bent during fabrication, bending shall be performed in accordance with the requirements of *AWS D1.5* and the applicable design code as defined in Subsection 506.03.

Cold bending of main members will not be permitted without written approval of the Agency. This approval may limit the radius of curvature and require nondestructive testing to verify that no internal distress or separation has occurred. Expenses incurred in performing any such nondestructive test examination shall be the responsibility of the fabricator.

506.10 WELDING.

(a) General Requirements. All design details, quality of work, procedures, and inspection of welding shall conform to the requirements of the *AWS D1.5*. For welding items other than those covered in *AWS D1.5*, the Contractor shall adhere to *AWS D1.1*, *AWS D1.2*, *AWS D1.3*, or *AWS D1.4* as applicable.

Welding will not be permitted without approved welding procedures and fabrication drawings meeting the requirements of Subsection 506.04.

Welding and inspection of shear connectors shall conform to the requirements of Section 508.

Stitch welds are not permitted, however, the skip-and-fill technique may be used when applicable to prevent distortion.

Prior to performing any corrective weld repairs to base metal, the fabricator shall do the following:

(1) Submit the proposed repair procedure to the Agency's Structural Steel Fabrication Engineer in writing. Corrective procedures for radiographed butt welds may be included in the welding procedure.

(2) Receive written authorization from the Agency to proceed. Repair procedures detailed in an approved welding procedure may be authorized by the Agency's quality assurance inspector.

The fabricator will be permitted a maximum of two repairs on any given welded joint. Should nondestructive test inspection indicate weld rejection after two repairs, the Agency may reject the entire weld and require its removal.

(b) Welding Processes. Shielded metal arc welding (SMAW) conforming to the requirements of *AWS D1.5, Section 1* shall be deemed prequalified. Submerged arc welding (SAW), flux core arc welding (FCAW), and gas metal arc welding (GMAW) shall be subject to qualification testing as described in *AWS D1.5* prior to approval. Other processes may be approved, on a project-by-project basis, provided procedure qualification results meet the specified acceptance criteria.

Submerged arc welding (SAW) shall be used for all principal welds, as follows:

(1) The fully automatic process shall be used for attaching cover plates, flange to web welds, and attaching connection or stiffener plates to girder webs.

(2) The semiautomatic process may be used when joint length, position, or physical location restricts the use of the automatic process.

The manual shielded metal arc welding process shall be limited to attaching connection plates to rolled beams, welding bearing assemblies, repairs, tack welding, joints under 24 inches in length, minor attachments, and other applications where the use of an automatic process is impractical.

When prior authorization has been granted, the GMAW and FCAW processes will be limited to indoor shop welding of bridge rail, expansion joints, cross frames, bearing devices, scuppers, sign fixtures, light fixtures, and low-stressed members or components. Gas metal arc welding-short circuit arc (GMAW-S) will not be permitted.

Any gas shielded process subject to wind velocities in excess of 5 mph shall be protected using draft barriers.

(c) Shop Welding. The fabricator shall maintain a file of the qualifications of all welders, welding operators, and tackers qualified in accordance with the requirements of *AWS D1.5*. Requalification may be required in accordance with the requirements of *AWS D1.5*. The requirements of *AWS D1.1* shall be adhered to for welding of items not covered in *AWS D1.5*.

Groove welds shall be started and terminated with extension bars or runoff plates.

Fillet welds shall be performed in the flat or horizontal position unless restricted by member size or physical position.

(d) Field Welding. Welding performed in the field shall be done by welders or welding operators who are on the Agency's *Pre-Qualified Welder List*.

The requirements for field welding are contained in the Agency's *Field Welding Manual* and shall be adhered to. This manual may be obtained from the Agency's website.

Welding performed in the field is subject to all of the requirements of Subsection 506.10. The SMAW process is the only process approved for field welding.

All welds used to attach miscellaneous construction fixtures to any portion of the bridge structure shall be approved in writing by the Engineer. Welding to tension members or tension components of members will not be allowed.

Welding of miscellaneous construction fixtures such as form supports, screed supports, and reinforcing steel chairs to any portion of the bridge structure will not be permitted without approved drawings and welding procedures. Any increase in material thickness made necessary by reduced allowable stresses resulting from such welding shall be at the Contractor's expense. Approval for any welding requiring an increase in material thickness shall be obtained before the affected structural steel is fabricated.

Shear connectors shall be installed in accordance with the requirements of Section 508.

(e) Process and Procedure Qualification.

(1) General Requirements. Welding processes and procedures requiring qualification shall be qualified in accordance with the requirements of *AWS D1.5*.

Welding and testing of samples shall be witnessed by the Agency, or the Agency's quality assurance inspector, or an authorized representative of a testing agency that is AWS certified in accordance with the provisions of *AWS QC 1*.

(2) Acceptance Requirements. The basis for acceptance shall conform to the requirements of *AWS D1.5*. The requirements of *AWS D1.1* shall be adhered to for items not covered in *AWS D1.5*.

506.11 FRACTURE CRITICAL MEMBERS. The Agency will identify in the Contract the members or member components that are categorized as fracture critical.

Material for members or member components identified as fracture critical shall be furnished and fabricated in conformance with the requirements of *AWS D1.5* for fracture critical components.

Welding performed on fracture critical members or components, and testing, shall be witnessed by an Agency representative. Qualification acceptance for any welding procedure shall be based on the results of mechanical tests and chemical analysis of deposited weld metal. Procedure requirements and basis of acceptance shall meet the requirements in *AWS D1.5* for fracture critical components.

506.12 ASSEMBLY.

(a) Camber. Beams and girders shall be fabricated to the camber indicated on the approved fabrication drawings.

(b) Curved Girders. Welded curved girders with a radius of less than 750 feet shall be fabricated by cutting the flange plates to the required curvature. Each plate shall be flame cut simultaneously on both edges to reduce unbalanced shrinkage stresses. The flange plate lengths between shop splices shall not be less than 20 feet. Web plates shall be aligned to the center of the flange plates.

If the final curvature is not as specified after the flanges have been welded to the web, the girder shall be corrected by application of heat in accordance with an approved procedure.

(c) Heat Curving and Cambering. The final horizontal curvature and vertical camber shall be measured only after the member has cooled. The member shall be supported in a manner that will ensure accurate measurements for sweep and camber. The web shall be in a vertical position for measuring curvature and in a horizontal position for measuring camber.

Heating shall be performed in such a manner that the temperature of the steel does not exceed 1,150°F. Any member heated to a temperature of more than 1,200°F shall be rejected.

Artificial cooling will not be permitted until a member has cooled to 600°F. Under no conditions will water be permitted for cooling. Dry air may be used subject to the approval of the quality assurance inspector.

(d) Finish. All sharp corners, and edges that are marred, cut, or roughened in handling shall be rounded to a minimum 1/16-inch radius by grinding.

(e) Connections and Bolting. The materials and fabrication procedures shall comply with the provisions of Subsection 506.18.

(f) Bearing Connections. Field bearing connections shall not be permitted. Connections in bearing may require different tolerances of fit. Terms used to define the fit of connections are as follows:

(1) Tight Fit. Tight fit means that 50% of the projected bearing area shall be in contact within 0.02 inch with a permissible variation of 1/16 inch for the remaining 50% of projected area.

(2) Grind to Bear. Grind to bear means that 75% of the projected area shall be in contact within 0.01 inch with a permissible variation of 1/32 inch for the remaining projected area.

(3) Mill to Bear. Mill to bear means that 100% of the projected bearing area shall be in full contact.

(g) Intermediate Stiffeners. The ends of intermediate stiffeners shall fit closely to the flanges with a maximum allowable gap of 1/16 inch.

(h) Straightening Material. Straightening or repair of any member or component will be subject to written approval by the Agency. Procedures will be required describing in detail the distortion to be corrected and all procedures for heating, cooling, verifying final dimensions, and nondestructive tests.

506.13 TOLERANCES. Rolled steel plates, shapes, and bars shall be supplied to the permissible tolerances specified in *ASTM A6*. The camber and sweep of fabricated rolled members shall be subject to the same dimensional tolerances specified for welded members in *AWS D1.5*.

The metal bearing surface of any masonry bearing plate shall be flat, with a maximum permissible variation of 0.04 inch from a plane determined by any three of its corners.

The fabricator is responsible for straightening to specification tolerances any weldments that may have been distorted through stress relieving during the galvanizing process.

506.14 SURFACE PREPARATION. All materials shall be blast-cleaned to the specified grade as defined by the *SSPC Painting Manual* and supplemented by reference to *SSPC-VIS 1*. Further preparation shall conform to the following:

(a) Surfaces to Remain Uncoated. Surfaces shall be blast-cleaned at least equivalent to *SSPC-SP 10*. This work may be performed either before or after fabrication. The final surface appearance after fabrication shall be clean and free from any contaminants or blemishes so as to allow the metal to weather uniformly.

(b) Surfaces to be Coated. Prior to application of any coating, all material to be coated shall be cleaned and prepared in accordance with the appropriate Contract specifications.

506.15 MARKING, STORING, AND SHIPPING.

(a) Marking. Each member shall be identified with an erection mark corresponding with the member identification mark on the approved fabrication drawings.

Identification marks may be painted on members that will receive field coats of paint.

Identification marks on unpainted steel shall be impressed into the member with a low-stress stamp in a non-stressed or low-stressed area of the member. The fabricator shall identify to the Contractor the procedure used for marking material.

(b) Storing. Material at the fabricator's plant shall be stored above ground on platforms, skids, or other suitable supports. It shall be kept clean, properly drained, and protected from unwanted corrosion. Free circulation of air shall be provided around all surfaces.

Girders and beams shall be stored in the upright position, supported at their ends or points of bearing. Long members (e.g. columns and chords) shall be supported at sufficient points to prevent damage from deflection.

Special care shall be taken for unpainted steel to ensure that it can weather uniformly.

In addition to the requirements specified above, material or raw material stockpile storage shall be subject to any other storage criteria deemed necessary by the Engineer in accordance with the requirements of Subsection 106.09.

(c) Shipping. Beams and girders shall be transported in the upright position. If the member's size or shape prohibits shipment in the upright position, the fabricator shall submit a proposed method and details of shipment to the Agency for approval.

The fabricator shall not ship any material, either to the project or to another manufacturer or subcontractor, without the Agency's approval. The Agency's quality assurance inspector will place a seal of approval on all material (or on the bill of lading) that has been accepted for shipment and will accept the loading, positioning, and anchorage of all material being shipped. If the quality assurance inspector is not available, the Structural Steel Fabrication Engineer shall be contacted for approval to ship.

506.16 FIELD HANDLING AND STORING. The Contractor is responsible for providing equipment that is adequate to safely lift and place, without damage, all material furnished. Permanent distortion caused by handling or storage will be cause for rejection.

The edges of nicks or bumps caused by handling shall be carefully ground to a 1/16-inch radius.

The storage requirements in Subsection 506.15 shall be applicable for all materials stored in the field.

506.17 ERECTION.

(a) Methods and Equipment. Cranes, lifting devices, and other equipment for all structural steel erection shall be of adequate design and capacity to safely erect, align, and secure all members and components in their final positions without damage. The Contractor is solely responsible for the methods and equipment employed for the erection of the structural steel. However, the Contractor shall lift and erect curved girders so that the web of the girder is maintained vertical within a 10° vertical tolerance.

The Contractor shall submit construction drawings in accordance with the requirements of Subsection 105.06 for the methods and sequence of structural steel erection, the temporary bracing, and the equipment to be used for the erection. The Agency will use the requirements specified in *AASHTO/NSBA S10.1, Appendix B* and *AASHTO/NSBA S10.1, Appendix C,* as the basis for review of erection plans.

The erection plan shall include the necessary computations to indicate the magnitude of stress in the segments during erection and to demonstrate that all of the erection equipment has adequate capacity for the work to be performed. The erection plan shall contain provisions for all stages of construction, including offloading, temporary storage conditions, and temporary stoppages.

The Contractor shall include additional information in the erection plan for curved girders as indicated in *AASHTO LRFD Bridge Construction Specifications, Section 11.8.2.*

The structural steel may be used for support of equipment prior to placement of the deck only with the written permission of the Engineer. The proposed use of structural steel for support of equipment shall be detailed in the erection plan.

Submittal of the erection plan is for documentation purposes only and shall in no way be construed as approval of the proposed method of erection. Unless otherwise directed by the Engineer, the Contractor shall follow the erection plan as submitted.

(b) Assembly.

(1) Parts shall be accurately assembled as shown on the Plans, fabrication drawings, or erection drawings, following match marks when provided. Material shall be carefully handled so that no members or pieces will be bent, broken, or damaged. Hammering that will injure or deform members will not be permitted. Bearing surfaces and contact surfaces shall be clean.

(2) Drift pins shall be used to align and center the connections of main and secondary members. Only light drifting will be permitted. Any member subjected to drifting that results in distortion of the member or elongation of the holes will be rejected. Cylindrical erection pins, the same size as the hole, shall be used at least in the extreme corners of all main member connections.

Main members shall be match marked by the fabricator and should fit together easily.

Main members shall not be reamed larger than the hole size indicated on the approved fabrication drawings without written authorization from the Project Manager. Secondary members may be subjected to limited field reaming with the written approval of the Engineer. Assembled parts that have been approved for field drilling or reaming shall be disassembled to remove any burrs, shavings, oils, or lubricants.

Pins used for hinged connections and bearings shall be inserted with care and aligned so the members take full and even bearing. Nuts shall be adequately tightened and locked in position either by upsetting the threads or tack welding the nut to the bolt.

(3) Errors in shop fabrication that prevent proper assembly shall be reported immediately to the Engineer. The Engineer shall approve any corrective action prior to it occurring.

506.18 BOLTING AND CONNECTIONS.

(a) General Requirements. Connections shall be made with high-strength bolts conforming to the requirements of Subsection 714.05 unless otherwise specified. Bolts and nuts shall be furnished by the same supplier. Bolts, nuts, and washers shall be packaged and shipped so they are kept dry. When not in transit, bolts, nuts, and washers shall be stored indoors under dry, ventilated conditions.

All bolts and nuts shall be adequately and uniformly lubricated. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation in accordance with applicable specifications.

Bolt holes are specified as 1/16 inch larger in diameter than the bolt. Bolt holes shall be fabricated to the requirements of the *AASHTO LRFD Bridge Construction Specifications, Section 11.4.8*, except that holes shall not be punched full-size unless otherwise permitted in the Contract or approved by the Structural Steel Fabrication Engineer.

(b) Bolted Parts. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or other interposed compressible material. All joint contact surfaces and areas adjacent to bolt holes shall be free of scale, burrs, dirt, and other foreign material that may prevent solid seating of the parts.

Unless otherwise specified in the Contract, faying surfaces of bolted connections shall have a Class B slip coefficient value of not less than 0.50 as specified by AASHTO.

Splices and field connections of main members shall have all holes filled with high-strength bolts or cylindrical drift pins, with bolts snug-tightened before external support systems are removed. Cylindrical drift pins shall be used in the extreme corners of all main member connections to ensure alignment and shall remain until all bolts in the connection have been fully tightened.

(c) Installation. Bolted connections shall be assembled with a hardened washer under the turned element. Hardened steel washers shall be used under both the head and the nut when bolts are used for the following connections:

(1) Oversized holes (fabricated as per the Contract)

(2) Replacing existing bolts or rivets

(3) Oversized and irregular hole conditions caused from field drilling or reaming (reaming shall not be allowed unless approved in writing by the Engineer)

(4) Connections between new and existing steel members

Where an outer face of the bolted parts has a slope of 1:20 (V:H) or steeper with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

Bolts installed with the stem oriented vertically shall have the heads up. Bolts installed with the stem oriented horizontally shall have the head towards the weather unless clearance restrictions dictate otherwise.

Normally the nut will be the turned element. However, if the position of bolt entering or wrench operation clearances prohibit this procedure, the bolt may be the turned element.

Tightening of a bolt group shall progress systematically from the most rigid part of the joint to its free edges.

Previously tightened bolts shall be re-tightened until all bolts in the connection are tightened to the minimum required tension.

Recalibration of the tightening wrench may be required any time there appears to be a significant change in the bolt tightening conditions.

All bolts in a connection shall first be brought to a snug tight condition. Snug tight is defined as initial tension sufficient to bring all the plies of the connection into firm contact while the drift pins remain in the connection. Snugging shall progress systematically, beginning at the most rigid part of the connection and progressing to the free edges until the connection is fully compacted.

All high-strength bolts shall be tightened to the specified tension as soon after installation as feasibly possible. Under no circumstances shall bolts be left untightened for more than 5 days after installation unless specific requirements to do so are indicated in the Contract or directed by the Engineer. Bolts left in place beyond five days without specific requirements in the Contract or as directed by the Engineer shall be removed and replaced with new bolts at the Contractor's expense.

Bolts shall be tightened to develop a tension not less than 5% more than the minimum bolt tension specified in Table 506.18A. Unless otherwise indicated on the Plans, *ASTM F3125* Grade A325 hex head bolts shall be used.

(d) Bolt Tensioning Methods. Bolts shall be tensioned by the Contractor in the presence of the Engineer using one of the following methods:

(1) Tension Control Assembly Method. A tension control assembly consists of a tension control bolt with a spline end and a suitable nut and washer. This method shall be employed when installing button-headed or dome-headed high-strength bolts. This method shall only be used when required by the Contract.

All bolts shall be tightened by the application of torque to the nut and counter-torque to the spline end of the bolt using an approved spline drive installation tool. A random sample of not less than three tension control assemblies of each diameter, length, grade, and type to be used in the work shall be checked a minimum of once each working day in a device capable of indicating bolt tension.

The test shall be performed to verify that the spline twist-off develops a tension at least 5% greater than the minimum bolt tension specified in Table 506.18A. Additional verification of the tension control assemblies shall be performed as directed by the Engineer. Separate checks will be required for each diameter fastener with hardened washers placed under the nut or bolt head as they will be used in the structure. Variations in the number or location of washers will require separate checks.

(2) Direct Tension Indicator Method. Direct tension indicators (DTIs) are compressible washers capable of indicating that a specified minimum bolt tension has been attained. DTIs installed with high strength bolts to indicate bolt tension shall be subjected to field verification testing prior to installation and the installation requirements specified in this subsection.

DTIs installed with high-strength bolts to indicate bolt tension shall be placed under the head of the bolt with the protrusions facing the head of the bolt, and the nut shall be turned, with a hardened washer underneath it, to tension the fastener. Additional hardened washers shall be provided if required by the DTI manufacturer for their specific product. If for reasons of wrench operations clearance it is necessary to place the DTI under the turned element, the DTI shall be oriented so that the protrusions face outward from the work, and a hardened washer shall be placed between the DTI and the turned element. Placement of the DTI under the turned element will only be allowed when approved by the Engineer.

The bolt, DTI, hardened washer, and nut assembly used in the verification testing device and installed in the work shall be such that at least three and preferably not more than five threads are in the grip. The grip is defined as the distance between the bearing face of the nut and the bolt head.

The Contractor shall supply 5-mil tapered feeler gauges, a calibrated bolt tension-measuring device and equipment necessary to perform field verification testing and inspection of tensioned bolts. The feeler gauges, fasteners, and impact and manual wrenches shall be the same as that to be used in the work.

The Contractor shall obtain the services of a qualified technical advisor employed by the DTI manufacturer to make at least one site visit to assist the Contractor and to ensure the proper installation and use of DTIs. This requirement may be waived by the Engineer if the Contractor can demonstrate to the Agency’s satisfaction successful use of DTIs on previous projects for the Agency.

Verification testing shall be performed in a calibrated bolt tension measuring device, such as a Skidmore-Wilhelm Calibrator, with a special flat insert (supplied by the Contractor) replacing the normal bolt head-holding insert. The special insert allows the DTI to be located on the flat front face of the tension measuring device for ease of observation and improved access for measuring the DTI gap during testing. The Contractor shall supply hardened steel spacers as needed for testing longer bolts in the bolt tension measuring device. Stacked washers will not be permitted as a substitute for hardened steel spacers.

The purpose of verification testing is to validate the DTI assembly's ability to indicate installation tension above the minimum. The verification tension specified in Table 506.18A is 5% higher than the minimum required installation tension in Table 506.18A. The increase provides confidence that the installation tension can be achieved for the lot. Three verification tests are required to be performed on random samples of each combination of fastener rotational-capacity lot, DTI lot and DTI position (under the nut or bolt head) used on the project. All three tests must pass for the DTI and assembly combination to be approved. Testing shall be performed at the project site by the Contractor and witnessed by the Engineer.

When testing for the normal DTI position, the nut shall be turned from the rear of the tension measuring device, with the bolt head against the DTI restrained from turning with another wrench. When testing with the DTI under the turned element, the turned element shall be placed on the flat front face of the tension measuring device and the unturned element will be in the rear held by another wrench.

a. Verification Test. The verification test shall be conducted as follows:

1. Tension the fastener to the verification tension load specified in Table 506.18A for the grade and size of fastener. If an impact wrench is used, tension to a load two-thirds below the required load and use a manual wrench to attain the required tension.

2. Determine and record the number of entries of a 5-mil feeler gauge in the spaces between the protrusions. When using galvanized or epoxy coated DTIs under the turned element, there shall be at least one entry of the feeler gauge.

   The DTI lot will be rejected if the number of entries is less than the value in column 2 of Table 506.18B. If coated DTIs are used under the turned element, the DTI lot will be rejected if there are no entries.

3. Further tension the fastener, as needed, until the number of entries is within the range in column 3 of Table 506.18B.

4. Verify that the pretension achieved is at least that specified for the verification tension load in Table 506.18A. If the actual pretension developed in the fastener is less than the verification tension load specified in Table 506.18A, the causes shall be determined and resolved before the fasteners are used in the work. Cleaning, lubrication, and retesting new fasteners is permitted for this step provided that all fastener assemblies are treated in the same manner.

If the bolts are too short to be tested in the tension measuring device, the verification test for the DTI shall be conducted on longer bolts supplied by the Contractor. The longer bolts shall be new, meet the requirements of Subsection 714.05, and be of the same type as the DTI being tested. Three verification tests are required as specified above.

Bolts and DTIs used in verification tests shall be marked and shall not be reused in the work.

TABLE 506.18A – BOLT TENSION VALUES FOR *ASTM F3125* BOLTS

Nominal Bolt Diameter (in.)	Minimum Bolt Tension (kips) [1]		Verification Tension (kips) [2]	
	Grade A325	Grade A490	Grade A325	Grade A490
1/2	12	15	13	16
5/8	19	24	20	25
3/4	28	35	29	37
7/8	39	49	41	51
1	51	64	54	67
1-1/8	64	80	67	84
1-1/4	81	102	85	107
1-3/8	97	121	102	127
1-1/2	118	148	124	155

[1] Equal to 70% of the specified minimum tensile strength of bolts.

[2] Verification tension is 1.05 times the minimum bolt tension.

b. Installation. Installation of fasteners using DTIs shall be conducted in two steps as follows:

1. Step 1. All of the bolts in a connection shall be installed to a snug-tight condition. Snugging shall progress systematically beginning at the most rigid part of the connection and progressing to the free edges until the connection is fully compacted. At the snug-tight condition all of the DTIs shall be inspected with the feeler gauge to verify that they meet the number listed in column 2 of Table 506.18B.

   If the number of entries is less than the values specified in Table 506.18B, the fastener shall be removed and another DTI installed, followed by re-snugging of the fastener. This is required because a fastener's tension may have relaxed during the snugging of adjacent fasteners. A compressed DTI does not rebound if the fastener tension is reduced. If a DTI which has fewer entries were left in place, it would give a false indication of bolt tension.

2. Step 2. The bolts in the connection shall then be further tensioned to the point that the number of entries for a 5-mil feeler gauge meets the number listed in column 3 of Table 506.18B. Tightening shall progress systematically beginning at the most rigid part of the connection and progressing to the free edges. Drift pins shall be removed during this process, with the exception that drift pins in the extreme corners of main member connections shall remain in place until all other bolts are fully tensioned. Several cycles may be required.

   The Contractor shall use the minimum amount of force necessary to achieve the number of entries listed in column 3 of Table 506.18B. If DTIs are consistently being tensioned to a point where there are zero entries of the feeler gauge, the amount of force applied to the bolt shall be reduced.

TABLE 506.18B – NUMBER OF DTI ENTRIES FOR *ASTM F3125* BOLTS

Number of Spaces Between DTI Protrusions	Verification - Required Number of DTI Entries [1, 2]	Installation - Required Number of DTI Entries [1, 3]
4	2 – 4	0 – 1
5	3 – 5	0 – 2
6	3 – 6	0 – 2
7	4 – 7	0 – 3
8	4 – 8	0 – 3
9	5 – 9	0 – 4

[1] An entry occurs when a 5-mil tapered feeler gauge fits into the space between DTI protrusions and touches the bolt shank.

[2] For coated DTIs under the turned element, at least one entry is required.

[3] For coated DTIs under the turned element, 0 – 1 entries are required.

(e) Acceptance of Bolt Tensioning. The installation and tightening of bolted connections shall be observed to determine if the tightening procedure is working properly and the correct tension has been achieved

The Contractor shall provide a tension measuring device, such as a Skidmore-Wilhelm Calibrator, which has been calibrated within the last year and is accompanied by a certificate verifying its date of calibration.

Before the installation of fasteners in the work, the Engineer shall check the marking, surface condition, and storage of bolts, nuts, and washers and the faying (contact) surfaces of joints for compliance with the Contract requirements.

Bolt tension for fasteners with DTIs shall be verified using 5-mil tapered feeler gauges provided and operated by the Contractor.

All bolts installed using DTIs shall be inspected after snug tightening and again after full tensioning, with 100% of the bolts inspected visually and 10% of the bolts in any connection (but not less than two) inspected by feeler gauge. If the installation of inspected bolts is accepted, then the connection shall be accepted as properly tensioned.

If any bolt in a connection does not pass inspection, then all (100%) of the bolts in that connection shall be inspected with the feeler gauge. Any bolt which does not pass inspection as described herein shall be further tensioned if required.

If the Engineer suspects that the Contractor is using an excessive amount of force on fasteners with DTIs, the Engineer may require a sample of no less than three fasteners to be removed from the work in one or more locations for further inspection. All costs for further inspection, including replacement fasteners, shall be at no additional cost to the Agency. Further inspection shall be performed as follows for each sample of fasteners:

(1) Step 1. Each fastener shall be checked to verify that the nut can be turned by hand for the full length of the threads, excluding thread runout. If this is successful for all fasteners, the fasteners represented by the sample will be accepted and new fastener assemblies and DTIs shall be installed in the work where the sample fasteners were removed. If the nut cannot be turned down the full length of the threads by hand on all fasteners, proceed to Step 2.

(2) Step 2. Each fastener shall be installed in a calibrated bolt tension measuring device and tensioned to the verification tension load in Table 506.18A. The bolt tension measuring device shall be supplied with short bolt plates and bushings as needed for testing shorter bolts and hardened steel spacers as needed for testing longer bolts. Stacked washers will not be permitted as a substitute for hardened steel spacers, with the exception that additional flat washers may be used in combination with hardened steel spacers if necessary to achieve the appropriate grip length. The complete fastener assembly that was removed from the work, excluding the DTI, shall be installed in the calibrated bolt tension measuring device with a grip length equal to or greater than the grip length when installed in the work. If this is successful for all fasteners, the fasteners represented by the sample will be accepted and new fastener assemblies and DTIs shall be installed in the work where the sample fasteners were removed. If all fasteners cannot be tensioned to the verification tension load in Table 506.18A, the Contractor shall replace all fasteners in the work represented by the sample as determined by the Engineer.

Bolts installed using tension control assemblies shall be visually inspected for consistent twist-off and thread stick-out.

Undamaged fasteners may only be reinstalled with the approval of the Engineer. Galvanized bolts, *ASTM F3125* Grade A490 bolts, tension control assemblies, and DTIs shall not be reinstalled.

An additional required inspection step is to check the bolt thread stick-out on the nut side after installation to the final specified gap to look for inconsistency of pattern. Any stick-outs greater than the other bolts shall be investigated and discarded (e.g. if necking down of the bolt has occurred or the wrong length bolt was used). The end of the properly installed bolt shall be at least flush with the nut.

The Engineer shall be provided with safe access in accordance with the requirements of Section 105 to conduct all inspection deemed necessary during and after the installation of the bolts. If the Engineer determines that the access provided is unsafe, work will be ordered to halt until such time that the access is made safe. Any delays incurred by the unsafe access will not be cause for a monetary, material, or delay claim.

506.19 RIVET REMOVAL. When the Plans specify existing rivets to be removed, they shall be removed without damaging the base metal. The rivets identified for removal shall have the rivet head ground flush with the base metal and the shaft drilled for removal. If necessary, the rivet head on the opposite side shall be removed in the same manner. The use of pneumatic rivet breakers and punching of rivet shanks will not be allowed, unless approved in writing by the Engineer. Flame cutting, performed by a certified welder on the Agency's *Pre-Qualified Welder List*, will be allowed if approved by the Engineer. Each worker performing rivet removal work shall successfully demonstrate the process on scrap metal to the satisfaction of the Engineer prior to each worker performing any rivet removal work on the bridge. If it is necessary to pierce the shaft of rivets with a torch, the outer surface of the rivet shank shall remain intact during this process.

Absolutely no gouging or other damage to the structural steel will be permitted on any member that will remain in service after the rivet is removed. If the rivet removal process causes any damage to structural steel, the damaged member shall be repaired or replaced in a manner satisfactory to the Engineer at the Contractor's expense. If any gouging or other damage to structural steel occurs, the rivet removal work shall stop immediately, and the Engineer shall be notified. At the discretion of the Engineer, the Contractor may be required to obtain the services of a professional engineer to assess the structural capacity of the damaged member prior to restoring traffic. All costs associated with assessing damage caused by this removal process will be at the Contractor's expense.

Where rivets are specified to be replaced, they shall be replaced with high-strength bolts meeting the requirements of Subsection 506.18 unless otherwise specified in the Contract. Rivets shall be replaced one at a time, unless otherwise specified in the Plans or approved by the Project Manager. Use of temporary bolts to replace a rivet will only be allowed with written approval from the Engineer, and provided that temporary bolts meet the requirements of Subsection 506.18.

506.20 STRAIGHTENING BENT MATERIAL. Damaged, bent, or misaligned structural steel may only be straightened or corrected by procedures approved by the Agency. The method of repair proposed by the Contractor shall be submitted as construction drawings for approval in accordance with the requirements of Subsection 105.06. No corrective work shall be performed without Agency approval. Heating limitations and procedures shall conform to the requirements of Subsection 506.12.

Members or parts to be heat straightened shall be free of stress from external forces other than those necessary and used in conjunction with the application of heat. Following straightening, the surface of the metal shall be free of any evidence of distortion or fracture. Required nondestructive tests shall be performed by NDT Level II or NDT Level III personnel at the Contractor's expense.

506.21 FIELD CLEANING. When assembly of the fabricated structural components is complete, any rust, scale, dirt, grease, or other foreign material shall be removed from the metal components. The cost of such necessary cleaning will not be paid for directly but will be considered incidental to the Section 506 items in the Contract.

506.22 STEEL SURFACES AND COATINGS. All welding and anticipated hot work shall be completed prior to applying any coatings on a given item unless approved in writing by the Structural Steel Fabrication Engineer.

(a) Uncoated Steel. Care shall be taken to keep chemicals and oils from contacting the exposed surfaces of unpainted steel during storage, erection, and construction of the deck.

(1) Staining of Masonry. The Contractor shall protect all concrete and masonry from staining due to oxide formation on the steel.

(2) Cleaning of Steel. After all concrete has been placed, the outside surface of the fascia beams and bottom surface of their lower flanges shall be cleaned of all foreign material to a uniform appearance. The Engineer may require the exposed surfaces to be blast cleaned to meet *SSPC-SP 10*. The use of acids for cleaning is prohibited.

(b) Galvanized Steel. All steel surfaces to be galvanized shall be coated in accordance with Subsection 726.06 and the following:

(1) Certifications as described in *ASTM A123, Section 10* for the completed products shall be furnished to the quality assurance inspector (or the Structural Steel Fabrication Engineer, if there is no quality assurance inspector assigned to the project) prior to shipment from the galvanizer's plant. Certifications shall include a report of all test results and measurements.

(2) Repairs to coating shall conform to Subsection 726.06 and shall be brush applied unless approved otherwise by the Engineer. Products containing aluminum shall not be used.

(3) Surfaces to be painted or powder coated after galvanizing shall not be water quenched or treated with chromate conversion coatings.

(c) Metalized Steel. All steel surfaces to be metalized as specified on the Plans shall be metalized and seal coated in accordance with Subsection 726.07.

(d) Powder Coated Steel. When the Plans specify powder coated steel, the work shall be performed in accordance with the requirements of this subsection.

(1) Materials. All products specified to be powder coated shall receive two coats of exterior grade powder meeting the requirements of Subsection 708.02.

(2) Submittals. The fabricator shall submit a complete package, in accordance with Subsection 105.06 for construction drawings, which includes the following information. The submittals shall be made sufficiently in advance of coating work to allow for review, resubmittals, and approval.

a. Surface Preparation Plan. The surface preparation plan shall include the specified methods of surface preparation and types of equipment to be used. The plan shall identify the solvents proposed for solvent cleaning.

b. Abrasives. The fabricator shall submit the type of abrasives to be used for abrasive blast cleaning.

c. Coating System Information. The fabricator shall submit the latest version of the product manufacturer's recommendations for coating thickness, curing, and product data sheets for each and every coating product.

d. Powder Coating Plan. The powder coating plan shall include the pre-bake time and temperature, the thickness of each coat to be applied, and the curing time and temperature for each coat, and shall be in accordance with the manufacturer's recommendations.

(3) Quality Control (QC) Inspections. The fabricator shall perform first line, in progress QC inspections. The personnel performing any QC tests shall be trained in coatings inspection and the use of the testing instruments. Documentation of training shall be provided upon request. Reports for all quality control testing and observations shall be completed and provided to the QA inspector on a daily basis unless otherwise authorized by the Structural Steel Fabrication Engineer.

Fabricator QC inspections shall include, but are not limited to, the following:

a. Surface preparation and surface profile (solvent cleaning, abrasive blast cleaning, etc.).

b. Pre-bake time and temperature

c. Coating application (materials verification, dry film thickness).

d. Records of fabricator QC inspections shall document any applicable product batch numbers.

e. Coating cure time and temperatures

(4) Surface Preparation. All steel surfaces to be powder coated shall be prepared in accordance with the manufacturer's recommendations. At a minimum, the steel surface shall be prepared by *SSPC-SP 1* followed by *SSPC-SP 7*.

When powder coating is to be applied over galvanizing, the galvanized surface shall be prepared by *SSPC-SP 1*, followed by *SSPC-SP 16*, and in accordance with *ASTM D7803*. Surface grinding in accordance with *SSPC-SP 11* and *ASTM D7803* will be permitted in areas where *SSPC-SP 16* is not achievable or practical.

(5) Surface Profile. A uniform surface profile of 1.5 mils to 3.5 mils for bare steel and 1 mil to 2 mils for galvanized steel shall be produced. If the profile requirements of the coating manufacturer are more restrictive, the fabricator shall advise the Structural Steel Fabrication Engineer and comply with the more restrictive requirements.

The surface profile produced by the fabricator's surface preparation procedures shall be determined by replica tape and spring micrometer and in accordance with *SSPC-PA 17*. Areas having unacceptable measurements shall be further tested to determine the limits of the deficient area. The replica tape shall be attached to the daily report.

When unacceptable profiles are produced, work shall be suspended. The fabricator shall make the necessary adjustments to ensure that the correct surface profile is achieved on all surfaces. The fabricator shall not resume work until the new profile is verified by the QA observations and they confirm that the profile is acceptable.

(6) Coating Application. Coatings should be applied as soon as possible after blast cleaning but shall be applied within 8 hours of the completion of blast cleaning.

(7) Coating Thickness. The dry film thickness of each coat shall be measured in accordance with *SSPC-PA 2* and shall be within the manufacturer's recommended thickness range. The minimum total DFT of the powder coating shall not be less than 5.0 mils.

(e) Painted Steel. When the Plans specify shop painted structural steel, the work shall be performed in accordance with the requirements of this subsection.

(1) Materials. The fabricator shall provide a three coat paint system meeting the requirements of Subsection 708.03.

Shop applied systems may have isolated areas where the coatings were damaged during shipping or erection and will have areas around faying surfaces that may need field applied primer, intermediate, and top coatings. Thus, any coating system that is used in the shop shall be acceptable for the field conditions that are expected to be encountered.

When the plans specify paint to be applied over galvanizing, a galvanized coating applied in accordance with Subsection 506.22(b) shall be used in place of the prime coat of the three coat system. The first coat of paint applied over the galvanizing (intermediate coat) shall be recommended for application over galvanizing by the manufacturer. Any and all galvanizing repair products used prior to painting shall be compatible with the intermediate coat.

(2) Submittals. The fabricator shall submit a complete package, in accordance with Subsection 105.06 for construction drawings, which includes the following information. The submittals shall be made sufficiently in advance of coating work to allow for review, resubmittals, and approval.

a. Surface Preparation and Painting Plan. The surface preparation and painting plan shall include the specified methods of surface preparation and types of equipment to be used for removal of rust, mill scale, or foreign matter.

The plan shall identify the solvents proposed for solvent cleaning, together with the solvent safety data sheets (SDS). If any detergents, additives, or inhibitors are incorporated into the water used for any coating work operations, the plan shall include the names of the materials and their SDS.

The plan shall also include the methods of coating application, including any required stripe coats, and all equipment to be used.

The plan shall also identify all applicable QC/QA hold points. Specific inspection items throughout these specifications are designated as hold points. These hold points are for the QA inspector to perform inspections. QA inspections will be performed only after a proper QC inspection by the fabricator. Permission to proceed beyond a hold point without a QA inspection will be granted solely at the discretion of the Structural Steel Fabrication Engineer, and only on a case-by-case basis. If re-work is necessary, as determined by a QA inspection, it shall be accomplished and a new hold point for the re-work shall be observed as defined above.

b. Abrasives. The fabricator shall submit the type of abrasives to be used for abrasive blast cleaning and their SDS. For expendable abrasives, the Contractor shall provide certification from the abrasive supplier that the abrasive meets the requirements of *SSPC-AB 1*. For steel grit abrasives, the certification shall indicate that the abrasive meets the requirements of *SSPC-AB 3*.

c. Coating System Information. The fabricator shall submit the latest version of the product manufacturer's application and thinning instructions, SDS, and product data sheets for each and every coating, thinner, sealer, and grease rustproofing compound. Specific attention shall be drawn to storage temperatures and the temperatures of the material, surface, and ambient air at the time of application. Recommended minimum ambient weather conditions during curing shall also be included A letter or written instructions from the coating manufacturer shall be provided indicating the length of time that each coat must be protected from cold or inclement weather (e.g. exposure to rain) during the drying/curing period.

When the Agency accepts the submittals, the fabricator will receive written notification. The fabricator shall not construe Agency acceptance of the submittals to imply approval of any particular method or sequence for conducting the work, or for addressing health and safety concerns. Acceptance of the submittals does not relieve the fabricator from the responsibility to conduct the work according to the requirements of federal, state, or local regulations, this specification, or to adequately protect the health and safety of all workers involved in the project and any members of the public who may be affected by the project. The fabricator remains solely responsible for the adequacy and completeness of the programs and work practices, and adherence to them.

(3) Quality Control (QC) Inspections. The fabricator shall perform first line, in progress QC inspections. The personnel performing any QC tests shall be trained in coatings inspection and the use of the testing instruments. Documentation of training shall be provided upon request. Painters shall perform wet film thickness measurements, with the quality control inspector conducting random spot checks of the wet film. Reports for all quality control testing and observations shall be completed and provided to the QA inspector on a daily basis.

a. Fabricator QC inspections shall include, but are not limited to, the following:

1. Ambient conditions.

2. Compressed air cleanliness.

3. Surface preparation and surface profile (solvent cleaning, abrasive blast cleaning, etc.).

4. Coating application (materials verification, mixing, thinning, induction/ sweat-in time, and wet/dry film thickness).

5. Recoat times and cleanliness between coats.

6. Coating continuity and coverage (freedom from runs, sags, overspray, dry spray, pinholes, shadow-through, skips, misses, etc.).

7. Records of fabricator QC inspections shall document any applicable product batch numbers.

b. The following equipment shall be provided by the fabricator as necessary to perform QC inspections:

1. Psychrometer or comparable equipment for the measurement of dew point and relative humidity, together with all necessary tables or psychrometric charts.

2. Surface temperature digital spot thermometer.

3 *SSPC-VIS 1* and *SSPC-VIS 3*, as applicable.

4. Commercially available putty knife of a minimum thickness of 40 mils and a width between 1 and 3 inches.

5. Replica tape and spring micrometer.

6. Wet film thickness gauge.

7. Blotter paper for compressed air cleanliness checks.

8. Type 2 electronic dry film thickness gauge per *SSPC-PA 2.*

9. Calibration standards for dry film thickness gauge.

10. Light meter for measuring light intensity during surface preparation, painting, and inspection activities.

11. Printed copies of all applicable ASTM and SSPC standards used for the work.

12. *SSPC Manual of Good Painting Practice, Volume 1*.

The instruments shall be calibrated within 12 months of the date of project usage or according to the equipment manufacturer's recommendations and the fabricator's QC Program if they require a shorter duration.

(4) Quality Assurance (QA) Observations. The QA inspector will conduct QA observations of any or all phases of the work. The presence or activity of QA inspector observations in no way relieves the fabricator of the responsibility to provide all necessary daily QC inspections and to comply with all requirements of this specification.

The Structural Steel Fabrication Engineer has the right to reject any work that was performed without adequate provision for QA observations.

(5) Inspection Access and Lighting. The fabricator shall provide artificial lighting in areas where natural light is inadequate, to allow proper cleaning, inspection, and painting. Illumination for inspection shall be at least 30 foot-candles.

(6) Surface Preparation and Painting Equipment. All cleaning and painting equipment shall include gauges capable of accurately measuring fluid and air pressures and shall have valves capable of regulating the flow of air, water, or paint as recommended by the equipment manufacturer. The equipment shall be maintained in proper working order.

Hand tools, power tools, abrasive blast cleaning equipment, brushes, rollers, and spray equipment shall be of suitable size and capacity to perform the work required. All power tools shall be equipped with vacuums and high efficiency particulate air (HEPA) filtration. Appropriate filters, traps, and dryers shall be provided for the compressed air used for abrasive blast cleaning and conventional spray application. Paint pots shall be equipped with air operated continuous agitation devices unless prohibited by the coating manufacturer. The air discharge from power tools and air motors shall be directed away from steel surfaces. If this is not possible a filtering device shall be appropriately placed.

(7) Ambient Conditions. Surfaces to be painted after cleaning shall remain free of moisture and other contaminants. The fabricator shall control operations to ensure that dust, dirt, or moisture does not come in contact with surfaces cleaned or painted that day. The following ambient conditions shall be met:

a. The surface and ambient temperatures shall be at least 5°F above the dew point during final surface preparation operations.

b. The surface and ambient temperatures shall be a minimum of 40°F, at least 5°F above dew point, and the maximum relative humidity shall be less than or equal to 85% during the application and cure/dry time of each coat of the paint system. If the manufacturer’s published literature is more restrictive it shall be followed for specific temperature, dew point, and humidity conditions during the application cure/dry of each coat. The cure/dry time shall be measured as the time following application when the ambient conditions are within the ranges above.

The fabricator shall monitor and document temperature, dew point, and relative humidity at the beginning of each work day and every 4 hours during surface preparation and coating application, in the specific areas where the work is being performed. The frequency of monitoring shall increase if weather conditions are changing. If the weather conditions are forecast to be borderline relative to the limits established by the manufacturer, monitoring shall continue at a minimum of 4 hour intervals throughout the curing/drying period. The Structural Steel Fabrication Engineer has the right to reject any work that was performed under unfavorable weather conditions. Rejected work shall be removed, re-cleaned, and repainted at the fabricator's expense.

(8) Compressed Air Cleanliness. Prior to using compressed air for abrasive blast cleaning, blowing down the surfaces, and painting with conventional spray, the fabricator shall verify that the compressed air is free of moisture and oil contamination in accordance with the requirements of *ASTM D4285*. The tests shall be conducted at least one time each shift for each compressor system in operation. If air contamination is evident, the fabricator shall change filters, clean traps, add moisture separators or filters, or make other adjustments as necessary to achieve clean, dry air. The fabricator shall also examine the work performed since the last acceptable test for evidence of defects or contamination caused by the compressed air. Affected work shall be repaired at the fabricator's expense.

(9) Surface Preparation and Profile (Hold Point).

a. Surface Preparation. All bare steel surfaces to be painted shall be prepared by dry abrasive blast cleaning to meet the requirements of *SSPC-SP 10*.

When the Plans specify paint to be applied over galvanizing, the galvanized surface shall be prepared prior to applying the intermediate coat. The galvanized surface shall be prepared by *SSPC-SP 1* followed by *SSPC-SP 16*, and in accordance with *ASTM D 6386*. Surface grinding in accordance with *SSPC-SP 11* and *ASTM D6386* will be permitted in areas where *SSPC-SP 16* is not achievable or practical.

b. Abrasives. Abrasive blast cleaning shall be performed using either expendable abrasives (other than silica sand), or recyclable steel grit abrasives. Expendable abrasives shall be used one time and disposed of. The fabricator shall verify that recycled abrasives are free of oil contamination by conducting oil content tests in accordance with *SSPC-AB 2* on a daily basis.

c. Surface Profile. The abrasives used for blast cleaning shall have a gradation such that the abrasive will produce a uniform surface profile of 1.5 mils to 3.5 mils for bare steel and 1 mil to 2 mils for galvanized steel. If the profile requirements of the coating manufacturer are more restrictive, the fabricator shall advise the Structural Steel Fabrication Engineer and comply with the more restrictive requirements. For recycled abrasives, an appropriate operating mix shall be maintained in order to control the profile within these limits.

The surface profile produced by the fabricator's surface preparation procedures shall be determined by replica tape and spring micrometer and in accordance with *SSPC-PA 17*. Areas having unacceptable measurements shall be further tested to determine the limits of the deficient area. The replica tape shall be attached to the daily report.

When unacceptable profiles are produced, work shall be suspended. The fabricator shall make the necessary adjustments to ensure that the correct surface profile is achieved on all surfaces. The fabricator shall not resume work until the new profile is verified by the QA observations and they confirm that the profile is acceptable.

d. Surface Condition Prior To Painting. Prepared surfaces shall meet the specified degrees of cleaning immediately prior to painting and shall be painted before rusting appears on the surface. If rust appears or bare steel remains unpainted for more than 8 hours, the affected area shall be prepared again at the expense of the fabricator.

All surface preparation cleaning residue on steel surfaces shall be removed prior to painting.

The quality of surface preparation and cleaning of surface dust and debris shall be accepted by the QA inspector prior to painting. The Structural Steel Fabrication Engineer has the right to reject any work that was performed without adequate provision for QA observations to accept the degree of cleaning. Rejected coating work shall be removed and replaced at the fabricator's expense.

(10) General Paint Requirements. Paint storage, mixing, and application shall be accomplished according to these specifications and as specified in the paint manufacturer's written instructions and product data sheets for the paint system used. In the event of a conflict between these specifications and the coating manufacturer's instructions and data sheets, the fabricator shall advise the Structural Steel Fabrication Engineer and comply with the most restrictive requirements.

a. Paint Storage and Mixing. All paint shall be stored according to the manufacturer's published instructions, including handling, minimum and maximum temperatures, and warming as required prior to mixing. All coatings shall be supplied in sealed containers bearing the manufacturer's name, product designation, batch number, and mixing/thinning instructions. Leaking containers shall not be used. The paint shall be stored in a secure fireproof location.

Mixing shall be performed according to the manufacturer's instructions. Thinning shall be performed using thinner provided by the manufacturer, and only to the extent allowed by the manufacturer's written instructions. In no case shall thinning be permitted that would cause the coating to exceed the local volatile organic compound emission restrictions. For multiple component paints, only complete kits shall be mixed and used. Partial mixing is not allowed.

The ingredients in the containers of paint shall be thoroughly mixed by mechanical power mixers according to the manufacturer's instructions, in the original containers before use or mixing with other containers of paint. The paint shall be mixed in a manner that will break up all lumps, completely disperse pigment, and result in a uniform composition. Paint shall be carefully examined after mixing for uniformity and to verify that no unmixed pigment remains on the bottom of the container.

Excessive skinning or partial hardening due to improper or prolonged storage will be cause for rejection of the paint, even though it may have been previously inspected and accepted. Manufacturer recommended induction/sweat-in times and temperature of mixed coatings shall be observed.

Multiple component coatings shall be discarded after the expiration of the pot life. Single component paint shall not remain in spray pots, paint buckets, etc. overnight and shall be stored in a covered container and remixed before use.

b. Paint Application. Painting shall be performed in a neat and skilled manner. Each coat of paint shall be applied as a continuous film of uniform thickness free of defects including, but not limited to, runs, sags, overspray, dry spray, pinholes, voids, skips, misses, and shadow-through. Defects such as runs and sags shall be brushed out immediately during application.

Unless prohibited by the coating manufacturer's written instructions, paint may be applied by spray methods, rollers, or brushes. If applied with conventional or airless spray methods, paint shall be applied in a uniform layer with overlapping at the edges of the spray pattern.

The painters shall monitor the wet film thickness of each coat during application. The wet film thickness shall be calculated based on the specified dry film thickness using the solids by volume of the material and the amount of thinner added.

When brushes or rollers are used to apply the coating, additional applications may be required to achieve the specified thickness per layer.

c. Re-Coating and Film Continuity (Hold Point for Each Coat). Paint shall be considered dry for re-coating according to the re-coat time/temperature/humidity criteria provided in the manufacturer's instructions, and when an additional coat can be applied without the development of film irregularities such as lifting, wrinkling, or loss of adhesion of the under coat.

d. Stripe Coats. Unless indicated otherwise in the Contract, the Contractor shall apply an additional stripe coat to edges, crevices, welds, and similar surface irregularities for the prime coat and intermediate coat. The stripe coat shall be applied by brush or roller, as per the manufacturer's recommendations, such that the coating is thoroughly worked into or on the irregular surfaces. The stripe coat shall extend onto the surrounding steel a minimum of 1 inch in all directions. The purpose of the stripe coat is to build additional thickness and to ensure complete coverage of these areas.

The stripe coat shall not be applied as part of the application of the full coat. The stripe coat shall be applied and dried separately according to the manufacturer's recommended drying times. Also, the color of the stripe coat shall contrast with the colors used for the full coats immediately preceding and succeeding the stripe coat.

e. Coating Sequence. For locations painted under this specification, coatings shall be applied as follows:

1. Prime Coat. The full prime coat shall be applied first to protect the steel. Once the full prime coat has dried, the prime stripe coat shall be applied.

2. Intermediate Coat. After the prime stripe coat has dried, an intermediate stripe coat shall be applied and allowed to dry, followed by the full intermediate coat.

3. Top Coat. After the full intermediate coat has dried, the full top coat shall be applied.

(11) Coating Thickness. The dry film thicknesses of the full coats shall be as follows, as measured in accordance with *SSPC-PA 2*. If the manufacturer's upper or lower thickness limit is more restrictive, it shall be followed instead.

a. Prime Coat. The prime coat of organic zinc-rich primer shall be between 3.5 mils and 5.0 mils dry film thickness.

b. Intermediate Coat. The intermediate coat of epoxy or urethane shall be between 3.0 mils and 6.0 mils dry film thickness.

c. Top Coat. The top coat of aliphatic urethane shall be between 2.5 mils and 4.0 mils dry film thickness. The top coat color shall be according to Contract.

(12) Amine Blush. Amine blush is a residue that can form on newly applied epoxy coating films under certain conditions. Amine blush often appears as a yellowish milky or blotchy residue on the coating surface and is a deterrent to the adhesion of subsequently applied coating layers. If amine blush is detected, the Contractor shall provide the Engineer with written procedures from the coating manufacturer for complete removal prior to the application of additional coating layers.

(13) Repair of Damage to New Coating System. The Contractor shall repair all damage to the newly installed coating system, at no cost to the Agency. If the damage extends to the substrate, the damaged areas shall be prepared to meet *SSPC-SP 3*.

The surrounding coating at each repair location shall be feathered for a minimum distance of 1-1/2 inches to achieve a smooth transition between the prepared areas and the existing coating.

If the bare steel is exposed, all coats shall be applied to the prepared area. If only the intermediate and finish coats are damaged, the intermediate and finish coats shall be applied. If only the finish coat is damaged, the finish coat shall be applied.

All hold points and specifications are applicable to the repair of damaged areas and areas concealed by containment.

(f) Field Connections.

(1) Waiver of Certifications. For applications of shop painting and field assembly, the Contractor may request that the Engineer waive the requirements for NACE certification and SSPC-QP 1 certification for the necessary field painting of the bolted connection areas. Requests will be reviewed on a case-by-case basis and will only be considered on projects with limited amounts of required field painting such as diaphragm and cross frame connections. If the Engineer grants the request, all other requirements for certifications, inspections, quality control, supplying inspection equipment, hold points, etc. will remain in effect.

(2) Surface Cleaning for Hardware. The requirements of this part shall apply when the Contract requires installation of bolts that are to be painted. This work shall occur after bolt tensioning has been completed. All exposed oils, lubricants, and wax on the bolts, nuts, washers, and surrounding surfaces to be painted shall be completely removed by solvent cleaning. This also includes any foreign material that has come out of the DTIs during the tensioning process. Light hand wire brushing or scrubbing with bristle brushes is allowed. Use of power tools is not allowed.

For galvanized hardware, the Contractor shall remove the colored lubricant from the nuts. The galvanizer may be able to provide information to the Contractor on the most effective solvent cleaner to remove the colored lubricant (common examples include methyl-ethyl-ketone (MEK), foaming glass cleaners containing ammonia, and foaming alkaline-type household cleaners). It is not necessary to remove 100% of the dye, and it is acceptable for some staining to remain after cleaning. A white cloth wipe test with no color transfer can be used to confirm that all lubricant and non-absorbed dye has been removed, leaving only the residual stain on the surface. The final cleanliness shall be acceptable to the Engineer.

(g) Grease Coating. When the Plans specify that any steel surfaces are to be grease coated, all work shall be performed in accordance with Subsection 708.04.

Grease rustproofing compound shall be uniformly applied in a single coat by brush or spray at an approximate rate of 20 square feet per gallon to the steel as specified. This shall occur after all concrete form work has been removed, and after the final coat of paint, including repairs, has fully cured. A fully cured condition has occurred when a thumbnail driven into the coating surface does not leave an impression and when a thumb firmly pushed against the surface and twisted does not disturb the coating.

Surfaces adjacent to areas being grease coated shall be protected against over-spray. Non-metallic and stainless steel surfaces shall not be coated.

506.23 METHOD OF MEASUREMENT.

(a) Bids on a Pound Basis. The quantity of Structural Steel, or other material being paid for under this item, to be measured for payment will be the number of pounds used in the complete and accepted work. The weight of the material to be measured for payment under this item will be computed based on the approved fabrication drawings, as follows:

(1) Weight determined by the volume of material will be computed based on the densities specified in Table 506.23A.

TABLE 506.23A – MATERIAL DENSITIES

Material	Density (lbs/ft^3)
Aluminum, Alloy	173
Bronze, Cast	536
Copper, Alloy	536
Copper, Sheet	558
Iron, Cast	445
Iron, Wrought	487
Lead, Sheet	707
Steel – Rolled, Cast, Copper Bearing, Silicon, Nickel, or Stainless	490

For any material not listed in Table 506.23A, the material will be paid for by actual weight as measured on a certified scale.

(2) The weight of rolled structural shapes will be computed based on their nominal weight per foot as shown on the Plans or, if not shown on the Plans, by the weights shown in the *AISC Steel Construction Manual*.

The weight of rolled shapes will be based on the overall net length shown on the approved fabrication drawings, with no allowance for milling, finishing, or overrun, and with no deduction for cuts, clips, copes, or open holes.

(3) The weight of plates will be based on the net finished dimensions shown on the approved fabrication drawings, with no allowance for milling, finishing, tolerance, or overrun, and with no deductions for copes, clips, and open holes. The weights of beveled plates or curved surface plates will be based on the finished maximum thickness shown on the approved fabrication drawings.

For gusset plates, scupper components, slotted plates, and similar minor fixtures the net finished dimensions will be the minimum rectangular dimensions from which the parts are cut, except when it is practical to cut the parts in multiples from pieces of larger dimensions, in which case the weight will be based on the dimensions of the larger pieces, making necessary allowance for the material lost in cutting.

The net finished dimensions of flange plates will be the nominal width and the finished length measured along the centerline of the flange without deduction for width transitions, bevels, or chamfers.

The net finished dimensions of the webs of all girders and of the webs of rigid frame legs will be the actual area of the web as detailed on the approved fabrication drawings.

(4) All welding shall be considered as incidental work to the fabrication, and no measurement will be made for the weight of weld metal used.

(5) The weight of permanent shop and field bolts, nuts, direct tension indicators, and washers incorporated into the structure and temporary erection bolts, nuts, and washers shall be incidental to the Structural Steel item and no measurement will be made for weight of the bolts, nuts, direct tension indicators, and washers.

(b) Bids on Lump Sum Basis. The quantity of Structural Steel, or other material being paid under this item, to be measured for payment will be on a lump sum basis in the complete and accepted work.

(c) Bids on an Each Basis. The quantity of Rivet Replacement to be measured for payment will be the number of existing rivets replaced with high strength bolts in the complete and accepted work. Rivets measured for replacement will be made in only the locations specified in the Contract and in any other locations identified for replacement by the Engineer. Unless otherwise specified in the Contract, rivet removal and installation of new fasteners associated with structural steel repairs will not be measured for payment as Rivet Replacement.

506.24 BASIS OF PAYMENT. The accepted quantity of Structural Steel will be paid for at the Contract unit price per pound or at the Contract lump sum price for the items specified in the Contract. Payment will be full compensation for furnishing, detailing, handling, transporting, and placing the materials specified, including nondestructive testing of welds; for preparing the surface of new steel to be painted, galvanized, metalized, or to remain unpainted; for necessary field cleaning; and for painting, metalizing, sealing, galvanizing, or grease coating of surfaces, unless otherwise paid for. Payment will also be full compensation for furnishing and implementing the erection plan, nondestructive testing, quality control activities, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The Engineer may authorize partial payments in the following manner:

(a) The first payment of 15% of the estimated quantity may be paid when the fabrication drawings are approved for fabrication.

(b) The second payment of 60% of the estimated quantity may be paid when the steel has been entirely completed and accepted in accordance with the approved fabrication drawings, stored in a location and manner accepted by the Structural Steel Fabrication Engineer, and all applicable material certifications have been approved.

(c) The third payment of 15% of the estimated quantity may be paid when the steel has been erected, falsework removed, and painting of connections and touch-up completed where required.

(d) The final payment of 10% of the estimated quantity may be paid after completion and acceptance of all work under this section, including extended weights being received and checked.

The accepted quantity of Rivet Replacement will be paid for at the Contract unit price for each. Payment will be full compensation for performing the work specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
506.5000	Structural Steel, Rolled Beam	Pound
506.5500	Structural Steel, Plate Girder	Pound
506.5600	Structural Steel, Curved Plate Girder	Pound
506.5700	Structural Steel, Truss	Pound
506.6000	Structural Steel	Pound
506.7500	Structural Steel	Lump Sum
506.8500	Rivet Replacement	Each

SECTION 507 – REINFORCING STEEL

507.01 DESCRIPTION. This work shall consist of furnishing and placing bar reinforcement of the level specified, dowels, wire, welded wire reinforcement (WWR), and mechanical bar connectors.

Levels and associated types of reinforcing steel are specified as follows:

(a) Level I (Limited Corrosion Resistance). Level I reinforcing includes plain, low-alloy, and epoxy-coated reinforcing steel.

(b) Level II (Improved Corrosion Resistance). Level II reinforcing includes dual-coated, continuously-galvanized, low-carbon chromium, and hot-dipped galvanized reinforcing steel.

(c) Level III (Exceptional Corrosion Resistance). Level III reinforcing includes solid stainless reinforcing steel.

The location, level, and when specified, type of reinforcing shall be as indicated on the Plans. Reinforcing supplied shall meet the requirements of the level specified or any higher level. Only one type of reinforcing steel shall be used for each level for the Contract work, unless permitted in writing by the Engineer.

507.02 MATERIALS. Materials shall meet the requirements of the following subsections:

507.03 FABRICATION AND SHIPMENT. Bar reinforcement shall be deformed bar cold bent to the shapes required. Bar reinforcement shall be fabricated, bundled, tagged, marked, and shipped in accordance with the CRSI *Manual of Standard Practice*. The fabricator shall maintain records that will provide traceability of identifying heat numbers for all material being fabricated for Agency projects or Contract orders referencing materials covered under this section.

507.04 PROTECTION OF MATERIAL. Reinforcing steel shall be protected from damage at all times by storing it on blocking, racks, or platforms. When multiple levels of reinforcing steel are used on a project, they shall be stored separately, including during transport in order that there is no direct contact between the bars.

When placed in the work, the reinforcing steel shall be free from dirt, detrimental scale, paint, oil, previously placed concrete, or other foreign substances.

All systems for handling and storing coated reinforcement shall have padded contact areas. Epoxy-coated and dual-coated reinforcement stored on a project or between phases of work shall be covered with canvas or other suitable material that will effectively protect it against damage from ultraviolet light. All slings and other installation equipment used for stainless steel reinforcing shall be synthetic, stainless steel, or otherwise padded to prevent non-stainless steels from coming into contact with the stainless steel reinforcing until concrete has been placed.

All damaged areas of reinforcement coating shall be repaired with materials and procedures recommended by the coating manufacturer. The materials and procedures shall be approved by the Engineer prior to the repairs.

Coatings shall be repaired prior to installation of the reinforcement. Repair prior to installation does not relieve the Contractor from repairing areas damaged during placement.

All repairs shall be inspected and accepted by the Engineer prior to placing concrete. All bars where the total damaged area, including previously repaired areas, exceeds 2% of the bar surface area will be rejected.

When cutting coated reinforcement, a cutting torch shall not be used. The use of a power hacksaw is acceptable. All cut ends shall be repaired per the coating manufacturer's recommendations and to the satisfaction of the Engineer.

Ends of Level II reinforcing steel where the mild steel is exposed shall be repaired in the following manner:

(a) Cut ends of dual-coated reinforcing steel shall be coated with a two-part epoxy patching material as specified by the coating manufacturer. The materials and procedures shall be approved by the Engineer prior to the repairs being performed.

(b) Cut ends of stainless-clad reinforcing steel shall be epoxied and capped in accordance with the manufacturer's recommendations with either stainless steel caps or plastic caps. Caps shall be sealed to prevent the intrusion of moisture.

(c) Cut ends of continuously-galvanized reinforcing steel shall be coated with a zinc-rich paint. The paint used in the repair shall be organic-rich and contain at least 92% zinc by weight in the dry film. The paint shall be applied per the manufacturer's recommendations to a thickness equivalent to the surrounding galvanizing.

507.05 PLACING AND FASTENING REINFORCING STEEL. Steel reinforcement shall be placed in the position shown on the Plans and held securely in place during the process of placing concrete. Unless otherwise noted on the Plans, placement tolerances for reinforcing steel shall be 1/4 inch for cover and clearance and 1 inch for spacing of bars. Stirrups and spirals shall pass around main tension members and be securely attached to those members.

Reinforcing steel shall be spaced as specified from the face of the forms. Horizontal layers shall be spaced vertically by means of approved supports. Horizontal mats of reinforcing steel shall have lines of support not exceeding a 4-foot spacing in either direction. Additional supports may be required near the fascia.

Tie wires and supports used for installation of reinforcement shall be composed of the same material and coating as any steel being contacted or shall be plastic. Uncoated steel support material will not be permitted within 1-1/2 inches of any exposed concrete surface. Steel supports shall be equipped with snug-fitting, high-density, polyethylene tips which provide a 1/4-inch clearance between the metal and any concrete surface.

Bars spaced 12 inches apart or farther shall be tied at every intersection. Bars spaced less than 12 inches apart shall be tied at every other intersection. If reinforcement shows signs of distress during construction, the Engineer may direct additional tying.

Bar reinforcement shall not be further bent or straightened from the curvature produced at initial fabrication except when approved by the Engineer. If heating is approved for field bends, the temperature should not exceed that which produces a dull red color in the bar.

Welding procedures shall be submitted for approval for any type of reinforcement welding. Welding of reinforcement steel will not be permitted without written permission of the Engineer. Welding shall conform to the requirements of Subsection 506.10. Special care shall be taken so that no undercut will occur and reduce the effective area of the reinforcing bars.

Reinforcement placed in any member shall be inspected and approved before any concrete is placed.

Mechanical bar connectors shall be installed per the manufacturer’s instructions.

507.06 PLACING DOWELS. Dowels shall be placed in existing concrete or bedrock at locations shown on the Plans. Dowels shall be grouted with Type IV mortar or other approved material. Epoxy or other adhesive materials shall be submitted for approval prior to their use, unless otherwise shown on the Plans.

Where Type IV mortar is to be used, holes shall be drilled to the depth shown on the Plans and shall be at least 1 inch greater in diameter than the dowel. If not shown on the Plans, the depth of drilled holes shall be 2 feet. Where approved adhesives are used, the manufacturer’s recommendations shall be followed for hole sizing.

507.07 SPLICES. All reinforcement shall be furnished in the lengths shown on the Plans. No splicing of any type, except where shown on the Plans, will be permitted without the written approval of the Engineer. Welded butt splices or mechanical splices shall be used only when specified in the Contract or with written approval of the Engineer.

Mechanical bar connectors shall be installed in accordance with the manufacturer's installation instructions. The Contractor shall provide a copy of the manufacturer's installation instructions to the Engineer prior to installing any mechanical bar connectors.

507.08 LAPPING. Sheets of WWR shall overlap by not less than the wire spacing and be securely fastened at the ends and edges. The edge lap shall be not less than the wire or bar spacing.

507.09 METHOD OF MEASUREMENT. The quantity of Reinforcing Steel of the type and size specified to be measured for payment will be the total number of pounds of reinforcing bars, dowels, wire, and WWR used in the complete and accepted work except as otherwise provided, computed on the following basis:

(a) The weight of bars, wire, and dowels will be measured as either:

(1) The product of the length as shown on the approved shop bar lists and the standard weight per foot of length as adopted by the CRSI.

(2) If approved by the Engineer, the weight on a certified bill of lading from the reinforcement supplier. The bill of lading shall be broken down and sub-totaled based on individual bar marks and types of reinforcement.

(b) The weight of WWR will be measured as either:

(1) The computed weight in accordance with the details shown on the Plans based on the standard weight accepted by the trade for the unit of material specified.

(2) If approved by the Engineer, the weight on a certified bill of lading from the reinforcement supplier. The bill of lading shall be broken down and sub-totaled based on individual bar marks and types of reinforcement.

(c) Measurement for payment will not be made for any clips, wire, or other material that may be used by the Contractor for keeping the reinforcing bars in their correct position.

(d) Measurement for payment will be adjusted for any material accepted with an overall dimensional length less than or greater than the 1 inch CRSI tolerance.

(e) When the substitution of bars of greater diameter than specified is permitted by written authorization of the Engineer, payment will be made only for the weight of steel that would have been required if the specified diameter had been used. In case short bars are used when full length bars are shown on the Plans, payment will be made only for the weight of steel that would have been required if the specified lengths had been used, with no allowance for laps.

The quantity of Drilling and Grouting Dowels to be measured for payment will be the number of linear feet of hole drilled and grouted. The dowel will be measured as Reinforcing Steel of the type specified.

The quantity of Mechanical Bar Connectors to be measured for payment will be the number of mechanical connectors installed in the complete and accepted work.

507.10 BASIS OF PAYMENT. The accepted quantities of Reinforcing Steel of the type specified will be paid for at the Contract unit price per pound. Payment will be full compensation for furnishing, handling, welding, and placing the material specified and for furnishing all labor, fastening devices, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Drilling and Grouting Dowels will be paid for at the Contract unit price per linear foot. Payment will be full compensation for drilling the dowel hole, grouting the dowel in the hole, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

When the Contract does not contain a quantity for Drilling and Grouting Dowels, this work will not be paid for directly but will be considered incidental to all other Contract items.

The accepted quantity of Mechanical Bar Connectors will be paid for at the Contract unit price for each.

Payment will be full compensation for furnishing, handling, placing, and joining the materials, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
507.1100	Reinforcing Steel, Level I	Pound
507.1200	Reinforcing Steel, Level II	Pound
507.1300	Reinforcing Steel, Level III	Pound
507.1600	Drilling and Grouting Dowels	Linear Foot
507.1900	Mechanical Bar Connector	Each

SECTION 508 – SHEAR CONNECTORS

508.01 DESCRIPTION. This work shall consist of furnishing and welding shear connectors.

508.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Welded Stud Shear Connectors 714.10

508.03 WEATHER LIMITATIONS. Application of stud shear connectors or other welding on shear connectors shall not be done when the base metal temperature is below 0°F or when the surface is wet or exposed to falling rain or snow.

508.04 PLACING, INSPECTING, AND TESTING.

(a) General Requirements. The Contractor shall install the shear connectors as detailed in the Contract and the approved structural steel fabrication drawings. Shear connectors shall be placed, inspected, and tested in accordance with *AWS D1.5*.

Welding procedures for automatically timed stud welding equipment do not need to be submitted for approval. Installation without automatically timed stud welding equipment and repair welding shall be done using an approved SMAW procedure.

If, during the progress of the work, inspection and testing indicate that the shear connectors being furnished are not satisfactory, the Contractor shall make changes in the welding procedure, welding equipment, and type of shear connector as necessary to provide satisfactory results. Such changes shall be made at the Contractor's expense.

(b) Studs. Installation and acceptance of stud shear connectors shall be in accordance with the requirements of *AWS D1.5*.

After being allowed to cool, the first two studs welded on each beam or girder shall be bent 45° by striking the stud with a hammer. If failure occurs in the weld zone of either stud, the procedure shall be corrected, and two additional studs shall be successfully welded and tested before any more studs are welded to the beam or girder. The Contractor shall promptly inform the Engineer of any changes in the welding procedure.

After the studs have been welded to the beams, the Engineer will make a visual inspection, and each stud will be given a light blow with a hammer. Any stud that does not emit a ringing sound when given a light blow with a hammer, that has been repaired by welding, or that has less than normal reduction in height due to welding shall be struck with a hammer and bent 15° from the correct axis of installation.

In the case of a repaired weld, the stud shall be bent 15° in the direction that will place the repaired portion of the weld in the greatest tension. Studs that crack either in the weld or in the shank shall be replaced.

All tested shear connectors that show no sign of failure shall be left in the bent position.

The Engineer may select additional studs to be subjected to the bend test specified above.

508.05 METHOD OF MEASUREMENT. The quantity of Shear Connectors to be measured for payment will be on a lump sum basis for all the shear connectors installed in the complete and accepted work at each structure specified.

508.06 BASIS OF PAYMENT. The accepted quantity of Shear Connectors will be paid for at the Contract lump sum price for each structure specified. Payment will be full compensation for detailing, furnishing, transporting, handling, preheating, and welding of the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
508.1500 Shear Connectors	Lump Sum

SECTION 509 – CONCRETE BRIDGE DECK SURFACE PREPARATION

509.01 DESCRIPTION. This work shall consist of blanket diamond grinding concrete bridge decks.

509.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Water.....745.01

509.03 SUBMITTALS. The Contractor shall submit a blanket grinding work plan to the Engineer. At a minimum, the submittal shall include detailed procedures and information for the following:

(a) Determining initial grinding depth.

(b) Monitoring depth of grinding.

(c) Determining location of wheel paths.

(d) Depth of grinding for the second pass and any subsequent passes.

(e) Repair procedures if the deck is damaged during grinding operations.

(f) Remedial action if depressions exceed geometric limits of grinding.

(1) Means of determining remaining clear cover over reinforcing steel for further grinding.

(2) Subsequent grinding patterns if sufficient clear cover remains over the reinforcing steel.

(g) Manufacturer's specifications for concrete bridge deck grinding equipment.

The Agency will review the submittal for compliance with the requirements of the Contract. If the procedures or information do not conform to the Contract requirements, the submittal will be returned as rejected. The submittal shall not be marked as approved or approved as noted until all of the required information has been received and reviewed.

Once a complete submittal has been received, the Agency shall be allowed 21 calendar days for the initial review period and 14 calendar days for the review of each subsequent resubmittal.

The Contractor will not be permitted to begin grinding until the blanket grinding work plan has been marked as approved or approved as noted by the Agency. After the blanket grinding work plan has been marked approved or approved as noted, no changes shall be made without the written approval of the Agency.

509.04 CONSTRUCTION REQUIREMENTS.

(a) Concrete Bridge Deck Grinding Equipment. The grinding equipment shall be power driven, self-propelled, and specifically designed to smooth and texture Portland cement concrete with diamond blades or diamond impregnated cylinder rings. The equipment shall have a minimum weight of 35,000 pounds, including the grinding head, and shall be capable of grinding a strip at least 3 feet wide. The effective wheelbase of the machine shall be no less than 12 feet. The equipment shall have a positive means of vacuuming the grinding residue from the deck pavement surface, leaving the surface in a clean, near-dry condition.

The equipment shall have a set of pivoting tandem bogey wheels at the front of the machine and rear wheels or tandem bogies that travel and track on the freshly cut surface. The equipment shall be maintained to ensure it is in proper working order, with attention paid to the roundness of the match and depth control wheels. Any wheels found to be out of round shall be immediately replaced.

The equipment shall be capable of grinding the surface in the longitudinal direction without causing spalls or other damage at cracks, joints, and other locations. Grinding equipment that causes raveling, aggregate fractures, or disturbance to the joints shall not be permitted. The equipment shall be capable of correcting the bridge deck profile and providing the proper cross slope.

The equipment shall be capable of grinding all concrete bridge deck materials, including rapid set concrete and ultra-high performance concrete (UHPC). If the Contract specifies the use of UHPC, the grinding of the UHPC surface shall be performed when a minimum compressive strength of 10 ksi has been achieved and per the manufacturer's recommendations. If significant fiber pullout is observed during grinding operations, grinding shall be suspended and not resumed until approved by the Engineer.

The Contractor shall provide equipment capable of feathering longitudinal ridges along the limits of grinding that remain after grinding is complete.

(b) Concrete Bridge Deck Grinding. Grinding operations shall not begin until the effective cure time for the bridge deck concrete is complete and the wearing course of bituminous concrete pavement has been placed on the bridge approaches. A minimum of two passes are required.

Grinding operations shall be performed in a longitudinal direction and provide a uniform finished texture. The beginning and end grinding lines shall be normal to the bridge centerline or along the deck skew. Grinding shall terminate 10 feet beyond the ends of the concrete bridge deck in the bituminous concrete pavement, except for locations with steel bridge joints or as otherwise directed by the Engineer. Unless otherwise indicated in the Contract, grinding shall be terminated as specified in Table 509.04A.

TABLE 509.04A – GRINDING TERMINATION DISTANCE REQUIREMENTS

Location	Closest Allowable Distance (in.)	Farthest Allowable Distance (in.)
Drainage structure	4	15
Face of curb or barrier	4	15
Steel bridge joint system [1]	4	15

[1] Dimension measured perpendicular to the centerline of the steel bridge joint system.

(1) Geometric Requirements. Each pass shall grind a strip at least 3 feet wide and not exceed the following vertical criteria:

a. Unless otherwise noted on the Plans, the maximum depth of material removed by diamond grinding shall be 3/4 inch.

b. The maximum vertical difference between longitudinal passes shall be 1/8 inch.

c. Proposals to correct depressions exceeding the allowable grinding depth shall be submitted to the Engineer for approval. All depressions shall meet the specified grinding smoothness and texture requirements post remediation.

(2) Smoothness. After grinding, the deck shall have a uniform transverse and longitudinal slope with no depressions or misalignment of slope greater than 1/8 inch in 10 feet when tested with a 10 foot straightedge. The surface will be checked at random by the Engineer during the grinding operation to ensure that no depressions exist that will pond water. The straightedge will be placed in contact with the surface in successive positions parallel to and perpendicular to the centerline of the structure. If the existing concrete surface is parabolic, the straight edge test shall not be used across the parabolic surface.

(3) Texture. The surface texture shall be a parallel, corduroy-type consisting of grooves between 1/16 inch and 1/8 inch wide. The peaks of the ridges shall be approximately 1/16 inch higher than the bottom of the grooves.

(4) Cleaning. Grinding residue shall be removed with a vacuum attached to the grinding machine. The vacuum shall leave the deck surface in a clean, near dry condition. Grinding residue shall be disposed of at an appropriate disposal facility.

(5) Grinding Operations. Grinding shall continue until one of the following criteria is approved by the Engineer:

a. The surface meets the smoothness and texture required.

b. The maximum depth of grinding, texture, and depression remediation measures are met.

(6) Feathering Ridges along Limits of Grinding. Longitudinal ridges along the limits of grinding that remain after grinding is complete shall be feathered out to provide a uniform transition from the deck surface at the face of curb or barrier to the finished deck surface after grinding.

509.05 METHOD OF MEASUREMENT. The quantity of Concrete Bridge Deck Surface Preparation to be measured for payment will be the number of square feet of concrete bridge deck surface prepared in the complete and accepted work. Measurement will be based on the horizontal distance between the face of curb or barrier as shown on the Plans and the longitudinal length of the bridge deck. The longitudinal length measured for payment will be extended by 10 feet beyond each end of the bridge deck except for locations with steel bridge joints or as otherwise directed by the Engineer.

509.06 BASIS OF PAYMENT. The accepted quantity of Concrete Bridge Deck Surface Preparation will be paid for at the Contract unit price per square foot. Payment will be full compensation for grinding the bridge deck; furnishing and implementing the required submittals; and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
509.1500 Concrete Bridge Deck Surface Preparation	Square Foot

SECTION 510 – PRESTRESSED CONCRETE

510.01 DESCRIPTION. This work shall consist of manufacturing, transporting, and erecting precast prestressed concrete members.

510.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Portland Cement....701.02
High Early-Strength Portland Cement....701.03
Portland-Pozzolan Cement....701.04
Portland-Limestone Cement....701.05
Portland Blast-Furnace Slag Cement....701.06
Ternary Blended Cement....701.07
Fine Aggregate for Concrete....704.01
Coarse Aggregate for Concrete....704.02
Lightweight Fine Aggregate for Concrete....704.19
Mortar, Type IV....707.01(e)
Preformed Joint Filler, Cork, and Asphalt-Treated Felt....707.06
Polyvinyl Chloride (PVC) Waterstop....707.08
Bar Reinforcement....713.01
Prestressing Strand and Post-Tensioning Strand....713.04
Structural Steel....714.02
High-Strength Low-Alloy Structural Steel....714.03
Carbon Steel Bolts, Nuts, and Washers....714.04
High-Strength Structural Bolts and Assemblies, 120 ksi....714.05
Concrete Curing Materials....725.01
Air-Entraining Admixtures....725.02(b)
Retarding Admixtures....725.02(c)
Water-Reducing Admixtures....725.02(e)
Water-Reducing and Retarding Admixtures....725.02(f)
Water-Reducing, High Range Admixtures....725.02(g)
Water-Reducing, High Range, and Retarding Admixtures....725.02(h)
Accelerating Admixtures....725.02(i)
Water-Reducing and Accelerating Admixtures....725.02(j)
Specific Performance Admixtures....725.02(k)
Mineral Admixtures....725.03
Polystyrene Insulation Board....735.01
Blanket Insulation Material....735.02
Pipe Insulation....740.06
Water....745.01
Concrete Repair Material, Type I....780.01(a)

Bearing pads for structures shall meet the requirements of Section 731.

510.03 GENERAL FABRICATION REQUIREMENTS.

(a) General Requirements. The manufacture of the prestressed units shall be in accordance with the requirements of *PCI MNL-116* and *PCI MNL-135*, except as modified in this section.

(b) Qualification. The prestressed members shall be manufactured in a plant that has been certified by PCI under its Plant Certification Program for prestressed concrete. The plant shall be certified at a minimum to the level of product being produced. If there is an architectural finish for the product, the plant shall be certified at a minimum to the level of product being produced plus the architectural certification at that level.

Prestressed concrete shall be manufactured in a plant that maintains a quality control laboratory that meets the requirements of the Agency's *Qualified Laboratory Program*. As a minimum, the laboratory shall be equipped with a compression testing machine, curing room or chamber, apparatuses for measuring slump/flow and air entrainment, and a complete set of Aggregate sieves. The compression testing machine shall be calibrated yearly by an independent laboratory using equipment that is certified by the National Institute of Standards and Technology. The testing machine shall be power-operated and capable of applying the load continuously rather than intermittently, and without shock.

(c) Quality Control. The fabricator shall demonstrate a level of quality control testing that satisfies the Agency as to its ability and commitment to produce concrete to the requirements of this section. A satisfactory program of quality control shall include gradation and moisture determinations of the aggregates, as well as slump, air content, and strength determinations of the concrete.

These tests shall be performed at regular and suitable intervals as specified in the *Materials Sampling Manual* and actively used to maintain the quality of the concrete within the specified requirements. The fabricator shall have a plant specific quality control plan approved by the Agency prior to the beginning of any fabrication activities.

510.04 SUBMITTALS. As soon as practical after award of the Contract, all required information shall be prepared and submitted.

Fabrication drawings, also referred to in the precast industry as production drawings or shop drawings, for the prestressed concrete shall be submitted in accordance with the requirements of Subsection 105.06, with an additional copy sent to the Structural Concrete Engineer. Fabrication drawings shall include such detail as needed to fully describe the intended as-built condition of the prestressed elements including any connections between prestressed elements or existing structures and materials.

In addition to the requirements in Subsection 105.06, the following shall be included:

(a) Concrete Mix Design. The concrete mix design submittal shall include, but not be limited to, the following items:

(1) Batch weights specifying dry or saturated surface dry.

(2) Material names and sources.

(3) Aggregate properties and testing dates. Aggregates shall be tested on an annual basis, at a minimum, to verify that they meet the requirements of *AASHTO T 84* and *AASHTO T 85* for absorption and specific gravity and *AASHTO T 19* for unit weight.

(4) Chemical and physical properties of cementitious materials.

(5) Admixture names and sources.

(6) Lab data that shall include, but not be limited to, the following items:

a. The maximum W/CM ratio that will be allowed during production, including water contributed to hydration by all admixtures, when the cumulative total exceeds 1 gallon per cubic yard.

All mix qualification test results shall be generated with concrete from batches that are produced at this maximum W/CM ratio.

b. The slump/spread minimums and maximums, as determined from trial batches.

The concrete shall be classified and tested as self-consolidating concrete (SCC) if the minimum spread is at least 18 inches. When the concrete is tested as an SCC mix, the difference between the J-ring test (*ASTM C1621*) and the spread test (*ASTM C1611*), shall be 2 inches or less for the minimum and maximum spread.

Concrete that fails to meet the 18 inches minimum spread threshold will be classified and tested as conventional concrete. The visual stability index (VSI) determination will be included for the minimum and maximum values and shall not be greater than 1. The concrete shall not demonstrate segregation at the minimum or maximum slump/spread.

c. Air content results obtained in accordance with the requirements of *AASHTO T 152*.

d. Temperature results obtained in accordance with the requirements of *ASTM C1064*.

e. Cylinder compression stress results obtained in accordance with the requirements of *AASHTO T 22* for early breaks and design strength, and 28-day standard cure results obtained in accordance with the requirements of *AASHTO R 100*. The type of cure shall be listed for each age of break.

f. The surface resistivity of the test mix shall be measured at 56 days based on the requirements of *AASHTO T 358*. Results shall be categorized as Low, Very Low, or Negligible in accordance with AASHTO T 358, Table 1. The surface resistivity may be accepted prior to 56 days if the results meet these requirements. The 56 day test results shall be completed and submitted regardless of the results of earlier tests.

Testing shall be performed by an independent AASHTO re:source qualified laboratory.

Test results that are suspected to have been adversely affected due to the presence of polymeric admixtures in the proposed mix may be retested with the polymeric admixture omitted.

g. The alkali-silica reactivity (ASR) of each type of aggregate shall be measured separately based on the requirements of *AASHTO T 303*. If one or more of the aggregates exceeds 0.10% expansion, then the aggregate shall be tested again according to the requirements of *ASTM C1567*.

The Contractor may elect to go directly to *ASTM C1567* testing if they suspect that the aggregate may exceed the 0.10% expansion if tested by *AASHTO T 303*. Testing shall be performed by an independent AASHTO re:source qualified laboratory accredited in the specific test method.

h. Length change test results obtained in accordance with the requirements of *AASHTO T 160*. Testing shall be performed by an independent AASHTO re:source qualified laboratory accredited in conducting testing that meets the requirements of *AASHTO T 160*. The maximum free shrinkage test result shall not exceed 0.06%. The cross-section of the prism shall be 4 inches × 4 inches. The requirements of *AASHTO T 160, Section 11.1.2* shall be followed for storage and measurements.

(7) Mix design approvals will be valid for a 12-month period. The approved mix design will be allowed re-approval if the following conditions are satisfied:

a. A determination has been made that no material proportioning or material sources have changed from the initial approved mix design.

b. The mix design for re-approval is submitted with updated aggregate properties and volumes adjusted accordingly. The properties to be tested include, but are not limited to, specific gravity, unit weight, and absorption.

Aggregate property values will be valid for 14 months from the date tested.

c. The re-approved mix design shall be accompanied by the test mix data that was completed and accepted for the initial mix design approval, as well as any applicable updated test information.

New mix designs and mix designs that were initially approved more than 36 months ago shall have new testing completed to be submitted for approval.

The proposed concrete mix design, including performance history and all requests for variance from the material requirements of these specifications, shall be submitted for approval. The Structural Concrete Engineer may require a minimum of 8 weeks for testing, review, and approval of new mix designs.

(b) Dimensions and Tolerances. The dimensions and tolerances of the sections to be fabricated shall be submitted. Fabricators shall calculate the camber estimate at the time of release and at the estimated time of delivery. The camber control plan shall be as detailed in Subsection 510.08(i).

(c) Locations. The locations of reinforcing steel and prestressing strands shall be submitted.

(d) Prestressing Methods. The methods of prestressing, including certified calibration charts for all jack and gauge combinations shall be submitted.

(e) Tensioning Calculations. Tensioning calculations for prestressing strands that include gauge pressure, elongations, and movement of anchorage abutments. A professional engineer shall review and stamp the calculations.

(f) Strand De-Tensioning. The method and sequence of strand de-tensioning.

(g) Surface Finish. The type of surface finish and how the finish will be obtained.

(h) Curing Method. The curing method, detailing the sequence and duration in accordance with the requirements of Subsection 510.09.

(i) Minimum Strength Requirement. The minimum required concrete strength for the transfer of prestress forces.

(j) Lifting Attachments. The design of the lifting attachments, including the minimum required concrete strength to allow lifting, based on calculations stamped by a professional engineer.

Lifting attachments are not required to be permanently installed in the work and may be removed or left in place at the Contractor's convenience, provided that the minimum clear cover requirements are met.

(k) Logistics. Transportation, handling, and storage details.

(l) Installation and Grouting. The installation and grouting procedures.

(m) Quality Control. A full description of all quality control procedures.

All design details shall be in accordance with the *VTrans Structures Design Manual* and the *AASHTO LRFD Bridge Design Specifications.* A professional engineer shall stamp any design calculations included in the submittal materials.

510.05 CONCRETE.

(a) Batch Plants. Batch plant equipment, materials, and batching procedures shall conform to the provisions of Section 501 identified in Table 510.05A.

TABLE 510.05A – BATCH PLANT OPERATION SUBSECTIONS AND TOPICS

Subsection	Topic
Subsection 501.04(a)	General Requirements [1]
Subsection 501.04(d)	Testing Laboratory
Subsection 501.04(e)	Bins and Scales
Subsection 501.04(f)	Production Tolerances for Batching
Subsection 501.04(g)	Storage and Proportioning of Materials
Subsection 501.05	Mixing and Delivery [2]

[1] Paragraphs 1 and 3 only.

[2] For plants not located in Vermont, the Agency has the option of waiving the requirements of Subsection 501.05(a)(6) in their entirety and Subsection 501.05(c), paragraph 1 only.

(b) Acceptance Testing. For acceptance testing, refer to the *Materials Sampling Manual* for sampling, curing, and testing requirements.

Specimens shall be tested either at the Agency's Materials Testing and Certification Section Central Laboratory, or at the fabricator's plant laboratory. An Agency representative shall witness all tests.

Concrete for prestressed members shall conform to the following:

(1) The compressive strength test results obtained at or before 28 days shall not be less than the design compressive strength shown on the Plans. When a 28-day test result is below the specified design strength, all concrete represented by that test shall be unacceptable for the requirements of this section. The Engineer reserves the right to reject all members that were manufactured from this concrete.

(2) The maximum total water batched shall not exceed 280 pounds per cubic yard, including water contributed to hydration by all admixtures when the cumulative total exceeds 1 gallon per cubic yard. If total cementitious material content exceeds 900 pounds per cubic yard, then water batched shall not exceed 300 pounds per cubic yard. The maximum W/CM ratio in production shall not exceed the maximum W/CM ratio specified in Subsection 510.04(a)(6)a.

(3) The air entrainment value shall be 7% (± 2%) when tested in accordance with *AASHTO T 152*.

(4) The temperature of the concrete at the time of placement shall be between 50°F and 85°F as tested in accordance with the requirements of *AASHTO T 309*.

(5) The concrete shall not demonstrate segregation at any time. If the mix fails to remain within the minimum and maximum slump or spread ranges submitted in the mix design, the load may be rejected. The VSI shall be less than or equal to 1.

(6) The Agency may request that the producer fabricate three concrete test cylinders that will be cured along with the piece they represent through the complete curing period. These cylinders shall be kept with the piece they represent until collected by the Agency as specified by the requirements of *AASHTO T 277* and *AASHTO T 358*.

(c) Cementitious Materials. Only the cementitious combinations and sources from the approved mix design shall be used in the prestressed units required for any one structure, unless otherwise authorized by the Structural Concrete Engineer. Any admixture containing calcium chloride shall not be used.

510.06 INSPECTION. Materials furnished and the work performed under the requirements of Section 510 shall be inspected by the Agency. The inspector shall have the authority to reject any material or work that does not meet the requirements of these specifications. Any work performed that has not been inspected may be rejected, unless waived in writing by the Engineer.

The inspector shall be provided with a minimum office space of 100 square feet with a least dimension of 6 feet. A desk surface with a minimum of two drawers, as well as dedicated private telephone and internet services, shall be provided to the laboratory. The phone and internet service shall be provided in accordance with Subsection 631.02(a)(4), except that selection of the service by the Engineer is not required.

Any variances shall be approved by the Structural Concrete Engineer. This office space shall be located on the premises as close to the production area as practicable.

The Engineer reserves the right to reject inadequate office facilities and require suitable alternatives.

510.07 PRESTRESSING. Prestressing shall be accomplished by the pre-tensioning method.

The fabricator shall provide all equipment necessary for the prestressing operations. Prestressing shall be done with approved jacking equipment. Hydraulic jacks shall be equipped with pressure gauges or other indicating devices. The combination of jack and pressure gauge, or other tensioning system, shall be accompanied by a certified calibration chart showing the relationship between the gauge reading and the force in the ram for both ascending and descending movements of the ram. The calibration date of each combination jack and gauge or indicating device shall be within the 12-month period immediately prior to the start of work.

If other types of jacks are used, calibrated proving rings or other devices shall be furnished so that the jacking force may be accurately determined.

Suitable precautions shall be taken by the fabricator to prevent accidents due to breaking of the prestressing steel or slippage of the grips during prestressing operations.

The tensioning operation shall proceed until the calculated gauge reading has been reached. The elongation of each strand shall then be measured. If the measured elongation differs from the theoretical by more than 5%, the tensioning operation shall be stopped, and the cause of the discrepancy determined prior to continuing.

Immediately after tensioning, the final position of each strand shall be marked to check any strand slippage prior to placing concrete. If slippage is suspected or if the time between tensioning and placing concrete exceeds 48 hours, then 10% of the total number of strands including the strands that are suspected to have slipped shall be re-tensioned and the elongation measured. The specific strands to be re-pulled will be selected by the Agency inspector, but no fewer than two strands shall be re-pulled.

If additional elongation is gained, the amount gained shall be subtracted from the theoretical elongation. If the result of the theoretical elongation minus the gain in elongation is less than the minimum allowable elongation per the requirements of *PCI MNL-116* for any of the strands tested, the final force shall be applied to all strands.

For abutment anchorage set-ups where the strands are anchored to abutments that are independent from the form, thermal adjustments shall be made if the ambient temperature at the time of tensioning differs by more than 25°F from the concrete temperature prior to placement and if the net force differential is greater than 2.5%.

Consideration shall be given to partial bed length usage and adjustments made when the net effect on the length of the bed used exceeds the allowable. The thermal coefficient of steel shall be taken as 6.5×10^{-6}/°F.

510.08 FABRICATION.

(a) Pre-Production Meeting. A pre-production meeting shall be requested by the producer a minimum of 14 calendar days prior to beginning concrete placement, unless the Engineer deems, in writing, that a pre-production meeting is unnecessary. The meeting shall be held a minimum of 5 calendar days prior to beginning concrete placement unless otherwise approved by the Structural Concrete Engineer.

At a minimum, the pre-production meeting shall be attended by the crew supervisor, plant manager, inspector or inspector's supervisor, a representative from the Agency's Materials Testing and Certification Section Structural Concrete Unit, and the Project Manager or designer. Additionally, the fabricator shall have available at the pre-production meeting the approved fabrication drawings and a complete anticipated production schedule for all components included in the fabrication drawings.

(b) Forming Members. Side forms shall be supported without the use of ties or spreaders within the body of the member. Any defects or damage due to formwork, stripping, or handling may be cause for rejection.

Forms for interior voids or holes in the members shall be constructed of a material that will adequately resist breakage or deformation during concrete placement and that will not materially increase the weight of the members. Interior void forms shall be accurately positioned as shown on the Plans and secured to prevent displacement during concrete placement. All voids shall be adequately vented to prevent damage to the members during curing. Each void shall contain a suitably located drain hole.

Holes or cutouts for anchoring devices, diaphragm connections, openings for connection rods, recesses for grout holes for railing bolts, and any other related details shown on the Plans shall be provided for in the members. Where diaphragm dowels do not pass through the member, the dowels may be attached by use of an approved anchorage embedded in the concrete member.

(c) Placing Transverse Conduits and Tendons. Each tendon to be post-tensioned shall be encased in an approved conduit. Unless otherwise shown on the Plans, the ratio of cross-sectional area of the tendon to be encased to the interior cross-sectional area of the conduit shall not exceed 0.4, except when a steel bar is used as a tendon. The inside diameter of the conduit shall be at least 3/8 inch greater than the diameter of the bar. Conduit that has been crushed or has opened seams shall not be used.

The conduit shall be rigidly constructed, completely sealed, accurately placed, and securely fastened to maintain the desired profile during concreting. No conduit shall be located more than 1/4 inch from the position shown on the Plans. Bundling of conduits will not be permitted.

(d) Placing Prestressing Strands. Prestressing strands shall be accurately placed in position to achieve the center of gravity of the steel as shown on the approved shop drawings. Prestress strands shall be protected against corrosion and be free of nicks, kinks, dirt, rust, oil, grease, and other deleterious substances.

(e) Bar Reinforcement and Welded Wire Reinforcement. Bar reinforcement and welded wire reinforcement shall be furnished and installed in conformance with the requirements of Section 507. The chairs or spacers used to support or locate the reinforcement that bears on the faces of the forms shall be made of, or be coated with, a non-corrosive material so that no discoloration will show on the faces of the prestressed concrete units.

(f) Pre-Tensioning. The prestressing strands shall be stressed by jacking in accordance with the requirements of Subsection 510.07, and in the presence of an Agency representative. The jacking force exerted and the elongation produced shall be recorded. Several units may be cast and stressed at one time in a continuous line. Sufficient space shall be maintained between the ends of the units to permit access for cutting strands after the concrete has attained the required strength.

(g) Placing Concrete. Concrete shall not be deposited in the forms until the Agency representative has reviewed and approved the placement of the reinforcement, conduits, anchorages, and prestressing strands.

The concrete shall be vibrated internally, externally, or a combination thereof to the required consolidation. The vibrating shall be done with care and in such a manner that the concrete is uniformly consolidated, any displacement of or damage to reinforcement, conduit, voids, and prestressing strand is avoided, and acceptable finish surfaces are produced.

When a vibrator is used with rebar with special coatings or made of non-metallic material or material that could be susceptible to damage, the vibrator head shall be non-metallic or rubber-coated.

SCC concrete should not be vibrated. If there is a need to vibrate SCC concrete, it shall only be vibrated for the minimum time necessary so as to avoid segregation.

(h) De-Tensioning. No stress shall be transferred to the concrete until 80% of the design compressive strength (f'_c) has been attained, or as stated on the approved fabrication drawings. The compressive strength shall be determined by cylinders tested in accordance with the *Materials Sampling Manual*. The prestressing strands shall be released in the de-tensioning pattern detailed on the shop drawings.

If de-tensioning is accomplished by single strand release, each strand shall be cut by gradually heating the strand at both ends of the member simultaneously. A minimum length of 5 inches of strand shall be heated to prevent any shock or snap when the strand is finally severed. Each strand shall be cut at all spaces between members cast continuously, before starting de-tensioning on the following strand in sequence.

Strands shall be cut flush and epoxy-painted unless otherwise specified on the Plans. If the strands are required to be recessed, a block-out shall be built into the bulkhead that will allow the strands to be cut without damaging the concrete. The recess shall be thoroughly cleaned and patched with Type IV mortar. The mortar shall be wet cured for three days or as specified by the manufacturer.

(i) Dimensional Tolerances. All dimensional tolerances shall be in accordance with *PCI MNL-116* and *PCI MNL-135* unless otherwise noted in the Contract or approved by the Engineer.

The camber and differential camber between beams measured at pre-shipping inspection shall be within PCI tolerances and shall be measured with dunnage placed under bearing areas of the beam and at no less than 72 hours after the removal of any means of camber correction. Tolerances shall be compared to the calculated camber estimates at the time of the pre-shipping inspection.

The camber control plan shall detail how the fabricator will achieve the calculated camber estimate submitted in the fabrication drawings as required in Subsection 510.04(b). The fabricator shall achieve a beam camber at time of delivery that is within PCI tolerances of the calculated camber estimate. In addition, it is the responsibility of the Contractor to confirm at the time of fabrication drawing review that the calculated camber estimate is compatible with the grades and elevations of the rest of the structure.

(j) Dimensional Tolerances for Prestress Deck Panels. Prestress deck panels shall have dimensional tolerances as specified in Table 510.08A.

TABLE 510.08A – PRESTRESS DECK PANEL TOLERANCES

Element	Tolerance
Vertical position of strand group (measured from bottom of panel)	+ 0 inches, - 1/8 inch
Dunnage	± 6 inches
Warping (distance from nearest adjacent corner)	1/16 inch per foot
Finish of strands (minimum extension beyond ends of panel)	4 inches

(k) Defects. Units that contain defects caused by manufacture or handling may be repaired at the manufacturing site.

Minor defects are defined as the intermittent presence of holes, honey-combing, chips, or spalls, which measure 6 inches or less in the longest dimension, and that do not penetrate deeper than 1 inch into the concrete. Minor defects may be repaired using an approved standard repair procedure as detailed in Subsection 510.08(k)(3).

Surface voids or bug holes that are less than 5/8 inch in diameter and less than 1/4 inch deep need not be repaired. Minor defects that recur with any identifiable regularity or pattern may be required to be addressed through a non-conformance report (NCR), at the discretion of the Structural Concrete Engineer.

Any defect that has the potential to affect structural capacity or integrity shall be categorized as a major defect. It is at the sole discretion of the Structural Concrete Engineer to determine into which category any defect is categorized.

(1) Cracking. Cracks less than 0.01 inch in width shall be sealed by a method approved by the Structural Concrete Engineer. Cracks equal to or greater than 0.01 inch in width may be cause for rejection based on their width, length, location, and frequency. At the Structural Concrete Engineer's discretion, cracked members shall be repaired or replaced at the Contractor's expense. De-tensioning procedures causing web-splitting or other member cracking shall be revised before de-tensioning the next bed. Cracks with a width of 0.05 inch and greater found in any member will be cause for rejection.

(2) Repairs. Repairs shall be made using an overhead and vertical concrete repair material from the Agency's *Approved Products List*. Any unsound concrete shall be carefully chipped out and the perimeter saw-cut to a minimum depth of 1/4 inch or deeper if recommended by the repair material manufacturer. The prepared surface profile shall be as specified by the repair material manufacturer. If not specified, the prepared surface profile shall conform to, at a minimum, the International Concrete Repair Institute's *CSP 6 (Medium Scarification)* surface profile. The repair material shall be cured as specified by the manufacturer.

(3) Standardized Repair Procedures. Standardized repair procedures (SRPs) shall be a comprehensive documented process for repairing minor defects at the fabricator's facility. At a minimum, the SRP shall detail the scope of defects for which that procedure is intended to be used, a detailed narrative including every step of the repair procedure, and the product documentation for the specific repair materials that will be used.

The SRP shall include example pictures of defects for which the procedure could be used, detailed example pictures covering every step of the repair procedure, and example pictures of a successfully completed repair job.

Approval to use an SRP for any given defect is at the sole discretion of the Structural Concrete Engineer, and all SRPs shall be approved by them prior to their use. SRPs shall be submitted to the Structural Concrete Engineer at least 14 calendar days in advance of the repair work. The Agency's consent to use an SRP for the repair of a defect does not constitute acceptance of that repair.

(4) Non-Conformance Report. Any defects existing in the pieces, other than those defined as minor above, shall be documented with a non-conformance report (NCR). NCRs shall be submitted within 2 working days of the discovery of the defect. At a minimum, the NCR shall detail what the defect is, including detailed pictures of the piece and defect, and what caused it.

The NCR shall further document the proposed repair, the procedure for carrying out the proposed repair, and a plan of action to prevent additional similar defects from occurring. Any approved repairs shall be documented and photographed during the repair work and after completion of the repair.

(l) Deck Panel Rejection Criteria. Deck panels that exhibit any of the following conditions shall be rejected.

(1) Any crack that has a transverse or diagonal orientation relative to the strand pattern and crosses more than one strand.

(2) Any crack that is parallel to a strand and is longer than 33% of the panel length.

(3) Cracks that are shorter than 33% of the panel length and occur at more than 12% of the total number of strands in the panel.

(4) Voids or honeycombed areas with exposed strands.

(5) Any other reason that the Structural Concrete Engineer determines could have an adverse impact on the structural integrity of the deck panel.

(m) Finishing Riding Surfaces with No Asphalt Wearing Surface. All exposed riding surfaces not covered with an asphalt wearing surface shall be given a finish as specified on the approved shop drawings, or if not specified, in accordance with the requirements of Subsection 501.14.

(n) Welding. All welding shall conform to the requirements of Subsection 506.10.

(o) Cold Weather Concrete. Cold weather concrete will be any concrete placed or cured when the ambient air temperature is expected to be below freezing at any point in time or below 40°F for an 8-hour continuous period. The requirements of Subsection 501.07(b) shall apply in addition to the requirements of Subsection 510.09.

(p) Marking. The date of manufacture, the production lot number, and the piece mark shall be clearly marked on each individual piece of prestressed concrete. The mark shall be in a location that will not be visible in the finished product.

510.09 CURING.

(a) General Requirements. All curing methods for prestressed concrete shall be subject to the Structural Concrete Engineer's approval. The fabricator shall submit complete details of the proposed methods for approval with the fabrication drawings.

The curing period for prestressed concrete is defined as wet curing for a minimum of 72 hours, to begin immediately following the completion of placing and finishing of the concrete. The following requirements shall apply:

(1) The method of curing shall prevent the loss of moisture throughout the cure period. Except where modified herein, prestressed concrete structure components shall be cured by water curing, by wetted burlap covered with white polyethylene sheeting, or by burlap-white polyethylene sheeting (burlene) as specified in Subsection 501.15.

(2) When a curing enclosure is used, free water shall be evident and the relative humidity within the enclosure shall exceed 90% throughout the duration of the curing period. A curing enclosure is considered any means of moisture-retention that allows air to contact the surface of the piece.

(3) The concrete's strength shall be determined by test specimens cured with the product they represent, or by specimens match-cured in an approved match-curing system.

(4) Wet curing shall continue until 80% of the 28-day design strength is achieved, but shall be no less than 72 hours in duration.

(5) Curing by the approved method shall continue uninterrupted until the start of de-tensioning operations. De-tensioning shall be accomplished while the product is still warm. Wet curing shall be resumed upon removal of the product from the forms.

(b) Curing Temperatures.

(1) The controlling temperatures for concrete curing shall be those actually achieved within the concrete elements, and not the ambient temperatures of the curing area unless specifically stated as such.

(2) The internal temperature of the prestressed concrete shall be raised to at least 68°F within the first 12 hours of the curing period, and shall be maintained at or above 68°F for the remainder of the entire curing period.

(3) The internal temperature of curing concrete shall be monitored using sacrificial thermocouples placed as near as practicable to the center of mass of the finished piece. In addition, the temperature within the curing enclosure shall be monitored using strategically placed temperature sensors so that the reported temperatures accurately represent the curing conditions.

The requirement for temperature monitoring may be waived by the Structural Concrete Engineer if the concrete is not subject to accelerated curing and ambient temperatures are expected to be well in excess of 40°F throughout the duration of production.

(c) Accelerated Curing. Accelerated curing procedures may be employed in lieu of the standard 72-hour curing procedure described in Subsection 510.09(a), in accordance with the requirements of *PCI MNL-116, Section 4.19* and the following:

(1) The initial time of set is defined in *AASHTO T 197* and *ASTM C403* as the time it takes for fresh concrete to attain a compressive strength of 500 psi.

Testing to determine the time of set shall be done when the concrete temperature is within ± 5°F of the anticipated concrete placement temperature.

Alternately, time of set may be found by taking a minimum of three different concrete temperatures at intervals of approximately 10°F, entering that data on a graph, and then drawing a best-fit smooth curve line through the three data points. This graph will be used to determine the time of set for the anticipated concrete placement temperature, rounded up to the nearest half hour.

(2) Immediately upon completing placement of the concrete for each prestressed concrete structure component, an enclosure that is suitable for containing live low-pressure steam or heat shall be placed over the forms. The fabricator shall make these enclosures available for inspection prior to casting.

(3) When low-pressure steam heating methods are used for accelerated curing, precautions shall be taken to prevent the live steam from being directed on the concrete or forms in such a way as to cause damage from localized high temperatures.

(4) When radiant heat is used for accelerated curing, all exposed concrete surfaces shall be covered with plastic sheeting. Radiant heat may be applied by means of circulation pipes containing steam, hot oil, or hot water, or by electric heating elements.

(5) While waiting for the initial set to take place, the temperature within the concrete may be increased at a maximum rate of 10°F per hour. However, the temperature within the concrete shall not be more than 40°F higher than the initial concrete placement temperature or more than 104°F, whichever is less.

Following the initial set, the internal concrete temperature shall be increased at a rate of not more than 40°F per hour until the desired curing temperature is reached. The maximum internal concrete temperature shall not exceed 160°F. The maximum differential between the curing enclosure temperature and internal concrete temperature shall not exceed 40°F. The selected curing enclosure temperature range shall be as approved on the fabrication drawings.

The accelerated curing cycle shall be considered complete when the method of supplying heat is stopped or the concrete temperature drops below 120°F. Two concrete cylinders shall be tested immediately upon completion of the accelerated cure cycle.

The maximum cooling rate from the sustained accelerated curing temperature shall be 50°F per hour. Cooling at this rate shall continue until the concrete temperature is 40°F or less above the ambient temperature outside the curing enclosure.

(6) Prestressed concrete that has not attained 80% of its 28-day design strength shall be additionally wet-cured until this strength threshold is met. If the precast concrete has attained 80% of its 28-day strength during the accelerated curing cycle, no further curing will be required.

(d) Conditioning. Following the completion of the chosen curing method, precast elements that are to be exposed to cold weather conditions as defined in Subsection 510.08(o) shall be allowed to cool and dry in an environment of at least 40°F for 24 hours to prior to exposure to cold weather conditions. For pieces cast outdoors in cold weather ambient conditions, all requirements of Subsection 501.07(b) shall apply.

(e) Temperature Recording. The fabricator shall install one automatic temperature recorder for every 100 feet of production length. The Structural Concrete Engineer may require that additional temperature recorders be installed if it is determined that the one per 100 feet of production length spacing does not allow for adequate monitoring of the curing conditions.

Temperatures recorded on the data logs shall be used to determine whether the prestressed concrete structure components have been cured in accordance with the specifications and the approved fabrication drawings.

The recorder shall record, at intervals not to exceed 15 minutes, the temperature of the air surrounding the piece as well as the internal concrete temperature. Temperature recording shall continue until completion of the chosen curing method.

Each recorder's data log shall indicate the casting bed, the date of casting, the start and finish times of record, and the mark number of the prestressed concrete structure component being cured. At the completion of the temperature recording period, the data logs shall be given to the Agency representative.

Recorder accuracy shall be certified at least once every 12 months, and the certificate displayed with the recorder. Calibration and certification shall be performed by either the manufacturer, the supplier, or an independent laboratory. Random temperature checks of each recorder may be made by an Agency representative.

510.10 HANDLING, STORAGE, AND SHIPPING. Handling and installation of prestressed members shall be performed with members in an upright position and with points of dunnage support and direction of lifting reactions as specified in the approved lifting calculations.

Prestressed concrete shall be handled, stored, and shipped in such a manner as to minimize chipping, cracks, fractures, discoloration, and excessive bending stresses. Units damaged by handling, storage, or shipping shall be replaced at the Contractor's expense.

Prior to shipment of any members, all NCRs shall be resolved and all required testing shall demonstrate that the design requirements have been met.

510.11 INSTALLATION.

(a) Prestressed Concrete Members.

(1) Methods, Equipment and Erection. Cranes, lifting devices, and other equipment for all prestressed concrete member erection shall be of adequate design and capacity to safely erect, align, and secure all members and components in their final positions without damage. The Contractor is solely responsible for the methods and equipment employed for the erection of the prestressed concrete member.

Construction drawings for prestressed concrete member erection shall be submitted in accordance with the requirements of Subsection 105.06. The erection plan shall include the methods and sequence of prestressed concrete member erection, temporary bracing requirements, the equipment to be used for the erection, and the necessary computations to demonstrate that all of the erection equipment has adequate capacity for the work to be performed.

The erection plan shall also include provisions for all stages of construction, including temporary stoppages. When the fabricator-designed lifting hooks will be used by the Contractor, computations indicating the magnitude of stress in the segments during erection are not required, unless otherwise ordered by the Engineer.

The prestressed concrete members may be used for support of equipment prior to placement of the deck only with written permission of the Engineer. The proposed use of the prestressed members for support of equipment shall be detailed in the erection plan.

Submittal of the erection plan is for documentation purposes only and shall in no way be construed as approval of the proposed method of erection. The Contractor shall follow the erection plan as submitted.

(2) Initial Post-tensioning. The Contractor shall insert post-tensioning strands in the conduits and tension them to 3.0 kips.

(3) Grout. Grout shall be placed in accordance with the requirements of Subsection 510.12.

(4) Fairing Surfaces. This work shall consist of placing grout between prestressed members as required for fairing out any unevenness between adjacent units. Type IV mortar shall be used, and grout placement shall occur at the same time mortar is placed to fill shear keys between members and in accordance with the requirements of Subsection 510.12.

The mortar shall be placed to eliminate unevenness, forming a smooth surface from the higher beam edges to the lower surface. The finished surface shall be feathered smoothly and be free of depressions or sharp edges.

(5) Final Post-Tensioning. Strands shall be post-tensioned in accordance with the requirements of Subsection 510.13.

(b) Prestressed Deck Panels.

(1) Prestressed deck panels shall be installed as shown on the Plans. The temporary supports shall be attached to the top of the flange of the girder with an adhesive, approved by the Engineer, in accordance with the manufacturer's recommendations.

The temporary supports shall be cut in the field to the required height after the blocking depth has been determined. The bottom of the panels shall be a minimum of 1 inch above the top of the top flange of the girder.

(2) Prestressed deck panels shall not be used to support heavy loads, such as additional deck panels, until the top slab is cast and cured. Construction loads on individual panels shall be uniformly applied and shall not exceed an average loading of 40 pounds per square foot.

(3) After the prestressed deck panels have been placed on temporary supports, the area under the ends of the panels and over the girder flanges up to the bottom of the panels shall be completely filled with the material specified on the Plans.

Temporary supports and grout dams for prestressed deck panels shall consist of continuous strips of high density, extruded polystyrene insulation board with a minimum compressive strength of 60 psi.

If leveling screws are used, polyethylene foam with a density of 1.7 pcf shall be employed as a grout dam. Prior to placement of the cast-in-place deck, the concrete shall be wet cured until a minimum of 85% of f'_c is attained by the average strength of two field-cured concrete cylinders. The leveling screws shall be completely removed and the holes filled with grout prior to the placement of deck concrete.

(4) Prior to placing the deck concrete, any laitance or other contaminates that would interfere with full bond to the panels shall be removed by an approved method.

510.12 GROUT.

(a) Surface Preparation. The fabricator shall ensure that surfaces to be grouted are clean, oil-free, and roughened in accordance with the Plans. The surface to be grouted shall be thoroughly wetted, yet free of all standing water. Shear keys shall be saturated surface dry prior to grouting.

(b) Grout Mixes. Grout shall be used to fill shear keys, transverse tie anchor recesses, and dowel holes, level screw voids, and for fairing joints as detailed in the Contract or as ordered by the Engineer.

Grout shall be Type IV mortar in accordance with Subsection 707.01(e)(1). Additional aggregates shall not be added to the material during field mixing.

Ready mixed mortar in accordance with Subsection 707.01(e)(2) may be substituted with written permission of the Engineer. Placement of ready mixed mortar shall be complete within 90 minutes of the time of batching.

The Contractor shall submit a proposed grouting procedure to the Engineer for their review and approval. The proposed grouting procedure shall include the required equipment, workforce, manufacturer's product data sheet for prepackaged mortar or the approved mix design of the ready mixed mortar when approved, placement rate, batch size, and all necessary details to explain how the grouted element will be placed in accordance with specification and manufacturer recommendations, as applicable, without air voids or cold joints.

Post-tensioning may occur when a field cured sample demonstrates conformance with post-tensioning strength requirements specified in the Contract, as determined in accordance with *ASTM C109*. Three cubes shall constitute a single sample.

(c) Placing Grout. The grout shall be mixed using a mechanical mixer according to the manufacturer's recommendations and shall be readily pourable so that it completely fills the shape of the shear keys or holes, depending on the product being installed. The placement of the grout for each shear key shall be continuous. The grouting of each shear key shall be completed in its entirety within a single working day.

(d) Curing Grout. In the absence of manufacturer curing recommendations, all exposed grout shall be cured for not less than 3 days by the wetted burlap method in accordance with the requirements of Subsection 501.15. Curing shall commence immediately following completion of grouting of individual shear keys.

510.13 POST-TENSIONING. Post-tensioning strands shall not be bonded to the concrete and shall be protected against corrosion as specified in the Contract.

Post-tensioning of strands shall not commence until a minimum compressive strength of 1,500 psi has been attained in the grout, when tested in accordance with the requirements of Subsection 510.12(b). If the design strength is met prior to completion of the required curing, the grout cure shall be maintained during the post-tensioning operation.

Strands shall be stressed in the following sequence:

(a) Before grouting, the strands shall be pulled with a maximum force of 3.0 kips.

(b) After the grout has attained the required strength, the strands shall be pulled to the final design tension. Stressing shall begin by pulling the inner-most strands first, then proceeding symmetrically towards the member's ends.

(c) The inner strands shall be rechecked to ensure the strands still have the design tension.

In the case where the Plans call for top and bottom strands, the sequence shall be followed using an initial pull of 15.0 kips, top and bottom, followed by a sequence using the final design tension.

No loading of elements shall be allowed until post-tensioning is completed.

510.14 METHOD OF MEASUREMENT. The quantities of Prestressed Concrete Box Beams, Prestressed Concrete Voided Slabs, Prestressed Concrete Girders, Prestressed Concrete Solid Slabs and Prestressed Concrete NEXT D Beams to be measured for payment will be the number of linear feet of the types and sizes of prestressed concrete members used in the complete and accepted work.

The quantity of Grouting Shear Keys to be measured for payment will be the number of linear feet of grouted shear keys in the complete and accepted work.

The quantity of Prestressed Concrete Deck Panels to be measured for payment will be the number of square feet of prestressed concrete deck panels used in the complete and accepted work.

510.15 BASIS OF PAYMENT. The accepted quantities of Prestressed Concrete Box Beams, Prestressed Concrete Voided Slabs, Prestressed Concrete Girders, Prestressed Concrete Solid Slabs, and Prestressed Concrete NEXT D Beams will be paid for at the Contract unit price per linear foot for the types and sizes of prestressed concrete members specified.

The accepted quantity of Prestressed Concrete Deck Panels will be paid for at the Contract unit price per square foot.

Payment will be full compensation for detailing, fabricating, repairing, sandblasting, quality control testing, transporting, handling, and installing the materials specified, including the concrete, reinforcement, prestressing steel, transverse ties, enclosures for prestressing steel, anchorages, mortar, and anchor rods. Payment will be full compensation for any other material contained within or attached to the members, for furnishing and implementing the erection plans, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The Engineer may authorize partial payments in the following manner:

(a) A maximum of 25% of the Contract bid amount may be paid when the fabrication drawings have been approved by the Agency.

(b) In accordance with the requirements of Subsection 106.09, stockpile payment may be authorized when the prestressed elements have met the requirements of Subsection 540.09 for shipping.

(c) After completion and acceptance of all work under this section, 100% of the quantity will be paid.

The accepted quantity of Grouting Shear Keys will be paid for at the Contract unit price per linear foot. Payment will be full compensation for providing all materials and performing the work specified herein, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Any other grouting work, such as fairing out unevenness between adjacent units and filling leveling screw holes, transverse anchor recesses, and dowel holes, will be considered incidental to the work for prestressed concrete members.

Payment will be made under:

Pay Item		Pay Unit
510.2100	Prestressed Concrete Box Beams	Linear Foot
510.2200	Prestressed Concrete Voided Slabs	Linear Foot
510.2300	Prestressed Concrete Girders	Linear Foot
510.2400	Grouting Shear Keys	Linear Foot
510.2500	Prestressed Concrete Solid Slabs	Linear Foot
510.2600	Prestressed Concrete NEXT D Beams	Linear Foot
510.4000	Prestressed Concrete Deck Panels	Square Foot

SECTION 511 – REMOVAL, CONTAINMENT, AND DISPOSAL OF LEAD PAINT

511.01 DESCRIPTION. This work shall consist of the washing of the existing lead paint coated surfaces, the removal of existing lead paint and grease rustproofing compounds, as well as the containment, collection, temporary storage, transportation, and disposal of the resulting waste.

Waste requiring containment and control includes, but is not limited to, old paint, spent abrasives, corrosion products, mill scale, dirt, dust, grease, oil, salts, solvents, and water used for cleaning the surface of existing lead coatings. Areas of paint removal operations shall be as indicated on the Plans.

511.02 GENERAL REQUIREMENTS. The existing coatings are assumed to contain lead and other toxic metals, regardless of any test results. All removal activities will be performed accordingly.

This specification provides the requirements for containment and for the protection of the public and the environment from exposure to harmful levels of toxic metals that may be present in the paint being removed or repaired. The Contractor shall take reasonable and appropriate precautions to protect the public from the inhalation or ingestion of dust or debris from the operations, and is responsible for the clean-up of all spills, releases, or emissions of waste at no additional cost to the Agency.

The Contractor shall comply with the requirements of this specification and all applicable federal, state, and local laws, codes, and regulations. These include, but are not limited to, the regulations of the U.S. Environmental Protection Agency, Vermont Occupational Safety and Health Administration (VOSHA), Vermont Department of Health, and the Vermont Agency of Natural Resources. The Contractor shall comply with all applicable regulations even if the regulation is not specifically referenced herein. If a federal, state, or local regulation is found to be more restrictive than the requirements of this specification, the more restrictive requirements shall prevail as determined by the Engineer.

511.03 PROJECT CLASSIFICATION. The removal, containment and disposal of lead paint will be classified as either a Type I or a Type II project as follows:

(a) Type I. Type I projects shall consist of work to remove all paint from a substantial portion of the existing structure, or to remove the paint from large, contiguous areas of a portion of a structure. Examples of such work would be projects where all or some of the main girders were completely stripped of paint.

Often, paint removal and repainting the structure will be a primary goal of a Type I project. Type I projects can usually be expected to require a full external containment system.

(b) Type II. Type II projects shall consist of work to selectively remove paint from multiple small, localized areas, or to remove paint from a few discrete, discontinuous and moderately sized areas. Examples of such work would be the removal of paint associated with gusset plate replacement, bolt or rivet replacement, installation of new cover plates, or installation of new shear studs on existing beams.

Typically, paint removal is either a secondary goal or merely a prerequisite for other work on a Type II project. Type II projects can often, but not always, be completed primarily with vacuum blast cleaning and vacuum-shrouded power tools and may not require a full containment system.

Unless identified as being specific to either a Type I or Type II project, all requirements of this specification shall apply to both Type I and Type II projects.

511.04 REQUIRED REFERENCES. For the duration of the project, the Contractor shall maintain printed copies of the following standards and regulations on the project site:

(a) *SSPC Guide 6*

(b) *SSPC Guide 7*

(c) *SSPC Guide 16*

(d) *SSPC TU-7*

(e) *29 C.F.R. § 1926.62*

(f) *40 C.F.R. Part 50, Appendix B* and *40 C.F.R. Part 50, Appendix G*

(g) *Vermont Regulations for Lead Control*

511.05 SUBMITTALS. The Contractor shall submit to the Engineer, in accordance with Subsection 105.06, the following information. Complete submittals shall be provided a minimum of 28 calendar days prior to the anticipated start of the work.

(a) Contractor and Contractor's Personnel Qualifications. The Contractor shall submit documentation verifying that they and their personnel meet the requirements below for the applicable project type.

(1) Type I Projects.

a. Contractor. The paint removal contractor shall possess a current Lead Abatement Contractor Entity license from the Vermont Department of Health permitting them to perform lead abatement work.

The paint removal contractor shall also possess current SSPC-QP 2 certification and shall maintain certified status throughout the duration of the paint removal work under the Contract.

b. Personnel. The names and qualifications, experience, and training of the personnel managing and implementing the quality control inspections shall be provided.

The quality control personnel shall possess a current Inspector Technician I license from the Vermont Department of Health allowing them to perform lead abatement QC inspections. All laborers performing lead abatement work shall be licensed by the Vermont Department of Health as Lead Workers, and a Vermont Department of Health licensed Lead Supervisor shall be on site whenever lead abatement work is being performed.

The quality control personnel shall also possess current SSPC-C 3 certification or equal, including the annual training necessary to maintain that certification (SSPC-C 5 or equal), and shall provide evidence of successful completion of two projects of similar or greater complexity and scope that have been completed in the last 2 years. References shall include the name, address, and telephone number of a contact person employed by the project owner. Proof of initial certification and the current annual training shall also be provided.

(2) Type II Projects.

a. Contractor. The paint removal contractor shall possess a current Lead Abatement Contractor Entity license from the Vermont Department of Health permitting them to perform lead abatement work.

b. Personnel. The names and qualifications, experience, and training of the personnel managing and implementing the quality control inspections shall be provided.

The quality control personnel shall possess a current Inspector Technician I license from the Vermont Department of Health allowing them to perform lead abatement QC inspections. All laborers performing lead abatement work shall be licensed by the Vermont Department of Health as Lead Workers, and a Vermont Department of Health licensed Lead Supervisor shall be on site whenever lead abatement work is being performed.

(b) Coating Removal Plan. The coating removal plan shall include the specified methods of coating removal and types of equipment to be used for water washing; hand and power tool cleaning; removal of rust, mill scale, grease (including grease rustproofing compounds), or foreign matter; and abrasive blast cleaning.

If detergents or additives are incorporated into the water used for any water washing operations, the plan shall include the names of the materials and safety data sheets (SDS).

The plan shall identify the solvents proposed for solvent cleaning, together with the SDS.

(c) Abrasives. If the Contractor intends to use abrasive blast cleaning, they shall submit the type of abrasives to be used and the SDS. For expendable abrasives, the Contractor shall provide certification from the abrasive supplier that the abrasive meets the requirements of *SSPC-AB 1*. For steel grit abrasives, the certification shall indicate that the abrasive meets the requirements of *SSPC-AB 3*.

(d) Containment Plan. The containment plan shall include drawings, equipment specifications, and calculations (including wind load and airflow) applicable to the removal method and containment system selected by the Contractor, as described in Subsection 511.12.

When the use of negative pressure and airflow inside containment is specified, the Contractor shall provide all ventilation calculations and details on the equipment that will be used for achieving the specified airflow and dust collection.

The plan shall include copies of the manufacturer's specifications for the containment materials and equipment that will be used to accomplish containment and ventilation. If abrasives are used, the plan shall note the type of abrasive and account for the weight of spent abrasive on the containment system.

The submittal shall provide drawings showing the containment system and indicating the methods of supporting the working platforms and containment materials to each other and to the existing structure and calculations that assure the structural integrity of the existing structure under all loading conditions.

Loading conditions shall include, but not be limited to, all equipment, materials, and containment system loads. The calculations and drawings shall be prepared, signed, and sealed by a qualified professional engineer. Additionally, the professional engineer shall inspect the completed containment system, review the materials used for its construction, and certify that the as-erected containment is in conformance with the drawings.

The design shall indicate the maximum wind speed allowed for the containment system. In all cases, the containment shall be dropped in the event of sustained winds of 40 mph or greater and all materials and equipment secured.

When working over a railroad or navigable waterways, unless otherwise directed by the Engineer, the Contractor shall provide evidence that the Operating Railroad, U.S. Coast Guard, U.S. Army Corps of Engineers, and other applicable agencies are satisfied with the clearance provided and other proposed safety measures.

(e) Environmental Monitoring Plan. The Contractor shall submit an environmental monitoring plan. The plan shall address the visual inspections, monitoring and clean-up of the air, soil, and water that the Contractor will perform, including final project inspection and cleanup.

(1) Type I Projects. The plan shall address the daily visible emission observations that will be performed and the corrective action that will be implemented in the event emissions or releases occur. The plan shall also establish a regulated area and ambient air monitoring program in accordance with *SSPC-TU 7*. The results of all area and ambient monitoring will be provided to the Engineer and the Agency's Hazardous Materials and Waste Coordinator within 72 hours of receipt by the Contractor.

(2) Type II Projects. The plan shall address the daily visible emissions observations that will be performed and the corrective action that will be implemented in the event emissions or releases occur.

(f) Site Specific Health and Safety Plan. The health and safety plan shall identify the Contractor's health and safety officer. The plan shall discuss the Contractor's lead testing program for workers and what course of action will be followed if the reported levels exceed accepted limits.

The plan shall also identify the VOSHA competent person for the VOSHA regulated activities. The competent person shall be on site during the progress of the regulated activities. In addition to the lead removal activities the plan should emphasize best practice fall protection and prevention and include plans for rescuing individuals hanging from fall arrest devices.

(g) Contingency Plan. The Contractor shall prepare a contingency plan for emergencies, including fire, accident, failure of power, failure of dust collection system, failure of supplied air system, or any other event that may require modification of standard operating procedures during lead removal. The plan shall include specific procedures to ensure safe egress and proper medical attention in the event of an emergency.

(h) Waste Management Plan. The waste management plan shall address all aspects of waste handling, storage, testing, hauling, and disposal. The plan shall include the names, addresses, and a contact person for the proposed licensed waste haulers and disposal facilities and the name and qualifications of the laboratory proposed for any testing or analysis.

On behalf of the Agency, the Contractor, in consultation with the Agency's Hazardous Materials and Waste Coordinator, shall request the U.S. Environmental Protection Agency ID number for hazardous waste disposal issued by the Vermont Agency of Natural Resources.

(i) Permits. The Contractor shall submit a copy of the site-specific lead abatement permit issued by the Vermont Department of Health for the project. Regardless of project type, the Contractor shall consult with and obtain any permits from the appropriate regulatory authority prior to the commencement of removal operations.

When the Engineer accepts the submittals, the Contractor will receive written notification. The Contractor shall not begin any work until the Engineer has accepted the submittals and the pre-work meeting has been held, as defined under Subsection 511.08. The Contractor shall not construe Engineer acceptance of the submittals to imply approval of any particular method or sequence for conducting the work, or for addressing health and safety concerns.

Acceptance of the plans does not relieve the Contractor from the responsibility to conduct the work according to the requirements of federal, state, or local regulations, this specification, or to adequately protect the health and safety of all workers involved in the project and any members of the public who may be affected by the project. The Contractor remains solely responsible for the adequacy and completeness of the programs and work practices, and adherence to them.

511.06 QUALITY CONTROL (QC) INSPECTIONS.

(a) Type I Projects. The Contractor shall perform first line, in process QC inspections of all environmental control and waste handling aspects of the project to verify compliance with these specification requirements and the accepted drawings and Plans. The Contractor shall use an environmental daily report form approved by the Engineer to record the results of the inspections. The completed reports shall be provided to the Engineer before work resumes the following day.

Contractor QC inspections shall include, but not be limited to, the following:

(1) Proper installation and continued performance of the containment systems in accordance with the Containment Plan.

(2) Visual inspections of emissions into the air and verification that the causes of any emissions are corrected.

(3) Visual inspections of spills or deposits of contaminated materials into the water or onto the ground, pavement, soil, or slope protection. Included is verification that proper cleanup is undertaken and that the causes of releases are corrected.

(4) Proper implementation of the Waste Management Plan.

(5) Proper implementation of the contingency plan for emergencies.

(b) Type II Projects. The Contractor shall monitor the paint removal work on a daily basis for compliance with these specification requirements and the accepted drawings and Plans, paying particular attention to the performance of the containment system. If any deviations from the specifications or Plans are found, the Contractor shall immediately submit a report to the Engineer and appropriate corrective action shall be taken. The Engineer may also direct the Contractor to submit a report at any time.

511.07 QUALITY ASSURANCE (QA) OBSERVATIONS. The Engineer will conduct QA observations of any or all of the QC monitoring inspections that are undertaken. The presence or activity of Engineer observations in no way relieves the Contractor of the responsibility to provide all necessary daily QC inspections and to comply with all requirements of this specification. The Engineer shall be allowed access to all work areas, including the containment.

511.08 PRE-WORK MEETING. A meeting shall be held after the acceptance of all submittals related to the paint removal and before any work covered under this specification may begin. The purpose of the meeting shall be to review all aspects of the removal, containment, and disposal of lead paint cleaning residues. The Engineer will notify the Contractor a minimum of 7 calendar days in advance of the meeting.

Individuals attending the meeting representing the Contractor shall be the project superintendent and the quality control inspector.

If field painting of the steel is included in the Contract, the pre-paint meeting required by that specification may be combined with the pre-work meeting of this specification. If combined into one meeting, the meeting shall occur prior to any paint removal or painting activities.

511.09 REGULATED AREAS. Physically demarcated regulated areas shall be established around exposure producing operations wherever concentrations exceed, or can reasonably be expected to exceed, the OSHA Action Level for the toxic metals present in the coating. The Contractor shall provide all required protective clothing and equipment for all personnel, including Agency personnel, entering into a regulated area. Unprotected street clothing is not permitted within the regulated areas.

511.10 GENERAL CONTAINMENT REQUIREMENTS. The Contractor shall install and maintain containment systems surrounding the work according to the requirements of Subsection 511.12. The containment systems chosen shall maintain the work area free of visible emissions of dust and debris according to all provisions of this specification, with no debris permitted outside of the regulated area at any time.

The containment materials shall be cleaned of loose material prior to relocation or dismantling. If paint chips or dust are observed escaping from the containment materials during moving, all associated operations shall be halted and the materials and components shall be re-cleaned by HEPA vacuuming.

Working platforms and containment materials that are used shall be firm and stable. Platforms shall be designed to support the workers, inspectors, spent surface preparation media (e.g. abrasives), and equipment during all phases of lead paint removal. Platforms, cables, and other supporting structures shall be designed according to VOSHA regulations.

If the containment needs to be attached to the structure, the containment shall be attached by bolting, clamping, or similar means, as detailed in the approved containment plan. The Contractor shall obtain approval from the Engineer prior to drilling into the structure. Welding onto the structure is prohibited.

The Contractor shall take appropriate action to avoid damage to the structure from the installation and use of the containment system. If the Engineer determines that there is the potential for structural damage caused by the installed containment system, the Contractor shall take appropriate action to correct the situation.

In addition to complying with the specific containment requirements of Subsection 511.12, the Contractor shall also provide and maintain coverage over the ground in the areas to be cleaned. These ground covers shall be capable of catching and containing surface preparation media, paint chips, and paint dust in the event of an accidental escape from the primary containment.

If the area to be cleaned is above an active roadway or railroad, ground covers are only required on areas outside of the traveled way. If the area to be cleaned is over a body of water, ground covers are required on the banks, and, when feasible, water booms, boats with skimmers, or other means as necessary shall be used to capture and remove paint chips or project debris that fall or escape into the water.

511.11 SURFACE CLEANING PRIOR TO PAINT REMOVAL.

(a) Type I Projects. No more than two weeks prior to starting coating removal operations, the Contractor shall conduct low pressure water washing on the designated surfaces to remove any existing debris. The Contractor shall notify the Engineer 24 hours in advance of beginning low pressure water cleaning.

(1) Low Pressure Water Washing. Washing shall involve the use of chlorine free potable water at a minimum of 1,000 psi and less than 5,000 psi pressure. Paint spray equipment shall not be used to perform the water cleaning. The cleaning shall be performed in such a manner as to remove dust, dirt, chalk, insect and animal nests, bird droppings, and other foreign matter prior to solvent cleaning. All water and debris shall be collected for proper disposal.

If detergents or additives are added to the water, the detergents or additives shall be included in the submittals and not used until accepted by the Engineer. When detergents or additives are used, the surface shall be rinsed with chlorine free potable water before the detergent water dries.

The tops of pier caps and abutments shall be cleaned free of dirt, insect and animal nests, bird droppings, and other foreign matter and the debris collected for proper disposal.

(2) Solvent Cleaning. After washing and debris removal has been accepted by the Engineer, all traces of asphaltic cement, oil, grease (including grease rustproofing compounds), diesel fuel deposits, and other soluble contaminants which remain on the steel surfaces shall be removed by solvent cleaning in accordance with *SSPC-SP 1,* supplemented with scraping (e.g. to remove large deposits of asphaltic cement or grease coatings) as required.

(3) Containment. Low pressure water cleaning shall be performed inside a containment structure meeting the requirements of SSPC Class 2W or SSPC Class 3W. The containment shall be designed, installed, and maintained in order to capture and contain all water and waste materials. The containment shall consist of impermeable floors and lower walls to prevent the water and debris from escaping. Permeable upper walls and ceilings are acceptable provided the paint chips, debris, and water, other than mists, are collected. A fine mist passing through the permeable upper walls is acceptable, provided the environmental controls specified herein are met. If paint chips, debris, or water, other than mists, escape the containment system, impermeable walls and ceilings shall be installed.

The collected water shall be filtered to separate the particulates from the water. Recycling of the water is preferred in order to reduce the volume of waste that is generated. The water after filtration shall be collected and disposed of according to the waste handling portions of this specification.

(b) Type II Projects. No more than 14 calendar days prior to starting coating removal operations, the Contractor shall clean all designated surfaces so that they are free of dirt, insect and animal nests, bird droppings, and other foreign matter. All debris shall be collected for proper disposal. Cleaning may be performed using physical methods (e.g. scraping), or other methods as approved by the Engineer, provided that debris are properly contained and disposed of.

Following debris removal, the Contractor shall remove all traces of asphaltic cement, oil, grease (including grease rustproofing compounds), diesel fuel deposits, and other soluble contaminants on the steel surfaces using solvent cleaning in accordance with *SSPC-SP 1*, supplemented with scraping (e.g. to remove large deposits of asphaltic cement or grease coatings) as required.

511.12 PAINT REMOVAL AND CONTAINMENT METHODS. Existing coatings shall be removed from the designated surfaces using one or more of the methods described in this subsection. The Contractor shall notify the Engineer 24 hours prior to beginning paint removal operations.

The Contractor shall note that the methods of removal specified below only apply to the work covered under this specification. Additional surface preparation work under other specifications may require the Contractor to use other methods.

(a) Allowable Removal Methods. The existing surface shall be cleaned using one or more of the following methods to meet the requirements of Subsection 511.12(c):

(1) Dry abrasive blast cleaning without vacuum

(2) Dry abrasive vacuum blast cleaning

(3) Wet abrasive blast cleaning

(4) Power tool cleaning without vacuum

(5) Vacuum-shrouded power tool cleaning

If dry abrasive blast cleaning is used, it shall be performed using either expendable abrasives (other than silica sand) or recyclable steel grit abrasives. Expendable abrasives shall be used one time and disposed of.

On a daily basis, the Contractor shall verify that recycled abrasives are free of oil contamination by conducting oil content tests in accordance with *SSPC-AB 2*.

All surfaces prepared with abrasives not meeting the *SSPC-AB 1*, *SSPC-AB 2*, or *SSPC-AB 3* requirements, as applicable, shall be solvent cleaned or low pressure water cleaned as directed by the Engineer, and re-blast cleaned at the Contractor's expense.

When metallic abrasives are used, extra care shall be given to recovering all of the abrasive from joints, horizontal surfaces, and hard to access areas to prevent rust bleed caused by fugitive abrasives.

(b) Containment Systems. The containment systems used for each method shall comply with the applicable *SSPC Guide 6* classifications.

(1) Dry Abrasive Blast Cleaning Without Vacuum. Dry abrasive blast cleaning shall be performed inside full containment with negative pressure meeting the requirements of SSPC Class 1A.

The enclosure shall be designed, installed, and maintained to sustain maximum anticipated wind forces, including negative pressure. Flapping edges of containment materials are prohibited and the integrity of all containment materials, seams, and seals shall be maintained for the duration of the project. Airflow inside containment shall be designed to provide visibility and reduce worker exposures to toxic metals according to VOSHA regulations and as specified in the submitted containment plan. The minimum airflow shall be 60 cfm for down draft systems and 100 cfm for cross draft systems.

When the location of the work on the structure permits, the blast enclosure shall extend a minimum of 3 feet beyond the limits of surface preparation to allow the workers to blast away from, rather than into, the seam between the containment and the structure. The blast enclosure shall have an entrance chamber to allow entrance and exit from the enclosure without allowing the escape of blasting residue.

If recyclable metallic abrasives are used, the Contractor shall operate the equipment in a manner that minimizes waste generation. Steps shall also be taken to minimize dust generation during the transfer of all abrasive or paint debris (expendable or recyclable abrasives) for recycling or disposal. Acceptable methods include, but are not limited to vacuuming, screw or belt conveyance systems, or manual conveyance. Manual conveyance is only permitted if the work is performed inside a containment that is equipped with an operating ventilation system capable of controlling the dust that is generated.

Appropriate filtration shall be used on the exhaust air of dust collection and abrasive recycling equipment as required to comply with the Vermont Department of Health lead abatement permit and state and federal regulations. The equipment shall be enclosed if visible dust and debris are being emitted or the regulated area or high-volume monitor lead levels are not in compliance.

Areas beneath containment connection points that were shielded from abrasive blast cleaning shall be prepared by vacuum blast cleaning or vacuum-shrouded power tool cleaning after the containment is removed.

(2) Dry Abrasive Vacuum Blast Cleaning. Dry abrasive vacuum blast cleaning shall meet the containment requirements of SSPC Class 4A.

Vacuum blasting equipment shall be fully automatic and capable of cleaning and recycling the abrasive. The system shall be designed to deliver cleaned, recycled blasting abrasives and provide closed system containment during blasting. The removed coating, mill scale, and corrosion shall be separated from the abrasive and stored for disposal.

The Contractor shall ensure that the vacuum shrouds are fully engaged while the tool is in use to prevent the escape of abrasive and lead paint chips. The Contractor shall attach containment materials around and under the work area to catch and contain abrasive and waste materials in the event of an accidental escape from the vacuum shroud. This containment is in addition to the ground covers specified in Subsection 511.10.

It is possible that the close proximity of some structural steel members, such as the end diaphragms or end cross-frames underneath transverse deck expansion joints, precludes the use of the vacuum blasting equipment for the removal of the old paint. For surfaces that are inaccessible for the nozzles of the vacuum blasting equipment, the Contractor shall remove the paint by means of dry abrasive blast cleaning inside a fully enclosed containment structure as directed by the Engineer.

(3) Wet Abrasive Blast Cleaning. Wet abrasive blast cleaning shall be performed inside a containment structure meeting the requirements of SSPC Class 2W or SSPC Class 3W. The containment shall be designed, installed, and maintained in order to capture and contain all water and waste materials. The containment shall consist of impermeable floors and lower walls to prevent the water and debris from escaping. Permeable upper walls and ceilings are acceptable provided the paint chips, debris, and water, other than mists, are collected. A fine mist passing through the permeable upper walls is acceptable, provided the environmental controls specified herein are met. If paint chips, debris, or water, other than mists, escape the containment system, impermeable walls and ceilings shall be installed.

(4) Power Tool Cleaning Without Vacuum. Power tool cleaning without vacuum shall be performed inside a containment meeting the requirements of SSPC Class 2P.

The Contractor shall securely install containment walls and flooring around the work area to capture and collect all debris that is generated. The containment material requirements for SSPC Class 2P are similar to the SSPC Class 3P requirements used for vacuum-shrouded tools, but the supporting structure shall be more substantial in SSPC Class 2P to better secure the containment materials from excessive movement that could lead to the loss of waste paint chips and debris.

Containment beneath the work shall be within 10 feet of the areas being cleaned and is in addition to the ground covers specified in Subsection 511.10.

(5) Vacuum-Shrouded Power Tool Cleaning. Vacuum-shrouded power tool cleaning shall meet the containment requirements of SSPC Class 3P.

The Contractor shall ensure that the vacuum shrouds are fully engaged while the tool is in use to prevent the escape of abrasive and lead paint chips. The Contractor shall use power tools equipped with vacuums and high efficiency particulate air (HEPA) filters.

The Contractor shall attach containment materials such as tarps adjacent to and under the work area to catch and contain waste materials in the event of an accidental escape from the vacuum shroud. This containment is in addition to the ground covers specified in Subsection 511.10 and shall be installed within 10 feet of the areas being cleaned.

(c) Cleaned Surface Condition. Work under this specification will be considered complete when the surface meets the requirements of either *SSPC-SP 6* (for all wet or dry abrasive blast cleaning, with or without vacuum), or *SSPC-SP 15* (for all power tool cleaning, with or without vacuum), except that a specific surface profile is not required. However, work under other specifications may require that a specific surface profile be achieved.

When viewed without magnification, the surface shall be free of all visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter. Random staining and discoloration shall be limited to no more than 33% of each 9 square inches.

If no further surface preparation is required by the Contract, paint removal will be considered complete when the Engineer has determined that the requirements above have been satisfied. If other Contract items require more extensive surface preparation that exceeds the requirements of this section, the Contractor may choose to have the Engineer inspect and pay for the paint removal after meeting the requirements above, or they may choose to wait until after the additional surface preparation has been completed.

511.13 ENVIRONMENTAL CONTROLS AND MONITORING. The Contractor shall follow the submitted and approved environmental monitoring plan. The purpose of the monitoring is to confirm that project dust and debris are not escaping the containment into the surrounding air, soil, and water.

(a) Soil and Water. The Contractor's containment systems shall be maintained to prevent the escape of paint chips, abrasives, and other debris into the water, and onto the ground, soil, slope protection, and pavements. Releases or spills of paint chips, abrasives, dust and debris on to surrounding property, structures, equipment or vehicles, and bodies of water are unacceptable.

If there are inadvertent spills or releases, the Contractor shall immediately shut down the emissions-producing operations, clean up the debris, and change work practices, modify the containment, or take other appropriate corrective action as needed to prevent similar releases from occurring in the future.

At the end of each work day, at a minimum, the work area inside and outside of containment, including ground covers, shall be inspected to verify that paint debris are not present. If debris are observed, they shall be removed by HEPA-vacuuming.

Upon project completion, the ground and water in and around the project site are considered to have been properly cleaned if paint chips, paint removal media (e.g. spent abrasives), fuel, materials of construction, litter, or other project debris have been removed, even if the material being cleaned was a pre-existing condition.

(b) Visible Emissions. The Contractor shall conduct observations of visible emissions and releases on an ongoing daily basis when dust-producing activities are underway, such as paint removal, clean-up, waste handling, and containment dismantling or relocation.

If visible emissions or releases are observed, the Contractor shall immediately shut down the emission-producing operations, clean up the debris, and change work practices, modify the containment, or take other appropriate corrective action as needed to prevent similar releases from occurring in the future.

(c) Emissions Monitoring.

(1) Type I Projects. The Contractor shall conduct monitoring of both the regulated area and the ambient air in accordance with *SSPC-TU 7*. The Contractor shall be prepared to conduct baseline and start-up monitoring and shall be prepared to conduct full-time or complaint-related monitoring as warranted. The Contractor shall verify that all calibration, sampling, and laboratory analysis are conducted in a manner compliant with *SSPC-TU 7*.

(2) Type II Projects. No monitoring of emissions is required, except as described in Subsection 511.13(b), or as specified elsewhere in the Contract based on site conditions.

511.14 HYGIENE FACILITIES. The Contractor shall provide clean lavatory and hand washing facilities according to VOSHA regulations and confirm that all employees wash hands, forearms, and face before breaks. The facilities shall be located at the perimeter of the regulated area in close proximity to the paint removal operation. Shower facilities shall be provided when workers' exposure exceeds the permissible exposure limit. Showers shall be located at each work site. The shower and wash facilities shall be cleaned at least daily during use.

All wash and shower water shall be filtered and containerized. The Contractor is responsible for filtration, testing, and disposal of the water.

The Contractor shall make the decontamination facilities on the project available for use by Agency personnel and other Agency representatives assigned to the project.

511.15 SITE EMERGENCIES.

(a) Stop Work. The Contractor shall stop work at any time the conditions are not within specifications and take the appropriate corrective action. The stoppage will continue until conditions have been corrected to the satisfaction of the Engineer. Standby time and cost required for corrective action is at the Contractor's expense. The occurrence of any of the following events shall be reported in writing to the Agency and shall require the Contractor to automatically stop lead paint removal and initiate clean-up activities.

(1) Break in containment barriers.

(2) Emissions in excess of specification or permit tolerances.

(3) Loss of negative air pressure when negative air pressure is specified (e.g. for dry abrasive blast cleaning).

(4) Serious injury within the containment area.

(5) Fire or safety emergency.

(6) Respiratory system failure.

(7) Power failure.

(b) Contingency Plans and Arrangements. The Engineer will refer to the contingency plan for site specific instructions in case of emergencies. The Contractor shall post the telephone numbers and locations of emergency services including fire, ambulance, doctor, hospital, police, power company, and telephone company on the clean side of the personnel decontamination area.

A copy of the contingency plan shall be maintained at each work site during cleaning operations and during the time the Contractor's personnel are at the work site. The Contractor shall designate the emergency coordinators required who shall be responsible for the activities described.

511.16 COLLECTION, STORAGE, TRANSPORTATION, AND DISPOSAL OF WASTE.

(a) General Requirements. The Agency will not require solid waste generated by the project to be tested. However, permitting agencies, waste haulers and disposal facilities may require testing of the waste, and the Contractor shall adhere to all such requirements. All paint removal waste shall be considered hazardous waste regardless of any test results. The Contractor and the Agency are considered to be co-generators of the waste.

The Contractor is responsible for all aspects of waste collection, testing and identification, handling, storage, transportation, and disposal according to these specifications and all applicable federal, state, and local regulations. The Agency will not perform any functions relating to the waste.

Contractor personnel shall be trained in the proper handling of hazardous waste and the necessary notification and clean up requirements in the event of a spill. The Contractor shall maintain a copy of the personnel training records at each work site.

The Contractor is responsible for paying all taxes, fees, and permit costs associated with the removal, transportation, and disposal of waste. The Contractor is also responsible for paying any fines and undertaking any clean-up activities mandated by state or federal environmental agencies for improper waste handling, storage, transportation, or disposal.

(b) Collection and Temporary Storage of Surface Preparation Waste. All surface preparation and paint residues within the regulated area and the containment, including spent abrasives, shall be collected at the end of the last shift each day, or every 24 hours for continuous operations. No residues shall remain on surfaces overnight, either inside or outside of the containment. Waste materials shall not be removed through floor drains or by throwing them over the side of the bridge.

The collected waste shall be deposited in all-weather containers supplied by the Contractor as temporary storage. The all-weather containers shall meet requirements for the transportation of hazardous materials.

The Contractor shall ensure that no breaks and no deterioration of these containers occurs and shall maintain a written log of weekly inspections of the condition of the containers. A copy of the log shall be furnished to the Engineer upon request.

The containers shall be kept closed and sealed from moisture except during the addition of waste. Each container shall be permanently identified with the date that waste was placed into the container, Contract number, hazardous waste name and ID number, and other information required by the Vermont Agency of Natural Resources.

The temporary waste storage area shall be located outside of any flood plain and secure to prevent unauthorized entry or tampering with the containers. Acceptable measures include storage within a fully enclosed (e.g. fenced-in) and locked area, within a temporary building, or implementing other reasonable means to reduce the possibility of vandalism or exposure of the waste to the public or the environment (e.g. securing the lids or covers of waste containers and roll-off boxes). Waste shall not be stored outside of the containers.

Flammable materials shall not be stored around or under any bridge structures.

Waste shall be collected and transferred to bulk containers, taking extra precautions as necessary to prevent the suspension of residues in the air or contamination of surrounding surfaces. Precautions may include the transfer of the material within a tarpaulin enclosure. All waste storage containers shall be placed on tarpaulins. Transfer into roll-off boxes shall be planned to minimize the need for workers to enter the roll-off box.

(c) Transportation and Disposal of Surface Preparation Waste. All paint removed from the structure, together with the surface preparation media (e.g. abrasive) shall be handled as a hazardous waste, regardless of any test results. The waste shall be transported by a licensed hazardous waste transporter, treated by a permitted treatment facility to a non-hazardous special waste, and disposed of at a permitted disposal facility.

The treatment and disposal facilities shall be approved by the Engineer and shall hold a Vermont Agency on Natural Resources permit for waste disposal and waste stream authorization for the cleaning residue. The permit and waste stream authorization shall be obtained prior to beginning cleaning, except that if necessary, limited paint removal will be permitted in order to obtain samples of the waste for the disposal facilities.

The waste shall be shipped to the facility within 90 calendar days of the waste generation. Arrangements for the final waste pickup shall be made with the waste hauler by the time paint removal operations are completed, or as required to meet the 90 calendar day limit.

The Contractor shall prepare a manifest approved by the Vermont Agency on Natural Resources for off-site treatment and disposal before transporting the hazardous waste off-site. The Contractor shall prepare a land ban notification for the waste to be furnished to the disposal facility. The Contractor shall obtain the handwritten signature of the initial transporter and date of the acceptance of the manifest.

The Contractor shall send one copy of the manifest to the Vermont Agency on Natural Resources within 2 working days of transporting the waste off-site. The Contractor shall furnish the generator copy of the manifest and a copy of the land ban notification to the Engineer. The Contractor shall give the transporter the remaining copies of the manifest.

(d) Waste Water. Waste water generated from washing the structure, hygiene purposes, and cleaning of equipment shall be filtered on site to remove particulates and disposed of at a publicly owned treatment works (POTW) according to state regulations.

The Contractor shall provide the Engineer with a letter from the POTW indicating that they will accept the waste water. If the POTW allows the filtered water to be placed into the sanitary sewer system, the Contractor shall provide a letter from the POTW indicating that based on the water test results, disposal in the sanitary sewer is acceptable to them. Water shall not be disposed of until the above letters are provided to, and accepted by, the Engineer.

(e) Other Project Waste. All other project waste shall be removed from the site according to federal, state, and local regulations, with all waste removed from the site prior to final Contractor demobilization.

The Contractor shall make arrangements to have other hazardous waste generated by the Contractor, such as used paint solvent, transported to the Contractor's facility at the end of each day that the waste is generated. These hazardous wastes shall be manifested using the Contractor's own generator number to a treatment or disposal facility from the Contractor's facility. The Contractor shall not combine solvents or other wastes with cleaning residue waste. All waste streams shall be stored in separate containers.

511.17 METHOD OF MEASUREMENT. The quantity of Removal, Containment, and Disposal of Lead Paint of the type specified to be measured for payment will be on a lump sum basis in the complete and accepted work.

511.18 BASIS OF PAYMENT. The accepted quantity of Removal, Containment, and Disposal of Lead Paint of the type specified will be paid for at the Contract lump sum price. Payment will be full compensation for performing the work specified, including construction of a work platform, construction of a containment structure, and removal of the existing paint and grease rustproofing compounds; soil, water, and air monitoring; collection, temporary storage, transportation, testing, and disposal of all project waste; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Partial payments will be made as follows:

(a) The first payment of 30% of the Contract unit price will be paid when all submittal requirements have been met and accepted by the Agency, and the Contractor is fully mobilized to begin work.

(b) An additional 30% of the Contract unit price will be paid when 50% of the paint has been removed.

(c) An additional 30% of the Contract unit price will be paid when 100% of the paint has been removed.

(d) The final 10% of the Contract unit price will be paid when the Contractor has fully demobilized the containment equipment and properly disposed of the waste to the satisfaction of the Engineer. The Engineer may elect to withhold the final 2% of the Contract unit price until the hazardous waste tax has been paid.

Payment will be made under:

Pay Item		Pay Unit
511.1001	Removal, Containment, and Disposal of Lead Paint, Type I	Lump Sum
511.1002	Removal, Containment, and Disposal of Lead Paint, Type II	Lump Sum

SECTION 513 – FIELD PAINTING STEEL

513.01 DESCRIPTION. This work shall consist of the preparation and coating of the designated surfaces with the materials and methods specified in the Contract. All steel to be painted under this specification shall be bare steel.

513.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Structural Steel Coating Systems.....708.03
Grease Rustproofing Compound.....708.04

513.03 QUALIFICATIONS. The following qualification requirements shall be met and certified status shall be maintained throughout the duration of the painting work under the Contract.

(a) Painting Contractor. The painting contractor shall possess current SSPC-QP 1 and SSPC-QP 2 certifications.

(b) Quality Control (QC) Manager. The QC manager shall possess a minimum classification as a NACE Coating Inspector Level 2 – Certified.

(c) Quality Control (QC) Inspector. The QC inspector shall possess a minimum classification as a NACE Coating Inspector Level 1 - Certified.

513.04 SEQUENCE OF WORK. The Contractor shall prepare the surfaces specified in the Plans in accordance with the following sequence:

(a) Remove Existing Coatings. Any existing coatings on the steel shall be removed in accordance with the requirements of the Contract prior to the initiation of work under this specification. All payment for the removal and disposal of existing coatings will be made under the appropriate Section 511 pay items.

(b) Prepare Surfaces. The Contractor shall prepare the surface of the existing steel to meet the requirements specified in Subsection 513.15.

(c) Remediate Soluble Salts. The Contractor shall remediate soluble salts on the existing bare steel as specified in Subsection 513.17.

(d) Apply Coatings. The Contractor shall apply the coating system specified in the Plans according to the requirements of this specification.

513.05 HOLD POINTS. Specific inspection items throughout these specifications are designated as hold points. These hold points are for the Engineer to perform QA inspections of the completed specified work.

Unless an alternative timeframe is required by this specification or other arrangements are made at the project site, the Contractor shall notify the Engineer a minimum of 4 hours before a hold point will be reached. If the 4 hour notification is provided and the work is ready for inspection at that time, and the necessary QC inspections are performed, the Engineer will conduct the necessary QA observations. QA inspections will be performed only after a proper QC inspection by the Contractor.

If the work is not ready at the appointed time, unless other arrangements are made, an additional 4 hour notification is required. Permission to proceed beyond a hold point without a QA inspection will be granted solely at the discretion of the Engineer, and only on a case-by-case basis.

If re-work is necessary as determined by a QA inspection, it shall be accomplished and a new hold point for the re-work shall be observed as defined above.

513.06 SUBMITTALS. The Contractor shall submit to the Engineer, in accordance with Subsection 105.06, the following information for completing the work. Complete submittals shall be provided a minimum of 21 calendar days prior to the anticipated start of the work.

(a) Contractor and Contractor's Personnel Qualifications. The Contractor shall submit evidence of their qualifications and the names and qualifications, experience, and training of the personnel managing and implementing the quality control program and conducting the quality control tests. At a minimum this shall include the quality control manager and the quality control inspector. Copies of certifications shall be provided to show that all requirements of Subsection 513.03 have been met.

(b) Quality Control (QC) Program. The QC program shall be signed by the quality control manager and shall identify the following:

(1) Instrumentation that will be used.

(2) Schedule of required measurements and observations.

(3) Procedures for correcting unacceptable work.

(4) Procedures for improving surface preparation and painting quality as a result of quality control findings.

(c) Inspection Access Plan. The inspection access plan is for use by the Contractor's QC personnel for ongoing inspections and by the Engineer during quality assurance (QA) observations. The plan shall include the design of any necessary scaffolding or staging required for QC/QA inspections. All staging and scaffolding shall be designed by a qualified professional engineer.

(d) Surface Preparation and Painting Plan. The surface preparation and painting plan shall include the specified methods of surface preparation and types of equipment to be used for water washing; hand and power tool cleaning; removal of rust, mill scale, grease, or foreign matter; abrasive blast cleaning; and remediation of chloride. If detergents, additives, or inhibitors are incorporated into the water used for any coating work operations, the plan shall include the names of the materials and safety data sheets (SDS).

The plan shall identify the solvents proposed for solvent cleaning, together with the SDS.

The plan shall also include the methods of coating application, including any required stripe coats, and all equipment to be used. Stripe coats shall only be applied by brushing, the use of rollers or daubers will not be permitted.

If the Contractor proposes to heat or dehumidify the containment, the methods and equipment proposed for use shall be included in the plan for the Engineer's consideration.

(e) Abrasives. The Contractor shall submit the type of abrasives to be used for abrasive blast cleaning and the SDS. For expendable abrasives, the Contractor shall provide certification from the abrasive supplier that the abrasive meets the requirements of *SSPC-AB 1*. For steel grit abrasives, the certification shall indicate that the abrasive meets the requirements of *SSPC-AB 3*.

(f) Coating System Information. The Contractor shall submit the latest version of the product manufacturer's application and thinning instructions, SDS, and product data sheets for each and every coating, thinner, sealer, and grease rustproofing compound. Specific attention shall be drawn to storage temperatures and the temperatures of the material, surface, and ambient air at the time of application. The following information shall be provided by the coating manufacturer's technical representative in written form:

(1) The recommended minimum ambient weather conditions and minimum surface temperatures during each of the curing/drying periods.

(2) Drying schedules (similar to that found on the product data sheet) representing dry to handle, dry to recoat, and full cure, for each coat, at both the minimum and maximum DFT range as specified in Subsection 513.19(g). These schedules shall also include the minimum time that each coat must be protected from cold and inclement weather (e.g. exposure to rain, snow, temperatures below 40°F, etc.) These drying schedules shall account for varying temperatures and low ventilation (where applicable).

If the product used is a moisture cured product or a water-based product, these schedules shall be for 50% relative humidity, or the lowest relative humidity that is expected to be encountered. It is acceptable for the manufacturer to provide variable ranges, or multiple curing/drying schedules.

The curing/drying times given in the schedule will be considered applicable provided that the actual field conditions are within the tolerances specified below. If the actual field conditions exceed the tolerances listed below, the schedule shall be modified by the manufacturer's technical representative prior to painting. It shall be noted that the unlimited tolerances listed below are only unlimited in regards to affecting curing/drying times and do not supersede limits stated elsewhere in this specification or the product data sheets.

a. Temperature. Schedule condition minus 0°F (positive tolerance unlimited)

b. Relative Humidity. Schedule condition minus 0% (positive tolerance unlimited) (only applies to moisture cured and water-based products)

c. Ventilation. If the actual containment systems have minimal ventilation, the schedule shall acknowledge these conditions and the curing/drying schedule shall reflect these conditions.

Copies of these documents shall be available on the project site at all times.

When the Contractor proposes to use penetrating sealer, sealant caulk, rust inhibitor, or chemical soluble salt remover, they shall submit a letter from the coating system manufacturer indicating that the material will not adversely affect the performance of the coating system.

(g) Containment of Paint and Debris. The Contractor shall submit a plan for containing or controlling surface preparation and paint debris (e.g. abrasive media, droplets, spills, overspray, etc.).

If dry abrasive blast cleaning without vacuum is used, the containment shall meet the requirements of SSPC Class 1A. If dry abrasive vacuum blast cleaning is used, the containment shall meet the requirements of SSPC Class 4A.

Any tarpaulins or protective coverings proposed for use shall be fire retardant.

(h) Progress Schedule. A progress schedule shall be submitted and shall identify all major work items and associated hold points (e.g. installation of rigging and containment, surface preparation, and coating application). The Contractor shall provide updated progress schedules as requested by the Engineer.

When the Engineer accepts the submittals, the Contractor will receive written notification. The Contractor shall not begin any work covered under this specification until the Engineer has accepted the submittals and a pre-paint meeting has been held, as defined in Subsection 513.11. The Contractor shall not construe Engineer acceptance of the submittals to imply approval of any particular method or sequence for conducting the work, or for addressing health and safety concerns.

Acceptance of the submittals does not relieve the Contractor from the responsibility to conduct the work according to the requirements of federal, state, or local regulations, this specification, or to adequately protect the health and safety of all workers involved in the project and any members of the public who may be affected by the project. The Contractor remains solely responsible for the adequacy and completeness of the programs and work practices, and adherence to them.

513.07 QUALITY CONTROL (QC) INSPECTIONS. The Contractor shall perform first line, in progress QC inspections. The Contractor shall implement the submitted and accepted QC program to ensure that the work accomplished complies with these specifications.

(a) Personnel. The Contractor's quality control manager is responsible for managing the Contractor's QC program. The quality control manager shall be on the project for the first 48 hours of paint application and after that time be available to be back on the project with 24 hours' notice.

The quality control inspector shall not participate in any production activities related to surface preparation or painting and shall be onsite full time during any operations that affect the quality of the coating system, including but not limited to surface preparation and chloride remediation, coating mixing and application, and evaluations between coats, and upon project completion. Completed daily reports for all quality control testing and observations shall be provided to the Engineer before work resumes the following day.

The personnel performing any QC tests shall be trained in coatings inspection and the use of the testing instruments. Documentation of training shall be provided. Painters shall perform wet film thickness measurements, with the quality control inspector conducting random spot checks of the wet film. The Contractor shall not replace the QC personnel assigned to the project without advance notice to the Engineer, and acceptance of the replacements by the Engineer.

(b) Inspection Focus. Contractor QC inspections shall include, but not be limited to, the following:

(1) Suitability of protective coverings and the means employed to control project debris and paint spills, overspray, etc.

(2) Ambient conditions.

(3) Compressed air cleanliness.

(4) Surface preparation and surface profile (solvent cleaning, pressure washing, hand and power tool cleaning, abrasive blast cleaning, etc.).

(5) Chloride remediation.

(6) Coating application (materials verification, mixing, thinning, induction/sweat-in time, and wet and dry film thickness).

(7) Re-coat times and cleanliness between coats.

(8) Coating continuity and coverage (freedom from runs, sags, overspray, dry spray, pinholes, shadow-through, skips, misses, etc.).

(9) Records of Contractor QC inspections shall document the location on the structure and any applicable product batch numbers.

(c) Inspection Equipment. The following equipment shall be provided by the Contractor as necessary to perform QC inspections:

(1) Psychrometer or comparable equipment for the measurement of dew point and relative humidity, together with all necessary weather bureau tables or psychrometric charts.

(2) Surface temperature digital spot thermometer.

(3) *SSPC-VIS 1* and *SSPC-VIS 3*.

(4) Commercially available putty knife of a minimum thickness of 40 mils and a width between 1 and 3 inches.

(5) Replica tape and spring micrometer.

(6) Chloride titrator strip for chloride determinations.

(7) Wet film thickness gauge.

(8) Blotter paper for compressed air cleanliness checks.

(9) Type 2 electronic dry film thickness gauge per *SSPC-PA 2*.

(10) Calibration standards for dry film thickness gauge.

(11) Light meter for measuring light intensity during surface preparation, painting, and inspection activities.

(12) Printed copies of all applicable ASTM and SSPC standards used for the work.

(13) *SSPC Manual of Good Painting Practice, Volume 1*.

The instruments shall be calibrated within 12 months of the date of project usage or according to the equipment manufacturer's recommendations and the Contractor's QC program if they require a shorter duration.

If item 631.1800 is not included in the Contract, the Contractor's QC inspection equipment shall be made available to the Engineer for QA observations as requested.

513.08 QUALITY ASSURANCE (QA) OBSERVATIONS. The Engineer will conduct QA observations of any or all phases of the work. The presence or activity of Engineer observations in no way relieves the Contractor of the responsibility to provide all necessary daily QC inspections and to comply with all requirements of this specification.

The Engineer has the right to reject any work that was performed without adequate provision for QA observations.

513.09 INSPECTION ACCESS AND LIGHTING. The Contractor shall facilitate the Engineer's observations as required, including allowing ample time to view the work. The Contractor shall furnish, erect, and move scaffolding or other mechanical equipment to permit close observation of all surfaces to be cleaned and painted. This equipment shall be provided during all phases of the work.

Examples of acceptable access structures include:

(a) Mechanical lifting equipment, such as scissor trucks, hydraulic booms, etc.

(b) Platforms suspended from the structure comprised of trusses or other stiff supporting members and including rails and kick boards.

(c) Simple catenary supports are permitted only if independent lifelines for attaching a fall arrest system according to VOSHA regulations are approved.

When the surface to be inspected is more than 6 feet above the ground or water surface, and fall protection is not provided (e.g. railings), the Contractor shall provide the Engineer with a lifeline according to VOSHA regulations. The lifeline and attachment shall not direct the fall into oncoming traffic. The Contractor shall provide a method of attaching the lifeline to the structure independent of the inspection facility or any support of the platform. When the inspection facility (e.g. platform) is more than 2-1/2 feet above the ground, the Contractor shall provide a VOSHA compliant means of access onto the platform.

The Contractor shall provide artificial lighting in areas where natural light is inadequate, as determined by the Engineer, to allow proper cleaning, inspection, and painting. Illumination for inspection shall be at least 30 foot-candles. Illumination for cleaning and painting, including the working platforms, access, and entryways shall be at least 20 foot-candles.

513.10 SURFACE PREPARATION AND PAINTING EQUIPMENT. All cleaning and painting equipment shall include gauges capable of accurately measuring fluid and air pressures and shall have valves capable of regulating the flow of air, water, or paint as recommended by the equipment manufacturer. The equipment shall be maintained in proper working order.

Diesel or gasoline powered equipment shall be positioned or vented in a manner to prevent deposition of combustion contaminants on any part of the structure.

Hand tools, power tools, pressure washing, water jetting, abrasive blast cleaning equipment, brushes, rollers, and spray equipment shall be of suitable size and capacity to perform the work required. All power tools shall be equipped with vacuums and high efficiency particulate air (HEPA) filtration.

Appropriate filters, traps, and dryers shall be provided for the compressed air used for abrasive blast cleaning and conventional spray application. Paint pots shall be equipped with air operated continuous agitation devices unless prohibited by the coating manufacturer.

The air discharge from power tools and air motors shall be directed away from steel surfaces. If this is not possible a filtering device shall be appropriately placed.

513.11 PRE-PAINT MEETING. A meeting shall be held after the acceptance of all submittals related to the structural steel painting. Work under this specification shall not proceed until after this meeting has been held.

The purpose of the meeting shall be to review all aspects of the surface preparation and painting of the steel.

Individuals attending the meeting representing the Contractor shall be the project superintendent, quality control manager, and the quality control inspector. a qualified manufacturer's technical representative for the coating system shall also attend.

The Engineer will notify the Contractor a minimum of 7 calendar days in advance of the meeting.

If a pre-work meeting for paint removal operations is required by another item in the Contract, that meeting may be combined with the pre-paint meeting of this specification. If combined into one meeting, the meeting shall occur prior to any paint removal or painting activities.

513.12 TEST SECTIONS (HOLD POINT). Prior to surface preparation, the Contractor shall prepare test sections on each structure to be painted in locations which the Engineer considers to be representative of the existing surface condition and steel type for the structure as a whole. More than one test section may be needed to represent the various design configurations of the structure.

The purpose of the test sections is to demonstrate the use of the tools and degree of cleaning required (cleanliness and profile) for each method of surface preparation that will be used on the project. Each test section shall be approximately 10 square feet. The test sections shall be prepared using the same equipment, materials, and procedures as the production operations.

The Contractor shall prepare the test sections to the specified level of cleaning according to the appropriate SSPC visual standards, modified as necessary to comply with the requirements of these specifications. The written requirements of these specifications prevail in the event of a conflict with the SSPC visual standards. Only after the test sections have been approved shall the Contractor proceed with surface preparation operations.

The test section shall be preserved and sealed with a clear coat. At the conclusion of painting activities the test section shall be re-blasted and the specified coating system applied.

For the production cleaning operations, these specifications and written definitions, the test sections, and the SSPC visual standards shall be used, in that order, for determining compliance with Contract requirements.

Additional compensation will not be paid to the Contractor for preparation of the test sections.

513.13 AMBIENT CONDITIONS. Surfaces to be painted after cleaning shall remain free of moisture and other contaminants. The Contractor shall control operations to ensure that dust, dirt, or moisture does not come in contact with surfaces cleaned or painted that day. The following ambient conditions shall be met:

(a) The surface and ambient temperatures shall be at least 5ºF above the dew point during final surface preparation operations.

(b) The surface and ambient temperatures shall be a minimum of 40ºF, at least 5ºF above the dew point, and the maximum relative humidity shall be 85% or less during the application and cure/dry time in accordance with the information provided in Subsection 513.06(f)(2). If the manufacturer's published literature is more restrictive, it shall be followed for specific temperature, dew point, and humidity conditions during the application and cure/dry time of each coat.

The cure/dry time shall be measured as the time following application when the ambient conditions are within the ranges above.

(c) If the Contractor proposes to control the weather conditions inside containment, proposed methods and equipment for heating or dehumidification shall be included in the surface preparation and painting plan submitted for the Engineer's review. Any heating or dehumidification proposals reviewed by the Engineer shall be implemented at no additional cost to the Agency.

(d) Cleaning and painting shall only be performed between April 16th and October 31st, inclusive, unless otherwise authorized in writing by the Engineer.

If the weather conditions are forecast to be outside the limits above during surface preparation, application, or the applicable curing/drying period, then work shall not proceed.

The Contractor shall monitor and document temperature, dew point, and relative humidity at the beginning of each work day and every 4 hours during surface preparation and coating application, in the specific areas where the work is being performed. The frequency of monitoring shall increase if weather conditions are changing.

If the weather conditions are forecast to be borderline relative to the limits established by the manufacturer, monitoring shall continue at a minimum of 4 hour intervals throughout the applicable curing/drying period.

The Engineer has the right to reject any work that was performed under unfavorable weather conditions. Rejected work shall be removed, re-cleaned, and re-painted at the Contractor's expense.

513.14 COMPRESSED AIR CLEANLINESS. Prior to using compressed air for abrasive blast cleaning, blowing down the surfaces, and painting with conventional spray, the Contractor shall verify that the compressed air is free of moisture and oil contamination in accordance with the requirements of *ASTM D4285*. The tests shall be conducted at least one time each shift for each compressor system in operation.

If air contamination is evident, the Contractor shall change filters, clean traps, add moisture separators or filters, or make other adjustments as necessary to achieve clean, dry air. The Contractor shall also examine the work performed since the last acceptable test for evidence of defects or contamination caused by the compressed air. Affected work shall be repaired at the Contractor's expense.

513.15 SURFACE PREPARATION (HOLD POINT). All designated surfaces shall be prepared for coating by dry abrasive blast cleaning, including areas that may be concealed by the containment connection points. All equipment allowed under *SSPC-SP 10*, including vacuum blast cleaning equipment, shall be permitted.

The Contractor shall note that the surface of the steel beneath the existing coating system may contain corrosion or mill scale. If said corrosion or mill scale is not removed under another item in the Contract, then its removal shall be considered included in this work and no extra compensation will be allowed. Following surface preparation, soluble salts shall be remediated as specified in Subsection 513.17.

(a) Blast Cleaning. All existing steel shall be prepared by dry abrasive blast cleaning to meet the requirements of *SSPC-SP 10*.

(1) Abrasives. Dry abrasive blast cleaning shall be performed using either expendable abrasives (other than silica sand) or recyclable steel grit abrasives. Expendable abrasives shall be used one time and disposed of.

On a daily basis, the Contractor shall verify that recycled abrasives are free of oil contamination by conducting oil content tests in accordance with *SSPC-AB 2*.

All surfaces prepared with abrasives not meeting the *SSPC-AB 1*, *SSPC-AB 2*, or *SSPC-AB 3* requirements, as applicable, shall be solvent cleaned or low pressure water cleaned as directed by the Engineer, and re-blast cleaned at the Contractor's expense.

When metallic abrasives are used, extra care shall be taken to recover all of the abrasive from joints, horizontal surfaces, and hard to access areas to prevent rust bleed caused by fugitive abrasives.

(2) Surface Condition. After surface preparation, the surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except for staining.

Random staining shall be limited to no more than 5% of each 9 square inches of surface area and may consist of light shadows, slight streaks, or minor discoloration caused by stains of rust, stains of mill scale, or stains of previously applied paint. With the exception of crevices as defined below, surface discoloration will be considered to be a residue that must be removed, rather than a stain, if it possesses enough mass or thickness that it can be removed as a powder or in chips when scraped with a pocketknife.

A surface profile shall be created on the steel as defined in Subsection 513.15(d).

At the discretion of the Engineer, after a best effort cleaning, slight traces of existing coating may be permitted to remain within crevices such as those created between rivets, bolts, and plates, and the underlying steel. When traces of coating are permitted to remain, the coating shall be tightly bonded when examined by probing with a dull putty knife. The traces of coating shall be confined to the bottom portion of the crevices only, and shall not extend onto the surrounding steel or plate or onto the outer surface of the rivets or bolts. Pitted steel is excluded from exemption considerations and shall be cleaned in accordance with *SSPC-SP 10*.

If hackles or slivers are visible on the steel surface after cleaning, the Contractor shall remove them by grinding followed by re-blast cleaning. At the discretion of the Engineer, the use of power tools to clean the localized areas after grinding, and to establish a surface profile acceptable to the coating manufacturer, can be used in lieu of blast cleaning.

(b) Limited Access Areas. A best effort with the specified method of cleaning shall be performed in limited access areas, such as the backsides of rivets inside built-up box members. The equipment being used for the majority of the cleaning may need to be supplemented with other commercially available equipment, such as angle nozzles, to properly clean the limited access areas. The acceptability of the best effort cleaning in these areas is at the sole discretion of the Engineer.

(c) Condition of Edges and Corners. All existing sharp edges and corners, such as those generated by torch cutting, shearing, or milling, shall be rounded to a radius between 1/16 inch and 1/8 inch. The Engineer will tactilely or visually assess the edges and corners and document that they were appropriately rounded.

(d) Surface Profile. The abrasives used for blast cleaning shall have a gradation such that the abrasive will produce a uniform surface profile of 1.5 mils to 3.5 mils. If the profile requirements of the coating manufacturer are more restrictive, the Contractor shall advise the Engineer and comply with the more restrictive requirements. For recycled abrasives, an appropriate operating mix shall be maintained in order to control the profile within these limits.

The surface profile produced by the Contractor's surface preparation procedures shall be determined by replica tape and spring micrometer at the beginning of the work, and each day that the surface preparation is performed. Areas having unacceptable measurements shall be further tested to determine the limits of the deficient area. The replica tape shall be attached to the daily report.

When unacceptable profiles are produced, work shall be suspended. The Contractor shall submit a plan for the necessary adjustments to ensure that the correct surface profile is achieved on all surfaces. The Contractor shall not resume work until the new profile is verified by the QA observations and the Engineer confirms that the profile is acceptable.

(e) Surface Cleaning for Hardware. The requirements of this part shall apply when the Contract requires installation of bolts that are to be painted. This work shall occur after bolt tensioning has been completed.

All exposed oils, lubricants, and wax on the bolts, nuts, washers, and surrounding surfaces to be painted shall be completely removed by solvent cleaning. This also includes any foreign material that has come out of the DTIs during the tensioning process. Light hand wire brushing or scrubbing with bristle brushes is allowed. Use of power tools is not allowed.

For galvanized hardware, the Contractor shall remove the colored lubricant from the nuts. The galvanizer may be able to provide information to the Contractor on the most effective solvent cleaner to remove the colored lubricant (common examples include methyl-ethyl-ketone (MEK), foaming glass cleaners containing ammonia, and foaming alkaline-type household cleaners). It is not necessary to remove 100% of the dye, and it is acceptable for some staining to remain after cleaning. A white cloth wipe test with no color transfer can be used to confirm that all lubricant and non-absorbed dye has been removed, leaving only the residual stain on the surface. The final cleanliness shall be acceptable to the Engineer.

513.16 STRUCTURAL STEEL MATING SURFACES. All laminar, stratified, or pack rust that has formed on or between the existing steel surfaces shall be removed as follows:

(a) Disassembled Mating Surfaces. When the Contract requires existing mating surfaces to be disassembled, or when new faying surfaces are created on existing steel due to additional steel being added, the Contractor shall clean and prepare the mating surface as a faying surface. Faying surfaces for all steel connections shall be abrasive blast cleaned and prime coated only as specified herein prior to being re-assembled.

The Contractor may request that the Engineer waive the requirements for NACE certification and SSPC-QP 1 certification from Subsection 513.03 for blast cleaning and priming of faying surfaces on existing steel only. Requests will be reviewed on a case-by-case basis and will only be considered if a fully qualified Contractor will not be on site when the faying surfaces are to be blast cleaned and primed. If the Engineer grants the request, all other requirements for certifications, inspections, quality control, supplying inspection equipment, hold points, etc. will remain in effect and the NACE and SSPC-QP 1 certifications will be required for all work other than blast cleaning and priming of the faying surfaces.

(b) Assembled Mating Surfaces. Pack rust formed along the perimeter of mating surfaces of connected plates or shapes of structural steel shall be removed to the extent feasible without mechanically detaching the mating surface.

Pack rust between mating surfaces shall be removed to a level equal to or below the level of mating surfaces between which the rust is packed. Any pack rust remaining after cleaning the mating surfaces shall be tight and intact when examined using a dull putty knife.

The tools used to remove these corrosion products shall be identified in the submittals and accepted by the Engineer.

If the surface preparation or removal of rust results in nicks or gouges, the work shall be suspended, and the damaged areas repaired at the Contractor's expense to the satisfaction of the Engineer. The Contractor shall also demonstrate that they have made the necessary adjustments to prevent a reoccurrence of the damage prior to resuming work.

Epoxy penetrating sealer and sealant caulk shall be applied to pack rusted mating surfaces which have been addressed as specified above. The sealer and caulk shall be applied per the manufacturer's recommendations.

513.17 SOLUBLE SALT REMEDIATION (HOLD POINT). Following dry abrasive blast cleaning, the Contractor shall implement surface preparation procedures and processes that will remove chloride from the surfaces. Surfaces that may be contaminated with chloride include, but are not limited to, expansion joints and all areas that are subject to roadway spray or run-off, such as fascia beams and stringers.

Methods of chloride removal shall be determined by the Contractor. If steam or water cleaning methods of chloride removal are used over surfaces where the coating has been completely removed, and the water does not contact any lead containing coatings, the water does not have to be collected. The Contractor shall provide the proposed procedures for chloride remediation in the surface preparation and painting plan.

Upon completion of the chloride remediation steps, the Contractor shall use chloride titrator strips to test representative surfaces that were previously rusted (e.g. pitted steel) for the presence of remaining chlorides. Remaining chloride levels shall be no greater than 7 micrograms per square centimeter as read directly from the surface without any multiplier applied to the results. The testing shall be performed, and the results must be acceptable, prior to painting each day.

A minimum of 5 tests per 1,000 square feet, or fraction thereof completed in a given day, shall be conducted. If any results of greater than 7 micrograms per square centimeter are detected, the surfaces shall be re-cleaned and re-tested at the same frequency. If acceptable results are achieved on three consecutive days in which testing is conducted, the test frequency may be reduced to 1 test per 1,000 square feet prepared each day, provided the chloride remediation process remains unchanged.

If unacceptable results are encountered, or the methods of chloride remediation are changed, the Contractor shall resume testing at a frequency of 5 tests per 1,000 square feet. The Engineer shall approve of the actual location of the chloride tests prior to them being performed.

513.18 SURFACE CONDITION PRIOR TO PAINTING (HOLD POINT). Prepared surfaces shall meet the specified degrees of cleaning immediately prior to painting, and shall be painted before rusting appears on the surface. If rust appears or bare steel remains unpainted for more than 8 hours, the affected area shall be prepared again at the expense of the Contractor.

All surface preparation cleaning residue on bridge steel surfaces, scaffolding and platforms, containment materials, and tops of abutments and pier caps shall be removed prior to painting.

The quality of the surface condition and cleaning of surface dust and debris shall be accepted by the Engineer prior to painting. The Engineer has the right to reject any work that was performed without adequate provision for QA observations to accept the degree of cleaning. Rejected coating work shall be removed and replaced at the Contractor’s expense.

513.19 GENERAL PAINT REQUIREMENTS. Paint storage, mixing, and application shall be accomplished according to these specifications and as specified in the paint manufacturer's written instructions and product data sheets for the paint system used. In the event of a conflict between these specifications and the coating manufacturer's instructions and data sheets, the Contractor shall advise the Engineer and comply with the most restrictive requirements.

Unless noted otherwise, if a new concrete deck or repair to an existing deck is required, painting**,** except primer painting of surfaces exposed by deck repairs, shall be done after the deck is placed and the forms have been removed.

(a) Paint Storage and Mixing. All paint shall be stored according to the manufacturer's published instructions, including handling, minimum and maximum temperatures, and warming as required prior to mixing. All coatings shall be supplied in sealed containers bearing the manufacturer's name, product designation, batch number, and mixing and thinning instructions. Leaking containers shall not be used. The paint shall be stored in a secure, fireproof location.

Mixing shall be performed according to the manufacturer's instructions. Thinning shall be performed using thinner provided by the manufacturer, and only to the extent allowed by the manufacturer's written instructions. In no case shall thinning be permitted that would cause the coating to exceed the local volatile organic compound emission restrictions. For multiple component paints, only complete kits shall be mixed and used. Partial mixing is not allowed.

The ingredients in the containers of paint shall be thoroughly mixed by mechanical power mixers according to the manufacturer's instructions, in the original containers before use or mixing with other containers of paint. The paint shall be mixed in a manner that will break up all lumps, completely disperse pigment, and result in a uniform composition. Paint shall be carefully examined after mixing for uniformity and to verify that no unmixed pigment remains on the bottom of the container.

Excessive skinning or partial hardening due to improper or prolonged storage will be cause for rejection of the paint, even though it may have been previously inspected and accepted.

Manufacturer recommended induction/sweat-in times and temperature of mixed coatings shall be observed.

Multiple component coatings shall be discarded after the expiration of the pot life. Single component paint shall not remain in spray pots, paint buckets, etc. overnight and shall be stored in a covered container and remixed before use.

The Engineer reserves the right to sample and test field paint (both individual components and the mixed material). If the paint does not meet the product requirements due to excessive thinning or because of other field problems, the coating shall be removed from that section of the structure and replaced as directed by the Engineer at no additional cost to the Agency.

(b) Manufacturer's Ambient Condition Recommendations. If the manufacturer's restrictions differ from the restrictions stated in Subsection 513.13, the more restrictive requirements shall be followed. The written recommendations required to be submitted in Subsection 513.06(f) shall be observed. If the actual field conditions differ from what was anticipated at the time of the submittal, then revised documentation shall be submitted and observed. Upon acceptance by the Engineer, these times shall be used to govern the duration that protection shall be maintained during curing/drying.

The manufacturer's technical representative shall be on the project for the first 48 hours of paint application and after that time be available to be back on the project with 24 hours' notice.

(c) Paint Application. Painting shall be performed in a neat and skilled manner. Each coat of paint shall be applied as a continuous film of uniform thickness free of defects, including, but not limited to, runs, sags, overspray, dry spray, pinholes, voids, skips, misses, and shadow-through. Defects such as runs and sags shall be brushed out immediately during application.

Unless prohibited by the coating manufacturer's written instructions, paint may be applied by spray methods, rollers, or brushes. If applied with conventional or airless spray methods, paint shall be applied in a uniform layer with overlapping at the edges of the spray pattern.

The painters shall monitor the wet film thickness of each coat during application. The wet film thickness shall be calculated based on the specified dry film thickness using the solids by volume of the material and the amount of thinner added.

When brushes or rollers are used to apply the coating, additional applications may be required to achieve the specified thickness per layer.

Prime coats shall be applied to all bare metal surfaces. Faying surfaces for disassembled mating surfaces for steel connections shall receive a prime coat that will remain in the assembled connection. If disassembled faying surfaces are slip critical, an organic zinc rich primer with an appropriate slip/creep coefficient shall be applied to the surfaces.

Damage to vehicles and property caused by the Contractor's painting or surface preparation activities shall be remedied at the Contractor's expense. The Contractor shall ensure that all areas not scheduled for paint will be protected against overspray. All areas accidentally painted will be cleaned at the Contractor's expense.

(d) Re-Coating and Film Continuity (Hold Point for Each Coat). Paint shall be considered dry for re-coating according to the re-coat time/temperature/humidity/dry film thickness criteria provided in the manufacturer's instructions submitted as required in Subsection 513.06(f), and when an additional coat can be applied without the development of film irregularities such as lifting, wrinkling, or loss of adhesion of the under coat.

If surfaces are contaminated, washing shall be accomplished prior to intermediate and final coats. Wash water does not have to be collected unless the water contacts existing lead-containing coatings.

(e) Stripe Coats. Unless indicated otherwise in the Contract, the Contractor shall apply an additional stripe coat to all edges, rivets, bolts, crevices, welds, and similar surface irregularities for each coating applied (prime, intermediate, and top coats).

The stripe coat shall be applied by brush only (the use of rollers or daubers will not be permitted) such that the coating is thoroughly worked into or on the irregular surfaces, and shall extend onto the surrounding steel a minimum of 1 inch in all directions. The purpose of the stripe coat is to build additional thickness and to assure complete coverage of these areas. The stripe coat is in addition to the requirement for penetrating sealer.

The stripe coat shall not be applied as part of the application of the full coat. The stripe coat shall be applied and dried separately according to the manufacturer's recommended curing/drying times for re-coating. The color of the stripe coat shall contrast with the colors used for the full coats immediately preceding and succeeding the stripe coat, except that the top stripe coat may be the same color as the full top coat.

(f) Coating Sequence. For locations painted under this specification, coatings shall be applied as follows:

(1) Prime Coat. The full prime coat shall be applied first to protect the steel. Once the full prime coat has dried, the prime stripe coat shall be applied.

(2) Intermediate Coat. After the prime stripe coat has dried, an intermediate stripe coat shall be applied and allowed to dry, followed by the full intermediate coat.

(3) Top Coat. After the full intermediate coat has dried, a top stripe coat shall be applied and allowed to dry, followed by the full top coat.

(g) Coating Thickness. The dry film thickness of each full coat shall be within the applicable range specified below, as measured in accordance with *SSPC-PA 2*.

(1) Prime Coat. The prime coat of organic zinc-rich primer shall be between 3.5 mils and 5.0 mils dry film thickness.

(2) Intermediate Coat. The intermediate coat of epoxy or urethane shall be between 3.0 mils and 6.0 mils dry film thickness.

(3) Top Coat. The top coat of aliphatic urethane shall be between 2.5 mils and 4.0 mils dry film thickness. The color of the top coat shall be as specified in the Contract and shall conform to the applicable *SAE AMS-STD-595* chip number specified in Subsection 708.03(b).

If the thickness range specified by the manufacturer differs from the range specified above for a given coat, the required dry film thickness range shall be between the largest specified minimum thickness and the smallest specified maximum thickness. For example, the thickness range specified above for the prime coat is 3.5 mils to 5.0 mils. If the manufacturer's specified prime coat thickness is 4.0 mils to 6.0 mils, the required thickness range would then be between 4.0 mils and 5.0 mils.

(h) Amine Blush. Amine blush is a residue that can form on newly applied epoxy coating films under certain conditions. Amine blush often appears as a yellowish milky or blotchy residue on the coating surface and is a deterrent to the adhesion of subsequently applied coating layers. If amine blush is detected, the Contractor shall provide the Engineer with written procedures from the coating manufacturer for complete removal prior to the application of additional coating layers.

513.20 WATER CLEANING AND SOLVENT CLEANING (HOLD POINT). When foreign matter has accumulated on a previously applied coat, washing shall be performed prior to the application of any subsequent coating products.

Washing shall involve the use of chlorine free potable water at a minimum of 1,000 psi and less than 5,000 psi pressure, in accordance with low pressure water cleaning of *SSPC-SP 12*. Paint spray equipment shall not be used to perform the water cleaning. The cleaning shall be performed in such a manner as to remove dust, dirt, chalk, insect and animal nests, bird droppings, and other foreign matter. The water does not need to be collected unless it contacts existing lead containing coatings.

If detergents or additives are added to the water, the detergents or additives shall be included in the submittals and not used until accepted by the Engineer. When detergents or additives are used, the surface shall be rinsed with chlorine free potable water before the detergent water dries.

513.21 REPAIR OF DAMAGE AND AREAS CONCEALED BY CONTAINMENT. The Contractor shall repair all damage to the newly installed coating system and areas concealed by the containment or protective covering attachment points, at no cost to the Agency.

If the damage extends to the substrate and the original preparation involved abrasive blast cleaning, the damaged areas shall be prepared to meet the requirements of *SSPC-SP 15*. If the original preparation was other than blast cleaning or the damage does not extend to the substrate, the loose, fractured paint shall be cleaned to meet the requirements of *SSPC-SP 3*.

The surrounding coating at each repair location shall be feathered for a minimum distance of 1-1/2 inches to achieve a smooth transition between the prepared areas and the existing coating.

If the bare steel is exposed, all coats shall be applied to the prepared area. If only the intermediate and finish coats are damaged, the intermediate and finish coats shall be applied. If only the finish coat is damaged, the finish coat shall be applied.

All hold points and specifications are applicable to the repair of damaged areas and areas concealed by containment.

513.22 GREASE COATING. If required by the plans, a coat of grease rustproofing compound shall be uniformly applied by brush or spray at an approximate rate of 20 square feet per gallon to the steel as specified.

The grease coating shall be applied after all concrete form work has been removed, and after the final coat of paint, including repairs, has fully cured. A fully cured condition has occurred when a thumbnail driven into the coating surface does not leave an impression and when a thumb firmly pushed against the surface and twisted does not disturb the coating.

Surfaces adjacent to areas being grease coated shall be protected against over-spray. Non-metallic and stainless steel surfaces shall not be coated.

513.23 SPECIAL INSTRUCTIONS.

(a) At the completion of the work, the Contractor shall stencil the painting date and the paint code on the bridge in a color contrasting to the color of the top coat. The letters shall be capitals, not less than 2 inches and not more than 3 inches in height.

The stencil shall contain the phrase “PAINTED BY (Insert the name of the Contractor)” and shall show the month and year in which the painting was completed, followed by the appropriate code for the coating material applied, all stenciled on successive lines.

Coding shall be as follows:

(1) CODE LA for full lead abatement. This code shall only be used when the entire steel structure has been prepared in accordance with this specification.

(2) CODE Z1 for a field-applied three coat system.

This information shall be stenciled on the cover plate of a truss end post near the top of the railing, or on the inside face of an outside beam or girder near one end of the bridge, or at some equally visible surface near the end of the bridge, as designated by the Engineer.

(b) All surfaces painted inadvertently shall be cleaned immediately to the satisfaction of the Engineer.

(c) The paint used for stenciling shall be compatible with the top coat.

The cost of all work outlined above for stenciling will be included in the cost of painting existing steel and no extra compensation will be allowed.

513.24 METHOD OF MEASUREMENT. The quantity of Field Painting Steel, Three Coat System at the location specified to be measured for payment will be on a lump sum basis in the complete and accepted work.

513.25 BASIS OF PAYMENT. The accepted quantity of Field Painting Steel, Three Coat System will be paid for at the Contract lump sum price. Payment will be full compensation for performing all work specified and for furnishing all labor, tools, equipment, and incidentals to complete the work.

Partial payments will be made as follows:

(a) The first payment of 15% of the Contract unit price will be paid when all submittal requirements have been met and accepted by the Agency and the Contractor is fully mobilized to begin work.

(b) An additional 75% of the Contract unit price will be paid when all cleaning and painting work is complete.

(c) The final 10% of the Contract unit price will be paid when the Contractor has fully demobilized and all equipment and waste have been removed from the project site to the satisfaction of the Engineer.

Payment will be made under:

Pay Item	Pay Unit
513.1030 Field Painting Steel, Three Coat System	Lump Sum

SECTION 514 – WATER REPELLENT, SILANE

514.01 DESCRIPTION. This work shall consist of furnishing and applying a penetrating-type protective sealer on concrete surfaces.

514.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Water Repellent, Silane 726.10

514.03 PACKAGING, DELIVERY, AND STORAGE. The material shall be delivered to the project in the original, unopened manufacturer's containers and stored in accordance with the manufacturer's recommendations.

514.04 PREPARATION OF SURFACES. All surfaces on which the protective sealer is to be applied shall be clean and thoroughly dry to the satisfaction of the Engineer and in accordance with the manufacturer's recommendations. Dirt, grease, curing compounds, asphalt, or other foreign materials shall be removed from the concrete surface before application of the sealer.

514.05 APPLICATION. The material shall be applied to the satisfaction of the Engineer and in accordance with the manufacturer's recommendations.

The minimum application rate for Type I silane water repellent shall be 125 square feet per gallon or per the manufacturer's recommendations, whichever is greater. The minimum application rate for Type II silane water repellent shall be 300 square feet per gallon or per the manufacturer's recommendation, whichever is greater.

In the absence of specific recommendations from the manufacturer, the protective sealer shall not be applied to new concrete surfaces that are less than 14 days old. The concrete surfaces shall be free from precipitation for 48 hours prior to application of the sealer. Application of the sealer shall be completed within 40 days of original concrete placement.

514.06 PROTECTION. After application of the sealer, the concrete surfaces shall be protected to the satisfaction of the Engineer and in accordance with the manufacturer's recommendations.

514.07 METHOD OF MEASUREMENT. The quantity of Water Repellent, Silane to be measured for payment will be the number of gallons of solution applied in the complete and accepted work, measured to the nearest gallon.

514.08 BASIS OF PAYMENT. The accepted quantity of Water Repellent, Silane will be paid for at the Contract unit price per gallon. Payment will be full compensation for furnishing, transporting, handling, and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
514.1000 Water Repellent, Silane	Gallon

SECTION 516 – EXPANSION DEVICES

516.01 DESCRIPTION. This work shall consist of furnishing and installing, or partially removing and modifying, expansion devices.

516.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Joint Sealer, Preformed Neoprene 707.04
Preformed Fabric Material 707.05
Joint Sealer, Butyl Rubber Tape 707.10
Asphaltic Plug Joints for Bridges 707.13
Structural Steel 714.02
High-Strength Low-Alloy Structural Steel 714.03
Carbon Steel Bolts, Nuts, and Washers 714.04
High-Strength Structural Bolts and Assemblies, 120 ksi 714.05
Welded Stud Shear Connectors 714.10
Epoxy Bonding Systems 719.01
Galvanizing 726.06

516.03 FABRICATION DRAWINGS. The fabricator of the expansion devices furnished under this section shall submit detailed fabrication drawings in accordance with the requirements of Subsection 105.06 and Section 506.

516.04 FABRICATION. Material furnished under this section shall conform to all applicable provisions of Section 506.

Assemblies shall be fabricated to the designed roadway cross-section within a 1/8 inch tolerance of the theoretical dimensions at any point.

Unless otherwise specified, all expansion devices shall be galvanized.

Extruded cellular and strip-type sealers shall be furnished in one continuous piece without splices.

When it is specified that a neoprene seal be bonded to a steel surface that is not galvanized, the contact surface area shall be blast-cleaned and properly primed with adhesive. Contact surfaces of neoprene seals that will be bonded with an adhesive shall be cleaned and primed in accordance with the seal manufacturer's instructions.

Expansion devices shall be fabricated, assembled, and certified by one supplier. Each device shall be completely shop-assembled and shipped as a complete unit except that curbs or other assemblies designed to be attached and adjusted by field bolting may be removed for transport. Angles or other suitable sections shall be furnished to secure opposite halves of a unit during shipment. Temporary shipping attachments shall be attached by bolting, welding will not be permitted.

516.05 INSTALLATION. Expansion devices shall be installed in conformance with the Plans and all applicable provisions of Section 506.

Final gap adjustments of an expansion joint assembly shall be made during installation in accordance with the movement chart shown on the Plans, fabrication drawings, or as directed by the Engineer.

Joint assemblies shall be properly positioned within 1/8 inch of theoretical crown and straightness and attached to the structure by anchorages furnished with the assembly or as specified in the Contract. Prior to the placement of the concrete, all steel surfaces that will be embedded in concrete shall be coated with an epoxy bonding system. Application of the epoxy bonding system shall be done in accordance with the manufacturer's recommendations.

516.06 PARTIAL REMOVAL AND MODIFICATION. The Contractor shall partially remove and modify the existing bridge joint at the locations indicated in the Plans and as directed by the Engineer.

Steel for new joint plates shall meet the requirements of Subsection 714.02. The Contractor shall remove and dispose of existing joint plates, drain troughs, and associated hardware.

The Contractor shall grind existing steel plates or shoulder concrete to the configuration shown on the Plans. The final surface shall be to the satisfaction of the Engineer.

516.07 METHOD OF MEASUREMENT. The quantity of Bridge Expansion Joint of the type specified to be measured for payment will be the number of linear feet used in the complete and accepted work, measured along its centerline.

The quantity of Partial Removal and Modification of Bridge Joint to be measured for payment will be the number of linear feet of bridge joint removed and modified in the complete and accepted work, measured along its centerline.

516.08 BASIS OF PAYMENT. The accepted quantity of Bridge Expansion Joint of the type specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for detailing, furnishing, handling, transporting, and placing the material specified, including nondestructive testing of welds, surface preparation, protective coating, epoxy bonding system, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Partial Removal and Modification of Bridge Joint will be paid for at the Contract unit price per linear foot. Payment will be full compensation for partially removing and modifying the existing joint as specified and as detailed in the Plans, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
516.1000	Bridge Expansion Joint, Asphaltic Plug	Linear Foot
516.1100	Bridge Expansion Joint, Vermont	Linear Foot
516.1200	Bridge Expansion Joint, Finger Plate	Linear Foot
516.2000	Partial Removal and Modification of Bridge Joint	Linear Foot

SECTION 519 – MEMBRANE WATERPROOFING

519.01 DESCRIPTION. This work shall consist of the application of a membrane to bridge decks to serve as a waterproof barrier between the concrete deck and the bituminous concrete surface pavement. This shall consist of either a torch applied membrane or a spray applied membrane as required by the Contract.

Torch applied membranes shall incorporate the use of a prime coat over the horizontal deck surface and an acceptable polyurethane liquid membrane on the lower portion of the curb face and adjacent deck area.

Spray applied membranes shall incorporate a primer, the waterproofing membrane, tack coat, and any required aggregate.

519.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Waterproofing Membrane System, Type I .....726.08(a)
Waterproofing Membrane System, Type II .....726.08(b)

Spray applied membranes shall be a Type I waterproofing membrane system and torch applied membranes shall be a Type II waterproofing membrane system.

519.03 SUBMITTALS. The following information shall be provided by the Contractor to the Engineer prior to application of the membrane system:

(a) Safety data sheets (SDS) and material detail sheets prepared by the membrane manufacturer, provided a minimum of 7 calendar days prior to the scheduled commencement of work.

(b) Written certification from the manufacturer regarding the applicator's qualifications and references for a minimum of three membrane projects completed by the applicator within the last 5 years, provided a minimum of 7 calendar days prior to the application of any system component. The certification shall apply only to the named individuals performing the application.

519.04 WEATHER LIMITATIONS. Membranes shall not be applied in rainy weather or when the temperature is below 40°F without the authorization of the Engineer.

519.05 SURFACE PREPARATION. The surface of the deck shall have a smooth, fine-textured finish. All honeycombed areas and surface cavities shall be cleaned and filled with Agency and manufacturer approved patching materials.

The entire deck shall be abrasive blast-cleaned to achieve an anchor profile that is clean and free of laitance, oil, and foreign materials. Prior to blast cleaning, the surface shall be dry and free of sharp protrusions.

In addition to these requirements, the deck surface shall meet any additional requirements of the manufacturer's recommendations.

519.06 CONSTRUCTION DETAILS.

(a) General Requirements. All work performed shall be in accordance with the manufacturer's recommendations. The entire system shall be applied by an individual (applicator) certified by the manufacturer.

The manufacturer shall have a competent technical representative with necessary equipment to perform the quality control testing at the job site during all phases of preparation and installation. The technical representative will be responsible for performing and reporting all quality control testing required during membrane application.

The technical representative shall present all quality-control testing equipment to the Engineer to verify calibration dates and demonstrate their competency to perform quality control testing.

Quality control testing includes, but is not limited to, measuring and verifying substrate moisture content and temperature, primer adhesion, membrane thickness, membrane pin holes, and membrane adhesion.

(b) Material Storage. All components of the membrane system shall be stored in accordance with the material detail sheets.

(c) Surface Condition. Prior to application of primer, the concrete deck shall be cured such that the moisture content reaches 6% or less. Except on minor areas of the deck as approved by the Engineer, torching or other forms of rapidly evaporating free moisture from the surface will not be allowed to achieve initial surface conditions. Cracks should be blown out to ensure excess water is not present. The Contractor shall supply a portable electronic surface moisture meter capable of measuring the moisture content percentage of concrete surfaces.

Immediately prior to the application of the primer, the deck shall be cleaned using brooms and compressed air that is free of oil. The concrete surfaces shall be inspected and approved by the Engineer and the applicator prior to priming.

(d) Application of Primer. The air temperature for primer application shall be at least 40˚F and rising. The primer shall consist of one coat covering the entire deck with an overall coverage rate of 200 square feet per gallon or as specified by the manufacturer. The primer shall be applied by brush, roller, or sprayer.

The primer shall cure tack-free in accordance with the manufacturer's recommendations before application of the waterproofing membrane.

(e) Membrane Application. The waterproofing membrane shall be applied by equipment approved by the Engineer. The equipment shall be capable of applying the membrane in a uniform manner onto the prepared substrate in accordance with the manufacturer's recommendations to ensure bond with the primed surface and elimination of air bubbles.

In small areas, the membrane shall be hand-welded by torch around drains, joints, and along the curb as directed by the Engineer. The applicator shall be responsible for the protection of adjacent areas.

Sheet membrane shall be installed in a shingled pattern so that water is permitted to drain to the low areas of the deck without accumulating against seams.

Laps shall be staggered at the beginning and ends of rolls, shall overlap the previous roll, and shall be sealed in accordance with the manufacturer's recommendations. Prior to suspension of work for any reason, all exposed edges shall be heated, troweled, and sealed in accordance with the manufacturer's recommendations.

The Contractor shall repair or correct any deficiencies in the membrane system and substrate noted during quality control testing as recommended by the manufacturer's representative to the satisfaction of the Engineer at no additional cost to the Agency.

If the membrane is damaged or de-bonding from the deck surface occurs after application and quality control testing is complete, the membrane shall be patched or repaired in accordance with the manufacturer's recommendations at no additional cost to the Agency.

519.07 PROTECTION OF MEMBRANE. Care shall be exercised to prevent damage to the completed membrane, especially during paving operations. All damaged areas shall be cleaned and patched to the satisfaction of the Engineer. A rubber-tired or rubber-tracked paver shall be used to place the bottom course of bituminous mix.

The temperature of the bituminous concrete pavement to be placed on the membrane shall be as recommended by the membrane manufacturer and approved by the Engineer.

(a) Membrane Waterproofing, Spray Applied. An aggregate wearing surface shall be adhered to the top membrane coat. Unless otherwise specified, the aggregate shall be broadcast at the rate of 0.25 to 0.50 pounds per square foot to achieve adequate uniform coverage.

Where bituminous concrete pavement will be applied to the membrane surface, a tack coat compatible with the membrane system shall be used between the membrane and the bituminous concrete pavement. The surface preparation and tack coat shall be applied per the manufacturer's recommendations.

(b) Membrane Waterproofing, Torch Applied Sheet. No traffic shall be permitted on an exposed membrane surface.

The specified bituminous overlay shall be placed on the membrane within three days after application.

The Contractor shall maintain a small supply of Portland cement on the project during the time of paving. The cement dust shall be sparingly cast over the membrane surface to reduce tackiness and thereby prevent the paver or truck tires from sticking to the membrane and damaging it.

The paver operator shall be directed not to ride the curb lines while paving such areas since the screed shoe may damage the polyurethane sealant on the vertical curb face.

519.08 PROTECTION OF EXPOSED SURFACES. The Contractor shall exercise care in the application of the waterproofing materials to prevent surfaces not receiving treatment from being spattered or marred. Particular reference is made to the face of curbs, copings, finished surfaces, substructure exposed surface, and outside faces of the bridge. Any material that spatters on these surfaces shall be removed and the surfaces cleaned to the satisfaction of the Engineer.

519.09 METHOD OF MEASUREMENT. The quantity of Membrane Waterproofing, Spray Applied or Membrane Waterproofing, Torch Applied Sheet to be measured for payment will be the number of square yards of the specified type used in the complete and accepted work. Measurement will be based on the horizontal distance between the face of the curbs and the horizontal length of membrane installed. Any material specified to be lapped up the face of the curb will not be included in the measured quantity.

519.10 BASIS OF PAYMENT. The accepted quantity of Membrane Waterproofing, Spray Applied and Membrane Waterproofing, Torch Applied Sheet will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, transporting, handling, and placing the waterproofing system specified, including primer, tack coat, aggregate, mastic, polyurethane membrane sealant, and surface preparation, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
519.1000 Membrane Waterproofing, Spray Applied	Square Yard
519.2000 Membrane Waterproofing, Torch Applied Sheet	Square Yard

SECTION 522 – LUMBER AND TIMBER

522.01 DESCRIPTION. This work shall consist of detailing, furnishing, fabricating, transporting, framing, and placing or erecting lumber, structural timber, or structural glued laminated timber, installing hardware, and applying preservative treatment.

522.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Joint Sealer, Hot Poured .....707.02(a)
Coatings for Wood 708.05
Structural Lumber and Timber 709.01
Miscellaneous Hardware, Shapes, and Fabricated Materials .....709.01(h)
Nonstructural Lumber 709.02
Structural Glued Laminated Timber 709.03
Timber Preservative 726.01
Waterproofing Pitch 726.03
Galvanizing 726.06

Unless otherwise specified, all metal parts and hardware shall be galvanized.

522.03 GENERAL FABRICATION REQUIREMENTS. Glued laminated timber furnished under this section shall be fabricated by an AITC or APA-EWS licensed laminator and shall comply with *ANSI/AITC A190.1*. In addition to being a licensed laminator, the fabricator shall have been in continuous operation for at least five years, and shall demonstrate the capability to fabricate the end products specified.

Unless otherwise specified, all material shall be fabricated prior to preservative treatment.

Dimensions and bolt hole locations of prefabricated material shall be within a tolerance of 1/16 inch of the details specified.

522.04 SUBMITTALS. Unless otherwise specified, as soon as practical after award of the Contract, the Contractor shall prepare and submit fabrication drawings for glued laminated timber in accordance with Subsection 105.06.

The Contractor shall prepare and submit construction drawings for structural timber erection in accordance with Subsection 105.06. The erection plan shall include methods and sequence of structural timber erection, temporary bracing requirements, the equipment to be used for the erection, the necessary computations to indicate the magnitude of stress in the segments during erection and to demonstrate that all of the erection equipment has adequate capacity for the work to be performed, and provisions for all stages of construction, including temporary stoppages. The Contractor shall follow the erection plan as approved.

522.05 STORAGE. Timber, lumber, and glued laminated materials stored on the site shall be kept in orderly piles, open stacked, and on supports that provide at least 12 inches of ground clearance. For outside storage, the ground area in the vicinity of the material shall be cleared of grass, weeds, and rubbish. Free circulation of air shall be provided between the tiers and courses for untreated timber. Treated timber shall be stacked together, with no separation between the tiers and courses. Free circulation of air shall be provided between the pile and the ground for both treated and untreated timber.

Timber, lumber, and glued laminated timber (treated or untreated) shall be stored under cover. The covering shall adequately protect these materials from direct and blowing rain or snow while providing for full circulation of air and adequate drainage.

All timber, lumber, and glued laminated timber (treated or untreated) shall meet the requirements of Subsection 709.01(b) before being incorporated into the work.

All glued laminated timber shall meet the moisture requirements of Subsection 709.03(b) at the time laminations are glued.

Fabricated material shall be stored in a manner that will prevent dimensional changes in the members prior to assembly.

522.06 HANDLING. Materials shall be carefully handled to avoid damaging the edges or surface and to keep them clean.

Materials shall be picked up or moved with slings or other devices that will not damage or mar the surface. Peavies, cant hooks, timber dogs, or other pointed tools will not be permitted.

Cranes, lifting devices, and other equipment for all structural timber erection shall be of adequate design and capacity to safely erect, align, and secure all members and components in their final positions without damage. The Contractor is solely responsible for the methods and equipment employed for the erection of the structural timber members.

522.07 FRAMING. Timber, lumber, and glued laminated timber shall be accurately cut and framed to a close fit in such a manner that the joints will have full and even bearing over the entire contact surface. Mortises shall be true to size for their full depth, and tenons shall fit snugly. Except as indicated in the Contract, shimming will not be permitted in making joints, and open joints will not be accepted. Nails and spikes shall be driven with the heads set flush with the surface of the wood. Except as directed by the Engineer, structure framing and boarding shall be constructed square, plumb, and straight.

When permitted by the Engineer, forms or temporary braces may be attached to treated material. Upon removal, any holes, cuts, or abrasions shall be treated in accordance with Subsection 522.13.

522.08 CONNECTIONS.

(a) Holes for Bolts, Dowels, Rods, and Lag Screws. Holes for metal round drift-bolts or dowels shall be bored with a bit 1/16 inch less in diameter than the drift-bolt or dowel to be used. The diameter of holes for square metal drift-bolts or dowels shall be equal to the least dimension of the drift-bolt or dowel.

Except as required for timber connectors in Subsection 522.08(d), holes for machine bolts shall be bored with a bit the same diameter as the bolt. Holes for round wood dowels or trunnels shall be bored with a bit the same diameter as the dowel. Holes for rods shall be bored with a bit 1/16 inch greater in diameter than the rod.

Lead holes for lag screws, wood screws, and spikes shall conform to requirements specified in the *AITC Timber Construction Manual*.

(b) Countersinking. Countersinking shall be done wherever smooth faces are required. All recesses in treated lumber and timber formed for countersinking shall be treated in accordance with *AWPA Standard M4*. Recesses likely to collect injurious materials shall be filled with a waterproof material as directed by the Engineer.

(c) Bolts and Washers. A washer of the size and type specified shall be used under all bolt heads and nuts that would otherwise come in contact with wood.

All nuts shall be effectively locked after they have been finally tightened.

(d) Timber Connectors. In addition to wood dowels, bolts, and rods, timber (wood member) connectors may be the split ring, shear plate, or spike grid type. The split ring and shear plate types shall be installed in precut grooves of dimensions as recommended by the manufacturer. The spike grid type shall be forced into the contact surfaces of the wood members joined by means of pressure equipment. All connectors of this type at any given joint shall be embedded simultaneously and uniformly.

Bolt holes shall be perpendicular to the face of the material and 1/16 inch larger in diameter than the bolt.

(e) Framed Bents. Framed bents shall be constructed in accordance with the *AASHTO LRFD Bridge Construction Specifications*.

522.09 TRUSSES. Trusses, when completed, shall show no irregularities of line. Chords shall be straight and true from end to end in horizontal projection and, in vertical projection, shall show a smooth curve through panel points conforming to the correct camber. All bearing surfaces shall fit accurately. Uneven or rough cuts at the points of bearing shall be cause for rejection of the piece containing the defect.

522.10 TRUSS HOUSING. The finished appearance of the housing is considered of primary importance. Special care shall be taken to secure a high quality of work and finish on this portion of the structure.

Unless otherwise directed by the Engineer, housing and railings shall be constructed after the removal of the falsework and the adjustment of the trusses to correct alignment and camber.

522.11 DECKING.

(a) Plank Flooring. Plank material shall be of dimension lumber of the grade specified.

Unless otherwise specified, all material shall be surfaced four sides (S4S).

Single layer plank floors shall consist of a single thickness of dimension lumber planks supported by stringers or floor beams. The planks shall be laid heart side down, with 1/4 inch openings between them. Each plank shall be securely fastened to each supporting member. The planks shall be carefully graded as to thickness and so laid that no two adjacent planks vary in thickness by more than 1/16 inch. Unless otherwise specified, the lengths of transverse planks on stringers shall be full width of the designed cross-section.

Two-ply plank floors shall consist of two layers of dimension lumber planks supported on stringers or floor beams. Each plank of the top course shall be securely fastened to the lower course. At the ends of the bridge, if required, the decking shall be beveled to match the approach surfaces. For stringer supports, the top course of planks may be laid either diagonal or parallel to the centerline of roadway. Joints in the top layer shall be staggered at least 3 feet and care shall be taken to securely fasten the ends of each plank. For floor beam supports, unless otherwise specified, the lengths of transverse top course planks shall be full width of the designed cross-section.

(b) Nail Laminated Decking. Nail laminated deck material shall be furnished and installed in accordance with the Contract or as ordered by the Engineer. Deck material shall be of the grade specified. Unless otherwise specified, in transverse applications the lengths of laminations shall be the full width of the designed cross-section.

Spike placement in laminated decks shall follow the requirements of the *AASHTO LRFD Bridge Design Specifications, Section 9*. Spikes shall be placed in pilot holes that are bored through pairs of laminations at each end and at intervals of not more than 12.0 inches. The spikes shall be driven alternately near the top and bottom edges of the laminations and shall be of sufficient length to fully penetrate four laminations. Laminations shall not be butt spliced within their unsupported length. Drive spike spacing at ship-lap joints shall be as shown on the Plans.

When timber nailing strips are used, every other plank shall be toe-nailed to every other nailing strip. The size of the spikes shall be as shown on the Plans or as directed by the Engineer.

When shown on the Plans or authorized by the Engineer, the laminated decking may be attached to steel supports by using approved metal clips. Care shall be taken to have each strip vertical and tight against the preceding one and bearing evenly on all supports.

(c) Glued Laminated Decking. Glued laminated decking material shall be furnished and installed in accordance with the Contract, approved fabrication drawings, or as directed by the Engineer.

522.12 SAWN LUMBER STRINGERS. Stringers shall be sized at bearings and shall be placed in position so that knots near edges will be in the compression portions of the stringers.

Outside stringers may have butt joints over intermediate supports with the ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least 1/2 inch for the circulation of air and shall be securely fastened by drift-bolting where specified. When stringers are two panels in length, the joints shall be staggered.

Cross-bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails in each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. Unless otherwise specified, cross-bridging shall be placed at the center of each span.

522.13 PRESERVATIVE TREATMENT.

(a) Pressure Treatment. Timber, lumber, and glued laminated timber shall be pressure treated with the type of preservative specified in the Contract. Prior to handling or erecting pressure treated timber, lumber, or glued laminated timber the Contractor shall read and provide a copy of any safety data sheets (or consumer information sheets) required for the material to the Engineer. The Contractor shall also provide the Engineer with a plan detailing clean-up, storage, and disposal procedures for pressure treated sawdust and cutoffs.

All preservative treatment shall adhere to the recommendations of *AASHTO M 133* and the American Wood Protection Association.

(1) Treatment of Cuts, Abrasions and Holes. Cuts, abrasions, and holes bored after treatment shall be treated in accordance with *AWPA Standard M4*. Cuts and abrasions shall be carefully trimmed prior to treatment. Holes left unfilled shall be filled with wooden plugs treated in accordance with *AWPA Standard M4*.

(2) Temporary Attachments. Holes remaining after the removal of nails and spikes used to attach temporary forms or bracing to treated material shall be filled by driving galvanized nails or spikes flush with the surface or plugging the holes with wooden plugs treated in accordance with *AWPA Standard M4*.

(b) Untreated Timber, Lumber and Glued Laminated Timber. For untreated timber, lumber, and glued laminated timber, all cuts, notches, bore holes, contact surfaces and other areas specified by the Contract shall be treated in accordance with *AWPA Standard M4*.

(c) Field Treatment. When field applications of preservative are specified, the materials shall be furnished, prepared, and applied in accordance with *AWPA Standard M4*.

522.14 PAINTING. The surface of any material to be painted or stained shall be dry and free of dirt, dust, oil, or other foreign materials. Unless otherwise specified, all surfaces shall be coated with a prime coat and one finish coat.

522.15 METHOD OF MEASUREMENT. The quantity of Structural Lumber and Timber, Untreated; Structural Lumber and Timber, Treated; Nonstructural Lumber, Untreated; Nonstructural Lumber, Treated; and Structural Glued Laminated Timber to be measured for payment will be the number of thousand feet board measure (MFBM) incorporated into the complete and accepted work, as computed from the actual cross-section sizes and the actual in-place lengths of members. The final accepted in-place length of any member will be determined as the maximum length of a member as projected along one edge-line, measured to the next whole 1-foot increment. Further measurement will not be made for cutoffs or actual stock lengths. For bridges requiring completely new materials for longitudinal nail-laminated decking, longitudinal plank decking, runners, or roof boards, member length will be measured as the overall superstructure length of the in-place decking, runners, or roof boards, rounded to the next whole 1-foot increment.

522.16 BASIS OF PAYMENT. The accepted quantities of Structural Lumber and Timber, Untreated; Structural Lumber and Timber, Treated; Nonstructural Lumber, Untreated; Nonstructural Lumber, Treated; and Structural Glued Laminated Timber will be paid for at the Contract unit prices per thousand feet board measure (MFBM). Payment for each quantity will be full compensation for detailing, fabricating, furnishing, transporting, handling, placing or erecting, and painting or treating the material specified, including all hardware and timber connectors; for providing all falsework, forms, bracing, sheeting, or other timber used for erection purposes; for furnishing and implementing the erection plan, when required; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Partial payments for Structural Glued Laminated Timber will be made as follows:

(a) The first payment of 50% of the total quantity will be made upon the original delivery of the timbers to the project, provided the materials are acceptable and certified.

(b) The remaining 50% of the total quantity will be paid when the installation is complete and the work accepted.

Payment will be made under:

Pay Item		Pay Unit
522.2000	Structural Lumber and Timber, Untreated	MFBM
522.2500	Structural Lumber and Timber, Treated	MFBM
522.3000	Nonstructural Lumber, Untreated	MFBM
522.3500	Nonstructural Lumber, Treated	MFBM
522.4000	Structural Glued Laminated Timber	MFBM

SECTION 524 – JOINT SEALER

524.01 DESCRIPTON. This work shall consist of furnishing and placing a joint sealer of the type specified at the locations shown on the Plans.

524.02 MATERIALS. Materials shall meet the requirements of the following subsections:

524.03 TEMPERATURE LIMITATIONS. The joint sealer shall be applied per the manufacturer's recommendations, however, the ambient air and pavement temperatures shall be greater than 40°F at the time of application.

524.04 SAWED JOINTS. Roadway or bridge deck joints shall be formed by means of concrete floor sawing equipment capable of dry-cutting the designed joint in a single pass.

The joint shall be cut and sealed in one continuous operation. The sawed joint shall not be exposed to traffic until after the sealer has been placed, cured, and is not subject to picking.

Joints sawn in bituminous concrete pavement shall be filled and sealed with hot poured or cold poured joint sealer or asphaltic plug joint binder, appropriate backer rod, and an approved bond breaker.

When placing new bituminous concrete pavement, each lift of pavement shall be scored with a single blade cut to a depth of 75% of the lift thickness, at the location of the center of the proposed joint. This work shall be completed prior to exposing the location to traffic or, where traffic is not maintained, the same working day that the lift of pavement is placed.

The sawed joint in the newly placed wearing course shall be cut and sealed within 24 hours of paving. If the joint location will not be exposed to traffic, the Engineer may allow the Contractor an additional 48 hours to cut and seal the joint.

The width of the sawed joint shall be as shown on the Plans or may be adjusted by the Engineer for seasonal temperature variations. The depth of the sealant shall be approximately 50% of the width of the sawn joint when hot or cold poured materials are specified in the Contract.

The equipment for sawing the single blade cut shall be on the project and approved by the Engineer prior to beginning paving operations.

524.05 PREPARATION OF JOINTS. Surfaces to which the joint sealer is to adhere shall be free of all foreign material, including curing compound, oil, dirt, sawing film, laitance, and rust. All surfaces shall be thoroughly dry before placing joint sealers.

(a) For Poured or Preformed Joint Sealers. Prior to placing poured or preformed joint sealers, the vertical faces of the sawed joint and the horizontal pavement surfaces within 1 inch of the joint edge shall be thoroughly blast-cleaned to improve joint sealant adhesion. The resulting dust, blasting debris, etc. shall be removed with a blast of high-pressure air or industrial vacuum equipment.

Regardless of the cleaning method used, the Contractor shall take all necessary precautions to avoid contaminating the other project construction work with the removed dust and debris.

(b) For Polyurethane Joint Sealer. Prior to placing polyurethane joint sealer, the concrete surface shall be blast-cleaned to remove surface mortar and expose underlying aggregate. Blast-cleaning equipment shall be operated such that no oil is introduced into the air line. Surfaces formerly sealed with other sealers shall be bush-hammered or sawed to clean the material and then blast-cleaned.

Steel surfaces shall be blast cleaned to the bare metal. Primer shall be applied immediately after the blast-cleaning is completed. Epoxy mortar surfaces shall be cleaned by use of suitable solvents or by blast-cleaning as required.

524.06 PLACEMENT.

(a) Joint Sealer, Hot Poured. The material shall be heated in a double-walled, oil-jacketed kettle equipped with positive temperature controls that allow the sealer to be heated to, and maintained within, a range of 390°F to 410°F or such other temperature range as recommended by the sealant manufacturer. The kettle shall arrive on the project empty.

Heating of the sealant to the placement temperature and maintaining the sealer at placement temperature shall not exceed six hours. The Contractor shall empty the kettle before heating more material. New material shall not be added to a partially filled kettle and cooled material shall not be reheated.

Prior to pouring the sealant into the joint, a heat-resistant backer rod shall be placed in the bottom of the joint. The rod shall be 1/8 inch greater in diameter than the joint width to ensure a leak-proof seal and to maintain the proper depth of sealant. The rod shall be specifically manufactured for use with hot poured sealants.

The hot sealant shall be poured into the joint in a single layer, except that multiple layers will be permitted if lateral flow is a problem. The joint shall be slightly overfilled, and the excess sealant shall be leveled with a U- or V-shaped squeegee to provide a thin layer of sealant spread over the blast-cleaned horizontal pavement surfaces adjacent to the joint.

(b) Joint Sealer, Cold Poured. The two-component material shall be mixed in the container in which it is furnished using 100% of both components. Mixing shall be accomplished with a variable-speed drill and mixing paddle operated at speeds not greater than 400 rpm for a period of not less than five minutes. Mixing by hand will not be permitted.

The mixed sealant may be transferred to a smaller clean container for ease of pouring. All mixed sealants shall be placed within the 30 minute to 45 minute pot life of the material.

Prior to pouring the sealant into the joint, a backer rod shall be placed in the bottom of the joint. The rod shall be 1/8 inch greater in diameter than the joint width to ensure a leak-proof seal and to maintain the proper depth of sealant. The rod shall be specifically manufactured for use with poured sealants.

The sealant shall be poured into the joint in a single layer, except that multiple layers will be permitted if lateral flow is a problem. The joint shall be slightly overfilled, and the excess sealant shall be leveled with a U- or V-shaped squeegee to provide a thin layer of sealant spread over the blast-cleaned horizontal pavement surfaces adjacent to the joint.

(c) Joint Sealer, Polyurethane. Polyurethane joint sealer shall be placed as shown on the Plans in accordance with the manufacturer's recommendations. Joint sealer shall not be installed until concrete has been in place for 28 days.

A foam spacer, approved by the Engineer, shall be installed in such a manner as to control the depth of the sealer and give support during its cure time. The foam spacer shall fit tightly against the sides of the opening beneath the sealer.

Polyurethane-coated tape, or other strip material approved by the Engineer, shall be applied to those surfaces where bond is not desired.

Primer materials shall be applied strictly as specified by the joint sealer manufacturer on the surfaces to which the joint sealer is intended to adhere. Primed surfaces that may have been contaminated by dirt or other foreign material shall be cleaned and primed again prior to the application of the joint sealer.

The finished surface of the joint sealer shall present a smooth, even appearance. Only minimum tooling of horizontal joints will be allowed. Overlaying or shimming material shall not be applied over material that has cured.

When it is necessary to place a portion of a joint, the edge of the cured material shall be primed as specified by the manufacturer prior to placing additional sealer.

Any joint sealer that is not completely bonded to the intended surface after being in place for 72 hours shall be removed, the joint prepared again, and the application repeated as specified.

(d) Asphaltic Plug Joint Binder. Asphaltic plug joint binder shall only be used in the saw-cut joint as indicated on the Plans.

The material shall be heated in a double-walled, oil-jacketed kettle equipped with positive temperature controls that allow the sealant to be heated to the temperature range recommended by the sealant manufacturer. The kettle shall arrive on the project empty.

Heating of the sealant to the placement temperature and maintaining the material at placement temperature shall not exceed the time interval recommended by the manufacturer. The Contractor shall empty the kettle before heating more material. New material shall not be added to a partially-filled kettle and cooled material shall not be reheated.

Prior to pouring the sealant into the joint, a heat-resistant backer rod shall be placed in the bottom of the joint. The rod shall be 1/8 inch greater in diameter than the joint width to ensure a leak-proof seal and to maintain the proper depth of sealant. The rod shall be specifically manufactured for use with hot poured sealants.

The hot sealant shall be poured into the joint in a single layer, except that multiple layers will be permitted if lateral flow is a problem. The joint shall be slightly overfilled, and the excess sealant shall be leveled with a U- or V-shaped squeegee to provide a thin layer of sealant spread over the blast-cleaned horizontal pavement surfaces adjacent to the joint.

524.07 JOINT PROTECTION. The completed joint shall be protected against damage from traffic during the curing time.

Polyurethane joint sealer shall be covered with an impervious material to prevent contact with the linseed oil-mineral spirits mixtures, paints, or other materials containing mineral spirits and similar solvents.

524.08 METHOD OF MEASUREMENT. The quantity of Joint Sealer of the kind specified to be measured for payment will be the number of linear feet used in the complete and accepted work.

524.09 BASIS OF PAYMENT. The accepted quantity of Joint Sealer of the kind specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, handling, placing, and installing the specified materials, including any required backer rod or bond breaker. Payment will also be full compensation for preparing the joint, including saw-cutting where required, cleaning the joint prior to installing the sealer and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
524.1100	Joint Sealer, Hot Poured	Linear Foot
524.1300	Joint Sealer, Cold Poured	Linear Foot
524.2100	Joint Sealer, Polyurethane	Linear Foot

SECTION 525 – BRIDGE RAILINGS

525.01 DESCRIPTION. This work shall consist of furnishing and erecting bridge railing and performing repairs to existing bridge railing.

525.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Mortar, Type IV .....707.01(e)
Grease Rustproofing Compound.....708.04
Structural Steel.....714.02
Anchor Bolts for Bridge Railing.....714.07
Galvanizing.....726.06
Metalizing 726.07
Bearing Pads 731.01
Metal Hand Railing.....732.01
Aluminum Bridge Railing.....732.02
Galvanized Box Beam Bridge Railing.....732.03
Steel Beam Bridge Railing.....732.04

Concrete shall meet the requirements of Section 501 for Performance-Based Concrete, Class PCD unless otherwise specified in the Contract. For any class of concrete that is not included in Section 501, a shrinkage-compensating admixture shall be added during the initial concrete mixing phase or as recommended by the chemical manufacturer's product representative. The Contractor shall provide a written recommendation from the chemical manufacturer's product representative for the appropriate shrinkage-compensating dosage.

Reinforcing steel shall meet the requirements of Section 507.

525.03 FABRICATION DRAWINGS. The fabricator of steel components furnished under this section shall submit detailed fabrication drawings in accordance with the requirements of Subsection 105.06 and Section 506.

The Contractor shall submit a bending schedule for concrete bridge railing reinforcement in accordance with the requirements of Subsection 105.06.

These requirements do not apply to work performed under Subsection 525.06(c) or Subsection 525.06(d).

525.04 FABRICATION.

(a) Steel Components. Material furnished under this section shall conform to the applicable provisions of Section 506.

Unless otherwise specified, all ferrous metal railing components shall be galvanized.

(b) Concrete Forms. Forms shall conform to the railing design shown in the Plans and forming requirements of Section 501. Forms shall be constructed to allow for checking and correcting the railing alignment and grade after the concrete has been placed and prior to initial set. The forms shall be reinforced in such a manner that finishing of the railing tops will not disturb the final adjusted alignment.

525.05 CONSTRUCTION TOLERANCES. Tolerances for railing components shall meet the requirements of the *AASHTO LRFD Bridge Construction Specifications*.

525.06 INSTALLATION.

(a) General Requirements. Railings shall be installed in conformance with the applicable provisions of Section 501, Section 506, Section 507, and these specifications. Alignment, grade, and clearances at joints shall be adjusted to the satisfaction of the Engineer.

Posts shall be adjusted and aligned to the satisfaction of the Engineer prior to placing any mortar.

Unless otherwise specified, removed railing shall become the property of the Contractor and shall be removed from the project.

Sleeves for hand railing shall be secured and accurately aligned prior to placement of any concrete.

Galvanized surfaces that have been scratched or have received minor abrasions shall be repaired in accordance with Subsection 726.06 or as directed by the Engineer.

Concrete railing shall receive an aesthetic finish in accordance with Subsection 501.14(a)(2). Cracks in concrete railing shall be repaired by a method approved by the Engineer. Cracks in concrete greater than 0.01 inch may be cause for rejection.

(b) Delineation. Delineation devices shall be of the design shown on the Plans and shall be securely fastened to the bridge railing posts as shown on the Plans or as directed by the Engineer.

(c) Bridge Railing Repair, HDSB. HDSB bridge railing repair of the type specified shall be performed at the locations indicated in the Plans and as directed by the Engineer.

(1) Bridge Railing Repair, HDSB, Type I. Type I HDSB bridge railing repair shall consist of installing new heavy duty steel beam panels and offset blocks on existing fascia-mounted or curb-mounted posts spaced at 6.25 feet or less.

(2) Bridge Railing Repair, HDSB, Type II. Type II HDSB bridge railing repair shall consist of installing new nested heavy duty steel beam panels and offset blocks on existing fascia-mounted or curb-mounted posts spaced greater than 6.25 feet.

(3) Bridge Railing Repair, HDSB, Type III. Type III HDSB bridge railing repair shall consist of installing new heavy duty steel beam panels and offset blocks on new fascia-mounted or curb-mounted posts using existing anchor bolts.

(d) Bridge Railing Repair, Box Beam. Box beam bridge railing repair of the type specified shall be performed at the locations indicated in the Plans and as directed by the Engineer.

(1) Bridge Railing Repair, Box Beam, Type I. Type I box beam bridge railing repair shall consist of installing new bridge railing beams and offset blocks on existing posts.

(2) Bridge Railing Repair, Box Beam, Type II. Type II box beam bridge railing repair shall consist of installing new bridge railing beams, offset blocks, and bridge railing posts, using existing anchor bolts.

(3) Bridge Railing Repair, Box Beam, Type III. Type III box beam bridge railing repair shall consist of installing new bridge railing beams, offset blocks, bridge railing posts, and new anchor bolts.

(e) Remove And Reset Bridge Railing. Existing railing components and hardware shall be re-used, as determined by the Engineer. Any missing or damaged railing components or hardware shall be replaced in-kind in accordance with the Plans.

525.07 METHOD OF MEASUREMENT. The quantity of Removal of Existing Bridge Railing and Reset Existing Bridge Railing to be measured for payment will be the number of linear feet of existing railing dismantled and disposed of, or repaired and reset, between the limits specified or as ordered by the Engineer.

The quantity of Bridge Railing of the type specified to be measured for payment will be the number of linear feet of the type of bridge railing used in the complete and accepted work. Measurement will be made along the face of the rail from end to end or between the pay limits specified. No deductions or additions will be made for joints.

The quantity of Bridge Railing Repair of the type specified to be measured for payment will be the number of feet of railing repaired in the complete and accepted work, measured within the limits shown on the Plans or as directed by the Engineer. No additional measurement will be made for nested beam panels.

525.08 BASIS OF PAYMENT. The accepted quantity of Removal of Existing Bridge Railing and Reset Existing Bridge Railing will be paid for at the Contract unit price bid per linear foot. Payment will be full compensation for dismantling and disposing of, or for repairing and resetting, existing railing and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Bridge Railing of the type specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for detailing, furnishing, handling, placing, delineating, galvanizing, applying grease rustproof compound, and painting or powder coating the railing components, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Bridge Railing Repair of the type specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for detailing, treating, furnishing, handling, and placing railing components, and for bolts and hardware necessary for installing railing components. Payment will also be full compensation for all work necessary for verifying and adjusting post height or bolt spacing of existing posts, for furnishing all forms, joint filler, admixtures, trial batches, and connection plates for approach railing terminal connectors, for satisfactory completion of any necessary repairs, surface finishing, and curing and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
525.1000	Removal of Existing Bridge Railing	Linear Foot
525.1100	Reset Existing Bridge Railing	Linear Foot
525.1210	Bridge Railing Repair, HDSB, Type I	Linear Foot
525.1220	Bridge Railing Repair, HDSB, Type II	Linear Foot
525.1230	Bridge Railing Repair, HDSB, Type III	Linear Foot
525.1310	Bridge Railing Repair, Box Beam, Type I	Linear Foot
525.1320	Bridge Railing Repair, Box Beam, Type II	Linear Foot
525.1330	Bridge Railing Repair, Box Beam, Type III	Linear Foot
525.3000	Bridge Railing, Fascia Mounted	Linear Foot
525.3120	Bridge Railing, Galvanized 2 Rail Box Beam	Linear Foot
525.3130	Bridge Railing, Galvanized 3 Rail Box Beam	Linear Foot
525.3140	Bridge Railing, Galvanized 4 Rail Box Beam	Linear Foot
525.3230	Bridge Railing, Galvanized 3 Rail Box Beam, Curbless	Linear Foot
525.4030	Bridge Railing, Aluminum 3 Rail	Linear Foot
525.4130	Bridge Railing, Aluminum 3 Rail, Pedestrian	Linear Foot
525.4400	Bridge Railing, Galvanized HDSB/Fascia Mounted/Steel Tubing	Linear Foot
525.5000	Bridge Railing, Galvanized Steel Tubing/Concrete Combination	Linear Foot
525.5100	Bridge Railing, Galv. Steel Hand Rail/Conc. Parapet Comb.	Linear Foot
525.5200	Bridge Railing, Texas Rail with Windows	Linear Foot
525.5210	Bridge Railing, Texas Rail without Windows	Linear Foot
525.5300	Bridge Railing, Concrete F-Shape	Linear Foot
525.5400	Bridge Railing, Concrete Single Slope	Linear Foot
525.5500	Bridge Railing, Concrete Vertical Face	Linear Foot
525.6100	Bridge Railing, Metal Truss Bridge	Linear Foot
525.6200	Bridge Railing, Covered Bridge	Linear Foot

SECTION 527 – MAINTENANCE OF STRUCTURES AND APPROACHES

527.01 DESCRIPTION. This work shall consist of the maintenance of existing structures and approaches within the project limits.

527.02 ROAD MAINTENANCE. The Contractor shall maintain all highway sections within the confines of the work under the Contract to the satisfaction of the Engineer. When traffic is to be maintained over the present highway, the full width of the roadway shall be maintained.

The maintenance shall be done by means of an approved road grader or other approved equipment of a type that will be efficient in keeping the roadway in a reasonably smooth and passable condition for traffic and shall be subject to the approval of the Engineer. The material for and the necessary filling of holes and similar depressions that develop in the roadway shall be included in the Contract price for this item.

If, in the opinion of the Engineer, the Contractor fails to maintain a reasonably smooth roadway surface, and fails to fix the same after written notification, the Engineer will make the necessary provisions to maintain the roadway surface, and the cost shall be deducted from any money due or to become due under the Contract.

527.03 BRIDGE MAINTENANCE. When traffic is maintained over an existing structure, the Contractor shall keep all parts of the structure safe for the legal or posted load of the structure including satisfactory maintenance of the substructure, superstructure, and the bridge surface. The Contractor shall strengthen, patch, shore, or renew any part or parts of this substructure or superstructure when necessary for the safety of the traveling public.

If the existing structure over which traffic is being maintained becomes unsafe for public travel, and if, following written order by the Engineer, the Contractor fails to make satisfactory repairs, the Engineer will make the necessary provisions to repair the structure, and the cost will be deducted from any monies due under the Contract.

527.04 METHOD OF MEASUREMENT. The quantity of Maintenance of Structures and Approaches to be measured for payment will be on a lump sum basis.

527.05 BASIS OF PAYMENT. The accepted quantity of Maintenance of Structures and Approaches will be paid for at the Contract lump sum price. Payment will be full compensation for performing the work specified and for furnishing all labor, materials, tools, equipment, and incidentals necessary to properly maintain substructures, superstructures, and roadway approaches.

Payment for this work will be made periodically as follows:

(a) 50% of the Contract lump sum price will be paid after all required repairs to the bridges or approaches have been made to the satisfaction of the Engineer and traffic is being maintained over the existing bridges and approaches.

(b) The remaining 50% of the Contract lump sum price will be paid when traffic is permanently moved to the new or rehabilitated bridges and approaches.

Payment will be made under:

Pay Item	Pay Unit
527.1000 Maintenance of Structures and Approaches	Lump Sum

SECTION 528 – TEMPORARY BRIDGE

528.01 DESCRIPTION. This work shall consist of the design, construction, maintenance, and removal of a temporary bridge, its substructures, and approaches.

528.02 MATERIALS. The Contractor may use any material or combination of materials that will conform to the requirements of this subsection and meet the approval of the Engineer. The Engineer reserves the right to reject materials and details that are structurally unsafe for the use proposed.

Unless specifically permitted in the Contract or upon written authorization of the Construction Engineer, the use of pipes will not be allowed for temporary bridges.

Unless otherwise authorized on the approved drawings, all main load carrying members shall be continuous between supports. Splices will only be approved for the following conditions:

(a) Fully-Bolted Connections. Fully bolted connections, with high-strength bolts, shall be designed for their location in accordance with the *AASHTO LRFD Bridge Design Specifications*.

(b) Fully-Welded Connections. Fully welded connections shall be designed, welded, inspected, and tested in accordance with the requirements of *AASHTO LRFD Bridge Design Specifications* and AWS requirements. Any welded connection performed in the absence of and without the approval of the Agency's welding inspector will not be approved.

Any welding done for work under this section shall be detailed on the working drawings and performed in conformance with Section 506.

528.03 WORKING DRAWINGS. Working drawings shall be prepared by the Contractor for the proposed work under this item in accordance with the requirements of Subsection 105.06.

(a) Calculations. The Contractor shall provide calculations for the horizontal and vertical alignments and all structural components of the temporary bridge. When a temporary bridge is expected to be open to traffic for longer than 24 months, the calculations shall include a load rating for the design vehicle as well as the other Vermont Standard Load Rating Trucks defined in the *VTrans Structures Design Manual*.

(b) Drawings. Drawings for bridge approaches shall include plans, profiles, typical sections, and specific cross-sections for the temporary roadway and channel, when applicable, with complete details and identification of materials to be used.

Drawings for the temporary bridge structure shall include plan, elevation, and section views of the structure and shall include size and spacing of all members or components for the following:

(1) Abutments

(2) Piers

(3) Main supporting members or stringers

(4) Floor system

(5) Diaphragms and lateral bracing

(6) Bridge railing and approach railing, including the connection details between the two

(7) Curbs

(8) Bearings

(9) Other applicable information

528.04 DESIGN REQUIREMENTS AND CONSTRUCTION DETAILS.

(a) Channel. The Contractor shall provide for the waterway and clearances shown on the Plans. When temporary bridge requirements are not shown on the Plans, the opening area shall be at least equal to 40% of the waterway provided for the 1% annual exceedance probability (AEP) for the new structure, with a minimum clear height equal to a 10% AEP headwater. This waterway shall be adequate for safely conveying 43% AEP flow at a headwater no greater than what would be created by the existing structure at 10% AEP. Questions regarding hydraulic information not furnished shall be addressed to the Engineer.

Fill placed in or adjacent to the stream shall be clean granular or rock material meeting the requirements of Subsection 703.04 or Subsection 703.05 and protected with sufficient stone to prevent erosion to a 10% AEP headwater elevation (based on the new structure). Any fill placed in the stream to protect the temporary bridge and approaches shall be removed to the satisfaction of the Engineer upon completion of the project.

(b) Roadway. The geometric design of the temporary bridge and approaches, except as otherwise shown on the Plans or as noted herein, shall be designed in accordance with *A Policy on Geometric Design of Highways and Streets*.

The roadway width shall be increased on curved portions of the approaches to account for the off tracking characteristics of a WB-62 vehicle in accordance with *A Policy on Geometric Design of Highways and Streets*.

Approach embankments shall be constructed of acceptable fill material, compacted to adequately support design loading requirements. A minimum of 15 inches of approved gravel or other acceptable surfacing material shall be provided for the full width of the typical section.

When the Plans designate paved approaches, the approaches shall be paved with a minimum 2 inch wearing course of Type IIIS or Type IVS bituminous concrete pavement with an N_{design} value of 65 gyrations and an asphalt binder grade of 58S-28. Bituminous concrete pavement shall conform to the requirements of Section 716.

The temporary pavement shall extend for the full length and width of the approaches and both the approaches and the bridge shall have temporary pavement markings applied in accordance with Section 646.

Turnouts with adequate space for two-way traffic shall be provided at each end of a one lane structure or coordinated with traffic signalization, if used.

(c) Bridge.

(1) Loading. Unless otherwise specified, all temporary bridge structures shall be designed for an HS-20 or HL-93 live load, and for all other applicable forces, in accordance with the *AASHTO Standard Specifications for Highway Bridges* or the *AASHTO LRFD Bridge Design Specifications*. Sidewalks and pedestrian structures shall be designed for a minimum live load of 60 pounds per square foot.

(2) Clearances. A one lane temporary bridge shall have a minimum clear width between the faces of railings of 14-1/2 feet. A two lane temporary bridge shall have a minimum clear width between the faces of railings of 24 feet.

Sidewalks and pedestrian bridges shall have a minimum clear width of 4 feet between the faces of railings or the edge of curb and face of railing.

A minimum vertical clearance of 14 feet shall be provided for vehicular traffic and 8 feet for pedestrian traffic.

(3) Erection. As part of the working drawings submittal, the Contractor shall, depending upon the type of structure being erected, include the information required under Section 506 or Section 510 pertaining to erection or installation. Submittal of the computations indicating the magnitude of the stresses in the segments is not required. For modular prefabricated panel bridge systems, the Contractor shall have a representative from the manufacturer of the bridge system present during the erection of the bridge components.

(d) Railing. Approach railing and temporary barrier rail shall conform to Subsection 621.07.

Details for either rail system or combination thereof shall conform to applicable AASHTO requirements. Rail sections shall be continuous from the approaches across the structure. Approach railing shall be provided for a minimum of 25 feet off the ends of any structure and shall be provided for all approach fill slopes steeper than 1:3 (V:H).

The ends of all rail or barrier systems shall be terminated in accordance with the requirements of the *MUTCD*, the *Roadside Design Guide*, and applicable Agency standards and specifications.

Bridge railing and pedestrian railing shall be designed in accordance with the *AASHTO LRFD Bridge Design Specifications*. Bridge railing shall be designed for Test Level 2 criteria unless a higher test level is specified on the Plans.

When temporary barrier rail is specified or used as a movable rail system, an adequate connection shall be provided when concrete median barrier is used in combination with standard steel beam rail.

(e) Walkways and Approaches. Temporary bridges with walkways, temporary pedestrian bridges, walkways, and approaches to walkways shall be designed and constructed to provide width, grade, surface, etc. in conformance with the requirements set forth in the *Americans with Disabilities Act* standards for sidewalks.

528.05 MAINTENANCE AND LIABILITY. The Contractor shall maintain each temporary bridge and its approaches in conformance with Contract requirements and to the satisfaction of the Engineer. The Contractor shall assume all liability for the installation, maintenance, and removal of the temporary bridge and its approaches. Unless otherwise specified, all rights-of-way on private property required for the performance of this work shall be provided by the Contractor.

Costs for replacing the loss of any part of the temporary bridge or its approaches shall be included in the unit price for the temporary bridge item except as provided in Subsection 107.17.

528.06 METHOD OF MEASUREMENT. The quantity of One Lane Temporary Bridge, Two Lane Temporary Bridge, or Temporary Pedestrian Bridge to be measured for payment will be on a lump sum basis for each type specified in the complete and accepted work.

528.07 BASIS OF PAYMENT. The accepted quantity of One Lane Temporary Bridge, Two Lane Temporary Bridge, or Temporary Pedestrian Bridge will be paid for at the Contract lump sum price for each type specified. Payment will be full compensation for designing, detailing, constructing, maintaining, and removing the bridge and its approaches, including placing and removing pavement and pavement markings when paved approaches are required.

Partial payments for these items may be made as follows:

(a) The first payment of 10% of the Contract lump sum price may be made when working drawings have been submitted and approved in accordance with the requirements of Subsection 105.06.

(b) The second payment of 65% of the Contract lump sum price may be made when the temporary bridge, its substructures, and approaches have been fully constructed and accepted by the Engineer.

(c) The third payment of 15% of the Contract lump sum price may be made when the temporary bridge and its approaches have been removed.

(d) The final payment of 10% of the Contract lump sum price may be made when the site has been cleaned up and vegetation has been established to the satisfaction of the Engineer.

Unless otherwise specified as a separate Contract item, the costs of all approach and bridge railing associated with the temporary bridge will be considered incidental to the applicable temporary bridge pay item.

Payment will be made under:

Pay Item		Pay Unit
528.1000	One Lane Temporary Bridge	Lump Sum
528.1100	Two Lane Temporary Bridge	Lump Sum
528.1200	Temporary Pedestrian Bridge	Lump Sum

SECTION 529 – REMOVAL OF STRUCTURES AND BRIDGE PAVEMENT

529.01 DESCRIPTION. This work shall consist of the removal, wholly or in part, and the satisfactory disposal of all structures, including accessories and appurtenances, bridge pavements, and the backfilling of holes when required.

529.02 GENERAL REQUIREMENTS. Unless otherwise specified, all materials resulting from the removal of structures and removal of bridge pavements shall become the property of the Contractor, who shall properly dispose of them.

529.03 REMOVAL OF BRIDGE PAVEMENTS. The removal of pavement on bridges shall include the removal of bituminous concrete material, and, when a new waterproofing membrane is included in the Contract or as directed by the Engineer, the removal of sealants or membranes. When not otherwise specified, sealants or membranes shall remain in place.

If removal is by milling, work shall be done in accordance with the requirements of Section 210. Removal methods shall be subject to the approval of the Engineer and shall be such as to prevent any damage to the remaining surface.

Any necessary deck repair will be paid for as shown on the Plans, except damage caused by Contractor's negligence shall be repaired at the Contractor's expense.

529.04 REMOVAL OF STRUCTURES. The Contractor shall dismantle the structure and shall remove the dismantled members or materials. Removal of structures spanning bodies of water will be conducted so as to avoid dropping materials into the water. The entire site of the old structure shall be restored to a condition satisfactory to the Engineer.

The existing concrete or masonry shall be removed by drilling, chipping, or other methods approved by the Engineer. All cut surfaces, unless otherwise specified, shall be on a reasonably vertical or horizontal plane with sharp straight corners. Existing reinforcing steel to be retained shall be carefully preserved and cleaned for use in the new construction. Existing reinforcing steel damaged beyond reuse as determined by the Engineer shall be replaced by splicing a bar of equal diameter to the damaged bar in a manner approved by the Engineer at no additional compensation to the Contractor. Holes for expansion bolts or dowels shall be drilled in the retained concrete at the locations shown on the Plans.

When the material from the structure is to be retained by the Agency or others, or is to be reused in the construction, it shall be carefully dismantled by the Contractor and all adhering concrete removed. Materials to be retained or reused shall be stored at the location specified in the Contract or as directed by the Engineer.

When the existing superstructure steel is to be retained for future use, the Contractor shall take every precaution necessary to prevent damage to the existing steel. Damage to the existing steel caused by the Contractor's operations shall be repaired by the Contractor to the satisfaction of the Engineer at no additional cost to the Agency.

Where portions of existing structures are to be removed, the portions indicated shall be removed to the lines shown on the Plans, or as directed by the Engineer, in such a manner as to leave the remainder of the structure undamaged and in proper condition for the intended use. Any damage to the portions remaining in service shall be satisfactorily repaired by the Contractor at no additional cost to the Agency. Explosives will not be permitted for partial removal of any structure.

Removed parts of the existing structure that are to be reused in the new construction shall be safeguarded, cleaned, or otherwise prepared as shown on the Plans or in the Contract and incorporated into the work as shown on the Plans or as directed by the Engineer.

529.05 METHOD OF MEASUREMENT. The quantity of Removal of Bridge Pavement to be measured for payment will be the number of square yards of bridge deck from which bituminous pavements, sealants, and membranes have been removed as shown on the Plans or ordered by the Engineer.

The quantity of other items to be measured for payment will be as follows:

(a) Removal of Structure will be on a unit basis for each removal at the locations shown on the Plans.

(b) Partial Removal of Structure will be on a unit basis for removal of the materials between the limits shown on the Plans.

(c) Removal of Concrete or Masonry will be the number of cubic yards or square yards of concrete or masonry measured in place and removed between the limits shown on the Plans or as ordered by the Engineer.

529.06 BASIS OF PAYMENT. The accepted quantity of Removal of Bridge Pavement will be paid for at the Contract unit price per square yard. The accepted quantity of Removal of Structure and of Partial Removal of Structure will be paid for at the Contract unit price per each. The accepted quantity of Removal of Concrete or Masonry will be paid for at the Contract unit price per cubic yard or square yard.

Payment will be full compensation for the removal and disposal of the specified items; for removal, salvage, and stockpiling of components and materials specified in the Contract; for excavating, backfilling, regrading, and performing site restoration incidental to the removal of specified items; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Removal of Bridge Pavement, when not included as a separate pay item, will not be paid for directly, but will be considered incidental to either Removal of Structure or Partial Removal of Structure as specified in the Plans.

Payment will be made under:

Pay Item		Pay Unit
529.1000	Removal of Bridge Pavement	Square Yard
529.1500	Removal of Structure	Each
529.2000	Partial Removal of Structure	Each
529.2500	Removal of Concrete or Masonry	Cubic Yard
529.2600	Removal of Concrete or Masonry	Square Yard

SECTION 531 – BRIDGE BEARING DEVICES

531.01 DESCRIPTION. This work shall consist of furnishing and installing bridge bearing devices.

531.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Unless otherwise specified, all materials shall conform to the *AASHTO LRFD Bridge Design Specifications, Section 14*; *VTrans Structures Design Manual, Section 14*; *AASHTO LRFD Bridge Construction Specifications, Section 18*; and all AASHTO or ASTM specifications referenced in this section. Substitutions will not be allowed unless approved on the fabrication drawings.

531.03 DESIGN AND FABRICATION DRAWINGS. The fabricator of bearings furnished under this section shall submit detailed fabrication drawings, bonding procedures, welding procedure specifications, and welder qualification test records in accordance with Subsection 105.06.

Fabrication drawings shall identify the number of layers of vulcanized sheets and corresponding sheet thicknesses to be used for fabricating the bearing pad and shall include detailed procedures for bonding these sheets together.

When a bearing design is not provided in the Plans or an alternate bearing configuration is proposed by the Contractor, a complete bearing design meeting the requirements of the Plans, *AASHTO LRFD Bridge Design Specifications, Section 14*, and *VTrans Structures Design Manual, Section 14* shall be provided in accordance with Subsection 105.06.

531.04 FABRICATION.

(a) General Requirements. Material furnished under this section shall conform to all applicable provisions of Section 506.

During any welding, surfaces in contact with the elastomer shall be restricted to 200°F, and surfaces in contact with PTFE shall be restricted to 300°F. Temperatures shall be determined by temperature indicating wax pencils or other suitable means.

Bearing devices shall be fabricated, assembled, and certified by one supplier. Anchor bolt assemblies may be fabricated and supplied by an alternate supplier.

The fabricator may propose minor alterations to the design of each device from that shown on the Plans to conform to the particular method of fabrication used at that fabricator's plant. The general design intent of the Plans shall be followed with modifications approved on the fabrication drawings, including minor changes to the overall height of the bearing.

If proposed bearing height varies from that shown in the Contract by more than 1/4 inch, the Contractor shall propose a method for accommodating the difference in height, which shall be shown in the submittal.

(b) Surface Protection. All bearings shall be galvanized in accordance with Subsection 726.06 or metalized in accordance with Subsection 726.07.

(c) Tolerances. After fabrication and application of surface protection, bearing devices or components shall be within the following tolerances:

(1) Plain elastomeric pads and steel reinforced elastomeric pads shall be within the tolerances specified in *AASHTO M 251, Table 2*.

(2) High-load multi-rotational bearings, external load plates, and guides shall be within the tolerances specified in the *AASHTO LRFD Bridge Construction Specifications, Section 18*.

(d) Sliding Surfaces.

(1) Stainless Steel. Stainless steel used as a mating surface with PTFE shall conform to the following parameters:

a. The thickness of the stainless steel sheet shall be at least 14 gauge when the maximum dimension of the surface is less than or equal to 12 inches, and at least 11 gauge when the maximum dimension is larger than 12 inches.

b. For bonded applications, stainless steel sheets may be affixed to backup plates with a combination of high-temperature resistant epoxy and mechanical attachment by spot welding or other approved procedures. The fabricator shall demonstrate that any proposed alternate procedure for attachment will maintain adhesion between the backup material and stainless steel under loading, movement, and weather conditions anticipated to be encountered during life of the bearing.

c. For welded applications, stainless steel sheets shall be circumferentially seal welded to backup plates. Procedure qualification will be required for any welding process and welding procedures shall be submitted for approval in accordance with Subsection 506.04 and Subsection 506.10.

d. Prior to adhesion or attachment of the stainless steel to a backup plate, the contact surface of the backup plate shall meet the sliding surface tolerance specified herein and shall be blast cleaned to an appearance equivalent to *SSPC-SP 10*. The contact surface of stainless steel sheets to be bonded with epoxy shall be mechanically abraded or etched prior to application of adhesive.

(e) High Load Multi-Rotational (Disc). High load multi-rotational bearings shall be tested in accordance with the requirements of *AASHTO LRFD Bridge Design Specifications* and the *AASHTO LRFD Bridge Construction Specifications, Section 18*, modified as follows:

(1) For each structure or pair of structures on a project, one of every ten fixed bearings and one of every ten expansion bearings shall be selected at random from the production lot. Sample or specially-made test bearings will not be permitted.

(2) Load measuring instruments used in conjunction with the testing equipment should be calibrated yearly and be accompanied by a certificate indicating their date of calibration.

(3) The measured static coefficient of friction shall be less than 4%.

(4) The measured dynamic coefficient of friction shall be less than 4%.

(5) The basis for acceptance shall be the following:

a. The coefficients of friction are less than 4%.

b. Acceptable material certifications.

c. Assembled bearings meet requirements and tolerances specified in the Contract.

d. Inspection of tested bearings shows no visual defects, such as extruded or deformed elastomer, polyether urethane, or PTFE, damaged seals or limiting rings, evidence of metal-to-metal contact between the pot wall and the top plate, or cracked steel.

(6) Test results and material certifications shall be sent to the Agency's Materials Testing and Certification Section.

(7) Acceptable test results are a prerequisite for certification acceptance. Expenses for performing any testing shall be incidental to the work.

531.05 INSTALLATION.

(a) General Requirements. Bearings shall be set level and parallel with full and uniform bearing. Pedestals detailed to be on a slope shall be set at the elevation and position specified.

The concrete under the bearing device shall be level.

Anchor bolts shall be positioned to the alignment and dimensions specified or approved in the fabrication drawings. When preset or cast-in anchorages are not specified, the Contractor shall drill holes and set the anchor bolts in a Type IV mortar. Additional aggregates shall not be added to the material during field mixing.

Prior to ordering materials and starting the work, the Contractor shall submit a drilling and mortaring proposal to the Engineer for approval, including a premixed mortar material brand name.

The drilled holes to be mortared shall be thoroughly cleaned, wetted, and free of standing water.

The mortar shall be mixed in a mechanical mixer in accordance with the manufacturer's recommendations and shall be readily pourable so that when poured it completely fills the remaining hole cavities. The placement of mortar for each bearing shall be continuous and complete at all hole locations.

All exposed mortar shall be cured for a period of not less than three days by the wetted burlap method in accordance with Section 501. Curing shall commence as soon as practical after mortar placement. The Contractor shall not apply any forces to the anchor bolts during the curing period.

If allowed in the Contract or ordered by the Engineer, a pre-approved adhesive may be used to set the anchor bolts into the concrete. If an adhesive is used, the manufacturer's installation requirements for the adhesive shall be followed during installation. The Engineer shall be provided with a copy of the safety data sheet (SDS) and a copy of the manufacturer's installation requirements.

Unless otherwise specified on the Plans, anchor bolts shall have a minimum embedment of 18 inches into the concrete and shall conform to Subsection 714.08.

Anchor bolts to be double nutted shall use the following procedure:

(1) Install lower nut in contact with top of sole plate, and then back off 1/2 turn

(2) Install upper nut snug tight to prevent lower nuts from loosening

Whenever a bridge seat is off by 1/4 inch or more from its designed or adjusted elevation, corrective measures shall be required.

If shims are required, they shall be a single thickness plate that meets the requirements of *AASHTO M 270,* Grade 250 (Grade 36) or Grade 345 (Grade 50), steel, galvanized in accordance with the requirements of Subsection 726.06 or metalized in accordance with the requirements of Subsection 726.07. Details of shims shall be furnished and approved in accordance with the requirements of Subsection 105.06.

The cost of any necessary corrective measures, including any costs due to a delay, shall be borne by the Contractor.

(b) Elastomeric Pad with External Load Plate and High-Load Multi-Rotational Bearings. During any welding, surfaces in contact with the elastomer shall be restricted to 200°F, and surfaces in contact with PTFE shall be restricted to 300°F. Temperatures shall be determined by temperature indicating wax pencils or other suitable means.

The welds for the sole plate connection should only be along the longitudinal girder axis. Transverse joints should be sealed with an acceptable caulking material.

Metal bearing plates shall be placed on a 1/8 inch thick bearing pad conforming to the requirements of Subsection 731.01. The bearing pad shall be the same size as the bearing plate with holes to accommodate the anchor bolts.

PTFE and stainless steel sliding surfaces shall be protected from splatter during welding, grouting, or painting operations if applicable.

High-load multi-rotational bearings shall not be disassembled once they have left the manufacturer, since the process could result in damage to the components or malfunction of the device.

531.06 METHOD OF MEASUREMENT. The quantity of Bearing Device Assembly of the type specified to be measured for payment will be the number of units used in the complete and accepted work.

All bearing device components and anchor bolt assemblies will be included as part of the measured unit. Anchor bolt assemblies include bolts, threaded rods, nuts, washers, and beveled plates required for attachment of bearing devices to the superstructure and substructure.

The quantity of Remove and Replace Existing Anchor Bolt to be measured for payment will be the number of each anchor bolt removed and replaced in the complete and accepted work.

531.07 BASIS OF PAYMENT. The accepted quantity of Bearing Device Assembly of the type specified will be paid for at the Contract unit price for each. Payment will be full compensation for detailing, furnishing, handling, transporting, and placing the material specified, including surface preparation, protective coating, testing, anchor bolt assemblies, drilling for anchor bolts, mortar, proprietary anchoring systems, bearing device components, and welding, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment for alternate bearing designs and submittals will be considered incidental to the appropriate Section 531 pay item in the Contract.

The accepted quantity of Remove and Replace Existing Anchor Bolt will be paid for at the Contract unit price for each. Payment will be full compensation for removing the existing anchor bolt, removing and replacing the existing bearing assembly, welding, drilling the for new anchor bolt, mortar, proprietary anchoring systems, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
531.1500	Bearing Device Assembly, High Load Multi-Rotational	Each
531.1600	Bearing Device Assembly, Plain Elastomeric Pad	Each
531.1700	Bearing Device Assembly, Steel Reinforced Elastomeric Pad	Each
531.1800	Bearing Device Assembly, Elastomeric Pad w/Ext. Load Plates	Each
531.1900	Remove and Replace Existing Anchor Bolt	Each

SECTION 540 – PRECAST CONCRETE

540.01 DESCRIPTION. This work shall consist of manufacturing, transporting, and erecting precast concrete structure components.

540.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Blanket Insulation Material.....735.02
Pipe Insulation 740.06
Water.....745.01
Concrete Repair Material, Type I .....780.01(a)
Concrete Repair Material, Type II .....780.01(b)

Bearing pads for structures shall meet the requirements of Section 731.

540.03 GENERAL FABRICATION REQUIREMENTS.

(a) General Requirements. The manufacture of the precast units shall be in accordance with *PCI MNL-116* and *PCI MNL-135*, except as modified in this section, or with the *NPCA Quality Control Manual for Precast Plants.*

(b) Qualification. Precast concrete shall be manufactured in a plant that has been certified by either PCI under its plant certification program for precast concrete or by the NPCA plant certification program.

Precast concrete shall be manufactured in a plant that maintains a quality control laboratory that meets the requirements of the Agency's *Qualified Laboratory Program*. As a minimum, the laboratory shall be equipped with a compression testing machine, curing room or chamber, apparatuses for measuring slump/flow and air entrainment, and a complete set of aggregate sieves.

The compression testing machine shall be calibrated yearly by an independent laboratory using equipment that is certified by the National Institute of Standards and Technology. The testing machine shall be power operated and capable of applying the load continuously rather than intermittently, and without shock.

(c) Quality Control. The fabricator shall demonstrate a level of quality control testing that satisfies the Agency as to its ability and commitment to produce precast concrete to the requirements of this section. A satisfactory program of quality control shall include gradation and moisture determinations of the aggregates, as well as slump, air content, and strength determinations of the concrete.

These tests shall be performed at regular and suitable intervals as specified in the *Materials Sampling Manual* and actively used to maintain the quality of the concrete within the specified requirements. The fabricator shall have a plant specific quality control plan approved by the Agency prior to the beginning of any fabrication activities.

540.04 SUBMITTALS. As soon as practical after award of the Contract, all required information shall be prepared and submitted.

A complete copy of the structural design calculations for the precast concrete shall be submitted as construction drawings in accordance with the requirements of Subsection 105.06. The design calculations shall substantiate that the proposed precast concrete satisfies the design parameters of the Contract.

The design calculations shall include a load rating for superstructures with a span length greater than or equal to twenty feet, measured along the roadway centerline. For all other superstructures, the design vehicle shall be clearly noted in the calculations. Where applicable, superstructures shall be load rated for all the vehicle configurations noted in the load rating section of the *VTrans Structures Design Manual*. The design calculations shall also include any general or construction notes required for the fabrication and construction of the precast concrete. The applicable design code will be the *AASHTO LRFD Bridge Design Specifications* unless otherwise indicated in the Contract.

Fabrication drawings, also referred to in the precast industry as production drawings or shop drawings, for the precast concrete shall be submitted in accordance with the requirements of Subsection 105.06, with an additional copy provided to the Structural Concrete Engineer. Fabrication drawings shall include such detail as needed to fully describe the intended as-built condition of the precast elements including any connections between precast elements or existing structures and materials.

In addition to the requirements for fabrication drawings in Subsection 105.06, the following shall be included:

(a) Concrete Mix Design. The concrete mix design shall include, but not be limited to, the following components:

(1) Batch weights specifying dry or saturated surface dry.

(2) Material names and sources.

(3) Aggregate properties and date tested. Aggregates shall be tested on an annual basis, at a minimum for absorption and specific gravity per the requirements of *AASHTO T 84* and *AASHTO T 85* and unit weight per the requirements of *AASHTO T 19*.

(4) Chemical and physical properties of cementitious material.

(5) Admixture names and sources.

(6) Lab data that shall include, but not be limited to, the following items:

a. The maximum water/cementitious materials (W/CM) ratio that will be allowed during production, including water contributed to hydration by all admixtures when the cumulative total exceeds 1 gallon per cubic yard.

All mix qualification test results shall be generated with concrete from batches that are produced at this maximum W/CM ratio.

b. Slump/spread minimum and maximum, determined from trial batches. The concrete shall be classified and tested as self-consolidating concrete (SCC) if the minimum spread is at least 18 inches. When the concrete is tested as a SCC mix, the difference between the J-ring test (*ASTM C1621*), and the spread test (*ASTM C1611*), shall be two inches or less for the minimum and maximum spread.

Concrete that fails to meet the 18 inches minimum spread threshold will be classified and tested as conventional concrete. The visual stability index (VSI) determination will be included for the minimum and maximum values and shall not be greater than 1. The concrete shall not demonstrate segregation at the minimum or maximum slump/spread.

c. Air content as tested in accordance with the requirements of *AASTHO T 152*.

d. Temperature as tested in accordance with *ASTM C1064.*

e. Cylinder compression results obtained in accordance with the requirements of *AASHTO T 22* for early breaks, design strength, and the 28-day standard cure as defined in *AASHTO R 100*. The type of cure shall be listed for each age of break.

f. The surface resistivity of the test mix shall be measured at 56 days based on the requirements of *AASHTO T 358*. Results shall be categorized as Low, Very Low, or Negligible in accordance with AASHTO T 358, Table 1. The surface resistivity may be accepted prior to 56 days if the results meet these requirements. The 56 day test results shall be completed and submitted regardless of the results of earlier tests.

Testing shall be performed by an independent AASHTO re:source qualified laboratory.

Test results that are suspected to have been adversely affected due to the presence of polymeric admixtures in the proposed mix may be retested with the polymeric admixture omitted.

g. The alkali-silica reactivity (ASR) of each type of aggregate shall be measured separately based on the requirements of *AASHTO T 303*. If one or more of the aggregates exceeds 0.10% expansion, then the aggregate shall be tested again according to the requirements of *ASTM C1567*.

The Contractor may elect to go directly to *ASTM C1567* testing if they suspect that the aggregate may exceed the 0.10% expansion if tested by *AASHTO T 303*. Testing shall be performed by an independent AASHTO re:source qualified laboratory accredited in the specific test method.

h. Length change test data that meets the requirements of *AASHTO T 160* shall be performed by an independent AASHTO re:source qualified laboratory accredited in testing in accordance with the requirements of *AASHTO T 160*. The maximum free shrinkage test result shall not exceed 0.06%. The cross-section of the prism shall be 4 inches × 4 inches. The requirements of *AASHTO T 160, Section 11.1.2* shall be followed for storage and measurements.

(7) Mix design approvals will be valid for a 12-month period. The approved mix design will be allowed re-approval if the following conditions are satisfied:

a. No material proportioning or material sources have changed from the initial approved mix design.

b. The mix design for re-approval is submitted with updated aggregate properties and volumes adjusted accordingly. The properties to be tested shall include, but not be limited to, specific gravity, unit weight, and absorption.

Aggregate property values will be valid for 14 months from the date tested.

c. The mix design shall be accompanied by the previously completed and accepted test mix data and any applicable updated test information.

New mix designs and mix designs that were approved more than 36 months ago shall have new testing completed to be submitted for approval.

The proposed concrete mix design, including performance history and all requests for variance from the material requirements of these specifications, shall be submitted for approval. The Structural Concrete Engineer may require a minimum of 8 weeks for testing, review, and approval of new mix designs.

(b) Dimensions and Tolerances. The dimensions and tolerances of the sections to be fabricated.

(c) Steel Locations. The location of reinforcing steel, welded wire fabric, mechanical bar connectors, and inserts.

(d) Surface Finish. The type of surface finish and how the finish will be obtained.

(e) Curing Method. The curing method, detailing the sequence and duration in accordance with the requirements of Subsection 540.08.

(f) Minimum Required Strength. The minimum required concrete strength for form removal.

(g) Lifting Attachments. The design of the lifting attachments, including the minimum required concrete strength to allow lifting, with calculations stamped by a professional engineer.

Lifting attachments are not required to be permanently installed in the work and may be removed or left in place at the Contractor's convenience, provided that the minimum clear cover is met.

(h) Logistics. A description of the transportation, handling, and storage details.

(i) Installation and Grouting. A description of the installation and grouting procedures.

(j) Quality Control. A description of the quality control procedures.

All design details shall be in accordance with the *VTrans Structures Design Manual* and the *AASHTO LRFD Bridge Design Specifications*. A professional engineer shall stamp any design calculations included in the submittals.

540.05 CONCRETE.

(a) Batch Plants. Batch plant equipment, materials, and batching procedures shall conform to the subsections of Section 501 listed in Table 540.05A.

TABLE 540.05A – BATCH PLANT OPERATION SUBSECTIONS AND TOPICS

Subsection	Topic
Subsection 501.04(a)	General Requirements [1]
Subsection 501.04(d)	Testing Laboratory
Subsection 501.04(e)	Bins and Scales
Subsection 501.04(f)	Production Tolerances for Batching
Subsection 501.04(g)	Storage and Proportioning of Materials
Subsection 501.05	Mixing and Delivery [2]

[1] Paragraphs 1 and 3 only.

[2] For plants not located in Vermont, the Agency has the option of waiving the requirements of Subsection 501.05(a)(6) in their entirety and Subsection 501.05(c), paragraph 1 only.

(b) Acceptance Testing. For acceptance testing, refer to the *Materials Sampling Manual* for sampling, curing, and testing requirements. Specimens shall be tested either at the Agency's Materials Testing and Certification Section Central Laboratory, or at the fabricator's plant laboratory. An Agency representative shall witness all tests.

Concrete for precast concrete shall conform to the following requirements:

(1) Compressive strength test results obtained at or before 28 days shall not be less than the design compressive strength shown on the Plans. When a 28-day test result is below the specified design strength, all concrete represented by that test shall be unacceptable for the requirements of this section. The Engineer reserves the right to reject all members that were manufactured from this concrete.

(2) The maximum total water batched shall not exceed 280 pounds per cubic yard, including water contributed to cement hydration by all admixtures when the cumulative total exceeds 1 gallon per cubic yard. If total cementitious material content exceeds 900 pounds per cubic yard, then water batched shall not exceed 300 pounds per cubic yard. The maximum W/CM ratio in production shall not exceed the maximum W/CM ratio determined in Subsection 540.04(a)(6)a.

(3) The air entrainment value shall be 7% (± 2%) when tested in accordance with *AASHTO T 152*.

(4) The temperature of the concrete at the time of placement shall be between 50°F and 85°F, as tested in accordance with the requirements of *AASHTO T 309*.

(5) The concrete shall not demonstrate segregation at any time. If the mix fails to remain within the minimum/maximum slump or spread submitted in the mix design, the load may be rejected. The visual stability index (VSI) shall be less than or equal to 1.

(6) The Agency may request that the producer fabricate three concrete test cylinders that will be cured with the piece they represent through the complete curing period. These cylinders shall meet the testing requirements of *AASHTO T 277* and *AASHTO T 358* and shall be kept with the piece they represent until collected by the Agency.

Any admixture containing calcium chloride shall not be used. Only the cementitious combinations and sources from the approved mix design shall be used in the precast units required for any one structure, unless otherwise authorized by the Structural Concrete Engineer.

540.06 INSPECTION. Materials furnished and the work performed under Section 540 shall be inspected by the Agency. The inspector shall have the authority to reject any material or work that does not meet the requirements of these specifications. Any work performed that has not been inspected may be rejected, unless waived in writing by the Engineer.

The inspector shall be provided with a minimum office space of 100 square feet with a least dimension of 6 feet. A desk surface with a minimum of two drawers, as well as dedicated private telephone and internet services, shall be provided to the laboratory. The phone and internet service shall be provided in accordance with Subsection 631.02(a)(4), except that selection of the service by the Engineer is not required. Any variances shall be approved by the Structural Concrete Engineer. This office space shall be located on the premises as close to the production area as practicable.

The Engineer reserves the right to reject inadequate office facilities and require suitable alternatives.

540.07 FABRICATION.

(a) Pre-Production Meeting. A pre-production meeting shall be requested by the producer a minimum of 14 calendar days prior to beginning concrete placement, unless the Engineer deems, in writing, that a pre-production meeting is unnecessary. The meeting shall be held a minimum of 5 calendar days prior to beginning concrete placement unless otherwise approved by the Structural Concrete Engineer.

At a minimum, the pre-production meeting shall be attended by the crew supervisor, plant manager, inspector or inspector's supervisor, a representative from the Agency's Materials Testing and Certification Section Structural Concrete Unit, and the Project Manager or designer. Additionally, the fabricator shall have available at the pre-production meeting the approved fabrication drawings and a complete anticipated production schedule for all components included in the fabrication drawings.

(b) Forming Members. Any defects or damage due to form work, stripping, or handling may be cause for rejection. Holes or cutouts for anchoring devices, diaphragm connections, openings for connection rods, recesses for grout holes for guardrail bolts, and any other related details shown on the Plans shall be provided for in the members.

(c) Post-Tensioning Strands and Conduits. Each post-tensioning strand to be post-tensioned shall be encased in an approved conduit. Unless otherwise shown on the Plans, the ratio of cross-sectional area of the post tensioning strand to be encased to the interior cross-sectional area of the conduit shall not exceed 0.4, except when a steel bar is used as a tendon, the inside diameter of the conduit shall be at least 3/8 inch greater than the diameter of the bar. Conduit that has been crushed or has opened seams shall not be used.

The conduit shall be rigidly constructed, completely sealed, accurately placed, and securely fastened to maintain the desired profile during concreting. No conduit shall be located more than 1/4 inch from the position shown on the Plans. Bundling of conduits will not be permitted.

(d) Bar Reinforcement and Welded Wire Reinforcement. Bar reinforcement and welded wire reinforcement shall be furnished and installed in conformance with the requirements of Section 507. The chairs or spacers used to support or locate the reinforcement that bears on the faces of the forms shall be made of, or be coated with, a non-corrosive material so that no discoloration will show on the faces of the precast concrete units.

(e) Placing Concrete. Concrete shall not be deposited in the forms until the Agency representative has approved placement of the reinforcement, conduits, and anchorages. The concrete shall be vibrated internally, externally, or a combination thereof to the required consolidation. When a vibrator is used with rebar with special coatings or made of non-metallic material or a material that could be susceptible to damage, the vibrator head shall be non-metallic or rubber-coated.

SCC concrete should not be vibrated. If there is a need to vibrate SCC concrete, it shall only be vibrated for the minimum time necessary so as to avoid segregation. The vibrating shall be done with care and in such a manner to ensure that the following conditions are met:

(1) The concrete is uniformly consolidated.

(2) Displacement of or damage to reinforcement, inserts, conduits, and anchorages is avoided.

(3) Acceptable finish surfaces are produced.

(f) Dimensional Tolerances. All dimensional tolerances shall be in accordance with *PCI MNL-116* and *PCI MNL-135*, or with the *NPCA Quality Control Manual for Precast Concrete*, unless otherwise noted in the Contract or as approved by the Engineer.

(g) Defects. Units that contain defects caused by manufacture or handling may be repaired at the manufacturing site.

Minor defects are defined as the intermittent presence of holes, honeycombing, chips, or spalls, which are 6 inches or less in the longest dimension, and that do not penetrate deeper than 1 inch into the concrete. Minor defects may be repaired using an approved standard repair procedure as detailed in Subsection 540.07(g)(3). Surface voids or bug holes that are less than 5/8 inch in diameter and less than 1/4 inch deep need not be repaired. Minor defects that recur with any identifiable regularity or pattern may be required to be addressed through a non-conformance report, at the discretion of the Structural Concrete Engineer.

Major defects are anything beyond the scope of minor as described above. It is at the sole discretion of the Structural Concrete Engineer to determine into which category any defect is categorized.

(1) Cracking. Cracks less than 0.01 inch in width shall be sealed by a method approved by the Structural Concrete Engineer. Cracks equal to or greater than 0.01 inch in width may be cause for rejection based on their width, length, location, and frequency.

At the Structural Concrete Engineer's discretion, cracked members shall be repaired or replaced at the Contractor's expense. Members with crack widths of 0.05 inch and greater will be rejected.

(2) Repairs. Repairs shall be made using an overhead and vertical concrete repair material from the Agency's *Approved Products List*. Any unsound concrete shall be carefully chipped out and the perimeter saw-cut to a minimum depth of 1/4 inch or deeper if recommended by the repair material manufacturer. The prepared surface profile shall be as specified by the repair material manufacturer. If not specified, the prepared surface profile shall conform to, at a minimum, the International Concrete Repair Institute's *CSP 6 (Medium Scarification)* surface profile. The repair material shall be cured as specified by the manufacturer.

(3) Standardized Repair Procedures. Standardized repair procedures (SRPs) will document a prescribed procedure for repairing minor defects at the fabricator's facility. At a minimum the SRP shall detail the scope of defects for which that procedure is intended to be used, detailed narrative including every step of the repair procedure, and the product documentation for the specific repair materials that will be used. The SRP shall include example pictures of defects for which the procedure could be used, detailed example pictures of every step of the repair procedure, and pictures of an example completed repair.

Approval to use an SRP for any given defect is at the sole discretion of the Structural Concrete Engineer, and all SRPs shall be approved by them prior to their use. SRPs shall be submitted to the Structural Concrete Engineer at least 14 calendar days in advance of the repair work. The Agency's consent to use an SRP for the repair of a defect does not constitute acceptance of that repair.

(4) Non-Conformance Report. Any defects existing in the pieces, other than those defined as minor above, shall be documented with a non-conformance report (NCR). At a minimum, the NCR shall detail what the defect is, including adequate pictures of the piece and defect, what caused it, the proposed repair, the procedure for carrying out the proposed repair, and a plan of action to prevent additional similar defects from occurring. Any approved repairs shall be documented and photographed during the repair work and after completion of the repair.

NCRs shall be submitted within 2 working days of the discovery of the defect.

(h) Welding. All welding shall conform to the requirements of Subsection 506.10.

(i) Cold Weather Conditions. Cold weather concrete will be any concrete placed or cured in ambient conditions when the ambient air temperature is expected to be below freezing at any point in time or below 40°F for an 8-hour continuous period. The requirements of Subsection 501.07(b) shall apply in addition to the requirements of Subsection 540.08.

(j) Marking. The date of manufacture, the production lot number and the piece mark shall be clearly marked on each individual piece of precast concrete. The mark shall be in a location that will not be visible in the finished product.

(k) Form Removal. Unless otherwise specified, form removal shall be permitted only after the strength required and approved in Subsection 540.04(f) is achieved as specified in the *Materials Sampling Manual*.

540.08 CURING.

(a) General Requirements. All curing methods for precast concrete shall be subject to the Structural Concrete Engineer's approval. The fabricator shall submit with the fabrication drawings complete details of the proposed methods for approval.

The curing period for precast concrete is defined as a minimum of 72 hours of wet curing to begin immediately following completion of placing and finishing of the concrete. The following requirements shall apply:

(1) The method of curing shall prevent the loss of moisture throughout the curing period. Except where modified herein, precast concrete structure components shall be cured by either water curing, wetted burlap covered with white polyethylene sheeting, or white burlap-polyethylene sheeting (burlene) as specified in Subsection 501.15.

(2) When a curing enclosure is used, free water shall be evident and the relative humidity within the enclosure shall exceed 90% throughout the duration of the curing period. A curing enclosure is considered any means of moisture retention that allows air to contact the surface of the piece.

(3) The strength of the product shall be determined by test specimens cured with the product they represent, or by specimens match-cured in an approved match-curing system. Wet curing shall be continued until 80% of the 28-day design strength is achieved, but shall be no less than 72 hours in duration.

(b) Curing Temperatures.

(1) The controlling temperatures shall be those actually achieved within the concrete elements, not ambient temperatures of the curing area unless specifically stated as such.

(2) The precast concrete shall be raised to an internal temperature of not less than 68°F within the first 12 hours of the curing period, and shall be maintained at or above 68°F for the remainder of the curing period.

(3) The internal temperature of curing concrete shall be monitored using sacrificial thermocouples placed as near as practicable to the center of mass of the finished piece. In addition, the temperature within the curing enclosure shall be monitored using temperature sensors placed carefully within the curing enclosure in such a way that temperatures being measured accurately represent the curing conditions.

The requirement for temperature monitoring may be waived by the Structural Concrete Engineer if the concrete is not subject to accelerated curing and ambient temperatures are expected to be well above 40°F throughout the duration of production.

(c) Accelerated Curing.

(1) Accelerated curing procedures may be employed in lieu of the standard 72-hour curing procedure described in Subsection 540.08(a), in accordance with the requirements of *PCI MNL-116, Section 4.19* and the following conditions:

a. The initial time of set is defined in *AASHTO T 197* and *ASTM C403* as the time it takes fresh concrete to reach a compressive strength of 500 psi.

Testing to determine the time of set shall be done when the temperature is within ± 5°F of the anticipated concrete placement temperature.

Alternately, time of set may be found by taking a minimum of three different concrete temperatures at intervals of approximately 10°F, entering that data on a graph, and then drawing a best-fit smooth curve line through the three data points. This graph will be used to determine the time of set for the anticipated concrete placement temperature, rounded up to the nearest half hour.

(2) Immediately upon completing placement of the concrete for each precast concrete structure component, an enclosure that is suitable for containing live low-pressure steam or heat shall be placed over the forms. The fabricator shall make these enclosures available for inspection prior to casting.

(3) When low-pressure steam heating methods are used for accelerated curing, precautions shall be taken to prevent the live steam from being directed on the concrete or forms in such a way as to cause damage from localized high temperatures.

(4) When radiant heat is used for accelerated curing, all exposed concrete surfaces shall be covered with plastic sheeting. Radiant heat may be applied by means of circulation pipes containing steam, hot oil, or hot water, or by electric heating elements.

(5) While waiting for the initial set to take place, the temperature within the concrete may be increased at a maximum rate of 10°F per hour. However, the temperature within the concrete shall not be more than 40°F higher than the initial concrete placement temperature or more than 104°F, whichever is less.

Following initial set, the internal concrete temperature shall increase at a rate not exceeding 40°F per hour until the desired curing temperature is reached. The maximum internal concrete temperature shall not exceed 160°F. The maximum differential between the curing enclosure temperature and internal concrete temperature shall not exceed 40°F. The selected curing enclosure temperature range shall be as approved on the fabrication drawings.

The accelerated curing cycle shall be considered complete when the method of supplying heat is stopped or the concrete temperature drops below 120°F. Two cylinders shall be tested immediately upon completion of the accelerated cure cycle.

The maximum cooling rate from the sustained accelerated curing temperature shall be 50°F per hour. Cooling at this rate shall continue until the concrete temperature is 40°F or less above the ambient temperature outside the curing enclosure.

(6) Precast concrete that has not attained 80% of the 28-day design strength shall be additionally wet cured until this strength threshold is met. If the precast concrete has attained 80% of the 28-day strength during the accelerated curing cycle, no further curing will be required.

(d) Conditioning. Following the completion of the chosen curing method, precast elements that will then be exposed to cold weather conditions as defined in Subsection 540.07(i) shall be allowed 24 hours to cool and dry in an environment of at least 40°F prior to exposure to cold weather conditions. For pieces cast outdoors in cold weather ambient conditions, all requirements of Subsection 501.07(b) shall apply.

(e) Temperature Recording. The fabricator shall install a minimum of one automatic temperature recorder per contiguous form group and common heat source, per day. The Structural Concrete Engineer may require that additional temperature recorders be installed if it is determined that one per day of production does not adequately monitor the curing conditions.

The recorder shall record, at intervals not to exceed 15 minutes, the temperature of the air surrounding the piece as well as the internal concrete temperature. Temperature recording shall continue until completion of the chosen curing method.

Each recorder's data log shall indicate the casting bed, date of casting, time of start and finish of record, and the mark number of the precast concrete structure component being cured. At the completion of the temperature recording, the data logs shall be given to the Agency representative. Temperatures recorded on the data logs shall be used to determine whether the precast concrete structure components have been cured in accordance with the specifications and the approved fabrication drawings.

Recorder accuracy shall be certified at least once every 12 months, and the certificate displayed with the recorder. Calibration and certification shall be performed by either the manufacturer, the supplier, or an independent laboratory. Random temperature checks of each recorder may be made by an Agency representative.

540.09 HANDLING, STORAGE, AND SHIPPING. All precast concrete shall be handled, stored, and shipped in such a manner as to minimize chipping, cracks, fractures, discoloration, and excessive bending stresses. Units damaged by handling, storage, or shipping shall be replaced at the Contractor's expense.

Prior to shipment of any members, all NCRs shall be resolved. In addition, all required testing shall demonstrate the design requirements have been met.

540.10 INSTALLATION.

(a) Methods, Equipment and Erection. Cranes, lifting devices, and other equipment for precast concrete structure erection shall be of adequate design and capacity to safely erect, align, and secure all members and components in their final positions without damage. The Contractor is solely responsible for the methods and equipment employed for the erection of the precast concrete structure components.

Construction drawings for precast concrete structure component erection shall be submitted in accordance with the requirements of Subsection 105.06. The erection plan shall include the necessary computations to indicate the magnitude of stress in the units during erection and to demonstrate that all of the erection equipment has adequate capacity for the work to be performed, and provisions for all stages of construction, including temporary stoppages. When the fabricator-designed lifting hooks will be used by the Contractor, computations indicating the magnitude of stress in the segments during erection are not required, unless otherwise ordered by the Engineer.

Submittal of the erection plan is for documentation purposes only and shall in no way be construed as approval of the proposed method of erection. The Contractor shall follow the erection plan as submitted.

(b) Sheet Membrane Waterproofing. A reinforced asphalt, synthetic resin, or coal-tar based preformed sheet membrane shall be placed over the joints of precast concrete units in accordance with the Contract. All work performed shall be in accordance with the manufacturer's recommendations.

Membrane material shall meet the requirements of Subsection 726.08(c).

Waterproofing shall not be performed in wet weather or when the temperature is below 40°F, without the authorization of the Engineer.

The concrete surfaces that are to be waterproofed shall be reasonably smooth and free from projections or holes and shall be cleaned of dust and loose material. The surfaces shall be visibly dry prior to and during application of the membrane system.

540.11 GROUT.

(a) Surface Preparation. The fabricator shall ensure that surfaces to be grouted are clean, oil-free, and roughened in accordance with the Plans. The surface to be grouted shall be thoroughly wetted, yet free of all standing water. Shear keys shall be saturated surface dry prior to grouting.

(b) Grout Mixes. Grout shall be used to fill shear keys, transverse tie anchor recesses, and dowel holes, level screw voids, and for fairing joints as detailed in the Contract or as ordered by the Engineer.

Grout shall be Type IV mortar in accordance with Subsection 707.01(e)(1). Additional aggregates shall not be added to the material during field mixing. Ready mixed mortar in accordance with Subsection 707.01(e)(2) may be substituted with written permission of the Engineer. Placement of ready mixed mortar shall be complete within 90 minutes of the time of batching.

The Contractor shall submit a proposed grouting procedure to the Engineer for their review and approval. The proposed grouting procedure shall include the required equipment, workforce, manufacturer's product data sheet for prepackaged mortar or the approved mix design of the ready mixed mortar when approved, placement rate, batch size, and all necessary details to explain how the grouted element will be placed in accordance with specification and manufacturer recommendations as applicable without air voids or cold joints.

Post-tensioning may occur when a field cured sample demonstrates conformance with post-tensioning strength requirements specified in the Contract, as determined in accordance with *ASTM C109*. Three cubes shall constitute a single sample.

(c) Placing Grout. The grout shall be mixed using a mechanical mixer according to the manufacturer's recommendations and shall be readily pourable so that it completely fills the shape of the shear keys or holes, depending on the product being installed. The placement of the grout shall be continuous. The grouting of each shear key shall be completed in its entirety within a single working day.

Grout shall be placed between precast concrete structure components as required for fairing out any unevenness between adjacent components. Type IV mortar shall be used. The mortar shall be placed to the thickness necessary to eliminate unevenness, forming a smooth surface from the higher edges to the lower surface. The finished surface shall be feathered smoothly and be free of depressions or sharp edges.

(d) Curing Grout. In the absence of manufacturer curing recommendations, all exposed grout shall be cured for not less than three days by the wetted burlap method in accordance with the requirements of Section 501. Curing shall commence as soon as practical after grout placement.

540.12 POST-TENSIONING. Post-tensioning strands shall not be bonded to the concrete and shall be protected against corrosion as specified in the Contract.

Post-tensioning of strands shall not commence until a minimum compressive strength of 1,500 psi has been attained in the grout, when tested in accordance with the requirements of Subsection 540.11(b). If the design strength is met prior to completion of the required curing, the grout cure shall be maintained during the post-tensioning operation.

Strands shall be stressed in the following sequence:

(a) Before grouting, the strands shall be pulled with a maximum force of 3.0 kips.

(b) After the grout has attained the required strength, the strands shall be pulled to the final design tension. Stressing shall begin by pulling the inner-most strands first, then proceeding symmetrically towards the member's ends.

(c) The inner strands shall be rechecked to ensure the strands still have the design tension.

In the case where the Plans call for top and bottom strands, the sequence shall be followed using an initial pull of 15.0 kips, top and bottom, followed by a sequence using the final design tension.

No loading of elements shall be allowed until post-tensioning is completed.

540.13 METHOD OF MEASUREMENT. The quantity of Precast Concrete Structure of the type and size specified to be measured for payment will be on a lump sum basis in the complete and accepted work. The lump sum will include all of the precast concrete structure components for each location specified in the Contract.

The quantity of Precast Concrete Deck Panels to be measured for payment will be the number of square feet of precast concrete deck panels used in the complete and accepted work.

540.14 BASIS OF PAYMENT. The accepted quantity of Precast Concrete Structure of the type and size specified will be paid for at the Contract lump sum price. The accepted quantity of Precast Concrete Deck Panels will be paid for at the Contract unit price per square foot. Payment will be full compensation for designing, detailing, fabricating, repairing, transporting, handling, and erecting the materials specified, for furnishing and implementing the erection plan, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. The Engineer may authorize partial payments in the following manner:

(a) A maximum of 25% of the Contract bid amount may be paid when the fabrication drawings have been approved by the Agency.

(b) In accordance with Subsection 106.09, stockpile payment may be authorized when the precast elements have met the requirements of Section 540.09 for shipping.

(c) After completion and acceptance of all work under this section, 100% of the quantity will be paid.

Furnishing and placing preformed sheet membrane waterproofing, including primer, mastic, polyurethane membrane sealant, and surface preparation, will be considered incidental to Precast Concrete Structure.

Any grouting work, such as fairing out unevenness between adjacent precast concrete structure components and filling leveling screw holes, shear keys, transverse anchor recesses, and dowel holes, will be considered incidental to the work for Precast Concrete Structure.

Payment will be made under:

Pay Item		Pay Unit
540.1000	Precast Concrete Structure	Lump Sum
540.2000	Precast Concrete Deck Panels	Square Foot

SECTION 541 – STRUCTURAL CONCRETE

541.01 DESCRIPTION. This work shall consist of furnishing and placing Portland cement concrete for structures and incidental construction.

The Portland cement concrete may consist of a homogeneous mixture of Portland cement, fine aggregate, coarse aggregate, water, admixtures, and pozzolans, proportioned and mixed according to these specifications.

541.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Normal weight coarse aggregate for superstructures shall be conditioned so that the total moisture percentage shall be the absorption percentage plus, at a minimum, 0.25% free moisture for the aggregate.

541.03 CLASSIFICATION AND PROPORTIONING. Concrete shall meet the requirements specified in Table 541.03A and shall be used as shown on the Plans.

TABLE 541.03A – STRUCTURAL CONCRETE CLASSES AND PROPERTIES

Concrete Type [1]	Min. Cementitious Material (lbs/CY) [2]	Max. W/CM Ratio	Slump/Spread Range (in.) [3]	Air Content	Coarse Aggregate Gradation Table	56-Day Compressive Strength (psi) [4]
Class HPAA	705 [5]	0.40	--	7.0% ± 1.5%	Table 704.02B	4,000
Class HPA	611 [5]	0.44	--	7.0% ± 1.5%	Table 704.02C	4,000
Class HPB	564 [5]	0.49	--	7.0% ± 1.5%	Table 704.02D	3,500
Class AA	705 [6]	0.40	--	7.0% ± 1.5%	Table 704.02B	4,000
Class A	660 [6]	0.44	--	7.0% ± 1.5%	Table 704.02C	4,000
Class B	611 [6]	0.49	--	7.0% ± 1.5%	Table 704.02C, Table 704.02D	3,500
Class C	564 [6]	0.49	--	5.5% ± 1.5%	Table 704.02C, Table 704.02D	3,000
Class D	470 [6]	0.58	--	4.5% ± 1.5%	Table 704.02C, Table 704.02D	2,500
Class SCC [7]	TBD [8]	0.44	TBD [9]	7.0% ± 1.5%	--	4,000
Class LW	660 [5]	0.44	--	7.0% ± 1.5%	[Note 10]	4,000
Flowable Fill	TBD [11]	TBD [12]	TBD [13]	10% (min.)	Table 704.01A	1,500 (max.) [14]
Flowable Fill, Excavatable	TBD [11]	TBD [12]	TBD [13]	10% (min.)	Table 704.01A	125 (max.) [14]

[1] HP = High Performance

SCC = Self-Consolidating Concrete

LW = Lightweight

[2] If optimized gradation is used, the minimum cementitious material may be reduced as specified herein.

[3] The mix shall not exhibit segregation at the slump/spread used at placement. If the Engineer suspects there is segregation, the Engineer will require a slump/spread test be performed by the Contractor to visually observe the characteristics of the mix. If, in the opinion of the Engineer, the mix does exhibit segregation, the load will be rejected and subsequent loads shall be tested for a minimum of three loads or until the problem is corrected.

If the Contractor needs a concrete with a slump/spread greater than 8 inches, the Contractor shall propose to the Engineer to use an SCC mix, which shall be submitted to the Engineer for review and acceptance.

[4] The concrete may be accepted if the design compressive strength from standard cured cylinders has been obtained at 28 days. Any 56 day acceptance cylinders shall be tested regardless of the results of earlier tests.

[5] See Table 541.03B, Table 541.03C, Table 541.03D, Table 541.03E, Table 541.03F, and Table 541.03G for required cementitious materials.

[6] A minimum 20% fly ash or 25% GGBFS replacement of total cement content is required.

[7] The Contractor shall determine the surface resistivity in accordance with Subsection 541.03(b)(1).

[8] A minimum 20% fly ash or 25% GGBFS replacement of total cement content is required. Silica fume may be used as an additional replacement in conjunction with fly ash or GGBFS.

[9] The Contractor shall determine the spread limits in accordance with Subsection 541.03(b)(2). The spread shall be maintained within the determined spread limits for the placement. The mix shall not exhibit segregation. If the mix does exhibit segregation or exceeds the upper spread limit, the load shall be rejected. and subsequent loads shall be tested by the Contractor until the mix meets the allowable limits. The Engineer may perform a J-ring test at the time of placement if blocking is a concern.

[10] Gradation for Class LW concrete shall meet the requirements of Subsection 704.14.

[11] A mineral admixture shall be used to replace a portion of the cement. The Contractor shall determine the replacement rate of cement.

[12] The minimum amount of water shall be used to produce the desirable flow for the intended use without showing segregation.

[13] The slump/spread (flowability) shall be such that material can completely fill the voids or area as needed without segregation.

[14] A minimum of three cylinders per test age are required to constitute a test. If the average strength at 56 days exceeds 115% of the maximum strength, then payment for item 541.4500 or item 541.4600 will be 85% of the Contract bid price.

TABLE 541.03B – REQUIRED CEMENTITIOUS MATERIALS, OPTION 1

Concrete Class	Portland Cement or Portland-Limestone Cement (lbs/CY)	Fly Ash (lbs/CY)	Silica Fume Admixture (lbs/CY)	Total Cementitious Materials (lbs/CY)
HPAA	524	141	40	705
HPA	449	122	40	611
HPB	412	113	40	565
LW	528	132	0	660

TABLE 541.03C – REQUIRED CEMENTITIOUS MATERIALS, OPTION 2

Concrete Class	Portland Cement or Portland-Limestone Cement (lbs/CY)	GGBFS (lbs/CY)	Silica Fume Admixture (lbs/CY)	Total Cementitious Materials (lbs/CY)
HPAA	489	176	40	705
HPA	418	153	40	611
HPB	384	141	40	565
LW	495	165	0	660

TABLE 541.03D – REQUIRED CEMENTITIOUS MATERIALS, OPTION 3

Concrete Class	Portland-Pozzolan Cement (5.0% to 9.0% Silica Fume)(lbs/CY)	Fly Ash (lbs/CY)	Total Cementitious Materials (lbs/CY)
HPAA	564	141	705
HPA	489	122	611
HPB	452	113	565

TABLE 541.03E – REQUIRED CEMENTITIOUS MATERIALS, OPTION 4

Concrete Class	Portland-Pozzolan Cement (5.0% to 9.0% Silica Fume)(lbs/CY)	GGBFS (lbs/CY)	Total Cementitious Materials (lbs/CY)
HPAA	529	176	705
HPA	458	153	611
HPB	424	141	565

TABLE 541.03F – REQUIRED CEMENTITIOUS MATERIALS, OPTION 5

Concrete Class	Ternary Blended Cement (5.0% to 9.0% Silica Fume, min. 20% GGBFS)(lbs/CY)	Total Cementitious Materials (lbs/CY)
HPAA	705	705
HPA	611	611
HPB	565	565
LW	660	660

TABLE 541.03G – REQUIRED CEMENTITIOUS MATERIALS, OPTION 6

Concrete Class	Portland Blast Furnace Slag Cement (Min 25.0% GGBFS)(lbs/CY)	Silica Fume Admixture (lbs/CY)	Total Cementitious Materials (lbs/CY)
HPAA	665	40	705
HPA	571	40	611
HPB	525	40	565
LW	620	40	660

Unless otherwise specified in the Contract, Class B concrete shall be used.

The Contractor, following mix design criteria and procedures outlined by the Agency, shall submit the mix design, required data, and test results to the Structural Concrete Engineer for review and acceptance. For initial submittals, a minimum of 14 calendar days shall be allowed for evaluation of the submitted mix design, test results and required data. No production of concrete for the project shall commence until the Structural Concrete Engineer has reviewed and accepted the concrete mix design.

(a) Mix Design Information. The mix design shall contain the following information:

(1) Class of concrete.

(2) Type of mix, conventional or self-consolidating concrete (SCC).

(3) Saturated surface dry or dry weights (specify which).

(4) Aggregate types, sources, specific gravities, and absorption values.

(5) 56 day design compressive strength, psi.

(6) Cementitious content and the amount of each, pounds per cubic yard.

(7) Air content and range, percent.

(8) 56 day surface resistivity value.

(9) Determined spread lower limit and upper limit for SCC.

(10) Maximum water/cementitious materials (W/CM) ratio.

(11) Volumetric quantities of each material in the mix design.

(12) Design unit weight of the mix.

(13) Chemical admixture types, brand names, and dosages.

(b) Mix Qualification Tests. The following mix qualification tests shall be performed for Class SCC concrete:

(1) The surface resistivity of the test mix shall be measured at 56 days based on the requirements of *AASHTO T 358*. Results shall be categorized as Low, Very Low, or Negligible in accordance with *AASHTO T 358, Table 1*. The surface resistivity may be accepted prior to 56 days if the results meet these requirements. The 56 day test results shall be completed and submitted regardless of the results of earlier tests.

(2) The Contractor shall determine the lower and upper spread limit. *ASTM C1621* testing shall be performed at the proposed upper and lower spread limits. Each spread limit shall not exceed the blocking assessment "Minimal to Noticeable Blocking". The slump cone shall be filled in accordance with *ASTM C1621, Procedure B*. At both the upper and lower limits, the visual stability index (VSI) shall not be greater than 1.

(c) Density of Class LW Concrete. The maximum unit density of Class LW concrete shall be 125 pounds per cubic foot when plastic.

At a minimum, an air entraining admixture shall be used. Other admixtures may be used in conjunction with an air entraining admixture. The use of an accelerating or water-reducing and accelerating admixture to alter the setting characteristics of concrete mixtures shall be permitted only with the approval of the Engineer.

The use of chlorides or admixtures containing chlorides is prohibited. All admixtures will be considered incidental to the work and included in the Contract unit price of the concrete.

The concrete materials shall be proportioned using the absolute volumes method in accordance with the requirements for each class as specified in Table 541.03A. The volumetric proportioning method such as that outlined in *ACI 211.1*, or other approved volumetric proportioning methods, shall be employed in the mix design.

The Contractor may use industry methods to develop gradations not specified in Section 704 that are better optimized to satisfy the required concrete characteristics. If the Contractor is using a combined gradation, they shall provide the method or methods of how they will monitor gradation, the limits of the gradation ranges, and the frequency of monitoring. The Contractor may also at the same time reduce the cementitious content per cubic yard for the intended class of concrete if a trial batch is performed to demonstrate that the minimum 56-day compressive strength is met, and the maximum W/CM ratio is not exceeded to obtain a workable mix using an air content within the specified range. The trial batch shall be a minimum of 3 cubic yards. Workable mix shall be defined as a cohesive mix which, when tested for slump in accordance with *AASHTO T119*, does not segregate or shear after removing the slump cone. Slump testing shall be conducted at 3 inches and 7 inches and performed on an individual batch for each slump along with testing the 56-day compressive strength in accordance with *AASHTO T 22*.

Production activities shall be conducted so that no intentional deviations are made from the reviewed and accepted mix design. If test results indicate a failure to obtain the 56-day compressive strength as specified in Table 541.03A based on tests conducted in accordance with *AASHTO T 22*, changes to the mix design shall be made with no extra payment. Changes may include, but are not limited to, using additional cement, changing the source of cement or aggregates, using a water reducer or other additives, or, if necessary, obtaining concrete from another supplier.

After the materials to be furnished by the Contractor have been approved, no proposed change in the source, proportions, or characteristics of the materials shall be made without the review and acceptance of the Engineer. No new materials shall be used until such materials and their proportions have been reviewed and accepted by the Engineer. In no case shall concrete from more than one mix design be permitted to be used during the same pour without prior written approval of the Engineer.

The Engineer may order concrete production and delivery suspended and a new mix design or altered mix design submitted if components or final product material characteristics are determined to be out of tolerance, unsatisfactory, or if proposed changes in the source, proportions, or characteristics of the materials are proposed. No production of concrete for the project shall resume until the Engineer has reviewed and accepted the new or altered mix design. For evaluation, new mix design submittals shall be considered as initial mix design submittals.

The various classes of concrete shall have an air content by volume as specified. The entrained air may be obtained using an approved admixture.

For Class AA, Class A, Class B, Class C, and Class D concrete, the Contractor, at their option or as required by the Structural Concrete Engineer, may substitute fly ash or ground granulated blast-furnace slag (GGBFS), Grade 100 or Grade 120, for Portland cement.

The minimum substitution rate for fly ash shall be 20.0% of the required Portland cement for concrete. The fly ash shall be substituted at a ratio of 1 pound of fly ash for 1 pound of Portland cement. The minimum substitution rate for GGBFS shall be 25.0% of the required Portland cement for concrete. The GGBFS shall be substituted at a ratio of 1 pound of GGBFS for 1 pound of Portland cement. A substitution of fly ash and GGBFS will not be permitted in the same concrete mixture.

When any mineral admixture is incorporated into a standard class of concrete, necessary adjustments to the mix design shall be made by the Contractor and reviewed and accepted by the Structural Concrete Engineer. Proportioning of the concrete mixtures containing mineral admixture shall be by the absolute volumes method in accordance with the requirements for each class as specified in Table 541.03A, except that the listed W/CM ratio shall be based on total cementitious material (Portland cement and mineral admixture).

When using concrete with mineral admixtures, the setting time may be retarded in cool weather. The Engineer, after consultation with the Structural Concrete Engineer, may require that the curing period, as designated in Table 541.15A, be extended.

541.04 BATCHING. Measuring and batching of materials shall be performed at an approved batch plant. Batch plants shall have an inspection completed prior to the first concrete placement on an Agency project if it has been more than 12 calendar months since the last inspection. Requests for inspection and required documentation shall be received by the Agency's Materials Testing and Certification Section a minimum of 21 calendar days prior to the date of the requested inspection.

All deficiencies shall be corrected and verified a minimum of 5 calendar days prior to the first concrete placement for any Agency project. The batch plant shall meet the requirements of *AASHTO M 157*, except as modified in these specifications, and shall always be maintained in good repair. The batch plant shall be subject to periodic inspections by authorized representatives of the Agency. The batch plant shall have approved methods of storing, measuring, and dispensing approved admixtures.

All concrete batch plants offered for Agency approval shall be equipped for semi-automatic batching and proportioning of all cementitious material, aggregates, water, and for the automatic insertion of admixtures. The plants shall be equipped to automatically and accurately record and report batch weights. Proper facilities shall be provided for the Engineer to inspect ingredients and processes used in the batching and delivery of the concrete. The Contractor shall, without charge, afford the Engineer all reasonable facilities for securing samples to determine whether the concrete is being furnished in accordance with these specifications. In the batch room area, the producer shall provide the inspector with a 24 inch × 18 inch horizontal working surface, at a sufficient working height with a seat and an adequate view of the batching controls, display, and power supply.

The Contractor shall give the Engineer 24-hours' notice of their intent to place concrete. Failure to give notice which causes postponement of placing operations will not be a reason for determining an extension of Contract time per the requirements of Subsection 108.11.

(a) Batch Weight Tickets. Batch weight tickets shall include the following information:

(1) Approved mix design identification number

(2) Weight of all aggregates

(3) Weight of cementitious material

(4) Quantity of admixtures by type

(5) Quantity of water batched

(6) Aggregate moistures

(7) Total water to cementitious ratio

Materials on the batch weight ticket shall be identified by type. All batch weight ticket information shall be provided in English units. All materials added to the concrete batch shall be added to the batch weight ticket prior to delivery.

(b) Semiautomatic Batch Plants. When actuated by a starting mechanism, the semiautomatic batch controller shall start the weighing operation of the materials and stop the flow automatically when the designated weight has been reached. It shall be interlocked to ensure that the discharge mechanism cannot be opened until the weight is within the tolerance specified in Subsection 541.04(e).

Water and admixtures may be batched in a weigh batcher or by volume in a volumetric device. When actuated, volumetric controls shall start the measuring operation and stop the flow automatically when the designated volume has been reached.

(c) Testing Laboratory. The Contractor shall provide a weatherproof building or room at the plant site for the use of Agency personnel as a testing laboratory. The Contractor shall attain and maintain a qualified laboratory status in accordance with the current edition of the Agency's *Qualified Laboratory Program*. Failure to comply with this program may result in suspension of material production for Agency projects.

The testing laboratory shall have a minimum gross internal area of 150 square feet with a layout providing a minimum internal width of 7 feet, in which to house and use the equipment specified. Should the Contractor elect to provide additional equipment relevant to testing of Portland cement concrete and materials, the gross inside floor area of the laboratory shall be increased in proportion to the area required to house and operate the additional equipment. If the additional equipment is to be operated on a bench, the length of bench sections shall also be proportionally increased.

Adequate ventilation, lighting, heating, and any necessary electrical or gas connections shall be provided. Proper sanitary toilet facilities with a lavatory shall be available for use by Agency personnel at the plant site. Dedicated private telephone and internet services shall be provided to the laboratory in accordance with Subsection 631.02(a)(4), except that selection of the service by the Engineer is not required.

The laboratory shall be equipped with the following items and equipment:

1 Standard office desk, with lockable drawers or a separate lockable two-drawer file cabinet and chair

1 Agency *Qualified Laboratory Binder* with producer equipment calibration data

1 Set of bench sections at least 2 feet wide providing a minimum of 28 square feet of working area with under-counter shelving

1 Standard laboratory stool

1 Electronic calculator with eight-digit capacity

1 Standard laboratory sink and faucet provided with an adequate supply of water meeting the requirements of Subsection 745.01. The sink shall drain to the outside of the laboratory.

1 Bench brush

1 Floor brush

1 Motorized 8-inch sieve shaker with an adjustable timer. The shaker's operation shall be conducted by means of lateral and vertical motion of the sieve accompanied by jarring action with the following 8-inch diameter sieves: 3/8 inch (9.50 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (0.600 mm), No. 50 (0.300 mm), No. 100 (0.150 mm), plus pan and cover.

1 Mechanical aggregate shaker with an adjustable timer, a 1 cubic foot capacity, together with the following screens: 1-3/4 inch (43.0 mm), 1-1/2 inch (37.5 mm), 1 inch (25.0 mm), 3/4 inch (19.0 mm), 1/2 inch (12.5 mm), 3/8 inch (9.50 mm), 1/4 inch (6.30 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), and pan. The aggregate shaker may be placed in a separate enclosed area, or be shielded for dust and sound control. When the aggregate shaker is placed in a separate enclosed area, there shall be a minimum of 5 feet of clear space measured from the front frame of the aggregate shaker outward, as well as a bench section measuring approximately 36 inches high, 24 inches deep, and 50 inches long located adjacent to the aggregate shaker. The area shall be well lit and ventilated.

1 Square pointed shovel

5 Five gallon plastic buckets, with handles

1 Electronic balance with a minimum capacity of 50 pounds and accurate to 0.0002 pounds. If separate fine and coarse aggregate scales are to be used, the fine aggregate scale shall meet the requirements of *AASHTO M 231, Table 2*, Class G2, with a minimum capacity of 1.75 pounds and readable to 0.0002 pounds. The coarse aggregate scale shall meet the requirements of *AASHTO M 231, Table 2*, Class G5, with a minimum capacity of 50 pounds and readable to 0.002 pounds.

1 Set of standard masses (weights) to use for verifying the accuracy of the electronic balance

2 Double-burner hot plates with variable temperature controls

3 Metal pans with a nominal size of 9 inches × 9 inches × 2 inches

5 Metal pans with a nominal size of 9 inches × 13 inches × 2 inches

1 Sample splitter with a 2-1/2 inch chute

1 10-inch blunted trowel

1 4 foot × 4 foot minimum heavy canvas for quartering samples

1 Brass wire-bristle brush

1 Pair of heat-resistant gloves (500°F, short-contact)

2 1-1/2 inch soft bristle paint brushes

Acceptable substitutes for these items and equipment may be made with the approval of the Structural Concrete Engineer.

Batching operations shall not begin until the testing laboratory has been approved as being in compliance with these specifications and all equipment and equipment calibration requirements of the Agency's *Quality Assurance Program* and *Qualified Laboratory Program* documents. Removal of any equipment, except upon written request and with the written approval of the Structural Concrete Engineer, will revoke any prior approvals or qualifications and require the termination of batching operations.

The building or room designated as a testing laboratory shall be maintained in a clean condition by the producer and kept free of all articles not necessary for the testing of materials. Cleaning supplies shall be furnished by the Contractor.

(d) Bins and Scales. The batch plant shall include bins, weighing hoppers, and scales with adequate separate compartments for fine aggregate and for each required separate size of coarse aggregate. If cement is used in bulk, a bin, hopper, and scale for cement shall be included. Each compartment shall be designed to discharge efficiently and freely into the weighing hopper or hoppers. Means of control shall be provided so that when required, the material may be added slowly in minute quantities and shut off with precision.

Hoppers shall be constructed to eliminate accumulations of tare materials and to discharge fully without jarring the scales. Partitions between compartments shall be configured to prevent spilling under any working condition. All batch plant structures shall be properly leveled and maintained in that condition within the tolerance required by the design of the weighing mechanism.

The scales for determining the mass (weight) of aggregate, water and cementitious material shall be comprised of a suitable system of levers or load cells. The levers or load cells shall determine the mass (weight) consistently within 0.5% under operating conditions, with loads indicated either by means of a beam with balance indicator, a full-reading dial, or a digital read-out or display.

Adequate means for checking the accuracy of the scales shall be provided by the Contractor either using 50 pound weights or by other methods approved by the Structural Concrete Engineer. Weights shall be certified annually by the Weights and Measures Section of the Vermont Agency of Agriculture, Food, and Markets. All exposed fulcrums, clevises, and similar working parts of scales shall be kept clean.

When beam-type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. Poises shall be designed to be locked in any position to prevent unauthorized change of position. All measuring and weighing indicating devices shall be in full view of the operator while charging the hopper and the operator shall have convenient access to all controls.

The scales shall be serviced and their accuracy verified annually by a hopper-scale service person licensed by the Weights and Measures Section. For Vermont plants, an inspector representing the Weights and Measures Section shall witness all testing conducted by the service person and will attach a seal to each hopper scale, provided it meets the current specifications, tolerances, and regulations adopted by the Weights and Measures Section. Standard test weights used to determine the accuracy of hopper scales shall be certified yearly by the Weights and Measures Section in accordance with their established standards.

The ready-mixed concrete producer shall hire a licensed hopper-scale service person for annual checking and service of scales. In addition, Vermont producers shall schedule an inspection with the Weights and Measures Section between February 16th and April 30th of each year, inclusive. After April 30th, Vermont plants without current seals affixed to the hopper scales will not be permitted to supply concrete to Agency projects, unless otherwise directed by the Engineer or until the seals are affixed.

Out-of-state concrete producers shall observe all annual hopper scale weighing and seal requirements of their respective states.

(e) Production Tolerances for Batching. For weighed ingredients, the accuracy of batching is determined by a comparison between the desired weight and the actual scale reading. For volumetric measurement of water and admixtures, accuracy is determined by checking the quantity either by weight on a scale or by volume in a calibrated container.

Admixture-dispensing systems shall, at a minimum, be annually calibrated by an admixture distributor representative. The admixture distributor representative shall check at least two volumes, with a check done at approximately 15% of the minimum and at 15% of the maximum manufacturer's recommended dosage range, or other targets as approved by the Structural Concrete Engineer.

Batching shall be conducted to accurately measure the desired quantities of materials within the tolerances specified in Table 541.04A.

TABLE 541.04A – CONCRETE PRODUCTION TOLERANCES FOR BATCHING

Material	Production Tolerance	
	Class HPAA, HPA, HPB, AA, A, B, C, D, SCC, or LW Concrete	Flowable Fill and Flowable Fill, Excavatable
Cement	± 1%	± 5%
Water	± 1%	--
Aggregates	± 2%	--
Chemical admixtures	± 3%	--
Mineral admixtures	+ 10%, - 1%	+ 25 lbs or 10% [1], -1%

[1] The positive tolerance will be the greater of the two based on the target batch quantity for mineral admixture.

(f) Storage and Proportioning of Materials.

(1) Portland Cement. Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed.

All bulk cement shall be weighed on an approved weighing device. The bulk cement-weighing hopper shall be properly sealed and vented to preclude dusting during operation. Facilities shall be provided for the sampling of cement at the batch plant, either from the storage silo or from the weighing hopper. The sampling device shall provide a sample that represents the true nature of the material being used. This device shall be a permanent installation located to allow for safe and easy access.

(2) Water. Water may be measured either by volume or by weight. When measurement is by meter, the water meter shall be so located that the measurements will not be affected by variable pressures and temperatures in the water supply line.

Measuring tanks shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tanks.

All water metering methods shall be verified and calibrated on an annual basis or at any time there is a question of accuracy. All water added to the concrete at any point shall be through an approved metering method.

(3) Aggregates. Aggregate stockpiles shall be formed on hard, well-drained areas that prevent contamination from underlying material and accumulation of excessive moisture.

Aggregates from different sources or of different gradations shall not be stockpiled together. Only rubber-tired equipment shall be permitted to operate on aggregate stockpiles.

Stockpiles shall be constructed as follows:

a. If the stockpile is to be made using mechanical equipment (front end loader, clam bucket, rock ladder, radial stacker, or other approved equipment), the stockpile shall be made in such a manner that segregation is kept to a minimum.

b. If the stockpile is to be made by dumping from trucks in multiple layers, each layer shall be approximately 4 feet in depth. Each layer shall be completely in place before commencing the next layer. Care shall be taken that successive layers do not cone down over the previous layer.

c. No equipment shall be used to haul aggregate over the stockpiled material except to deposit the material for the layer being placed. It shall be the responsibility of the Contractor to ensure that the aggregate is kept free from deleterious material or degradation.

Stockpiles shall be maintained in such a manner that twice the anticipated aggregate requirement for any Agency project placements will be on hand and available for sampling and testing at least 48 hours before mixing operations for the placements are scheduled to begin. The Engineer may modify this requirement when special aggregates are required.

Aggregates shall be handled from stockpiles or other sources to the batch plant in such a manner as to secure a uniform grading of the material. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates, except lightweight coarse aggregate, produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. In case the aggregates have a high or non-uniform moisture content, a storage or stockpile period longer than 12 hours may be required by the Engineer.

Stockpiles being watered per the specifications or allowed through producer QC procedures shall be watered for a sufficient time to ensure consistent moisture throughout the stockpile. Aggregate stockpiles being watered shall be loaded in the bin within 1 hour of being batched.

The Contractor shall conduct moisture content tests within 1.5 hours of the anticipated concrete batching time. If there is a visual difference in aggregate moisture appearance, aggregate moisture content will be tested again and new moisture test results shall be obtained and used as soon as possible. Material that has been stored in a storage bin for more than 10 hours shall be retested for moisture content. A minimum of one cubic yard of aggregate will be removed from the bottom of the storage bin and discarded. A minimum of one cubic yard of aggregate will then be removed and a moisture content sample taken.

Plants that employ moisture probes shall have them calibrated and verified a minimum of 24 hours prior to batching or as directed by the Structural Concrete Engineer. The procedure for checking the meter will be to run aggregate over the probe and then collect a portion of the aggregate on which to perform a moisture content test. If the difference between the meter and the tested moisture content is greater than 0.5%, then the meter shall be calibrated.

d. Lightweight coarse aggregate stockpiles shall be presoaked for a minimum period of time to ensure that the aggregate is completely saturated surface dry or greater immediately prior to use as indicated by moisture testing. Soaking shall be accomplished by continuous sprinkling or other suitable means that will provide a uniform moisture content throughout the stockpile. The stockpile shall be allowed to drain for 12 hours to 15 hours immediately prior to use.

(4) Admixtures. The Contractor shall follow an approved procedure for adding the necessary amounts of admixtures to each batch. Admixtures shall be dispensed in such a manner that will ensure uniform distribution of the material throughout the batch within the required mixing period. Except as specified herein, all admixtures shall be added to the batch at the plant, unless otherwise authorized by the Structural Concrete Engineer.

Chemical admixture containers, metering equipment, and scales shall be calibrated annually by a qualified admixture distributor representative. Admixture calibration and verification shall be done at 15% of the high, at approximately the middle, and at 15% of the low recommended ranges for the admixture being dispensed by the system. The calibration and verification shall be done in the presence of an Agency representative when requested by the Agency.

All dispensers shall include visual inspection aids such as graduated transparent cylinders. A separate dispenser shall be provided for each liquid admixture. If the dispensing system does not provide visual inspection aids, then periodic verification tests shall be done at a frequency satisfactory to the Structural Concrete Engineer. Calibration and verification records shall be kept at the production facility for a minimum of one year. The producer shall perform the calibration and verification of the metering systems when requested.

Storage and dispensing systems for liquid admixtures shall be equipped to allow thorough circulation and agitation of all liquid in the system. This shall be required prior to the first batching of concrete for Agency projects in any calendar year and periodically thereafter at intervals not to exceed 60 calendar days for the duration of the period the plant is supplying concrete for Agency projects.

If the plant has received a delivery of at least 25% of the volume of the storage container, this will be considered as a method of circulation or agitation. If the circulation method is used, the admixture shall be circulated until a complete exchange of admixture is achieved. If an agitation method is used, the method shall be subject to approval by the Structural Concrete Engineer. If an admixture does not need agitation, then the admixture manufacturer shall submit a written statement annually indicating that agitation is not required.

Storage and dispensing systems for liquid admixtures shall be maintained within the manufacturer's stated temperature and environmental conditions.

It shall be the responsibility of the Contractor to use the quantity of Agency-approved admixtures needed to obtain concrete meeting the requirements of the Contract. All admixtures shall be approved by the Structural Concrete Engineer prior to incorporation into the mix.

a. Air-entraining admixtures shall be used as required to obtain the specified air content.

b. The dosages of water-reducing, retarding, and water-reducing and retarding admixtures, accelerators and specialty admixtures shall be in the recommended range as stated by the manufacturer, unless otherwise approved by the manufacturer.

(5) Fly Ash or GGBFS. Fly ash or GGBFS shall be stored at the batch plant in separate storage or holding bins or other approved holding containers and shall be protected from rain and moisture.

541.05 MIXING AND DELIVERY.

(a) General Requirements. Concrete may be mixed at the site of construction, at a central point, or wholly or in part in transit mixers. The production of concrete shall meet the requirements of *AASHTO M 157* with the following additional requirements:

(1) All concrete shall reach its final position in the forms no more than 1.5 hours after the cement has been added to the water. When an approved admixture to slow or temporarily halt the hydration process of the cement is used, this time limit will be extended to 2 hours, provided the mix has adequate workability. Prior to discharge, the Contractor shall perform concrete temperature testing on every load of concrete which will be deposited after the 1.5 hour time limit, as defined above, to verify the concrete temperature is within the limits specified in Subsection 541.07.

A time limit greater than 2 hours may be approved if the request is made a minimum of 3 working days prior to the placement and all quality control test results are within specification immediately prior to placement. The request to extend the time limit beyond 2 hours shall include the requested time limit and required admixture dosages. Acceptance testing will be performed by the Engineer, concrete will not be accepted on the basis of quality control tests performed by the Contractor.

Concrete shall not have water added once discharging has begun. Admixtures may be adjusted as required by the producer before discharge has begun. Admixtures to slow or temporarily halt the hydration process of the cement shall only be added at the production facility.

If, in the opinion of the Engineer, any concrete appears to have visually changed from previously placed concrete, the Contractor shall perform quality control tests to confirm the concrete conforms to the specifications.

(2) To obtain the required concrete characteristics, a representative from the concrete producer shall be present on the project to determine the final admixture dosage and water addition for each load of concrete. The dosage shall be applied by means of a dispenser, or by other means of accurately measuring volume as approved by the Engineer. The Contractor shall provide QC concrete testing personnel, with current ACI Concrete Field Testing Technician Grade I Certification, to confirm the concrete is within specifications for the required work.

(3) Addition of water or admixtures at the project site shall be communicated to field inspection personnel. If additional mixing water, admixtures, or other additions are required, a minimum of 30 revolutions of the mixer drum at mixing speed shall be required before discharge of any concrete. If water is added in excess of the specified maximum W/CM ratio, the concrete shall not be used.

(4) The Engineer may require the Contractor to perform uniformity tests on a transit mixer or agitator, in accordance with *AASHTO M 157* and reported except as modified below. Two samples shall be taken. The first sample shall be taken after 15% of the load volume has been discharged, and the second prior to 85% of the load volume being discharged.

Slump and air content tests shall be performed on each sample. The maximum difference in air content between the two samples shall be 1%. For concretes with a specified slump of 4 inches or less, the maximum difference between the two samples shall be 1 inch. For concretes with a specified slump greater than 4 inches, the maximum difference shall be 1-1/2 inches. If both conditions are not met, then the Contractor will be required to either modify the mixing procedure or batching sequence, or that transit mixer or agitator will not be allowed to deliver concrete to the project. The Contractor will be required to perform uniformity tests to confirm the changes have satisfactory results.

(5) Each load of concrete delivered to the job site shall be accompanied by a batch weight ticket meeting the requirements of Subsection 541.04(a).

(6) The Contractor shall provide direct communication service from the site of the work to the batch plant that shall be available to the Engineer at all times during concrete operations. The cost of this service will be considered incidental to the work.

(7) All concrete shall be discharged into the forms before 300 revolutions of the drum or blades, not including initial mixing revolutions. The total allowed number of revolutions may be increased as directed by the Engineer.

Mortar shall be mixed in an approved mixer at the site of placement or in transit mixers when approved by the Engineer. The Engineer will withdraw approval for use of transit mixers, if necessary, to ensure a quality product or if the rate of delivery cannot be coordinated with finishing requirements.

(b) Stationary Mixers. When a stationary mixer is used for the complete mixing of the concrete, the mixing time for mixers that have a capacity of 10 cubic yards or less shall be not less than 90 seconds. For mixers that have a capacity of more than 10 cubic yards, the mixing time shall be determined by the concrete producer.

The time is valid provided that mixer efficiency tests prove the concrete is satisfactory for uniformity and strength. The plant shall be equipped with a timing device that will not permit the batch to be discharged before the predetermined mixing time has elapsed. Vehicles used in hauling shall comply with the requirements of Subsection 541.05(c).

(c) Transit Mixers. Transit mixers and agitators shall be subject to periodic inspections by an authorized representative of the Agency. Such equipment shall bear a currently dated inspection sticker supplied by the Agency indicating that the transit mixer or agitator conforms to the Agency's requirements.

For the purpose of this specification, the term agitator shall be interpreted to mean a vehicle with a drum that is not used to perform the initial mixing of the concrete but is used to transport the concrete and mix the concrete prior to discharge.

Transit mixers shall be equipped with a water-measuring tank with a visible sight gauge for use when the water for the batch is supplied from the transit mixer tank. The gauge shall be clean and legibly graduated. Measuring tanks shall be provided with outside drain valves or other means to check their calibration. These should be easily opened for checking at any time.

Electrically actuated revolution counters shall be required on all transit mixers except on mixers charged at central mix plants and used as agitator trucks only.

All mechanical details of the mixer or agitator such as water measuring and discharge apparatus, condition of the blades, speed of rotation of the drum, general mechanical condition of the unit and clearance of the drum shall be checked before a further attempt to use the unit will be permitted.

Mixers and agitators shall be kept free from accumulation of hardened concrete or mortar. The mixing blades shall be rebuilt or replaced when any part or section is worn 3/4 of an inch or more below the original height of the manufacturer's design. A copy of the manufacturer's design, showing the dimensions and arrangements of blades shall be available to the Engineer at the plant at all times.

Concrete containing silica fume shall be mixed in accordance with the appropriate situation:

(1) When silica fume is added to the batch by bags or in bulk from a silo, each batch of concrete shall be mixed for not less than 125 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as the mixing speed. The mixing and agitating speeds shall be found on the metal plate on the mixer.

(2) When silica fume is blended with cement or a combination of cement and mineral admixture at the cement plant prior to being delivered to the concrete plant, each batch of concrete shall be mixed for not less than 70 nor more than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as the mixing speed. The mixing and agitating speeds shall be found on the metal plate on the mixer. If inconsistent test results are obtained, or the batch of concrete appears not to be completely mixed, the mixing revolutions shall be extended as necessary.

When a transit mixer or agitator is used for transporting concrete, mixing during transport shall be continuous and at two to six rotations per minute or as designated by the manufacturer of the equipment as agitating speed. Failure to do so will be cause for rejection of the concrete.

Transit mixers and agitators assigned to a project shall not be used for other purposes until the desired work is completed at the site, and shall arrive at the project within the cycle that anticipated placement conditions dictate. The interval between loads shall be controlled such that concrete in place shall not become partially hardened prior to placing succeeding batches. The plant capacity and transportation facilities shall be sufficient to ensure continuous delivery at the rate required.

Before discharging concrete from a transit mixer that has been operating at agitating speed, the drum or blades shall be rotated approximately one minute at mixing speed. The same procedure shall apply to agitators.

Upon discharge of the concrete from the drum, a sufficient amount of water shall be charged into the drum to properly cleanse the drum. This water shall not be used as a part of the next succeeding batch but shall be discharged from the drum prior to the charging of the drum with the concrete ingredients. The drum shall be completely emptied before receiving materials for the succeeding batch. Re-tempering of concrete or mortar that has partially hardened, by remixing with or without additional materials, shall not be permitted.

541.06 QUALITY CONTROL. The Contractor shall provide assistance, equipment, materials, and curing for field sampling and testing as required by the Engineer. All costs shall be included in the Contract unit prices under Section 631. The Engineer shall perform all acceptance sampling and testing in accordance with the Agency's *Quality Assurance Program*. The Contractor shall perform all on-site quality control (QC) sampling and testing. The person performing the QC sampling and testing shall have, as a minimum, current ACI Concrete Field Testing Technician Grade I Certification.

(a) Sampling. Sampling for tests shall be taken in accordance with the requirements of *AASHTO R 60* or other procedures approved by the Agency. Sampling will be done at the point of placement or as close to it as practical.

(1) Changes. Any time that there is a change in admixture dosage outside of the allowable tolerances, whether modified at the batch plant or at the site, additional QC sampling and testing shall be performed on the modified load prior to incorporating the concrete into the work.

(2) Beginning of Load Sampling. Beginning of load sampling is sampling for QC testing purposes that is taken before 15% of the load has been discharged. Beginning of load sampling shall be performed as required by the Engineer, or as needed to ensure that the concrete meets the Contract requirements at the point of placement. The QC personnel shall monitor the placement operation and adjust the mix accordingly to ensure that the material being incorporated into the work meets Contract requirements.

(b) Slump Tests. Slump tests shall be made in accordance with *AASHTO T 119*.

(c) Spread Tests. Spread tests for Class SCC concrete shall be performed in accordance with *ASTM C1611, Procedure B*. The concrete inside the cone shall not be tamped.

(d) Visual Stability Index (VSI) Tests. VSI tests for Class SCC concrete shall be performed in accordance with *ASTM C1611, Appendix X.1* and shall be performed on each completed spread test.

(e) Air Content Tests. Air content tests shall be made in accordance with the pressure method specified in *AASHTO T 152*.

For Class SCC concrete, the specimens shall be fabricated in accordance with *ASTM C1758*.

A volumetric air meter shall be used for determining the air content of Class LW concrete in accordance with *AASHTO T 196*.

(f) Compressive Strength Tests.

(1) General Requirements. The number of compressive strength tests performed for acceptance will be as specified in the *Materials Sampling Manual*. The Engineer may order additional tests as deemed necessary.

Compressive test cylinders shall be made in accordance with the requirements of *AASHTO R 100* and tested for compressive strength in accordance with the requirements of *AASHTO T 22*.

For Class SCC concrete, the specimens shall be fabricated in accordance with *ASTM C1758*.

(2) Categories of Testing.

a. Acceptance Testing. Acceptance testing uses specimens to determine the compliance with requirements for the project. All test cylinders used for quality acceptance testing shall be stored in an approved curing box until they are shipped to the Agency's Materials Testing and Certification Section Central Laboratory.

b. Job Control Testing. Job control testing uses specimens to determine whether adequate curing procedures are being followed and for early form removal or early loading of structure. All job control specimens shall be stored on the structure and shall receive the same curing and protection from the elements as the concrete that they represent up until 24 hours before anticipated testing of specimens.

c. Specimen Curing Requirements. Specimen curing requirements shall be as stated in the specifications or as directed by the Engineer. If not specifically stated, the curing shall be as specified in Table 541.06A.

TABLE 541.06A – CONCRETE SPECIMEN CURING REQUIREMENTS

Testing Category	Number of Specimens	Curing Location
Acceptance	See the *Materials Sampling Manual*	Curing box
Job control	2 per test	On structure

(g) Concrete Temperature. Concrete temperature tests shall be conducted in accordance with the requirements of *ASTM C1064*.

541.07 WEATHER AND TEMPERATURE LIMITATIONS. The temperature of the concrete just prior to placement in the forms shall not be less than 50°F nor more than 85°F. Aggregates and water shall be heated or cooled as necessary to produce concrete within these temperature limits.

Placement and curing procedures shall be approved by the Engineer prior to actual placement.

(a) Hot Weather Concrete. Placement of concrete during hot weather may be limited by the Engineer based on an assessment of temperature, humidity, wind velocity, and sun radiation conditions. No concrete shall be placed when the ambient air temperature is, or is expected to be, above 90°F.

(b) Cold Weather Concrete.

(1) General Requirements. Cold weather concrete will be any concrete placed or cured when the ambient air temperature is expected to be below freezing at any point or below 40°F for a continuous 8-hour period. No concrete shall be placed when the ambient air temperature is lower than 10°F except by written permission of the Engineer. A cold weather concrete plan shall be submitted to the Engineer for their review and acceptance before any cold weather concrete is placed.

When placing cold weather concrete, the Contractor shall have adequate equipment for heating and protecting the materials and freshly placed concrete meeting the approval of the Engineer. This equipment shall be on the job and ready to deploy prior to the commencement of concrete placing operations.

No concrete shall be placed in any superstructure or thin section under cold weather conditions.

(2) Heating of Materials. The heating equipment deployed for cold weather concrete placement shall be capable of heating the materials uniformly. Aggregates shall not be heated to a temperature exceeding 150°F. If water is heated to a temperature exceeding 140°F, the water shall be mixed with the aggregate before the cementitious material is added.

The materials shall be heated in such a manner, for such a period of time, and in such quantity, as to produce concrete having a uniform temperature within the specified temperature range at the time of placement. Materials containing frost or frozen lumps shall not be used.

Stockpiled aggregates may be heated using dry heat or steam. Aggregates shall not be heated directly by gas or oil flame, or on sheet metal over a fire. When aggregates are heated in bins, steam-coil or water-coil heating, or other methods that will not be detrimental to the aggregates, may be used.

(3) Antifreeze Compounds. Salts, chemicals, or other foreign materials shall not be used in the mix to lower the freezing point of the concrete.

(4) Preparation of Forms. Before placing concrete, any ice, snow, or frost shall be completely removed from the forms.

Concrete shall not be placed on any surface or in any forms that are frozen, have surface temperatures below 32°F, or that contain frozen materials. The frozen surface or forms shall be completely thawed the day before the placement of the concrete and shall be kept continuously thawed until the concrete is poured. The temperature difference between forms or substrate and the plastic concrete shall not exceed 40°F.

(5) Housing. The Contractor shall furnish sufficient canvas with a supporting framework or other suitable type of housing to fully enclose and protect the structure when placing and curing cold weather concrete. The sidewalls and roofing of the protective housing shall be completely built before the placing of any concrete.

The protective housing shall be constructed independently of the forms and bracing and with adequate space to allow for form removal and the initial finishing of the concrete as required during the heating period. Joists shall be located to suitably support the housing roof with no sagging. The protective enclosure shall be heated to the proper temperature before placing any concrete.

When the temperature readings taken on or in the concrete indicate the temperature of the concrete may fall below 50°F, the Contractor shall, without exposing the concrete, immediately build the necessary enclosures around the area involved and supply heat to ensure curing conditions as specified in Subsection 541.15. The enclosure shall be removed when directed by the Engineer.

(6) Heating the Enclosure. The enclosure shall be heated in such a manner that the temperature of the concrete and the enclosed air shall be kept above 50°F, and not more than 40°F above the internal concrete temperature, for the designated curing period. During this time, the concrete shall be kept continuously wet to provide proper curing. The internal concrete temperature shall not exceed 160°F. After the curing period, the temperature shall be gradually lowered to that of the surrounding atmosphere, taking at least 48 hours for the transition but at no time exceeding a 1°F change per hour.

When dry heat is used, a means of maintaining atmospheric moisture shall be supplied. The Contractor shall also maintain adequate fire protection and shall provide personnel to keep the heating units in continuous operation. When concrete placement operations are in locations where water levels may fluctuate, the supports for heating equipment shall be built so that the heating equipment can be raised and steam lines shall be placed above the probable high water level.

The enclosure shall be well-ventilated to avoid accumulation of carbon dioxide and carbon monoxide.

When using a hydronic heating system with heat-transfer fluid that circulates through a series of hoses, the heat-transfer hoses shall be laid on top of the vapor barrier, usually plastic sheeting, then covered with approved insulating materials or by other approved methods for retaining heat.

(7) Temperature Records. The Contractor shall provide an automatic temperature recorder to continuously record concrete curing temperatures and ambient air temperatures for the entire curing period. Recording thermometers shall be capable of measuring and recording temperatures within the range of 0°F to 200°F with maximum graduations of 5°F.

Temperature sensors shall be carefully placed within the curing enclosure or in the concrete to ensure that temperatures are measured at typical locations. Concrete temperature sensors shall be embedded between 2 inches and 3 inches into the concrete or as directed by the Engineer. The recorder's accuracy shall be certified once every 12 months, with the certificate displayed with each recorder. The Engineer may make random checks of each recorder.

On each recorder chart or file, the Contractor shall indicate the location of the representative concrete, the placement date, and start and finish times of the temperature record. At the completion of the curing period, the recorder charts shall be submitted to the Engineer.

A thermometer shall be provided that is capable of displaying the current ambient temperature with a maximum gradation of 1°F. The inspector will use the thermometer to take periodic temperature measurements of the enclosure at varying locations.

The Contractor shall provide a hand-held infrared thermometer capable of taking no-contact measurements that is accurate within plus or minus 2% of the reading. The thermometer's accuracy shall be certified once every 12 months, with the certificate provided with each thermometer.

When the Contractor places concrete at more than one location within the specified curing period or if the Engineer determines that monitoring of a single pour is necessary in multiple locations, additional monitoring and recording equipment shall be furnished to provide temperature records at each location.

541.08 FORMS. The Contractor shall be responsible for, and shall make good, any injury arising from inadequate forms. The Engineer shall be provided the opportunity to inspect all forms prior to concrete placement.

Unless the Plans specifically allow for the use of stay-in-place forms, such forms shall not be used in the construction of any superstructure or bridge deck. Stay-in-place forms will only be allowed as approved by the Engineer.

(a) Falsework. In general, falsework that cannot be founded upon a solid footing shall be supported by falsework piling. The Engineer may require the Contractor to employ screw jacks or hardwood wedges to correct any deflections or settlement, however slight, occurring in the falsework.

(b) Construction. Forms shall be mortar-tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations, including vibration. Forms shall be constructed and maintained to prevent the opening of joints due to shrinkage of the lumber. Sealers and caulking as approved by the Engineer shall be used where forms abut structural steel members, such as top flanges of beams and girders.

To ensure their easy removal, forms shall be filleted and chamfered at all sharp corners, unless otherwise shown on the Plans or directed by the Engineer, and shall be given a bevel or draft in the case of all projections, such as girders and copings.

Falsework and forms for slabs, beams, and girders shall be constructed to provide the camber shown on the Plans or ordered by the Engineer.

Falsework and forms for Class SCC concrete construction shall be designed with consideration given to concrete placement rates, mix temperature, additives, and placement procedures that affect hydrostatic pressure of the concrete. Forms shall be water-tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations, including vibration.

(c) Form Lumber. All face form lumber for exposed surfaces shall be concrete form exterior grade plywood, not less than five ply and with a minimum thickness of 3/4 inch. In computing stud spacing, plywood shall be considered 1-inch lumber, provided that the grain of three of the plies runs perpendicular to the studs.

Form lumber for unexposed surfaces may be dressed tongue-and-groove, dressed shiplap, or square-edge surfaced four sides of uniform width and thickness, with a minimum thickness, after finishing, of 3/4 inch.

All form lumber shall be sound and free from loose or rotten knots, knotholes, checks, splits, or wanes showing on the surface that will be in contact with the concrete. Used face form lumber, having defects or patches which may produce work inferior to that resulting from new material, shall not be used.

Other form materials may be used with the permission of the Engineer.

(d) Form Ties. Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 1 inch from the face without injury to the concrete. Wire ties shall be used only in locations where they will not extend through surfaces exposed in the finished work and then only when authorized by the Engineer.

Unless otherwise specified, cavities shall be filled with a product that meets the requirements of Subsection 780.01. The manufacturer's recommendations shall be followed for surface preparation, mixing, application, and curing.

(e) Surface Treatment. All forms shall be treated with commercial form oil prior to placing reinforcement and wood forms shall be saturated with water immediately before placing the concrete. Any material that will adhere to or discolor the concrete shall not be used.

(f) Metal Forms. The specifications for wood forms regarding design, mortar-tightness, filleted and chamfered corners, beveled projections, bracing, alignment, removal, reuse, and oiling also apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape throughout the concrete placement operations.

All bolt and rivet heads shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms that do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease, or other foreign matter.

(g) Removal of Forms.

(1) Deck Superstructure. The forms, or their supports, for any portion of a structure shall not be removed before the end of the cure period for the deck specified in Table 541.15A. Forms under beams or floor slabs may be removed upon approval of the Engineer after the concrete attains 85% of the minimum compressive strength as specified in Table 541.03A, but not prior to the end of the cure period specified in Table 541.15A.

(2) Substructure. The forms, or their supports, for any portion of a substructure shall not be removed before the end of the cure period specified in Table 541.15A unless otherwise approved by the Engineer. Removal of forms prior to the end of the cure period will only be allowed if a vertical surface curing plan has been approved by the Engineer. Forms under arches, pier caps, or other special design conditions may be removed upon approval of the Engineer after the concrete attains 85% of the minimum compressive strength as specified in Table 541.03A, but not prior to the end of the cure period specified in Table 541.15A.

Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and their supports shall not be removed without approval of the Engineer. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take up the stresses due to its own dead load.

(h) Stay-In-Place Corrugated Metal Forms (SIPCMF) for Superstructure Deck Slabs.

(1) General Requirements. When SIPCMF are allowed, their use for superstructure deck slab construction shall be subject to the following requirements:

a. Fascia overhangs shall be formed with removable forms that leave the resulting concrete with a flat-surfaced finish.

b. Bays that are constructed in stages such that a longitudinal joint is required shall be made with removable forms.

c. Form flutes (or valleys) shall be filled with closed cell foam, or approved equal, to maintain the deck thicknesses shown on the plans.

(2) Design Requirements. The following requirements shall govern the design of SIPCMF:

a. The design span shall be the clear span of the form plus 2 inches, measured parallel to the form flute (also referred to as the form valley).

b. The design load shall be the sum of the weight of forms, bar reinforcement, plastic concrete, and 55 pounds per square foot for construction loads.

c. The unit working stress shall not exceed 75% of the specified minimum yield strength of the material.

d. The dead load deflection shall not exceed 1/180 times the form span length or 1/2 inch, whichever is less.

e. Physical design properties shall be computed with the requirements of the AISI *North American Specification for the Design of Cold-Formed Steel Structural Members*.

(3) Construction Requirements. The following construction requirements shall apply to the use of SIPCMF:

a. Construction Drawings. The Contractor shall submit construction drawings for SIPCMF in accordance with the requirements of Subsection 105.06. These drawings shall contain the following information as a minimum:

1. The name of the SIPCMF supplier.

2. A layout showing the compression and tension region of each beam or girder.

3. The method of SIPCMF attachment for the compression and tension regions.

4. The geometric properties of each type of panel being used.

5. The number, location, and type of panels being used within each girder bay.

6. Panel laps, considering the direction of concrete pours.

7. The specifications for the material used to fill the flutes.

8. Any other material data, erection information, or miscellaneous notes that may be required.

b. Handling and Installation. Care and protection shall be given the metal form sheets, supports, and accessory items during handling, shipping, and storage. During loading, hoisting, and unloading operations, extra precautions and care shall be taken to prevent damage to ends, corners, and edges of form sheets, supports, and accessory items.

If the form units and accessories are to be stored prior to installation, they shall not be placed in contact with the ground and shall be adequately covered or protected to keep them dry.

Form supports shall be placed in direct contact with the flange of the beam, girder, stringer, or floor beam. All attachments shall be made by permissible welds, bolts, clips, or other approved means. The welding of form supports to steel not considered weldable or to portions of flanges subject to tensile stresses shall not be permitted. Welds and welding shall be in accordance with the requirements of Subsection 506.10, with the exception that a 1/8-inch fillet weld will be permitted.

Form sheets shall not be permitted to rest directly on the flanges. They shall be securely fastened to form supports by self-tapping screws and shall have a minimum bearing length of 1 inch at each end. Transverse construction joints shall be located at the bottom of a valley. A 1/4 inch diameter weep hole shall be drilled at the lower end of each flute or valley.

Screed and pouring runway supports shall not be located directly on the form sheets, form supports, or reinforcing steel. No loose sheets or miscellaneous hardware shall be left on the structural slab at the end of the working day.

The corrugated metal sheets shall be fabricated for the placement sequence used, with the joints between sections of sheets overlapped or securely fastened to eliminate differential deflections. Any exposed form metal where galvanizing has been damaged shall be cleaned and repaired to the satisfaction of the Engineer.

(4) Inspection Procedures. The following three-step inspection procedure will be used to check the soundness of the concrete deck against the SIPCMF.

a. Step 1. Not less than two days after completion of a concrete structural slab pour, but prior to the next slab pour, one panel of the SIPCMF shall be removed from the most recently completed pour of each span, at a location selected by the Engineer, to provide visual evidence that the concrete mix or the construction procedures are obtaining the desired results.

If the concrete mix or the construction procedures are varied significantly within a pour, such as a change in the extent of vibration or change in the workability of the mix, another section of forming shall be removed to verify that the new procedures are yielding desirable results.

b. Step 2. After the concrete has attained 85% of the specified design strength, the Engineer will spot-check the underside areas of the steel forms by sounding with a suitable weight hammer. If honeycomb or voided areas are detected, the SIPCMF at that location shall be removed for a visual inspection.

c. Step 3. A minimum of 2% of the total SIPCMF area shall be removed for visual inspection of the concrete surface. The amount of sounding and form removal may be moderated, at the Engineer's discretion, after a substantial amount of the slab has been constructed and inspected, if the Contractor's methods of construction and results of the inspections as outlined above indicate that sound concrete is being obtained throughout the slab.

If, after removing a section of form, the concrete is found to be defective, additional panels shall be removed as directed by the Engineer. All defective concrete shall be repaired to match the adjacent concrete in section and color to the satisfaction of the Engineer.

The Contractor shall provide all facilities required for the safe, suitable, and convenient means of access to the forms for the Engineer's inspection procedures.

The form sections shall be removed by a metal saw or air-carbon-arc gouging with minimum damage to the concrete. Cuts shall only be sufficiently deep to sever the form. Any other method of removal shall be submitted to the Engineer for approval. Cuts parallel to the corrugations in the forms shall be located on the sloping surface midway between a crest and valley. Cuts parallel to the supporting beams or girders shall be made through the supporting angles taking care not to damage the structural steel beams or girders.

The Contractor will not be required to replace the forms which have been removed.

541.09 PLACING CONCRETE.

(a) Workforce. The Contractor shall always have sufficient skilled personnel during the concreting operations to properly place, consolidate, and finish the concrete. If, in the opinion of the Engineer, the Contractor does not have sufficient skilled personnel to handle the concrete properly, the Engineer may postpone the start of the concreting operations until the Contractor has remedied this situation.

(b) Pre-Placement Meeting. For deck pours, or as required by the Engineer, a pre-placement meeting shall be scheduled by the Contractor to take place at least 7 calendar days before concrete placement. Attendees at the pre-placement meeting shall include, but not be limited to, the Contractor's project superintendent, the Engineer, the Structural Concrete Engineer, and the concrete producer.

The Contractor shall provide a placement plan that addresses, but is not limited to, the following topics:

(1) Time of concrete placement and amount

(2) Batch plant testing

(3) Delivery of concrete

(4) Method of concrete placement on the deck

(5) Consolidation and finishing of concrete

(6) QC testing of the plastic concrete

(7) Protection of the concrete from evaporation

(8) Curing of the concrete

(9) How to avoid long delays for balance loads

(10) Screed, work bridge, and rail set-up

(11) Dry run schedule

(12) Contingency plans for long delays, break downs, weather events and other potential problems

(13) Crew size and responsibilities

(14) Available equipment

(15) Project layout including locations for all pumps, cranes, testing, cleanouts, staging, etc.

(c) Placement Limitations. All concrete shall be placed in daylight, unless otherwise authorized in writing by the Engineer. Authorization to place concrete at any other time shall not be given unless an adequate lighting system is provided prior to beginning the concrete placement operations.

Concrete shall not be placed under adverse environmental conditions that the Engineer determines will interfere with acceptable placement or finishing operations.

Concrete shall not be placed until the depth and character of the foundation, the apparent adequacy of the forms and falsework, and the placing of the reinforcing steel have been approved by the Engineer. The interior of the forms shall be clean of all debris before concrete is placed.

The Contractor shall submit to the Engineer a schedule of batching, delivery, and placement prior to the beginning of the concreting operations. The Contractor shall comply with the requirements of Subsection 541.05.

For deck pours, the Contractor shall submit the required retarder schedule to the Engineer a minimum of 3 working days in advance of the placement. The retarder schedule shall demonstrate how the Contractor will ensure that concrete will remain plastic until the deck is fully placed. The retarder schedule shall include considerations for the maximum time between batching and discharge, duration of the pour, weather, possible delays, and any other factors that may impact the time to initial set.

Equipment and tools necessary for handling materials and performing all parts of the work shall meet the approval of the Engineer as to design, capacity, and mechanical condition and shall be on the site before the work is started. Any equipment, in the judgment of the Engineer, that proves inadequate to obtain results prescribed shall be improved or new equipment substituted or added.

The Engineer may suspend the pour or reject the pour if the Contractor deviates from the accepted pour plan which will also include unacceptable delivery rates. The Contractor will not be allowed compensation due to the pour being suspended or rejected due to the Contractor deviating from the accepted pour plan or uncontrolled delivery rates.

For simple spans, concrete shall be deposited by beginning at the lower end of the span and working toward the upper end. For continuous spans, where required by design considerations, the concrete placing sequence shall be as shown on the Plans.

Concrete shall not be deposited in the forms more than 4 feet from its final position.

The dropping of unconfined concrete more than 5 feet will not be permitted.

Concrete shall not be deposited in running water.

The rate of placing the concrete shall be so regulated that no excessive stresses are placed on the forms. Concrete in all decks shall be placed in one continuous operation, unless otherwise specified.

Concrete shall be placed in continuous horizontal layers, the thickness of which shall not exceed 18 inches, unless otherwise directed by the Engineer. Each succeeding layer shall be placed before the underlying layer has taken initial set and shall be consolidated in a manner that will eliminate any line of separation between the layers. When it is necessary, due to any emergency, to place less than a complete horizontal layer at one operation, such layer shall terminate in a vertical bulkhead.

After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or straining the ends of projecting reinforcing bars.

Flowable fill shall be applied to voids and other locations as specified in the Contract and as directed by the Engineer. Flowable fill shall be able to completely fill the existing voids.

If voids are discovered, the Engineer may direct the Contractor to submit a plan for filling the remaining voids. This work, including preparing and submitting the plan and filling any remaining voids, will be at the Contractor's expense.

(d) Placement of Overlays. For a period of at least 24 hours before the placement of overlay material, the prepared surface shall be flooded with water. After removal of all free water, the overlay material shall be deposited on the damp surface and manipulated to coat the horizontal and vertical surfaces to be covered. The rate of progress shall be controlled to prevent the drying of previously deposited materials.

(e) Use of Chutes. Chutes, troughs, and pipes used in placing concrete shall be arranged to avoid segregation of the materials and the displacement of the reinforcement and shall be approved by the Engineer. Aluminum chutes, troughs, or pipes will not be permitted.

All chutes, troughs, and pipes shall be kept clean and free of hardened concrete by thoroughly flushing with water after each run. Open troughs or chutes shall be either made of metal or be metal-lined and shall extend as nearly as possible to the point of deposit. When the discharge must be intermittent, a hopper or other device for regulating the discharge shall be provided.

Dropping of unconfined concrete more than 5 feet or depositing a large quantity at any point and running or working it along the forms will not be permitted.

(f) Use of Vibrators. Unless otherwise specified, the concrete shall be consolidated with mechanical vibrators, of an approved type and design, operating within the concrete. When required, vibrating may be supplemented by hand-spading with suitable tools to ensure proper and adequate consolidation.

Vibrators shall be manipulated to work the concrete thoroughly around the reinforcement and imbedded fixtures and into corners and angles of the forms to produce surfaces free of imperfections. Vibrators shall not be used to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish consolidation but shall not be prolonged to the point where segregation occurs.

Vibrators shall have non-metallic or rubber-coated heads. Vibrating machines shall at no time be left running unattended in the concrete.

When it is necessary due to an emergency to discontinue the placing of a monolithic section, the use of vibrators shall cease. Vibrators shall not again be used until a sufficient depth of fresh concrete is placed to prevent any possibility of the effect of vibration on the concrete already in place and in no case shall this depth be less than 2 feet.

The number of vibrators used shall be ample to consolidate the incoming concrete immediately after it is deposited in the form. The Contractor shall have at least one spare vibrator in serviceable condition at the site of the structure in which more than 25 cubic yards of concrete are to be placed.

The vibrators shall be capable of transmitting vibration to the concrete at frequencies of not less than 4,500 impulses per minute under load. The vibration shall be of sufficient intensity and duration to cause plasticity, settlement, and complete consolidation of the concrete without causing segregation. The vibrator shall visibly affect a mass of concrete of 2-inch slump over a radius of at least 18 inches.

Unless otherwise specified, Class SCC concrete shall not be consolidated with mechanical vibrators. If the Engineer requests the use of a vibrator, it shall be of an approved type and design, operating within the concrete. To avoid segregation of the concrete, it shall be used as little as possible.

(g) Blasting Operations. All blasting operations within 200 feet of any concrete work shall be completed prior to the placement of the concrete. Regardless of the above limitation on blasting operations, the Contractor shall be responsible for any damage resulting from blasting operations.

541.10 DEPOSITING CONCRETE UNDER WATER.

(a) General Requirements. Concrete shall not be deposited under water except as specified by the Contract or upon approval of the Engineer. Class SCC concrete shall be used for all underwater concrete, unless otherwise approved by the Engineer. An anti-washout admixture shall be added to the mix design for all underwater concrete. Underwater concrete with an anti-washout admixture shall have a minimum air content of 3%. The anti-washout admixture may cause a delay in set times.

(b) Placement. When placing concrete underwater, the Contractor shall use a tremie or an alternate method of conveyance, approved by the Engineer, which minimizes the mixing of fresh concrete and water. A tremie shall have a hopper at the top that empties into a watertight tube at least 10 inches in diameter.

The discharge end of the tube on the tremie shall include a device to seal out water while the tube is first filled with concrete. An inflatable ball will not be permitted. The device shall keep its shape and float without danger of deflation.

The placement shall be continuous to the elevations shown on the Plans and the resulting concrete shall be monolithic and homogeneous.

Concrete shall not be deposited in water that has a temperature of 35°F or less. When the water temperature is between 35°F and 40°F, the mixing water, the aggregates, or both shall be heated as specified in Subsection 541.07(b).

A tremie shall be constructed of heavy-gauge steel pipe and consist of watertight joints between the tremie sections with a diameter of not less than 10 inches. The tremie hopper shall have a capacity of at least 1/2 cubic yard. When a batch is dumped into the hopper, the flow of the concrete shall be induced by slightly raising the discharge tube, always keeping it in the concrete.

Tubes shall be kept continuously submerged in concrete during discharge. The depth that the tube is submerged in concrete and the height of the concrete in the tube shall be sufficient to prevent water from entering the tube. The Contractor shall continuously monitor the difference in elevation between the top of the concrete and the end of the discharge tube.

Horizontal movement of discharge tubes through the concrete will not be allowed.

For minor quantities, at the sole discretion of the Engineer, a direct pumping method may be approved. If a direct pumping method is to be implemented, the pipe discharging the concrete shall consist of heavy-gauge steel sections. The Contractor shall demonstrate the ability to pump the concrete without the pump line surging or otherwise moving in the water as concrete is being pumped.

Cylinders cured as field cure shall be cured at the same temperature as the water covering the concrete.

541.11 PUMPING. Where concrete is conveyed and placed by mechanically-applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. The pump shall be capable of pumping concrete within the specified slump limits. The use of aluminum pipe as a conveyance for the concrete will not be permitted.

The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. The equipment shall be arranged so that no resulting vibrations may damage freshly placed concrete.

The pumping of Class LW concrete will not be permitted.

541.12 CONSTRUCTION JOINTS.

(a) Construction Joint Locations. Joints shall be formed at the location shown on the Plans. Any variation or new location of joints shall require written permission of the Engineer. Feather edges at construction joints will not be permitted. Joints shall be formed with inset formwork so that each layer of concrete will have a thickness of not less than 6 inches.

(b) Joining Fresh Concrete to Previously Set Concrete. When joining fresh concrete to concrete that has hardened, the surface of the set concrete shall be roughened in such a manner that will not leave loosened particles or damaged concrete at the surface and shall be thoroughly cleaned of all laitance, loose, and foreign material. Immediately prior to the placing of the new concrete, the surface shall be saturated with water.

When shown on the Plans or ordered by the Engineer, the surface shall be thoroughly coated with a very thin coating of mortar, neat cement grout, or epoxy bonding system and all forms drawn tight against the face of the concrete. This coating shall not be allowed to dry out before being covered with fresh concrete.

(c) Filled Construction Joints. Filled construction joints shall contain a pre-formed cork joint filler or other pre-formed joint filler that may be shown in the Contract. Joint filler shall be cut to fit exactly and shall completely fill the space that is shown on the Plans. Where a pour grade or caulking grade filler is indicated to be used in the joints, that portion of the joint to be filled shall be formed with a separate material (other than the pre-formed joint filler) that can easily be removed prior to placement of the above indicated filler.

(d) Water Stops. Approved water stops shall be placed at locations shown on the Plans. They shall form continuous watertight joints.

(e) Bond Breakers. Bond breakers shall be asphalt-treated felt or pipe insulation, as shown on the Plans.

541.13 EXPANSION JOINTS. All expansion joints shall be constructed according to details shown on the Plans.

(a) Filled Compression and Expansion Joints. Filled compression and expansion joints shall be made with a pre-formed self-expanding cork joint filler or other pre-formed joint filler that may be shown in the Contract. Joint filler shall be cut to fit exactly and shall completely fill the space that is shown on the Plans. Where a pour grade or caulking grade filler is indicated to be used in the joint, that portion of the joint to be filled shall be formed with a separate material (other than the expansion joint filler) that can easily be removed prior to placement of the above indicated filler.

(b) Special Types of Expansion Joints. Special types of expansion joints may be used when shown on the Plans or ordered by the Engineer.

541.14 CONCRETE FINISHING.

(a) Formed Concrete. Unless otherwise specified, all concrete surfaces shall be given a dressed finish. Other finish classes may be shown on the Plans for designated surfaces.

(1) Dressed Finish. All fins and irregular projections shall be removed from all surfaces except from those that are not to be exposed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other minor defects shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a product that meets the requirements of Subsection 780.01. The manufacturer's recommendations shall be followed for surface preparation, mixing, application, and curing.

All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint shall be left exposed to its full length with clean and true edges.

Areas that contain minor defects shall be repaired to the satisfaction of the Engineer. Minor defects are defined as the intermittent presence of holes, honeycombing, chips, or spalls, which are 6 inches or less in the longest dimension, and that do not penetrate deeper than 1 inch into the concrete. Surface voids or bugholes that are less than 1/4 inch in diameter and less than 1/8 inch deep need not be repaired.

Major defects are anything beyond the scope of minor as described above. The Contractor shall submit a corrective action proposal to the Engineer for all major defects.

(2) Aesthetic Finish. In addition to the requirements for a dressed finish, the following work shall be performed when an aesthetic finish is specified.

On all exposed surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other minor defects shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a mortar composed of the same cement and fine aggregate and mixed in the same proportions used in the concrete being finished, unless otherwise directed by the Engineer. Mortar used in pointing shall be not more than 1 hour old. The mortar patches shall be cured for a minimum of 72 hours in accordance with Subsection 541.15.

(b) Float Finish. This finish for horizontal surfaces shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be smoothed with a magnesium float.

Immediately after float finishing, the surface shall be given a broom finish, burlap drag finish, or left smooth as determined by the Engineer.

(c) Bridge Seats. Surfaces of bridge seats under bearing devices shall be level. The entire bridge seat surface shall be smoothed with a magnesium float.

(d) Finishing Bridge Decks and Overlays.

(1) General Requirements. The Contractor shall follow the procedures and details for placing the deck in accordance with the pre-placement meeting. The procedure shall provide for adequate labor, equipment, and material supply to complete placement of concrete on the entire deck, or specified portion thereof.

If, during the placement, unforeseen circumstances delay the progression of the pour to a point where the concrete begins to lose plasticity, the Contractor shall be prepared to place a bulkhead, as directed by the Engineer.

If at any time the screed machine does not advance in a 15-minute period due to delayed concrete delivery, mechanical breakdown, or other problem, the Contractor shall immediately cover concrete that is under the screed machine past the leading edge of the concrete with wet burlap. Just before concrete placement is to begin, the burlap shall be removed, the screed machine will be moved back, fresh concrete will be added to the area that was directly under the screed to the leading edge, and the area will be vibrated again. The screed machine may then be advanced forward to continue the placement.

Approval of their methods and equipment does not relieve the Contractor of full responsibility for obtaining the required surface finish.

Prior to texturing, the finished concrete surface shall be examined by the Contractor. Surface irregularities greater than 1/8 inch in 10 feet in either the longitudinal or the transverse direction shall be corrected in a manner acceptable to the Engineer. When a bituminous concrete surface is to be placed on a bridge deck, the deviation shall not be greater than 1/4 inch. When a sheet membrane is being applied, sharp ridges shall not be allowed. Thin mortar or laitance, which may have accumulated ahead of the finishing machine screed, shall be removed from the work site. These materials shall not be used to fill depressions.

If the bridge deck concrete does not meet the above smoothness requirements, the Contractor shall remove high spots up to 1/2-inch high by means of grinding. Any other corrections shall be made only with the written approval of the Engineer. The use of bush hammers will not be allowed. No concrete shall be removed that will result in a concrete slab thickness less than that shown on the Plans.

Any deck that cannot be corrected by a method satisfactory to the Engineer shall be removed and replaced at the Contractor's expense.

Sidewalks shall receive their final finish with a fine bristled broom.

(2) Turf Drag. When specified on the Plans, the surface shall be given a suitable texture with an artificial turf drag made of molded polyethylene or other material or method that will provide an acceptable finish. The selection of turf drag or other method should be capable of producing a surface texture with a horizontal peak-to-peak distance ranging from 0.02 inch to less than or equal to 0.25 inch and having a peak-to-peak amplitude of 0.005 inch to 0.8 inch. A turf drag material or other acceptable method that will minimize tearing and rolling of coarse aggregate from the surface shall be used.

The Contractor shall apply the finish texture in a transverse direction using hand methods. Other directions may be allowed with the approval of the Engineer. All texturing shall be performed from a work bridge immediately following the finishing operations and prior to curing operations. A second work bridge will be required for curing purposes unless a method using a single work bridge has been approved by the Engineer.

One pass of the turf drag over the finished area is desired. The drag shall leave a seamless strip between passes. The finish texture resulting from the drag shall stop within 15 inches of the curb face, rail anchor bolts, or edge of deck. Any buildup of concrete at the beginning or end of the pass shall be hand troweled to provide an even transition.

The drag shall produce a transverse, skid-resistant micro-texture acceptable to the Engineer, but shall not tear the surface. If the drag is not producing an acceptable micro-texture, the Contractor shall adjust the means and methods until an acceptable micro-texture is achieved.

The Contractor shall check the drag material before the deck pour and from time-to-time during finishing for tears, worn surface, or hardened concrete. The Contractor shall clean or replace the drag as often as necessary to maintain a well-defined micro-texture.

The turf drag or other acceptable methods shall not be applied when the surface is so wet or plastic that the ridges formed flow back into the valleys when the drag has passed, nor shall dragging be delayed until the concrete is so hard that sharp ridges cannot be formed by the drag. Fogging or similar methods shall be deployed to ensure that the surface does not dry prematurely.

If the 10-minute maximum, as specified in Subsection 541.15(c), for applying the wet cure cannot be met, then fogging of the area shall be performed in a manner that keeps the relative humidity above the evaporation rate of the concrete surface, but not so excessive that water begins to collect on the surface prior to texturing or other surface manipulating procedures.

(3) Finishing Machine Rail Supports. Finishing machine rail supports shall be of substantial construction and accurately set so that the finished deck surface will conform to the profile and transverse sections shown in the Plans. Finishing machine rail supports shall be placed and adjusted to properly provide for the deflection of forms, falsework, and structural supporting members which will occur during the placement of the concrete.

The finishing machine rail supports shall be spaced at a maximum of 2 feet on center and of sufficient design as to secure the rail to prevent it from falling off the support. The screed rails shall be configured to allow the screed machine and work bridges to be fully functional over the entire deck area.

Sufficient screed rails shall be provided so that all rails necessary for any one continuous pour may be preset and graded before the start of concreting operations. The removal of screed rails and exposed chairs shall be accomplished without walking in the fresh concrete and while the concrete is still plastic.

The Contractor shall furnish a work bridge or bridges of an approved type, capable of spanning the entire width of the deck without deflection to the concrete slab surface.

(4) Finishing. After the concrete has been placed, it shall be struck off by a finishing machine and the operation shall be repeated as necessary to produce a uniformly consolidated, dense, smooth surface. The final passage of the finishing machine shall result in a uniform surface at the required grade and slope over its entire area.

Finishing machines shall be kept in true adjustment. Machines shall not be used until the proper adjustments have been made and the adjustments have been checked and approved by the Engineer.

Sufficient time shall be provided prior to beginning concreting operations for the finishing machine to be operated over the full length of the bridge deck segment to be placed. This test run shall be made with the screed adjusted to its finishing position. While operating the finishing machine in this test, the screed rails shall be checked for deflection and proper adjustment, the cover on slab reinforcement shall be measured, and the controlling dimensions of slab reinforcement and forms shall be checked.

After the concrete is placed, it shall be struck off by one of the following methods:

a. A self-propelled concrete finishing machine may be deployed, supported on suitable rails, and equipped with adjustable strike-off and finishing roller screeds capable of producing the required finish surface for the full width of the bridge from face-to-face of curbs.

b. An approved mechanical vibrating screed, capable of exerting a force of at least 12 pounds per linear foot and generating at least 6,500 vibrations per minute when checked by a vibration reed-type tester, may be deployed. The vibrating screed shall provide a uniform finish throughout its entire length and shall be properly adjusted so as not to drive the aggregate more than 1/4 inch below the surface.

The concrete finishing machine, or screed, shall be oriented perpendicular to centerline of the bridge. Screed supports shall extend beyond the end of the deck as needed to ensure that the finishing machine can operate over the full length of the bridge deck segment to be placed. The finishing machine or screed shall not be operated on a skew unless the Contractor is able to demonstrate by calculation that the design deck thickness and cross slopes can be maintained throughout the full length of the segment placed.

In areas that are inaccessible to finishing machines, an approved manual vibratory-equipped power screed with an approved grade-control method may be used with approval from the Engineer. Smoothness shall be checked as specified in Subsection 541.14(d)(1) to ensure a smooth ride and seamless transition to the finishing machine's finished area. If manual vibratory-equipped power screeds are used, then initial vibration of the concrete for consolidation in those areas shall be of the minimal duration possible to avoid over-vibration and loss of air entraining of the surface concrete in these areas.

Hand finishing will be allowed only in areas inaccessible to finishing machines or manually driven vibratory-equipped power screeds. Hand screeds or bull floats shall be magnesium and at least 10 inches in width. Care shall be taken not to overwork the concrete surface during any finishing operation. Smoothness shall be checked as specified in Subsection 541.14(d)(1) to ensure a smooth ride and seamless transition to the finishing machine's finished area.

541.15 CURING CONCRETE.

(a) General Requirements. Water for use in curing concrete shall conform to the requirements of Subsection 745.01. The effective cure time shall be only the time that the concrete has been maintained in a wet condition with the concrete surface temperature above 50°F. If the concrete is not maintained in a wet condition or the concrete surface temperature drops below 50°F, it shall not be counted as effective cure time. The cure period will be extended 4 hours for every 1 hour the concrete is below 50°F, beginning when the concrete temperature is raised to or exceeds the minimum curing temperature.

Regardless of the curing medium specified, the entire surface of the newly placed concrete shall be kept damp. This shall be achieved by applying water with a nozzle that atomizes the flow so that a mist and not a spray is formed. The moisture shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate in a quantity sufficient to cause a flow or washing of the surface.

The atomized flow shall be applied continuously until the surfaces can be covered by the specified curing mediums. For bridge barriers, curbs, and sidewalks the curing method shall be applied within 15 minutes of the completion of the finishing process.

Concrete components shall be cured for the times specified in Table 541.15A.

TABLE 541.15A – CURING TIMES FOR CONCRETE COMPONENTS

Type of Construction	Curing Methods	Effective Cure Time (Days)
Substructure	Subsection 541.15(b)(1), (2), (3), (5), (7), and (8)	7
Superstructure	Subsection 541.15(b)(2) and (8)	7 [1]
Retaining walls	Subsection 541.15(b)(1), (2), (5), (6), and (8)	7
Headwalls	Subsection 541.15(b)(1), (2), (5), (6), and (8)	7
Sidewalks, curbs, and gutters	Subsection 541.15(b)(1), (2), (3), (5), (6), (7), and (8)	7

[1] There shall be no activity on the superstructure during the cure period.

(b) Curing Methods. All exposed surfaces of newly placed concrete shall be cured by one of the following specified methods:

(1) Water Curing. Curing with water shall be performed by continuously sprinkling or flooding all exposed surfaces with water for the entire required curing period.

(2) Burlap Curing. The entire exposed surface of the concrete shall be covered with two layers of approved burlap that has been pre-soaked with water. The burlap shall then be covered with a lapped layer of white polyethylene sheeting. Once the concrete superstructure has hardened sufficiently, a stream of water, applied with a soaker hose or similar device, shall be run continuously under the polyethylene sheeting until the cure period is complete.

(3) Sand Cover. The entire exposed surface of the concrete shall be covered with at least 3 inches of approved sand that shall be kept wet for the entire curing period.

(4) White Polyethylene Sheeting. The entire exposed surface of the concrete shall be covered with a blanket of white polyethylene sheeting, maintained and fastened to provide a nearly airtight condition in contact with the surface where possible. If, in the opinion of the Engineer, this cover is not adequately provided or maintained to ensure the proper conditions for the concrete cure, then the white polyethylene sheeting cure shall be terminated and another method substituted.

(5) White Burlap-Polyethylene Sheeting. The entire exposed surface of the concrete shall be covered with a blanket of white burlap-polyethylene sheeting. The burlap shall be thoroughly dampened prior to placing and shall be placed next to the concrete. All joints shall be lapped a minimum of 18 inches. The burlap shall be kept damp throughout the curing period.

(6) Membrane-Forming Curing Compounds. White-pigmented or fugitive-dye membrane-forming curing compounds may be used for curing concrete in minor drainage structures. All other uses of curing compounds shall be approved in writing by the Engineer. Only membrane-forming curing compounds approved by the Agency's Materials Testing and Certification Section shall be used.

When membrane curing is used, the exposed concrete shall be thoroughly sealed immediately after the free water has left the surface. The concrete inside the forms shall be sealed immediately after the forms are removed and necessary finishing has been done.

The solution shall be applied in one or two separate applications. If the solution is applied in two increments, the second application shall follow the first application within 30 minutes. Satisfactory equipment shall be provided, together with means to properly control and ensure the direct application of the curing solution to the concrete surface to result in a uniform coverage of the surface area at the rate of 1 gallon of solution for every 150 square feet.

If rain falls on the newly coated concrete before the film has dried sufficiently to resist damage, or if the film is damaged in any other manner, a new coat of the solution shall be applied to the affected portions equal in curing value to that specified above.

Should the surface be subject to continuous injury or the use of curing compound results in a streaked or blotchy appearance, the method shall be stopped and water curing applied.

(7) White Polyethylene Sheeting with Sand Cover. This method may be used only when approved by the Engineer and shall conform to the requirements of Subsection 541.15(b)(4). The airtight condition shall be obtained by the addition of a uniform sand cover with a minimum depth of 2 inches.

(8) Pre-Dampened Cotton Mats. The entire exposed surface of the concrete shall be covered with a blanket of cotton mats that has been pre-dampened with water. The mats shall be maintained in a damp condition until the curing period is complete.

If, in the opinion of the Engineer, the Contractor's curing procedure is not producing an adequate cure, the Engineer may direct a change in the cure method at no additional cost to the Agency.

(c) Bridge Decks. For bridge decks, the curing method shall promptly follow the screed machine, within a maximum lag time of 10 minutes and without interruption. If this lag time cannot be met, then fogging of the area shall be performed in a manner that keeps the relative humidity above the evaporation rate of the concrete surface, but not so excessive that water begins to collect on the surface prior to texturing or other surface manipulating procedures.

541.16 LOADING OF CONCRETE. After the concrete has been placed and the finishing operations concluded, it shall not be walked on or disturbed in any manner, including removal of forms, for a minimum period of 18 hours. If retarder is used as an admixture, this minimum period may be extended as directed by the Engineer.

(a) Substructure. No backfill material shall be placed against a newly completed structure unless the concrete cure is maintained in accordance with Table 541.15A, and until the field cured test cylinders have attained 85% of the compressive strength specified in Table 541.03A. However, the Contractor may erect forms for subsequent concrete placement on footings after 18 hours have elapsed from the time that the footing placement was completed, provided the concrete has sufficient strength to allow it to be worked on without damage, and proper cure is maintained.

Static loads, such as forms, reinforcing steel, or other materials necessary for construction, may be placed on any concrete after it has been in place 72 hours, or a compressive strength of 1,800 psi has been obtained, provided proper curing is maintained. Superimposed loads from subsequent concrete pours will not be allowed on any substructure unit or section in place until the field cured test cylinders have attained 85% of the compressive strength specified in Table 541.03A, and provided curing of the supporting section is maintained in accordance with Table 541.15A.

(b) Superstructure. Static loads, such as forms, granite curbing, cast-in-place concrete curb, and other materials necessary for deck construction, shall not be placed on deck concrete until the effective cure time specified in Table 541.15A is complete and the field-cured test cylinders for this concrete have attained 85% of the compressive strength specified in Table 541.03A.

The Contractor shall keep bridge floors free of all motor vehicles, transit mixers, and heavy construction equipment until the curing period is satisfactorily completed, the field-cured test cylinders for the bridge floor concrete have attained the compressive strength specified in Table 541.03A, and the field-cured test cylinders for the curb concrete or bridge rail concrete, as applicable, have attained 85% of the compressive strength specified in Table 541.03A.

(c) Vertical Joints. Concrete shall not be placed against a vertical construction joint until the previously placed concrete has been in place a minimum of 72 hours.

541.17 METHOD OF MEASUREMENT. The quantity of Concrete, Class HPAA, HPA, HPB, AA, A, B, C, D, SCC, LW; Mortar, Type I; Mortar, Type IV; Flowable Fill; and Flowable Fill, Excavatable to be measured for payment will be the number of cubic yards specified in the complete and accepted work, as determined by the prismoidal method using dimensions shown on the Plans or as directed by the Engineer.

The quantity of concrete shall exclude the volume of steel or other stay-in-place forms and form filling materials. No deductions will be made for the volume of concrete displaced by steel reinforcement, structural steel, expansion joint material, scuppers, weep holes, conduits, tops of piles, scoring, chamfers or corners, inset panels of 1-1/2 inches or less in depth, or any pipe less than 8 inches in diameter.

541.18 BASIS OF PAYMENT. The accepted quantity of Concrete, Class HPAA, HPA, HPB, AA, A, B, C, D, SCC, LW; Mortar, Type I; Mortar, Type IV; Flowable Fill; and Flowable Fill, Excavatable, will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for performing the work specified, including designing the mix, and satisfactory finishing and curing. Payment will also be full compensation for furnishing all forms, materials, including joint filler and bond breaker, labor, tools, admixtures, and equipment, including automatic temperature recording units, trial batches, and incidentals necessary to complete the work.

The cost of heating materials and protecting the concrete against cold weather, and any additional cost for cement, will not be paid for separately but will be considered incidental to the Contract unit prices for the applicable concrete pay items.

The cost of furnishing testing facilities and supplies at the batch plant and the setting of inserts, benchmarks, and bridge plaques furnished by the Agency will not be paid for separately but will be considered incidental to the Contract unit prices for the applicable concrete item.

Costs for all materials, labor and incidentals for steel or other stay-in-place forms and form filling materials will not be paid for separately, but will be considered incidental to the Contract unit prices for the applicable concrete item.

Payment will be made under:

Pay Item		Pay Unit
541.1000	Concrete, Class HPAA	Cubic Yard
541.1100	Concrete, Class HPA	Cubic Yard
541.1200	Concrete, Class HPB	Cubic Yard
541.2000	Concrete, Class AA	Cubic Yard
541.2100	Concrete, Class A	Cubic Yard
541.2200	Concrete, Class B	Cubic Yard
541.2300	Concrete, Class C	Cubic Yard
541.2400	Concrete, Class D	Cubic Yard
541.2800	Concrete, Class SCC	Cubic Yard
541.2900	Concrete, Class LW	Cubic Yard
541.4500	Flowable Fill	Cubic Yard
541.4600	Flowable Fill, Excavatable	Cubic Yard
541.5100	Mortar, Type I	Cubic Yard
541.5400	Mortar, Type IV	Cubic Yard

SECTION 542 – HIGH PERFORMANCE CONCRETE, RAPID SET

542.01 DESCRIPTION. This work shall consist of designing, furnishing, and placing a high early strength, high performance, Portland cement concrete for structures and incidental construction.

The Portland cement concrete may consist of a homogeneous mixture of cement, fine aggregate, coarse aggregate, water, admixtures, and pozzolans, proportioned and mixed according to these specifications.

542.02 MATERIALS. Materials shall meet the material requirements specified in Subsection 501.02 and the following subsections:

High Early-Strength Portland Cement 701.03

542.03 CLASSIFICATION AND PROPORTIONING. Concrete shall meet the requirements specified in Table 542.03A and shall be used as shown on the Plans.

TABLE 542.03A – HIGH PERFORMANCE CONCRETE, RAPID SET PROPERTIES

Min. 28-Day Compressive Strength (psi)	Max. W/CM Ratio [1]	Max. VSI [2]	Slump Limit	Spread Limit	Air Content Limits	Max. Free Shrinkage	Max. 56-Day Surface Resistivity [3]
5,000	TBD	1	N/A [4]	TBD [5]	7.0% ± 1.5%	0.040%	Low

[1] The maximum W/CM ratio shall be determined by the Contractor as established by mix qualification testing. During production, the W/CM ratio shall be less than or equal to the W/CM ratio from the approved qualification mix. See Subsection 542.03(b). The W/CM ratio shall be rounded to two decimal places in accordance with *ASTM E29*.

[2] For SCC mixes, visual stability index (VSI) as determined in accordance with *ASTM C1611*.

[3] The Contractor shall determine the surface resistivity in accordance with Subsection 542.03(b)(3).

[4] The mix shall not exhibit segregation. If the mix does exhibit segregation, the load shall be rejected. If the spread is equal to or exceeds 20 inches, the mix shall be classified as SCC mix.

[5] For SCC mixes, the Contractor shall determine the spread target and limits in accordance with Subsection 542.03(b)(4). The spread shall be maintained within the determined spread limits for the placement. The mix shall not exhibit segregation. If the mix does exhibit segregation or exceeds the upper spread limit, the load shall be rejected. and subsequent loads shall be tested by the Contractor until the mix meets the allowable limits. The Engineer may perform a J-ring test at the time of placement if blocking is a concern.

If a nominal maximum aggregate size is not specified, the Contractor shall determine the nominal maximum aggregate size using guidance from *ACI 211.1*. In no case shall the maximum aggregate size exceed 1/5 of the narrowest dimension between sides of the forms, 1/3 the depth of slabs, or 3/4 of the minimum clear spacing between individual reinforcing bars, bundles of bars, or pre-tensioning strands unless approved by the Engineer.

The Contractor may use industry methods to develop gradations not specified in Section 704 that are better optimized to satisfy the required concrete performance characteristics. If the Contractor is using a combined gradation, they shall provide the method or methods of how they will monitor gradation, the limits of the gradation ranges, and the frequency of monitoring.

Lightweight fine aggregate may be used to replace up to 30% of the volume of normal weight sand. The gradation of the lightweight fine aggregate shall conform to the requirements of *AASHTO M 195*. The lightweight fine aggregate shall be conditioned for enough time to fully saturate the material.

The stockpile shall be constructed so that the moisture content is uniform throughout the pile. The stockpile will be allowed to drain for 12 hours to 15 hours immediately prior to use, unless an alternate procedure is approved by the Structural Concrete Engineer. The Contractor shall state the method, duration and procedure used to confirm that the material is at or above its saturated surface dry (SSD) value, by weight, throughout the pile.

The use of chlorides or admixtures containing chlorides is prohibited. All admixtures will be considered incidental to the work and included in the Contract unit price of the concrete.

The concrete materials may be proportioned using the absolute volumes method in accordance with the specified requirements. The volumetric proportioning method, such as that outlined in *ACI 211.1* or other approved volumetric proportioning methods, shall be employed in the mix design.

Prior to placing concrete on the project (or prior to the trial pour, whichever occurs first), the Contractor shall submit for approval the single mix design formulation that satisfies all mix design qualification requirements and testing for the class of concrete specified. The mix designs shall be submitted to the Structural Concrete Engineer at the Agency's Materials Testing and Certification Section Central Laboratory. The Structural Concrete Engineer may require a minimum of 8 weeks for testing, review, and approval of new mix designs. No class of concrete shall be placed on a project, including the trial pour, until the mix design is approved.

If the proposed performance concrete mix design fails to meet the qualification requirements, the Contractor shall submit a revised mix design formula in writing to address the mix qualification deficiencies of the original failed mix design. Review of the revised mix design formula by the Structural Concrete Engineer will be completed within 14 calendar days.

(a) Mix Design Information. The mix design shall contain the following information:

(1) Class of concrete.

(2) Type of mix, conventional or self-consolidating concrete (SCC).

(3) Saturated surface dry or dry weights (specify which).

(4) Aggregate types, sources, specific gravities, and absorption values.

(5) 28 day design compressive strength, psi.

(6) Cementitious content and the amount of each, pounds per cubic yard.

(7) Air content lower limit, percent.

(8) 56 day surface resistivity value.

(9) Determined spread lower limit and upper limit for SCC.

(10) Maximum water/cementitious materials (W/CM) ratio.

(11) Volumetric quantities of each material in the mix design.

(12) Design unit weight of the mix.

(13) Chemical admixture types, brand names, and dosages.

Concrete test mix or mixes shall be used to obtain the test results where applicable. All wet testing shall be done by personnel with current ACI Concrete Field Testing Technician Grade I certifications. All other tests shall be performed by a laboratory that is accredited by AASHTO re:source or the Concrete and Cement Reference Laboratory (CCRL) in the particular test method, or as allowed by the Engineer.

(b) Mix Qualification Tests. The following mix qualification tests shall be performed. The minimum air content value and the maximum water/cementitious materials ratio of the material used to pass the mix qualification tests shall become the minimum air content value and the maximum water/cementitious materials ratio allowed during production.

(1) The free shrinkage rate of the concrete shall be tested in accordance with Subsection 501.03(b)(1).

(2) The compressive strength of the concrete shall be measured based on the requirements of *AASHTO T 22* for 3, 7, 14, and 28 day standard cured cylinders.

(3) The surface resistivity of the concrete shall be measured in accordance with Subsection 501.03(b)(4).

(4) For SCC mixes, the Contractor shall determine the lower and upper spread limit in accordance with Subsection 501.03(b)(5).

(c) Alkali-Silica Reactivity. The alkali-silica reactivity (ASR) of each type of aggregate shall be measured in accordance with Subsection 501.03(c). Test results shall be submitted with the mix design.

(d) Mix Design Approval and Changes. After the mix design furnished by the Contractor has been reviewed and approved by the Structural Concrete Engineer, no changes to the mix design will be allowed. If a source change is requested due to a change in product or material name that does not include any significant change in product formulation or material characteristic, and this is substantiated by the product or material supplier in writing, re-testing is not required.

No new materials shall be incorporated without prior written approval of the Engineer. In no case shall concrete from more than one mix design be permitted to be used during the same pour without prior written approval of the Engineer.

The approved mix design will be allowed consecutive re-approval if no material proportioning or material sources have changed from the previous year's approved mix design and the mix design is submitted with updated aggregate properties and volumes adjusted accordingly. The aggregate properties shall be tested annually. Aggregate property values will be valid for 14 months from the date tested. The properties to be tested include, but are not limited to, specific gravity and absorption.

The mix design shall be accompanied by the previously completed and accepted mix qualification test data and any applicable updated test information. The submittal shall also include all applicable quality control test results and all requests for variance from the material requirements of these specifications.

(e) Proprietary Mix Designs. A proprietary concrete mix design meeting the same performance requirements may also be considered for use.

542.04 BATCHING. Batching shall meet the requirements of Subsection 501.04.

542.05 MIXING AND DELIVERY. Mixing and delivery shall meet the requirements of Subsection 501.05.

542.06 QUALITY CONTROL. The Contractor shall provide assistance, equipment, materials, and curing for field sampling and testing as required by the Engineer. All costs shall be included in the Contract unit prices under Section 631. The Engineer shall perform all acceptance sampling and testing in accordance with the Agency's *Quality Assurance Program*. The Contractor shall perform all on-site quality control (QC) sampling and testing. The person performing the QC sampling and testing shall have, as a minimum, current ACI Concrete Field Testing Technician Grade I Certification.

(a) Trial Batch. Between 21 and 7 calendar days prior to the first placement, the Contractor shall produce and place a 2 cubic yard trial batch, at a location agreed upon by the Contractor and the Engineer. The purpose of this trial batch is to demonstrate that the mix is capable of producing the wet test results within the specified ranges. The Engineer shall be given a minimum notice of 7 calendar days prior to the trial batch pour. The trial batch shall be poured in the presence of the Engineer and the Structural Concrete Engineer. The trial batch shall be produced and poured in the same manner, estimated concrete temperature, and time frames that will occur during construction. For SCC the spread shall be within ± 3 inches of the target spread, but still be within the established spread range limits for SCC. The J-ring test will be performed for SCC mix, and the difference between the J-ring and spread test shall not be greater than 2 inches. The Contractor shall provide qualified personnel to test spread, air content, and temperature of the trial batch. A trial batch will be required for each mix design used on the project.

If SCC will be used in work with a sloped finished surface, the Contractor shall produce a mock-up during the trial batch to demonstrate that the mix can be finished with the sloped surface.

(b) Sampling. Sampling for tests shall be performed in accordance with the requirements of *AASHTO R 60* or other procedures approved by the Agency. Sampling shall be done at the point of placement or as close to it as practical.

(1) Changes. Any time that there is a change in admixture dosage outside of the allowable tolerances, whether modified at the batch plant or at the site, additional QC sampling and testing shall be performed on the modified load prior to incorporating the concrete into the work.

(2) Beginning of Load Sampling. Beginning of load sampling is sampling for QC testing purposes that is taken before 15% of the load has been discharged. Beginning of load sampling shall be performed as required by the Engineer, or as needed to ensure that the concrete meets the Contract requirements at the point of placement. The QC personnel shall monitor the placement operation and adjust the mix accordingly to ensure that the material being incorporated into the work meets Contract requirements.

(c) Slump Tests. Slump tests shall be made in accordance with *AASHTO T 119*.

(d) Spread Tests. Spread tests for SCC mixes shall be performed in accordance with *ASTM C1611, Procedure B*. The concrete inside the cone shall not be tamped.

(e) Visual Stability Index (VSI) Tests. VSI tests for SCC mixes shall be performed in accordance with *ASTM C1611, Appendix X.1* and shall be performed on each completed spread test.

(f) Air Content Tests. Air content tests shall be made in accordance with the pressure method specified in *AASHTO T 152*.

For SCC mixes, the specimens shall be fabricated in accordance with *ASTM C1758.*

(g) Compressive Strength Tests.

(1) General Requirements. The number of compressive strength tests performed for acceptance will be as specified in the *Materials Sampling Manual*. The Engineer may order additional tests as deemed necessary.

Compressive test cylinders shall be made in accordance with the requirements of *AASHTO R 100* and tested for compressive strength in accordance with the requirements of *AASHTO T 22*.

For SCC mixes, the specimens shall be fabricated in accordance with *ASTM C1758.*

(2) Categories of Testing.

a. Acceptance Testing. Acceptance testing uses specimens to determine the compliance with requirements for the project. All test cylinders used for quality acceptance testing shall be stored in an approved curing box until they are shipped to the Agency's Materials Testing and Certification Section Central Laboratory.

b. Job Control Testing. Job control testing uses specimens to determine whether adequate curing procedures are being followed and for early form removal or early loading of structure.

1. All job control specimens shall be stored on the structure and shall receive the same curing and protection from the elements as the concrete that they represent up until 24 hours before anticipated testing of specimens.

2. The maturity method may be used as an alternative to compressive strength testing for estimating the concrete strength. The procedures of *ASTM C1074* shall be followed for the maturity method except as noted below:

i. For *ASTM C1074, Section 8.1*, there shall be a minimum of 17 cylinders cast. Two of the 17 shall have temperature sensors embedded in them to be used for monitoring.

ii. For *ASTM C1074, Section 8.4*, there shall be 3 cylinders tested for each test age.

iii. For *ASTM C1074, Section 8.4*, for rapid set concrete mixes the test ages shall be 12 hours, 1 day, 2 days, 7 days, and 28 days. The Contractor may adjust or add test ages if approved by the Engineer.

All temperature measuring devices shall be verified or calibrated on a 12 month basis, or sooner if there are questions about their accuracy. The devices shall have an accuracy of ± 2° F.

At least two temperature sensors shall be embedded each day in each pour. One sensor shall be placed where maturity is expected to develop the slowest at, or near, an exposed outer edge, and a second sensor shall be placed in the concrete poured from the last load of the day. Sensors shall be placed 2 inches to 4 inches from any existing concrete or an exposed outer edge. The temperature sensing end of the monitor shall not be placed in direct contact with reinforcing materials or other elements that will protrude through the surface of the concrete. The Contractor shall submit the proposed locations to the Engineer for review and approval.

c. Specimen Curing Requirements. Specimen curing requirements shall be as stated in the specifications or as directed by the Engineer. If not specifically stated, the curing shall be as specified in Table 542.06A.

TABLE 542.06A – CONCRETE SPECIMEN CURING REQUIREMENTS

Testing Category	Number of Specimens	Curing Location
Acceptance	See the *Materials Sampling Manual*	Curing box
Job control	2 per test	On structure

(h) Concrete Temperature. Concrete temperature tests shall be conducted in accordance with *ASTM C1064*.

542.07 WEATHER AND TEMPERATURE LIMITATIONS. Weather and temperature limitations shall be as specified in Subsection 501.07.

542.08 FORMS. Forms shall meet the requirements of Subsection 501.08.

542.09 PLACING CONCRETE. Placing concrete shall be performed as specified in Subsection 501.09.

542.10 PUMPING. Pumping shall meet the requirements of Subsection 501.11.

542.11 CONSTRUCTION JOINTS. Construction joints shall meet the requirements of Subsection 501.12.

542.12 EXPANSION JOINTS. Expansion joints shall meet the requirements of Subsection 501.13.

542.13 CONCRETE FINISHING. Concrete finishing shall meet the requirements of Subsection 501.14.

542.14 CURING CONCRETE.

(a) General Requirements. Water for use in curing concrete shall conform to the requirements of Subsection 745.01. The effective cure time shall be only the time that the concrete has been maintained in a wet condition with the concrete surface temperature above 50°F. If the concrete is not maintained in a wet condition or the concrete surface temperature drops below 50°F, it shall not be counted as effective cure time. The cure period will be extended 4 hours for every 1 hour the concrete is below 50°F, beginning when the concrete temperature is raised to or exceeds the minimum curing temperature.

Regardless of the curing medium specified, the entire surface of the newly placed concrete shall be kept damp. This shall be achieved by applying water with a nozzle that atomizes the flow so that a mist and not a spray is formed. The moisture shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate in a quantity sufficient to cause a flow or washing of the surface.

The atomized flow shall be applied continuously until the surfaces can be covered by the specified curing mediums. The curing method shall be applied within 15 minutes of the completion of the finishing process.

Unless otherwise specified in the Contract, concrete shall be wet cured until it has reached the minimum 28-day compressive strength, verified by testing of job control specimens.

(b) Curing Methods. All exposed surfaces of newly placed concrete shall be cured by one of the following specified methods:

(1) Burlap Curing. The entire exposed surface of the concrete shall be covered with two layers of approved burlap that has been pre-soaked with water. The burlap shall then be covered with a lapped layer of white polyethylene sheeting. Once the concrete superstructure has hardened sufficiently, a stream of water, applied with a soaker hose or similar device, shall be run continuously under the polyethylene sheeting until the cure period is complete.

(2) Pre-Dampened Cotton Mats. The entire exposed surface of the concrete shall be covered with a blanket of cotton mats that has been pre-dampened with water. The mats shall be maintained in a damp condition until the curing period is complete.

542.15 LOADING OF CONCRETE. After the concrete has been placed and the finishing operations concluded, it shall not be walked on or disturbed in any manner, including the removal of forms, until curing is complete as specified in the Contract.

A portable compression testing machine calibrated in accordance with *ASTM C39, Section 5* shall be provided by the Contractor and available on-site for cylinder testing of field-cured cylinders for construction progress. There shall also be a hand-held grinding stone included with the compression testing machine. The hand-held grinding stone will be used to grind the top of the cylinders to relieve any sharp projections on the cylinder surface. All testing and equipment shall conform to *ASTM C39*. Testing will be performed, and equipment operated by, qualified Agency personnel. The individual shall be trained in the operation of the machine by the owner or representative of the machine who is proficient in the operations and functions of the machine.

If an independent lab is proposed to be used to test the field-cured cylinders instead of a portable compression testing machine, the Contractor shall submit the following documentation:

(a) Calibration records of the compression machine in accordance with *ASTM C39, Section 5*.

(b) Proof that the compression machine meets the requirements of *ASTM C39*.

(c) Evidence of proficiency of the technician who will be performing the test methods.

The Agency at any time reserves the right to perform an independent proficiency test of the technician for the test methods used and a review of the testing facility.

542.16 METHOD OF MEASUREMENT. The quantity of High Performance Concrete, Rapid Set to be measured for payment will be the number of cubic yards of concrete placed in the complete and accepted work, as determined by the prismoidal method using dimensions shown on the Plans or as directed by the Engineer.

The quantity of concrete will exclude the volume of steel or other stay-in-place forms and form filling materials. No deductions will be made for the volume of concrete displaced by steel reinforcement, structural steel, expansion joint material, scuppers, weep holes, conduits, tops of piles, scoring, chamfers, or corners, inset panels of 1-1/2 inches or less in depth, or any pipe less than 8 inches in diameter.

542.17 BASIS OF PAYMENT. The accepted quantity of High Performance Concrete, Rapid Set will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for performing the work specified, including designing the mix, performance of trial pours, satisfactory finishing and curing. Payment will also be full compensation for furnishing all forms, materials, including joint filler and bond breaker, labor, tools, admixtures, and equipment, including automatic temperature recording units, trial batches, and incidentals necessary to complete the work.

The cost of heating materials and protecting the concrete against cold weather, and any additional cost for cement, will not be paid for separately but will be considered incidental to High Performance Concrete, Rapid Set.

The cost of furnishing testing facilities and supplies at the batch plant and the setting of inserts, benchmarks, and bridge plaques furnished by the Agency will not be paid for separately but will be considered incidental to High Performance Concrete, Rapid Set.

Costs for all materials, labor, and incidentals for steel or other stay-in-place forms and form filling materials will not be paid for separately, but will be considered incidental to High Performance Concrete, Rapid Set.

Payment will be made under:

Pay Item	Pay Unit
542.1000 High Performance Concrete, Rapid Set	Cubic Yard

SECTION 543 – CONTRACTOR-FABRICATED PRECAST CONCRETE STRUCTURE

543.01 DESCRIPTION. This work shall consist of manufacturing, transporting, handling, and erecting precast concrete structure components fabricated by the Contractor at a location other than a PCI or NPCA certified precast concrete facility.

543.02 MATERIALS. Materials shall meet the material requirements specified in Subsection 501.02, Subsection 507.02, and Subsection 540.02. Concrete shall meet the material requirements specified in Subsection 540.05.

543.03 GENERAL FABRICATION REQUIREMENTS. Unless noted otherwise herein, Contractor-fabricated precast concrete (CFPC) shall meet the requirements of Section 501, Section 507, and Section 540.

543.04 SUBMITTALS. As soon as practical after award of the Contract, all required information shall be prepared and submitted. Fabrication drawings and erection plans shall be submitted as separate submittals.

If the Contractor proposes a different configuration than what is provided in the Plans then a complete copy of the structural design calculations for the CFPC shall be submitted accompanying the construction drawings in accordance with Subsection 105.06. The design calculations shall substantiate that the proposed precast concrete satisfies the design parameters of the Contract. The applicable design code will be the *AASHTO LRFD Bridge Design Specifications* unless indicated otherwise in the Contract.

Fabrication drawings for the precast concrete shall be submitted in accordance with Subsection 105.06. In addition to the requirements for fabrication drawings in Subsection 105.06, the following shall also be included:

(a) The concrete mix design in accordance with Subsection 540.04(a).

(b) Dimensions and tolerances of the sections to be fabricated.

(c) The location of reinforcing steel, splices, welded wire fabric, mechanical bar connectors, and inserts. Reinforcing steel material lists, material designations, and bending details shall also be included.

(d) The type of concrete surface finish and how the finish will be obtained.

(e) The concrete curing method, detailing sequence, and duration in accordance with the requirements of Subsection 501.15.

(f) The minimum required concrete strength for form removal.

(g) The design of the lifting attachments, including the minimum required concrete strength to allow lifting. A professional engineer shall stamp calculations.

Lifting attachments are not required to be permanently installed in the work and may be removed or left in place at the Contractor's convenience, provided that the minimum clear cover is met.

(h) Transportation, handling, and storage details along with calculations to substantiate the proposed CFPC units will not be cracked or damaged by handling or transport. A professional engineer shall stamp calculations.

(i) The installation procedures, including a detailed grouting procedure.

543.05 INSPECTION. Materials furnished and the work performed herein shall be inspected by the Agency. The Agency will test all concrete incorporated into the work in accordance with Section 501. The inspector shall have the authority to reject any material or work that does not meet the requirements of the specifications. Advance notification of at least 14 calendar days shall be provided by the Contractor to the Engineer and the Structural Concrete Engineer concerning the proposed intention to commence work. A minimum notification of 5 working days shall be provided by the Contractor to the Engineer and the Structural Concrete Engineer to confirm the fabrication start date.

543.06 FABRICATION.

(a) Forming Members. Forms and formwork shall meet the requirements of Subsection 501.08.

(b) Reinforcing Steel. Bar reinforcement shall be furnished and installed as per Section 507.

(c) Pre-Production Meeting. Unless the Engineer deems, in writing, that a pre-production meeting is unnecessary, then a pre-production meeting shall be held a minimum of 7 calendar days prior to beginning concrete placement. At a minimum, the pre-production meeting shall be attended by the crew supervisor, Contractor project manager, concrete producer, Engineer, Construction Structures Engineer, and Project Manager.

(d) Placing Concrete. Concrete placement shall be in accordance with Subsection 501.09 and as specified herein. Concrete shall not be deposited in the forms until the appropriate Agency representative has approved placement of the reinforcement, conduits, and anchorages.

(e) Curing. Curing shall meet the requirements of Subsection 501.15.

(f) Removal of Forms. Forms shall not be removed until the curing period has ended.

(g) Concrete Finishing. Finishing shall conform to the requirements of Subsection 501.14.

(h) Repairs and Patching. CFPC structure components that contain minor defects caused by manufacture or handling may be repaired at the manufacturing site. Minor defects are defined as holes, honeycombing, or spalls which are 6 inches or less in diameter and that do not penetrate deeper than 1 inch into the concrete. Surface voids or bug holes that are less than 5/8 inch in diameter and less than 1/4 inch deep need not be repaired. Repairs shall be made using a material from the Agency's *Approved Products List* for overhead and vertical concrete repair. The repair material shall be cured as specified by the manufacturer. Repairs shall be approved by the Engineer.

(i) Cracking. Cracks less than 0.01 inch in width shall be sealed by a method approved by the Engineer. Cracks in excess of 0.01 inch may be cause for rejection. At the Engineer's discretion, cracked CFPC structure components shall be repaired or replaced at the Contractor's expense.

(j) Dimensional Tolerances. All tolerances shall be in accordance with both *PCI MNL-116* and *PCI MNL-135*, or with the *NPCA Quality Control Manual for Precast Concrete*, unless otherwise noted in the Contract or as approved by the Engineer.

(k) Marking. The date of manufacture, the production lot number, and the piece mark shall be clearly marked on each individual piece of precast concrete. The mark shall be in a location that will not be visible in the finished product.

(l) Production Site Handling. Units shall not be lifted, moved, or otherwise disturbed until the curing period is complete and the concrete has reached the minimum compressive strength required for lifting per the approved lifting attachment design.

543.07 HANDLING, STORAGE, AND SHIPPING. Each CFPC structure shall be handled, stored, and shipped in such a manner as to minimize chipping, cracks, fractures, discoloration, and excessive bending stresses. A unit damaged by handling, storage, or shipping shall be replaced at the Contractor's expense.

A CFPC structure shall not be installed until the respective unit has been inspected. This inspection shall verify that the pieces are free from defects, and that all specification requirements, including but not limited to those for compressive strength and tolerance requirements, have been achieved. In addition, a CFPC structure will not be considered for shipment until the completion of the cure period and the required strength has been attained as demonstrated by field cured cylinder breaks.

Field cured test cylinders for production site handling and shipping strength verification purposes shall be tested either at the Agency's Materials Testing and Certification Section Central Laboratory or at an independent laboratory approved by the Engineer. An Agency representative shall witness all tests.

If an independent laboratory is proposed to be used to test the field cured cylinders, the Contractor shall submit documentation providing verification for the following:

(a) That calibration of the compression machine has been performed in accordance with *ASTM C39, Section 5*

(b) That the compression machine meets the requirements of *ASTM C39*

(c) That the technician who will be performing the test is proficient in the test methods

The Agency at any time reserves the right to perform an independent proficiency evaluation of the technician for the test methods used and review the testing facility.

543.08 INSTALLATION METHODS, EQUIPMENT, AND ERECTION. Cranes, lifting devices, and other equipment for CFPC structure erection shall be of adequate design and capacity to safely erect, align, and secure all members and components in their final positions without damage. The Contractor is solely responsible for the methods and equipment employed for the erection of the CFPC structure components.

Construction drawings for CFPC structure component erection shall be submitted in accordance with Subsection 105.06. The erection plan shall include the necessary computations to indicate the magnitude of stress in the units during erection and to demonstrate that all of the erection equipment has adequate capacity for the work to be performed, and provisions for all stages of construction, including temporary stoppages.

Post tensioning shall comply with Subsection 540.12.

Submittal of the erection plan is for documentation purposes only and shall in no way be construed as approval of the proposed method of erection. The Contractor shall follow the erection plan as submitted.

543.09 GROUT. Grout shall be placed in accordance with the requirements of Subsection 540.11.

543.10 METHOD OF MEASUREMENT. The quantity of Contractor-Fabricated Precast Concrete Structure of the type and size specified to be measured for payment will be on a lump sum basis in the complete and accepted work. The lump sum will include all of the CFPC structure components for each location specified in the Contract.

543.11 BASIS OF PAYMENT. The accepted quantity of Contractor-Fabricated Precast Concrete Structure of the type and size specified will be paid for at the Contract lump sum price. Payment will be full compensation for designing, detailing, fabricating, repairing, transporting, handling, and erecting the materials specified, for furnishing and implementing the erection plan, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Any grouting work, such as fairing out unevenness between adjacent precast concrete structure components and filling leveling screw holes, shear keys, transverse anchor recesses, and dowel holes, will be considered incidental to the work for Contractor-Fabricated Precast Concrete Structure.

Payment will be made under:

Pay Item		Pay Unit
543.1000	Contractor-Fabricated Precast Concrete Structure	Lump Sum

SECTION 544 – PREFABRICATED BRIDGE UNIT SUPERSTRUCTURE

544.01 DESCRIPTION. This work shall consist of manufacturing, transporting, and erecting concrete and steel composite Prefabricated Bridge Units (PBUs) as shown on the Plans.

The work under this section shall be performed in accordance with these provisions, the Plans, and Section 501, Section 506, Section 507, and Section 508.

544.02 MATERIALS. Materials shall meet the material requirements specified in Subsection 501.02, Subsection 506.02, Subsection 507.02, and Subsection 508.02.

544.03 GENERAL FABRICATION REQUIREMENTS. The structural steel furnished under this section shall be fabricated in a plant meeting the requirements of Subsection 506.03. After fabrication, the structural steel shall be transported to a location approved by the Agency where the steel will be shop galvanized, metallized, or painted, or where the remainder of the composite superstructure unit will be fabricated.

The fabricator or Contractor constructing the reinforced concrete portion of the PBUs shall have demonstrated experience in forming, casting, curing, and finishing performance-based concrete superstructure decks in accordance with Section 501.

544.04 SUBMITTALS. As soon as practical after award of the Contract, all required information shall be prepared and submitted. Fabrication drawings and erection plans shall be submitted as separate submittals.

Fabrication drawings for the PBUs shall be submitted in accordance with Subsection 105.06. In addition to the requirements for fabrication drawings in Subsection 105.06, the following shall be included:

(a) Structural steel information in accordance with Subsection 506.04.

(b) Dimensions and tolerances of the sections to be fabricated.

(c) The location of reinforcing steel, splices, welded wire fabric, mechanical bar connectors, and inserts. Reinforcing steel material lists, material designations, and bending details shall also be included.

(d) The type of concrete surface finish and how the finish will be obtained.

(e) The concrete curing method, detailing sequence, and duration in accordance with the requirements of Subsection 501.15.

(f) Temporary assembly plan and procedure.

(g) Temporary support elevations.

(h) Method of supporting the screed.

(i) The design of the lifting attachments. A professional engineer shall stamp all calculations.

Lifting attachments are not required to be permanently installed in the work and may be removed or left in place at the Contractor's convenience, provided that the minimum clear cover is met.

(j) Transportation, handling, and storage details along with calculations to substantiate that the PBUs will not be cracked or damaged by handling or transport. A professional engineer shall stamp all calculations.

544.05 INSPECTION. Structural steel shall be inspected by the Agency in accordance with Subsection 106.04 and Section 506.

Concrete elements furnished and the work performed herein shall be inspected by the Agency. The inspector shall have the authority to reject any material or work that does not meet the requirements of these specifications. Advance notification of at least 14 calendar days shall be provided by the Contractor to the Engineer and the Structural Concrete Engineer concerning the proposed intention to commence work. A minimum notification of 5 working days shall be provided by the Contractor to the Engineer and the Structural Concrete Engineer to confirm the fabrication start date.

544.06 FABRICATION.

(a) Forming Members. Forms and formwork shall meet the requirements of Subsection 501.08. Relative bearing elevations shall be within ± 0.01 feet of that shown on the Plans.

(b) Structural Steel. Structural steel shall be fabricated in conformance with Section 506. All diaphragms shown on the Plans shall be installed prior to placing any concrete formwork.

(c) Welding. All welding shall conform to the requirements of Subsection 506.10.

(d) Reinforcing Steel. Bar reinforcement shall be furnished and installed in conformance with Section 507.

(e) Concrete. Concrete mix and proportioning shall meet the requirements of Subsection 501.03 for Performance-Based Concrete, Class PCD. Concrete shall be produced and tested in accordance with Subsection 501.04 through Subsection 501.07.

(f) Pre-Production Meeting. Unless the Engineer deems, in writing, that a pre-production meeting is unnecessary, then a pre-production meeting shall be held a minimum of 7 calendar days prior to beginning concrete placement. The pre-production meeting shall be attended by, but not be limited to, the crew supervisor, Contractor project manager, concrete producer, Engineer, Construction Structures Engineer, and Project Manager.

(g) Placing Concrete. Concrete placement shall conform to the requirements of Subsection 501.09.

Concrete shall not be deposited in the forms until the Agency representative has approved placement of the reinforcement and inserts. The concrete shall be vibrated internally, externally, or a combination thereof to the required consolidation. The vibrating shall be done with care and in such a manner that:

(1) Concrete is uniformly consolidated

(2) Displacement of reinforcement and inserts is avoided

(3) Acceptable finish surfaces are produced

(h) Curing. Curing shall meet the requirements of Subsection 501.15.

(i) Removal of Forms. Forms shall not be removed until the curing period has ended.

(j) Concrete Finishing. Finishing shall conform to the requirements of Subsection 501.14.

(k) Dimensional Tolerances.

(1) Geometry of PBUs.

a. The length of each unit shall be within a tolerance of ± 3/4 inch (i.e. adjacent unit lengths shall not vary by more than 3/4 inch).

b. The width shall be within a tolerance of ± 3/8 inch.

c. The deck thickness shall have a tolerance of + 3/8 inch, - 1/4 inch.

d. The allowable deviation from diagonals shall be ± 3/4 inch (horizontal).

e. The allowable deviation from end squareness or skew shall be ± 3/4 inch (horizontal).

f. The tolerance for girder spacing within a unit shall be ± 1/2 inch.

g. The tolerance for horizontal alignment, measured as the deviation from a straight line parallel to the centerline of the unit, shall be ± 3/8 inch.

h. The tolerance for insert locations shall be ± 3/8 inch.

(2) Reinforcing.

a. The tolerance for reinforcing spacing shall be ± 1 inch (non-cumulative).

b. The tolerance for reinforcing clear cover on the top and bottom mat shall be ± 1/4 inch.

(3) Field Installation.

a. The vertical deviation between units prior to closure pour concrete placement shall not exceed 1/4 inch.

b. The allowable deviation in joint width between units shall be ± 1/2 inch.

(l) Acceptance of Units. Individual precast units will not be accepted for any of the following reasons:

(1) Fractures or cracks passing through the deck

(2) Camber that does not meet the requirements in the approved fabrication drawings

(3) Honeycombed open texture

(4) Dimensions not within the allowable tolerances as specified

(5) Separation of the concrete deck from the steel girders

(6) Defects that indicate proportioning, mixing, and molding not in compliance with the specifications

(7) Damaged ends where such damage would prevent making a satisfactory joint

(8) Units with cracks within any part of the concrete that are greater than 0.03 inches in width

(9) Significant damage to the units during transportation, erection, or construction as determined by the Engineer

(10) Units not fabricated in accordance with the Contract

(m) Repairing and Patching. Units that contain minor defects caused by manufacture or handling may be repaired at the manufacturing site. Minor defects are defined as holes, honeycombing, or spalls which are 6 inches or less in diameter and do not penetrate deeper than 1 inch into the concrete. Surface voids or bug holes that are less than 5/8 inch in diameter and less than 1/4 inch deep need not be repaired. Repairs shall be made using an overhead and vertical concrete repair material satisfactory to the Engineer. The repair material shall be cured as specified by the manufacturer. Repairs shall be approved by the Engineer.

(n) Cracks. Crack widths less than 0.01 inch in width shall be sealed with a penetrating sealer using Agency approved materials and procedures. Crack widths measuring 0.01 inch to 0.03 inch in width shall be epoxy injected using Agency approved materials and procedures. At the Engineer's discretion, cracked members shall be repaired or replaced at the Contractor's expense.

(o) Labeling. Each unit shall be clearly and permanently labeled on the underside of the deck (in the vicinity of the upstation end diaphragm) with the following information:

(1) Manufacturer

(2) Date of manufacture

(3) Mark number

(p) Production Site Handling. Units shall not be lifted, moved, or otherwise disturbed until the curing period is complete and the concrete has reached full design strength.

(q) Pre-Assembly. The units shall be pre-assembled at the fabrication location to ensure proper match between adjacent units before shipping to the project site, to the satisfaction of the Agency.

(r) Shipping. Units shall not be shipped until the minimum 28-day strength is attained and they have been stamped by the Agency. The Contractor shall give the Engineer 48-hours' advanced notice of the loading and shipping schedule. The units shall be secured on the vehicle in order that no fatigue cracking will occur during transport. The Contractor shall secure the necessary hauling permits.

544.07 HANDLING. PBUs shall be handled, stored, and shipped in such a manner as to minimize chipping, cracks, fractures, discoloration, and excessive bending stresses. Units damaged by handling, storage, or shipping shall be replaced at the Contractor's expense.

Field cured test cylinders for production site handling and shipping strength verification purposes shall be tested either at the Agency's Materials Testing and Certification Section Central Laboratory or at an independent laboratory approved by the Engineer. An Agency representative shall witness all tests.

If an independent lab is proposed to be used to test the field cured cylinders, the Contractor shall submit documentation providing verification for the following:

(a) That calibration of the compression machine has been performed in accordance with *ASTM C39, Section 5*

(b) That the compression machine meets the requirements of *ASTM C39*

(c) That the technician who will be performing the test is proficient in the test methods

The Agency at any time reserves the right to perform an independent proficiency of the technician for the test methods used and review of the testing facility.

544.08 INSTALLATION.

(a) General Requirements. The PBUs shall be fabricated in accordance with the applicable sections of the specifications for each respective item. Construction procedures and permissible variations other than those contained herein shall be submitted for approval.

(b) Erection Plan. Cranes, lifting devices, and other equipment for erecting PBUs shall be of adequate design and capacity to safely erect, align, and secure all members and components in their final positions without damage. The Contractor is solely responsible for the methods and equipment employed for the erection of the PBUs.

The Contractor shall submit construction drawings in accordance with Subsection 105.06 for the methods and sequence of PBU erection, the temporary bracing, and the equipment to be used for the erection. The erection plan shall include the necessary computations to indicate the magnitude of stress in the segments during erection and to demonstrate that all of the erection equipment has adequate capacity for the work to be performed. The erection plan shall contain provisions for all stages of construction, including temporary stoppages.

The PBUs may be used to support equipment prior to placement of the closure pour concrete only with written permission of the Engineer. The proposed use of the PBUs for support of equipment shall be detailed in the erection plan.

Submittal of the erection plan is for documentation purposes only and shall in no way be construed as approval of the proposed method of erection. Unless otherwise directed by the Engineer, the Contractor shall follow the erection plan as submitted.

(c) Erection of Units. Erection of units shall not proceed until substructure concrete has been cured for the minimum length of time specified in the Plans or appropriate specifications. Units shall be installed to the correct line and grade as shown on the approved drawings and as indicated in the approved erection procedure. Prior to setting units and to avoid torsion stresses, bearing elevations within a given PBU shall be adjusted to match relative elevations used during the deck casting operations. After all the units are erected, they shall be inspected to ensure the correctness of their location.

(d) Matching Elevation of Units During Erection. Adjacent units shall match elevation within 1/4 inch vertically (along longitudinal edges) and 1/4 inch vertically at the end of units.

(e) Filling and Sealing Longitudinal Joints. Prior to the placement of closure pour concrete or grout material, the surface of the joint shall be free of any material, such as oil, grease, or dirt, which may prevent bonding of the sealing materials.

(f) Sealing of Lifting Holes. After the units are in their final locations, a bonding agent shall be applied and the lifting holes filled with a Type IV mortar. A removable form shall be provided at the bottom surface of the deck to retain the grout.

(g) Loading. Units may be loaded upon erection and before the joints are sealed only with written permission of the Engineer and in accordance with the approved erection procedure. Once the joints are sealed, no further loading or unloading of the units will be allowed until the joint material has properly and finally cured and as approved by the Engineer.

(h) Final Repairs. After the installation work is complete, remaining concrete defects, holes for inserts, and lifting holes shall be repaired as indicated and approved by the Engineer.

(i) Grout. Grout shall be placed in accordance with the requirements of Subsection 540.11.

544.09 METHOD OF MEASUREMENT. The quantity of Prefabricated Bridge Unit Superstructure to be measured for payment will be the number of linear feet installed in the complete and accepted work. Measurement will be the end-to-end length of the structural steel girder along the centerline per unit.

544.10 BASIS OF PAYMENT. The accepted quantity of Prefabricated Bridge Unit Superstructure will be paid for at the Contract unit price per linear foot. Payment will be full compensation for detailing, fabricating, repairing, quality control testing, transporting, handling, and installing the materials specified, including concrete, reinforcing steel, structural steel, shear connectors, mechanical connectors, and shims; for designing and installing lifting devices and any other material contained within or attached to the members; for any grouting work required; for furnishing and implementing the erection plan; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
544.1000 Prefabricated Bridge Unit Superstructure	Linear Foot

SECTION 546 – PRE-EXCAVATION OF ABUTMENT PILES

546.01 DESCRIPTION. This work shall consist of drilling a hole to remove all subsurface material and backfilling in designated areas to provide suitable pile placement or driving conditions.

546.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Sand Borrow and Cushion 703.03

546.03 CONSTRUCTION REQUIREMENTS. The pre-excavation of abutment piles shall consist of augering, pre-boring, or some other means of excavation to produce an excavation to the depth and diameter specified in the Contract. The excavation shall be maintained to allow for backfilling with sand in accordance with the Contract. Temporary casing will be considered an acceptable option.

Unless otherwise specified in the Plans, the entire pre-excavation shall be filled with sand and the temporary casing shall be removed prior to installing piles.

546.04 DEFINITIONS.

(a) Earth. In addition to the definition of earth in Subsection 101.02, cobbles, boulders, and densely packed gravel will be considered excavation of earth.

(b) Rock. All excavation of bedrock as determined by the Engineer.

546.05 METHOD OF MEASUREMENT. The quantities of Pre-Excavation of Abutment Piles, Earth and Pre-Excavation of Abutment Piles, Rock to be measured for payment will be the total number of linear feet of excavation to the depth specified in the Contract or as ordered by the Engineer, measured to the nearest linear foot.

(a) Earth. Where Structure Excavation and Pre-excavation of Abutment Piles, Earth occur jointly or separately at the same location, measurement for Pre-excavation of Abutment Piles, Earth will be made only below the lower limits of Structure Excavation.

(b) Rock. The quantity of Pre-excavation of Abutment Piles, Rock to be measured for payment will be below the top surface of bedrock as determined by the Engineer.

546.06 BASIS OF PAYMENT. The accepted quantities of Pre-Excavation of Abutment Piles, Earth and Pre-Excavation of Abutment Piles, Rock will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, storing, and installing the materials specified including the sand, for performing required excavation, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
546.1000	Pre-Excavation of Abutment Piles, Earth	Linear Foot
546.2000	Pre-Excavation of Abutment Piles, Rock	Linear Foot

SECTION 551 – PUBLIC PROTECTION FOR BRIDGE PROJECTS

551.01 DESCRIPTION. This work shall consist of providing protection for vehicular and pedestrian traffic traveling below or adjacent to a bridge that is under construction.

551.02 SUBMITTALS. The Contractor shall submit construction drawings in accordance with the requirements of Subsection 105.06 for the methods and sequence of work, including the materials and equipment to be used for the work. The plan shall contain provisions for all stages of construction where any member of the public could be exposed to danger from falling objects or construction operations. Any calculations required to prepare the construction drawings shall be included in the submittal.

551.03 GENERAL REQUIREMENTS. The Contractor shall determine the materials and methods to use for this work based on the conditions at a particular location.

(a) Shielding. Should the Contractor choose to use shielding supported by the existing structure, it shall be made of material of adequate strength and size to completely protect the public from any falling objects related to the construction activities. The existing structure shall be evaluated to determine if it can support the additional loads from the shielding system.

(b) Enclosures. Should the Contractor choose to use an enclosure, it shall be made of material of adequate strength and size to completely protect the public from any falling objects related to the construction activities. Any roadway enclosure or containment system shall be of adequate width and height to allow passage of oversize vehicles. If required by the Engineer, vehicular enclosures which are more than 50 feet long shall have their interior illuminated during daylight hours. Pedestrian enclosures of any length shall have their interior illuminated for the full duration of their use.

(c) Diversions. Should the Contractor choose to divert the vehicular and pedestrian traffic from passing beneath the bridge under construction, the diversion course shall be as shown in the approved traffic control plan and meet the requirements of this specification. Diversions are only allowed when specified in the Contract.

(d) Interruptions. Should the Contractor choose to interrupt the flow of vehicular or pedestrian traffic below a bridge under construction, flaggers shall be used. An interruption shall be defined as the stopping of traffic. The duration of time for each individual interruption shall not exceed 10 minutes, and the total of the interruptions shall not exceed thirty minutes in any hour. Interruptions are not allowed on interstate highways or limited access highways unless otherwise specified in the Contract.

The method or combination of methods the Contractor chooses to use shall be fully operational before any construction work which might endanger the public begins on the bridge.

551.04 METHOD OF MEASUREMENT. The quantity of Public Protection for Bridge Projects to be measured for payment will be on a lump sum basis in the complete and accepted work.

The quantities for uniformed traffic officers and flaggers will be measured separately in accordance with Section 630.

551.05 BASIS OF PAYMENT. The accepted quantity of Public Protection for Bridge Projects will be paid for at the Contract lump sum price. Payment will be full compensation for preparing a public protection plan, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Partial payments will be made as follows:

(a) The first 25% of the Contract lump sum price will be paid once the construction drawings are returned as conforming or conforming with comments.

(b) The remaining 75% of the Contract lump sum price will be paid on a prorated basis for the estimated duration of the Contract work remaining.

Uniformed traffic officers and flaggers will be paid for separately under Contract items 630.1000 and 630.1500, respectively.

Payment will be made under:

Pay Item	Pay Unit
551.1000 Public Protection for Bridge Projects	Lump Sum

SECTION 580 – STRUCTURAL CONCRETE REPAIR

580.01 DESCRIPTION. This work shall consist of the removal and disposal of delaminated and unsound concrete from an existing superstructure or substructure and its replacement with new Portland cement concrete or concrete repair material.

The work under this section shall be performed in accordance with these provisions, the Plans, and Section 541.

580.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Portland Cement 701.02
Portland-Limestone Cement.....701.05
Epoxy Bonding System, Type V.....719.01(b)
Concrete Curing Materials.....725.01
Water 745.01
Concrete Repair Material, Type I.....780.01(a)
Concrete Repair Material, Type II.....780.01(b)
Concrete Repair Material, Type III.....780.01(c)
Concrete Repair Material, Type IV.....780.01(d)

Coarse aggregate for concrete shall meet the requirements of Table 704.02B.

Concrete shall meet the requirements of Section 541.

580.03 GENERAL REQUIREMENTS. The depth of superstructure repair shall be as defined in Table 580.03A and the depth of substructure repairs shall be as defined in Table 580.03B.

For each identified repair area, concrete shall be removed until sound concrete is encountered and the minimum depth of the required repair classification is met. If sound concrete is not encountered within the removal limits for a given repair classification, concrete removal shall continue and the repair shall conform to the requirements of the subsequent repair classification. If the Contractor removes sound concrete to a depth greater than the maximum allowed in the required classification, and exposes more than half of the bar diameter for reinforcing steel beyond the maximum removal limits, the concrete repair area shall be extended to the next classification of repair at no additional cost to the Agency.

TABLE 580.03A – SUPERSTRUCTURE REPAIR CLASSIFICATIONS

Superstructure Repair Class	Minimum Removal [1]	Maximum Removal [1]
Class I	1 inch	Closest face of first mat of reinforcing
Class II	3/4 inch beyond the furthest face of first mat of reinforcing	Closest face of second mat of reinforcing
Class III	Full deck thickness	N/A

[1] As measured from the plane of the original concrete surface in the repair area.

TABLE 580.03B – SUBSTRUCTURE REPAIR CLASSIFICATIONS

Substructure Repair Class	Reinforced Concrete		Unreinforced Concrete	
	Minimum Removal [1]	Maximum Removal [1]	Minimum Removal [1]	Maximum Removal [1]
Class I	1 inch	Closest face of first mat of reinforcing	0 inches	3 inches
Class II	3/4 inch beyond the furthest face of first mat of reinforcing	6 inches [2]	3 inches	6 inches
Class III	6 inches [2]	N/A [2]	6 inches	N/A

[1] As measured from the plane of the original concrete surface in the repair area.

[2] If reinforcing steel is encountered within the specified removal limits and more than half of the bar diameter is exposed, additional concrete shall be removed to a minimum of 3/4 inch beyond the furthest face of the bar. The maximum removal limit for the specified class shall be extended to meet this requirement if necessary.

Unless otherwise specified on the Plans, all superstructure repairs shall be performed with Class HPAA concrete, all substructure repairs shall be performed with Class HPAA concrete or Class SCC concrete, and all overhead repairs shall be performed with Type I concrete repair material.

When the use of concrete repair material is specified on the Plans, it shall be used in accordance with Table 580.03C.

TABLE 580.03C – CONCRETE REPAIR MATERIAL APPLICATIONS

Type of Concrete Repair Material	Position	Formed or Unformed
Type I	Vertical or overhead	Unformed
Type II [1]	Vertical or horizontal	Formed
Type III [1]	Vertical or horizontal	Formed
Type IV [2]	Overhead, vertical, or horizontal	Formed or unformed

[1] The layer thickness of the repair area shall be used to determine whether Type II concrete repair material or Type III concrete repair material will be used for formed vertical and horizontal repairs.

[2] Type IV concrete repair material shall only be used when specified on the Plans.

580.04 PROPORTIONING AND MIXING. All concrete repair materials shall be mixed with a mechanical mixer at the project site in accordance with the manufacturer's recommendations on the project packaging, one bag (unit) at a time. The product shall not be extended with sand or gravel, except for Type III concrete repair material when mixed with approved aggregates in conformance with the manufacturer's recommendations.

At no time shall the recommended water content be exceeded, nor shall any mixture be re-tempered by adding water or remixing once the material has reached initial set.

Type III concrete repair material shall be mixed with approved materials in the proportions designated by the manufacturer or by the Structural Concrete Engineer.

580.05 SURFACE PREPARATION FOR REPAIRS AND MEMBRANES. Surfaces to be repaired shall be removed to sound concrete as directed by the Engineer using approved hand tools, power-driven chipping hammers, or hydro-demolition. When existing reinforcing steel is specified to remain, concrete removal methods shall avoid damaging the reinforcing steel. If the methods of concrete removal cause any damage to reinforcing steel, the Contractor shall replace the damaged reinforcing steel at no additional cost to the Agency and lighter methods of concrete removal shall be used. The use of machine mounted hydraulic hammers is prohibited.

When removing unsound portions of an existing structure in preparation for repair, the edges of all areas to be repaired shall be saw-cut in straight lines to a minimum depth of 1 inch. If methods of concrete removal damage square saw-cut edges, they shall be recut at no additional cost to the Agency.

After complete removal of unsound concrete, the entire concrete surface to be patched, and all exposed steel which will have concrete placed against or around it, including metal plate expansion joints, scuppers, finger plate expansion joints, reinforcing steel, etc., shall be abrasive blast-cleaned a maximum of 24 hours prior to placing the new concrete. Exposed steel shall be abrasive blast-cleaned to a white metal finish. All repair areas shall be flushed using high-pressure air or water to remove all loose particles, dust, and debris.

Air used for cleaning shall be free of oil and other contaminants. After blast-cleaning, once the concrete is wet, whether from flushing or rain, the concrete shall be kept wet until the placing of concrete materials. If the concrete is allowed to dry out or the 24-hour time limit has lapsed, the entire area shall be blast-cleaned and flushed again.

Where concrete repair materials are specified, surface preparation required by the manufacturer shall be performed in addition to the requirements of this subsection.

Surface preparation for membranes shall include all necessary griding required to produce a smooth uniform surface for application of a waterproofing membrane. Hand-held grinders, or a wheel mounted grinder unit specifically designed for the purpose, shall be used. Ridges or areas of unevenness designated by the Engineer shall be ground so that no surface deviation greater than 1/16 inch remains. Further surface preparations shall be performed as required by the manufacturer of waterproofing membrane system. Where the pay item Surface Preparation for Membrane is not included on the Plans, preparing surfaces of superstructure repairs for membrane will be considered incidental to the applicable superstructure repair item.

580.06 FORMS. In addition to the requirements of Subsection 541.08, the forms shall be constructed in such a manner that the final concrete surface has the same architectural score marks and exterior face appearance as the original surface.

580.07 PLACING CONCRETE. In addition to the requirements of Subsection 541.07 and Subsection 541.09, the following is applicable to concrete repair:

(a) Portland Cement Concrete. When an epoxy bonding system is not specified on the Plans, the prepared concrete surface shall be flooded with water for at least one hour prior to fresh concrete placement, standing water shall be removed, and a neat cement paste shall be brushed into the surface. The cement and water shall be mixed to a thick latex paint consistency. The neat cement paste shall not be allowed to dry out before it is covered with fresh concrete. The neat cement paste will not be required for formed vertical substructure repairs.

(b) Concrete Repair Material. The moisture condition of the prepared concrete surface, the use of bonding agents, and the placement of concrete repair materials shall be as recommended by the manufacturer of the product being placed.

580.08 CURING CONCRETE. Concrete repairs shall be cured in accordance with Subsection 541.15 and the requirements of this subsection.

All concrete repairs shall be cured for 7 days regardless of the curing method chosen.

Concrete patches shall be wet cured using one of the methods provided in Subsection 541.15(b). The method described in Subsection 541.15(b)(6) may only be used for unformed vertical and overhead repairs performed with Type I concrete repair material. Membrane-forming curing compounds shall be removed from the concrete surface prior to the application of silane per the manufacturer's instructions. If the method used does not produce the desired results, alternate curing procedures may be required by the Engineer. Evidence of improper cure could be a dry surface, a cracked or cracking surface, or a streaked or blotchy appearance of the surface.

Concrete repair materials shall be cured in accordance with the manufacturer's recommendations on the product packaging or specification sheet. Where the manufacturer's recommendations do not specify curing requirements, the concrete repairs shall be cured in accordance with this subsection.

580.09 METHOD OF MEASUREMENT. The quantity of Repair of Concrete Superstructure Surface, Class I and Repair of Concrete Superstructure Surface, Class II to be measured for payment will be the number of square yards of concrete surfaces repaired.

The quantity of Repair of Concrete Superstructure Surface, Class III to be measured for payment will be the number of cubic yards of concrete or concrete repair material, as applicable, placed.

The quantity of Repair of Concrete Substructure Surface, Class I and Repair of Concrete Substructure Surface, Class II to be measured for payment will be the number of square yards of substructure surfaces repaired.

The quantity of Repair of Concrete Substructure Surface, Class III to be measured for payment will be the number of cubic yards of concrete or concrete repair material, as applicable, placed.

The quantity of Surface Preparation for Membrane to be measured for payment will be the number of square feet of surface prepared. Payment will be made for surface preparation of existing surfaces, with no deductions made for areas of new patches.

The quantity of Concrete Repair Material, Type I; Concrete Repair Material, Type II; and Concrete Repair Material, Type III to be measured for payment will be the number of cubic feet of material mixed for use, as approved by the Engineer. The volume will be computed on the basis of the quantity identified as being contained in the product packaging.

The quantity of Concrete Repair Material, Type IV to be measured for payment will be the number of cubic yards of material mixed for use, as approved by the Engineer. The volume will be computed on the basis of the quantity identified as being contained in the product packaging.

580.10 BASIS OF PAYMENT. The accepted quantity of Repair of Concrete Superstructure Surface, Class I; Repair of Concrete Superstructure Surface, Class II; Repair of Concrete Substructure Surface, Class I; and Repair of Concrete Substructure Surface, Class II will be paid for at the Contract unit price per square yard.

The accepted quantity of Repair of Concrete Superstructure Surface, Class III and Repair of Concrete Substructure Surface, Class III will be paid for at the Contract unit price per cubic yard.

Payment will be full compensation for performing the work, including surface preparation as specified, removal and replacement of concrete, satisfactory completion of curing, and for furnishing all forms, materials (including joint filler), labor, tools, admixtures, equipment, and incidentals necessary to complete the work. The cost of heating or cooling materials and protecting the concrete against cold weather and any additional cost for cement shall be included in the Contract unit price for the applicable concrete repair item in the Contract.

Duplicate payment will not be made for preparation of concrete surfaces in any area. For example, if an area is originally prepared as Class I and the Engineer orders a change to the Class II depth, the area will be paid as Class II.

The accepted quantity of Surface Preparation for Membrane will be paid for at the Contract unit price per square foot. Payment will be full compensation for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Concrete Repair Material, Type I; Concrete Repair Material, Type II; and Concrete Repair Material, Type III will be paid for at the Contract unit price bid per cubic foot. Payment will be full compensation for furnishing, transporting, storing, handling, and placing the materials specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Concrete Repair Material, Type IV will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for furnishing, transporting, storing, handling, and placing the materials specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
580.1001	Repair of Concrete Superstructure Surface, Class I	Square Yard
580.1002	Repair of Concrete Superstructure Surface, Class II	Square Yard
580.1003	Repair of Concrete Superstructure Surface, Class III	Cubic Yard
580.1101	Repair of Concrete Substructure Surface, Class I	Square Yard
580.1102	Repair of Concrete Substructure Surface, Class II	Square Yard
580.1103	Repair of Concrete Substructure Surface, Class III	Cubic Yard
580.1201	Concrete Repair Material, Type I	Cubic Foot
580.1202	Concrete Repair Material, Type II	Cubic Foot
580.1203	Concrete Repair Material, Type III	Cubic Foot
580.1204	Concrete Repair Material, Type IV	Cubic Yard
580.1600	Surface Preparation for Membrane	Square Foot

SECTION 590 – BUILDINGS

590.01 DESCRIPTION. This work shall consist of constructing buildings at the locations shown in the Plans and as directed by the Engineer.

590.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Mortar, Type IV .....707.01(e)
Joint Sealant, Elastomeric 707.16
Joint Sealant, Latex 707.17
Structural Lumber and Timber 709.01
Structural Steel 714.02
Carbon Steel Bolts, Nuts, and Washers 714.04
Anchor Bolts for Bearing Devices 714.08
Roofing Systems 715.04
Epoxy Bonding Systems 719.01

Paint shall be a durable, latex-based, exterior paint. The paint shall be a green color that matches the green roof color as closely as possible. The color shall be approved by the Engineer.

The moisture content requirements of Subsection 709.01(b) will not apply to timbers where the actual (dressed) width and thickness of the timber are both greater than or equal to 5 inches.

Oil sealers shall maintain stability under freeze/thaw conditions, provide deep penetration, shall be capable of being reapplied without sanding or stripping, contain no toxic solvents or chemicals, and provide UV, mildew, and rot protection.

(a) Roofing. Metal panels shall be 12 inches wide, 1 inch tall, have vertical ribs at the panel edges for the full length of the panel, and a flat pan between ribs. The panels shall be designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of the panels, engaging the opposite edge of adjacent panels, and snapping the panels together.

Metal panel joints shall be fabricated with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.

Metal panels may be factory-formed or fabricated on-site. Panels fabricated on-site shall be produced using UL-certified portable roll-forming equipment and shall be of the same profile and warrantied by the manufacturer to be equal to factory-formed panels. Panels shall be fabricated according to the equipment manufacturer's written instructions and shall comply with the details shown on the Plans.

(b) Windows. Windows shall be single panel fixed units. All frame and sash extruded sections shall be constructed from aluminum alloys suitable for the finish selected. The hardware components shall be of non-ferrous, non-magnetic metals or stainless steel.

Frames shall be sized to accommodate 1/2-inch-thick polycarbonate plastic.

Windows shall be a clear 1/2-inch-thick polycarbonate plastic sheet that is impact, abrasive, UV, weathering, and graffiti resistant with high light transmission.

Windows shall be accompanied by a 10-year manufacturer's warranty against yellowing, abrasion, breakage, loss of light transmission, and coating failure.

(c) Joint Sealants. Joint sealants shall be in accordance with Subsection 707.16 or Subsection 707.17. Joint sealants, backings, and other related materials shall be compatible with one another and with the joint substrates under conditions of service and application, as demonstrated by the sealant manufacturer, based on testing and field experience. The color of the joint sealants shall be as indicated by the manufacturer's designations.

(d) Anchors. The Contractor may use cast-in-place anchors, drilled and mortared anchors, or an injection adhesive anchor system. Anchors shall be hot dipped galvanized threaded steel rods, complete with nuts, washers, and, where applicable, a polymer or hybrid mortar adhesive injection system.

Cast-in-place anchors shall be L-shaped, at least 8 inches long, and have a diameter of 3/4 inch.

Drilled and mortared anchors and injection adhesive anchors shall have a straight shank with a diameter of 3/4 inch.

The adhesive component of injection adhesive anchor systems shall comply with *AASHTO M 235*.

590.03 SUBMITTALS. The Contractor shall submit fabrication drawings in accordance with Subsection 105.06. The submittal shall contain, as a minimum, the following information:

(a) Product data and test reports for each type of product.

(b) Fabrication and installation layouts of metal roof panels. These shall include details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, accessories, and special details.

(c) Drawings of the windows showing all sections and details.

(d) Instructions and installation recommendations and a full explanation of proper receipt, handling, storage, and installation procedures for all components.

(e) Samples of special warranties.

Prior to performing any work under this section, the Contractor shall have received approval for all fabrication drawings. The Contractor shall notify the Engineer a minimum of 7 calendar days prior to beginning assembly. The Contractor shall bear full responsibility for costs of all materials ordered, raw materials stockpiled, and for work performed prior to approval of the fabrication drawings or written authorization from the Engineer.

590.04 INSTALLATION. Installation shall meet the following requirements:

(a) Framing. Timber framing joints shall be mortised and tenoned using traditional timber framing methods.

MDO plywood exposed surfaces shall be primed and painted with a durable exterior latex paint to the satisfaction of the Engineer.

All exposed wood surfaces shall be finished with a transparent penetrating oil sealer to the satisfaction of the Engineer.

(b) Roofing.

(1) Pre-Installation Conference. Prior to installing the roof, a conference shall be conducted with the Engineer at a location determined by the Agency.

(2) Qualifications. The Contractor shall employ installers and supervisors who are trained and approved by the manufacturer.

(3) Preparation. Sub-framing, furring, and other miscellaneous panel support members and anchorages shall be installed in accordance with *ASTM C754* and the metal panel manufacturer's written recommendations.

(4) Underlayment Installation. Felt underlayment shall be applied over the entire roof surface in a shingle fashion to shed water. Joints shall be lapped at least 2 inches.

Slip sheet shall be applied over the underlayment before metal roof panels are installed.

Flashing shall be installed to cover underlayment and to comply with industry standards.

(5) Roof Installation.

a. Standing-Seam Metal Roof Panel Installation. Metal roof panels shall be fastened to supports with concealed clips at each standing-seam joint at locations, spacings, and with fasteners recommended in writing by the manufacturer.

1. Clips. Clips shall be connected to supports with self-tapping fasteners.

2. Pressure Plates. Pressure plates shall be installed at the locations indicated in the manufacturer's written installation instructions.

3. Snap Joint. Standing seams shall be nested and fastened together by interlocking such that the factory-applied sealant is completely engaged.

4. Seamed Joint. Standing seams shall be crimped with a manufacturer-approved motorized seamer tool so that the clip, metal roof panel, and factory-applied sealant are completely engaged.

5. Watertight Installation. A continuous ribbon of sealant or tape, as recommended by the manufacturer, shall be applied to seal joints of metal panels to make them watertight.

Sealant or tape shall be placed between panels and protruding equipment, vents, and accessories.

At panel splices, panels shall be nested with a minimum 6-inch end lap, sealed with sealant, and fastened together by interlocking clamping plates.

b. Accessory Installation. Accessories shall be positively anchored using a weathertight mounting that provides for thermal expansion. Installation shall be coordinated with flashings and other components.

c. Flashing and Trim. Installation of flashing and trim shall comply with performance requirements, the manufacturer's written installation instructions, and the SMACNA *Architectural Sheet Metal Manual*. Concealed fasteners shall be used where possible, and units shall be set true to line and level as indicated. Laps, joints, and seams shall be permanently watertight and weather resistant.

(6) Cleaning and Protection. Temporary protective coverings and strippable films, if present, shall be removed as metal panels are installed, unless otherwise indicated in the manufacturer's written installation instructions. Upon completion of metal panel installation, finished surfaces shall be cleaned as recommended by the metal panel manufacturer. The roof shall be maintained in a clean condition during construction.

(c) Windows. The Contractor shall comply with the manufacturer's specifications and recommendations for the installation of window units, hardware, operators, and other components of the work.

Units shall be set plumb, level, and true to line, without warp or rack of frames or sash, and anchored securely in place. Aluminum, zinc coated, and other corrodible metal surfaces shall be separated from sources of corrosion or electrolytic action at points of contact with other materials.

Metal surfaces shall be cleaned promptly after installation of windows. Care shall be taken to avoid damage to the protective coating, if any. Any excess glazing and sealant compounds, dirt, or other substances shall be removed.

The manufacturer shall advise the Contractor of protective treatments and other precautions required through the remainder of the construction period to ensure that window units will not have suffered damage or deterioration at the time of acceptance.

(d) Joint Sealant.

(1) General Requirements. Joint sealants shall not be installed under the following conditions:

a. When ambient and substrate temperature conditions are outside limits permitted by the joint-sealant manufacturer or are below 40°F.

b. When joint substrates are wet.

c. Where joint widths are less than or greater than those allowed by the joint-sealant manufacturer for the applications indicated.

d. When contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

e. When substrates have not cured sufficiently.

(2) Surface Cleaning of Joints. Joints shall be cleaned out immediately prior to installing joint sealants to comply with the joint-sealant manufacturer's written instructions and the following requirements:

a. All foreign material that could interfere with adhesion of the joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by the sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost shall be removed from joint substrates.

b. Porous joint substrate surfaces shall be cleaned by brushing, grinding, blast cleaning, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing an optimum bond with joint sealants. Loose particles remaining after cleaning operations shall be removed by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include concrete, masonry, wood, and unglazed surfaces of ceramic tile.

c. Nonporous surfaces shall be cleaned with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with the adhesion of joint sealants. Nonporous joint substrates include metal, glass, porcelain enamel, and glazed surfaces of ceramic tile.

(3) Joint Priming. Masking tape shall be used where required to prevent contact of sealants with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Masking tape shall be removed immediately after tooling without disturbing the joint seal.

This work shall comply with the joint sealant manufacturer's written installation instructions, unless more stringent requirements apply.

(4) Sealant Installation. Sealant backings shall be installed to support sealants during application. Installation shall meet the following requirements:

a. Gaps shall not be left between the ends of sealant backings.

b. Sealant backings shall not be stretched, twisted, punctured, or torn.

c. Excess material shall be removed.

d. Absorbent sealant backings that have become wet shall be removed before sealant application and replaced with dry materials. Bond-breaker tape shall be installed behind sealants where sealant backings are not used between sealants and backs of joints.

e. Sealants shall be installed using proven techniques at the same time backings are installed.

f. Sealants shall be placed so they directly contact and fully wet joint substrates.

g. Recesses in each joint configuration shall be completely filled.

h. Installation shall produce uniform cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

i. Sealants shall be applied in uniform, continuous ribbons without gaps or air pockets.

(5) Tooling of Sealants. Immediately after sealant application and before skinning or curing begins, sealant shall be tooled according to the requirements specified below.

a. Excess sealant shall be removed from surfaces adjacent to joints.

b. Only tooling agents that are approved in writing by the sealant manufacturer and that do not discolor sealants or adjacent surfaces shall be used.

c. The joint shall have a concave configuration as shown in *ASTM C1193, Figure 5A*, unless otherwise indicated on the Plans.

Damaged or deteriorated joint sealants shall be removed immediately such that installations with repaired areas are indistinguishable from original work.

Excess sealant or sealant smears adjacent to joints shall be cleaned off as the work progresses by methods and with cleaning materials approved in writing by the manufacturers of the joint sealant and of the products in which the joints occur.

(e) Anchors.

(1) Cast-In-Place Anchors. Cast-in-place anchors shall have a minimum embedment of 6 inches.

(2) Post-Installed Anchors.

a. General Requirements. Unless otherwise shown on the Plans, all holes shall be drilled perpendicular to the concrete surface. Post-installed anchors shall have a minimum embedment of 6 inches.

1. Embedded Items. The position of reinforcing steel and other embedded items shall be identified prior to drilling holes for anchors. The Contractor shall exercise care in drilling to avoid damaging existing reinforcing or embedded items. The Contractor shall notify the Engineer if reinforcing steel or other embedded items are encountered during drilling.

2. Base Material Strength. Unless otherwise specified, holes shall not be drilled in the concrete until it has achieved its full design strength.

b. Drilled and Mortared Anchors. Holes for drilled and mortared anchors shall be 1 inch to 1-1/2 inches greater in diameter than the anchor. Holes shall be cleaned to remove any loose material and drilling dust prior to the installation of anchor. Anchors shall be secured with Type IV mortar.

c. Injection Adhesive Anchor Systems. Holes for injection adhesive anchor systems shall be of the diameter specified by the anchor manufacturer. All holes shall be cleaned in accordance with the manufacturer's instructions to remove loose material and drilling dust prior to the installation of adhesive.

The Contractor shall follow the manufacturer's recommendations to ensure proper mixing of adhesive components. Adhesive shall be injected into holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive. Sufficient adhesive shall be injected into the hole to ensure that the annular gap is filled to the surface. Excess adhesive shall be removed from the surface. Anchors shall be shimmed with a suitable device to center the anchor in the hole. Anchors shall not be disturbed or loaded before the cure time specified by the manufacturer has elapsed.

The manufacturer's recommendations with respect to installation temperatures shall be observed.

(3) Misplaced or Malfunctioning Anchors. Misplaced or malfunctioning anchors shall be removed and replaced at no additional cost to the Agency. Empty anchor holes and failed anchor locations shall be filled and patched with high-strength, non-shrink, non-metallic grout. Anchors that fail to meet proof load requirements will be regarded as malfunctioning.

(4) Testing. Each anchor shall be subjected to a proof load of 3,000 pounds in accordance with *ASTM E3121*. The proof load shall be applied with a calibrated hydraulic ram. The displacement of the anchor at the proof load shall not exceed D/10, where D is the nominal anchor diameter.

590.05 METHOD OF MEASUREMENT. The quantity of Bus Shelter to be measured for payment will be the number of bus shelters installed in the complete and accepted work.

590.06 BASIS OF PAYMENT. The accepted quantity of Bus Shelter will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing and installing a bus shelter as specified and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
590.0010 Bus Shelter	Each

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DIVISION 600

MISCELLANEOUS CONSTRUCTION

SECTION 601 – CULVERTS AND STORM DRAINS

601.01 DESCRIPTION. This work shall consist of the construction, cleaning, and reconditioning or reconstruction of culverts and storm drains, hereinafter referred to as pipe.

601.02 MATERIALS. Materials shall meet the requirements of the following subsections:

All units in each pipe or pipe arch installation, including elbows, end sections, coupling bands, and reducer units, shall be of the same material, except that corrugated steel pipe end sections shall be used with polymeric coated corrugated steel pipe and pipe arches.

When either corrugated steel pipe or pipe arches with 5 inch × 1 inch corrugations are shown on the Plans, the Contractor may substitute pipe or pipe arches of the same thickness with 3 inch × 1 inch corrugations at no additional compensation.

601.03 GENERAL REQUIREMENTS. Care shall be exercised when unloading pipes from delivery trucks and moving pipes to their final position. If the Engineer rejects damaged pipe, new pipe shall be furnished by the Contractor at no additional cost to the Agency.

Unless otherwise directed by the Engineer, the Contractor shall provide for the temporary diversion of water to permit the installation of the pipe in a reasonably dry trench.

The location of all pipe installations shall be approved by the Engineer.

Where existing pipe is to be retained or re-laid and it becomes damaged due to the fault of the Contractor, it shall be replaced with new pipe at the Contractor's expense.

Aluminum, aluminized, or aluminum-zinc alloy coated pipe that is to be in contact with concrete or mortar shall have the contact surfaces thoroughly coated with an approved barrier coating recommended by the pipe manufacturer or approved by the Agency's Materials Testing and Certification Section. This coating shall be dry before installation.

Where the protective coating has been removed from the metal, either by cutting, burning, welding, placing, or any other means, it shall be repaired by thoroughly cleaning with a wire brush and treating the damaged areas in accordance with *AASHTO M 36* or in accordance with *AASHTO M 245* for damaged polymeric coatings.

601.04 EXCAVATION. Where pipe is to be laid below the existing ground line, a trench shall be excavated to the required depth and to a width sufficient to allow for joining of the pipe and compaction of the bedding and backfill material under and around the pipe.

The completed trench bottom shall be firm for its full length and width.

If shown on the Plans or directed by the Engineer, unsuitable foundation material encountered below the normal grade of the culvert bed shall be removed and replaced with granular backfill for structures, or other specified or approved material.

Bedrock, rocky or gravelly soil, hard pan, or other unyielding foundation material encountered at the normal grade of the culvert bed shall be removed and replaced with granular backfill for structures to a width equal to the inside diameter of the pipe plus 24 inches and to a minimum depth of 12 inches below the pipe grade, unless otherwise shown on the Plans or directed by the Engineer.

601.05 PLACEMENT. No pipe shall be placed until the trench and the prepared foundation have been approved by the Engineer.

Placement shall begin at the outlet end. The bottom of the pipe shall be in contact with the bedding throughout its full length. Bell or grooved ends of rigid pipes and the outside circumferential laps of flexible pipe shall be placed facing upstream. The longitudinal laps or seams of riveted pipe shall be at the sides.

The handling holes in concrete pipes shall be filled with a precast plug, sealed, and covered with mastic or mortar.

601.06 JOINING PIPE.

(a) Concrete Pipe. Concrete pipe shall be of bell and spigot or tongue and groove design, or as specified. Pipe sections shall be joined so that the ends are fully entered and the inner surfaces are reasonably flush and even.

Joints shall be made with Portland cement mortar, Portland cement grout, rubber gaskets, or any one type as specified and approved by the Engineer. Joints in concrete pipes shall be thoroughly wetted before mortar or grout is applied.

Mortar joints shall be made with an excess of mortar to form a bead around the outside of the pipe and finished smooth on the inside. For grouted joints, molds or runners shall be used to retain the poured grout. Rubber ring gaskets shall be installed so as to form a flexible, watertight seal.

When Portland cement mixtures are used, the completed joints shall be protected against rapid drying by suitable curing materials and protected from freezing until adequate set and strength have been reached, as determined by the Engineer.

The first three sections, at ends of culverts that are not restrained by drop inlets or catch basins, shall be connected at the springline on each side of the pipe to restrain movement of the sections. If an end section is used, it shall be one of the three sections to be connected.

The connecting devices shall be at least 12 feet in length when used with 7-1/2 foot minimum length sections and at least 10 feet in length when used with 6 foot minimum length sections. Each device shall be securely anchored to the pipe, with minimum slack in the device and the joints. The anchoring points shall be a minimum of 18 inches from the end of the pipe sections and the flared end sections. Each end of the device shall be anchored with a 1-inch bolt with a nut and washer, or its equivalent, through the section wall.

Each device shall be a steel strap with an effective cross-sectional area of 0.23 square inches for all pipes 48 inches in diameter or smaller. For pipes larger than 48 inches in diameter, the required steel area for restraining devices shall be as shown on the Plans.

Alternate designs of restraining devices and anchoring hardware will be considered for approval if they provide equivalent restraining properties and durability.

Restraining devices shall be placed on the outside of the pipe. Any bending of the device for proper installation shall be done by the cold bending method. Holes in the pipe and end sections, required for the anchor bolts, may be drilled in the field.

(b) Metal Pipe. Metal pipes shall be firmly joined by coupling bands.

Pipes with an effective diameter greater than 36 inches shall be joined by coupling bands that fully engage the second full corrugation from the end of each pipe.

Pipes on steep grades (greater than 14%) will be joined either by 24 inch wide coupling bands or by bands additionally equipped with silo rods or cables for positive attachment.

In all cases, ends of pipes joined by coupling bands shall be as close together as the corrugations will allow.

(c) Corrugated Polyethylene Pipe. Corrugated polyethylene pipe shall be joined by a system designed and approved by the pipe manufacturer. Couplings and fittings shall provide sufficient longitudinal strength to preserve pipe alignment and prevent separation at the joints.

(d) Corrugated Polypropylene Pipe. Corrugated polypropylene pipe shall be joined by a system designed and approved by the pipe manufacturer. Couplings and fittings shall provide sufficient longitudinal strength to preserve pipe alignment and prevent separation at the joints.

601.07 BACKFILLING. Installed pipe will be inspected and approved before any backfill is placed. Any pipe found to be damaged or out of alignment shall be removed and replaced or re-laid without additional compensation.

Unless otherwise shown on the Plans or directed by the Engineer, the backfill material shall be fine selected compactable soil from excavation when available, or granular backfill for structures. This material shall be placed to a height of 24 inches over the pipe. No stones more than 3 inches in diameter shall be placed in contact with the pipe. Rock fill or boulders shall not be placed within 24 inches of the outside of the pipe.

The backfill material shall be placed in 6-inch-thick layers and compacted in accordance with Subsection 203.11(d) using a mechanical tamper. Care shall be exercised to thoroughly compact the material under the haunches of the pipe. The backfill shall be placed evenly on both sides of the pipe for its full length.

In embankment sections the fill shall be compacted for a width on each side of the pipe equal to at least twice the horizontal inside diameter of the pipe or 12 feet, whichever is less. Fill at the sides of the pipe may be compacted by operating compaction equipment longitudinally parallel with the pipe, provided care is taken to avoid displacement or injury to the pipe.

All pipes shall be protected by a cover of fill 4 feet thick before heavy equipment or traffic is permitted to cross during construction. Whenever this cover extends above the subgrade, the Contractor shall temporarily place earth which shall be removed when necessary to complete the work in accordance with the details shown on the Plans or as directed by the Engineer. Any deviation from this practice shall have prior approval by the Engineer. However, compliance with the 4-foot protective cover requirement shall not relieve the Contractor of any responsibility concerning damage to the pipe.

601.08 CLEANING CULVERTS. Pipe culverts at the locations shown on the Plans, or as directed by the Engineer, shall have the silt, debris, and other material removed and disposed of by methods that do not damage the pipe.

With the approval of the Engineer, all or part of a pipe designated to be cleaned in place may be removed, cleaned, and re-laid in accordance with these specifications. In these cases, the Contractor shall furnish all material required to replace damaged pipes and joints, perform all excavation and backfill, and re-lay the pipe, all at the Contract unit price for Cleaning Culvert Pipe, In-Place.

However, if the Engineer determines that the pipe must be replaced, through no fault of the Contractor, replacement will be paid for under the appropriate Contract items.

601.09 METHOD OF MEASUREMENT. The quantities of culverts and storm drains to be measured for payment will be the number of linear feet used in the complete and accepted work, as shown on the Plans or as ordered by the Engineer. No allowance will be made for growth in length at joints when this increase exceeds the ordered length. When it is necessary to cut pipe in the field, the quantity of pipe to be measured for payment will be the length necessary, rounded up to the next whole foot increment.

The quantity of Re-Laying Pipe Culverts of the size specified to be measured for payment will be the number of linear feet of pipe re-laid in the complete and accepted work.

The quantities of pipe elbows and end sections to be measured for payment will be the number of each size and type of unit installed in the complete and accepted work.

The quantity of Cleaning Culvert Pipe, In-Place to be measured for payment will be the total length of pipe for each pipe acceptably cleaned, as determined along the flow line of the pipe. The cost to clean material from pipes as the result of on-project construction activities shall be at the Contractor’s expense.

601.10 BASIS OF PAYMENT. The accepted quantities of culverts and storm drains of the type and size specified will be paid for at the respective Contract unit price per linear foot.

The accepted quantity of Re-Laying Pipe Culverts of the size specified will be paid for at the Contract unit price per linear foot.

The accepted quantities of pipe elbows and end sections of the type and size specified will be paid for at the respective Contract unit price each.

Payment will be full compensation for fabricating, furnishing, transporting, handling, and placing the material specified to include bituminous or other coating, coupling bands, joint material, cutting when necessary, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Excavation, including backfill operations and the disposal of excavated material (excess or unsuitable for backfill), will be paid for separately and in accordance with Section 204.

Anchor bolts, required in the construction of headwalls, will not be paid for separately but will be considered incidental to the Contract unit price for the pipe on which they are required.

The accepted quantity of Cleaning Culvert Pipe, In-Place will be paid for at the Contract unit price per linear foot for the specified size of pipe. Payment will be full compensation for cleaning the pipe; for excavating, backfilling, and re-laying the pipe, if necessary; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
601.0005	12 Inch CSP .064 (2-2/3 × 1/2)	Linear Foot
601.0010	15 Inch CSP .064 (2-2/3 × 1/2)	Linear Foot
601.0011	15 Inch CSP .079 (2-2/3 × 1/2)	Linear Foot
601.0015	18 Inch CSP .064 (2-2/3 × 1/2)	Linear Foot
601.0016	18 Inch CSP .079 (2-2/3 × 1/2)	Linear Foot
601.0025	24 Inch CSP .064 (2-2/3 × 1/2)	Linear Foot
601.0036	30 Inch CSP .079 (2-2/3 × 1/2)	Linear Foot
601.0046	36 Inch CSP .079 (2-2/3 × 1/2)	Linear Foot
601.0052	42 Inch CSP .109 (2-2/3 × 1/2)	Linear Foot
601.0057	48 Inch CSP .109 (2-2/3 × 1/2)	Linear Foot
601.0068	60 Inch CSP .138 (2-2/3 × 1/2)	Linear Foot
601.0132	60 Inch CSP .109 (3 × 1)	Linear Foot

Pay Item		Pay Unit
601.0205	12 Inch CAAP .060 (2-2/3 × 1/2)	Linear Foot
601.0210	15 Inch CAAP .060 (2-2/3 × 1/2)	Linear Foot
601.0211	15 Inch CAAP .075 (2-2/3 × 1/2)	Linear Foot
601.0215	18 Inch CAAP .060 (2-2/3 × 1/2)	Linear Foot
601.0216	18 Inch CAAP .075 (2-2/3 × 1/2)	Linear Foot
601.0217	18 Inch CAAP .105 (2-2/3 × 1/2)	Linear Foot
601.0225	24 Inch CAAP .060 (2-2/3 × 1/2)	Linear Foot
601.0226	24 Inch CAAP .075 (2-2/3 × 1/2)	Linear Foot
601.0227	24 Inch CAAP .105 (2-2/3 × 1/2)	Linear Foot
601.0236	30 Inch CAAP .075 (2-2/3 × 1/2)	Linear Foot
601.0237	30 Inch CAAP .105 (2-2/3 × 1/2)	Linear Foot
601.0246	36 Inch CAAP .075 (2-2/3 × 1/2)	Linear Foot
601.0252	42 Inch CAAP .105 (2-2/3 × 1/2)	Linear Foot
601.0257	48 Inch CAAP .105 (2-2/3 × 1/2)	Linear Foot
601.0262	54 Inch CAAP .105 (2-2/3 × 1/2)	Linear Foot
601.0268	60 Inch CAAP .135 (2-2/3 × 1/2)	Linear Foot
601.0305	30 Inch CAAP .060 (3 × 1)	Linear Foot
601.0306	30 Inch CAAP .075 (3 × 1)	Linear Foot
601.0310	36 Inch CAAP .060 (3 × 1)	Linear Foot
601.0316	42 Inch CAAP .075 (3 × 1)	Linear Foot
601.0342	72 Inch CAAP .105 (3 × 1)	Linear Foot
601.0405	12 Inch PCCSP .064 (2-2/3 × 1/2)	Linear Foot
601.0410	15 Inch PCCSP .064 (2-2/3 × 1/2)	Linear Foot
601.0415	18 Inch PCCSP .064 (2-2/3 × 1/2)	Linear Foot
601.0416	18 Inch PCCSP .079 (2-2/3 × 1/2)	Linear Foot
601.0425	24 Inch PCCSP .064 (2-2/3 × 1/2)	Linear Foot
601.0426	24 Inch PCCSP .079 (2-2/3 × 1/2)	Linear Foot
601.0427	24 Inch PCCSP .109 (2-2/3 × 1/2)	Linear Foot
601.0436	30 Inch PCCSP .079 (2-2/3 × 1/2)	Linear Foot
601.0437	30 Inch PCCSP .109 (2-2/3 × 1/2)	Linear Foot
601.0446	36 Inch PCCSP .079 (2-2/3 × 1/2)	Linear Foot
601.0447	36 Inch PCCSP .109 (2-2/3 × 1/2)	Linear Foot
601.0452	42 Inch PCCSP .109 (2-2/3 × 1/2)	Linear Foot
601.0457	48 Inch PCCSP .109 (2-2/3 × 1/2)	Linear Foot
601.0526	54 Inch PCCSP .079 (3 × 1)	Linear Foot
601.0527	54 Inch PCCSP .109 (3 × 1)	Linear Foot
601.0542	72 Inch PCCSP .109 (3 × 1)	Linear Foot

Pay Item	Pay Unit
601.0615 18 Inch PCCSP(PI) .064 (2-2/3 × 1/2)	Linear Foot
601.0625 24 Inch PCCSP(PI) .064 (2-2/3 × 1/2)	Linear Foot
601.0636 30 Inch PCCSP(PI) .079 (2-2/3 × 1/2)	Linear Foot
601.0646 36 Inch PCCSP(PI) .079 (2-2/3 × 1/2)	Linear Foot
601.0657 48 Inch PCCSP(PI) .109 (2-2/3 × 1/2)	Linear Foot
601.0805 12 Inch RCP Class III	Linear Foot
601.0806 12 Inch RCP Class IV	Linear Foot
601.0810 15 Inch RCP Class III	Linear Foot
601.0811 15 Inch RCP Class IV	Linear Foot
601.0815 18 Inch RCP Class III	Linear Foot
601.0816 18 Inch RCP Class IV	Linear Foot
601.0817 18 Inch RCP Class V	Linear Foot
601.0820 21 Inch RCP Class III	Linear Foot
601.0821 21 Inch RCP Class IV	Linear Foot
601.0825 24 Inch RCP Class III	Linear Foot
601.0826 24 Inch RCP Class IV	Linear Foot
601.0827 24 Inch RCP Class V	Linear Foot
601.0835 30 Inch RCP Class III	Linear Foot
601.0836 30 Inch RCP Class IV	Linear Foot
601.0837 30 Inch RCP Class V	Linear Foot
601.0845 36 Inch RCP Class III	Linear Foot
601.0846 36 Inch RCP Class IV	Linear Foot
601.0850 42 Inch RCP Class III	Linear Foot
601.0855 48 Inch RCP Class III	Linear Foot
601.0866 60 Inch RCP Class IV	Linear Foot
601.0870 66 Inch RCP Class III	Linear Foot
601.0905 12 Inch CPEP	Linear Foot
601.0910 15 Inch CPEP	Linear Foot
601.0915 18 Inch CPEP	Linear Foot
601.0920 24 Inch CPEP	Linear Foot
601.2603 8 Inch CPEP(SL)	Linear Foot
601.2605 12 Inch CPEP(SL)	Linear Foot
601.2610 15 Inch CPEP(SL)	Linear Foot
601.2615 18 Inch CPEP(SL)	Linear Foot
601.2620 24 Inch CPEP(SL)	Linear Foot
601.2625 30 Inch CPEP(SL)	Linear Foot
601.2630 36 Inch CPEP(SL)	Linear Foot

Pay Item		Pay Unit
601.2635	42 Inch CPEP(SL)	Linear Foot
601.2640	48 Inch CPEP(SL)	Linear Foot
601.2645	54 Inch CPEP(SL)	Linear Foot
601.2650	60 Inch CPEP(SL)	Linear Foot
601.2805	12 Inch CPPP(SL)	Linear Foot
601.2810	15 Inch CPPP(SL)	Linear Foot
601.2815	18 Inch CPPP(SL)	Linear Foot
601.2820	24 Inch CPPP(SL)	Linear Foot
601.2825	30 Inch CPPP(SL)	Linear Foot
601.2830	36 Inch CPPP(SL)	Linear Foot
601.2835	42 Inch CPPP(SL)	Linear Foot
601.3236	35 Inch × 24 Inch CAAPA .075 (2-2/3 × 1/2)	Linear Foot
601.3258	57 Inch × 38 Inch CAAPA .135 (2-2/3 × 1/2)	Linear Foot
601.3436	35 Inch × 24 Inch PCCSPA .079 (2-2/3 × 1/2)	Linear Foot
601.3457	57 Inch × 38 Inch PCCSPA .109 (2-2/3 × 1/2)	Linear Foot
601.4252	49 Inch × 33 Inch CAAPA(SL) .105 (2-2/3 × 1/2)	Linear Foot
601.4258	57 Inch × 38 Inch CAAPA(SL) .135 (2-2/3 × 1/2)	Linear Foot
601.4457	57 Inch × 38 Inch PCCSPA(SL) .109 (2-2/3 × 1/2)	Linear Foot
601.5005	12 Inch CSP Elbow .064 (2-2/3 × 1/2)	Each
601.5010	15 Inch CSP Elbow .064 (2-2/3 × 1/2)	Each
601.5015	18 Inch CSP Elbow .064 (2-2/3 × 1/2)	Each
601.5036	30 Inch CSP Elbow .079 (2-2/3 × 1/2)	Each
601.5046	36 Inch CSP Elbow .079 (2-2/3 × 1/2)	Each
601.5205	12 Inch CAAP Elbow .060 (2-2/3 × 1/2)	Each
601.5210	15 Inch CAAP Elbow .060 (2-2/3 × 1/2)	Each
601.5215	18 Inch CAAP Elbow .060 (2-2/3 × 1/2)	Each
601.5225	24 Inch CAAP Elbow .060 (2-2/3 × 1/2)	Each
601.5236	30 Inch CAAP Elbow .075 (2-2/3 × 1/2)	Each
601.5252	42 Inch CAAP Elbow .105 (2-2/3 × 1/2)	Each
601.5405	12 Inch PCCSP Elbow .064 (2-2/3 × 1/2)	Each
601.5410	15 Inch PCCSP Elbow .064 (2-2/3 × 1/2)	Each
601.5415	18 Inch PCCSP Elbow .064 (2-2/3 × 1/2)	Each
601.5425	24 Inch PCCSP Elbow .064 (2-2/3 × 1/2)	Each
601.5436	30 Inch PCCSP Elbow .079 (2-2/3 × 1/2)	Each
601.5456	42 Inch PCCSP Elbow .109 (2-2/3 × 1/2)	Each
601.5802	12 Inch CPEP Elbow	Each
601.5808	15 Inch CPEP Elbow	Each

Pay Item	Pay Unit
601.5814 18 Inch CPEP Elbow	Each
601.5824 24 Inch CPEP Elbow	Each
601.5902 12 Inch CPPP Elbow	Each
601.5908 15 Inch CPPP Elbow	Each
601.5914 18 Inch CPPP Elbow	Each
601.5924 24 Inch CPPP Elbow	Each
601.6005 12 Inch CSPES .064 (2-2/3 × 1/2)	Each
601.6010 15 Inch CSPES .064 (2-2/3 × 1/2)	Each
601.6015 18 Inch CSPES .064 (2-2/3 × 1/2)	Each
601.6025 24 Inch CSPES .064 (2-2/3 × 1/2)	Each
601.6036 30 Inch CSPES .079 (2-2/3 × 1/2)	Each
601.6046 36 Inch CSPES .079 (2-2/3 × 1/2)	Each
601.6052 42 Inch CSPES .109 (2-2/3 × 1/2)	Each
601.6057 48 Inch CSPES .109 (2-2/3 × 1/2)	Each
601.6210 15 Inch CAAPES .060 (2-2/3 × 1/2)	Each
601.6215 18 Inch CAAPES .060 (2-2/3 × 1/2)	Each
601.6225 24 Inch CAAPES .060 (2-2/3 × 1/2)	Each
601.6236 30 Inch CAAPES .075 (2-2/3 × 1/2)	Each
601.6246 36 Inch CAAPES .075 (2-2/3 × 1/2)	Each
601.6252 42 Inch CAAPES .105 (2-2/3 × 1/2)	Each
601.6257 48 Inch CAAPES .105 (2-2/3 × 1/2)	Each
601.6810 15 Inch RCPES Class III	Each
601.6815 18 Inch RCPES Class III	Each
601.6825 24 Inch RCPES Class III	Each
601.6835 30 Inch RCPES Class III	Each
601.6845 36 Inch RCPES Class III	Each
601.6855 48 Inch RCPES Class III	Each
601.7005 12 Inch CPEPES	Each
601.7010 15 Inch CPEPES	Each
601.7015 18 Inch CPEPES	Each
601.7020 24 Inch CPEPES	Each
601.7025 30 Inch CPEPES	Each
601.7030 36 Inch CPEPES	Each
601.7105 12 Inch CPPPES	Each
601.7110 15 Inch CPPPES	Each
601.7115 18 Inch CPPPES	Each
601.7120 24 Inch CPPPES	Each
601.7125 30 Inch CPPPES	Each
601.7130 36 Inch CPPPES	Each

Pay Item		Pay Unit
601.8036	35 Inch × 24 Inch CSPAES .079 (2-2/3 × 1/2)	Each
601.8236	35 Inch × 24 Inch CAAPAES .075 (2-2/3 × 1/2)	Each
601.9900	Re-Laying Pipe Culverts	Linear Foot
601.9915	Re-Laying Pipe Culverts, 15 Inch	Linear Foot
601.9918	Re-Laying Pipe Culverts, 18 Inch	Linear Foot
601.9924	Re-Laying Pipe Culverts, 24 Inch	Linear Foot
601.9950	Cleaning Culvert Pipe, In-Place (0 to 24 Inches, Inclusive)	Linear Foot
601.9960	Cleaning Culvert Pipe, In-Place (Greater than 24 Inches)	Linear Foot

SECTION 602 – MASONRY

602.01 DESCRIPTION. This work shall consist of furnishing materials and constructing walls and other masonry of the types and sizes specified; or rebuilding, repairing, or repointing existing masonry; or coring into an existing concrete structure and mortaring pipe, ducts, or conduit (collectively termed pipe in this section) into the structure.

602.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Granular Backfill for Structures.....704.08
Stone for Masonry.....706.01
Stone for Masonry Facing.....706.02
Mortar, Type II.....707.01(c)
Mortar, Type IV.....707.01(e)
Mortar, Type V.....707.01(f)
Mortar, Type VI.....707.01(g)
Bar Reinforcement.....713.01

Materials used for rebuilding or repairing stone masonry shall be approved by the Engineer prior to use. New stone, as required, shall match as closely as practical the existing stone masonry color, texture, and size. If required to match the existing stone masonry, chemical treatment processes to aid in providing stone of similar color shall be investigated by the Contractor.

Mortar used in stone masonry and repointing stone masonry shall be Type II, Type V, or Type VI mortar as specified in the Contract.

Concrete for headwalls shall meet the requirements of Section 541 for Concrete, Class B.

Dowels shall be in accordance with the requirements of Subsection 713.01(a), unless otherwise specified on the Plans.

602.03 MIXING OF MORTAR. The fine aggregate and cement shall be mixed in a clean, tight container until a mixture of uniform color is produced, after which clean water shall be added in such quantity as to form a mortar with the consistency of stiff paste. If desired, the Contractor will be permitted to use a batch mixer of an approved size and type. Mortar which has been mixed for more than 45 minutes shall not be used, and re-tempering of mortar will not be permitted.

602.04 PLACING OF STONE. The placing and shaping of stone shall be the same for dry or cement masonry, however, dry masonry shall be placed without the use of mortar.

The bed shall be clean and well moistened just prior to the placement of the stone. The stone shall be thoroughly saturated with water, well bedded into the mortar, and carefully settled in place before the mortar has set. No spalls will be permitted in the bed. Joints and beds shall not average over 1 inch in thickness.

The masonry shall be laid in full mortar beds to the lines shown on the Plans and in approximately level courses. The bottom or foundation courses shall be composed of large, selected stones.

All courses shall be laid with bearing beds parallel to the natural bed of the materials. The larger stone shall be used near the bottom and the smaller stone near the top of the masonry, the latter corresponding, as nearly as possible, to the minimum thickness of the masonry at its top.

The construction of stone masonry will not be permitted in freezing weather or when frost is in the stone, except by written permission of the Engineer and subject to conditions as the Engineer may require.

In walls where the thickness is over 4 feet, the stones used as headers for holding in the heart of the wall shall extend not less than 4 feet into the core and shall occupy not less than 20% of the front and back surface area of the wall. In walls where the thickness is 4 feet or less, the stones used as headers shall extend entirely through the wall.

The break in joints of the stone shall be at least 6 inches on the exposed faces of the wall and the backing stones shall be laid so that the joints are broken. The rear face of the wall shall present an approximately plane surface.

The stone shall be roughly squared on joints, beds, and faces, and shall be pitched to line, at all angles and ends of walls. All shaping or dressing of stones shall be done before the stone is laid in the wall, and no dressing or hammering that would tend to loosen the stones already set will be permitted after their placement. Any stone around which the bond has become broken shall be removed, the mortar shall be thoroughly cleaned from the bed and joints, and the stone shall be reset in fresh mortar.

602.05 WEEP HOLES. Weep holes shall be constructed as shown on the Plans or as ordered by the Engineer.

602.06 REBUILT STONE MASONRY AND REPAIRING STONE MASONRY.

(a) General Requirements.

(1) Rebuilt Stone Masonry. The stone masonry of the existing substructure and wingwalls shall be mapped, removed, and rebuilt as indicated and specified in the Contract.

Following backfill excavation, the existing stones, tree stumps, roots, and other foreign matter shall be removed in the areas shown on the Plans or where directed by the Engineer. The existing stones shall be reset in their original locations, removing any gaps that occurred due to previous damage to the walls. Rebuilt stone masonry shall match securely into adjacent masonry.

(2) Repairing Stone Masonry. Earth, minor vegetation, and other foreign matter shall be removed and cavities in the stone substructure and wingwalls filled as indicated and specified in the Contract.

(b) Construction Requirements.

(1) Rebuilt Stone Masonry. The work shall be performed by a stone mason who is highly knowledgeable and experienced in the construction of dry stone masonry walls and fascia. The Contractor's stone mason performing the work must demonstrate at least five years of experience in the construction of dry stone masonry walls. Documentation of experience, including a list of previous projects and references, shall be submitted to the Engineer prior to commencement of the work.

The existing stone masonry in the areas of reconstruction shall be mapped out and documented. Each stone's size and location shall be noted. The Contractor, prior to stone removal, shall submit documentation to the Engineer for approval.

Special care and precautions shall be taken during removal and storage of the existing stone masonry to ensure that the stone is not damaged.

All stones shall be carefully removed in the areas shown on the Plans. The Contractor shall shore the remaining portions of the walls to ensure that they do not shift during construction.

The existing stones shall be replaced in their original locations, removing any gaps that occurred due to previous damage to the walls. All joints in the reconstructed stone walls shall be no larger than 3/4 inch between stones. Any existing stones that are not suitable for replacement or that are missing shall be replaced by the Contractor with stones of similar size and appearance.

(2) Repairing Stone Masonry.

a. Examination. The Contractor and Engineer shall jointly examine the abutments and wingwalls to field verify the extent of the work.

All work shall be performed by stonemasons with a minimum of three years of experience with similar work.

b. Repair. Gaps between horizontal faces of existing stones less than 1 inch shall not be repaired. The size of these gaps shall equal the approximate diameter of a 7/8-inch steel dowel.

Gaps between horizontal faces of existing stones between 1 inch and 6 inches shall have small stone blocks added, with the depth of the blocks as large as possible for good bearing. The minimum width of said blocks shall be 4 inches.

Gaps between horizontal faces of existing stones greater than 6 inches shall have crushed gravel and stone blocks added. The crushed gravel shall be placed at the back of the stone and compacted in place up to 12 inches of the exposed wall face. The crushed gravel shall be compacted by tamping rods or other methods acceptable to the Engineer. Stone blocks shall then be added to achieve a tight fit. New stone blocks shall not extend beyond the face of the stone wall.

602.07 POINTING AND REPOINTING. All joints shall be filled with mortar, well driven in, and finished with an approved pointing tool for a distance of 1/2 inch back from the surface of the stone.

When joints are in old masonry, they shall be cleaned of all loose mortar and dirt for a depth in from the face of the wall of at least twice the width of the joint and moistened.

All mortar shall be cleaned from the face of the stones after the pointing is completed and the work has cured for a period of three days.

602.08 CORING CONCRETE. The existing concrete structure shall be cored to allow the new pipe to extend into or through the structure. The diameter of the core shall be between 1/2 inch and 1-1/2 inches larger than the diameter of the installed pipe. The pipe shall be mortared in place using Type II mortar, filling any voids between the pipe and the structure.

602.09 DOWELS AND TIES. Where required, bonding of various portions of the work shall be accomplished with dowels and ties of the shapes and dimensions shown on the Plans or approved by the Engineer. They shall be placed, as shown or required, in the stone so as to clear the bed of the succeeding course.

Dowel holes shall be drilled into each stone, to match dowels already set, before the stone is placed. No drilled holes will be permitted in the exposed top surfaces.

602.10 BACKFILLING. Spaces excavated for masonry structures, but not occupied by these structures, shall be backfilled. The backfill shall be placed in horizontal layers of not more than 6 inches in depth. Each layer shall be thoroughly compacted by means of air or mechanical tampers in a manner approved by the Engineer.

602.11 METHOD OF MEASUREMENT. The quantities of Cement Masonry and Dry Masonry to be measured for payment will be the number of cubic yards used in the complete and accepted work, measured in accordance with the dimensions shown on the Plans or ordered by the Engineer.

The quantity of Stone Masonry Facing to be measured for payment will be the number of square yards in the complete and accepted work, measured as the height of the front face plus the width of the capstones times the length of the stone masonry facing. No deductions will be made for weep holes, drain pipes, or other openings with an area of less than 2 square feet.

The quantity of Repointing Masonry to be measured for payment will be the number of square yards in the complete and accepted work, measured as the total surface area of the masonry repointed.

The quantity of Rebuilt Stone Masonry to be measured for payment will be the number of cubic yards of stone masonry rebuilt in the complete and accepted work, measured in accordance with the dimensions shown on the Plans or as determined by the Engineer.

The quantity of Repairing Stone Masonry to be measured for payment will be the number of square yards of stone masonry repaired in the complete and accepted work, measured as the total surface area of the repaired masonry.

The quantity of Coring Concrete to be measured for payment will be the number of each core made in the complete and accepted work.

602.12 BASIS OF PAYMENT. The accepted quantities of Cement Masonry, Dry Masonry, Stone Masonry Facing, and Repointing Masonry will be paid for at the Contract unit price per cubic yard or square yard for the item specified. Payment will be full compensation for furnishing, transporting, handling, and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The dowels and ties required for constructing stone masonry facing will not be paid for separately but will be considered incidental to the Contract unit price per square yard for Stone Masonry Facing.

Excavation will be paid for as Trench Excavation, unless otherwise shown on the Plans.

The accepted quantity of Rebuilt Stone Masonry will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for mapping, documenting, and removing existing stone masonry; furnishing new stone as needed; furnishing, transporting, handling, and placing the materials specified; backfilling when not paid under a separate Contract item; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Excavation adjacent to Rebuilt Stone Masonry and disposal of excess or unsuitable excavated material will be paid for at the Contract unit price per cubic yard for Structure Excavation. Excavation shall be backfilled with material acceptable to the Engineer. When Granular Backfill for Structures is required for backfill material, it will be paid for at the Contract unit price per cubic yard.

The accepted quantity of Repairing Stone Masonry will be paid for at the Contract unit price per square yard. Payment will be full compensation for removing material specified from the face of stone masonry; filling cavities; furnishing, transporting, handling, and placing the materials specified; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Coring Concrete will be paid for at the Contract unit price per each. Payment will be full compensation for coring the existing concrete structure, for mortaring new pipe in place, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

New pipe will be paid for under the appropriate Contract items.

Excavation, including backfill operations and the disposal of excavated material (excess or unsuitable for backfill), will be paid under the appropriate Contract excavation items.

Payment will be made under:

Pay Item		Pay Unit
602.1500	Cement Masonry	Cubic Yard
602.2000	Dry Masonry	Cubic Yard
602.2500	Stone Masonry Facing	Square Yard
602.3000	Repointing Masonry	Square Yard
602.3500	Rebuilt Stone Masonry	Cubic Yard
602.4000	Repairing Stone Masonry	Square Yard
602.4500	Coring Concrete	Each

SECTION 604 – DROP INLETS, CATCH BASINS, AND MANHOLES

604.01 DESCRIPTION. This work shall consist of the construction, rehabilitation, adjustment, or decommissioning of drop inlets (DIs), catch basins, and manholes, and the furnishing and placing of cast iron or precast concrete covers.

604.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Granular Backfill for Structures.....704.08
Manhole Brick .....705.01(a)
Concrete Masonry Blocks.....705.02
Precast Drop Inlets, Catch Basins, and Manholes 705.03
Mortar, Type II.....707.01(c)
Mortar, Type IV .....707.01(e)
Reinforced Concrete Pipe 710.01
Bar Reinforcement.....713.01
Welded Wire Reinforcement 713.03
Structural Steel.....714.02
Gray Iron Castings .....715.01(b)
Ductile Iron Castings .....715.01(c)
Treated Timber Curb.....729.05

Unless otherwise specified, cast-in-place concrete shall conform to the requirements of Section 541 for Concrete, Class B.

Flowable fill shall conform to the requirements of Section 541 for Flowable Fill, Excavatable.

Pipe stubs for precast reinforced concrete curb drop inlets shall meet the requirements of Section 601.

The term cast iron, as used in these specifications, or in the names of various pay items, when used in conjunction with covers and frames, shall be understood to mean gray iron castings or ductile iron castings. Covers and frames shall be gray iron castings or ductile iron castings.

Steps or ladder rungs in drop inlets, catch basins, or manholes shall be plastic, complying with all applicable OSHA dimensional and structural requirements. Unless otherwise shown on the Plans, the rungs shall be cast into the fresh concrete, except that for precast units, the rungs may be grouted into preformed voids with a non-shrink grout approved by the Engineer after the concrete has cured.

604.03 GENERAL CONSTRUCTION REQUIREMENTS. The excavation shall be to the depth shown on the Plans or ordered by the Engineer, and carefully shaped and graded.

The bases for drop inlets, catch basins, and manholes may be either precast or cast-in-place concrete.

For construction of drop inlets, catch basins, or manholes, the bricks used on top of the concrete to adjust the top to the correct elevation shall meet the requirements of Subsection 705.01(a).

Unless directed otherwise by the Engineer, when adjusting the elevation of the tops of existing drop inlets, catch basins, sewer manholes, or manholes, the Contractor shall remove all existing bricks and replace them with new bricks meeting the requirements of Subsection 705.01(a) as part of the work and costs included in Changing Elevation of DIs, Catch Basins, or Manholes, or Changing Elevation of Sewer Manholes.

Channels, inverts, and floor areas for sewer manholes shall be constructed of brick and mortar or Class C concrete conforming to Section 541. Inverts shall have the exact shape of the sewer to which they are connected and any change in size or direction shall be gradual and even. All construction of sewer manholes must be carried out to ensure watertight work. Any leaks in manholes shall be repaired to the satisfaction of the Engineer, or the entire structure shall be removed and rebuilt. Leakage testing shall be performed in accordance with Subsection 628.09.

Prior to rehabilitating or changing the elevation of any drop inlet, catch basin, or manhole, the Contractor shall completely clean out the interior of the unit, including cleaning at least 12 inches but not more than 24 inches into any openings in the walls for inspection to determine the extent of the work that will be required.

Except for components cast using the dry cast process, precast concrete components shall not have the forms removed until a minimum compressive strength of 2,000 psi has been achieved. Precast components shall not be moved until two hours after they have been cast and until a minimum compressive strength of 2,000 psi has been achieved.

Reinforced precast sections shall not be shipped from the manufacturing facility until the eighth calendar day from the date of manufacture, except when the supplier provides test results demonstrating that the design strength has been achieved.

604.04 CONSTRUCTION OF DROP INLETS, CATCH BASINS, AND MANHOLES.

(a) Concrete Drop Inlet, Catch Basin, or Manhole. The concrete walls shall be constructed on the approved base to the lines, grades, and dimensions shown on the Plans or directed by the Engineer.

The required courses of brick shall be placed on top of the concrete to the elevation shown on the Plans or directed by the Engineer. After the bricks are laid, the joints on the inside of the brick masonry shall be neatly pointed.

The top section may be precast or cast-in-place.

The cast iron frame shall be set in the concrete tops as shown on the Plans. When tops are precast, they shall be placed in a full mortar bed. The grate or cover shall be properly placed in the frame.

(b) Precast Reinforced Drop Inlet, Catch Basin, or Manhole. The precast reinforced concrete risers shall be set reasonably close to line and grade on the previously placed concrete base. The top section shall be capped with courses of mortared brick.

The cast iron frame shall be placed in a full mortar bed on the brick masonry and the cast iron cover or grate shall be placed on top of the frame.

(c) Precast Reinforced Concrete Pipe Drop Inlet. The precast reinforced concrete pipe sections shall be set on a concrete base as shown on the Plans or as directed by the Engineer.

A precast concrete cover or a cast iron grate shall be placed as shown on the Plans.

(d) Precast Reinforced Concrete Curb Drop Inlet. The precast reinforced concrete curb drop inlet shall be set to the line and grade as shown on the Plans or as directed by the Engineer.

The brick masonry, concrete top, and grate shall conform to the requirements of Subsection 604.04(a).

(e) Changing Elevation of Drop Inlets, Catch Basins, or Manholes. Existing drop inlets, catch basins, and manholes that are to be altered or adjusted in elevation of the existing top shall be reconstructed to the required grade using the existing grates, frames, covers, or tops as specified. If the existing grates, frames, covers, or tops are not suitable for reuse, this Contract item shall not be used.

Should any grate, frame, cover, or top become broken through carelessness on the part of the Contractor, it shall be replaced at the Contractor's expense.

The existing structure shall be dismantled sufficiently to allow elevation adjustment as shown on the Plans or as directed by the Engineer. The existing grates, frames, covers, or tops to be reused shall be thoroughly cleaned of mortar before being reused. Any deteriorated brick, mortar, or missing brick in the structure, including any curb portions of the tops, shall be repaired or replaced by the Contractor.

Granite or concrete curbs, curb board, and bituminous fillet disturbed for this work shall be replaced. New treated timber curb board required shall meet the requirements of Subsection 729.05. Bituminous fillet shall conform to the applicable requirements of Section 716 for the type of mix specified by the Engineer and, after installation, shall be sealed in accordance with Subsection 616.07(d). Concrete curb and granite curb shall conform to the applicable requirements of Section 616.

Where the unit is to be raised and the change in elevation is less than 2 inches, concentric structural steel rings of nominally 1/2 inch thick material properly welded to the frame may be used.

If excavating through paved surfaces is required, the edges of the excavated area shall be saw-cut to a minimum depth of 1-1/2 inches.

(f) Cast Iron Cover with Frame. The covers with frames shall be properly installed at the locations shown on the Plans or directed by the Engineer.

Covers for sanitary sewer manholes shall have the word "SEWER" cast into the top surface. Covers for storm sewer manholes shall have the word "STORM" cast into the top surface.

(g) Grates. The grates shall be properly installed at the locations shown on the Plans or directed by the Engineer.

(h) Sanitary Sewer Manhole. Sanitary sewer manholes shall be precast sewer manholes of the type and diameter shown on the Plans and shall meet the requirements of Subsection 705.03 except that all barrel joints shall contain an O-ring seal. Steps shall meet OSHA requirements for new construction. The exterior of the entire manhole shall be coated with a bitumastic or other watertight sealant meeting the approval of the sewer line owner. All joints between pipes and the manhole shall be made using an approved watertight boot.

(i) Changing Elevations of Sewer Manholes. Existing sewer manholes that are to be altered or adjusted shall be reconstructed in accordance with Subsection 604.04(e), except that all exterior surfaces disturbed by the necessary reconstruction shall be coated or recoated with a watertight sealant approved by the sewer line owner. Necessary steps, pipe joints, and barrel joints shall conform to the requirements of Subsection 604.04(h).

The Contractor may be required to provide a specific step to match the existing steps as part of the work and costs included in this pay item.

(j) Rehabilitation of Drop Inlets, Catch Basins, or Manholes. Existing drop inlets, catch basins, and manholes that are to be altered, adjusted, or reconstructed shall be constructed to the required grade using existing grates, frames, covers, or tops, if useable, as specified.

This work shall belong to one of three classes. Class I shall include all work down to a depth of 3 feet. Class II shall include all work greater than 3 feet in depth down to a depth of 6 feet. Class III shall include all work greater than 6 feet in depth.

If the existing grates, frames, covers, or tops are suitable for reuse, but the remainder of the top requires replacement, the Contractor shall carefully remove the frame from the existing top and cast a new top using the existing grate, frame, or cover. If the existing grates, frames, covers, or tops are unsuitable for reuse, new ones shall be furnished as required. Unless otherwise specified, the replacement shall match the existing grate, frame, or cover in size and design.

Should any useable, existing grate, frame, cover, or top become broken through carelessness on the part of the Contractor, it shall be replaced at the Contractor’s expense.

The existing structure shall be dismantled sufficiently to allow rehabilitation as shown on the Plans for completed drop inlets, catch basins, and manholes. Any existing grate, frame, cover, or top to be reused shall be thoroughly cleaned of mortar before being reused. Any deteriorated brick, concrete, reinforcement, steps, mortar, or missing brick in the structure, including any curb portions of the tops, shall be repaired or replaced by the Contractor as directed by the Engineer.

If the rehabilitation proceeds to a point where the culverts or other pipes entering or exiting the unit are within the area of rehabilitation or replacement, the necessary pipe stubs and collars to connect the existing piping to the rehabilitated unit shall be provided and installed by the Contractor.

Granite, bituminous, or concrete curbs, curb board, and bituminous fillet disturbed for this work shall be replaced. New treated timber curb board shall meet the requirements of Subsection 729.05. Bituminous fillet shall conform to the applicable requirements of Section 716 for the type of mix specified by the Engineer and, after installation, shall be sealed in accordance with Subsection 616.07(d). Concrete, bituminous, and granite curb shall conform to the applicable requirements of Section 616.

Where the unit is to be raised and the change in elevation is less than 2 inches, concentric structural steel rings of nominally 1/2 inch thick material properly welded to the frame may be used.

Unless otherwise directed by the Engineer, the Contractor shall saw-cut all pavements to a minimum depth of 1-1/2 inches.

(k) Rehabilitation of Sewer Manholes. Rehabilitation of sewer manholes shall consist of removing the existing top with cover, with or without frame, and rehabilitation of the existing unit to a safe and useful structure, satisfactory to the Engineer. If necessary, this pay item shall include the complete reconstruction of the sewer manhole to current standards.

This work shall consist of replacing broken or deteriorated bricks, mortar, concrete, reinforcement, frames, and covers with new materials. New barrel sections shall be precast of the type and diameter existing or as shown on the Plans and shall meet all requirements of Subsection 705.03 except that all barrel joints shall contain an O-ring.

Steps, if required, shall meet OSHA requirements for new construction. The exterior of the entire manhole shall be coated with a bitumastic or other water-tight sealant meeting the approval of the sewer line owner. All joints between pipes and the manholes shall be made using an approved watertight boot.

604.05 CURING AND PROTECTION. After the masonry work is completed, it shall be kept moist and protected from the elements in a satisfactory manner for a period of at least 48 hours. Concrete shall be cured in accordance with Subsection 541.15.

Precast concrete shall be cured using membrane curing compound. The curing compound shall be applied to the concrete surface after finishing, as soon as the free water on the surface has disappeared and no water sheen is visible, but not so late that the liquid curing compound will be absorbed into the concrete. When the curing compound cannot be applied as specified herein, the manufacturer shall instead immediately begin wet curing the unit until curing compound can be applied. When this method is used in conjunction with the dry-cast process, the curing room shall be kept at 100% humidity until a minimum compressive strength of 2,000 psi has been obtained.

When the forms are removed prior to 7 days, the exposed concrete surfaces shall be wet with water within one-half hour of form removal and shall be kept wet until the curing compound is applied. Before application, the concrete shall be allowed to reach a uniformly damp appearance with no free water on the surface, and then the compound shall be applied immediately.

Precast concrete drainage components shall not be subjected to freezing temperatures prior to attaining the specified 28-day compressive strength. Components which are exposed to freezing before reaching the required 28-day compressive strength shall be rejected without further cause. Any additional testing on the rejected components as determined by the Engineer to gain acceptance will be at the expense of the manufacturer.

604.06 BACKFILLING. Backfill material shall meet the requirements of Subsection 704.08 unless otherwise directed by the Engineer.

Backfilling shall not begin until the end of the curing period. Backfill material shall be approved by the Engineer and placed in layers not exceeding 6 inches in depth. Each layer shall be thoroughly tamped using mechanical tampers. Special care shall be taken to ensure adequate compaction around the inlet and outlet pipes.

604.07 CAPPING DROP INLETS. Drop inlets shall be capped as detailed and at the locations shown on the Plans. Capping shall include saw-cutting existing pavement as necessary, excavating to the required depth to remove the top portions of the drop inlet, placing a steel plate and backfilling.

Pavement shall be saw-cut to minimize damage to the adjacent pavement and shall be kept to the minimum required to cap the drop inlet. The steel plate shall be securely placed to the satisfaction of the Engineer and shall be in accordance with Subsection 714.02. The drop inlet shall be backfilled with granular backfill for structures in accordance with Section 204.

604.08 DECOMMISSIONING DROP INLETS. Drop inlets shall be decommissioned as detailed and at the locations shown on the Plans. Decommissioning shall include saw-cutting existing pavement as necessary, excavating to the required depth to remove the cover, removal and disposal of covers and grates, filling the drop inlet with flowable fill, and backfilling as necessary.

Pavement shall be saw-cut to minimize damage to the adjacent pavement and shall be kept to the minimum required to decommission the drop inlet. Inlets and outlets of culverts within the drop inlets to be decommissioned shall be covered in such a manner so as to prevent the flowable fill from entering the culverts.

Flowable fill shall completely fill all voids within the drop inlet. The drop inlet shall be backfilled with granular backfill for structures in accordance with Section 204.

604.09 METHOD OF MEASUREMENT. The quantities of new Drop Inlets, Catch Basins, or Manholes of the type specified to be measured for payment will be the number of units of the respective types used in the complete and accepted work. and Cast Iron Grate with Frame, Cast Iron Grate, and Cast Iron Cover with Frame, when used and not included in a specific unit, will be measured as the number of each type specified.

The quantity of Changing Elevation of DIs, Catch Basins, or Manholes; Rehabilitating DIs, Catch Basins, or Manholes, Class I; Rehabilitating DIs, Catch Basins, or Manholes, Class II; and Rehabilitating DIs, Catch Basins, or Manholes, Class III; Cap Drop Inlet; or Decommission Drop Inlet to be measured for payment will be the number of units modified, decommissioned, or capped in the complete and accepted work.

604.10 BASIS OF PAYMENT. The accepted quantities of new Drop Inlets, Catch Basins, or Manholes will be paid at the Contract unit price per each for each of the specified types. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified, including concrete, concrete risers, top sections, reinforcing steel, steps, mortar, brick, frames, grates, covers, base sections, coatings, pipe stubs, weep holes, underdrain ends, curb board, and bituminous fillets, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Excavation will be paid for in accordance with Section 204.

The accepted quantity of Changing Elevation of DIs, Catch Basins, or Manholes; Rehabilitating DIs, Catch Basins, or Manholes, Class I; Rehabilitating DIs, Catch Basins, or Manholes, Class II; and Rehabilitating DIs, Catch Basins, or Manholes, Class III will be paid for at the Contract unit price per each for the specified unit or class. Payment will be full compensation for all necessary cleaning of the interior of the unit to determine the extent of the work; for excavating, cutting of pavement, and backfilling; for removing deteriorated materials and designated materials; for furnishing all materials, including backfill material, concrete, concrete risers, top sections, reinforcing steel, steps, concrete block, brick, mortar, frames, grates, covers, coatings, weep holes, and underdrain ends required for reconstructing the unit as shown on the Plans or directed by the Engineer; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The cost for cutting pavements and excavating around the top of the unit and the bricks to provide room to accomplish the work; for backfilling around the unit up to the bottom of pavement or the upper surface of the unit top, as appropriate to the individual location; and the cost of curb replacement will not be paid for directly, but will be considered incidental to Changing Elevation of DIs, Catch Basins, or Manholes; Rehabilitating DIs, Catch Basins, or Manholes, Class I; Rehabilitating DIs, Catch Basins, or Manholes, Class II; or Rehabilitating DIs, Catch Basins, or Manholes, Class III, as applicable.

When rehabilitation of a DI, catch basin, or manhole requires the installation of a pipe stub and collar and the Contract includes a pay item for the pipe, the pipe stub and collar will be paid for under the appropriate Section 601 or Section 605 pay item in the Contract. If the Contract does not include a pay item for the pipe, the pipe stub and collar will not be paid for directly, but will be considered incidental to Rehabilitating DIs, Catch Basins, or Manholes, Class I; Rehabilitating DIs, Catch Basins, or Manholes, Class II; or Rehabilitating DIs, Catch Basins, or Manholes, Class III, as applicable.

The items Sanitary Sewer Manhole; Changing Elevation of DIs, Catch Basins, or Manholes; Rehabilitating DIs, Catch Basins, or Manholes, Class I; Rehabilitating DIs, Catch Basins, or Manholes Class II; Rehabilitating DIs, Catch Basins, or Manholes and Class III are mutually exclusive. Only one of these items will be paid at any designated location.

The item Changing Elevation of DIs, Catch Basins, or Manholes will include adjusting the elevation of an existing top, including replacement of deteriorated bricks and mortar, only.

The item Rehabilitating DIs, Catch Basins, or Manholes, Class I will include adjusting the elevation of the top and all rehabilitation or reconstruction work on an existing unit down to a maximum depth of 3 feet below the elevation of the upper surface of the unit top.

The item Rehabilitating DI, Catch Basins, or Manholes, Class II will include adjusting the elevation of the top and all rehabilitation or reconstruction work on an existing unit extending below a depth of 3 feet to a maximum depth of 6 feet below the elevation of the upper surface of the unit top.

The item Rehabilitating DIs, Catch Basins, or Manholes, Class III will include adjusting the elevation of the top and all rehabilitation or reconstruction work on an existing unit extending below a depth of 6 feet below the elevation of the upper surface of the unit top.

The items Cast Iron Grate with Frames, Cast Iron Grate, and Cast Iron Cover with Frame, when used and not included in a specific unit, will be paid for at the Contract unit price per each for each type installed in the complete and accepted work.

The accepted quantity of Cap Drop Inlet and Decommission Drop Inlet will be paid for at the Contract unit price for each. Payment will be full compensation for saw-cutting the existing shoulder surfaces; performing any required excavation; protecting the remaining portions of the drop inlet and drainage components; covering inlets and outlets of existing culverts; furnishing and placing steel plates; furnishing and placing flowable fill; backfilling; and for furnishing all labor, tools equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
604.1000	Concrete Catch Basin with Cast Iron Grate	Each
604.1100	Concrete Manhole with Cast Iron Cover	Each
604.1800	Precast Reinforced Concrete DI with Cast Iron Grate	Each
604.2000	Precast Reinforced Concrete Catch Basin with Cast Iron Grate	Each
604.2100	Precast Reinforced Concrete Manhole with Cast Iron Cover	Each
604.2200	Sanitary Sewer Manhole	Each
604.2500	Precast Reinforced Concrete Pipe DI with Cast Iron Grate	Each
604.2600	Precast Reinforced Concrete Pipe DI with Concrete Cover	Each
604.3000	Precast Reinforced Concrete Curb DI with Cast Iron Grate	Each
604.4000	Changing Elevation of DIs, Catch Basins, or Manholes	Each
604.4101	Rehabilitating DIs, Catch Basins, or Manholes, Class I	Each
604.4102	Rehabilitating DIs, Catch Basins, or Manholes, Class II	Each
604.4103	Rehabilitating DIs, Catch Basins, or Manholes, Class III	Each
604.4200	Changing Elevation of Sewer Manholes	Each
604.4501	Cast Iron Grate with Frame, Type A	Each
604.4502	Cast Iron Grate with Frame, Type B	Each
604.4504	Cast Iron Grate with Frame, Type D	Each
604.4505	Cast Iron Grate with Frame, Type E	Each
604.4903	Cast Iron Grate, Type C	Each
604.5500	Cast Iron Cover with Frame	Each
604.5600	Cast Iron Cover with Frame, Sewer	Each
604.6000	Cap Drop Inlet	Each
604.6500	Decommission Drop Inlet	Each

SECTION 605 – UNDERDRAINS

605.01 DESCRIPTION. This work shall consist of constructing drainage systems using underdrains, underdrain outlets, flushing basins, and risers.

605.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Granular Backfill for Structures.....704.08
Drainage Aggregate 704.16
Corrugated Polyethylene Pipe (CPEP) 710.03
Polyvinyl Chloride (PVC) Plastic Pipe.....710.05
Corrugated Steel Pipe, Pipe Arches, and Underdrains 711.01
Corrugated Aluminum Alloy Pipe, Pipe Arches, and Underdrains.....711.02
Gray Iron Castings .....715.01(b)
Geotextile for Underdrain Trench Lining 720.05

If the Contract does not specify a particular type of underdrain or carrier pipe, the Contractor may furnish underdrain and carrier pipe of the diameter indicated and in any one of the following materials:

(a) Corrugated steel

(b) Corrugated aluminum alloy

(c) Corrugated polyethylene

(d) PVC plastic

Each system of underdrain, carrier pipes, and underdrain risers shall be constructed of the same material.

605.03 PROTECTION OF MATERIALS. Corrugated polyethylene or PVC plastic pipe stored on the job site prior to use shall be protected from prolonged exposure to sunlight. The Engineer may require impact or other strength tests of the pipe prior to installation when ultraviolet light degradation is suspected.

605.04 INSTALLATION.

(a) Excavation. Trenches for underdrain shall be excavated to the dimensions and grade shown on the Plans or as directed by the Engineer. The surface of the trench shall be prepared to a smooth condition free of debris, depressions, or obstructions which may damage the geotextile.

Trenches for carrier pipe shall be excavated to a width 24 inches greater than the inside diameter of the pipe. Proper bedding material shall be provided where excavation is in solid rock or other unyielding material.

(b) Placing Geotextile. The geotextile fabric shall be placed loosely with no wrinkles or folds. Care shall be taken to ensure direct contact with the soil such that there are no voids between the geotextile and the trench. The geotextile shall be overlapped a minimum of 12 inches at the top of the trench. Additional overlap or anchoring may be required as determined by the Engineer. The upstream geotextile shall be overlapped over the downstream. Drainage aggregate shall be placed to a depth of 6 inches to provide a bed and uniform slope for underdrain pipe placement.

(c) Placing Underdrain. The underdrain pipe shall be placed in the center of the trench and firmly embedded in the drainage aggregate. Placing shall be started at the outlet end and proceed toward the inlet end. The underdrain shall be placed with the perforations down, unless otherwise directed by the Engineer.

The joints between sections shall be made by fitting the ends as tightly as practical. Corrugated steel or aluminum alloy underdrain shall be joined with an approved coupling. Polyethylene or PVC plastic underdrain shall be joined with approved fittings.

The inlet ends of all underdrain pipe installations shall be closed with suitable plugs to prevent entry of soil material.

Underdrain flushing basins, consisting of corrugated steel or aluminum alloy pipe of the length and diameter shown on the Plans and a cast iron cover, shall be installed at locations shown on the Plans or as directed by the Engineer.

Underdrain risers shall be installed as shown on the Plans or as directed by the Engineer.

(d) Placing Carrier Pipes. Carrier pipes used in an underdrain system shall be placed on a firm bed and joined in the same manner as underdrain. Non-perforated pipe shall be used for carrier pipes.

(e) Backfill. After an underdrain pipe installation has been inspected and approved, material meeting the requirements of drainage aggregate shall be placed to a height of 12 inches above the top of the underdrain and the layer compacted. Care shall be taken not to displace the underdrain pipe. The remainder of the backfill material shall be placed in uniform layers of not more than 6 inches in thickness and thoroughly compacted by use of air or mechanical tampers.

After inspection and approval of a carrier pipe installation, the trench shall be backfilled with suitable material placed in layers not more than 6 inches in thickness and thoroughly compacted. Unless otherwise specified, this material shall be from trench excavation.

The backfill material shall not be placed directly in the trench by dumping from haul vehicles or by pushing material into trenches by bulldozers, graders, or other equipment. Placing shall be limited to the use of hand shovels, backhoes, front end loaders, or other similar types of equipment as approved by the Engineer.

(f) Flushing. Prior to the acceptance of the project, each underdrain system shall be thoroughly flushed with water to remove any accumulation of silt, sand, or other debris.

605.05 METHOD OF MEASUREMENT. The quantity of the specified size of Underdrain or Underdrain Carrier Pipe to be measured for payment will be the number of linear feet installed in the complete and accepted work. When it is necessary to cut underdrain or carrier pipe in the field, the quantity of underdrain or carrier pipe to be measured for payment will be the length necessary, rounded up to the next whole foot increment.

The quantity of Underdrain Flushing Basin to be measured for payment will be the number of units installed in the complete and accepted work including the corrugated pipe and the cast iron cover.

605.06 BASIS OF PAYMENT. The accepted quantities of each type and size of Underdrain or Underdrain Carrier Pipe will be paid at the respective Contract unit price per linear foot.

Underdrain Flushing Basins will be paid at the respective Contract unit price for each. Underdrain used for vertical stand pipes at flushing basin locations or risers will be paid as Underdrain Carrier Pipe.

Payment will be full compensation for fabricating, furnishing, transporting, handling, and placing the material specified, including coupling bands and fittings, drainage aggregate, geotextile fabric, and the necessary backfill material to an elevation 7 feet above the flowline, and for furnishing of all labor, tools, equipment, and incidentals necessary to complete the work.

Excavation for all underdrain, carrier pipe, flushing basins, vertical stand pipes, and risers will be paid for as Trench Excavation.

Payment will be made under:

Pay Item	Pay Unit
605.1006 Underdrain Pipe, 6 Inch	Linear Foot
605.1008 Underdrain Pipe, 8 Inch	Linear Foot
605.1012 Underdrain Pipe, 12 Inch	Linear Foot
605.2006 Underdrain Carrier Pipe, 6 Inch	Linear Foot
605.2008 Underdrain Carrier Pipe, 8 Inch	Linear Foot
605.2012 Underdrain Carrier Pipe, 12 Inch	Linear Foot
605.9500 Underdrain Flushing Basin	Each

SECTION 608 – EQUIPMENT RENTAL

608.01 DESCRIPTION. This work shall consist of furnishing, operating, and supervising the use of equipment for performance of work shown on the Plans, in accordance with these specifications or as directed by the Engineer.

608.02 GENERAL REQUIREMENTS. Equipment shall be maintained in good mechanical condition and shall be operated by capable and experienced operators.

Equipment that is to operate on paved surfaces shall be equipped with rubber tires or smooth street plates. Tracked equipment used to draw any other equipment shall be of a type that will not damage the work being done and has sufficient power to operate the drawn equipment effectively.

Equipment used under this section shall meet the following specific requirements as to type, size, capacity, power, or dimensions.

In determining whether a particular piece of equipment is classified as Type I, Type II, or Type III in Subsection 608.02(a), Subsection 608.02(c), Subsection 608.02(d), Subsection 608.02(e), or Subsection 608.02(g), the make and model number shall be referenced against an equipment guide book.

Whenever equipment of a certain size is requested by the Engineer and the Contractor supplies a larger size, payment will be for the size requested.

(a) Bulldozer. Bulldozers shall be of the crawler type furnished with an angle type blade and power operated controls. The machine shall be classified by size as follows:

(1) Type I. Type I bulldozers shall have a net engine or flywheel power rating of less than 150 horsepower.

(2) Type II. Type II bulldozers shall have a net engine or flywheel power rating of 150 horsepower or greater.

(b) Grader. Power graders shall be self-propelled with pneumatic tire wheels, power-operated controls, and a wheelbase of at least 18 feet.

(c) All-Purpose Excavator. All-purpose excavators shall be hydraulic excavators and may be self-propelled, truck-mounted, or crawler-mounted. The excavator shall include all attachments necessary to efficiently perform the work for which it is rented. The machine shall be classified as follows:

(1) Type I. Type I all-purpose excavators shall have a rated bucket capacity of at least 1/2 cubic yard but less than 1 cubic yard.

(2) Type II. Type II all-purpose excavators shall have a rated bucket capacity of 1 cubic yard or greater.

(d) Special Purpose Excavator.

(1) Type I. Type I special purpose excavators shall have a hydraulic hammer with a minimum working weight of 5,000 pounds, a minimum tool diameter of 6 inches, and produce a minimum impact energy of 8,000 foot-pounds.

(e) Power Broom. Power brooms shall provide a sweeping path of not less than 80 inches and be capable of maintaining a speed of 4 mph when sweeping. Sweeping shall take place at locations and times directed by the Engineer. The disposal of all sweepings shall meet with the approval of the Engineer. All hand labor required in connection with sweeping operations shall be incidental.

(1) Type I. Type I power brooms may be of the self-propelled or towed type. Towed power brooms shall include the tow vehicle.

(2) Type II. Type II power brooms shall consist of a pickup sweeper and accessory equipment. Type II power brooms shall be used for removing earth or other dust producing materials from paved surfaces to allay dust conditions. This equipment shall include suitable provisions for the application of water ahead of the sweeping brooms to prevent dusting, for the pickup, internal storage, and removal of sweepings, and for the cleaning of areas of heavy accumulation beyond the capacity of the sweeper.

(3) Type III. Type III power brooms shall be a regenerative type air sweeper capable of removing and containing all micron-sized fine dust particles from the designated surface.

(f) Truck. Trucks may be the highway type or off-highway type with a minimum capacity of 6-1/2 cubic yards. The capacity of the truck shall be determined by three-dimensional measurement of the body. All off-highway type trucks will be restricted unless otherwise approved by the Engineer.

(g) Loader. Loaders may be of the wheeled or crawler type, straight or articulated, and shall be furnished with a standard bucket. The machine shall be classified by size as follows.

(1) Type I. Type I loaders shall have a rated bucket capacity of at least 1 cubic yard but less than 4 cubic yards.

(h) Truck-Mounted Attenuator. A truck-mounted attenuator (TMA) is a crash cushion designed to smoothly decelerate an impacting vehicle. The TMA may be mounted on either a trailer or a truck. The unit on which the TMA is mounted shall weigh at least 10,000 pounds, with a heavier unit being preferable. The unit on which the TMA is mounted shall be used as a barrier vehicle as described in the *MUTCD*. All such attenuators shall meet TL-3 criteria as defined in *NCHRP Report 350* or *MASH*.

The Contractor shall provide the type of TMA, date of manufacture, and the current FHWA eligibility letter for the truck-mounted attenuator to the Engineer for approval prior to installation. The TMA shall be placed in accordance with the Contract and as directed by the Engineer.

(i) Truck-Mounted Attenuator, Advanced Warning Vehicle/Protection Vehicle (AWV/PV). An AWV/PV shall consist of a truck-mounted attenuator meeting the requirements of Subsection 608.02(h) and equipped with a changeable message sign in accordance with the *MUTCD* and Subsection 641.05, including the requirement to maintain a spare unit. The changeable message sign shall be mounted to be clearly visible to the traveling public and shall be capable of being controlled from inside the cab of the vehicle. At a minimum, the controls shall be capable of turning the sign on and off, changing between preset messages, and inserting new messages when approved by the Engineer.

608.03 METHOD OF MEASUREMENT. For work not specified in the Contract, the Engineer will issue written orders to the Contractor for work to be performed by the specified equipment.

The quantity of equipment to be measured for payment will be the number of hours each piece of equipment actually worked, including necessary travel time within the project limits.

608.04 BASIS OF PAYMENT. The accepted quantity of the specified equipment will be paid for at the Contract unit price per hour. Payment will be full compensation for performing the work specified; for furnishing, operating, and supervising the use of this equipment, including fuel, repairs, attachments, and transportation of the equipment to and from the project; and for furnishing all labor, tools, other equipment, and incidentals necessary to complete the work.

The Contract unit price for the items Truck-Mounted Attenuator and Truck-Mounted Attenuator, AWV/PV shall also include all costs of furnishing the unit on which the attenuator is mounted.

The costs of any spare changeable message signs will be considered incidental to Truck-Mounted Attenuator, AWV/PV.

Payment will be made under:

Pay Item		Pay Unit
608.1001	Bulldozer Rental, Type I	Hour
608.1002	Bulldozer Rental, Type II	Hour
608.1500	Power Grader Rental	Hour
608.2501	All-Purpose Excavator Rental, Type I	Hour
608.2502	All-Purpose Excavator Rental, Type II	Hour
608.2601	Special Purpose Excavator Rental, Type I	Hour
608.3001	Power Broom Rental, Type I	Hour
608.3002	Power Broom Rental, Type II	Hour
608.3003	Power Broom Rental, Type III	Hour
608.3700	Truck Rental	Hour
608.4001	Loader Rental, Type I	Hour
608.4500	Truck-Mounted Attenuator	Hour
608.5000	Truck-Mounted Attenuator, AWV/PV	Hour

SECTION 609 – DUST CONTROL

609.01 DESCRIPTION. This work shall consist of treating traveled areas to control dust on the project.

609.02 MATERIALS. Materials shall meet the requirements of the following subsections:

609.03 DUST CONTROL WITH WATER. Water shall be applied to traveled areas as the Engineer may designate. The number of applications and the amount of water used shall be based upon field and weather conditions and as ordered in writing by the Engineer.

The equipment for water application shall be equipped with an adequate shutoff valve control in the cab and shall be approved by the Engineer. The equipment shall be available at all times in readiness to perform the work at any time, including Sundays and holidays, upon written order of the Engineer.

609.04 DUST CONTROL WITH CALCIUM CHLORIDE. Calcium chloride shall be applied in such a manner and by such devices that uniform distribution is obtained over the entire area on which it is ordered by the Engineer.

Unless otherwise authorized in writing by the Engineer, calcium chloride shall be applied at the rate of 1/2 pound per square yard for dust control.

When used on granular surfaces on which bituminous material will be applied, the surface shall be reworked by grading or other means to ensure that the surface is sufficiently free of excess calcium chloride as determined by the Engineer.

609.05 METHOD OF MEASUREMENT. The quantity of Dust Control with Water to be measured for payment will be the number of thousands of gallons (MGAL) of water actually used in the complete and accepted work. The Contractor shall provide equipment meeting the approval of the Engineer for measuring the quantity of water applied.

The quantity of Dust Control with Calcium Chloride to be measured for payment will be the number of tons of calcium chloride actually used in the complete and accepted work. When calcium chloride is delivered in bulk, the quantity will be determined from load tickets.

609.06 BASIS OF PAYMENT. The accepted quantity of Dust Control with Water will be paid for at the Contract unit price per thousand gallons (MGAL). The accepted quantity of Dust Control with Calcium Chloride will be paid for at the Contract unit price per ton. Payment will be full compensation for furnishing, measuring the load, transporting, handling, and placing the material specified, including any reworking of granular surfaces as specified, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
609.1000 Dust Control with Water	MGAL
609.1500 Dust Control with Calcium Chloride	Ton

SECTION 610 – GNSS CONSTRUCTION EQUIPMENT

610.01 DESCRIPTION. This work shall consist of using grading equipment controlled with a global navigation satellite system (GNSS) machine control system in the construction of the roadway design and building the required surface models to facilitate GNSS machine control grading.

This work shall also consist of furnishing, configuring, installing, maintaining, and removing GNSS units as needed for use by the Engineer and their inspection staff, including building the required surface models and loading them into the Contractor provided data collectors, and the training of the Engineer and their representatives on the use of the GNSS units provided.

610.02 EQUIPMENT. The Contractor may use any type of GNSS machine control grading equipment and systems which will generate end results meeting the Contract requirements.

The Contractor shall supply GNSS construction inspection units for use by the Engineer. Each unit shall include all necessary components, communication devices, integrated antennae and receiver and cables, data collectors, operating manuals, attachments, and fastening hardware to meet the minimum requirements described below.

(a) GNSS units provided for a single Contract shall be the same model and manufacturer and shall include, and be licensed to operate, the same version of GNSS planning software and data collection software to be used by the Engineer for data collection. Units shall be capable of tracking multiple constellations and allow for software updates within two years from the time of delivery. At the time of delivery of the GNSS units, all software provided (including firmware) shall be the most current available from the manufacturer and shall not be more than two years old. The Contractor shall provide a printed copy of the date of software installation for verification.

(b) The Contractor shall provide the Engineer with a GNSS rover (with the same capabilities as units used by the Contractor) for use during the duration of the Contract. At the end of the Contract, the GNSS rover unit will be returned to the Contractor.

(c) GNSS units shall include both standard USB cable and Bluetooth wireless technology for data transfer between the GNSS units and the data collectors.

(d) GNSS units shall be equipped, at a minimum, to receive GPS and GLONASS data.

(e) GNSS units shall be equipped to receive, and be capable of using, real time kinematics (RTK) correctional data (current version of RTCM format) through internet protocol provided from the VT Continuously Operating Reference System (VT CORS) Network. This shall include all necessary communication devices, repeaters, and systems, data service plans, and communications to meet the minimum required accuracy and not exceed 2 second latency at the rover. Whichever communication method is used by the Contractor to broadcast the VT CORS RTK correctional data, the Contractor shall ensure that the RTK data shall be available at all locations across the entire Contract site during all hours of construction and inspection operations.

(f) GNSS units shall include either an integrated or modular communication device capable of receiving RTK correctional data to satisfy the requirement of using VT CORS RTK corrections.

(g) GNSS units shall be capable of collecting dual frequency GPS data.

(h) The minimum required kinematic accuracy relative to primary project control (CORS) shall be 0.033 feet + 1.0 ppm horizontally and 0.065 feet + 1.0 ppm vertically.

(i) Necessary hardware and software shall be included (including communication drivers) to connect the GNSS units to an Agency-provided PC and communicate and exchange positional data with that Agency PC.

(j) GNSS units shall have an internal, or modular, rechargeable battery system capable of operating through all active working hours (may include interchangeable batteries), including the battery charger.

(k) GNSS units shall include a hard or soft shell carry case, and all appropriate operation manuals.

(l) GNSS data collectors shall have a touchscreen with a minimum size of 7 inches.

(m) GNSS rover units shall include one fixed height rover rod of 6.56 feet in length, one attachable bipod which is compatible with the rover rod, one bracket connecting the data collector to the rover rod, and one topo shoe.

(n) A GNSS unit set up to operate as a base station shall include all necessary additional cables, hardware, fasteners, or accessories necessary to install it in a fixed semi-permanent location. This setup will not be considered as a rover unit and therefore will not require a rover rod, a bipod, a data collector bracket, or a topo shoe.

610.03 CONSTRUCTION REQUIREMENTS.

(a) GNSS Machine Control Grading.

(1) Agency Responsibilities.

a. Control Points. The Engineer will set the initial horizontal and vertical control points in the field for the project as indicated in the Contract.

b. Localized Coordinate System. The Engineer will provide the project specific localized coordinate system. The control information used in establishing the localized coordinate system, specifically the rotation, scaling, and translation, can be obtained from the Engineer upon request.

c. Electronic Data Files. Following the award of the Contract, the Agency will make available the following electronic data files. The files that will be made available were originally created with the computer software applications MicroStation (CAD software) and InRoads or OpenRoads (civil engineering software). The data files will be in the native formats and other software formats as described below.

1. CAD Files.

i. InRoads or OpenRoads DTM files representing the design surfaces.

ii. InRoads or OpenRoads ALG files containing horizontal and vertical geometry.

iii. MicroStation alignment design file.

iv. MicroStation cross section design files.

v. MicroStation ROW design file.

vi. MicroStation existing ground topography design file.

2. Machine Control Surface Model Files.

i. LandXML (ASCII format).

3. Alignment Data Files.

i. Alignment geometry report (ASCII report format).

ii. LandXML (ASCII format).

The Contractor is notified that the Agency uses the US survey foot as a basis for all engineering work. Particular care shall be taken to ensure that the US survey foot is used in any conversion or evaluation of the files provided. This includes any required conversion from MicroStation DGN to AutoCAD DWG, or from InRoads or OpenRoads to other engineering formats.

The XML files shall also be checked to ensure that the US survey foot is used.

Information shown on the Plans governs over the provided electronic data. The electronic information shall not to be considered a representation of actual conditions to be encountered during construction. Providing the Contractor this information does not relieve the Contractor from the responsibility of making an investigation of conditions to be encountered, including but not limited to site visits, and basing any bid on information obtained from these investigations and their professional interpretations and judgment.

The Contractor assumes all risk of error if the information is used for any purposes for which the information was not intended.

Any assumptions the Contractor makes from this electronic information are at their own risk.

d. Spot Checks. The Engineer will perform spot checks of the machine control grading results, surveying calculations, records, field procedures, and actual staking.

(2) Contractor Responsibilities.

a. The Contractor shall review and apply the data the Agency has provided to perform GNSS machine control grading and build the 3D model to do the same.

b. The Contractor shall bear all costs, including but not limited to the cost of actual reconstruction of work, that may be incurred due to errors in the application of GNSS machine control grading techniques. Grade elevation errors and associated quantity adjustments resulting from the Contractor's activities shall be corrected at no cost to the Agency.

c. The Contractor shall convert the Agency's electronic data into a format compatible with the machine control grading system.

d. Manipulation of the Agency's electronic data will be at the Contractor's own risk.

e. The Contractor shall check the GNSS machine control system at the beginning of each work day and recalibrate if necessary.

f. GNSS machine control grading shall meet the same accuracy requirements as conventional grading construction as required by the Standard Specifications.

g. The Contractor shall establish secondary control points at appropriate intervals and at locations along the length of the project and outside the project limits or where work is performed beyond the project limits as required at intervals not to exceed 1,000 feet. The horizontal position of these points shall be determined using static GNSS sessions or by traverse connection from the original baseline control points.

The elevation of these control points shall be established using differential leveling from the project benchmarks, forming closed loops. A copy of all new control point information shall be provided to the Engineer prior to construction activities.

The Contractor is responsible for all errors resulting from their efforts and shall correct all deficiencies to the satisfaction of the Engineer at no additional cost to the Agency.

h. All reference points and monuments that are established by the Engineer within the project limits shall be preserved. Reference points that have not been preserved shall be reestablished at no additional cost to the Agency.

i. The Contractor shall set hubs at the top of the finished subgrade at all hinge points on the cross section at 1,000 foot intervals on mainline and at least two cross sections on the side roads and ramps. These hubs shall be established using conventional survey methods for use by the Engineer to check the accuracy of the construction.

j. The Contractor shall provide controls points and conventional grade stakes at locations such as, but not limited to, PCs, PTs, superelevation points, and other critical points required for the construction of drainage and roadway structures.

k. At least one week prior to the preconstruction conference, the Contractor shall submit to the Engineer for review a written machine control grading work plan which includes the equipment type, control software manufacture and version, and the proposed location of the local GNSS base station used for broadcasting differential correction data to rover units.

(b) GNSS Construction Inspection Equipment.

(1) The Contractor shall furnish, configure, install, maintain, and remove the GNSS units, and provide the Engineer and their representatives with training on the operation of the GNSS units. The Contractor shall ensure all GNSS units are fully operational and training has been provided before construction begins.

The Contractor shall maintain all GNSS units and software in good working condition and shall provide replacement due to breakdown, damage, or theft within 2 working days. The Contractor shall retain ownership of all supplied GNSS units at the end of the Contract.

(2) All projects shall use VT CORS as the spatial reference network from which RTK corrections are derived. The Contractor shall choose which communication technique and devices will be used which will ensure the consistent and reliable delivery of RTK correctional data from VT CORS to the GNSS units. When geographic locations or lack of a reliable communications network prohibit the use of the VT CORS directly, the Engineer may approve the use of a survey grade GNSS inspection unit as a base station in place of the VT CORS, which will be paid for separately through a change order.

(3) The Contractor shall semi-permanently mount the base station in a stable and secure location where it shall not be disturbed by construction activities nor be easily damaged by vandalism, and where it will be capable of providing radio signal coverage over the entire Contract area. If the base station cannot broadcast a signal that covers the entire site, the Contractor shall provide adequate repeater radios or other communications at such frequency and locations such that a minimum of 90% signal strength is maintained throughout the project site. A GNSS unit installed as a base station for inspection operations shall only be moved with the approval of the Engineer.

(4) For all construction grade GNSS units, the Engineer and their representatives shall be provided with a minimum of 16 hours of training on the use and operation of the GNSS equipment and software. Initial training shall occur within one week of delivery of GNSS units to the site unless otherwise directed by the Engineer. The remainder of the training hours shall occur at the request of the Engineer. If a Contract has multiple years of work, an additional 8 hours of training shall be provided every additional year at the request of the Engineer.

All training shall be performed by a manufacturer-verified trainer who is approved by the Engineer. The training shall occur at the Engineer’s field office or at a location agreed to by the Engineer.

(5) The GNSS units shall be maintained and remain in service until either a maximum of one week after the Engineer requests its removal in writing, or the Agency relinquishes the Engineer's field office.

(c) GNSS Construction Inspection Surface Models.

(1) The Contractor shall build the required GNSS construction inspection surface models using the data provided by the Agency as described in Subsection 610.03(a)(1)c. The Contractor shall load the models onto the provided data collectors to facilitate construction inspection by the Engineer.

(2) At a minimum, the following GNSS construction inspection surface models shall be provided by the Contractor.

a. Proposed finish grade

b. Existing ground

610.04 METHOD OF MEASUREMENT. The quantity of GNSS Machine Control Grading to be measured for payment will be on a lump sum basis in the complete and accepted work.

The quantity of GNSS Construction Inspection Equipment to be measured for payment will be the number of each GNSS Construction Inspection Unit provided and operational in the complete and accepted work.

The quantity of GNSS Construction Inspection Surface Models to be measured for payment will be for all required GNSS Construction Inspection Surface Models on a lump sum basis in the complete and accepted work.

610.05 BASIS OF PAYMENT. The accepted quantity of GNSS Machine Control Grading will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing all labor, equipment, and material necessary in preparing the electronic data files for use in the Contractor's machine control system, the required system check and needed recalibration, training of the Contractor's staff, machine control equipment, maintenance, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of GNSS Construction Inspection Equipment will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all equipment, support, training for the Engineer, maintenance, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of GNSS Construction Inspection Surface Models will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing the required surface models, performing corrections and updates to the models if issues are discovered, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Delays due to satellite reception of signals to operate the GNSS machine control system or inspection equipment will not result in adjustment to the Contract unit price for any Contract items or be justification for granting Contract time extensions.

(a) Partial payments for GNSS Machine Control Grading will be made as follows:

(1) The first payment of 75% of the Contract lump sum price will be made with the first biweekly estimate as determined by the Engineer pending progress on other Contract items.

(2) The second payment of 25% of the Contract lump sum price will be made on the first estimate following the completion of 50% of the Contract.

(b) Partial payments for GNSS Construction Inspection Equipment will be made as follows:

(1) The first payment of 75% of the Contract unit price will be made once the equipment has been delivered to the Engineer and is fully operational.

(2) The second payment of 25% of the Contract unit price will be made on the first estimate following the completion of 50% of the Contract.

(c) Partial payments for GNSS Construction Inspection Surface Models will be made as follows:

(1) The first payment of 75% of the Contract unit price will be made once the model has been delivered to the Engineer and installed on the equipment.

(2) The second payment of 25% of the Contract unit price will be made on the first estimate following the completion of 50% of the Contract.

Payment will be made under:

Pay Item		Pay Unit
610.1000	GNSS Machine Control Grading	Lump Sum
610.2000	GNSS Construction Inspection Equipment	Each
610.2500	GNSS Construction Inspection Surface Models	Lump Sum

SECTION 613 – STONE FILL AND RIPRAP

613.01 DESCRIPTION. This work shall consist of furnishing and placing protective materials.

613.02 MATERIALS. Materials shall meet the requirements of the following subsections:

E-Stone fill shall be of the type specified on the Plans, supplemented with material excavated from the channel or the tailings of a topsoil screening operation. Bed material shall be approved by the Engineer and the Vermont Agency of Natural Resources prior to use. Similar sized river sediment is an acceptable alternative as is a mixture of angular material and river sediment.

613.03 PREPARATION. The areas to be protected shall be constructed and graded to the lines shown on the Plans or as directed by the Engineer and, if a fill area, shall be compacted. All slopes shall be maintained to the neat lines shown on the Plans prior to the placing of filter or bedding material, stone fill, or riprap.

613.04 PLACING.

(a) E-Stone Fill and Stone Fill. The specified stone fill shall be placed as shown on the Plans in a manner that will result in a reasonably well graded surface. Care shall be taken in the placing to avoid displacing the underlying material. Stone fill placed inside of a closed structure shall be placed such that the structure is not damaged.

The stones shall be so placed and distributed that there will be no segregation of either the larger or smaller sizes of stone.

Rearrangement of the stone fill by hand labor or mechanical equipment may be required to obtain the specified results.

When stone fill and gravel filter are to be placed as part of an embankment, the protective materials shall be placed concurrently with the construction of the embankment, unless otherwise directed by the Engineer.

Where stone fill is to be placed under water, methods shall be used that will minimize segregation and ensure that the required thickness of protective material will be obtained.

Once all material has been placed, the Contractor shall slowly wet the stream to minimize the effects of the initial sediment pulse. Every attempt shall be made to minimize the movement of sediment downstream of the site. Sand borrow shall be added to seal the bed and prevent subsurface flow as directed by the Engineer. There shall be no subsurface flow upon final inspection.

(b) Riprap. The stones shall be placed on the prepared slope or gravel filter so that there will be a minimum of space between the stones. The depth of each stone shall be equal to the thickness of the course shown on the Plans. The voids between the stones shall be chinked with smaller stones to produce a relatively smooth and uniform surface.

613.05 METHOD OF MEASUREMENT. The quantities of E-Stone Fill, Stone Fill, and Riprap of the type specified to be measured for payment will be the number of cubic yards of the material specified installed in the complete and accepted work, measured within the limits shown on the Plans or as directed by the Engineer.

613.06 BASIS OF PAYMENT. The accepted quantities of E-Stone Fill, Stone Fill, and Riprap of the type specified will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for furnishing, transporting, mixing, and placing the specified material and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Excavation required for placing stone fill, riprap, and the gravel filter or bedding material will be paid for at the Contract unit price per cubic yard for the same type of excavation removed directly above the face of the protective materials, except that when no other type of excavation has been removed, excavation will be paid for under an appropriate excavation pay item.

Unless otherwise shown on the Plans, the filter blanket will be paid for under Gravel Filter for Slope Stabilization.

Payment will be made under:

Pay Item		Pay Unit
613.0601	E-Stone Fill, Type I	Cubic Yard
613.0602	E-Stone Fill, Type II	Cubic Yard
613.0603	E-Stone Fill, Type III	Cubic Yard
613.0604	E-Stone Fill, Type IV	Cubic Yard
613.1001	Stone Fill, Type I	Cubic Yard
613.1002	Stone Fill, Type II	Cubic Yard
613.1003	Stone Fill, Type III	Cubic Yard
613.1004	Stone Fill, Type IV	Cubic Yard
613.1510	Riprap, Light Type	Cubic Yard
613.1520	Riprap, Heavy Type	Cubic Yard

SECTION 614 – STREAM DIVERSION AND IN-WATER SEDIMENT ISOLATION MEASURES

614.01 DESCRIPTION. This work shall consist of implementing adequate control measures to protect the flow of water through the construction site using temporary stream relocation or in-water sediment isolation measures. This shall include designing, furnishing, installing, maintaining, and removing the control measures, as well as erosion prevention and sediment control, channel maintenance, and debris removal in accordance with these specifications.

614.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Stone Fill.....706.04
Geotextile for Roadbed Separator.....720.02
Geotextile Under Stone Fill.....720.04
Geotextile for Filter Curtain.....720.06

Other materials which effectively separate sediment or pollutants from waters of the state, as defined in the *Vermont Water Quality Standards*, may be used. These shall be detailed on the EPSC plan and are subject to approval.

614.03 TEMPORARY RELOCATION OF STREAM.

(a) Submittals. Prior to beginning the work under this section, the Contractor shall submit to the Engineer site-specific plans, including all construction, erosion prevention and sediment control, and maintenance details, for providing temporary stream relocations at the stream crossings specified in the Plans. These details shall be developed in accordance with the requirements of Section 653 and will be considered a component of the overall project EPSC plan.

All relocation plans shall be reviewed by applicable regulatory agencies and approved by the Engineer prior to beginning work. These plans shall adequately provide for the storm generated flow values listed on the Plans and shall be stamped by a professional engineer. The plans shall address erosion prevention and sediment control, channel maintenance, debris removal, and the materials and methods of creating the upstream diversion from the existing channel. These plans shall conform to any state and federal permits which have been issued for the project, or the Contractor shall be responsible for obtaining the necessary amendments to those permits.

(b) Construction Requirements. The Contractor shall maintain the relocated stream channel for the duration of its existence so as not to impact the free flow of the stream or to increase any flood levels or potential for property damage upstream or downstream of the project site. Unless otherwise approved, existing flow shall be maintained for the duration of the relocation.

The Contractor shall be responsible for sizing their own temporary relocation components. It shall be incumbent upon the Contractor to determine the level of protection required to protect the work. However, the protection of existing facilities, structures, and property must also be undertaken, and any damage thereto shall be repaired by the Contractor at no additional expense to the Agency.

In-stream construction shall be undertaken during the period specified in the project permits. Any changes to this period shall be approved in writing by the appropriate permitting agency. It shall be the responsibility of the Contractor to obtain any variances to the in-stream construction period.

Excavation for the relocated stream channel shall be performed in conformance with the requirements for channel excavation specified in Subsection 203.06. Geotextile fabrics and stone fill shall be furnished and installed in conformance with the requirements of Section 649 and Section 613, respectively. Pipes shall be furnished and installed in conformance with Section 601.

The upstream diversion shall be done in such a manner as to minimize erosion and sedimentation. Upstream diversion shall not be done when stream conditions are such that the possibility of excessive erosion and sedimentation will occur. This work shall be scheduled such that it is performed during a period that no heavy rains or storm events are anticipated.

The relocation shall be maintained, throughout the time it is in place, free from debris, logs, stumps, and other obstructions which might impair the free flow of water through the diversion.

After completion of the new permanent channel improvements and the re-diversion of channel flow through the new permanent channel, the entire length of the temporary channel shall be excavated to remove all muck, sediment, debris, and foreign matter.

Any portion of the temporary channel which falls outside of the embankment limits shall be restored to match the existing ground.

614.04 IN-WATER SEDIMENT ISOLATION MEASURES.

(a) Submittals. The proposed in-water sediment isolation measures shall be submitted for acceptance as part of the EPSC plan and in accordance with any permit conditions, including review by regulatory agencies, as applicable. The proposal shall include the design, and a plan for the construction, installation, and maintenance of the in-water sediment isolation measures.

(b) Construction Requirements. When used to contain sediments or pollutants from a work area that is adjacent to or under water, the measures shall be installed to completely enclose the portion of the work area that will be under water. The measures shall deflect and withstand existing current or wave action and be effective at the anticipated water levels. The measures shall be continuously anchored along the bottom to prevent the escape of all sediments or pollutants into the mainstream or body of water.

The Contractor shall repair or replace damaged or otherwise ineffective measures as ordered by the Engineer. The Contractor shall remove material accumulated behind the measures as directed by the Engineer.

The Contractor shall remove the measures and all supporting and anchoring material prior to acceptance of the project, unless otherwise directed by the Engineer.

614.05 METHOD OF MEASUREMENT. The quantity of Temporary Relocation of Stream to be measured for payment will be on a unit basis for each temporary stream location specified on the Plans.

The quantity of In-Water Sediment Isolation Measures to be measured for payment at the locations specified on the Plans will be on a lump sum basis for the complete and accepted work.

614.06 BASIS OF PAYMENT. The accepted quantity of Temporary Relocation of Stream will be paid for at the Contract unit price for each temporary stream relocation. Payment will be full compensation for designing, constructing, maintaining, and removing each temporary stream relocation, and for furnishing all labor, tools, equipment, materials, and all incidentals necessary to complete the work.

Where a temporary relocation of stream is constructed for the convenience of the Contractor and is not specified in the Plans or ordered by the Engineer, the costs for the temporary relocation shall be considered incidental to all other Contract items.

Payment for the design and detailing of erosion prevention and sediment control measures for Temporary Relocation of Stream will be considered incidental to item 653.0100.

Payment for the monitoring and maintenance of erosion prevention and sediment control measures for Temporary Relocation of Stream will be considered incidental to item 653.0200 and item 653.0300, respectively.

Payment for erosion prevention and sediment control measures and turf establishment for Temporary Relocation of Stream will be made under the appropriate Contract items.

Partial payments for Temporary Relocation of Stream will be made as follows:

(a) The first payment of 75% will be made when the construction of the temporary stream relocation has been completed and it is operational and accepted by the Engineer.

(b) The remaining 25% will be paid when the temporary stream relocation has been removed and the site restored and stabilized to the satisfaction of the Engineer.

The accepted quantity of In-Water Sediment Isolation Measures will be paid for at the Contract lump sum price. Payment will be full compensation for designing, furnishing, installing, handling, maintaining, and removing the In-Water Sediment Isolation Measures and accumulated sediments, and for furnishing all labor, tools, equipment, materials, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
614.1000	Temporary Relocation of Stream	Each
614.2000	In-Water Sediment Isolation Measures	Lump Sum

SECTION 616 – CURBS AND GUTTERS

616.01 DESCRIPTION. This work shall consist of the construction, resetting, or removal of curbs and gutters.

616.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Performance-Graded Asphalt Binder.....702.01
Emulsified Asphalt.....702.02
Sand Borrow and Cushion 703.03
Mortar, Type I.....707.01(b)
Mortar, Type IV .....707.01(e)
Joint Sealer, Hot Poured .....707.02(a)
Preformed Joint Filler, Cork, and Asphalt-Treated Felt 707.06
Preformed Joint Filler, Bituminous Type .....707.12(a)
Bituminous Concrete Mixtures 716.02
Bituminous Mixing Plant and Laboratory 716.03
Preparing and Mixing Bituminous Concrete Mixtures.....716.04
Timber Preservative.....726.01
Vertical Granite Curb.....729.01
Granite Slope Edging.....729.02
Precast Reinforced Concrete Curb.....729.03
Bituminous Concrete Curb 729.04
Treated Timber Curb.....729.05

All cast-in-place concrete for curbing and gutters shall conform to the requirements of Section 541 for Concrete, Class B. There shall be a mineral admixture substitution for Portland cement of 20% fly ash or 25% ground granulated blast-furnace slag (GGBFS).

616.03 GRANITE CURBING AND SLOPE EDGING.

(a) Excavation. Excavation shall be made to the required depth. The base material on which the curb is to be set shall be compacted to a firm, even surface. All soft and unsuitable material shall be removed and replaced with suitable material that shall be thoroughly compacted.

(b) Installation. Shall be installed in conformance with the line and grade shown on the Plans. All space under the curbing shall be filled and thoroughly tamped with material meeting the requirements of the material for the bed course.

(c) Joints. The curb and slope edging shall be laid and fitted so there will be no open joints exceeding 1 inch between stones. Joints between stones shall be carefully filled with Type I mortar and neatly pointed on the top and exposed front portions. After pointing, the stone shall be satisfactorily cleaned of all excess mortar and the joints kept moist until the mortar has set.

(d) Backfilling. After the joints have set, any remaining excavated areas shall be filled and tamped with approved material placed in layers not exceeding 6 inches in depth.

616.04 REPOINTING GRANITE BRIDGE CURB. The existing mortar bed and vertical curb joints shall be repointed as shown on the Plans. Mortar shall meet the requirements of Subsection 707.01(b).

616.05 CAST-IN-PLACE CONCRETE CURB.

(a) Excavation. Excavation and bedding shall conform to the requirements of Subsection 616.03(a).

(b) Forms. Forms shall be made of wood or metal, straight or curved as required, free from warp and shall be in accordance with Subsection 541.08. Form construction shall be such that there will be no interference to the inspection of grade or alignment. All forms shall extend for the entire depth of the curb and shall be braced and secured sufficiently so that no deflection from alignment or grade will occur during the placing of the concrete.

(c) Mixing and Placing. Compaction of concrete placed in the forms shall be by spading or other approved methods. Forms shall be left in place for 24 hours or until the concrete has set sufficiently so that they can be removed without injury to the curbing. Upon removal of the forms, the exposed curbing face shall be finished in accordance with Subsection 541.14(a).

(d) Sections. Curbing shall be constructed in sections having a uniform length of 10 feet, unless otherwise specified. Sections shall be separated by open joints 1/8 inch wide except at expansion joints.

(e) Expansion Joints. Expansion joints shall be formed using a preformed joint filler having a thickness of 1/4 inch. They shall be constructed at 20 foot intervals or as directed by the Engineer.

(f) Curing. Curbs shall be cured in accordance with Subsection 541.15.

(g) Backfilling. After the concrete has set sufficiently, the spaces in front and back of the curb shall be filled to the required elevation with layers of not more than 6 inches of the same material as the bedding and thoroughly tamped.

(h) Curb Machine. With the approval of the Engineer, the curb may be constructed by a curb-forming machine.

616.06 PRECAST CONCRETE CURB.

(a) Excavation. Excavation and bedding shall conform to the requirements of Subsection 616.03(a).

(b) Installation. Precast concrete curb shall be installed in accordance with Subsection 616.03(b).

(c) Joints. The curb sections shall be placed and fitted so that there will be no open joints between them exceeding 1/8 inch in width. Unless otherwise shown on the Plans or directed by the Engineer, expansion joints shall be placed every 20 feet. Expansion joints shall be filled with preformed joint filler having a thickness of 1/4 inch.

Joints in the curb at concrete deck joints shall be treated as shown on the Plans.

The Contractor shall protect the curb against damage or discoloration of the exposed surfaces until completion of the Contract.

(d) Backfilling. The space in front and back of the curb shall be filled and compacted in layers not exceeding 6 inches with the same material as the bedding, unless otherwise specified.

616.07 BITUMINOUS CONCRETE CURB.

(a) General Requirements. The bituminous concrete curb mixture shall conform with the requirements of Section 729. The plant and equipment necessary for this work shall be in conformance with the requirements of Section 716 and Section 406.

(b) Preparation of Bed. The bituminous concrete curb shall be placed on bituminous concrete pavement or another hard surface. The surface shall be thoroughly cleaned of all dirt, dust, sand, or other loose material and treated with a rapid setting emulsified asphalt tack coat applied at a rate of 0.05 to 0.10 gallons per square yard prior to placing the curb. All exposed surfaces not to be treated shall be protected against spattering of the bituminous material.

(c) Placing. After the tack coat has cured and become tacky, the mix for the curb shall be placed with an automatic bituminous concrete curb laying machine approved by the Engineer. The machine shall form curbing that is uniform in texture, shape, and density.

The Engineer may permit the construction of curbing by means other than the automatic curber or machine, when short sections or sections with short radii are required, or for such other reasons as may be warranted. The resulting curbing shall conform in all respects to the curbing produced using the machine.

(d) Sealing. After the curb has been in place for 7 calendar days, the exposed surface shall be treated with two coats of emulsified asphalt.

616.08 TREATED TIMBER CURB. The treated timber, bituminous fillet, and granular material behind the curb shall be installed as shown on the Plans. The fillet shall be sealed as specified in Subsection 616.07(d).

616.09 REMOVING AND RESETTING CURB.

(a) Salvage of Curbing. The Contractor shall carefully remove, store, and clean any curbing specified for resetting. Any existing curbing to be reset that is lost, damaged, or destroyed as a result of the Contractor's operations, or failure to store and protect it in a manner that would prevent its loss or damage, shall be replaced at the Contractor's expense.

(b) Placing. Excavation, setting joints, and backfilling shall be in accordance with specifications for the type of curb being removed and reset.

(c) Cutting and Fitting. Cutting, fitting, or dressing may be necessary to install the curbing at the locations directed.

(d) Joints. All sections shall be placed so that the maximum opening between sections is not more than 1 inch wide for the entire top and face. Any dressing of the ends of the curbing necessary to meet this requirement shall be done by the Contractor.

Joints shall be filled completely with mortar and kept moist until the mortar has been set.

(e) Backfilling. After the joints have set, any remaining excavated areas shall be filled and tamped with approved material placed in layers not exceeding 6 inches in depth.

616.10 REMOVAL OF EXISTING CURB. The Contractor shall remove existing curb at the locations shown on the Plans or as directed by the Engineer. When shown in the Contract that the curb will remain the property of the state or municipality, the Contractor shall exercise care to avoid damage to the curb during removal. Salvaged curb shall be carefully and neatly stacked with wooden spacers at locations specified in the Contract or as directed by the Engineer.

616.11 BITUMINOUS CONCRETE GUTTERS AND TRAFFIC ISLANDS.

(a) General Requirements. The bituminous concrete mixture shall meet the requirements of Subsection 716.02 for Type IVS bituminous concrete pavement unless otherwise specified on the Plans. The plant and equipment necessary for this work shall be in conformance with the requirements of Section 716 and Section 406.

(b) Preparation of Bed. The bed upon which the bituminous concrete surface is to be placed shall be thoroughly compacted to the lines, grades, and shape shown on the Plans or directed by the Engineer. In the case of gutters, all soft, yielding, or unsuitable material below the bed shall be removed and replaced with suitable material and compacted to a firm, smooth surface.

(c) Construction. The bituminous concrete shall be placed as shown on the Plans. Each course shall be rolled with a roller weighing at least 150 pounds. The finished gutter shall be smooth, uniform in appearance, and free from irregularities.

616.12 METHOD OF MEASUREMENT. The quantities of Granite Slope Edging; Vertical Granite Curb; Vertical Granite Curb, Mountable; Precast Reinforced Concrete Curb of the type specified; Cast-In-Place Concrete Curb of the type specified; Bituminous Concrete Curb of the type specified; Treated Timber Curb; and Removing and Resetting Curb to be measured for payment will be the number of linear feet installed in the complete and accepted work, as determined along the face of the finished curb.

The quantity of Repointing Granite Bridge Curb to be measured for payment will be the number of gallons of mortar applied in the completed and accepted work, measured to the nearest gallon.

The quantities of Bituminous Concrete Gutters and Traffic Islands to be measured for payment will be the number of tons installed in the complete and accepted work, as determined from the load tickets.

The quantity of Removal of Existing Curb to be measured for payment will be the number of linear feet removed in the complete and accepted work, measured along the face of the curb in its original position.

616.13 BASIS OF PAYMENT. The accepted quantities of Granite Slope Edging; Vertical Granite Curb; Vertical Granite Curb, Mountable; Precast Reinforced Concrete Curb of the type specified; Cast-In-Place Concrete Curb of the type specified; Bituminous Concrete Curb of the type specified; Treated Timber Curb; Removing and Resetting Curb; and Removal of Existing Curb will be paid for at the Contract unit price per linear foot of curb placed, removed, or removed and reset.

The accepted quantity of Repointing Granite Bridge Curb will be paid for at the Contract unit price per gallon.

The accepted quantities of Bituminous Concrete Gutters and Traffic Islands will be paid for at the Contract unit price per ton.

Payment will be full compensation for furnishing, transporting, handling, and placing the specified materials, including all excavation, providing, placing and compacting backfill material when not otherwise specified, mortar for the bed and joints of curbs, joint material for curbs and gutters, anchors for bridge curbs, cleaning, cutting, fitting, dressing or stockpiling of curb, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Tack, prime, or seal coats of bituminous material required for the construction of Bituminous Concrete Curb of the type specified and Treated Timber Curb will not be paid for separately but will be considered incidental to the Contract unit price for the specific item. The bituminous fillet shown on the Plans to be placed in front of timber curb will not be paid for separately but will be considered incidental to the Contract unit price for Treated Timber Curb.

The removal of treated timber curbing, including the bituminous concrete fillet, from installations where the existing guardrail is removed will not be paid for separately but will be considered incidental to Removing and Resetting Guardrail or Removal and Disposal of Guardrail, as appropriate.

When shown on the Plans, concrete radius curb installed in conjunction with vertical granite curb will be measured and paid for as Vertical Granite Curb.

Foundation materials for Bituminous Concrete Gutters and Traffic Islands will be paid for separately as specified in the Contract.

Payment will be made under:

Pay Item		Pay Unit
616.2000	Granite Slope Edging	Linear Foot
616.2100	Vertical Granite Curb	Linear Foot
616.2150	Vertical Granite Curb, Mountable	Linear Foot
616.2250	Repointing Granite Bridge Curb	Gallon
616.2501	Precast Reinforced Concrete Curb, Type A	Linear Foot
616.2502	Precast Reinforced Concrete Curb, Type B	Linear Foot
616.2701	Cast-In-Place Concrete Curb, Type A	Linear Foot
616.2702	Cast-In-Place Concrete Curb, Type B	Linear Foot
616.3101	Bituminous Concrete Curb, Type A	Linear Foot
616.3102	Bituminous Concrete Curb, Type B	Linear Foot
616.3500	Treated Timber Curb	Linear Foot
616.4000	Removing and Resetting Curb	Linear Foot
616.4100	Removal of Existing Curb	Linear Foot
616.4700	Bituminous Concrete Gutters and Traffic Islands	Ton

SECTION 617 – MAILBOXES

617.01 DESCRIPTION. This work shall consist of the removal and relocation of existing mailbox installations to permanent locations, or the removal of existing mailbox installations and replacement with new installations in permanent locations. The work shall include the replacement of any non-conforming mailboxes, supports, or attachment hardware.

617.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Timber Preservative 726.01
Wood Posts .....750.01(b)

Brackets and platforms shall be made of galvanized steel sheets. Holes shall be neatly punched or drilled.

Fasteners shall be galvanized in accordance with Subsection 726.06 and meet the requirements of *ASTM A307*.

New mailboxes shall meet the approval of the U.S. Postal Service.

617.03 GENERAL REQUIREMENTS. Mailbox installations designated to be removed and reset shall be carefully removed and reinstalled as shown on the Plans. Any minor components (such as hardware, brackets, or lettering) of the existing installation that are missing, damaged, or become damaged during construction shall be replaced with new materials. Materials not reused shall remain the property of the owner.

Mailbox installations designated to be replaced shall be carefully removed. The removed materials shall remain the property of the owner. New mailbox installations shall be constructed and installed as shown on the Plans.

It is the Contractor's responsibility to ensure that each completed relocation has the approval of the mail carrier.

617.04 RELOCATION. Posts may be set in holes or they may be driven if the posts or any attached anti-twist devices are not damaged. The installed posts shall be plumb and placed to the depth shown on the Plans. The space around the posts set in holes shall be backfilled with suitable granular material in 6 inch layers. The backfill material shall be thoroughly tamped.

Mailboxes shall be attached to the posts using either the existing mountings and hardware, or the mountings and hardware shown on the Plans. All fasteners shall be drawn sufficiently tight to ensure that the mailboxes do not pivot or otherwise move.

Existing nameplates shall be attached to any new mailboxes. Names and rural box numbers lettered on existing mailboxes shall be copied onto new mailboxes using good commercial-quality stick-on letters acceptable to the Engineer.

617.05 METHOD OF MEASUREMENT. The quantity of Remove and Reset Mailbox, Single Support and Remove and Reset Mailbox, Multiple Support to be measured for payment will be the number of each type relocated in the complete and accepted work, as determined by the Engineer.

The quantity of Remove and Replace Mailbox, Single Support and Remove and Replace Mailbox, Multiple Support to be measured for payment will be the number of each type replaced in the complete and accepted work, as determined by the Engineer.

617.06 BASIS OF PAYMENT. The accepted quantity of Remove and Reset Mailbox, Single Support and Remove and Reset Mailbox, Multiple Support will be paid for at the Contract unit price for each. Payment will be full compensation for removing the existing mailbox installation, reinstalling the mailbox installation in its permanent location, replacing minor broken or missing components (such as hardware, brackets, or lettering, but excluding posts and the mailbox itself), excavating as necessary, backfill, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

If any major components (such as posts or the mailbox itself) of mailbox installations designated to be reset are missing, damaged, or become damaged during construction, the entire installation will be paid for as Remove and Replace Mailbox, Single Support or Remove and Replace Mailbox, Multiple Support.

The accepted quantity of Remove and Replace Mailbox, Single Support and Remove and Replace Mailbox, Multiple Support will be paid for at the Contract unit price for each. Payment will be full compensation for removing the existing mailbox installation, furnishing all new materials, including mailboxes, supports, brackets, hardware, and lettering, installing the mailbox installation in its permanent location, excavating as necessary, backfill, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Any temporary relocation of mailboxes due to project construction will not be paid under this section. The costs of this temporary work will be considered incidental to other Contract items.

Pay Item		Pay Unit
617.1100	Remove and Reset Mailbox, Single Support	Each
617.1200	Remove and Reset Mailbox, Multiple Support	Each
617.2100	Remove and Replace Mailbox, Single Support	Each
617.2200	Remove and Replace Mailbox, Multiple Support	Each

SECTION 618 – SIDEWALKS AND APRONS

618.01 DESCRIPTION. This work shall consist of the construction of bituminous or Portland cement concrete sidewalks, curb ramps, and stamped concrete aprons and islands.

618.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Emulsified Asphalt.....702.02
Preformed Joint Filler, Cork, and Asphalt-Treated Felt 707.06
Preformed Joint Filler, Bituminous Type .....707.12(a)
Reinforcing Steel .....713.01(a)
Welded Wire Reinforcement 713.03
Bituminous Concrete Mixtures.....716.02
Bituminous Mixing Plant and Laboratory 716.03
Preparing and Mixing Bituminous Concrete Mixtures.....716.04
Water Repellent, Silane 726.10
Detectable Warning Surface 751.03

Concrete shall conform to the requirements of Section 541 for Concrete, Class B. There shall be a mineral admixture substitution for Portland cement of 20% fly ash or 25% ground granulated blast-furnace slag.

The type of bituminous materials for sidewalks shall be as specified in the Plans or as directed by the Engineer.

618.03 PORTLAND CEMENT CONCRETE SIDEWALK.

(a) Excavation and Foundation. Excavation shall be made to the required depth and to a width that will permit placing of bed course material and the installation and bracing of the forms. Bed course material shall be placed as shown on the Plans. When the depth of bed course required exceeds 6 inches, two layers of approximately equal depth shall be placed, and each layer thoroughly compacted so that it is hard and unyielding. The wetting of bed course material may be necessary to obtain the required compaction.

(b) Forms. Forms shall meet the applicable requirements of Subsection 541.08. Forms shall be made of wood or metal and shall extend for the full depth of the concrete. All forms shall be straight or curved as required and free from warp.

(c) Placing Concrete. The forms and foundation shall be wetted immediately prior to the placing of the concrete.

The concrete shall be deposited within the forms to such a depth that, after being consolidated and finished, it is of the full thickness required. The concrete shall be consolidated using a method approved by the Engineer.

(d) Finishing. The surface shall be finished with a wooden float or mag. No plastering will be permitted. The edges shall be rounded with an edger having a radius of 1/4 inch. Before the concrete has taken its initial set, it shall be tested for waves or irregularities with a straightedge at least 10 feet long. Deviations of 1/4 inch or more, either above or below the general contour of the surface, shall be immediately remedied.

The surface of the sidewalk, after the floating and screeding process is completed, shall be finished with a broom of a type approved by the Engineer, drawn over the surface parallel to the transverse joints.

(e) Joints. Unless otherwise shown on the Plans or directed by the Engineer, expansion joints shall be placed every 20 feet.

Expansion joints shall be formed around all appurtenances such as manholes, utility poles and other obstructions extending into and through the sidewalk. Preformed joint filler with a thickness of 1/4 inch shall be installed in these joints. Expansion joint filler of the thickness indicated shall be installed between concrete sidewalks and any fixed structure such as a building or bridge. This expansion joint material shall extend for the full depth of the sidewalk.

Between the expansion joints, the sidewalk shall be divided at intervals of 5 feet by dummy joints formed by a jointing tool or other acceptable means to provide grooves approximately 1/8 inch wide and at least 33% of the total sidewalk depth.

When the sidewalk is constructed next to a concrete or granite curb, asphalt-treated felt shall be placed between the sidewalk and curb for the total depth of the sidewalk.

(f) Curing. Concrete shall be cured in accordance with Subsection 541.15. During the curing period, all traffic, both pedestrian and vehicular, shall be excluded. Vehicular traffic shall be excluded for such additional time until 85% of the design strength has been attained as demonstrated by field-cured cylinders.

(g) Backfilling. After sidewalk construction has been completed, the space on each side shall be backfilled to the required elevation with suitable material as shown on the Plans or as directed by the Engineer.

618.04 REINFORCED PORTLAND CEMENT CONCRETE SIDEWALK.

(a) General Requirements. All requirements of Subsection 618.03 shall apply to reinforced Portland cement sidewalks.

(b) Reinforcing. Welded wire reinforcement shall be 6-inch × 6-inch 10-gauge welded wire steel. Dowels shall be No. 5 reinforcing bars, each two feet long. Both welded wire reinforcement and dowels shall be placed at mid-depth of the concrete sidewalk. Dowels shall be placed at all sidewalk construction joints, two feet on center.

(c) Submittals. The Contractor shall submit to the Engineer for approval their proposed method of supporting the welded wire reinforcement to ensure it is placed at the specified location in the concrete.

618.05 BITUMINOUS CONCRETE SIDEWALK.

(a) Excavation and Foundation. Excavation and foundation shall conform to the requirements of Subsection 618.03(a).

(b) Forms. Where no headers, curbing, or other suitable supports are provided, grade control forms shall be installed when hand methods are utilized to assist in obtaining proper alignment and adequate compaction of the sidewalk course. The alignment and grade of all forms set shall be approved by the Engineer immediately prior to placing any material against them. The forms shall be cleaned thoroughly each time they are used. String or wire lines staked to grade will not be accepted as a substitute for grade control forms. When a suitable abutting curb or header is available and is approved by the Engineer as being in conformity with the intended grade, it may be utilized as a grade control form.

(c) Placing Bituminous Sidewalk Material. Bituminous sidewalk material shall be placed on the compacted bed course as directed by the Engineer by either mechanical or hand spreading methods in a manner that the required depth will result after rolling. When placing over an existing surface, the surface shall be cleaned and emulsified asphalt applied before the bituminous concrete is placed.

(d) Compaction. Compaction shall be accomplished by means of a hand operated or power roller of a type and mass acceptable to the Engineer. In areas inaccessible to the roller, hand tamping will be permitted. In any case, the bituminous sidewalk material shall be uniformly compacted and shall present a smooth, even surface.

618.06 DETECTABLE WARNING SURFACE.

(a) General Requirements. Detectable warning surfaces shall be furnished and installed as indicated in the Contract and in conformance with the *Americans with Disabilities Act* and the *Public Rights-of-Way Accessibility Guidelines*.

(b) Handling. Detectable warning surface materials shall be suitably packaged or crated to prevent damage in shipment or handling. Finished surfaces shall be protected by sturdy wrappings.

(c) Installation. The detectable warning surface shall be installed in accordance with all applicable supplier and manufacturer requirements and recommendations for environmental conditions, surface preparation, installation procedures, curing procedures, and materials compatibility.

The Contractor shall be responsible for removing any material spatters. The Contractor shall repair any damage to the surface resulting from either installation or clean-up of surface materials. This work shall be performed at no additional cost to the Agency.

618.07 STAMPED CONCRETE APRONS AND ISLANDS.

(a) General Requirements. The pattern and color of stamped concrete shall be as specified on the Plans. The color shall be fully integrated into the concrete.

Alternative stamping patterns or colors may be used if approved by the Engineer. If alternative products are to be used, they shall be of equal quality, detail, function, and performance to that specified.

(b) Qualifications. The installer shall be ACI certified as a Concrete Flatwork Finisher.

(c) Preparation. The Contractor shall plan the pattern layout to coordinate slab dimensions and construction joint locations with stamping pattern dimensions where necessary.

The Contractor shall provide a minimum four-foot by four-foot mock-up to the Engineer for approval to demonstrate methods of obtaining consistent visual appearance. The mock-up shall be constructed a minimum of 28 calendar days prior to the start of final work, using materials and methods to be used in the final work. The mock-up shall be located on site in a location determined by the Engineer. Samples of materials used in the mock-up shall be retained for comparison with materials used in the final work. The accepted mock-up will constitute a visual standard for the final work. The mock-up shall be removed when no longer required as determined by the Engineer for comparison with the final work. The work and materials required for the mock-up shall be incidental to the final installed stamped concrete island or apron.

(d) Finishing. The stamping operation shall be performed using the stamping tool kit, per the manufacturer's recommendations and across the entire pour.

The concrete slab shall be allowed to cure thoroughly prior to rinsing residual powder release from the surface. The Contractor shall ensure that the surface is clean and apply silane water repellent to all exposed surfaces in accordance with Section 514.

618.08 METHOD OF MEASUREMENT. The quantity of Portland Cement Concrete Sidewalk, 5 Inch; Portland Cement Concrete Sidewalk, 8 Inch; Reinforced Portland Cement Concrete Sidewalk, 5 Inch; and Reinforced Portland Cement Concrete Sidewalk, 8 Inch to be measured for payment will be the number of square yards of the specified depth of sidewalk installed in the complete and accepted work.

The quantity of Bituminous Concrete Sidewalk to be measured for payment will be the number of tons of material installed in the complete and accepted work, as determined from load tickets.

The quantity of Detectable Warning Surface to be measured for payment will be the number of square feet of approved material installed in the complete and accepted work.

The quantity of Stamped Concrete Apron, 5 Inch and Stamped Concrete Island, 8 Inch to be measured for payment will be the number of square yards of stamped concrete placed in the complete and accepted work.

618.09 BASIS OF PAYMENT. The accepted quantities of Portland Cement Concrete Sidewalk, 5 Inch; Portland Cement Concrete Sidewalk, 8 Inch; Reinforced Portland Cement Concrete Sidewalk, 5 Inch; and Reinforced Portland Cement Concrete Sidewalk, 8 Inch will be paid for at the Contract unit price per square yard for the specified depth. The accepted quantity of Bituminous Concrete Sidewalk will be paid for at the Contract unit price per ton. The accepted quantity of Detectable Warning Surface will be paid for at the Contract unit price per square foot. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified, including expansion joint material, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The cost of cleaning an existing surface before placing a Bituminous Concrete Sidewalk and the application of emulsified asphalt will not be paid for directly but will be considered incidental to Bituminous Concrete Sidewalk.

The accepted quantity of Stamped Concrete Apron, 5 Inch and Stamped Concrete Island, 8 Inch will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, handling, preparation and placing the materials specified, including concrete, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Bed course material will be paid for under the appropriate Section 301 pay item.

Excavation, unless otherwise specified, will be paid for under the appropriate Section 203 pay item.

Payment will be made under:

Pay Item		Pay Unit
618.1005	Portland Cement Concrete Sidewalk, 5 Inch	Square Yard
618.1008	Portland Cement Concrete Sidewalk, 8 Inch	Square Yard
618.1205	Reinforced Portland Cement Concrete Sidewalk, 5 Inch	Square Yard
618.1208	Reinforced Portland Cement Concrete Sidewalk, 8 Inch	Square Yard
618.1500	Bituminous Concrete Sidewalk	Ton
618.3000	Detectable Warning Surface	Square Foot
618.4005	Stamped Concrete Apron, 5 Inch	Square Yard
618.4108	Stamped Concrete Island, 8 Inch	Square Yard

SECTION 619 – MARKERS

619.01 DESCRIPTION. This work shall consist of furnishing and placing boundary markers, marker posts, and bollards, and removing and resetting of existing property markers.

619.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Crushed Gravel for Subbase 704.05
Mortar, Type I .....707.01(b)
Bar Reinforcement 713.01
Wood Posts .....728.01(a)
Steel Posts and Anchors .....751.01(a)

Paints and stains shall meet the requirements of Subsection 708.01.

Concrete shall meet the requirements of Section 541 for Concrete, Class B.

619.03 PLACING.

(a) General Requirements. Boundary markers, marker posts, and bollards of the dimensions shown in the Contract shall be placed vertically in holes to the depths indicated and shall be backfilled with suitable material placed and compacted in layers not more than 6 inches in depth.

Marker posts and bollards may be driven if suitable caps and driving equipment are used to prevent damage to the post.

Yielding marker posts shall be 6-1/2 feet long and shall be embedded to a depth of 3 feet in the ground.

(b) Boundary Markers. When the marker point falls on bedrock, a steel rod marker shall be placed in a hole of the diameter and depth shown on the Plans or as directed by the Engineer. The rod shall be securely wedged into the hole and cut off to the required elevation. The space around the rod shall be filled with Type I mortar.

(c) Bollards. Bollards shall be installed as shown on the Plans or as directed by the Engineer.

(d) Removing and Resetting Property Markers. Prior to the removal of any property marker, the Contractor shall verify that the Engineer has located and properly referenced the marker location. The Contractor shall remove, properly identify, and store the property markers to be reset prior to beginning any other construction in the immediate vicinity.

If the property marker is to be installed at a new location, the hole after removal shall be properly backfilled with suitable material. Each property marker shall be reset at the location directed and shall be 6 inches above the ground, sidewalk, or other surface unless otherwise directed by the Engineer.

When the marker point falls on bedrock and the use of a steel rod marker is directed by the Engineer, it shall be set in accordance with Subsection 619.03(b).

619.04 METHOD OF MEASUREMENT. The quantity Boundary Markers, Bollards, Wood Marker Posts, and Yielding Marker Posts to be measured for payment will be the number of markers, bollards, or posts set in the complete and accepted work.

The quantity of Removing and Resetting Property Markers to be measured for payment will be the number of property markers removed and reset in the complete and accepted work.

619.05 BASIS OF PAYMENT. The accepted quantity of Boundary Markers, Bollards, Wood Marker Posts, Yielding Marker Posts, and Removing and Resetting Property Markers will be paid for at the Contract unit price each. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified, including object markers, paint, locking devices, excavation, backfill, mortar, concrete, and subbase, and for furnishing all labor, tools, materials, equipment, and incidentals necessary to complete the work.

The Contract unit prices for the items Wood Marker Posts and Yielding Marker Posts will also include the costs of removing the remaining portion of the existing marker post, when the designated new marker post is used as a replacement for an existing marker post.

Payment will be made under:

Pay Item	Pay Unit
619.1000 Boundary Markers	Each
619.1400 Bollards	Each
619.1500 Wood Marker Posts	Each
619.1700 Yielding Marker Posts	Each
619.2000 Removing and Resetting Property Markers	Each

SECTION 620 – FENCES AND HAND RAILINGS

620.01 DESCRIPTION. This work shall consist of the construction of fences, gates, and hand railings.

620.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Mortar, Type I.....707.01(b)
Structural Steel.....714.02
Carbon Steel Bolts, Nuts, and Washers.....714.04
Steel Tubing.....714.11
Galvanizing.....726.06
Metalizing.....726.07
Woven Wire Fence.....727.01
Chain-Link Fence.....727.02
Snow Barrier Fence.....727.05
Plank Rail Fence.....727.06
Posts.....728.01
Cable, W-Beam, and Thrie Beam Guardrail Hardware.....728.03(a)
Metal Hand Railing.....732.01
Grounding Electrodes.....752.11

Barbed wire for barbed wire fence shall be in accordance with Subsection 727.01(b). Posts and braces for barbed wire fence shall be wood in accordance with Subsection 727.01(c) or steel in accordance Subsection 727.01(d) as specified on the Plans. Miscellaneous hardware for barbed wire fence shall be in accordance with Subsection 727.01(f).

When split-rail fence is specified on the Plans, rails and posts shall be made of premium white cedar. Rails and posts shall be free of any chemicals or toxic preservatives or treatments.

The Contractor may use preformed 1/16 inch × 3/8 inch flat aluminum wire bands to attach the chain-link fabric to the galvanized pipe support framework. The bands shall be made of 5052-H32 alloy having a minimum tensile strength of 30 ksi, and an approved closure, as an alternative to the stainless steel clips shown on the Plans.

Concrete shall meet the requirements of Section 541 for Concrete, Class B.

Unless otherwise specified, all material for hand railings shall be galvanized. Hand railing base plates shall meet the requirements of Subsection 727.01(d) and hand railing hardware shall meet the requirements of Subsection 727.01(f).

620.03 GENERAL REQUIREMENTS. All trees, brush, and other obstructions which interfere with proper grade, alignment, and construction of fences shall be removed and disposed of as specified in Section 201, unless otherwise directed by the Engineer. Modification of the alignment may be made as directed by the Engineer to preserve valuable trees or other features.

Posts shall be set plumb at the spacing and depth shown on the Plans and, when used for property line fence, shall be erected parallel to and 6 inches inside the right-of-way line. The wire shall be placed on the far side of the posts with respect to the transportation facility.

Existing fences shall be connected to new fences as shown on the Plans. Corner posts with braces for every direction of strain shall be placed at the junction with existing fences, and the wire in both fences shall be properly fastened to the posts.

In no case shall the fence be connected to a structure.

620.04 WOVEN WIRE FENCE. Where the ground is too soft to hold the post firmly and in depressions where stresses will tend to pull posts from the ground, a second post shall be installed to such depth as necessary, and the two posts tied together securely as shown on the Plans.

Wood posts shall be set with the large end down in previously dug holes and backfilled with approved material. When tops of treated posts are cut as shown on the Plans or directed by the Engineer, the cut end shall be treated in accordance with *AWPA Standard M4*.

Steel posts shall be set with anchor plates down, except that when set in rock the anchor plates shall be omitted. When driving posts, the tops shall be protected by driving caps.

When bedrock is encountered, steel posts shall be used instead of wood posts. The posts shall be set in drilled holes to the depth shown on the Plans and grouted with Type I mortar so that they are firmly held in position. When boulders are encountered, they shall be removed, the hole backfilled with suitable materials, thoroughly compacted, and the holes re-drilled before installing the posts in the usual manner.

The fence shall be braced as shown on the Plans or directed by the Engineer, with one brace at each end post, including end posts at gates and two braces at each intermediate post, or pull post, and at corner posts where the change in horizontal alignment is in excess of 15°.

The posts and braces for steel corner, end, and pull posts shall be set in concrete as shown on the Plans. The concrete may be mixed by hand.

The woven wire fence shall be stretched taut and attached to the posts so that the bottom wire is approximately 3 inches above the ground.

When wood posts are used, each horizontal wire shall be fastened to the posts with 9-gauge galvanized or aluminum-coated staples 1-1/2 inches long. When steel posts are used, each horizontal wire shall be fastened to the posts with aluminum bars, galvanized steel bars, or 11-gauge rust-resistant spring wire clips. Instead of the fasteners, posts equipped with fastening studs approximately 1/2 inch high and 2-1/4 inches apart may be used.

620.05 CHAIN-LINK FENCE. Posts shall be set in concrete bases of the dimensions shown on the Plans.

Where the ground is too soft to firmly hold the line, end, corner, pull, or gate posts, a post of sufficient length shall be used to obtain stability as directed by the Engineer.

Where rock is encountered, the posts shall be set in drilled holes to the depth shown on the Plans and grouted with Type I mortar so they are firmly held in position. When boulders are encountered, they shall be removed, the hole backfilled with suitable materials, thoroughly compacted, and the hole re-drilled before installing the posts in the usual manner.

The wire fabric shall be properly stretched, without sags or buckles, and attached to the posts as shown on the Plans. Tension wires shall be installed top and bottom as indicated. After erection, any galvanized parts or fittings that have been abraded so that the base metal is exposed shall be painted with two coats of an approved coating.

Any abrasions on aluminum-coated steel chain-link fence and the contacting surface of aluminum alloy, or aluminum-coated steel chain-link fence with concrete, stone, or masonry shall be thoroughly coated with an approved coating. Abraded areas shall receive a second coat of aluminum paint. The paint shall be allowed to dry thoroughly before installation of the fence.

Where chain-link fence is used in the areas of bicycle paths, the top selvedge shall be knuckled.

620.06 BARBED WIRE FENCE. Barbed wire fencing shall be installed as shown on the Plans and as directed by the Engineer. Fence wire shall be stretched by a mechanical stretcher or other devices designed for this use. Posts shall be equally spaced to match existing fencing and shall be of the type and size specified on the Plans. Anchor or corner posts shall be installed to a buried depth of 3-1/2 feet. Intermediate posts shall be installed to a buried depth of 2-1/2 feet. The exposed height of posts shall match that of existing posts.

620.07 SPLIT RAIL FENCE. Posts and rails shall be installed true, plumb, and level at the spacing and depths shown in the Plans. The use of explosive fasteners, screws, or nailing for securing framing and blocking will not be allowed unless approved by the Engineer.

620.08 SQUARE STEEL FENCE. Posts for fencing shall be set plumb at the spacing and depth shown on the Plans. Fencing shall be installed to the configuration shown in the Plans, as recommended by the manufacturer and as directed by the Engineer. Steel tubing shall be in accordance with Subsection 714.11 and metalized in accordance with Subsection 726.07.

620.09 PLANK RAIL FENCE. Plank rail fence shall be installed as shown on the Plans.

620.10 SNOW BARRIER FENCE. Snow barrier fence shall be installed as detailed and at the locations shown on the Plans. The wire fabric for the snow barrier fence shall be 1 inch square mesh. The bottom and top selvedges shall be knuckled.

The snow barrier mesh shall be installed on the traffic side of the snow barrier framework.

620.11 REMOVING AND RESETTING FENCE. Existing fence and posts shall be carefully removed at locations shown on the Plans. Any material damaged while being removed, hauled, or stored and during the process of resetting, due to carelessness on the part of the Contractor as determined by the Engineer, shall be replaced with new materials at the Contractor's expense.

The posts shall be reset in the same manner as posts for new fence and to the same depth and spacing of the fence before removal.

The material used for fencing between posts shall be securely fastened to the posts in their new locations as shown on the Plans for the type of fence being installed.

620.12 REMOVAL OF EXISTING FENCE. Existing fence and posts shall be removed at locations shown on the Plans. When fence is to be salvaged for future use, the Contractor will exercise care during removal to prevent damage and will stockpile the fence at locations indicated in the Contract or as directed by the Engineer. When fence is not to be salvaged, it shall become the property of the Contractor and will be removed from the project area in a manner acceptable to the Engineer.

620.13 GATES. The gates shall be of the design shown on the Plans and shall be completed in a neat and professional manner. The gate holdbacks and center stops shall be set in concrete similar to the design and specifications for chain-link fence line posts. The top rail of the gates shall be level along the entire top of the gates.

620.14 HAND RAILING. Hand railings shall be installed as shown on the Plans. The Contractor shall prepare and submit fabrication drawings in accordance with Subsection 105.06. Hand railing installation, handling, and repair shall conform to all applicable provisions of Section 506 and the surfaces and coatings shall meet the requirements of Subsection 506.22.

620.15 METHOD OF MEASUREMENT. The quantity of the type and size of fence specified to be measured for payment will be the number of linear feet installed in the complete and accepted work. Measurement will be along the top of the fence from outside to outside of end posts for each continuous run of fence. Measurement will include fence at bracing assemblies but not at gates.

The quantity of the type and size of gate specified to be measured for payment will be the number of linear feet of clear distance between gate posts in the complete and accepted work.

The quantity of Bracing Assembly for Chain-Link Fence of the type and size specified to be measured for payment will be the number of bracing assemblies installed for end, gate, corner, and pull posts in the complete and accepted work.

The quantity of Steel Brace for Woven Wire Fence and Wood Brace for Woven Wire Fence to be measured for payment will be the number of braces installed in the complete and accepted work. If double braces are installed on a post, two units will be measured for payment.

The quantity of Removing and Resetting Fence and Removal of Existing Fence to be measured for payment will be the number of linear feet of fence in its original position, measured outside of its end posts for each continuous run of fence, including gates.

The quantity of Hand Railing to be measured for payment will be the number of linear feet of hand railing placed in the complete and accepted work.

620.16 BASIS OF PAYMENT. The accepted quantities of the type and size of fence and gate specified to be installed or removed and reset will be paid for at the Contract unit price per linear foot.

The accepted quantities of Bracing Assembly for Chain-Link Fence, Steel Brace for Woven Wire Fence, and Wood Brace for Woven Wire Fence will be paid for at the Contract unit price for each type specified.

The accepted quantity of Removing and Resetting Fence will be paid for at the Contract unit price per linear foot.

The accepted quantity of Removal of Existing Fence will be paid for at the Contract unit price per linear foot. Payment will include compensation for stockpiling or disposal, as appropriate.

The accepted quantity of Hand Railing will be paid for at the Contract unit price per linear foot.

Payment will be full compensation for furnishing, transporting, handling, assembling, and placing the materials specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The costs of clearing and grubbing, excavation, backfilling, concrete bases, brace plates, anchor plates, electrical grounding, drilling of rock, grouting of holes, extra length posts, and countersunk posts will not be paid for directly but will be considered incidental to the Contract items involved.

Payment will be made under:

Pay Item		Pay Unit
620.1004	Chain-Link Fence, 4 Foot	Linear Foot
620.1006	Chain-Link Fence, 6 Foot	Linear Foot
620.1008	Chain-Link Fence, 8 Foot	Linear Foot
620.1504	Gate for Chain-Link Fence, 4 Foot	Linear Foot
620.1506	Gate for Chain-Link Fence, 6 Foot	Linear Foot
620.1508	Gate for Chain-Link Fence, 8 Foot	Linear Foot
620.2004	Bracing Assembly for Chain-Link Fence, 4 Foot	Each
620.2006	Bracing Assembly for Chain-Link Fence, 6 Foot	Each
620.2008	Bracing Assembly for Chain-Link Fence, 8 Foot	Each
620.2500	Woven Wire Fence with Steel Posts	Linear Foot
620.2600	Woven Wire Fence with Wood Posts	Linear Foot
620.3000	Drive Gate for Woven Wire Fence	Each
620.4000	Steel Brace for Woven Wire Fence	Each
620.4100	Wood Brace for Woven Wire Fence	Each
620.4500	Plank Rail Fence	Linear Foot
620.5000	Removing and Resetting Fence	Linear Foot
620.5500	Removal of Existing Fence	Linear Foot
620.7500	Snow Barrier Fence	Linear Foot
620.8000	Barbed Wire Fence	Linear Foot
620.8100	Split Rail Fence	Linear Foot
620.8200	Square Steel Fence	Linear Foot
620.9000	Hand Railing	Linear Foot

SECTION 621 – TRAFFIC BARRIERS

621.01 DESCRIPTION. This work shall consist of furnishing, assembling, removing, repairing, or resetting traffic barriers.

621.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Grease Rustproofing Compound.....708.04
Coatings for Wood.....708.05
Galvanizing.....726.06
Posts.....728.01
Beam and Cable Elements.....728.02
Hardware.....728.03
Offset Blocks.....728.04
Concrete Anchors.....728.05
Manufactured Terminal Sections.....728.06
Energy Absorption Attenuators.....728.07
Temporary Traffic Barrier.....728.08
Flat Sheet Aluminum.....750.03
Retroreflective Sheeting.....750.04

Reinforcing steel shall meet the requirements of Section 507.

Materials for removing and resetting guardrail, replacing guardrail post assemblies, replacing guardrail beam units, and adjust the height of guardrail shall consist of the acceptable beams and cable, posts, offset blocks, bolts, and other hardware of the existing guardrail together with the necessary new replacement parts. The new replacement parts shall match the existing components they replace as closely as possible.

All welding shall conform to the requirements of Subsection 506.10.

621.03 FABRICATION DRAWINGS. The fabricator of guardrail approach sections furnished under this section shall submit detailed fabrication drawings in accordance with Subsection 105.06.

621.04 POSTS AND OFFSET BLOCKS. Posts may be set in holes, or they may be driven if suitable caps and driving equipment are used to prevent damage to the posts. The installed posts shall be plumb, accurately aligned, spaced as shown on the Plans, and placed to the full depth indicated. The space around the posts shall be backfilled with suitable material in 6 inch layers and tamped thoroughly with air or mechanical tampers.

Posts for steel backed timber guardrail may be driven or installed into pre-drilled holes. The dimensions of the pre-drilled hole shall not exceed the dimensions of the post by more than 1 inch. If impenetrable material is encountered while placing the post, the pre-drilled hole shall be enlarged to provide not less than 6 inches of clearance on all sides and a minimum depth of 2-1/2 feet and the post shall be set in concrete to within 6 inches of the top of the hole. The type of concrete shall be approved by the Engineer. The remaining 6 inches shall be backfilled with a suitable material and compacted to the satisfaction of the Engineer.

The guardrail designated to be removed and reset shall be carefully removed, temporarily stored when necessary, and reinstalled at the new location. Materials damaged or lost shall be replaced with new material by the Contractor at no cost to the Agency. The new materials shall be equal to or better than the material of the existing guardrail. Guardrail to be removed and reset shall be installed at the height specified on the Plans for the type of guardrail being reset.

Guardrail posts and anchors shall be installed prior to placing the adjacent top course of pavement unless otherwise directed by the Engineer.

621.05 RAIL ELEMENTS.

(a) Beam Rail. Rail elements shall be erected in a manner resulting in a smooth, continuous installation. All bolts, except adjustment bolts, shall be drawn tight. Bolts shall be of sufficient length to extend beyond the nuts.

(b) Steel-Backed Timber Rail. Timber rails shall be cut to produce a close fit at all joints. Field cuts shall be treated with an approved material as determined by the Engineer.

621.06 ENERGY ABSORPTION ATTENUATORS. Energy absorption attenuators, permanent or temporary, shall be installed at the locations shown on the Plans or in the approved traffic control plan and per the manufacturer's recommendations. Installation of any traffic barrier requiring protection with an energy absorption attenuator shall not begin until the complete energy absorption attenuator is on the project site and ready to be installed. Attenuators shall be a minimum of Test Level 3 for posted speed limits greater than 40 mph and a minimum of Test Level 2 for posted speed limits of 40 mph and less, in accordance with *MASH*.

(a) Permanent. Permanent energy absorption attenuators shall be in accordance with Subsection 728.07(b).

(b) Temporary. Temporary energy absorption attenuators shall be in accordance with Subsection 728.07(a). It shall be the Contractor's responsibility to maintain all in-service temporary energy absorption attenuators in accordance with the manufacturer's recommendations. Any damage which affects the performance of the attenuator, as determined by the Engineer, shall be repaired immediately in accordance with the manufacturer's recommendations or the attenuator shall be replaced with the spare temporary energy absorption attenuator as necessary.

A single spare temporary energy absorption attenuator, of each type installed, shall be on the project site while any temporary energy absorption attenuator is in service and shall be ready to be installed in the case a temporary energy absorption attenuator needs to be replaced or repaired. In the case a spare temporary energy absorption attenuator has been used, completely or in part, the Contractor shall replace all used components of the spare so that a fully functioning spare is available within 48 hours of the use of any spare.

Temporary energy absorption attenuators shall be removed from the project upon determination, by the Engineer, that they are no longer needed and shall remain the property of the Contractor.

Liquid or sand filled temporary energy absorption attenuators shall not be used between November 16th and March 31st, inclusive.

621.07 TEMPORARY TRAFFIC BARRIER. Temporary traffic barrier shall be installed at the locations shown on the Plans, in the approved traffic control plan, or as directed by the Engineer and per the manufacturer's recommendations. The barrier shall be one of the barriers included in the FHWA *Roadside Hardware Policy Memoranda and Guidance* for crashworthy longitudinal barriers, at the Contractor's discretion, unless otherwise specified.

The Contractor shall provide the name of the temporary traffic barrier and current FHWA eligibility letter for the temporary traffic barrier to the Engineer prior to installation. If temporary traffic barrier meeting *NCHRP Report 350* is used, the Contractor shall submit an affidavit certifying that it was manufactured prior to January 1, 2020.

Temporary traffic barrier components shall be in a condition satisfactory to the Engineer prior to placement on the project and maintained as such until removed from the project.

Temporary traffic barrier shall be removed from the project when no longer needed and shall remain the property of the Contractor. The area from which the barrier was removed shall be restored to a satisfactory condition.

Temporary traffic barrier and required appurtenances shall be removed and reset as shown on the Plans or as ordered in writing by the Engineer.

621.08 TEMPORARY TRAFFIC PROTECTION. Barrier used for temporary traffic protection shall be existing guardrail that is removed and reset, new guardrail, or temporary traffic barrier installed in locations detailed on the Plans to allow full-width construction.

Barrier for temporary traffic protection shall only be used during the construction season on active projects as a temporary protection method. Any traffic protection measures that are required during shutdowns of work activities shall be permanent and conform to applicable standards.

621.09 TERMINALS AND END ASSEMBLIES. Terminals and end assemblies shall be installed at the locations shown on the Plans and as detailed on the Plans or per the manufacturer's recommendations. New traffic barrier installations shall be protected by a terminal or end assembly the same day the traffic barrier is installed and may be protected permanently as shown on the Plans or temporarily as approved by the Engineer. Temporary terminals and end assemblies shall not be in place more than 48 hours and will be considered incidental to other traffic barrier items.

All new terminal and end assembly installations shall include a permanent identification of the year of installation and model identified on the Agency's *Approved Products List* or the Standard Drawing used. Payment will be incidental to the traffic barrier items.

Terminals and end assemblies shall be of the type specified in the Contract.

621.10 ANCHORS. Anchors shall be installed at the locations shown on the Plans. Backfill material shall be placed in layers of not more than 6 inches and shall be thoroughly compacted by use of a mechanical tamper, to the satisfaction of the Engineer.

Cables, when required, shall be drawn taut and fastened securely to the anchor assemblies as shown on the Plans and adjusted to equalize the stresses.

621.11 DELINEATION. Delineation devices shall consist of flat sheet aluminum and retroreflective sheeting of the design shown on the Plans and shall be securely fastened to traffic barriers as shown on the Plans or as directed by the Engineer.

621.12 FIELD PAINTING. Galvanized components that have been cut, abraded, or damaged such that base metal is exposed shall be repaired with two coats of zinc paint in accordance with Subsection 726.06, and paint when specified on the Plans.

Wherever guardrail panels are nested, the surfaces on both panels that will be in contact with each other shall be coated with grease rustproofing compound. Overlapping at splices will not be considered nesting.

621.13 REPLACEMENT, ADJUSTMENT, REMOVAL, AND DISPOSAL. Guardrail which is to remain in place will be inspected by the Engineer for damage, unsuitability, and conformance to current guardrail standards. The Engineer will mark guardrail components which are to be replaced. The guardrail shall then be checked for height conformance.

Guardrail sections which measure outside of the allowable heights specified in Table 621.13A shall be adjusted to the standard height described for the type of guardrail to be adjusted. All measurements shall be taken from the adjacent pavement surface to the top of rail.

TABLE 621.13A – ALLOWABLE GUARDRAIL HEIGHTS

Guardrail Type	Low Measure Tolerance (in.)	High Measure Tolerance (in.)	Adjust to Height (in.)
Standard W-beam (splice at post)	27-3/4	31	29
Midwest Guardrail System (MGS, splice between posts)	29-3/4	33	31
Box beam	25-3/4	29	27

Sections which generally conform for height but have many variations due to erosion or filling of the shoulder from normal mechanisms shall have the shoulder graded as specified on the Plans before being checked for height conformance. After adjustment is complete, the existing rail shall conform to current design standards for height as appropriate for the type of guardrail being adjusted.

Guardrail height adjustments shall be made to reflect guardrail height at final grade. The Contractor shall repair or replace all damaged or missing components. Components shall be repaired or replaced as determined by the Engineer and in accordance with the Plans or current standards, as applicable.

The finished appearance of the rehabilitated rail shall be a continuous smooth line without abrupt dips over the entire section, to the satisfaction of the Engineer.

Offset blocks designated for replacement shall be replaced with polyvinyl blocks unless wood blocks are specifically called for on the Plans. Materials shall be in conformance with the applicable requirements of Subsection 728.04.

Unless otherwise specified in the Contract, material to be removed shall become the property of the Contractor. Materials removed from service shall be removed from the state right-of-way limits at the end of each work day, unless otherwise approved by the Engineer. Materials removed shall be disposed of in accordance with applicable local, state, and federal regulations.

Unless otherwise indicated, anchors which are designated for removal and disposal, not removal and salvage, may have the anchor or anchor block abandoned in place with the anchor rod cut in such a manner that no portion of the anchor assembly is within 1 foot of the ground, shoulder, or roadway surface.

If posts or anchors are removed from an area where there is no other excavation or embankment work, the resulting holes shall be backfilled with suitable material matching as closely as possible the surface, subbase, and other materials in both type and depth. The backfill shall be placed in layers not more than 6 inches in depth, thoroughly compacted using a mechanical tamper, and the area seeded in accordance with Section 651.

Existing materials to be salvaged shall be protected from damage or loss by the Contractor during construction operations. Materials lost or damaged shall be replaced with new materials by the Contractor at no expense to the Agency. New materials shall be equal to, or better than, the materials in the existing guardrail.

621.14 METHOD OF MEASUREMENT. The quantity of Removal of Guardrail to be measured for payment will be the number of linear feet removed in the complete and accepted work, measured from end post to end post to which rail was attached.

The quantity of Removal of Guardrail Posts and Removal of Guardrail Offset Blocks to be measured for payment will be the number of each removed in the complete and accepted work.

The quantity of Remove and Reset Temporary Traffic Barrier to be measured for payment will be the number of linear feet removed and reset, measured from end-to-end of the allowable length, including energy absorption attenuators as needed, as described herein, as shown on the Plans, or as directed by the Engineer.

The quantity of Remove and Reset Guardrail to be measured for payment will be the number of linear feet reset in the complete and accepted work, measured in accordance with the type of guardrail specified.

The quantity of Adjust Height of Guardrail to be measured for payment will be the number of linear feet of adjusted guardrail complete in place measured from center to center of the end posts to which the rail elements are attached. Payment will not include measurement of any rail element or anchorage which extends beyond the last post to which the rail elements are attached, nor will any factor based on post spacing distances be applied to the measured distance.

The quantity of Replace Guardrail Beam Unit, W-Beam; Replace Guardrail Beam Unit, Box Beam; and Replace Guardrail Beam Unit, Thrie Beam to be measured for payment will be the number of 12.5-foot rail panels replaced. Those rail panels that are longer or shorter than 12.5 feet in length shall be converted to an equivalent number of 12.5-foot rail panels. The quantity will not be factored for post spacing.

The quantity of Replace Guardrail Post Assembly, W-Beam with 6 Foot Posts; Replace Guardrail Post Assembly, W-Beam with 8 Foot Posts; Replace Guardrail Post Assembly, Box Beam; and Replace Guardrail Post Assembly, Thrie Beam to be measured for payment will be the number of individual posts replaced in the complete and accepted work.

The quantity of Steel Beam Guardrail; Steel Beam Guardrail with 8 Foot Posts; Steel Beam Guardrail, Nested; Steel Beam Guardrail with 8 Foot Posts, Nested; HD Steel Beam Guardrail; HD Steel Beam Guardrail with 8 Foot Posts; HD Steel Beam Guardrail, Nested; HD Steel Beam Guardrail with 8 Foot Posts, Nested; and Thrie Beam Guardrail to be measured for payment will be the number of linear feet of each kind specified installed in the complete and accepted work, measured center to center of end posts to which rail is attached. The measured quantity will not include those portions of the installation within the pay limits for manufactured terminal section (MTS) or terminal connector items. Where terminal end sections are installed, an additional 2 feet of guardrail will be included for each end section. W-beam to Thrie beam transition sections will be paid for as an equal length of Thrie beam guardrail.

The measured quantity of Steel Beam Guardrail of the type specified, HD Steel Beam Guardrail of the type specified, and Thrie Beam Guardrail will be multiplied by the post spacing factors specified in the Table 621.14A.

TABLE 621.14A – BEAM GUARDRAIL POST SPACING FACTORS

Post Spacing	Factor
6 ft 3 in.	1.0
4 ft 2 in.	1.2
3 ft 1-1/2 in.	1.4

The quantity of Steel Beam Guardrail Offset Block; Terminal Connector for Steel Beam Guardrail; Anchor for Steel Beam Guardrail; Anchor for Steel Beam Guardrail, MGS; Anchor for Steel Beam to Box Beam Transition; and Traffic Barrier Delineator to be measured for payment will be the number of each component installed in the complete and accepted work.

The quantity of Guardrail Transition, Steel Beam to Box Beam to be measured for payment will be the number of linear feet of transition rail used in the complete and accepted work. Measurement will be made along the face of the rail from end to end or between the pay limits specified.

The quantity of Box Beam Guardrail to be measured for payment will be the number of linear feet installed in the complete and accepted work, measured from center to center of end posts. An additional 1 foot of guardrail will be allowed for each overhang.

The quantity of Temporary Traffic Barrier to be measured for payment will be the number of linear feet installed and removed in the complete and accepted work, measured from end to end of each installation, including terminals. Any barrier removed and not reset will not be measured for payment under this item, but will be considered incidental to the original installation of the barrier. No measurement for payment will be made for barrier that is removed and reset for the convenience of the Contractor, for minor adjustments of 2 feet or less in any direction, or for any removal and resetting that was not approved by the Engineer.

The quantity of Temporary Traffic Protection to be measured for payment will be the number of linear feet of barrier placed in the complete and accepted work, measured from end to end of each installation, including end terminals and anchors. Only the initial removal and resetting of existing guardrail, placement of new guardrail, or placement of temporary traffic barrier used for temporary traffic protection will be measured for payment. Any other interim placements or adjustments prior to installation of permanent guardrail, either for the convenience of the Contractor, damage after initial placement, or as directed by the Engineer, will be considered incidental to the work.

The quantity of Steel Backed Timber Guardrail to be measured for payment will be the number of linear feet installed in the complete and accepted work, measured from end to end along the face of rail, including terminal sections. The measured length will be multiplied by a factor of 1.4 for a post spacing of 5 feet.

The quantity of MTS of the type specified; Box Beam Guardrail End Assembly, Type IIA; and Guardrail Approach Section of the type specified to be measured for payment will be the number of units of each type specified, installed in the complete and accepted work.

The quantity of Energy Absorption Attenuator, Temporary of the type specified and Energy Absorption Attenuator, Permanent of the type specified to be measured for payment will be the number of each unit installed in the complete and accepted work. The spare temporary energy absorption attenuator will not be measured for payment since supplying a spare on the project will be considered incidental to the Energy Absorption Attenuator, Temporary item.

621.15 BASIS OF PAYMENT. The accepted quantity of Removal of Guardrail will be paid for at the Contract unit price per linear foot. Removed guardrail that is not reset will be paid for as Removal of Guardrail. Payment will be full compensation for removing and disposing of materials, including treated timber curbing and the associated bituminous concrete fillet, and for restoration of the old site when required.

The accepted quantity of Removal of Guardrail Posts and Removal of Guardrail Offset Blocks will be paid for at the Contract unit price for each. Payment will be full compensation for removing and disposing of materials and for restoration of the old site when required.

The accepted quantity of Remove and Reset Temporary Traffic Barrier will be paid for at the Contract unit price per linear foot. Payment will be full compensation for removing, transporting, storing, reassembling all parts necessary, cutting, furnishing of new parts when necessary, reinstalling at the new locations, reinstalling required terminals or energy absorption attenuators, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Payment will also include removing and replacing anchors.

The accepted quantity of Remove and Reset Guardrail will be paid for at the Contract unit price per linear foot. Payment will be full compensation for removing, transporting, storing, reassembling all parts necessary; removing and disposing of treated timber curbing and the associated bituminous concrete fillet; cutting; furnishing of new hardware when necessary; reinstalling at the new locations; furnishing and applying stain, paint, and preservative material; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Payment for removing and replacing anchors, terminals, and end assemblies when required will be paid for under the applicable Contract items. Replacing panels, offset blocks, and posts will be paid for separately under the applicable Contract items.

The accepted quantity of Adjust Height of Guardrail will be paid for at the Contract unit price per linear foot. Payment will be full compensation for adjusting the height of the existing guardrail to conform to current standards; for any necessary excavation and backfill, including proper compaction; for furnishing, transporting, handling, and installing components which are necessary to make the adjusted guardrail a complete installation and which are not part of any other pay item in the Contract; for disposing of removed components which are not reused; and for furnishing the labor, tools, equipment, and incidentals necessary to complete the work. Replacing panels, offset blocks, and posts will be paid for separately under the applicable Contract items.

The accepted quantity of Replace Guardrail Beam Unit, W-Beam; Replace Guardrail Beam Unit, Box Beam; and Replace Guardrail Beam Unit, Thrie Beam will be paid for at the Contract unit price for each. Payment will be full compensation for removing and disposing of the designated beam panel; for furnishing, transporting, handling, and installing the replacement components needed, including new rail beam units of the required length; replacement backer plates if required and not covered under another Contract item, new reflectors or other delineation if required and not covered under a post assembly replacement item; new bolts, nuts, washers, and any other necessary hardware; for drilling holes as required to complete the installation of the replacement panel; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Minor repairs and replacement of parts for anchorage devices, such as tightening nuts, adjusting turn buckles, replacing nuts or bolts, rethreading rod ends, etc. will be considered incidental to the other Section 621 pay items in the Contract.

The accepted quantity of Replace Guardrail Post Assembly, W-Beam with 6 Foot Posts; Replace Guardrail Post Assembly, W-Beam with 8 Foot Posts; Replace Guardrail Post Assembly, Box Beam; and Replace Guardrail Post Assembly, Thrie Beam will be paid for at the Contract unit price for each. Payment will be full compensation for removing and disposing of the designated post and hardware; for any necessary excavation and backfill, including proper compaction; for furnishing, transporting, handling, and installing the replacement post or backup plate if required; new bolts, nuts, washers and any other necessary hardware; steel strapping as necessary; stain, paint, and preservative; and for furnishing all labor, tools, equipment, and incidentals necessary for the work.

The accepted quantity of Steel Beam Guardrail; Steel Beam Guardrail with 8 Foot Posts; Steel Beam Guardrail, Nested; Steel Beam Guardrail with 8 Foot Posts, Nested; HD Steel Beam Guardrail; HD Steel Beam Guardrail with 8 Foot Posts; HD Steel Beam Guardrail, Nested; HD Steel Beam Guardrail with 8 Foot Posts, Nested; Thrie Beam Guardrail; and Box Beam Guardrail will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified; removing and disposing of damaged guardrail components; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Steel Beam Guardrail Offset Block; Terminal Connector for Steel Beam Guardrail; Anchor for Steel Beam Guardrail; Anchor for Steel Beam Guardrail, MGS; Anchor for Steel Beam to Box Beam Transition; and Traffic Barrier Delineator will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified; removing and disposing of damaged guardrail components; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Guardrail Transition, Steel Beam to Box Beam will be paid for at the Contract unit price per linear foot. Payment will be full compensation for detailing, furnishing, handling, placing, delineating, and galvanizing the railing components, including W-beam sections requiring replacement; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Temporary Traffic Barrier will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing and installing barrier and any required terminals or protective end devices, and for removal and site restoration where required.

The accepted quantity of Temporary Traffic Protection will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, detailing, transporting, handling, and installing the temporary traffic protection system, including, but not limited, to excavation, backfill, re-grading the installation area as necessary, delineation devices, posts, blocks, terminals, and hardware, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. New guardrail installed permanently on the project will be paid for separately under the appropriate Contract items. Existing guardrail removed and not reset on the project, either temporarily or permanently, will be paid for separately under the appropriate Contract items. Placement of barrels or other delineation devices for the purpose of providing temporary traffic protection will not be paid for under this item but will be incidental to the appropriate traffic control item.

The accepted quantity of Steek Backed Timber Guardrail will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified; removing and disposing of damaged guardrail components; enlarging holes as necessary for placement of posts; furnishing and placing concrete fill and backfill material, and compacting backfill to the satisfaction of the Engineer; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of MTS of type specified; Box Beam Guardrail End Assembly, Type IIA; and Guardrail Approach Section of the type specified will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, detailing, transporting, handling, and installing the terminal sections, assemblies, and approach sections used, including, but not limited to, excavation, backfill, re-grading the installation area as necessary, delineation devices, restraining devices, hardware, preservative treatment, and for furnishing all labor, tools, equipment, and incidentals necessary for installing a complete and properly functioning unit.

The accepted quantity of Energy Absorption Attenuator, Temporary will be paid for at the Contract unit price for each. Payment will be full compensation for fabricating, furnishing, transporting, handling, and installing the materials required, including all hardware; any necessary manufacturer’s supervision; the furnishing of all labor, tools, equipment, and incidentals necessary for installing the attenuator; maintaining, repairing, or replacing the attenuator as necessary while it is in service; and for removing and disposing of the attenuator when it is no longer needed.

The accepted quantity of Energy Absorption Attenuator, Permanent will be paid for at the Contract unit price for each. Payment will be full compensation for fabricating, furnishing, transporting, handling, and installing the materials required, including all hardware; any necessary manufacturer's supervision; and the furnishing of all labor, tools, equipment, and incidentals necessary for installing the attenuator, complete and in place.

(a) Partial payments for Energy Absorption Attenuator, Temporary will be made as follows:

(1) The initial 70% of the Contract unit price will be paid when the attenuator is installed and functioning to the satisfaction of the Engineer.

(2) The remaining 30% of the Contract unit price will be paid when the Engineer has determined that the attenuator is no longer required for use at the original installed location.

(b) Partial payments for Temporary Traffic Barrier will be made as follows:

(1) The initial 50% of the accepted quantity will be paid for upon the satisfactory installation of the barrier.

(2) The remaining 50% of the accepted quantity will be paid for upon the final removal of the barrier.

(c) Partial payments for Remove and Reset Temporary Traffic Barrier will be made as follows:

(1) The initial 50% of the accepted quantity will be paid for upon the removal of the originally installed barrier.

(2) The remaining 50% of the accepted quantity will be paid for upon the satisfactory reinstallation of the barrier.

Payment will be made under:

Pay Item		Pay Unit
621.0100	Removal of Guardrail	Linear Foot
621.0110	Removal of Guardrail Posts	Each
621.0120	Removal of Guardrail Offset Blocks	Each
621.0200	Remove and Reset Temporary Traffic Barrier	Linear Foot
621.0210	Remove and Reset Guardrail	Linear Foot
621.0220	Adjust Height of Guardrail	Linear Foot
621.0300	Replace Guardrail Beam Unit, W-Beam	Each
621.0360	Replace Guardrail Post Assembly, W-Beam with 6 Foot Posts	Each
621.0380	Replace Guardrail Post Assembly, W-Beam with 8 Foot Posts	Each
621.0400	Replace Guardrail Beam Unit, Box Beam	Each
621.0450	Replace Guardrail Post Assembly, Box Beam	Each
621.0500	Replace Guardrail Beam Unit, Thrie Beam	Each
621.0550	Replace Guardrail Post Assembly, Thrie Beam	Each
621.1060	Steel Beam Guardrail	Linear Foot
621.1080	Steel Beam Guardrail with 8 Foot Posts	Linear Foot
621.1160	Steel Beam Guardrail, Nested	Linear Foot
621.1180	Steel Beam Guardrail with 8 Foot Posts, Nested	Linear Foot
621.1260	HD Steel Beam Guardrail	Linear Foot
621.1280	HD Steel Beam Guardrail with 8 Foot Posts	Linear Foot
621.1360	HD Steel Beam Guardrail, Nested	Linear Foot
621.1380	HD Steel Beam Guardrail with 8 Foot Posts, Nested	Linear Foot
621.1500	Steel Beam Guardrail Offset Block	Each
621.1510	Terminal Connector for Steel Beam Guardrail	Each
621.1520	Anchor for Steel Beam Guardrail	Each
621.1530	Anchor for Steel Beam Guardrail, MGS	Each
621.1540	Anchor for Steel Beam to Box Beam Transition	Each
621.1550	Guardrail Transition, Steel Beam to Box Beam	Linear Foot
621.1560	Traffic Barrier Delineator	Each
621.2200	Thrie Beam Guardrail	Linear Foot
621.2300	Box Beam Guardrail	Linear Foot
621.2400	Temporary Traffic Barrier	Linear Foot
621.2500	Temporary Traffic Protection	Linear Foot
621.2600	Steel Backed Timber Guardrail	Linear Foot

Pay Item		Pay Unit
621.3020	MTS, MGS, Tangent, TL-2	Each
621.3030	MTS, MGS, Tangent, TL-3	Each
621.3120	MTS, MGS, Flared, TL-2	Each
621.3130	MTS, MGS, Flared, TL-3	Each
621.4020	MTS, Box Beam, Tangent, TL-2	Each
621.4030	MTS, Box Beam, Tangent, TL-3	Each
621.4120	MTS, Box Beam, Flared, TL-2	Each
621.4130	MTS, Box Beam, Flared, TL-3	Each
621.6021	Box Beam Guardrail End Assembly, Type IIA	Each
621.7020	Energy Absorption Attenuator, Temporary, TL-2	Each
621.7030	Energy Absorption Attenuator, Temporary, TL-3	Each
621.7120	Energy Absorption Attenuator, Permanent, TL-2	Each
621.7130	Energy Absorption Attenuator, Permanent, TL-3	Each
621.8010	Guardrail Approach Section, Type I	Each
621.8020	Guardrail Approach Section, Type II	Each
621.8030	Guardrail Approach Section, HD Steel Beam	Each
621.8040	Guardrail Approach Section, HD Steel Beam with 8 Foot Posts	Each
621.8120	Guardrail Approach Section, 2 Rail Box Beam	Each
621.8130	Guardrail Approach Section, 3 Rail Box Beam	Each
621.8140	Guardrail Approach Section, 4 Rail Box Beam	Each
621.8230	Guardrail Approach Section, 3 Rail Box Beam, Curbless	Each
621.8231	Guardrail Approach Section to 3 Rail Aluminum	Each
621.8232	Guardrail Approach Section to 3 Rail Aluminum, Pedestrian	Each
621.8320	Guardrail Approach Section to Concrete Bridge Rail, TL-2	Each
621.8330	Guardrail Approach Section to Concrete Bridge Rail, TL-3	Each
621.9980	Guardrail Approach Section, Metal Truss Bridge	Each
621.9990	Guardrail Approach Section, Covered Bridge	Each

SECTION 622 – INSULATION BOARD

622.01 DESCRIPTION. This work shall consist of furnishing and installing extruded or expanded polystyrene insulation board on a prepared surface.

622.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Sand Borrow and Cushion 703.03
Polystyrene Insulation Board 735.01

Skewers shall conform to the requirements of the insulation manufacturer.

622.03 PREPARATION OF SURFACE. The surface shall be prepared as follows:

(a) The surface on which insulation board is to be placed shall be shaped as shown on the Plans. Any unsuitable material shall be replaced with satisfactory material. The surface shall be compacted to attain at least 95% of the maximum dry density and the in-place moisture content shall be not more than 2% above the optimum moisture content, as determined by *AASHTO T 99, Method C*.

(b) When sand borrow is required, it shall be spread and compacted to a minimum depth of 3 inches just prior to the placement of the insulation board.

(c) Compaction shall be performed in accordance with Subsection 203.11(d).

622.04 PLACEMENT OF INSULATION. The insulation board shall be placed and secured as follows:

(a) The boards shall be placed in such a manner that the transverse joints will be staggered. If two layers of insulation are used, the second shall be placed to cover the joints of the first layer.

(b) Means will be provided to ensure a straight alignment of the boards.

(c) A minimum of two skewers, as approved by the Engineer, shall be used to hold each insulation board in place. The skewers shall be driven at an angle of less than 90° from the horizontal until flush with the surface of the insulation boards. Skewers shall be used for each layer when more than one layer of material is used.

622.05 PLACEMENT OF MATERIAL ON THE INSULATION BOARD. Special care shall be taken that the equipment used in placing the material does not operate directly upon the installed insulation board.

The first layer of material shall be placed to a minimum depth of 8 inches, loose measurement, by dumping in piles and then moving it forward onto the insulation board by approved equipment. The first layer of material shall be compacted to the satisfaction of the Engineer. The compaction of subsequent layers shall be made with the same construction procedures required for the type of material being placed.

Any insulation board that becomes displaced or damaged prior to or during placing of the material shall be repositioned or removed and replaced with new insulation board at the Contractor's expense.

622.06 METHOD OF MEASUREMENT. The quantity of Insulation Board to be measured for payment will be the number of thousand feet board measure (MFBM) installed in the complete and accepted work, based on the nominal dimensions of material. No allowance will be made for waste.

622.07 BASIS OF PAYMENT. The accepted quantity of Insulation Board will be paid for at the Contract unit price per thousand feet board measure (MFBM). Payment will be full compensation for furnishing, transporting, handling, and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work, except that sand will be paid for under pay item 203.3100.

Payment will be made under:

Pay Item	Pay Unit
622.1000 Insulation Board	MFBM

SECTION 625 – UTILITY SYSTEMS

625.01 DESCRIPTION. This work shall consist of furnishing and installing utility sleeves, concrete encased and direct burial conduit, junction and pull boxes, power drop stanchions, utility vaults, and other utility equipment and components as specified on the Plans.

625.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Sand Borrow and Cushion 703.03
Brick.....705.01
Mortar, Type II.....707.01(c)
Mortar, Type IV .....707.01(e)
Joint Sealer, Hot Poured .....707.02(a)
Preformed Joint Filler, Cork, and Asphalt-Treated Felt 707.06
Polyvinyl Chloride (PVC) Waterstop 707.08
Reinforced Concrete Pipe 710.01
Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe.....710.04
Polyvinyl Chloride (PVC) Plastic Pipe.....710.05
Corrugated Steel Pipe, Pipe Arches, and Underdrains 711.01
Corrugated Aluminum Alloy Pipe, Pipe Arches, and Underdrains 711.02
Bar Reinforcement 713.01
Plastic Pipe, Flexible.....740.01
Rigid Polyvinyl Chloride (PVC) Electrical Conduit .....752.06(a)
High-Density Polyethylene (HDPE) Electrical Conduit.....752.06(b)
PVC Coated Rigid Metal Conduit (RMC).....752.06(c)
Junction Boxes .....752.09(a)
Pull Boxes .....752.09(b)
Power Drop Stanchion 752.14

Concrete shall conform to the requirements of Section 541 for Concrete, Class B.

All wood blocks used as skids shall be oak or maple structural lumber No. 2 Grade or better.

All prefabricated casing spacers shall be designed for the intended application and be of the centered restrained type.

Stainless steel strapping shall meet the requirements of *ASTM A666.*

Sleeves for power and communication lines shall be non-metallic.

Steel sleeves shall conform to *ASTM A53* and the wall thickness shall be compatible with the specified buried depth.

Carrier pipes shall have restrained joints to allow for future removal of the pipe without having to de-couple the pipe joints.

Casing end seals shall be of masonry construction. Modular wall and pipe seals shall be stainless steel hardware or prefabricated casing end seals with stainless steel bands.

Pedestals, vaults, handholes, and transformer cabinets shall conform to the requirements of the respective utility company specifications.

Pull boxes shall be designed and constructed to support at least an HS-20 loading in accordance with the *AASHTO Standard Specifications for Highway Bridges*.

625.03 GENERAL REQUIREMENTS. The Contractor shall coordinate and work with each utility company, as necessary, to ensure that the conduit and utility equipment installed are constructed in accordance with the Plans and the utility company's specifications.

625.04 CONSTRUCTION REQUIREMENTS.

(a) Earthwork. The Contractor shall perform all excavations, backfilling, and resurfacing work, including removal and replacement of curbs, sidewalks, paved surfaces, and any other materials necessary to complete the work in accordance with the Contract or as directed by the Engineer.

All pavement surfaces to be removed shall be saw-cut to the full pavement depth along the neat lines of the area to be removed.

All landscaping and underground utility systems that have been disturbed during construction shall be restored to their original condition upon the completion of the work.

Backfill of suitable material shall be placed and compacted in layers not exceeding 6 inches.

(b) Sleeves for Utilities. Sleeves for utilities shall be installed as specified on the Plans or as directed by the Engineer. When the method of installation to be used is not specified or directed by the Engineer, the Contractor may use either trenchless or open-cut methods. Trenchless installation shall be performed in accordance with the requirements of Section 209. Open-cut installation shall be performed in accordance with the requirements specified for culverts in Section 601.

All pipes shall be positively joined.

Unless otherwise specified, any sleeve installed for future use shall be fitted with plugs or caps at both ends and shall contain a suitable pull wire or pull cord accessible from both ends.

The size of utility sleeve specified on the Plans shall be the nominal inside diameter of the sleeve.

Carrier pipe for water, sewer, or gas with an outside diameter greater than 2 inches shall be installed in a sleeve that has an inside diameter at least 12 inches greater than the outside diameter of the carrier pipe.

Utility pipe for power, communications, or cable with an outside diameter greater than 2 inches shall be installed in a sleeve that has an inside diameter at least 4 inches greater than the outside diameter of the utility pipe.

For utilities with an outside diameter of 2 inches or less, the inside diameter of sleeves shall be as specified in Table 625.04A.

TABLE 625.04A – MINIMUM SLEEVE DIAMETERS FOR CARRIER OR UTILITY PIPE

Carrier or Utility Pipe	Min. Inside Diameter of Sleeve (in.)
Power lines	4
Telephone lines	4
Cable TV lines	4
Water pipes	6
Water service lines	4
Sewer pipes	6
Gas pipes	6
Fiber optic cables	4

Unless otherwise specified, utility sleeves placed under roadways or drives shall have a minimum cover depth of 5 feet measured from the finished roadway surface. Sleeves shall have a pitch or grade no flatter than 1:400 (V:H) and provisions shall be made for draining moisture away from the sleeve location or as directed by the Engineer.

Unless otherwise specified, the Contractor shall install utility sleeves in a straight line with no bends. The installed sleeve shall terminate a minimum of 4 feet outside the face of curb, 4 feet outside the edge of shoulder of the roadway, 4 feet outside the edge of the drive that the sleeve crosses, or 4 feet outside the edge of sidewalk, whichever situation applies.

(c) Installation of Conduit. Conduit shall be installed at the locations shown on the Plans or as directed by the Engineer.

Unless otherwise specified, conduit shall be placed not less than 2 feet below the top of curb in sidewalk areas and not less than 3 feet below the finished grade of pavement when passing under roadways. When conduit is placed below the roadway, it shall be placed in a utility sleeve. Conduit shall have a pitch or grade no flatter than 1:400 (V:H) and provision shall be made for draining moisture away from pull boxes as directed by the Engineer.

Only high density polyethylene (HDPE) plastic pipe conduit shall be used for underground installations.

Where factory bends are not being used, the conduit shall be bent using the longest radius possible, but not less than six times the inside diameter of the conduit, in a manner that will not crimp or flatten the conduit.

Not more than three 90° bends or equivalent (270° total) shall be used on a continuous conduit line. If more than 270° in total bends are necessary, then a pull box or junction box shall be installed.

Once the conduit lines are completed, any obstructions, including stone and dirt, shall be removed. Damaged conduit shall be removed and replaced at the Contractor's expense. Conduit may be subjected to a mandrel test at the direction of the Engineer. Unless otherwise specified by the Engineer or the utility, the diameter of the mandrel shall be 1/4 inch less than the diameter of the conduit and shall be a minimum of one conduit diameter in length.

Conduit spacers, as approved by the Engineer and the utility company's inspector, shall be used to ensure separation between the conduits as shown on the Plans. Spacers shall be placed at 6-foot intervals or as recommended by the project manufacturer.

When conduit is to be left empty under the Contract, the Contractor shall furnish and install a pull cord with a minimum pull strength of 5 kips in each conduit. The pull cord shall terminate beyond the end of the conduit in each pull box, or just under the cap at concrete bases for poles.

Detectable underground warning tape 6 inches wide shall be placed in the excavated trench 12 inches to 18 inches below the finished grade for all open cut conduit and sleeve runs. Tape indicating electrical conduit shall be red and tape indicating communication conduit shall be orange.

Conduit joints shall be made watertight using brush-applied cement as recommended by the manufacturer.

Where shown on the Plans, wired conduit may be either pre-wired before the conduit is installed or the wire may be installed after the conduit is installed. The item for wired conduit includes both the conduit and the wires contained within the conduit, however, the wires and the conduit shall not be attached to each other, and the wires shall be readily pulled from the conduit for replacement without excessive effort.

Except where otherwise shown on the Plans, installed conduit shall have a minimum nominal inside diameter of 2 inches or it shall match the size of the existing conduit to which it is being attached. In either case, the installed conduit shall be of sufficient inside diameter to contain wiring of a size such that the voltage drop in the secondary circuits will not exceed 3%.

Wired conduits shall have a sufficient inside diameter such that the combined cross-sectional area of the wiring does not exceed the percentage of conduit fill specified in the *National Electrical Code*. Conduits shall, in accordance with the other requirements of this subsection, contain all the wiring necessary to make the completed system or subsystem to which they are attached function.

(d) Concrete Encased Conduit. The Contractor shall confirm, before placing forms or conduit lines, that the surface on which the concrete is to be poured is firmly compacted and free from voids, rocks, and rubble.

Prior to pouring concrete, the conduit shall be securely anchored to prevent movement during the pour. Anchors shall be within 2 feet and on each side of a joint, at each end of a bend, and have a maximum spacing between anchors of 10 feet. All conduit placements shall require approval by the Engineer. Any field modifications shall only be done with the approval of the Engineer.

When it is expected that there will be an interval of four hours or longer between concrete pours, reinforcement bars shall be installed across the construction joint. The bars shall be No. 4 and not less than 6 feet in length. One bar shall be installed in each corner, and between conduits in the top and bottom of the concrete envelope, 4 inches from the outside surface. Each reinforcement bar shall extend an equal distance into the two pours of concrete.

The conduit envelope shall be square or rectangular in cross section and shall provide for concrete thickness over the outside conduits as shown on the Plans.

The concrete shall be placed carefully so as not to disturb or damage the conduit. The concrete shall be consolidated as directed by the Engineer to eliminate honeycombing or other defects. The Contractor shall ensure that all clearances shown on the Plans are maintained during concrete placement.

To aid in curing, the Contractor may place 6 inches of approved backfill material on the concrete as soon as the surface is set. However, actual backfilling shall not begin until at least 24 hours after placement of concrete. In instances where accelerant is used in the concrete, the 24-hour waiting period for backfill may be reduced by the Engineer.

(e) Junction Boxes and Pull Boxes. Junction boxes and pull boxes shall be placed at the locations shown on the Plans or as directed by the Engineer.

Excavation for the junction boxes and pull boxes shall include excavation of an area one foot outside the box and extending one foot below the finished grade of the bottom of the boxes. One foot of granular material shall be placed in the excavated area and compacted prior to installation. Junction boxes and pull boxes shall be constructed so that there is no standing water present. Additional drainage may be required at the discretion of the Engineer.

All conduits shall enter the junction box through the bottom, not though the side wall. Conduit may enter pull boxes through the side walls.

All covers for junction boxes and pull boxes covers shall be flush with the boxes and frames.

(f) Backfilling. Approved material shall be placed over the conduits in 6-inch layers and compacted in accordance with Subsection 203.11(d) by approved mechanical tampers. Hand tampers will not be permitted. The material shall be brought to the subgrade beneath roadway, grass belt, and any other paved or gravel areas. For grassed areas outside the highway construction limits, the material shall be brought to within 4 inches of the finished grade, a 4-inch layer of topsoil placed, and the area seeded and mulched in accordance with the applicable requirements of Section 651. Paved, concrete, or gravel areas outside the highway construction limits shall be replaced in kind as directed by the Engineer. Backfill shall not contain any stones larger than 1-1/2 inches.

(g) Power Drop Stanchion. Power drop stanchions shall be installed at the locations shown in the Plans or as directed by the Engineer and shall be grounded as shown on the Plans.

Power drop stanchions shall be constructed such that the meter face is oriented facing away from the roadway.

A disconnect breaker for each circuit shall be installed in a locked, rainproof cabinet meeting the requirements of *ANSI/NEMA 250*, Type 3R on a stanchion next to or below the meter socket. If street lighting is present, the traffic signal circuits shall be separate from the street lighting circuits. Disconnect breakers shall be labeled to indicate which circuit they control. All meter disconnects shall have a bypass.

(h) Pedestals, Vaults, and Pads. Pedestals, vaults, and prefabricated concrete pads will be supplied by the utility for the Contractor to install and shall be placed at the locations shown on the Plans or as directed by the Engineer. All work installing pedestals, vaults, and pads shall conform to the respective utility standards and requirements.

625.05 METHOD OF MEASUREMENT. The quantity of Sleeves for Utilities, Concrete Encased Conduit, Direct Burial Conduit, and Wired Conduit of the type and size specified to be measured for payment will be the number of linear feet installed in the complete and accepted work, measured to the nearest foot along the center of the sleeve or conduit.

The quantity of Power Drop Stanchion; Junction Box; Pull Box, Single; Pull Box, Double; Utility Pedestal; Communications Vault; Electric Vault; and Utility Pad to be measured for payment will be the number of each installed in the complete and accepted work.

625.06 BASIS OF PAYMENT. The accepted quantity of Sleeves for Utilities of the type and size specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for fabricating, furnishing, transporting, handling, saw-cutting, and placing all materials, including pull wire and end caps, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantities of Concrete Encased Conduit and Direct Burial Conduit of the type and size specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified, including conduit, conduit spacers, transition couplings, elbows, and other fittings; caps, plugs, pulling wire, bedding material, concrete encasement, rebar, and all other material needed for a complete concrete encased or direct burial conduit system; backfill; placing of concrete; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Wired Conduit of the size specified will be paid for at the Contract unit price per linear foot. Payment will include both the installed conduit and the wiring inside the conduit.

The accepted quantities of Power Drop Stanchion; Junction Box; Pull Box, Single; and Pull Box, Double, will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing and installing the materials specified, as well as any excavation, granular material, and any additional drainage pipes needed.

The accepted quantities of Utility Pedestal, Electric Vault, Communications Vault, and Utility Pad will be paid for at the Contract unit price for each. Payment will be full compensation for transporting, handling, and placing the materials specified; for any coordination with the utility company; excavation, furnishing and placing any subbase material needed; furnishing, and installing grounding material as needed, furnishing and installing any drainage needed; and all materials, tools, labor, equipment, and incidentals needed to complete the work.

The cost of temporary pavements patches required for work under this section will be considered incidental to the applicable item.

Payment will be made under:

Pay Item		Pay Unit
625.1000	Sleeves for Utilities, HDPE	Linear Foot
625.1002	Sleeves for Utilities, HDPE, 2 Inch	Linear Foot
625.1004	Sleeves for Utilities, HDPE, 4 Inch	Linear Foot
625.1006	Sleeves for Utilities, HDPE, 6 Inch	Linear Foot
625.1008	Sleeves for Utilities, HDPE, 8 Inch	Linear Foot
625.1010	Sleeves for Utilities, HDPE, 10 Inch	Linear Foot
625.1012	Sleeves for Utilities, HDPE, 12 Inch	Linear Foot
625.1014	Sleeves for Utilities, HDPE, 14 Inch	Linear Foot
625.1016	Sleeves for Utilities, HDPE, 16 Inch	Linear Foot
625.1018	Sleeves for Utilities, HDPE, 18 Inch	Linear Foot
625.1020	Sleeves for Utilities, HDPE, 20 Inch	Linear Foot
625.1022	Sleeves for Utilities, HDPE, 22 Inch	Linear Foot
625.1024	Sleeves for Utilities, HDPE, 24 Inch	Linear Foot
625.2000	Sleeves for Utilities, PVC	Linear Foot
625.2002	Sleeves for Utilities, PVC, 2 Inch	Linear Foot
625.2004	Sleeves for Utilities, PVC, 4 Inch	Linear Foot
625.2006	Sleeves for Utilities, PVC, 6 Inch	Linear Foot
625.2008	Sleeves for Utilities, PVC, 8 Inch	Linear Foot
625.2010	Sleeves for Utilities, PVC, 10 Inch	Linear Foot
625.2012	Sleeves for Utilities, PVC, 12 Inch	Linear Foot
625.2014	Sleeves for Utilities, PVC, 14 Inch	Linear Foot
625.2016	Sleeves for Utilities, PVC, 16 Inch	Linear Foot
625.2018	Sleeves for Utilities, PVC, 18 Inch	Linear Foot
625.2020	Sleeves for Utilities, PVC, 20 Inch	Linear Foot
625.2022	Sleeves for Utilities, PVC, 22 Inch	Linear Foot
625.2024	Sleeves for Utilities, PVC, 24 Inch	Linear Foot

Pay Item		Pay Unit
625.3000	Sleeves for Utilities, Steel	Linear Foot
625.3002	Sleeves for Utilities, Steel, 2 Inch	Linear Foot
625.3004	Sleeves for Utilities, Steel, 4 Inch	Linear Foot
625.3006	Sleeves for Utilities, Steel, 6 Inch	Linear Foot
625.3008	Sleeves for Utilities, Steel, 8 Inch	Linear Foot
625.3010	Sleeves for Utilities, Steel, 10 Inch	Linear Foot
625.3012	Sleeves for Utilities, Steel, 12 Inch	Linear Foot
625.3014	Sleeves for Utilities, Steel, 14 Inch	Linear Foot
625.3016	Sleeves for Utilities, Steel, 16 Inch	Linear Foot
625.3018	Sleeves for Utilities, Steel, 18 Inch	Linear Foot
625.3020	Sleeves for Utilities, Steel, 20 Inch	Linear Foot
625.3022	Sleeves for Utilities, Steel, 22 Inch	Linear Foot
625.3024	Sleeves for Utilities, Steel, 24 Inch	Linear Foot
625.4000	Concrete Encased Conduit	Linear Foot
625.4004	Concrete Encased Conduit, 1 to 4 Conduits	Linear Foot
625.4008	Concrete Encased Conduit, 5 to 8 Conduits	Linear Foot
625.4012	Concrete Encased Conduit, 9 to 12 Conduits	Linear Foot
625.5000	Direct Burial Conduit	Linear Foot
625.5004	Direct Burial Conduit, 1 to 4 Conduits	Linear Foot
625.5008	Direct Burial Conduit, 5 to 8 Conduits	Linear Foot
625.5012	Direct Burial Conduit, 9 to 12 Conduits	Linear Foot
625.6000	Wired Conduit	Linear Foot
625.6002	Wired Conduit, 2 Inch	Linear Foot
625.6003	Wired Conduit, 3 Inch	Linear Foot
625.6004	Wired Conduit, 4 Inch	Linear Foot
625.6006	Wired Conduit, 6 Inch	Linear Foot
625.7000	Power Drop Stanchion	Each
625.7010	Junction Box	Each
625.7021	Pull Box, Single	Each
625.7022	Pull Box, Double	Each
625.7030	Utility Pedestal	Each
625.7040	Communications Vault	Each
625.7045	Electrical Vault	Each
625.7050	Utility Pad	Each

SECTION 628 – SANITARY SEWER SYSTEMS

628.01 DESCRIPTION. This work shall consist of the construction or reconstruction of sanitary sewer lines and appurtenances.

628.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Granular Backfill for Structures.....704.08
Sewer Brick.....705.01(b)
Rubber Gaskets.....707.09
Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe.....710.04
Polyvinyl Chloride (PVC) Plastic Pipe.....710.05
Ductile Iron Pipe, Cement Lined.....740.05

Concrete shall conform to the requirements of Section 541 for Concrete, Class B, unless otherwise specified.

Sleeves shall conform to the requirements of Section 625.

628.03 GENERAL REQUIREMENTS. Operation of existing sanitary sewer facilities shall not be interrupted without prior written approval of the Engineer.

When existing underground utilities not scheduled for removal or abandonment are encountered in the excavation, they shall be adequately supported and protected from damage. Any damage to utilities shall be repaired promptly in accordance with Subsection 107.12 at no additional cost to the Agency.

The Contractor shall be responsible for the unloading, storing, hauling, and distribution of all materials. All materials that are damaged, destroyed, or lost during and after unloading shall be replaced at the Contractor's expense. All pipes, pipe fittings, and accessories shall be handled to avoid shock. Pipes having factory-applied joint material shall be stacked and blocked to prevent damage to the joint material. Material not needed for immediate use shall be safely stored at places provided by the Contractor and approved by the Engineer.

The Contractor's attention is called to the fact that sewer pipe and fittings are comparatively brittle. Care shall be taken in handling and laying to avoid damaging the pipe and fittings.

The locations of all pipes shall be approved by the Engineer.

When directed by the Engineer, the Contractor shall remove, replace, or rework all sewer piping and appurtenances that do not meet the requirements of this section. The Contractor shall perform all remedial measures at no additional cost to the Agency.

628.04 SUBMITTALS. Fabrication drawings shall be submitted in accordance with Subsection 105.06 for all sewer system components including sewer piping, PVC fittings including reducers and end caps, solid sleeve transition couplings, flexible rubber transition couplings, gaskets, urethane insulation, cleanouts including ring and cover, and all ancillary appurtenances.

Manufacturers' technical data sheets shall be submitted for each type of pipe and fitting to be used on the project, including dimensions, specifications of material, gasket material, class and pressure rating, coatings, and linings, joint restraints, and appurtenances.

628.05 EXCAVATION. Where pipe is to be laid below the existing ground line, a trench shall be excavated to the required depth and to a width sufficient to allow for joining of the pipe and compaction of the bedding and backfill material under and around the pipe. Where feasible, trench walls shall be vertical. The completed trench bottom shall be firm for its full length and width.

If shown on the Plans or directed by the Engineer, poor foundation material encountered below the normal grade of the pipe bed shall be removed and replaced with granular backfill for structures.

Where ledge rock, rocky or gravelly soil, hardpan, or other unyielding foundation materials are encountered in the trench excavation at the normal grade of the pipe bed, the trench shall be excavated to a width equal to the inside diameter of the pipe plus 36 inches, and to a depth of 12 inches below the pipe grade. This area shall be backfilled with granular backfill for structures.

The length of trench to be opened at one time shall be kept within the limit set by the Engineer, unless otherwise permitted or directed by the Engineer.

No tunneling will be permitted except by written approval of the Engineer. Permission to tunnel will be granted only in short sections where, in the opinion of the Engineer, the pipe can be safely and properly installed and the backfill properly compacted.

During construction, the Contractor shall conduct operations to prevent at all times the accumulation of water, ice, and snow in excavations or near excavated areas, and to prevent water from interfering with the progress or quality of the work. Under no conditions shall water be allowed to rise in open trenches after the pipe has been placed.

Accumulated water, ice, and snow shall be promptly removed and disposed of by pumping or other approved means. Disposal shall be carried out in a manner which will not create a hazard to public health; cause injury to public or private property, work completed or in progress, or public streets; or cause any interference in the use of streets and roads by the public. Pipes under construction shall not be used to drain excavations.

Where pipes are to be placed in an embankment, excavation for the pipe shall be made after the embankment has been completed to the specified height above the designed grade for those pipes shown on the Plans.

Sheeting and bracing required for trenches shall be removed to the elevation of the pipe, but no sheeting will be allowed to be pulled, removed, or disturbed below the pipe.

628.06 BEDDING FOR PIPE. The bed shall be prepared in accordance with Subsection 601.04 unless otherwise specified.

Concrete cradle bedding shall be installed on approved subgrades when shown on the Plans or directed by the Engineer.

628.07 LAYING PIPE. No pipe shall be placed until the trench and the prepared bedding have been approved by the Engineer.

The laying shall begin at the outlet end and the lower segment of the pipe shall be in contact with the shaped bedding throughout its full length. Bell or grooved ends of rigid pipes and the circumferential laps of flexible pipe shall be placed facing upstream. The longitudinal laps or seams of flexible pipe shall be at the sides.

All pipes and fittings shall be carefully examined for defects and no pipe or fittings shall be laid which are known to be defective. If any defective piece is discovered after laying, it shall be removed and replaced at the Contractor's expense. All pipes and fittings shall be cleaned before they are laid and shall be kept clean until accepted in the completed work.

The pipe shall be laid to conform to the lines and grades shown on the Plans or as directed by the Engineer. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and to bring the inverts continuously to the required grade.

Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be pulled or cramped unless permitted by the Engineer.

Before any joint is made, the pipe shall be checked to ensure that a closed joint with the next adjoining pipe has been maintained and that the inverts are matched and conform to the required grade. The pipe shall not be driven down to grade by striking it.

The Contractor shall take all necessary precautions to prevent flotation of the pipe in the trench.

When pipe laying is not in progress, the open ends of the pipe shall be closed with temporary watertight plugs. If water is in the trench when work is resumed, the plug shall not be removed until all danger of water entering the pipe is eliminated.

The sewers and manholes shall be made as nearly watertight as practicable and leakage measurements shall be made wherever possible.

For sewer force mains, concrete reaction blocking shall be provided as detailed at all bends deflecting 22.5° or more. At the Contractor's option, retainer glands may be used at bends instead of concrete blocking. Retainer glands shall also be provided at all joints within three pipe lengths on each side of the bends.

628.08 JOINING PIPE. Sewer pipe shall be joined in accordance with the detailed instructions of the manufacturer.

Sewer pipes with pre-molded gaskets shall be driven completely home and the gasket checked for proper positioning. Where poured joints are used, the pipe shall be properly positioned and the joint completely filled with joint sealer in accordance with the accepted practice for that type of sewer joint. The sealer shall be allowed to cool completely before the runner is removed.

Where recommended by the manufacturer, the Contractor shall furnish coupling pullers for joining the pipe. Gasket feeler gauges shall be available for use by the pipe layer and the Engineer for checking the position of the rubber gaskets in the completed joint, if so directed by the Engineer.

Any fittings showing a crack, and any fitting or pipe that has received a severe blow which may have caused a fracture, even though no fracture can be seen, shall be marked as rejected and removed at once from the work.

Sewer pipe shall be cut by means of a handsaw, metal-inserted abrasive wheels, or by pipe cutters with blades, not rollers, doing the cutting. All cut ends shall be examined for possible cracks caused by cutting.

628.09 TESTING OF SYSTEM. The Contractor shall provide all necessary equipment and instrumentation required for proper completion of the flushing and testing. Quality of water, testing procedures, and method of disposal of water shall be approved by the Engineer. Prior to testing, the system shall be flushed with water to remove construction debris.

All tests shall be performed in the presence of the Engineer. Preliminary tests made by the Contractor without being observed by the Engineer will not be accepted. The Engineer shall be notified at least eight hours before any work is to be inspected or tested.

All defects in the system shall be corrected and retested until acceptable to the Engineer. Repairs shall be made to achieve the standard of quality specified for the entire system.

Sections of the system may be tested separately, but any defect that may develop in a section previously tested and accepted shall be promptly corrected and retested.

Test data shall be recorded on a form acceptable to the Engineer. A copy of all test data shall be submitted to the Engineer at the completion of testing.

All piping shall be tested in accordance with the following test methods, in addition to any test required by state and local codes or building authorities:

(a) Gravity Sewer Testing.

(1) General Requirements. The Contractor shall have the option of using the air test or water test for testing sewers.

The maximum sewer length to be tested at one time shall be that length between any two successive manholes.

Pipe trenches shall be backfilled prior to performing the test. All service laterals, stubs, and fittings shall be plugged or capped and adequately braced to withstand thrust forces.

The depth of groundwater above the pipe section to be tested shall be determined.

Portions of sewer lines in conflict with water mains shall be tested as ordered by the Engineer.

(2) Air Testing. Low pressure air testing shall be conducted in accordance with the following procedures:

a. Each end of the test section shall be plugged, capped, and braced. Necessary safety precautions shall be taken to prevent blowouts and possible injury.

b. An air hose shall be connected to a tapped plug used for an air inlet. The hose shall be connected to the air control equipment, which shall include valves and pressure gauges. These shall allow air to enter the sewer test line, monitor air pressure in the sewer, shut off air, and provide pressure reduction and 0 psi to 10 psi relief. The monitoring pressure gauge shall have a range of 0 psi to 14.5 psi with divisions of 0.10 psi, and an accuracy of 0.05 psi.

c. The air compressor and air supply shall be connected to the test line and the test section filled slowly until a constant pressure of 3.5 psi is maintained.

d. A pressure above 3 psi shall be maintained for at least five minutes to allow the temperature to stabilize. A check for leaks shall be made and if any are found, the pressure shall be released and the fitting replaced or repaired.

e. After the stabilization period, the pressure shall be adjusted to 3.5 psi and the air supply disconnected.

f. The time interval for the test line pressure to drop from 3.0 psi to 2.5 psi shall be measured and recorded.

g. If the groundwater table is above the pipe, the test pressures specified above shall be increased by 0.6 psi for every 1 foot the groundwater is above the invert of the pipe.

h. The minimum time required for a pressure drop of 0.6 psi using the air test shall be 75 seconds per inch of diameter of the main sewer being tested.

i. Any line tested that does not hold the minimum specified pressure for the specified time will be considered to have failed the pressure test and shall be repaired and retested.

(3) Exfiltration Test. An exfiltration test measures the amount of water leaking out of the sewer while maintaining a low pressure on the entire sewer being tested. The exfiltration test procedure shall be as follows:

a. A tapped plumber's plug shall be inserted in the downstream manhole inlet sewer. The water supply connection shall be made at this point, but never directly from a public water supply system or hydrant.

b. A stand pipe shall be tightly connected at the upstream end of the sewer. The height of the stand pipe shall be as directed, but in all cases it shall be 24 inches higher than any point in the sewer or 24 inches higher than the highest known groundwater table, whichever is higher, and shall be not higher than 25 feet above the lowest point in the section being tested.

c. Water shall be added at the downstream connection to avoid air pockets. The line shall be filled to the elevation designated in the stand pipe. A manhole may be used as a stand pipe. The Engineer may require the manholes to be tested independently in accordance with procedures specified in this subsection.

d. The line shall be allowed to stand with water for at least 4 hours in order to allow air to escape and absorption to take place.

e. The lines shall be filled to the reference mark and the drop or loss that occurs during a 15-minute period shall be measured. The minimum head shall be maintained throughout the test and the Contractor shall add any volume of water required and include that volume in the leakage measurements. The test shall be repeated as directed.

f. The reading shall be recorded, and the leakage shall be recorded as gallons per inch of pipe diameter per mile of sewer per 24-hour day.

g. Allowable leakage shall be 100 gallons/inch/mile/day.

(4) Infiltration Test. If the groundwater table is at least 24 inches above the entire sewer section to be tested, the Engineer may allow the Contractor to perform an infiltration test. The infiltration test procedure shall be as follows:

a. The upstream end of the section shall be plugged or taped.

b. The measuring device shall be installed in the downstream end. If a V-notch weir is used, it shall be installed to maintain a watertight seal between the weir and the interior surface of the pipe. The measuring device shall meet the approval of the Engineer.

c. Sufficient time shall be allowed for infiltrating water to develop a steady, uniform flow.

d. The reading shall be recorded as gallons per inch of pipe diameter per mile of sewer per 24-hour day.

e. Allowable leakage shall be 100 gallons/inch/mile/day.

(b) Pressure Pipe Testing. The following procedure shall be used:

(1) General Requirements. All force mains shall pass the hydrostatic pressure test and the leakage test described below.

Prior to testing, all anchors and braces shall be installed. All concrete thrust blocks and restraints shall be in place and cured for at least 7 days. All buried pipes shall be backfilled. Suitable test plugs shall be installed and air release valves shall be installed at the high points.

(2) Hydrostatic Pressure Test. The following procedure shall be used:

a. All air release valves shall be opened and the pipe shall be filled with water at a rate not to exceed the venting capacity of the air release valves.

b. The water pressure shall be raised to 150% of the designed operating pressure and adjusted to the lowest point of the section being tested.

c. The pressure shall be maintained for 10 minutes and for an additional period as is required for the Engineer to complete inspection. However, the manufacturer's suggested time duration at the test pressure shall not be exceeded.

d. Any defects noted shall be repaired and the test repeated.

e. Upon successful completion of the hydrostatic test, the leakage test shall be performed.

(3) Leakage Test. The following procedure shall be used:

a. The water pressure in the section shall be brought up to the designed operating pressure and adjusted to the lowest point of the section. This pressure shall be maintained within a maximum variation of 5% for the test duration of two hours minimum. Testing shall be conducted in accordance with *ANSI/AWWA C600*.

b. The amount of leakage shall be measured by means of a water meter installed on the supply side of the pump, and the leakage recorded as gallons per hour.

c. The allowable leakage will be as follows:

1. No leakage will be allowed for exposed piping; buried piping with flanged, threaded, or welded joints; or buried piping in conflict with potable water lines.

2. Leakage for buried pipe with slip-type or mechanical joints shall not exceed the rate determined by the following formula:

$$L = 0.00102 \times N \times D \times \sqrt{P}$$

where:

L = Maximum allowable leakage (gallons/hour)

N = Number of gasketed joints in the line under test

D = Nominal internal diameter of the pipe (inches)

P = The average test pressure on the line being tested (psi gauge)

(c) Sanitary Sewer Manhole Testing. Each manhole shall be tested by means of a water or vacuum test.

(1) Water Test. If the water test was used on the sewer line and the manhole was tested with the sewer, and the line passed, the Engineer may waive the requirement for an independent manhole test at their discretion. In any case, there shall be no visible leakage into the base or walls of a completed manhole.

All pipes and other openings into the manhole shall be suitably plugged and the plugs braced to prevent blowout.

The manhole shall then be filled with water to the top of the cone section. With the approval of the Engineer, a period of time may be permitted to allow for absorption. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and the measuring time of at least four hours begun. At the end of the test period, the manhole shall be refilled to the top of the cone, measuring the volume of water added. This amount shall be recorded as gallons per vertical foot of depth per 24-hour day.

Allowable leakage for each manhole shall not exceed 1 gallon per foot per day. If leakage exceeds the allowable rate, repairs shall be made as approved by the Engineer and the manhole retested.

If the Contractor elects to backfill prior to testing, the testing shall be at the Contractor's own risk, and it shall be incumbent upon the Contractor to determine the reason for any failure of the test. No adjustment in the leakage allowance will be made for unknown causes such as leaking plugs, or absorption. It will be assumed that all loss of water during the test is a result of leaks through the joints or through the concrete. Furthermore, the Contractor shall take any steps necessary to assure the Engineer that the groundwater table is below the bottom of the manhole throughout the test.

If the groundwater table is above the highest joint in the manhole, and if there is no leakage into the manhole as determined by the Engineer, this test can be used to evaluate the water-tightness of the manhole. However, if the Engineer is not satisfied, the Contractor shall lower the groundwater table and carry out the test as described above.

(2) Vacuum Test. The vacuum test shall be performed on fully constructed manholes, with inlet and outlet pipes in place, before any backfilling begins. Any material around the base section shall be removed to expose the entire side of the manhole. Pinholes and horizonal seams shall be plugged with non-shrinking concrete grout.

The inlet and outlet pipes and plugs shall be braced to prevent movement during the test. The Contractor shall use air inflated plugs in good condition.

The vacuum test shall be performed using equipment acceptable to the Engineer. The equipment shall be in good operating condition. Gauges shall not have any broken glass or other visible abnormalities. The test shall be performed by trained personnel familiar with the equipment and the test.

The test shall have a minimum duration of two minutes. The vacuum shall be pumped down to 10 inches of mercury on an acceptable gauge and held. At the time the removal of air is stopped, the test time shall begin.

Any manhole where the vacuum drops to nine inches of mercury or less in a time less than that specified in Table 628.09A shall have failed the test.

TABLE 628.09A – MINIMUM TIME REQUIRED TO HOLD VACUUM

Depth of Manhole (feet)	Minimum Time Required to Hold Vacuum (sec.)		
	36 Inch Diameter	48 Inch Diameter	60 Inch Diameter
< 4	7	10	13
6	11	15	20
8	14	20	26
10	18	25	33
12	21	30	39
14	25	35	46
16	29	40	52
18	32	45	59
20	35	50	65
22	39	55	72
24	42	59	78
26	46	64	85
28	49	69	91
30	53	74	98

628.10 BACKFILLING.

(a) General Requirements. Immediately prior to backfilling, all debris, forms, and similar materials shall be removed from the excavation. Backfilling shall not be done in freezing temperatures, with frozen materials, or when materials already placed are frozen.

(b) Pipe Bedding Area. Prior to laying the pipe, bedding material shall be placed to the limits of the excavation and to a depth beneath the pipe as specified on the Plans. This material shall be sand, granular backfill for structures, or crushed stone and shall not contain large lumps and stones over 1 inch in diameter. As the pipe is laid, bedding material shall be extended to the spring line of the pipe and leveled along the width of the trench.

The pipe installation shall be inspected and approved by the Engineer before being covered.

(c) Pipe Envelope Area. The pipe envelope consists of selected suitable material placed from the spring line of the pipe to a depth of 12 inches over the top of the pipe. The material shall be carefully placed and spread over the width of the trench and compacted using an approved tamper.

The Contractor shall take all necessary precautions during placement and compaction of the bedding and pipe envelope materials to prevent either damage to or displacement of the pipe.

(d) Above Envelope Area. Unless otherwise shown on the Plans, material used for backfilling trenches above the envelope area shall be suitable material that was removed during excavation or obtained from borrow, and when compacted shall make a dense stable fill. The material shall not contain vegetation, porous matter, masses of roots, individual roots more than 18 inches long or 1/2 inch thick, or stones greater than 50 pounds or larger than 6 inches in the widest dimension.

If additional material is required, it shall be furnished from approved sources.

Backfill material shall be evenly spread and compacted in lifts not more than 12 inches thick or as approved by the Engineer. Previously placed or new materials shall be moistened by sprinkling, if required, to ensure proper bond and compaction and shall conform to the requirements of Subsection 203.11(d).

Whatever method of compacting backfill is used, care shall be taken that stones and lumps shall not become nested and that all voids between stones shall be completely filled with fine material.

No compacting shall be done when the material is too wet to be compacted properly. If the material is too wet, the work shall be suspended until the previously placed and new materials have dried out sufficiently to permit proper compaction, or until other precautions are taken as necessary to obtain proper compaction.

Backfill material shall be compacted to maximum dry density percentages specified in Table 628.10A and the in-place moisture content shall be not more than 2% above the optimum moisture content, as determined by *AASHTO T 180, Method C*.

TABLE 628.10A – MAXIMUM DRY DENSITY FOR BACKFILL

Backfill Location	Maximum Dry Density
Around all structures, under roadway paving, shoulders, and embankments	95%
All other areas	90%

628.11 HOUSE CONNECTIONS. In general, the Engineer will require new house connections for each existing residential and commercial structure. The actual location of each new house connection shall be determined in the field by the Engineer.

Stub-outs for future connections shall be a minimum of 24 inches long and shall have ends closed with suitable approved plugs specially made for the purpose. All joints and spaces shall be thoroughly filled with mortar. Plugs shall be installed so as to be readily removable without damage to the pipe when future connections are made.

628.12 MANHOLES. Manholes shall conform to the requirements of Section 604.

628.13 TRANSFER OF EXISTING SYSTEM TO NEW SYSTEM. The Contractor shall maintain existing sewage flows during construction of the new sanitary sewer systems and during connection of the new system to the existing system. In locations of conflict between new sanitary sewer main and existing lateral services, Contractor shall furnish and install temporary sewer services. The Contractor shall submit and receive approval of a maintenance of flow plan which shall include a detailed construction schedule and procedure for transferring service from the existing system to the new system prior to beginning work on the system.

When new sewers are connected to existing manholes and existing pipe penetrations cannot be used, pipe openings shall be core drilled to accommodate the new pipe. Approved watertight boots or gaskets shall be furnished and installed in accordance with the manufacturer's instructions, and then the opening around the gasket shall be grouted to a watertight seal. Existing manhole grouted inverts, flow lines, and aprons, shall be chipped out and re-grouted to accommodate the new piping. Grout holes or damage in manhole wall opening shall be repaired with non-shrink grout until flush with the outside face of wall. The exterior of the manholes shall be coated with a bitumastic or other watertight sealant meeting the approval of the sewer owner.

Prior to making the connection, the Contractor shall notify the owner and the Engineer in writing 3 calendar days in advance of the date when the Contractor will be ready to complete the work.

After this connection is made, the Contractor shall divert the sewage flow to the new sewer, transfer the house services from the existing system to the new sewer, and abandon the existing system as shown on the Plans or directed by the Engineer.

Where existing manholes and other underground structures are to be abandoned, the Contractor shall remove the frame and cover, remove the top a minimum of 24 inches below subgrade or final slope grade, whichever is greater, plug the pipes with Class C concrete, and backfill with suitable material. Frames and covers shall remain the property of the owner of the system. Material placed in the manholes and other structures shall be compacted to the requirements of the surrounding subgrade material.

628.14 WATER MAIN AND SEWER SEPARATION. Where water mains and sewer lines are in the same area as a result of work under the Contract, parallel installations or crossings of such installations shall conform to the requirements as specified in the *Recommended Standards for Water Works* and *Recommended Standards for Wastewater Facilities*, as well as the standards of the Vermont Drinking Water and Groundwater Protection Division, and as specified below.

In addition, all reconstruction or relocation of existing water or sewer facilities shall be as approved by the utility owner. Such approval shall be obtained for scheduling, materials, and configuration of the reconstruction or relocation.

(a) Parallel Installation. Under normal conditions, water mains shall have a separation of at least 10 feet horizontally from sewers, storm drains, or manholes whenever possible, with the distance measured edge-to-edge.

When local conditions prevent a horizontal separation of 10 feet, a water main and sewer may be laid closer to each other provided that:

(1) Special written approval is obtained from the Vermont Agency of Natural Resources.

(2) The bottom of the water main is at least 18 inches above the top of the sewer main.

(3) Where this vertical separation cannot be obtained, the sewer shall be constructed of materials and with joints that are equivalent to water main standards of construction and shall be pressure tested to ensure that it is watertight prior to backfilling.

(b) Crossings. The Contractor shall assume responsibility for identifying all crossings that may exist. All crossings, whether identified by the Engineer or the Contractor, shall be constructed in accordance with these specifications and as approved by the Engineer.

Under normal conditions, water mains crossing house sewers, storm sewers, or sanitary sewers shall be laid above the sewer line with a separation of at least 18 inches between the bottom of the water main and the top of the sewer pipe.

When local conditions prevent such a vertical separation, the following construction shall be used:

(1) Sewers passing over or under water mains shall be constructed of materials and joints that are equivalent to water main standards of construction, such as cast or ductile iron pipe with push-on or mechanical joints, or approved equal.

(2) Adequate structural support for the sewers to prevent excessive deflection of joints and settling on and breaking of the water mains.

(3) The length of water pipe shall be centered at the point of crossing so that the joints will be equidistant and as far as possible from the sewer.

628.15 METHOD OF MEASUREMENT. The quantity of PVC Sewer Pipe; PVC Sewer Pipe, All-Inclusive; Ductile Iron Sewer Pipe; and Ductile Iron Sewer Pipe, All-Inclusive of the size specified to be measured for payment will be the number of linear feet of sewer line installed in the complete and accepted work, as measured along the flow line of the pipe.

The quantity of Re-Laying Sewer Pipe to be measured for payment will be the number of linear feet of sewer pipe re-laid in the complete and accepted work, as measured along the flow line of the pipe.

The quantity of Sewer Cleanout and Sewer Cleanout, All-Inclusive to be measured for payment will be the number of units of each installed in the complete and accepted work.

The quantity of Transfer to New System, Sanitary Sewer, All-Inclusive to be measured for payment will be on a unit basis for each transfer performed in the complete and accepted work.

628.16 BASIS OF PAYMENT. The accepted quantity of PVC Sewer Pipe and Ductile Iron Sewer Pipe of the size specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, installing, and testing the materials specified; for making all necessary connections; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

The accepted quantity of PVC Sewer Pipe, All-Inclusive and Ductile Iron Sewer Pipe, All-Inclusive of the size specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, installing, and testing the materials specified including, but not limited to, saw-cutting existing pavement and existing concrete roadway, excavation, dewatering as required, pipe bedding and blanket, backfill, sewer pipe, fittings including elbows, eccentric reducers when reducing size, solid sleeves, gasketed couplings, flexible rubber transition couplings, and end caps; and for making all necessary connections; for calibrated television inspection for deflection testing; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

If the excavation and backfill for a sanitary sewer system component is increased by 12 inches or less due to lowering the grade, changing the location, or poor foundation material, additional excavation and backfill will be considered incidental to PVC Sewer Pipe, All-Inclusive or Ductile Iron Sewer Pipe, All-Inclusive. If the excavation and backfill for a sanitary sewer system component is increased by more than 12 inches due to lowering the grade, changing the location, or poor foundation material, additional excavation and backfill will be paid under the appropriate Contract items.

The accepted quantity of Re-Laying Sewer Pipe will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing all labor, equipment, tools, and incidentals necessary for re-laying sewer pipe at the locations specified in the Contract and as directed by the Engineer.

Excavation, including backfill and disposal of excavated material not suitable for backfill, will be paid for at the Contract unit price per cubic yard for Trench Excavation of Earth or Trench Excavation of Rock, as specified in Section 204. When material is required to replace poor foundation material below the normal grade of the pipe it will be paid for as Granular Backfill for Structures. Concrete shown on the Plans or directed by the Engineer will be paid for as Concrete, Class B, unless otherwise specified. Sheeting left in place will be paid for as incidental to the appropriate excavation Contract item.

The accepted quantity of Sewer Cleanout will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, installing, and testing the materials specified including, but not limited to, PVC pipe, fittings, caps, cast iron sewer cleanout ring and covers, concrete collar, and for making all necessary connections; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

The accepted quantity of Sewer Cleanout, All-Inclusive, will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, installing, and testing the materials specified including, but not limited to, excavation, dewatering as required, bedding, backfill, PVC pipe, fittings, caps, cast iron sewer cleanout ring and covers, concrete collar, and for making all necessary connections; and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

The accepted quantity of Transfer to New System, Sanitary Sewer, All-Inclusive will be paid for at the Contract lump sum price bid. Payment will be full compensation for furnishing all labor, materials, equipment, tools, and incidentals suitable for effecting the transfer of systems as specified. Items for payment under this lump sum amount include, but are not limited to, development of a maintenance of flow plan, maintenance of existing sewage flows including all bypass pumping as required, installation of temporary sewer service piping at conflicts between new and existing piping and the subsequent removal of the temporary sewer service piping when no longer required, and performing all exploratory excavation as indicated in the exploratory excavation plan on each existing lateral sewer service as necessary prior to construction of the new sewer main to determine the service’s size, material, and location; excavation and location of the new connection point, diversion of sewage flow from the connection point, associated pumping and dewatering of connection area, making the physical connection into the existing system including, but not limited to, excavation and backfill, all fittings, piping and appurtenances, coring into existing structures as required, transfer of sewage flow to the new system, abandonment of existing system, and furnishing all labor, equipment, tools, and incidentals necessary to complete the work. Payment for excavatable flowable fill required to abandon existing sewer mains and services will be made under item 541.4600.

Payment will be made under:

Pay Item		Pay Unit
628.1400	PVC Sewer Pipe	Linear Foot
628.1406	PVC Sewer Pipe, 1.5 Inch	Linear Foot
628.1408	PVC Sewer Pipe, 2 Inch	Linear Foot
628.1416	PVC Sewer Pipe, 4 Inch	Linear Foot
628.1424	PVC Sewer Pipe, 6 Inch	Linear Foot
628.1432	PVC Sewer Pipe, 8 Inch	Linear Foot
628.1440	PVC Sewer Pipe, 10 Inch	Linear Foot
628.1448	PVC Sewer Pipe, 12 Inch	Linear Foot
628.1460	PVC Sewer Pipe, 15 Inch	Linear Foot
628.1472	PVC Sewer Pipe, 18 Inch	Linear Foot
628.1496	PVC Sewer Pipe, 24 Inch	Linear Foot
628.1500	PVC Sewer Pipe, All-Inclusive	Linear Foot
628.1506	PVC Sewer Pipe, All-Inclusive, 1.5 Inch	Linear Foot
628.1508	PVC Sewer Pipe, All-Inclusive, 2 Inch	Linear Foot
628.1516	PVC Sewer Pipe, All-Inclusive, 4 Inch	Linear Foot
628.1524	PVC Sewer Pipe, All-Inclusive, 6 Inch	Linear Foot
628.1532	PVC Sewer Pipe, All-Inclusive, 8 Inch	Linear Foot
628.1540	PVC Sewer Pipe, All-Inclusive, 10 Inch	Linear Foot
628.1548	PVC Sewer Pipe, All-Inclusive, 12 Inch	Linear Foot
628.1560	PVC Sewer Pipe, All-Inclusive, 15 Inch	Linear Foot
628.1572	PVC Sewer Pipe, All-Inclusive, 18 Inch	Linear Foot
628.1596	PVC Sewer Pipe, All-Inclusive, 24 Inch	Linear Foot
628.1600	Ductile Iron Sewer Pipe, Cement-Lined	Linear Foot
628.1624	Ductile Iron Sewer Pipe, Cement-Lined, 6 Inch	Linear Foot
628.1632	Ductile Iron Sewer Pipe, Cement-Lined, 8 Inch	Linear Foot
628.1640	Ductile Iron Sewer Pipe, Cement-Lined, 10 Inch	Linear Foot
628.1648	Ductile Iron Sewer Pipe, Cement-Lined, 12 Inch	Linear Foot
628.1660	Ductile Iron Sewer Pipe, Cement-Lined, 15 Inch	Linear Foot
628.1672	Ductile Iron Sewer Pipe, Cement-Lined, 18 Inch	Linear Foot
628.1696	Ductile Iron Sewer Pipe, Cement-Lined, 24 Inch	Linear Foot

Pay Item		Pay Unit
628.1700	Ductile Iron Sewer Pipe, Cement-Lined, All-Inclusive	Linear Foot
628.1724	Ductile Iron Sewer Pipe, Cement-Lined, All-Inclusive, 6 In.	Linear Foot
628.1732	Ductile Iron Sewer Pipe, Cement-Lined, All-Inclusive, 8 In.	Linear Foot
628.1740	Ductile Iron Sewer Pipe, Cement-Lined, All-Inclusive, 10 In.	Linear Foot
628.1748	Ductile Iron Sewer Pipe, Cement-Lined, All-Inclusive, 12 In.	Linear Foot
628.1760	Ductile Iron Sewer Pipe, Cement-Lined, All-Inclusive, 15 In.	Linear Foot
628.1772	Ductile Iron Sewer Pipe, Cement-Lined, All-Inclusive, 18 In.	Linear Foot
628.1796	Ductile Iron Sewer Pipe, Cement-Lined, All-Inclusive, 24 In.	Linear Foot
628.1800	Re-Laying Sewer Pipe	Linear Foot
628.3000	Sewer Cleanout	Each
628.3100	Sewer Cleanout, All-Inclusive	Each
628.4300	Transfer to New System, Sanitary Sewer, All-Inclusive	Lump Sum

SECTION 629 – WATER SYSTEMS

629.01 DESCRIPTION. This work shall consist of the construction or reconstruction of water lines and appurtenances.

629.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Sand Borrow and Cushion 703.03
Coarse Aggregate for Concrete.....704.02
Granular Backfill for Structures.....704.08
Plastic Pipe, Flexible.....740.01
Plastic Pipe, Rigid (PVC) 740.02
Copper Tube, Seamless.....740.03
Ductile Iron Pipe, Cement Lined 740.05
Chlorine Solution 742.01

Concrete shall conform to the requirements of Section 541 for Concrete, Class B, unless otherwise specified.

Sleeves shall conform to the requirements of Section 625.

Crushed stone bedding shall be in accordance with Subsection 704.02 and meet the gradation requirements of Table 704.02C.

Ductile iron fittings shall be so-called compact or short-bodied fittings.

629.03 GENERAL REQUIREMENTS. The Contractor shall not disrupt the operation of existing water facilities without prior written approval of the Engineer.

When existing underground utilities, which are not scheduled for removal or abandonment, are encountered in the excavation, they shall be adequately supported and protected from damage. Any damage to utilities shall be repaired promptly in accordance with Subsection 107.12 at no additional cost to the Agency.

Any work associated with existing water lines or appurtenances shown on the Plans to be removed or abandoned in place will be considered incidental to the work under this section.

The Contractor shall be responsible for the unloading, storing, hauling, and distribution of all materials. All such material that is damaged, destroyed, or lost during and after unloading shall be replaced at the Contractor's expense. All pipes, pipe fittings, and accessories shall be handled to avoid shock. Pipe having factory-applied joint material shall be stacked and blocked to prevent damage to the joint material. Material not needed for immediate use shall be stored in a safe manner at locations selected by the Contractor and approved by the Engineer.

The Engineer shall approve the location of all pipes.

The utility owner will provide the services of a professional engineer to oversee construction of the waterline, to ensure that state requirements are met and to sign and stamp all paperwork required by the Vermont Agency of Natural Resources, Department of Environmental Conservation, Water Supply Division. The professional engineer shall advise the Engineer, and the Engineer will provide direction to the Contractor.

629.04 SUBMITTALS. Fabrication drawings shall be submitted in accordance with Subsection 105.06 for all water system components, including water pipe and copper tubing, fittings, valves, tapping sleeves and tapping valves, valve box alignment devices, corporation stops, curb stops with extension box, urethane insulation and all ancillary appurtenances.

Manufacturers' technical data sheets shall be submitted for each type of pipe and fitting to be used on the project, including dimensions, specifications of material, gasket material, class and pressure rating, coatings, and linings, joint restraints, and appurtenances.

629.05 EXCAVATION. Where the pipe is to be laid below the existing ground line, a trench shall be excavated to the required depth and to a width sufficient to allow for joining of the pipe. The bedding and backfill material under and around the pipe shall be compacted per the applicable material specification. Where feasible, trench walls shall be vertical.

The completed trench bottom shall be firm for its full length and width.

Ledge rock, rocky or gravelly soil, hardpan, or other unyielding foundation material encountered at the normal grade of the pipe bed shall be removed and replaced with granular backfill for structures. The width of the pipe bed shall be equal to the inside diameter of the pipe plus 36 inches. The minimum depth shall be 12 inches below the pipe grade, unless otherwise shown on the Plans or directed by the Engineer.

No tunneling will be permitted except with the written approval of the Engineer. Permission to tunnel will be granted only in short sections where, in the opinion of the Engineer, the pipe can be safely and properly installed and the backfill properly compacted.

The Contractor shall conduct operations to prevent the accumulation of water, ice, and snow in excavations or near excavated areas, and to prevent water from interfering with the progress or quality of the work at all times. Under no conditions shall water be allowed to rise in open trenches after the pipe has been placed.

Accumulated water, ice, and snow shall be promptly removed and disposed of by pumping or other approved means. Disposal shall be carried out in a manner which will not create a hazard to public health; cause injury to public or private property, work completed or in progress, or public streets; or cause any interference in the use of streets and roads by the public. Pipes under construction shall not be used for drainage of excavations.

Where pipes are to be placed in embankment fill, the excavation shall be made after the embankment has been completed to a height of 3 feet plus one pipe diameter above the designed grade of the pipe.

Sheeting and bracing required for trenches shall be removed to the elevation of the pipe, but no sheeting will be allowed to be pulled, removed, or disturbed below the pipe.

629.06 BEDDING FOR PIPE. Ductile iron pipe shall be laid on suitable soil and backfilled and compacted to the centerline of the pipe with select material. Select material shall be sand, crushed stone bedding, or suitable material excavated from the trench, and free from rocks, foreign materials, and frozen earth.

Seamless copper tube shall be bedded and covered with sand borrow.

Concrete cradle bedding shall be installed on approved subgrades when shown on the Plans or directed by the Engineer.

629.07 LAYING PIPE. Installation of all water lines shall be in accordance with *ANSI/AWWA C600, Recommended Standards for Water Works*, *Recommended Standards for Wastewater Facilities*, and the standards of the Vermont Drinking Water and Ground Water Protection Division.

Pipe laying shall begin at the outlet end. The lower segment of the pipe shall be in contact with the shaped bedding throughout its full length. Bell or grooved ends of rigid pipes and the circumferential laps of flexible pipe shall be placed facing upstream. The longitudinal laps or seams of flexible pipe shall be at the sides.

All pipes and fittings shall be carefully examined for defects, and no pipe or fittings that are known to be defective shall be laid. If any defective piece is discovered after laying, it shall be removed and replaced at the Contractor's expense. All pipes and fittings shall be cleaned before they are laid and shall be kept clean until accepted in the completed work.

The pipe shall be laid to conform to the lines and grades indicated on the Plans or as directed by the Engineer. Each pipe shall be so laid as to form a closed joint with the next adjoining pipe and to bring the inverts continuously to the required grade.

Each length of pipe shall be driven home against the pipe previously laid and held securely in position. Joints shall not be pulled or cramped unless permitted by the Engineer.

Before any joint is made, the pipe shall be checked to ensure that a closed joint with the next adjoining pipe has been maintained and that the inverts are matched and conform to the required grade. The pipe shall not be driven down to grade by striking it.

The Contractor shall take all necessary precautions to prevent flotation of the pipe in the trench.

When pipe laying is not in progress, the open ends of the pipe shall be closed with temporary watertight plugs. If water is in the trench when work is resumed, the plug shall not be removed until all danger of water entering the pipe is eliminated.

The use of concrete reaction blocking shall be limited to caps, tees, hydrants, and bends of 22.5° and greater. Blocking shall be placed only on the sides of each fitting in the direction of thrust and not underneath for use as a foundation or support. All other bends less than 22.5° shall be restrained by use of retainer glands at each bend and at all joints within three pipe lengths on each side of the bend.

Separation of water mains and sewers shall conform to the requirements of Subsection 628.14.

629.08 JOINING PIPE. Water pipe shall be joined in accordance with the detailed instructions of the manufacturer.

Where recommended by the manufacturer, the Contractor shall furnish coupling pullers for joining the pipe. Gasket feeler gauges shall be available for use by the pipe layer and the Engineer for checking the position of the rubber gaskets in the completed joint, if so directed by the Engineer.

The electrical conductivity of the pipeline and attached services shall be maintained at all joints, couplings, valves, and fittings through the use of three brass wedges at each joint, or with conduction straps. No couplings shall be made at any point on the pipeline or attached services without incorporating provisions to maintain electrical conductivity.

Any fittings showing a crack, and any fitting or pipe which has received a severe blow that may have caused a fracture, even though no such fracture can be seen, shall be marked as rejected and removed immediately.

Water pipe shall be cut by means of a handsaw, metal-inserted abrasive wheels, or by pipe cutters with blades, not rollers, doing the cutting. All cut ends shall be examined for possible cracks caused by cutting.

629.09 SETTING OF VALVES AND FITTINGS. Valves, fittings, plugs, and caps shall be set and joined to pipe in the manner specified above for laying and joining pipe.

A valve box shall be provided for every valve that has no gearing or operating mechanism or in which the gearing or operating mechanism is fully protected with a gear case. The valve box shall not transmit shock or stress to the valve and shall be centered and plumb over the wrench nut of the valve, with the box cover flush with the surface of the finished pavement or other such level as directed by the Engineer.

A masonry valve pit shall be provided for every valve that has exposed gearing or operating mechanisms. The valve nut shall be readily accessible for operation through the opening in the manhole, which shall be set flush with the surface of the finished pavement, or such other level as specified by the Engineer. Pits shall be constructed to permit minor valve repairs and afford protection to the valve and pipe from impact where they pass through the pit walls.

Mains shall be drained through drainage branches or blow-offs to dry wells from which the water can be pumped. Drainage branches, blow-offs, air vents, and appurtenances shall be provided with valves and shall be located and installed as shown on the Plans.

Drainage branches or blow-offs shall not be connected to any sewer, submerged in any stream, or be installed in any other manner that will permit back siphonage into the distribution system.

All dead ends of new mains shall be closed with plugs or caps and shall be equipped with suitable blow-off facilities.

Corporation stops shall, in all instances, be tapped into the main on the side in a horizontal position or in such a position as will provide a minimum of 5 feet of cover over the connecting service line. The main shall be tapped by skilled workers and the stop installed in accordance with the manufacturer's recommendations at the locations shown on the Plans or as directed by the Engineer. The stops may be installed later, at which time the main may be tapped under pressure. All defective taps shall be repaired or replaced at the Contractor's expense.

Prior to installation, the Contractor shall thoroughly clean all exposed portions of any valves, removing all labels and all traces of foreign substance using only a cleaning solution approved by the manufacturer of the valve and being careful to avoid all damage to surfaces and coatings.

629.10 SETTING OF HYDRANTS. Hydrants shall be located as shown on the Plans or as directed so as to provide complete accessibility and minimize the possibility of damage from vehicles or injury to pedestrians.

When placed behind the curb, the hydrant barrel shall be set so that no portion of the pumper or hose nozzle cap is less than 6 inches or more than 12 inches from the gutter face of the curb.

When set in the area between the curb and the sidewalk, or between the sidewalk and the property line, no portion of the hydrant or nozzle cap shall be within 6 inches of the sidewalk.

All hydrants shall stand plumb and shall have their nozzles parallel with, or at right angles to, the curb, with the pumper nozzle facing the curb, except hydrants having two hose nozzles 90° apart shall be set with each nozzle facing the curb at an angle of 45°. Hydrants shall be set to the established grade, with nozzles at least 12 inches above the ground, as shown or as directed by the Engineer.

Each hydrant shall be connected to the main with a 6 inch or larger branch controlled by an independent gate valve, unless otherwise specified.

If, as determined by the Engineer, the waste opening of any hydrant will be below the normal sub-surface water elevation, the waste opening shall be securely plugged and no drainage pit will be required.

Wherever a dry-barrel hydrant is set in soil that is pervious, drainage shall be provided at the base of the hydrant by placing coarse gravel or crushed stone mixed with coarse sand, from the bottom of the trench to at least 6 inches above the waste opening in the hydrant, and 12 inches around the elbow. No drainage system shall be connected to a sewer.

Wherever a dry-barrel hydrant is set in clay or other impervious soil, a drainage pit 24 inches wide × 24 inches long × 36 inches deep shall be excavated below each hydrant and backfilled with coarse gravel or crushed stone mixed with coarse sand, and compacted under and around the elbow of the hydrant to a level of 6 inches above the waste opening. No drainage pit shall be connected to a sewer.

629.11 ANCHORAGE. The bowl of each hydrant shall be well braced against unexcavated earth at the end of the trench with stone slabs or concrete backing, or the hydrant shall be tied to the pipe with suitable metal tie rods, clamps, or retainer glands as shown on the Plans or directed by the Engineer.

All plugs, caps, tees, and bends, unless otherwise specified, shall be provided with a reaction backing, or movement shall be prevented by attaching suitable metal rods or clamps as shown or specified.

Concrete reaction backing shall be placed between solid ground and the fitting to be anchored; the area of bearing on the pipe and on the ground in each instance shall be that shown on the Plans or directed by the Engineer. The backing shall, unless otherwise shown or directed, be placed in such a manner as to contain the resultant thrust forces in such a way that the pipe and fitting joints will be accessible for repair.

A metal harness of tie rods, clamps, or retainer glands of adequate strength to prevent movement may be used instead of concrete backing, as directed by the Engineer. Steel rods or clamps shall be galvanized or otherwise rust proofed, or shall be painted as shown in the Plans or directed by the Engineer.

629.12 PRESSURE AND LEAKAGE TESTS. Except as otherwise directed, all pipelines shall be tested. Pipelines laid in excavation or bedded in concrete shall be tested prior to field painting. Pipe to be insulated shall be tested prior to installing insulation.

The Contractor shall furnish all gauges, testing plugs, caps, and all other necessary equipment and labor to perform leakage and pressure tests in sections of an approved length. Each valved section or a maximum length of 1,000 feet of pipe shall be tested. The Contractor shall provide and bear the costs of any additional taps to the waterline necessary to perform the pressure and leakage test between valves.

All water required for testing shall be potable. All testing shall be conducted in the presence of the Engineer.

The Contractor shall make the necessary provisions to tap the pipe at the high point to release all air and shall plug the pipe after completing the test. Hydrants or blow-offs located at high points may be used for air release instead of taps if approved by the Engineer.

For the pressure test, the Contractor shall develop and maintain for two hours, 150% of the working pressure measured in pounds per square inch. Failure to hold the designated pressure for the two-hour period will constitute a failure of the section tested.

The leakage test shall be performed for a duration of two hours, only after the pressure test has been satisfactorily completed. During the leakage test, the Contractor shall measure the quantity of water required to maintain the maximum operating pressure of the main. Leakage shall not exceed allowable values for leakage presented in *ANSI/AWWA C600, Table 6B*. All testing shall be conducted in accordance with *ANSI/AWWA C600*.

Should any section of pipe fail either the pressure or leakage test, the Contractor shall do everything necessary to locate and repair or replace the defective pipe, fittings, or joints at no expense to the Agency.

If for any reason the Engineer should alter the foregoing procedure, the Contractor shall remain responsible for the tightness of the line within the above requirements for the duration of the tests.

629.13 DISINFECTING. Before being placed in service, the pipeline, valves, hydrants, etc., shall be chlorinated in accordance with *ANSI/AWWA C651*. The entire procedure for chlorinating the pipes shall be approved by the Engineer 14 calendar days prior to the time the work is performed. The location of chlorination and sampling points will be determined by the Engineer in the field.

The general procedure for chlorination shall be to first flush out the lines until all dirty or discolored water has disappeared, then to apply the chlorine in approved dosages through a tap at one end of the line while water is being drawn at the other extremity of the line until the entire line contains chlorine solution. The chlorine solution shall remain in the pipeline for a period of 24 hours.

Within 24 hours following the chlorination period, all treated water shall be flushed from the lines or portions thereof at their extremities and replaced with water from the distribution system.

Special disinfecting procedures shall be used as directed by the Engineer where the above outlined method is not practical, and when making connections to existing mains. The Contractor shall provide all necessary apparatus, materials, and labor for disinfecting the mains and shall make the required taps for this purpose. Disinfection of the mains shall be under the immediate direction of the Engineer during all phases of the work.

Prior to being placed in operation for domestic use, all new portions of the system shall be flushed, pressure tested, disinfected, and flushed again. Following this procedure, at least two water samples shall be collected from representative sample points and sent to the Vermont Department of Health laboratory, or another testing laboratory approved by the Vermont Department of Health, for bacteriological testing. Passing sample results are required before the system may be placed on line for drinking. Sample bottles shall be obtained from the same laboratory.

629.14 HOUSE CONNECTIONS. Service lines disrupted within the project limits shall be repaired or replaced as ordered by the Engineer. The actual location of each ordered house connection shall be determined in the field by the Engineer.

All service lines shall be seamless copper water tube from the corporation stop to the curb stop. The copper tubing shall be attached to the corporation stop and curb stop in a manner satisfactory to the Engineer. Sufficient slack shall be left adjacent to the corporation stop and curb stop to prevent damage to the copper tubing by movement of the pipeline.

Care shall be exercised in the placing and laying of copper tubing to be sure that the pipe does not have kinks or lie directly on sharp stones or ledge which would cause damage to the pipe. The Contractor shall place at least 6 inches of selected material as approved by the Engineer, adjacent to, above, and below the tubing.

In making cuts in copper service pipe, a cutter or tool designed for tube cutting shall be used. The tubing shall be reamed and after placing the coupling nut on the pipe, the pipe shall be flanged using a flanging tool designed particularly for this purpose and connected. A compression fitting may also be used.

All services shall be tested for leakage and, in all instances, the corporation stops shall be left in the open position upon completion of the installation.

The Contractor shall install the curb stop and the curb box at the end of the service line, usually at the approximate property line, or as shown on the Plans and connect the stop to the water main with new copper tubing. The curb box shall be installed vertically and centered over the operating key, with the elevation of the top adjusted to conform to the finished grade. The Contractor shall adequately support the curb box during backfilling to maintain its vertical alignment. The Contractor shall also ensure that the curb box does not rest on the curb stop owner's services and furnish any adapters or special couplings needed for these connections.

Any necessary piping from the curb stop to the existing service shall match the existing service line, unless otherwise directed by the Engineer. If no service exists, the Contractor shall furnish a curb stop for connection to a copper service line.

Iron pipe threads shall be supplied under the tube nuts of curb stops and corporation stops.

629.15 BACKFILLING.

(a) General Requirements. Immediately prior to backfilling, all debris, forms, and similar materials shall be removed from the excavation. Backfilling shall not be done in freezing temperature, with frozen materials, or when materials already placed are frozen.

(b) Pipe Bedding Area. Prior to laying the pipe, bedding material shall be placed to the limits of the excavation and to a depth beneath the pipe as specified. This material shall be sand, gravel, or crushed stone and shall not contain large lumps or stones larger than 1 inch in diameter. The Engineer may direct the use of material meeting the requirements for granular backfill for structures. As the pipe is laid, bedding material shall be extended to the spring line of the pipe and leveled along the width of the trench.

The pipe installation shall be inspected and approved by the Engineer before being covered.

(c) Pipe Envelope Area. The pipe envelope consists of selected suitable material placed from the spring line of the pipe to a depth of 12 inches over the top of the pipe. The material shall be carefully placed and spread over the width of the trench and compacted using an approved tamper.

The Contractor shall take necessary precautions during placement and compaction of the bedding and pipe envelope materials to prevent either damage to or displacement of the pipe.

(d) Above Envelope Area. Unless otherwise shown on the Plans, material used for backfilling trenches above the envelope area shall be suitable material that was removed during excavation, or obtained from borrow, and when compacted shall make a dense stable fill. The material shall not contain vegetation, porous matter, or stones larger than 6 inches in the widest dimension.

If additional material is required, it shall be furnished from approved sources.

Backfill material shall be evenly spread and compacted in lifts not more than 6 inches thick or as approved by the Engineer. Previously placed or new material shall be moistened by sprinkling, if required, to ensure proper bond and compaction and shall conform to the requirements of Subsection 203.11(d).

When compacting backfill, care shall be taken that stones and lumps shall not become nested and that all voids between stones shall be completely filled with fine material.

No compacting shall be done when the material is too wet to be compacted properly. If the material is too wet, the work shall be suspended until the previously placed and new materials have dried out sufficiently to permit proper compaction, or until other precautions are taken as necessary to obtain proper compaction.

Backfill material shall be compacted to the maximum dry density percentage specified in Table 629.15A and the in-place moisture content shall be not more than 2% above the optimum moisture content, as determined by *AASHTO T 180, Method C*.

TABLE 629.15A – MAXIMUM DRY DENSITY FOR BACKFILL

Backfill Location	Maximum Dry Density
Around all structures, under roadway paving, shoulders, and embankments	95%
All other areas	90%

629.16 TRANSFER OF EXISTING SYSTEM TO NEW SYSTEM. The Contractor shall maintain the existing water service during construction of the new water distribution systems and during the connection of the new system to the existing system. The Contractor shall submit to the system owner, and where required, to the Vermont Drinking Water and Ground Water Protection Division, a detailed construction schedule and procedure for transferring service from the existing system to the new system and shall receive approvals of the submittal prior to beginning work on the system.

Prior to making the transfer, the Contractor shall notify the owner and the Engineer 3 calendar days in advance, in writing, that the system is ready to be transferred.

After the new connection is made, the Contractor shall divert the water to the new water main, disinfect the system, transfer affected individual service lines to the new water main, and abandon the existing system as shown on the Plans or as directed by the Engineer.

629.17 METHOD OF MEASUREMENT. The quantity of Crushed Stone Bedding to be measured for payment will be the number of cubic yards of material placed in the complete and accepted work within the confines of the limits shown on the Plans or as directed by the Engineer.

The quantity of Seamless Copper Water Tube; Seamless Copper Water Tube, All-Inclusive; Plastic Water Pipe, Flexible; Plastic Water Pipe, Flexible, All-Inclusive; Plastic Water Pipe, Rigid; Plastic Water Pipe, Rigid, All-Inclusive; Ductile Iron Water Pipe, Cement Lined; and Ductile Iron Water Pipe, Cement Lined, All-Inclusive of the size specified to be measured for payment will be the number of linear feet of the size, type, and class specified installed in the complete and accepted work, as measured along the flow line of the pipe.

The quantity of Extension Service Box and Curb Stop; Extension Service Box and Curb Stop, All-Inclusive; Gate Valve with Valve Box; Gate Valve with Valve Box, All-Inclusive; Tapping Sleeve and Valve with Valve Box; Tapping Sleeve and Valve with Valve Box, All-Inclusive; Adjust Elevation of Valve Box; Blow-Off Assembly; Blow-Off Assembly, All-Inclusive; Permanent Manual Air Release; Permanent Manual Air Release, All-Inclusive; Corporation Stop; Corporation Stop, All-Inclusive; Hydrant; Hydrant, All-Inclusive; Relocate Hydrant; Remove Hydrant; and Expansion Assembly to be measured for payment will be the number of units of each size and type specified installed in the complete and accepted work.

The quantity of Transfer to New System, Water, All-Inclusive to be measured for payment will be on a lump sum basis in the complete and accepted work.

629.18 BASIS OF PAYMENT. The accepted quantity of Crushed Stone Bedding will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for furnishing, transporting, handling, placing, and grading the material as specified and for the furnishing of all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantities of Seamless Copper Water Tube; Plastic Water Pipe, Flexible; Plastic Water Pipe, Rigid; and Ductile Iron Water Pipe, Cement Lined of the size specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, installing, testing, and disinfecting the materials specified, including fittings and clamps; for making all necessary connections; for furnishing and placing the concrete or other materials for reaction backing or furnishing and installing tie rods, clamps, and restrained joints; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantities of Seamless Copper Water Tube, All-Inclusive; Plastic Water Pipe, Flexible, All-Inclusive; Plastic Water Pipe, Rigid, All-Inclusive; and Ductile Iron Water Pipe, Cement Lined, All-Inclusive of the size specified will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, installing, testing, and disinfecting the materials specified, including temporary chlorination injection points, end caps with valves or temporary blow-offs for flushing, for all fittings and clamps; for all tracer wire, tracer wire boxes, metallic tape and brass wedges; for making all necessary connections; for furnishing and installing all required fittings including elbows, tees, reducers and couplings as required, including mechanical joint retainer glands; for furnishing and placing concrete or other materials for reaction backing or furnishing and installing tie rods, clamps, and restrained joints including ductile iron pipe joint restraint harnesses; furnishing and installing all sleeves, casing spacers, and insulation where required; for saw-cutting pavement and existing concrete roadway, excavation, dewatering as required, pipe bedding and cover, pipe insulation, backfill, compaction; and for furnishing all tools, labor, equipment and incidentals necessary to complete the work. Excavation, including excavation support, bedding and cover, backfill operations, and disposal of excavated material not suitable for backfill will not be paid for separately, but will be considered incidental to the respective Contract item.

The accepted quantities of Extension Service Box and Curb Stop, Gate Valve with Valve Box, Tapping Sleeve and Valve with Valve Box, Adjust Elevation of Valve Box, Hydrant, Relocate Hydrant, Remove Hydrant, and Expansion Assembly will be paid for at their respective Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, installing, and testing all materials, including fittings and clamps; for painting hydrants and constructing drainage pits; for furnishing and placing concrete or stone slabs for reaction backing or furnishing and installing tie rods and clamps; for all other costs incidental to the work, including any cost involved for shipping, rental, or royalty charges, or for manufacturer’s supervision in conjunction with the special work of installing valves; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantities of Extension Service Box and Curb Stop, All-Inclusive; Gate Valve with Valve Box, All-Inclusive; Tapping Sleeve and Valve with Valve Box, All-Inclusive; and Hydrant, All-Inclusive will be paid for at their respective Contract unit price per each. Payment will be full compensation for the furnishing, transporting, handling, installing, and testing all materials, including fittings and clamps; for painting hydrants and constructing drainage pits; for furnishing and placing concrete or stone slabs for reaction backing or furnishing and installing tie rods and clamps; for furnishing all labor, tools, equipment, excavation, dewatering as required, backfill; for all other costs incidental to the work, including any cost involved for shipping, rental, or royalty charges, or for manufacturer’s supervision in conjunction with the special work of installing valves; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity for Blow-off Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all labor, tools, equipment, branch piping, gate valves, fittings, couplings, piping extensions where required, drainage aggregate, concrete thrust restraint, metal tie rods and clamps, stainless steel screens, outlet flanges, concrete splash pads, stone fill; for painting blow-offs; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity for Blow-off Assembly, All-Inclusive will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all labor, tools, equipment, including all excavation, dewatering as required, backfill, compaction, branch piping, gate valve, fittings, couplings, piping extensions where required, drainage aggregate, concrete thrust restraint, metal tie rods and clamps, stainless steel screens, outlet flanges, concrete splash pads, stone fill; for painting blow-offs; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Permanent Manual Air Release will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, installing, and connecting all components of the permanent manual air release, including the corporation stop, drilling and tapping of the water main for the corporation stop, connecting the curb stop with rod, copper water tubing, valve box and cover, fittings, couplings, end caps, piping extensions where required, testing, and disinfecting the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Permanent Manual Air Release, All-Inclusive, will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, installing, and connecting all components of the permanent manual air release, including the corporation stop, drilling and tapping of the water main for the corporation stop, connecting the curb stop with rod, copper water tubing, valve box and cover, fittings, couplings, end caps, piping extensions where required, testing, and disinfecting the materials specified, and for furnishing all labor, tools, equipment, excavation, dewatering as required, backfill, and incidentals necessary to complete the work.

The accepted quantity of Corporation Stop will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, transporting, handling, installing, and connecting the corporation stop, including drilling and tapping of the water main, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Corporation Stop, All-Inclusive will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, transporting, handling, installing, and connecting the corporation stop, including drilling and tapping of the water main, and for furnishing all labor, tools, equipment, excavation, dewatering as required, backfill, and all incidentals necessary to complete the work.

The accepted quantity of Transfer to New System, Water, All-Inclusive will be paid for at the Contract unit price per lump sum. Payment will be full compensation for performing all work items as directed by the Engineer to abandon existing mains, laterals, and hydrants, closing existing valves and curb stops, for maintaining existing water systems flows including temporary relocation of water main and service piping; for construction, flushing, testing, and disinfection of all proposed temporary water mains, services, and interconnections for maintenance of water service to users at all times during construction; for preparation of a transfer of service and temporary water service plan; for performing all work associated with final interconnections with existing water system piping; for removing existing valve boxes and curb boxes, and removal of any existing main which conflicts with the construction necessary to complete the transfer to the new system, including disinfection; for providing specialized labor, materials, dewatering, and all concrete thrust restraints, for performing all exploratory excavation as indicated in the exploratory excavation plan and per direction of the Engineer on each existing lateral water service at the time of connection to the new water main, tools, and equipment for effecting the transfer of systems as specified, and for furnishing all tools, labor, equipment, and incidentals necessary to complete the work. Payment for excavatable flowable fill required to abandon existing sewer mains and services will be made under item 541.4600.

When not using an all-inclusive item, excavation, including backfill and disposal of excavated material not suitable for backfill, will be paid for at the Contract unit price per cubic yard as Trench Excavation of Earth or Trench Excavation of Rock under Section 204. When material is required to replace poor foundation material below the normal grade of the pipe, it will be paid for as Granular Backfill for Structures.

When using an all-inclusive item, excavation including excavation support, bedding, backfill operations and disposal of excavated material not suitable for backfill, will not be paid for separately, but will be considered incidental to the respective Contract item. If the excavation and backfill for a water system component is increased by more than 12 inches due to lowering the grade, changing the location, or poor foundation material, additional excavation and backfill will be paid under the appropriate Contract items.

Payment will be made under:

Pay Item		Pay Unit
629.0500	Crushed Stone Bedding	Cubic Yard
629.1000	Seamless Copper Water Tube	Linear Foot
629.1003	Seamless Copper Water Tube, 0.75 Inch	Linear Foot
629.1004	Seamless Copper Water Tube, 1 Inch	Linear Foot
629.1005	Seamless Copper Water Tube, 1.25 Inch	Linear Foot
629.1006	Seamless Copper Water Tube, 1.5 Inch	Linear Foot
629.1007	Seamless Copper Water Tube, 1.75 Inch	Linear Foot
629.1008	Seamless Copper Water Tube, 2 Inch	Linear Foot

Pay Item		Pay Unit
629.1100	Seamless Copper Water Tube, All-Inclusive	Linear Foot
629.1103	Seamless Copper Water Tube, All-Inclusive, 0.75 Inch	Linear Foot
629.1104	Seamless Copper Water Tube, All-Inclusive, 1 Inch	Linear Foot
629.1105	Seamless Copper Water Tube, All-Inclusive, 1.25 Inch	Linear Foot
629.1106	Seamless Copper Water Tube, All-Inclusive, 1.5 Inch	Linear Foot
629.1107	Seamless Copper Water Tube, All-Inclusive, 1.75 Inch	Linear Foot
629.1108	Seamless Copper Water Tube, All-Inclusive, 2 Inch	Linear Foot
629.1200	Plastic Water Pipe, Flexible	Linear Foot
629.1203	Plastic Water Pipe, Flexible, 0.75 Inch	Linear Foot
629.1204	Plastic Water Pipe, Flexible, 1 Inch	Linear Foot
629.1205	Plastic Water Pipe, Flexible, 1.25 Inch	Linear Foot
629.1206	Plastic Water Pipe, Flexible, 1.5 Inch	Linear Foot
629.1207	Plastic Water Pipe, Flexible, 1.75 Inch	Linear Foot
629.1208	Plastic Water Pipe, Flexible, 2 Inch	Linear Foot
629.1300	Plastic Water Pipe, Flexible, All-Inclusive	Linear Foot
629.1303	Plastic Water Pipe, Flexible, All-Inclusive, 0.75 Inch	Linear Foot
629.1304	Plastic Water Pipe, Flexible, All-Inclusive, 1 Inch	Linear Foot
629.1305	Plastic Water Pipe, Flexible, All-Inclusive, 1.25 Inch	Linear Foot
629.1306	Plastic Water Pipe, Flexible, All-Inclusive, 1.5 Inch	Linear Foot
629.1307	Plastic Water Pipe, Flexible, All-Inclusive, 1.75 Inch	Linear Foot
629.1308	Plastic Water Pipe, Flexible, All-Inclusive, 2 Inch	Linear Foot
629.1400	Plastic Water Pipe, Rigid	Linear Foot
629.1403	Plastic Water Pipe, Rigid, 0.75 Inch	Linear Foot
629.1404	Plastic Water Pipe, Rigid, 1 Inch	Linear Foot
629.1405	Plastic Water Pipe, Rigid, 1.25 Inch	Linear Foot
629.1406	Plastic Water Pipe, Rigid, 1.5 Inch	Linear Foot
629.1407	Plastic Water Pipe, Rigid, 1.75 Inch	Linear Foot
629.1408	Plastic Water Pipe, Rigid, 2 Inch	Linear Foot
629.1412	Plastic Water Pipe, Rigid, 3 Inch	Linear Foot
629.1416	Plastic Water Pipe, Rigid, 4 Inch	Linear Foot
629.1424	Plastic Water Pipe, Rigid, 6 Inch	Linear Foot
629.1432	Plastic Water Pipe, Rigid, 8 Inch	Linear Foot
629.1440	Plastic Water Pipe, Rigid, 10 Inch	Linear Foot
629.1448	Plastic Water Pipe, Rigid, 12 Inch	Linear Foot

Pay Item		Pay Unit
629.1500	Plastic Water Pipe, Rigid, All-Inclusive	Linear Foot
629.1503	Plastic Water Pipe, Rigid, All-Inclusive, 0.75 Inch	Linear Foot
629.1504	Plastic Water Pipe, Rigid, All-Inclusive, 1 Inch	Linear Foot
629.1505	Plastic Water Pipe, Rigid, All-Inclusive, 1.25 Inch	Linear Foot
629.1506	Plastic Water Pipe, Rigid, All-Inclusive, 1.5 Inch	Linear Foot
629.1507	Plastic Water Pipe, Rigid, All-Inclusive, 1.75 Inch	Linear Foot
629.1508	Plastic Water Pipe, Rigid, All-Inclusive, 2 Inch	Linear Foot
629.1512	Plastic Water Pipe, Rigid, All-Inclusive, 3 Inch	Linear Foot
629.1516	Plastic Water Pipe, Rigid, All-Inclusive, 4 Inch	Linear Foot
629.1524	Plastic Water Pipe, Rigid, All-Inclusive, 6 Inch	Linear Foot
629.1532	Plastic Water Pipe, Rigid, All-Inclusive, 8 Inch	Linear Foot
629.1540	Plastic Water Pipe, Rigid, All-Inclusive, 10 Inch	Linear Foot
629.1548	Plastic Water Pipe, Rigid, All-Inclusive, 12 Inch	Linear Foot
629.1600	Ductile Iron Water Pipe, Cement-Lined	Linear Foot
629.1612	Ductile Iron Water Pipe, Cement-Lined, 3 Inch	Linear Foot
629.1616	Ductile Iron Water Pipe, Cement-Lined, 4 Inch	Linear Foot
629.1624	Ductile Iron Water Pipe, Cement-Lined, 6 Inch	Linear Foot
629.1632	Ductile Iron Water Pipe, Cement-Lined, 8 Inch	Linear Foot
629.1640	Ductile Iron Water Pipe, Cement-Lined, 10 Inch	Linear Foot
629.1648	Ductile Iron Water Pipe, Cement-Lined, 12 Inch	Linear Foot
629.1700	Ductile Iron Water Pipe, Cement-Lined, All-Inclusive	Linear Foot
629.1712	Ductile Iron Water Pipe, Cement-Lined, All-Inclusive, 3 In.	Linear Foot
629.1716	Ductile Iron Water Pipe, Cement-Lined, All-Inclusive, 4 In.	Linear Foot
629.1724	Ductile Iron Water Pipe, Cement-Lined, All-Inclusive, 6 In.	Linear Foot
629.1732	Ductile Iron Water Pipe, Cement-Lined, All-Inclusive, 8 In.	Linear Foot
629.1740	Ductile Iron Water Pipe, Cement-Lined, All-Inclusive, 10 In.	Linear Foot
629.1748	Ductile Iron Water Pipe, Cement-Lined, All-Inclusive, 12 In.	Linear Foot
629.2000	Corporation Stop	Each
629.2003	Corporation Stop, 0.75 Inch	Each
629.2004	Corporation Stop, 1 Inch	Each
629.2005	Corporation Stop, 1.25 Inch	Each
629.2006	Corporation Stop, 1.5 Inch	Each
629.2007	Corporation Stop, 1.75 Inch	Each
629.2008	Corporation Stop, 2 Inch	Each

Pay Item		Pay Unit
629.2100	Corporation Stop, All-Inclusive	Each
629.2103	Corporation Stop, All-Inclusive, 0.75 Inch	Each
629.2104	Corporation Stop, All-Inclusive, 1 Inch	Each
629.2105	Corporation Stop, All-Inclusive, 1.25 Inch	Each
629.2106	Corporation Stop, All-Inclusive, 1.5 Inch	Each
629.2107	Corporation Stop, All-Inclusive, 1.75 Inch	Each
629.2108	Corporation Stop, All-Inclusive, 2 Inch	Each
629.2200	Extension Service Box and Curb Stop	Each
629.2203	Extension Service Box and Curb Stop, 0.75 Inch	Each
629.2204	Extension Service Box and Curb Stop, 1 Inch	Each
629.2205	Extension Service Box and Curb Stop, 1.25 Inch	Each
629.2206	Extension Service Box and Curb Stop, 1.5 Inch	Each
629.2207	Extension Service Box and Curb Stop, 1.75 Inch	Each
629.2208	Extension Service Box and Curb Stop, 2 Inch	Each
629.2300	Extension Service Box and Curb Stop, All-Inclusive	Each
629.2303	Extension Service Box and Curb Stop, All-Inclusive, 0.75 In.	Each
629.2304	Extension Service Box and Curb Stop, All-Inclusive, 1 In.	Each
629.2305	Extension Service Box and Curb Stop, All-Inclusive, 1.25 In.	Each
629.2306	Extension Service Box and Curb Stop, All-Inclusive, 1.5 In.	Each
629.2307	Extension Service Box and Curb Stop, All-Inclusive, 1.75 In.	Each
629.2308	Extension Service Box and Curb Stop, All-Inclusive, 2 In.	Each
629.2400	Gate Valve with Valve Box	Each
629.2412	Gate Valve with Valve Box, 3 Inch	Each
629.2416	Gate Valve with Valve Box, 4 Inch	Each
629.2424	Gate Valve with Valve Box, 6 Inch	Each
629.2432	Gate Valve with Valve Box, 8 Inch	Each
629.2440	Gate Valve with Valve Box, 10 Inch	Each
629.2448	Gate Valve with Valve Box, 12 Inch	Each
629.2500	Gate Valve with Valve Box, All-Inclusive	Each
629.2512	Gate Valve with Valve Box, All-Inclusive, 3 Inch	Each
629.2516	Gate Valve with Valve Box, All-Inclusive, 4 Inch	Each
629.2524	Gate Valve with Valve Box, All-Inclusive, 6 Inch	Each
629.2532	Gate Valve with Valve Box, All-Inclusive, 8 Inch	Each
629.2540	Gate Valve with Valve Box, All-Inclusive, 10 Inch	Each
629.2548	Gate Valve with Valve Box, All-Inclusive, 12 Inch	Each
629.2600	Tapping Sleeve and Valve with Valve Box	Each
629.2700	Tapping Sleeve and Valve with Valve Box, All-Inclusive	Each
629.2800	Adjust Elevation of Valve Box	Each

Pay Item		Pay Unit
629.3000	Blow-Off Assembly	Each
629.3100	Blow-Off Assembly, All-Inclusive	Each
629.3200	Permanent Manual Air Release	Each
629.3300	Permanent Manual Air Release, All-Inclusive	Each
629.3400	Hydrant	Each
629.3500	Hydrant, All-Inclusive	Each
629.3600	Relocate Hydrant	Each
629.3800	Remove Hydrant	Each
629.4000	Expansion Assembly	Each
629.4300	Transfer to New System, Water, All-Inclusive	Lump Sum

SECTION 630 – UNIFORMED TRAFFIC OFFICERS AND FLAGGERS

630.01 DESCRIPTION. This work shall consist of furnishing uniformed traffic officers (UTOs) and flaggers for the handling of traffic in, around, and through work zones. Wherever used in this section, the term flaggers shall mean highway flaggers. UTOs and flaggers collectively are also referred to as traffic control personnel. UTOs and flaggers shall be used to control and protect the traveling public and workers during construction operations as specified in Subsection 107.09 and as directed by the Engineer. UTOs and flaggers shall conform to the requirements of the Contract and the *MUTCD*.

630.02 GENERAL REQUIREMENTS.

(a) Standard Procedures. The Contractor shall designate a person responsible for coordinating traffic control personnel in accordance with the reviewed for conformance traffic control plan and as directed by the Engineer.

Traffic control personnel determined by the Engineer to be ineffective in their duties, as specified herein, shall be removed by the Contractor from all traffic control on the project. The Contractor shall immediately comply with the directive from the Engineer and shall suspend operations as necessary until a replacement, meeting the qualifications as specified herein, can be provided. Such a suspension of operations shall not be considered as a basis for a claim or an extension of time.

(b) Safety Apparel. Traffic control personnel shall wear safety apparel in accordance with the *MUTCD*. Traffic control personnel deemed to have unsuitable safety apparel by the Engineer shall be considered ineffective and shall be removed.

When operating during nighttime hours, between sunset and sunrise, traffic control personnel shall wear safety apparel meeting or exceeding performance Class 3 requirements of *ANSI/ISEA 107*, including Class E pants or gaiters.

(c) Communication. The Contractor shall equip all traffic control personnel on the project with two-way radios capable of maintaining all necessary communication within the work zone. The traffic control personnel shall use these radios to maintain communication and coordination whenever distance, noise, intervening operations, dust, or other conditions make it difficult or impossible to communicate on a line-of-sight basis or whenever the use of two-way radios is ordered by the Engineer. The Contractor shall always keep sufficient spare batteries, parts, and complete units on the project so that no individual performing traffic control is without a working two-way radio for a period longer than 10 minutes.

Without exception, when two-way radios are required and a person performing traffic control is without a working two-way radio for more than 10 minutes, that person shall either be supplied with a working two-way radio or be considered ineffective, removed in the manner set forth in Subsection 630.02(a), and replaced with a person with a working two-way radio.

630.03 UNIFORMED TRAFFIC OFFICERS.

(a) Requirements. A UTO shall be a law enforcement officer who has law enforcement authority at the location where the services are provided.

UTOs shall wear a uniform approved by their law enforcement department with an exposed badge that clearly identifies them as a law enforcement officer. When operating outside the vehicle, the UTO shall wear safety apparel in accordance with Subsection 630.02(b).

UTOs shall be accompanied by a law enforcement vehicle with operating blue or blue and white law enforcement signal lamps as permitted under *23 V.S.A. § 1252*. The signal lamps on a UTO's law enforcement vehicle shall be in operation when and where required by the approved traffic control plan or as directed by the Engineer.

Law enforcement vehicles shall not be parked within the buffer space as defined in the *MUTCD* or within 25 feet of the centerline of a railroad track.

The presence of law enforcement shall not be a substitute for temporary traffic control devices required by the Contract.

(b) Equipment. When operating on the project during nighttime hours, between sunset and sunrise, UTOs shall be equipped with hand-held, lighted signals that display a red light suitable for directing traffic.

(c) Duties. UTOs shall perform the following duties in accordance with the Contract or as directed by the Engineer.

(1) Promoting voluntary compliance, by motorists, with speed and other rules of the road through an obvious presence. This may include the presence of marked law enforcement vehicles displaying law enforcement signal lamps, the presence of a UTO in or near the highway, or signage indicating their presence. This presence is generally stationary, with a law enforcement vehicle serving as an advanced warning signal and the UTO usually positioned outside the vehicle, to direct or control traffic as necessary.

(2) Directing and controlling traffic, including at intersections with non-functioning or malfunctioning signals.

(3) Serving as a flagger.

630.04 FLAGGERS.

(a) Requirements. The Contractor shall verify that flaggers meet the following requirements. Flaggers shall have successfully completed a 4-hour training course taught by a certified instructor within the last 24 months and shall carry proof of training at all times when on the project. Certified instructors shall have successfully completed one of the following courses:

(1) Associated General Contractors of Vermont Traffic Control Technician/Flagger Trainer Course

(2) American Traffic Safety Services Association Flagger Instructor Training Course

(3) National Safety Council Flagger Instructor Course

(b) Equipment. Flaggers shall be equipped with a STOP/SLOW paddle signaling device as detailed in the *MUTCD*.

(c) Duties. Flaggers shall be used to stop and release traffic within a designated work zone or where the entrance or exit of construction equipment or other construction activity constitutes a hazard to the traveling public or as directed by the Engineer. Flaggers shall not be used to direct traffic at intersections.

630.05 METHOD OF MEASUREMENT. The quantities of Uniformed Traffic Officers and Flaggers to be measured for payment will be the number of hours for each as authorized by the Engineer. No additional allowance will be made for premium time (overtime), and no allowance or payment will be allowed for the required 4-hour training.

630.06 BASIS OF PAYMENT. The accepted quantities of Uniformed Traffic Officers and Flaggers will be paid for at the Contract unit price per hour. Payment will be full compensation for hiring, training, transporting, and supervising; for furnishing clothing, badges, vehicles, law enforcement signal lamps, signs, lighting devices, reflectorized equipment; for providing all taxes and insurance; and for furnishing all radios and other equipment, materials, and incidentals necessary to perform this work.

When the items for Uniformed Traffic Officers or Flaggers are not included in the Contract, or when uniformed traffic officers or flaggers are employed by the Contractor without authorization by the Engineer, the costs will not be paid for directly but will be considered incidental to all other Contract items.

Payment will be made under:

Pay Item		Pay Unit
630.1000	Uniformed Traffic Officers	Hour
630.1500	Flaggers	Hour

SECTION 631 – FIELD OFFICE

631.01 DESCRIPTION. This work shall consist of furnishing, erecting, equipping, and maintaining field offices and testing equipment. The work shall include cleaning, supplying utility services, office furniture, equipment, and supplies as required for the exclusive use of the Agency engineering staff at locations approved by the Engineer. Upon completion of the project, the field offices, furniture, accessories, and equipment provided shall remain the property of the Contractor.

The testing equipment and supplies shall be furnished for the use of the Agency during the term of the Contract and shall be subject to use by Agency personnel to conduct tests of any materials at any location as directed by the Engineer. Equipment furnished for testing of protective coatings will be used by the Engineer as required by the Contract.

631.02 FIELD OFFICES.

(a) General Requirements. Field offices shall be available solely to the representatives of the state and the federal government throughout the duration of use and shall be removed when released by the Engineer. Field offices and equipment shall always be cleaned, disinfected, and maintained in working condition to the satisfaction of the Engineer, including adequate supplies.

Field offices shall not be located within any Operating Railroad right-of-way.

All field offices shall meet the following requirements:

(1) Foundation. Field offices shall be constructed on a firm foundation that will remain vibration free and that will not be adversely affected by frost action or water runoff.

(2) Design. Field offices shall be a commercial-type field office trailer of standard commercial quality, or a building, in good condition as determined by the Engineer, with a minimum width of 10 feet. They shall have a minimum of two means of egress equipped with dead bolt locks and a minimum 4 foot × 4 foot deck with steps and railings in accordance with the VOSHA *Safety and Health Regulations for Construction*.

The Contractor shall provide the Engineer with three sets of keys. The Contractor shall not access the field office without approval of the Engineer.

Commercial-type field office trailers shall have a minimum of four side windows, one front window, and one rear window. Standard buildings shall have sufficient windows to the satisfaction of the Engineer. All windows shall be glassed and screened with provisions for opening and locking and shall be equipped with adjustable louvered blinds.

Field offices shall have a lighting system capable of providing a minimum of 50 foot-candles on all work surfaces and shall have an exterior security light satisfactory to the Engineer.

(3) Electrical Service. Field offices shall be equipped with a 120 volt AC, 60 Hz, single-phase electrical system with service entrance equipment suitable for power company attachment and with at least 12 properly positioned interior electrical duplex outlets. The materials and installation methods of all electrical wiring, connections, switches, and grounds shall conform to the provisions of the *National Electrical Code* and shall be in accordance with all state and local electrical ordinances.

The Contractor shall be responsible for arranging the connection of the electrical service to the field office.

(4) Communications Services. Field Offices shall have independent telephone and internet services such that both can be used simultaneously without impacting functionality. The Contractor shall provide the Engineer with a list of all internet services available at the proposed field office location and the Engineer will select the service to be provided. In all cases, internet service shall have a minimum download speed of 4 Mbps and a minimum upload speed of 1 Mbps. The specified internet speeds shall be achieved without using compression algorithms. Jacks for connection to internet and telephone services shall be located at each end of the field office for both services.

When telephone or internet service is not practical, as determined by the Engineer, services may be omitted from the field office.

The Contractor shall be responsible for establishing all connections for communications services and maintaining communications services throughout the duration the field office is in use.

(5) Heating and Cooling Systems. Field offices shall have heating and cooling systems capable of maintaining a temperature of 68°F at all times. Field offices shall have thermostats capable of controlling and displaying the interior temperature.

The heating and cooling systems shall be fitted with high efficiency particulate air (HEPA) filters meeting the requirements of *DOE-STD-3020*. New HEPA filters shall be installed upon initial erection of the field office. All HEPA filters shall be replaced with new filters every 12 months, or when airflow through the filter becomes restricted, or as recommended by the manufacturer, whichever is more frequent.

(6) Sanitary Facilities and Cleaning Supplies. Sanitary facilities consisting of a flush toilet, chemical toilet, or other approved type, shall be furnished by the Contractor, with proper sewage disposal as is necessary to comply with the requirements and regulations of the state and local Boards of Health and VOSHA. Sanitary facilities shall be cleaned and disinfected regularly, in accordance with current CDC guidance. The frequency of cleaning shall be as outlined in the CDC guidance, or as directed by the Engineer. The degree of cleanliness shall be approved by the Engineer. Sanitary facilities shall be provided with either hot, running, potable water, and soap, or an alcohol-based hand sanitizer containing at least 70% alcohol by volume, for use in washing hands.

A potable water system consisting of a sink with a faucet within the office, with a continuous supply of pressurized clean potable water, shall be supplied for the duration of the project. When clean potable water is not available, a commercial bottled drinking water system shall be installed in the field office complete with necessary disposable drinking cups (8 oz. size or larger) and cup dispenser. The system shall supply both hot and cold water. The system and the bottled water shall be furnished by a commercial water service on a regular basis agreeable to the Engineer for the duration of the Contract.

The Contractor shall supply the field office with hand sanitizer to be used for washing hands, and with a disinfectant for use in disinfecting surfaces. The hand sanitizer shall be alcohol based and shall contain at least 70% alcohol by volume. The disinfectant shall be one of the products identified on *EPA List N: Disinfectants for Coronavirus (COVID-19)* and shall have a contact time of 5 minutes or less, as specified on the list. If the disinfectant supplied is of the liquid or spray-on type, the Contractor shall also supply the field office with disposable paper towels for use in applying the disinfectant.

(7) Office Equipment. All field offices shall contain the following standard commercial-quality office equipment, with substitutions allowed upon approval of the Engineer:

1 Standard office desk a minimum of 60 inches wide × 30 inches deep and with drawers, locks, and keys

1 Ergonomic office chair with adjustable lumbar support, adjustable height, and rolling casters

1 Secure, four-drawer, legal-size file cabinet, fire-resistant (rated to withstand a one-hour fire) with lock and two keys

1 Telephone with touch tone dial, compatible with the local telephone service available, and capable of receiving and storing messages

2 30-gallon trash cans with trash bags

1 Electric clock having a dial face at least 8 inches in diameter

1 First aid kit conforming to *ANSI/ISEA Z308.1*

1 5-pound dry chemical fire extinguisher, with a UL rating of 3A:40B:C or better, or as needed in accordance with OSHA requirements

1 Outdoor thermometer, weatherproof, easy to read, and having a minimum scale range of -40°F to 120°F in graduations of 2°F

Field offices shall be provided with ventilation and gas connections as required.

The Contractor shall furnish all labor and materials for winterizing field offices.

(b) Field Office, Engineer's. The field office shall be available for use 7 calendar days prior to any work commencing, including erection of construction approach signing, until 30 calendar days after final inspection of the project, unless otherwise directed by the Engineer.

In addition to Subsection 631.02(a), the field office shall meet the following requirements:

(1) Size. The field office shall have a minimum floor space of 360 square feet.

(2) Office Equipment. The field office shall contain the following standard commercial quality office equipment, with substitutions allowed upon approval of the Engineer:

1 Rain gauge

2 Standard office desks a minimum of 60 inches wide × 30 inches deep and with drawers, locks, and keys

2 Ergonomic office chairs with adjustable lumbar support, adjustable height, and rolling casters

1 Storage cabinet a minimum of 36 inches wide × 24 inches deep × 24 inches high

1 Storage locker or closet of sufficient size for secure storage of surveying equipment

1 Printer/scanner/copier combination unit, color when deemed necessary by the Engineer, with a minimum tray capacity of 50 sheets and a minimum print speed of 10 sheets per minute. The combination unit shall be capable of handling 11 inch × 17-inch sheets. The combination unit shall be compatible with Microsoft Windows 10 and later versions and shall have wired and wireless network capabilities.

The printer/scanner/copier combination unit shall have a stand of sufficient size and strength to support the unit. Supplies for the printer/scanner/copier shall include 8-1/2 inch × 11-inch paper, 11 inch × 17-inch paper, and ink or toner in black and color as applicable.

1 Microwave with a minimum capacity of 1 cubic foot

1 Refrigerator with a minimum capacity of 4 cubic feet

All furnished equipment shall be maintained in good working order. Replacement equipment shall be provided within 48 hours for all equipment that is damaged, stolen, or becomes inoperative in any way.

The Contractor shall provide training to the Engineer in the use of the furnished equipment.

(c) Field Office, Soils and Materials. The field office shall be available for use from the day the Contractor commences any work requiring the testing of soils and materials until 30 calendar days after acceptance of the project, or upon release by the Engineer.

In addition to Subsection 631.02(a), the field office shall meet the following requirements:

(1) Size. The field office shall have a minimum floor space of 240 square feet.

(2) Office Equipment. The field office shall contain the following standard commercial quality office equipment with substitutions allowed upon approval of the Engineer.

1 Bench top cabinet, approximately 36 inches high and 24 inches wide with a minimum bench area of 32 square feet and a minimum storage area of 32 square feet using a suitable combination of fully enclosed shelf space and drawers

1 Sink with gooseneck faucet located within the office, with a continuous supply of pressurized, clean, potable water for the duration of the project

2 Adjustable height drafting stools

(3) Testing Equipment and Supplies. At a minimum, the field office shall contain the following testing equipment and supplies, with substitutions allowed upon approval of the Engineer.

1 Balance scale with a 20-pound minimum capacity, accurate to 0.2 ounces

1 Scale with a 2-pound minimum capacity, accurate to 0.004 ounces

1 Double-burner electric hot plate with variable temperature controls

1 Electric motorized sieve shaker, with either rocking and tapping action or circular and tapping action, with a capacity of at least six sieves, cover, and 8-inch diameter pan, confined in a dust-retaining enclosure

1 Set of U.S. Standard Sieves, brass, 8-inch diameter, full height, woven wire, meeting the requirements of *ASTM E11*. The required sieves are as follows:

1	4 inch (100.0 mm)	1	3-1/2 inch (90.0 mm)
1	3 inch (75.0 mm)	1	2-1/2 inch (63.0 mm)
1	2 inch (50.0 mm)	1	1-3/4 inch (43.0 mm)
1	1-1/2 inch (37.5 mm)	1	1 inch (25.0 mm)
1	3/4 inch (19.0 mm)	1	5/8 inch (16.0 mm)
1	1/2 inch (12.5 mm)	1	3/8 inch (9.50 mm)
2	No. 4 (4.75 mm)	2	No. 8 (2.36 mm)
2	No. 10 (2.00 mm)	2	No. 16 (1.18 mm)
2	No. 30 (0.600 mm)	2	No. 40 (0.425 mm)
2	No. 50 (0.300 mm)	2	No. 100 (0.150 mm)
4	No. 200 (0.075 mm)	3	8-inch sieve pans
3	8-inch sieve covers		

(4) Additional Equipment. Additional equipment and supplies shall include the following items:

2 Pairs of safety gloves, 14 inches in length and capable of withstanding temperatures up to 1,110°F

1 Brush, brass (wire bristle)

1 Broom, standard floor type

1 Shovel, round-pointed with D-handle

1 Shovel, square-pointed with D-handle

2 Heavy canvas sheets, 4 feet long × 2-1/2 feet wide, for quartering samples

10 Aluminum moisture cans, 3-1/2 inches in diameter × 2 inches deep

2 Paint brushes, soft bristle, 2 inch

4 Table brushes, 2 inches × 8 inches

1 Mason's trowel, pointed, 8 inch

4 Plastic dish pans, 14 inches long × 12 inches wide × 5 inches deep

8 Cake pans, 9 inches long × 9 inches wide × 2 inches deep

1 Grain scoop, 6 inch

1 Spatula with 10 inch × 1-1/8 inch blade

2 Mixing spoons, heavy duty plated steel, 12 inches long

4 Microwaveable pans a minimum of 8 inches long × 8 inches wide × 2 inches deep

1 Compaction mold, 4 inches in diameter and meeting the requirements of *AASHTO T 99*

1 Rammer, 5-1/2 pounds in weight and meeting the requirements of *AASHTO T 99*

1 Straightedge, steel and meeting the requirements of *AASHTO T 99*

1 Density apparatus consisting of a sand cone and baseplate and meeting the requirements of *AASHTO T 191*

2 One-gallon mason jugs with standard “G” mason jar top threading with covers

1 Carrying box, cushioned, for the two one-gallon mason jugs

2 One-gallon metal cans with moisture-proof friction covers and handles (similar to paint cans)

1 Two-pound rubber mallet with 10-inch handle

1 Storage box to of adequate size to contain the compaction testing equipment

A microwave oven with a minimum rating of 500 watts, a digital display of power level and time, and a minimum of ten adjustable power levels. The microwave shall have a minimum internal volume of approximately 0.7 cubic feet. The interior dimensions shall be approximately 11 inches long × 11 inches wide with an acceptable height. The interior dimensions shall be of adequate size to accept the microwaveable pans listed in this subsection.

Standard Ottawa sand meeting the requirements of *ASTM C778, Section 3.1* shall be supplied in the amount of approximately 100 pounds of sand for every 50,000 cubic yards of embankment.

When compaction testing in accordance with *AASHTO T 180* is required, the Contractor shall also supply one 10 pound rammer meeting the requirements of *AASHTO T 180*.

All the foregoing testing equipment shall be in good condition and shall be replaced or repaired by the Contractor if, during the duration of the project, it becomes unsuitable for testing purposes. All calibration records shall be available to the Engineer.

Equipment provided for concrete testing, bituminous testing, or grout testing, when such equipment is also in the Contract, will not be considered common to the testing equipment for the soils and materials field office and shall not be used as such.

631.03 TESTING EQUIPMENT, CONCRETE. The following equipment shall be provided to perform concrete field tests:

(a) General Concrete Testing Equipment.

1 Cylinder test set meeting the requirements of *AASHTO R 100*

1 Slump test set meeting the requirements of *AASHTO T 119*

1 Platform beam scale sensitive to 0.01 pounds with a minimum capacity of 100 pounds

1 Wheelbarrow, steel, contractor-grade

1 Shovel, square-pointed with D-handle

1 Pressure air meter meeting the requirements of *AASHTO T 152* and all accessory items required for use with the particular design of apparatus used. Accessory items shall include a flat, rectangular, metal plate at least 1/4 inch thick, a glass or acrylic plate at least 1/2 inch thick, or a wire reinforced glass plate at least 1/4 inch thick with a length and width at least 2 inches greater than the diameter of the measuring bowl of the air meter with which it is to be used.

1 Concrete curing box of standard commercial quality and designed to maintain an internal water temperature of 70°F ± 10°F and 100% humidity. One or more curing boxes shall be supplied to meet specimen requirements for the project.

1 Straightedge, a minimum of 10 feet long

(b) Class LW Concrete Testing Equipment. For testing Class LW concrete, the following additional testing equipment shall be provided:

1 Volumetric air meter meeting the requirements of *AASHTO T 196*, supplied with a wooden carrying case, syringe, tamping rod, measuring vessel, and baffle

1 One-unit weight measure meeting the requirements of *AASHTO T 121*, supplied with a flat, rectangular, metal plate at least 1/4 inch thick, a glass or acrylic plate at least 1/2 inch thick, or a wire reinforced glass plate at least 1/4 inch thick with a length and width at least 2 inches greater than the diameter of the measuring bowl of the air meter with which it is to be used

All of the foregoing testing equipment shall be in good condition and shall be replaced or repaired by the Contractor if, during the duration of the project, it becomes unsuitable for testing purposes.

All equipment and supplies furnished by the Contractor shall be available prior to placing any concrete.

When the Contractor places concrete at more than one location simultaneously, the necessary testing equipment shall be furnished at each location.

When concrete testing equipment is required by the Contract, it will not be considered common to the equipment for gradation testing, compaction testing, or bituminous concrete testing and shall not be used as such.

631.04 TESTING EQUIPMENT, BITUMINOUS. The following equipment shall be provided:

1 Straightedge, a minimum of 16 feet long

1 Straightedge, 10 feet in length

1 Shovel, round-pointed with D-handle

1 Metal shovel, square-head, 5.5 inch minimum width, with long handle

1 Metal spatula, of an appropriate size to clean shovels

1 Thermometer, electronic hand-held with a digital display visible under all lighting conditions, a temperature range of -60°F to 1,200°F in increments of 2°F, automatic zero adjustment, and low battery indication, with instruction manual. The unit shall be completely self-contained and shall not require any external probes or other attachments to perform the required functions.

1 Probe thermometer

1 Micrometer with a range of 0 to 1 inch with graduations of 0.1 mils

1 Building level with case. The level shall be a 48-inch electronic model, with bubble indicators, digital readout with a range of 0° to 90° degrees in 0.1° increments, percent slope from 0% to 100% in 0.1% increments, and pitch in inches of rise per foot of run. The level shall be capable of being recalibrated.

1 Mechanical measuring wheel with a minimum wheel circumference of 3 feet and a sealed counter capable of measuring a minimum of 9,999 feet

1 Relative humidity pen

The Contractor shall provide a non-petroleum asphalt release agent for cleaning the bituminous testing equipment.

The Contractor shall provide 7.5 inch × 7.5 inch × 7.5 inch sampling containers meeting the requirements of *AASHTO R 97*. The number of containers provided shall be sufficient for the quantity of bituminous concrete material installed and the sampling frequency identified in the *Materials Sampling Manual*.

Black duct tape and tar paper or asphalt-treated felt shall be supplied in adequate amounts for the Engineer to perform necessary thickness and moisture testing.

All the foregoing testing equipment shall be in good condition and shall be replaced or repaired by the Contractor if, during the duration of the project, it becomes unsuitable for testing purposes.

All equipment and supplies furnished by the Contractor shall be available prior to the placement of any bituminous concrete or pavement markings.

When the Contractor places bituminous concrete or pavement markings at more than one location simultaneously, the necessary testing equipment shall be furnished at each location.

When the equipment to be provided for bituminous concrete testing is required by the Contract, it will not be considered common to equipment for gradation testing, compaction testing, or concrete testing and shall not be used as such.

631.05 TESTING EQUIPMENT, PROTECTIVE COATINGS. The following equipment shall be provided:

1 Psychrometer kit with wet-bulb and dry-bulb thermometers for measuring dew point, meeting the requirements of *ASTM E337, Method B*, with a range from 34°F to 110°F and an accuracy of ± 1°F. As a minimum the psychometer kit shall include matching thermometers with conversion charts and a thermometer for measuring the surface temperature of a steel object.

1 Thickness probe, electronic dry film, meeting the requirements of *ASTM D7091*. The probe shall be capable of measuring a range of 0 mils to 60 mils with an accuracy of ± 2%.

1 Adhesion testing kit meeting the requirements of *ASTM D3359, Method A*. At a minimum, the adhesion testing kit shall include a cutting tool, a cutting guide, tape, rubber eraser, and an illuminated magnifier.

1 Surface profile kit meeting the requirements of *ASTM D4417, Method C*. The surface profile kit shall include coarse and extra coarse tapes as specified in *ASTM D4417, Section 6.3* with a minimum of one roll (100 pieces) of tape for each range, plus extras as required.

All the foregoing testing equipment shall be in good condition and shall be replaced or repaired by the Contractor if, during the duration of the project, it becomes unsuitable for testing purposes.

The equipment furnished shall have been calibrated within one year or shall have appropriate means of being calibrated in the field.

631.06 TESTING EQUIPMENT, GROUT. For testing mortar, flowable fill, and other combinations of sand and cement, the following additional testing equipment shall be provided:

1 Trowel having a steel blade 4 inches to 6 inches in length, with straight edges

1 Tamper meeting the requirements of *AASHTO T 106*

Specimen molds meeting the requirements of *AASHTO T 106*. The number of molds shall be sufficient to perform both the acceptance testing required for the Contract item and any necessary control of work testing. Each specimen mold shall be capable of producing 3 individual cubes.

All of the foregoing testing equipment shall be in good condition and shall be replaced or repaired by the Contractor if, during the duration of the project, it becomes unsuitable for testing purposes.

All equipment and supplies furnished by the Contractor shall be available prior to placing any grout.

When the Contractor places grout at more than one location simultaneously, the necessary testing equipment shall be furnished at each location.

When the equipment to be provided for grout testing is required by the Contract, it will not be considered common to the equipment for gradation testing, compaction testing, concrete testing, or bituminous concrete testing and shall not be used as such.

631.07 METHOD OF MEASUREMENT. The quantity of each type of Field Office or Testing Equipment to be measured for payment will be on a lump sum basis for each type specified and used on the project.

The quantity of Field Office Communications (N.A.B.I.) to be measured for payment will be to the nearest hundredth of a dollar for all communication services supplied. The Agency will include in the proposal a quantity of dollars for all communication services required. However, the Contractor will be reimbursed the actual costs of providing the communication services as evidenced by the paid bills submitted to the Engineer.

631.08 BASIS OF PAYMENT. The accepted quantity of Field Office or Testing Equipment of the type specified will be paid for at the Contract lump sum price. Payment will be full compensation for performing the work and furnishing all materials, labor, tools, equipment, and incidentals necessary to provide, construct, install, maintain, and remove the type of field office or testing equipment specified, including the installation, removal, and connection of communications lines and waste removal. Replacement of equipment that becomes unsuitable and providing supplies that become exhausted will not be paid for directly but will be considered incidental to the Contract item they are furnished under.

Partial payments for this work will be made as follows:

(a) The first payment of 25% will be made after each specified office or equipment unit has been installed on the project in full working order.

(b) The second payment of 25% will be made when 33% of the anticipated construction time has elapsed.

(c) The third payment of 25% will be made when 67% of the anticipated construction time has elapsed.

(d) The final payment of 25% will be paid upon completion and acceptance of the project.

The quantity of Field Office Communications (N.A.B.I.) to be paid will be the total dollar value of all communications bills, paid by the Contractor, for providing all telephone and internet services supplied to the field offices. Payment for this work will be made upon receipt of each paid communications bill submitted to the Engineer. The total will be limited to the total of paid communications bills submitted to the Engineer.

The cost of furnishing separate telephone lines, including installation and removal, will not be paid for directly, but will be considered incidental to the appropriate Field Office item. The monthly service charges will be paid under Field Office Communications (N.A.B.I.).

Payment will be made under:

Pay Item		Pay Unit
631.1000	Field Office, Engineer's	Lump Sum
631.1100	Field Office, Soils and Materials	Lump Sum
631.1600	Testing Equipment, Concrete	Lump Sum
631.1700	Testing Equipment, Bituminous	Lump Sum
631.1800	Testing Equipment, Protective Coatings	Lump Sum
631.1900	Testing Equipment, Grout	Lump Sum
631.2600	Field Office Communications (N.A.B.I.)	Dollar

SECTION 632 – RAILROAD FLAGGERS

632.01 DESCRIPTION. This work shall consist of maintaining Operating Railroad traffic and coordinating with the Agency and the Operating Railroad for inspection and review of the Contractor's work in conjunction with construction operations. A railroad flagger shall be requested any time construction operations will be within 25 feet of the nearest rail or within the Operating Railroad right-of-way, whichever is furthest.

632.02 GENERAL REQUIREMENTS. A railroad flagger shall be a person who is furnished, employed, and qualified by the Operating Railroad. When, as stipulated in the Contract, or in the opinion of the Engineer and the Operating Railroad, the construction work would cause hazard to the safe operation of trains and other facilities in the Operating Railroad right-of-way, including signal and communication lines, the Operating Railroad will furnish the necessary qualified employees to protect their trains and other facilities.

The Contractor shall provide advanced notice to the Operating Railroad prior to the commencement of any work, or any portion of the work, over or adjacent to the Operating Railroad right-of-way, so that necessary arrangements can be made by the Operating Railroad to protect Operating Railroad traffic.

Railroad flaggers shall be required whenever the Contractor is performing work over, under, or adjacent to the Operating Railroad tracks or right-of-way, such as excavation, sheeting, shoring, erection or removal of forms, or handling material. Railroad flaggers shall also be required whenever equipment is used which, by swinging over or by failure, could foul the track, or when any other type of work is being performed that, in the opinion of the Engineer or the Operating Railroad, requires such service.

The Contractor shall be required to plan, coordinate, and organize the work effort in a way that shall absolutely minimize the use and number of Operating Railroad protective personnel required. The Agency and the Operating Railroad will review and approve all Contractor work schedules prior to the commencement of work and prior to the assignment of protective personnel. Misuse of these protective services by the Contractor due to inadequate work procedures will not be allowed and shall be sufficient cause for the Agency to require the Contractor to bear all inappropriate costs.

Operating Railroad train crews necessary for the operation of Contractor-scheduled work trains or Contractor-owned or leased locomotive equipment shall not be paid by the Agency under this section, as all such costs will be considered incidental to the Contractor's work and therefore shall be entirely borne by the Contractor.

632.03 CONSTRUCTION REQUIREMENTS. The Contractor shall obtain verification of the time and schedule of track occupancy from the Operating Railroad before proceeding with any construction or demolition work over, under, within, or adjacent to the Operating Railroad right-of-way.

All work to be done under, upon, or over the Operating Railroad right-of-way shall be performed by the Contractor in a manner satisfactorily to the Engineer and shall be performed at such times and in such manner as to not interfere with the movement of trains or traffic upon the tracks. The Contractor shall use all necessary care and precaution to avoid accidents, delay, or interference with the trains or other property.

The Contractor shall conduct the work and handle equipment and materials so that no part of any equipment should foul an operated track or wire line without the written permission of the Operating Railroad.

When it is noted that the work will foul an operating track, the Contractor shall give the Operating Railroad written notice 15 calendar days in advance so that, if approved, arrangements can be made for proper protection of the railroad.

632.04 SUBMITTALS.

(a) At the preconstruction meeting, the Contractor shall submit for approval by the Agency a detailed description of proposed methods for accomplishing the construction work required under the Contract, to include methods for protecting Operating Railroad traffic. Approval by the Agency shall not serve in any way to relieve the Contractor of complete responsibility for the adequacy and safety of the proposed methods.

(b) Prior to beginning work, the Contractor shall submit for the approval of the Engineer a detailed description of the procedures for work to be performed over, under, within, or adjacent to the Operating Railroad right-of-way. Work shall not proceed until the proposed procedures have been approved by the Agency.

632.05 METHOD OF MEASUREMENT. The quantity of Railroad Flaggers (N.A.B.I.) to be measured for payment will be in a quantity of dollars for the specified flagging and protective services provided.

632.06 BASIS OF PAYMENT. A value in dollars has been included in the bid proposal for flagging and protective services. Payment for Railroad Flaggers (N.A.B.I.) will be for reimbursing the Contractor for the actual invoice amounts paid to the Operating Railroad by the Contractor for flagging and protective services. The Contractor’s overhead will not be reimbursed.

The dollar amount will be adjusted to the actual amount paid to the Operating Railroad for flagging and protective services, after review and approval of paid invoices. No additional payment will be made under this item. All other costs for coordination and railroad flaggers in accordance with these provisions will be considered incidental.

If the Contract is not completed within the specified time limit for completion of the Contract (or authorized extended time), no payment will be made for any costs incurred beyond the specified time of completion.

Payment will be made under:

Pay Item		Pay Unit
632.1000	Railroad Flaggers (N.A.B.I.).....	Dollar

SECTION 633 – CRITICAL PATH METHOD SCHEDULE

633.01 DESCRIPTION. This work shall consist of developing and furnishing a critical path method (CPM) schedule, including narratives, updates, and revisions for the duration of the Contract.

If item 633.1000 is included in the Contract, the provisions of this section shall supersede those of Subsection 108.03(a).

633.02 SUBMISSIONS.

(a) Scheduling Contract Work. The Contractor is responsible for the scheduling of all Contract work, which shall include, but is not limited to subcontracted work, complete and acceptable submissions, work component fabrications, and delivery of materials. The schedule shall include allowance for time for all aspects of the work including sufficient time for the Agency to perform its functions as indicated in the Contract, including, but not limited to, acceptance inspection or testing and review and acceptance or approval of any submittals required in the Contract.

(b) Gantt Chart. The schedule shall be a Gantt chart prepared with Microsoft Project. The following items shall be included with each schedule submission:

(1) An electronic copy in Microsoft Project format with run date and version of the schedule.

(2) A PDF illustrated in color, depicting no more than 50 activities on each 11 inch × 17 inch sheet, and with each sheet including title, project name and number, match data for diagram correlation, and a key.

(3) A four-week, look-ahead narrative to provide a more detailed plan of upcoming work highlighting the near-term priorities. The Contractor shall indicate the anticipated workdays per week, number of shifts per day, number of hours per shift, crew sizes, and assumed resources. If the project requires a closure, the Contractor shall identify any changes in anticipated resources or work schedule during the closure period.

(c) CPM Schedule. The CPM schedule shall include the following items:

(1) Activities that describe the essential features of the work, activities that might delay Contract completion, and which activities are on the critical path.

(2) The planned start and completion dates for each activity and the duration of each activity stated in working days. Field activities more than 15 working days in duration shall be broken into two or more activities distinguished by location or some other logical feature. This estimated figure shall include considerations for permit limitations, seasonal limitations, and any other anticipated delays.

(3) When the project contains a defined closure period of a minimum of 24 hours and up to a maximum of 28 calendar days, the duration for work within the closure period shall be shown in hours instead of days. Except for cure times, the maximum duration of each activity within the closure period shall be limited to 12 hours.

(4) The finish-to-start relationships among activities, without leads or lags unless justified in the narrative and approved by the Engineer.

(5) Distinct columns showing predecessors, successors, duration, actual start, and actual finish for each activity.

(6) Project suspension or work inactivity that is 3 calendar days or longer.

(7) Dates related to the procurement of materials, equipment, and articles of special manufacture. Any anticipated delays due to the procurement schedule shall be included.

(8) Dates related to the submission of working drawings, plans, and other data specified for review or approval by the Agency.

(9) Key milestone dates specified in the Contract including, but not limited to, the Notice to Proceed, interim completion, permit restriction dates, and the Contract completion date. These shall be the only constraints in the schedule logic unless others are justified in the logic and approved by the Engineer.

(10) Activities related to Agency or third-party reviews and inspections.

(d) High-Value Contracts. For Contracts with an original Contract amount in excess of $8,000,000, the following additional information shall be shown on the CPM schedule:

(1) Each Contract item shall be identified with at least one activity, except for items paid by the lump sum, hour, or dollar, Section 641 pay items, and Section 653 pay items.

(2) Each compensable activity shall identify the applicable Contract items, along with the total quantity intended to be placed during that activity.

633.03 BASELINE SCHEDULE. The CPM schedule submittal shall be received by the Engineer a minimum of 7 calendar days prior to the preconstruction meeting. The Engineer and Contractor may review the schedule at the preconstruction meeting. Any requested information and a revised schedule shall be submitted within 7 calendar days after receiving the Engineer's request.

The Engineer shall be allowed 21 calendar days to review the schedule and provide a response. The Engineer will review the schedule by assessing the schedule's compliance with these provisions and conformance with the Contract requirements. By accepting the schedule, the Engineer does not modify the Contract in any way. The baseline schedule shall be accepted before the Notice to Proceed. The accepted schedule will be used as the baseline schedule for the remainder of the project.

The schedule shall define and sequence activities to accurately describe the project and to meet Contract requirements for scope of work, phasing, accommodations for traffic, and interim and Contract completion dates. The schedule shall begin with the date of Contract execution.

633.04 SCHEDULE UPDATES. The schedule shall be updated during active construction at the end of every other biweekly estimate period (update period) and when directed by the Engineer. Projects with short duration closures are of particular importance as the project float will be limited. The Contractor shall promptly inform the Engineer of any schedule delays or changes that occur during these periods.

The Engineer shall be allowed 10 calendar days to review the update for compliance with these provisions and provide a response. The following items shall be included with each update:

(a) The actual start dates of each activity started.

(b) The actual finish dates of each activity finished, or remaining durations of activities started but not yet completed.

(c) A narrative report describing progress during the update period, shifts in the critical activities from the previous update, sources of delay, potential problem areas, work planned for the next update period, and changes made to the schedule. Changes include additions, deletions, or revisions to activities due to the issuance of a Contract revision, changes to an activity duration, changes to relationships between activities, or changes to the planned sequence of work or the method and manner of its performance.

(d) The original schedule shown as a baseline.

633.05 REVISIONS. Schedule revisions shall be submitted no more than 10 calendar days after the occurrence of any of the following:

(a) A written request to revise the schedule from the Engineer.

(b) A delay (actual or projected) to scheduled milestones or Contract completion dates.

(c) When actual progress falls behind the most recent schedule accepted by the Engineer, either by falling more than two weeks behind schedule or by 5% of the total Contract time, the Contractor shall immediately inform the Engineer in writing.

The Engineer may require the Contractor to submit a revised schedule. Neither the Engineer's acceptance of such revised schedule nor any Agency feedback regarding the revised schedule shall be construed as an approval of the revised schedule, nor shall it be construed as the Agency's dictation of the Contractor's means and methods.

(d) Issuance of change orders that by adding, deleting, or revising activities, changes the planned sequence of work or the method and manner of its performance.

(e) Issuance of change orders that add time to the Contract.

(f) The Contractor shall participate in progress meetings at the request of the Engineer to review and discuss the updated schedule information including any activity delay, coordination requirements, change orders, potential delays, and other relevant issues.

The Engineer will review the revised schedule for compliance with these provisions and provide a response within 10 calendar days.

633.06 FLOAT. Any float in the schedule is to be credited to the project only.

633.07 FAILURE TO SUBMIT SCHEDULE. Failure to submit a schedule (i.e. original baseline schedule, required updates, revisions, and when requested by the Engineer) in accordance with these provisions may be grounds for suspension of partial payments, as identified in Subsection 109.08, until a satisfactory schedule meeting the requirements of these provisions is received by the Engineer.

633.08 METHOD OF MEASUREMENT. The quantity of CPM Schedule to be measured for payment will be the number of each CPM Schedule (i.e. original baseline schedule, required updates, revisions, and when requested by the Engineer), accepted by the Engineer through the duration of the Contract.

633.09 BASIS OF PAYMENT. The accepted quantity of CPM Schedule will be paid for at the Contract unit price for each. Payment will be full compensation for preparing and submitting a schedule as specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
633.1000 CPM Schedule	Each

SECTION 634 – EMPLOYEE TRAINEESHIP

634.01 DESCRIPTION. This work shall consist of providing on-the-job training for qualified employees in accordance with applicable approved training programs.

634.02 GENERAL REQUIREMENTS. The training requirements specified herein supersede *FHWA-1273, Part II, Subparagraph 6b* and implement *23 U.S.C. § 140(a)*.

The Contractor shall provide on-the-job training aimed at developing full journeyman qualifications in the type of trade, craft, or job classification involved.

The training program shall be carried out in accordance with a training schedule and curriculum devised to give the employee an understanding of the trade, craft, or skill together with instructions in safety operations and performance of the actual specialty covering all aspects of the work involved. The training program shall be one approved by the Agency and the U.S. Department of Transportation.

The required number of employee traineeship hours to be provided by the Contractor is shown in the Contract. If a Contractor subcontracts a portion of the work, the Contractor shall determine how many, if any, of the trainees are to be trained by the subcontractor. However, the Contractor shall retain the primary responsibility for meeting the training requirements specified herein.

634.03 PROCEDURE. The procedures followed in carrying out the training shall be consistent with the approved training program for the particular trade, craft, or skill and the trainee shall be employed insofar as practical in a useful and constructive manner assisting in the work on the project until such time as the Contractor deems the trainee as being qualified to operate independently in the field in which the trainee has been trained. The Contractor shall then give the trainee a certificate of satisfactory completion of apprenticeship training specifying the field of accomplishment.

The Contractor shall maintain payroll records and training records in a manner acceptable to the Engineer as to provide all the information necessary to properly and adequately support progress and final payment for this item, as well as to show the status of training accomplishment.

It is normally expected that a trainee will begin training on the project as soon as feasible after start of work utilizing the skill involved, and remain on the project as long as training opportunities exist in the work classification or until the training program has been completed. It is not required that all trainees be on board for the entire length of the Contract. The Contractor will have fulfilled the requirements of this item if they have provided acceptable training to the number of trainees specified. The number trained shall be determined based on the total number enrolled on the project for a significant period.

634.04 TRAINEES. The number of trainees shall be distributed among the work classifications based on the Contractor's needs and the availability of journeymen in the various classifications within a reasonable area of recruitment. Where feasible, 25% of apprentices or trainees in each occupation shall be in their first year of apprenticeship or training.

Prior to commencing construction, the Contractor shall submit to the Engineer for approval the number of trainees to be trained in each selected classification and training program to be used. Furthermore, the Contractor shall specify the starting time for training in each of the classifications. The Contractor will be credited for each trainee employed on the project that is currently enrolled or becomes enrolled in an approved program and will be reimbursed for such trainees as provided herein.

634.05 RECRUITMENT. Training and upgrading of minorities and women toward journeymen status is a primary objective of this item. Accordingly, the Contractor shall make every effort to enroll minority trainees and women (e.g. by conducting systematic and direct recruitment through public and private sources likely to yield minority and women trainees) to the extent that such persons are available within a reasonable area of recruitment.

The Contractor will be responsible for demonstrating the steps taken in pursuance thereof, prior to a determination as to whether the Contractor is in compliance with the requirements of this item. This training commitment is not intended, and shall not be used, to discriminate against any applicant for training, whether a member of a minority group or not.

634.06 TRAINING PROGRAM. The minimum length and type of training for each classification will be as established in the training program selected by the Contractor and approved by the Engineer. The FHWA shall approve a program if it is reasonably calculated to meet the equal employment opportunity obligations of the Contractor and to qualify the average trainee for journeyman status in the classification concerned by the end of the training period.

Apprenticeship programs registered with the U.S. Department of Labor, Employment and Training Administration shall also be considered acceptable provided they are being administered in a manner consistent with the equal employment obligations of federal-aid highway construction Contracts. Approval or acceptance of a training program shall be obtained from the state prior to commencing work on the classification covered by the program.

It is the intent of these provisions that training is to be provided in the construction crafts rather than in clerical or administrative positions. Training is permissible in lower-level management positions, such as office engineers, estimators, and timekeepers where the training is oriented toward construction applications. Training in the laborer classification may be permitted provided that significant and meaningful training is provided and approved by the FHWA division office.

Some offsite training is permissible if the training is an integral part of an approved training program and does not comprise a significant part of the overall training.

The Contractor may be eligible for reimbursement for training persons more than the number of hours specified in the Contract. This reimbursement will be made even though the Contractor receives additional training program funds from other sources, provided such other sources do not specifically prohibit the Contractor from receiving other reimbursement. Reimbursement for offsite training indicated above may only be made to the Contractor when the Contractor either contributes to the cost of the training, provides the instruction to the trainee, or pays the trainee's wages during the offsite training period, and the trainees are concurrently employed on a federal-aid project.

The Contractor shall furnish the trainee a copy of the program the Contractor will follow in providing the training. The Contractor shall provide each trainee with a certification showing the type and length of training satisfactorily completed.

Trainees shall be paid at least 60% of the appropriate minimum journeyman's rate specified in the Contract for the first half of the training period, 75% for the third quarter of the training period, and 90% for the last quarter of the training period, unless apprentices or trainees in an approved existing program are enrolled as trainees on the project. In that case, the appropriate rates approved by the U.S. Department of Labor or U.S. Department of Transportation for the existing program shall apply to all trainees being trained for the same classification who are covered by these provisions. In no case shall the Contractor pay trainees less than the prevailing rate for labor as shown in the Contract wage decision.

634.07 SANCTIONS FOR NON-COMPLIANCE. If the Agency finds the Contractor or subcontractor in non-compliance with the terms of this item, it shall do the following:

(a) Issue a show cause notice and notify the Contractor in writing that within 30 calendar days a written plan outlining the steps that will be taken to bring the Contractor into compliance must be submitted to the Agency by the Contractor. In the event the Contractor fails or refuses to submit the plan within the specified period, or if the Contractor does not exercise the corrective actions outlined in the plan, the Agency will commence enforcement proceedings under *Executive Order 11246*, as amended. Such actions could include:

(1) The recovery by the Agency from the Contractor of 0.10% of the Contract award amount or $1,000, whichever sum is greater, as liquidated damages for each week the Contractor fails or refuses to comply. If a subcontractor is in non-compliance, the recovery by the Agency from the Contractor, to be assessed by the Contractor as a back charge against the subcontractor, of 0.10% of the subcontract price, or $500, whichever sum is greater, in the nature of liquidated damages, for each week that such party fails or refuses to comply; or

(2) The suspension of any payment or part thereof due under the Contract until the Contractor or subcontractor can demonstrate compliance with the terms of the Contract; or

(3) The termination or cancellation of the Contract, in whole or in part, unless the Contractor or subcontractor can demonstrate within a specified time compliance with the terms of the Contract; or

(4) The denial to the Contractor or subcontractor of the right to participate in any future Contracts awarded by the Agency for a period of up to three years.

(b) If at any time after the imposition of sanctions one and two above, the Contractor can demonstrate compliance with the requirements of this item, the Contractor may request the Agency to suspend the sanctions conditionally, pending a final determination by the Agency as to whether the Contractor is in compliance. Following the final determination, the Agency will either lift the sanctions or impose them.

(c) The above sanctions for non-compliance will also apply to *41 C.F.R. § 60-4.3*.

634.08 METHOD OF MEASUREMENT. The quantity of Employee Traineeship to be measured for payment will be the number of hours completed in the complete and accepted work.

634.09 BASIS OF PAYMENT. The accepted quantity of Employee Traineeship will be paid for at the Contract unit price per hour. Payment will be full compensation for furnishing all tools, equipment, supervision, and incidentals necessary to provide complete training for each trainee.

If, in the judgment of the Contractor, a trainee becomes proficient enough to qualify as a journeyman before the end of the prescribed training period, and the Contractor so employs such trainee, full credit and full payment to the Contractor will be made if the period of training given, plus the length of employment as a journeyman in the classification for which trained, are equal to, or more than, the training period specified in the approved training program.

If the period of training given plus the period employed as a journeyman does not equal or exceed the training period specified in the approved training program, the Contractor will be paid the Contract amount for each hour the trainee was trained and employed as a journeyman by the Contractor.

In the event of partial employee traineeship, the Contractor will be paid for each hour the trainee was trained and employed as a trainee by the Contractor.

Payment will be made under:

Pay Item	Pay Unit
634.1000 Employee Traineeship	Hour

SECTION 635 – MOBILIZATION/DEMOBILIZATION

635.01 DESCRIPTION. This work shall consist of preparatory work and operations including, but not limited to, those necessary for the movement of personnel, equipment, supplies, and incidentals to and from the project site; for the establishment and removal of all Contractor's field offices, buildings, and other facilities necessary for work on the project; and for all other work and operations that must be performed or costs incurred prior to beginning work and upon completion of Contract items. It shall also include compensation for any costs associated with demobilization, project clean up, establishment of vegetation, and completion of all work that is not associated with acceptance of a specific pay item.

635.02 METHOD OF MEASUREMENT. The quantity of Mobilization/Demobilization to be measured for payment will be on a lump sum basis.

635.03 BASIS OF PAYMENT. The accepted quantity of Mobilization/Demobilization will be paid for at the Contract lump sum price. Payment will be full compensation for performing the work specified and for furnishing all labor, tools, materials, equipment, and incidentals necessary to complete the work.

For the purposes of computing payment under the Contract item Mobilization/Demobilization, the adjusted Contract price will be a summation of all items bid, excluding the amount bid specifically for the Mobilization/Demobilization item.

Partial payments will be made as follows:

(a) The first payment of 50% of the lump sum price for Mobilization/Demobilization, or 10% of the adjusted Contract price, whichever is less, will be made within 30 calendar days after execution of the Contract.

(b) The second payment of 40% of the lump sum price for Mobilization/Demobilization or 5% of the adjusted Contract price, whichever is less, will be made on the first estimate following the completion of 10% of the Contract, excluding Mobilization/Demobilization.

(c) Payment of any remaining amount bid for Mobilization/Demobilization will be made after the acceptance date.

Payment will be made under:

Pay Item	Pay Unit
635.1100 Mobilization/Demobilization	Lump Sum

SECTION 641 – TRAFFIC CONTROL

641.01 DESCRIPTION. This work shall consist of establishing and maintaining traffic control measures to protect the traveling public, including bicyclists and pedestrians, and construction operations.

The requirements for uniformed traffic officers (UTOs) and flaggers used in conjunction with traffic control shall be as specified in Section 630.

641.02 GENERAL CONSTRUCTION REQUIREMENTS.

(a) General Requirements. Traffic shall be maintained in accordance with Subsection 104.04 and with reference to the requirements of Subsection 107.08.

The Contractor shall establish traffic controls to divert traffic from the area of construction operations during working hours in accordance with the Contract or as authorized by the Engineer. Working hours shall be as specified in the Contract. If the Contractor desires to work at night, as defined in Subsection 101.02, a written request shall be submitted to the Engineer in accordance with Subsection 641.03.

During hours other than working hours, all highway facilities, including sidewalks, shall be open to the unrestricted flow of traffic, unless otherwise specified. Traffic control devices, equipment, and materials shall be removed from the traveled way, auxiliary lanes, ramps, and shoulders. Traffic signs related to traffic control for construction operations shall be removed, covered, or turned so they are not readable from the highway. All equipment and materials shall be stored outside of the travel lanes, shoulders, and clear zone for the facility.

When work is in progress within an interchange area, no more than one ramp at a time may be closed to traffic. Traffic service that would be eliminated by the closing of a ramp shall be maintained elsewhere as specified in the Contract or as authorized by the Engineer.

(b) Traffic Control. When the Contract includes the Traffic Control pay item, the Plans will contain an Agency-designed traffic control plan. The Contractor may implement the Agency-designed plan or submit an alternate traffic control plan for the project. When the Contractor will implement an Agency-designed traffic control plan, written certification shall be submitted to the Engineer indicating that traffic control will be performed in accordance with the Agency design.

The Contractor may choose to submit an alternate traffic control plan for the entire project or submit modifications to various phases of the Agency's design in the Plans, including the specific location of the lanes where the traffic will be maintained. Any alternate plan submitted shall conform to the *MUTCD*.

For an alternate traffic control plan, construction drawings shall be submitted in accordance with Subsection 105.06. The submitted alternative plan shall include complete construction details, including all aspects of traffic control, to the same extent provided in the Agency design.

(c) Traffic Control, All-Inclusive. When the Contract includes the Traffic Control, All-Inclusive pay item, the Contractor shall design and submit a site-specific traffic control plan in accordance with Subsection 105.06. The submitted site-specific plan shall include, for each phase of construction requiring a significant change in temporary traffic control, a narrative description of the proposed temporary traffic control for each phase, including pedestrian accommodations where appropriate, and the major work activities to be completed in each phase.

The submitted site-specific plan shall also include a layout for each phase of construction showing existing lane configurations, existing traffic control devices (signs, signals, and pavement markings), driveways, ramps, and highway intersections, and the location of all proposed temporary traffic control devices, flaggers, and UTOs. All pertinent dimensions, such as taper lengths, sign spacing, temporary lane widths, and distances from existing traffic control devices shall be labeled.

(d) Maintenance of Pedestrian Traffic. When the Contract includes the Maintenance of Pedestrian Traffic pay item, the Contractor shall design and submit a site-specific temporary pedestrian access route (TPAR) traffic control plan in accordance with Subsection 105.06. The Contractor shall provide measures that establish and maintain the TPAR through the work zones in compliance with the *MUTCD*, the *Public Rights-of-Way Accessibility Guidelines*, and the Agency's *Work Zone Safety & Mobility Policy and Guidance*. The various devices or features shall be installed in a uniform manner to provide a consistent accessible route for pedestrians.

The submitted site-specific plan shall also include a layout for each phase of construction showing existing sidewalks and shared use paths, existing traffic control devices (signs, signals, and pavement markings), driveways, ramps, highway intersections, and the location of all proposed temporary traffic control devices, pedestrian channelizing devices, and temporary curb ramps. All pertinent dimensions, such as temporary sidewalk width, sign spacing, length of channelizing devices and the distance from existing features, shall be labeled.

At the conclusion of construction, all temporary items related to the provision of the TPAR shall be removed and the area in which they were installed restored to previous conditions to the satisfaction of the Engineer.

641.03 NIGHT WORK.

(a) General Requirements. If the Contractor intends to perform work at night, they shall submit a request to do so to the Engineer, unless night work is explicitly allowed or required by the Contract. The Contractor shall justify the request and detail the enhanced safety procedures they propose to protect the safety of the traveling public and project personnel. The request shall be submitted at least 21 calendar days prior to the date the Contractor plans to begin night work.

All work performed at night shall comply with the noise restrictions specified in Subsection 105.14 and the Contract.

(b) Lighting Plan. If night work is anticipated or required, the Contractor shall design a lighting plan that addresses each type of work zone expected to be used on the project and include it as part of the traffic control plan submittal. The Contractor shall not perform any night work or night activities within the project limits until the lighting plan has been approved and the lighting system is in place on the project.

The lighting plan shall describe the lights to be used and how the Contractor's operations will minimize the potential for glare. The designed lighting system shall be portable and illuminate the entire work area to the minimum level of illuminance required in different work areas and for different tasks. The lighting system shall not cause excessive shadows or light patterns. A light meter shall be provided to the Engineer to confirm lighting conditions meet minimum lighting plan requirements.

(1) Stationary Work Zones. Work zones are considered stationary when the traffic control package does not move or only moves periodically (e.g. bridge construction and paving operations).

The lighting plan shall include a narrative description of the light fixtures and light towers to be used, including the number, spacing, wattage, and lamp configuration. Light fixture and light tower specification sheets with photometric data and the minimum illuminance intensities to be measured in foot-candles for various work situations shall be submitted. The lighting plan shall take into consideration the guidelines provided in *NCHRP Report 476*.

(2) Mobile Work Zones. Work zones are considered mobile when the traffic control package moves intermittently or continuously (e.g. line striping and crack sealing). Mobile nighttime work shall be performed in accordance with the FHWA *Traffic Control Handbook for Mobile Operations at Night*. Mobile work zones may have lights mounted to vehicles.

641.04 TEMPORARY TRAFFIC CONTROL SIGNAL SYSTEMS.

(a) General Requirements. Temporary traffic control signal systems shall include all necessary existing or Contractor provided materials and equipment, including, but not limited to, controllers, flashers, wiring, conduit, strain poles, associated signs, sign posts, pavement markings, electrical service, vehicle detectors, span wires, interconnect cables, signal heads, and portable signal carts. The temporary signal system shall include all signals and other components necessary to cover every approach to the work zone or lane restriction.

The proposed location and operation of the temporary traffic signal equipment shall be shown on the Contractor's traffic control plan.

Temporary traffic control signal systems shall meet the following requirements:

(1) Temporary traffic control signal systems shall be compliant with AASHTO 80 mph wind load requirements.

(2) Portable temporary traffic control signal systems shall be powered by solar panels and batteries. The batteries shall allow the system to be operable for a minimum of 20 days without additional solar power. The batteries shall be housed and secured within a steel lock down box.

(3) Temporary traffic control signals shall include a conflict monitor or malfunction management unit.

(4) Temporary traffic control signals shall include long range microwave or video sensor vehicle detection, including signal preemption for emergency vehicles.

(5) All associated signing shall conform to the *MUTCD* and Section 675.

(6) Pavement markings shall conform to the *MUTCD* and Section 646.

(b) Installation. The components of the temporary traffic control signal systems shall be installed in accordance with the applicable requirements of Section 646, Section 675, Section 677, Section 678, and Section 679, with the following modifications:

(1) Concrete bases will not be required for temporary traffic signal installations.

(2) The Contractor shall correct all deficiencies found in the traffic control signal system and shall repair or replace defective equipment at no cost to the Agency.

(3) During installation of the temporary traffic signal systems, no conduit shall be placed under the existing roadway.

(4) The entire signal system, including signs, warning beacons, poles, lights, detectors, and other required materials, shall be in place and operating correctly prior to the start of the part of the project requiring its operation. Removal of the temporary signal system in its entirety and restoration of the disturbed areas shall constitute completion of the item.

(5) The Contractor shall be responsible for all permits and costs associated with providing electrical power for the temporary traffic signal system.

(6) The Contractor shall notify the Engineer or the town or city officials at least 48 hours prior to turning off the existing traffic control signals or installing any temporary signals.

(7) Pavement marking shall meet the requirements for temporary pavement markings, unless otherwise shown on the Plans.

(c) Detectors. Unless otherwise shown on the Plans, detectors for temporary traffic signal activation may be of the type and manufacture chosen by the Contractor. However, the furnished detector must function properly and provide the actuation required for the specific installed site. If, in the opinion of the Engineer, the furnished detector either does not function properly or does not perform the required actuation, the Contractor shall replace the detector within 24 hours of receiving notice to do so from the Engineer, at no cost to the Agency.

641.05 TRAFFIC CONTROL DEVICES. All traffic control devices shall conform to the requirements of Subsection 107.08, the Contract, and the *MUTCD*. Traffic control devices required in the performance of this work may include, but are not limited to, lane markings, barricades, signs with yielding posts or portable supports, reflectorized drums, traffic cones, delineators, portable arrow boards, portable changeable message signs, traffic signal lights, and street lighting. In addition, flashing warning lights may be required by the Engineer for use on signs and barricades to improve visibility.

The location of traffic control devices shall be adjusted in the field as directed by the Engineer to provide maximum visibility and usefulness. When protected by guardrail, these devices shall be placed outside the deflection distance of the particular guardrail in use.

All temporary construction signs shall meet the following requirements:

(a) Where sign installations are not protected by guardrail or other approved traffic barriers, all sign stands and post installations shall meet the requirements of *NCHRP Report 350* or *MASH*. The appropriate resource shall be determined as described in the *MASH* publication.

(b) At a minimum, roll-up sign material shall have *ASTM D4956*, Type VI, fluorescent orange retroreflective sheeting.

(c) All post-mounted signs and solid substrate portable signs shall have *ASTM D4956*, Type VII, Type VIII, or Type IX fluorescent orange retroreflective sheeting.

(d) All signs of the same type (roll-up or post-mounted) shall be composed of the same retroreflective material.

(e) All stationary signs shall be mounted on two 3 pound per foot flanged channel posts or 2 inch square steel posts inserted in 2-1/4 inch galvanized square steel anchors. No sign posts shall extend over the top edge of the sign installed on said posts.

(f) Construction signs shall be installed so as to not interfere with or obstruct the view of existing traffic control devices, stopping sight distance, and corner sight distance from drives and town highways.

Traffic cones shall be orange, at least 28 inches high, and shall be spaced as shown on the Plans. They shall be weighted or nailed for stabilization. Tires may be used to stabilize the cones only if they have been circumferentially sliced to a minimum of 50% of their original thickness.

At a minimum, all retroreflective sheeting on traffic cones, barricades, and drums shall be *ASTM D4956*, Type III sheeting.

A temporary pedestrian surface shall be provided in areas that are not accessible, such as those with a grass or loose aggregate surface. The temporary pedestrian surface shall be smooth, stable, and slip resistant. If an aggregate surface is proposed, it shall meet the requirements of Subsection 704.12(b).

Temporarily installed or relocated crosswalks shall include temporary ramps that comply with the *Public Rights of Way Accessibility Guidelines* to allow access to sidewalks. Temporarily installed or relocated crosswalks shall include appropriate warning signs, temporary pavement markings, and temporary walkway surfaces to connect them to existing pedestrian routes.

Pedestrian channelizing devices shall comply with the *MUTCD*.

Portable changeable message signs (PCMSs) shall be used with a maximum of two phases, each consisting of a maximum of three lines of eight characters. Each PCMS unit shall be tamper-resistant and the control cabinet shall be locked when not in use. Each PCMS shall have a security system that will only allow access if a code or password is entered. The default code or password shall be changed upon deployment of the PCMS by the Contractor. PCMSs featuring remote access shall also be password protected.

Portable arrow boards (PABs) shall conform to Type C portable arrow board requirements in the *MUTCD*.

The Contractor shall operate and maintain the PCMSs or PABs as recommended by the manufacturer. The locations of the units and the messages to be used shall be as specified in the traffic control plan shown in the Plans or as directed by the Engineer. The Contractor shall supply the Engineer with the name and telephone number of the Contractor's responsible person in charge of the placement, maintenance, and repair of the PCMSs or PABs and their components for the duration of the Contract.

If PCMS or PAB pay items are included in the Contract, the Contractor shall maintain one spare PCMS unit, or a PAB unit if no PCMS unit is being used, on site to replace a non-operational unit if necessary. If any unit becomes non-operational during use, and a replacement unit is not available, the Contractor shall provide flaggers or other approved traffic control methods until the unit is repaired or replaced, at no additional cost to the Agency. Non-operational units shall be repaired or replaced as soon as possible, but no later than 24 hours after the Engineer determines that repairs or replacement are necessary.

The Contractor shall conduct daily inspections of both daytime and nighttime operations to ensure proper placement, maintenance, and operation of all traffic control devices. Traffic control devices shall be kept clean to ensure that they are clearly visible at all times.

Deficient traffic control devices shall be repaired or replaced as soon as possible. Time lost due to failure to correct deficient traffic control devices will not be considered justifiable cause for granting an extension of time in accordance with Subsection 108.11.

641.06 PERSONNEL. Personnel involved with the placement and use of traffic control devices shall receive orientation and explanation of the requirements of the *MUTCD* and the special project requirements prior to working on the project. The orientation and explanation are the Contractor's responsibility.

641.07 SPEED ZONE ENACTMENT. If the traffic control plan included in the Plans is based on a recommended speed limit reduction, or if a speed limit reduction is requested by the Contractor, the Agency will obtain the necessary permit for this speed reduction. In either case, the Contractor shall provide the Agency with a written plan of work and a detailed sketch of the work zones that will be the basis for the permit application. The Contractor shall allow three weeks for the permit to be processed. The traffic control plan shall not be implemented until the permit is approved.

Speed zones, if used, should be a maximum of 10 mph below existing posted speeds. Temporary speed limit certificates must be approved by the Chief Engineer.

641.08 METHOD OF MEASUREMENT. The quantity of Traffic Control; Traffic Control, All-Inclusive; and Maintenance of Pedestrian Traffic to be measured for payment will be on a lump sum basis for the complete and accepted work.

The quantities of Portable Changeable Message Sign and Portable Arrow Board to be measured for payment will be the number of each type of unit specified and used on the project. A unit shall consist of the designated sign panel or board complete with controller, power supply, fuel, backup power supply, and trailer, installed, maintained, and removed as indicated on the Plans and directed by the Engineer.

The quantities of Portable Changeable Message Sign Rental and Portable Arrow Board Rental to be measured for payment will be the number of days of the type specified, as authorized in writing by the Engineer. The minimum quantity to be measured for payment will be five days.

The quantity of Temporary Traffic Control Signal System, Portable and Temporary Traffic Control Signal System, Fixed to be measured for payment will be the number of each system installed in the complete and accepted work, maintained during construction, and then removed from the project when the Engineer determines it is no longer required.

641.09 BASIS OF PAYMENT.

(a) Traffic Control; Traffic Control, All-Inclusive; and Maintenance of Pedestrian Traffic. The accepted quantity of Traffic Control; Traffic Control, All-Inclusive; and Maintenance of Pedestrian Traffic will be paid for at the Contract lump sum price. Payment will be full compensation for designing, preparing, implementing, inspecting, maintaining, cleaning, and removing the applicable traffic control plan and specified traffic control devices, and for furnishing all labor (including traffic patrol vehicle operators, if used by the Contractor), tools, materials, equipment, and incidentals necessary to complete the work. If a lighting plan is required, all costs associated with designing and implementing the plan, including any necessary lighting systems or traffic control devices, will be considered incidental to the appropriate traffic control item.

Partial payments for Traffic Control; Traffic Control, All-Inclusive; and Maintenance of Pedestrian Traffic will be made as follows:

(1) The first 15% of the Contract lump sum price will be paid upon receipt of written certification from the Contractor that traffic control will be performed in accordance with the Agency-designed traffic control plan, or upon approval of the Contractor’s traffic control plan.

(2) The remaining 85% of quantity payments will be made on a prorated basis for the estimated duration of the Contract work remaining.

(b) Portable Changeable Message Sign and Portable Arrow Board. The accepted quantities of Portable Changeable Message Sign and Portable Arrow Board will be paid for at the Contract unit price for each. There will be no payment for any spare units, as they shall be considered incidental to the units being used and paid for through the Contract.

Partial payments for Portable Changeable Message Sign and Portable Arrow Board will be made as follows:

(1) The first 50% of quantity payments will be made upon the erection of complete Portable Changeable Message Signs and Portable Arrow Boards as specified in Subsection 641.08.

(2) The remaining 50% of quantity payments will be made on a prorated basis for the estimated duration of the Contract work remaining.

The accepted quantities of Portable Changeable Message Sign Rental and Portable Arrow Board Rental will be paid for at the Contract unit price per day.

Payment for the accepted quantities of Portable Changeable Message Sign, Portable Arrow Board, Portable Changeable Message Sign Rental, and Portable Arrow Board Rental will be full compensation for furnishing, operating, maintaining, transporting, and installing the unit specified, for removing the unit when it is no longer needed, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

When both pay items are in the Contract, a PCMS used as a PAB will be paid for at the Contract unit price for Portable Arrow Board.

(c) Temporary Traffic Control Signal Systems. The accepted quantity of Temporary Traffic Control Signal System, Portable and Temporary Traffic Control Signal System, Fixed will be paid for at the Contract unit price per each. Payment will include the set up and removal of trailer and trailer poles or strain poles, as applicable, signal heads, controller and cabinet, luminaires, power source, and all other materials necessary for a fully operational temporary traffic control signal system.

Partial payments will be made as follows:

(a) The first payment of 50% of the Contract unit price will be made once the entire system has been set up at a site (including signing and pavement markings) and working for 24 hours to the satisfaction of the Engineer.

(b) The second payment of 30% of the Contract unit price will be made once the system has been in place and operational for 30 calendar days or work is complete, whichever occurs first.

(c) The final payment of 20% of the Contract unit price will be made upon complete removal of the system from the site and restoration of disturbed areas.

No additional payment will be made for moving, relocating, or resetting temporary traffic control signal system components, either as directed by the Engineer or for the convenience of the Contractor.

Payment will be made under:

Pay Item		Pay Unit
641.1000	Traffic Control	Lump Sum
641.1100	Traffic Control, All-Inclusive	Lump Sum
641.1200	Maintenance of Pedestrian Traffic	Lump Sum
641.1500	Portable Changeable Message Sign	Each
641.1600	Portable Arrow Board	Each
641.1700	Portable Changeable Message Sign Rental	Day
641.1800	Portable Arrow Board Rental	Day
641.2100	Temporary Traffic Control Signal System, Fixed	Each
641.2200	Temporary Traffic Control Signal System, Portable	Each

SECTION 646 – PAVEMENT MARKINGS

646.01 DESCRIPTION. This work shall consist of furnishing, installing, removing, and masking pavement markings, including durable, nondurable, and temporary markings on pavement and other surfaces.

646.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Pavement marking materials furnished shall be the ones shown on the Plans or listed in these specifications as being acceptable for the project. The Contractor may submit alternate materials for approval in accordance with Subsection 646.16.

646.03 CLASSIFICATION.

(a) Optics. Glass beads or composite material incorporated into waterborne paint and liquid durable pavement markings that provide different levels of reflectivity.

(b) Waterborne Paint. Liquid waterborne based paint binder used in permanent and temporary applications.

(c) Liquid Durable Pavement Markings. Liquid based binder markings that include epoxy paint, polyurea paint, and extruded thermoplastic.

(d) Preformed Durable Pavement Markings. Preformed durable pavement markings include preformed thermoplastic, Type A pavement marking tape, and Type B pavement marking tape.

(e) Temporary Pavement Markings. Temporary pavement markings include Type C pavement marking tape, pavement marking mask, line striping targets, and paint.

646.04 GENERAL APPLICATION OF MARKINGS.

(a) Surface Preparation. The surface shall be clean, dry, and free of all dust, oil, debris, and any other material that might interfere with the bond to the existing surface at the time of application, as recommended by the manufacturer.

Cleaning and marking removal operations shall be conducted such that the finished pavement surface is not damaged or left in a pattern that will mislead or misdirect motorists. The Contractor shall be responsible for removal and repair of any associated damage at no additional cost to the Agency. Minor abrasions, as determined by the Engineer, resulting from cleaning and removal operations will not be considered damage.

The Contractor shall control and minimize airborne dust and similar debris generated by surface preparation and cleanup to prevent a hazard to motor vehicle operation or nuisance to adjacent property.

(b) Placement of Markings. Prior to marking placement, the Engineer will inspect the pavement to determine if conditions are suitable for the placement of markings. The Engineer will check the pavement for cleanliness, moisture content, and temperature, and will check ambient air conditions. The Engineer will make the final determination as to the suitability of project conditions for the application of pavement markings. Where required, the Contractor shall clean the surface to be marked to the satisfaction of the Engineer to provide for an acceptable bond between the marking and the pavement or surface.

Weather conditions must be sufficient to allow the placement and curing of the pavement marking material without violating the manufacturer's requirements.

All markings shall be applied in a neat and professional manner. The lines shall be sharp and clear with no feathered edging or fogging, and precautions shall be taken to prevent tracking by tires of the marking equipment. Adequate quantities of the material shall be applied to ensure constant thickness of marking material. Glass beads shall be delivered at a velocity that is at least 60% of ground speed for the application device. Markings shall be applied parallel to the roadway centerline or as shown on the Plans with no unsightly deviations.

After application, markings shall be protected from crossing vehicles for a time at least equivalent to the drying time of the marking material used, according to manufacturer's recommendations. Markings shall be protected from the moment of application until they are sufficiently dry to bear traffic without damage to the marking, tracking, or adhering to vehicle tires.

Any pavement marking materials spilled or tracked on the roadway surfaces shall be removed by the Contractor to the satisfaction of the Engineer and at no additional cost to the Agency. The method of removal shall be acceptable to the Engineer and not injurious to the roadway or other surfaces.

All temporary pavement markings, including line striping targets when used, shall be applied so that at the end of each working day, all centerlines, edge-line, island markings, gore markings, lane lines, special markings, etc. are in place on all paved surfaces where traffic will be maintained. During paving and milling, work shall be scheduled so that the pavement markings are complete immediately after the paving and milling operations cease for the day.

When line striping targets (LSTs) are not shown on the Plans but are used as a short-term substitute for other temporary pavement markings, they shall be placed as directed by the Engineer and will be paid for as the equivalent quantity of temporary pavement marking for which the LSTs are substituted. However, if the Engineer determines it is necessary to replace those temporary LSTs with either more LSTs or the actual temporary pavement markings designated for that particular location, no further payment for the temporary pavement markings at that location will be made.

At all times, the Contractor shall have on hand on the project all necessary materials, equipment, and labor to place any and all necessary interim pavement markings, including temporary line striping targets, required by the Plans or as directed by the Engineer. The markings shall be paid for under the appropriate Contract items.

With the exception of colored pavement markings as described in Subsection 646.13 and centerline markings in areas where centerline rumble strips are installed and fog sealed, permanent markings shall be placed within 14 calendar days of paving the wearing surface. Temporary pavement markings shall be removed concurrent with the placement of permanent pavement markings.

Failure on the part of the Contractor to comply with the provisions of this part of the specifications may be grounds for suspension of biweekly estimate payments for the Contract in accordance with Subsection 105.01(b), until the required work is performed to the satisfaction of the Engineer.

(c) Weather Limitations.

(1) At the time of application of painted markings, the temperature of the surface to be painted shall be a minimum of 50°F and the ambient air temperature shall be 50°F and rising. Ambient hygrometric conditions required for drying within a 20-minute period shall exist or painting shall be suspended.

At the time of application of durable pavement markings, the pavement surface and ambient air temperatures shall be as per the manufacturer's published specified application temperatures, and the dew point shall be 5°F or more below the ambient air temperature. If the manufacturer's published recommendations are unavailable, the pavement surface and ambient air temperatures shall both be a minimum of 50°F. Durable pavement markings shall be installed in the same calendar year that the wearing course of pavement is placed.

(2) If weather conditions do not permit the application of durable markings on or before November 15th, waterborne paint shall be applied in accordance with Subsection 646.06 and Subsection 646.15.

(3) When it is in the public interest, the Engineer may authorize the application of pavement markings under conditions that vary from these limitations or the manufacturer's published recommendations.

(d) Layout and Control. Once the wearing course has been placed, the Engineer will establish the layout for the permanent centerline traffic markings, including passing zones, breaks for town highways and side roads, and any other items required for the centerline markings. The Contractor shall be responsible for laying out all non-centerline markings. The pattern of painted, durable, or temporary markings shall be as follows, unless otherwise shown in the Contract or directed by the Engineer.

(1) Centerline Markings. Centerline markings shall be positioned at the geometric center of the roads or as shown in the Plans. Solid (barrier) lines and dashed lines shall start and end at points shown on the Plans or as directed by the Engineer. A dashed line shall consist of 10 foot ± 6 inch line segments, and 30 foot ± 6 inch spaces. The spacing between a double barrier line and between a barrier line and a dashed line shall be the same width as the lines. The width of centerlines shall be as shown on the Plans, ± 1/4 inch.

(2) Edge Line Markings. Edge line markings shall be applied along both edges of the road, as shown on the Plans or as directed by the Engineer. Edge lines shall be discontinued through intersections of paved public side roads, unless otherwise shown on the Plans. The width of edge lines shall be as shown on the Plans, ± 1/4 inch.

(3) Dotted Line. Dotted lines shall be positioned as shown on the Plans or as directed by the Engineer. A dotted line shall consist of 3 foot ± 2 inch line segments, and 9 foot ± 2 inch spaces, unless otherwise specified in the Contract. The width of dotted lines shall be as shown on the Plans, ± 1/4 inch.

(4) Control. The Contractor shall provide the necessary horizontal and longitudinal control to keep all longitudinal lines within 2 inches of their designated locations.

In addition, on tangents, the Contractor shall not allow longitudinal lines to vary from either side of a straight line by more than 1 inch in 100 feet.

(5) Gaps and Overlaps. When applying durable diagonal pavement markings that are to be enclosed within durable long line borders, the Contractor shall apply the diagonals in such a manner as to allow a maximum of a single overlap and no gaps between the diagonals and the long lines.

(e) Application Equipment. The pavement marking equipment shall meet the approval of the Engineer and shall be maintained in working condition at all times. The pavement marking equipment shall be of standard commercial manufacture of the type capable of satisfactorily applying the designated material at required application temperatures and rates, and in accordance with the manufacturer's recommended application practices.

For long line markings, each machine shall be capable of applying two separate stripes, either solid or dashed, at the same time. Each applicator shall be equipped with satisfactory cutoffs that will apply broken, dashed, or dotted lines automatically.

Each applicator shall have a mechanical bead dispenser that will operate simultaneously with the applicator and distribute the beads in a uniform pattern at the rate specified over the entire surface area of the marking. The bead placement device shall maximize bead embedment in the marking material. Each applicator shall also be equipped with line guides acceptable to the Engineer.

Equipment for application shall be mobile and maneuverable such that straight lines can be followed and normal curves can be made in a true arc. Equipment shall include adequate process controls to regulate the application of marking materials and maintain required temperatures, pressures, and delivery speed of components in the pavement marking.

The pavement marking equipment shall be operated in accordance with recommendations of the equipment manufacturer, unless otherwise directed by the Engineer. Operating speeds shall be such as to provide uniformity and the specified wet or dry film thicknesses.

The application equipment shall be constructed so as to ensure continuous uniformity in the dimensions of stripes. The applicator shall provide a means for cleanly and squarely cutting off stripe ends and shall provide a method of applying dashed and dotted lines. The equipment shall be capable of applying varying widths of traffic markings.

Pavement marking vehicles shall operate in the lane for traffic moving in the same direction. They shall not encroach into the lane for opposing traffic flow. Exceptions to this requirement shall be approved in writing by the Engineer.

Equipment to be used for determining temperature, moisture, and material thickness including, but not limited to, a thermometer and a micrometer are specified in Subsection 631.04.

(f) Documentation Requirements. The Contractor shall provide to the Agency a written daily installation report of the application for all projects 2 miles or greater in length. The report shall include the following:

(1) Date of installation report.

(2) Date and beginning and ending time of application.

(3) Striping contractor.

(4) The highway number, highway name, and town name with the beginning and ending reference points.

(5) Approved mix design number.

(6) Designation of the marking being applied (LEL – left edge line, REL – right edge line, CL – centerline, LL – lane line).

(7) Width of marking applied.

(8) Vendor and product (binder and optics).

(9) Lot numbers of products used.

(10) Specific weight of binder lots used in pounds per gallon.

(11) Weight in pounds or volume in gallons of binder used by color.

(12) Weight in pounds of reflective glass beads or elements used.

(13) Number of optic drops.

(14) Optic types per each drop.

(15) Pavement surface temperature (°F).

(16) Air temperature (°F).

(17) Dew point (°F).

(18) Humidity (percent).

(19) Dates of retroreflectivity testing.

(20) Reflectometer model.

(21) Reflectometer factory calibration date.

(22) Retroreflectivity testing values.

(23) Retroreflectivity testing locations.

646.05 PAVEMENT MARKING MIX DESIGN. The Contractor shall submit a pavement marking mix design for liquid durable pavement markings to the Agency's Materials Testing and Certification Section Central Laboratory. Any change to the mix design will need to be resubmitted and reviewed for conformance in accordance with the requirements of Subsection 105.06. The mix design shall include:

(a) Application.

(1) Pavement type (e.g. Type IVS or Bonded Wearing Course, Type C)

(2) Whether the markings are to be surface applied or recessed

(b) Binder.

(1) Liquid durable type

(2) Product name

(3) Thickness in mils

(4) Color

(c) Optics.

(1) Optic types

(2) Product names

(3) Optic drops

a. Number of optic drops

b. Drop rates

c. Composition of optic drops

(d) Minimum Retroreflectivity Values.

(1) Contractor test data, as determined in accordance with *ASTM D7585*, shall be submitted with the mix design when available. When test data is not available at the time of submittal it shall be submitted as soon as practical after installation on the project. Pavement marking mix designs will not be eligible for renewal for subsequent years when Contractor test data has not been submitted.

The Contractor shall submit a letter of intent a minimum of 14 calendar days prior to the start of production identifying the approved mix designs intended to be used for that Contract. Letters of intent shall be submitted electronically. The letter of intent shall include the Contract name and number, pay item numbers, and mix design number. Usage of the mix design on Agency contracts will not be authorized without the letter of intent being approved by the Engineer.

646.06 WATERBORNE PAINT PAVEMENT MARKINGS.

(a) Application Requirements. Waterborne paint application shall be in accordance with the manufacturer's recommendations. The material shall be applied in a smooth uniform coat, free from excessively thick or thin film placement.

Liquid tanks on paint application equipment shall be equipped with mechanical agitators. Beads shall be conditioned to provide a smooth uniform rate of release. All materials shall be maintained in the condition recommended by the marking manufacturer prior to and at the time of marking.

(1) Mil Thickness. The markings shall be applied at a rate to create a uniform wet film in-place minimum thickness as follows, unless otherwise specified in the Contract:

a. 20 mils for pavement constructed under the same Contract as the markings.

b. 15 mils for all other pavement surfaces.

(2) Retroreflectivity. Type I optics shall be uniformly applied across the width of the line at a rate of 8 pounds per gallon of paint. The Contractor shall provide the Engineer with the optic drop-on rates of all optic materials and daily binder application rates.

646.07 EPOXY PAINT.

(a) Application Requirements. Epoxy paint application shall be in accordance with the manufacturer's recommendations. Mixing of the epoxy reagents shall be complete prior to the placement of the marking. Failure of the epoxy to set to a hard condition shall be grounds for rejection.

(1) Mil Thickness. The markings shall be applied at a rate to create a uniform wet film in-place minimum thickness as follows, unless otherwise specified in the Contract:

a. 25 mils for bonded wearing course constructed under the same Contract as the markings.

b. 18 mils for all other pavement surfaces.

(2) Retroreflectivity.

a. Surface Applied Application. Initial dry retroreflectivity minimums for surface applied epoxy shall be 300 millicandelas per square meter per lux (mcd/m^2/lx) for yellow markings and 400 mcd/m^2/lx for white markings. For surface applied markings, optics shall be applied in either one or two drops. Type I optics or Type II optics shall be applied at a minimum rate of 12 pounds per gallon.

b. Recessed Application. Initial dry retroreflectivity minimums for recessed epoxy shall be 400 mcd/m^2/lx for yellow markings and 600 mcd/m^2/lx for white markings per *ASTM E1710*. The wet average initial retroreflectivity of the markings shall be 300 mcd/m^2/lx for yellow and 375 mcd/m^2/lx for white per *ASTM E2177*.

For recessed markings, optics shall be applied in two drops. The first drop shall include Type III optics and be applied at a minimum rate of 5 pounds per 100 square feet. The second drop shall be Type II optics and be applied at a minimum rate of 8 pounds per gallon.

646.08 POLYUREA.

(a) Application Requirements. Polyurea paint application shall be in accordance with the manufacturer's recommendations. Mixing of the polyurea reagents shall be complete prior to the placement of the marking. Failure of the polyurea to set to a hard condition shall be grounds for rejection.

(1) Mil Thickness. Polyurea paint shall be applied at a rate to create a uniform wet film in-place minimum thickness as follows, unless otherwise specified in the Contract:

a. 25 mils for bonded wearing course constructed under the same Contract as the markings.

b. 18 mils for all other pavement surfaces.

(2) Retroreflectivity.

a. Surface Applied Application. Initial dry retroreflectivity minimums for surface-applied polyurea shall be 300 mcd/m^2/lx for yellow markings and 400 mcd/m^2/lx for white markings.

For surface applied markings, optics shall be applied in either one or two drops. Type I or Type II optics shall be applied at a minimum rate of 10 pounds per gallon.

b. Recessed Application. Initial dry retroreflectivity minimums for recessed polyurea shall be 400 mcd/m^2/lx for yellow markings and 600 mcd/m^2/lx for white markings per *ASTM E1710*. The wet average initial retroreflectivity of the markings shall be 300 mcd/m^2/lx for yellow and 375 mcd/m^2/lx for white per *ASTM E2177*.

For recessed markings, optics shall be applied in two drops. The first drop shall include Type III optics and be applied at a minimum rate of 5 pounds per 100 square feet. The second drop shall be Type II optics and be applied at a minimum rate of 8 pounds per gallon.

646.09 EXTRUDED THERMOPLASTIC. Extruded thermoplastic markings shall be Type A thermoplastic pavement markings meeting the requirements of Subsection 708.08. The thermoplastic pavement marking compound shall be extruded onto the pavement surface in a molten state. The temperature of the material shall not exceed the manufacturer's recommended heating temperature or rate of temperature increase. The surface shall be properly prepared for receipt of the marking material, including surface roughness, cleanliness, and moisture levels. The surface shall be primed when the manufacturer's recommendations require priming.

Following an application of glass beads to the marking surface, and upon cooling to normal pavement temperatures, the resultant marking shall be an adherent retroreflective stripe of the specified thickness and width that is capable of resisting deformation by traffic.

(a) Thermoplastic Application Equipment. Thermoplastic application equipment shall be approved by the Engineer prior to the start of work.

Thermoplastic material shall be applied to the pavement surface by the extrusion method, wherein the bottom of the extrusion shoe is the pavement and the top and other three sides are contained by, or are part of, suitable equipment for maintaining the temperature and controlling the flow of material. The fourth side contains the extrusion opening.

The ribbon extrusion method will not be permitted for the application of extruded thermoplastic material.

The equipment used for the placement of extruded thermoplastic pavement markings shall be of two general types:

(1) Mobile Applicator Equipment. The mobile applicator shall be defined as truck-mounted equipment designed to apply thermoplastic by the extrusion method. The unit shall be equipped to apply the thermoplastic material at temperatures exceeding 400°F, and at the widths and thicknesses specified herein. The mobile unit shall be capable of operating continuously or installing a minimum of 3.8 miles of longitudinal markings in an 8-hour day.

The mobile unit shall be equipped with extrusion shoes and shall be capable of simultaneously marking edge lines or two centerline stripes. The extrusion shoes shall be closed, heat-jacketed or suitably insulated units, and shall hold the molten thermoplastic at a temperature between 400°F and 435°F.

The mobile unit shall be capable of extruding a line from 4 inches to 8 inches wide. Material temperature gauges shall be affixed, adjacent to or incorporated in the extrusion shoe, in such a manner as to be visible and capable of monitoring the composition temperature throughout the marking operation.

The mobile unit shall be equipped with an electronic and programmable line pattern control system, or mechanical system, to be capable of applying dashed, dotted, or solid lines in any sequence and through any extrusion shoe in any cycle length.

(2) Portable Applicator Equipment. The portable applicator shall be defined as hand-operated equipment specifically designed for placing thermoplastic installations such as crosswalks, stop bars, legends, arrows, and short lengths of lane lines, edge lines, and centerlines. The portable applicator shall be capable of applying thermoplastic markings by the extrusion method.

It is intended that the portable applicator will be loaded with hot thermoplastic composition from the melting kettles or that the material will be melted by an integral melting stack when so equipped. The portable applicator shall be equipped with all the necessary components, including a material storage reservoir, bead dispenser, extrusion shoe and heating accessories.

The portable applicator shall be capable of holding the molten thermoplastic at a temperature of between 400°F and 435°F, and of extruding a line from 4 inches to 8 inches wide in 2-inch increments.

Material temperature gauges shall be affixed, adjacent to or incorporated in the extrusion shoe, in such a manner as to be visible and capable of monitoring the composition temperature throughout the marking operation. If a machine, as manufactured, cannot be equipped with gauges at the extrusion shoe, the Engineer may approve an alternate method of monitoring the composition temperature at the point of deposition.

(b) Application Requirements. Bituminous concrete primer shall be applied to pavements older than two years at the application rates and procedures recommended by the thermoplastic material manufacturer. Primer shall be applied under such conditions, at such rates and thicknesses, and of a type as recommended by the thermoplastic material manufacturer.

(1) Mil Thickness. All extruded markings shall be applied at the specified width and at a uniform hot film in-place minimum thickness of 105 mils.

(2) Retroreflectivity.

a. Surface Applied Application. Initial dry retroreflectivity minimums for surface-applied extruded thermoplastic shall be 300 mcd/m^2/lx for yellow markings and 400 mcd/m^2/lx for white markings.

For surface applied markings, optics shall be applied in either one or two drops. Type I or Type II optics reflective media shall be applied at a minimum rate of 8 pounds per square foot.

b. Recessed Application. Initial dry retroreflectivity minimums for extruded thermoplastic shall be 400 mcd/m^2/lx for yellow markings and 600 mcd/m^2/lx for white markings per *ASTM E1710*. The wet average initial retroreflectivity of the markings shall be 300 mcd/m^2/lx for yellow and 375 mcd/m^2/lx for white per *ASTM E2177*.

For recessed markings, optics shall be applied in two drops. The first drop shall include Type III optics and be applied at a minimum rate of 5 pounds per 100 square feet. The second drop shall be Type II optics and be applied at a minimum rate of 8 pounds per gallon.

c. Intermix. Type I optics shall be incorporated into the intermix of the thermoplastic composition at a rate of between 30% and 40% by weight of the combined material.

646.10 PREFORMED THERMOPLASTIC. Preformed thermoplastic markings shall be Type B thermoplastic pavement markings meeting the requirements of Subsection 708.08.

646.11 PAVEMENT MARKING TAPE.

(a) Pavement Marking Tape, Type A. Type A pavement marking tape, when used as a final durable marking, shall be applied in a recess as defined in Subsection 646.14, and shall be applied in accordance with the manufacturer's requirements.

(b) Pavement Marking Tape, Type B. Type B pavement marking tape, when used as a final durable marking, shall be applied in a recess as defined in Subsection 646.14, and shall be applied in accordance with the manufacturer's requirements.

646.12 TEMPORARY PAVEMENT MARKINGS. Temporary pavement markings are classified as temporary pavement marking tape (removable), pavement marking mask, line striping targets (LSTs), and waterborne paint. All temporary pavement markings shall be maintained at all times at no additional cost.

Temporary markings on the wearing course of pavement shall be temporary pavement marking tape or line striping targets. Paint will not be permitted for use as a temporary marking on the wearing course of pavement. Unless otherwise indicated in the Contract, the Contractor may choose any temporary pavement marking types on all pavement surfaces except for the wearing course.

(a) Pavement Marking Tape, Type C. This tape for pavement markings is classified as temporary and is removable and shall be installed in accordance with the manufacturer's requirements.

(b) Pavement Marking Mask. Black or other compatible pavement color pavement marking mask is classified as removable. It shall be installed in accordance with the manufacturer's requirements.

(c) Line Striping Targets. Line striping targets are intended to be temporary substitutes for pavement markings. Line striping targets shall be maintained and replaced as needed or as directed by the Engineer, until replaced by another temporary pavement marking or permanent pavement marking. Line striping targets shall only be used in conjunction with Unsafe to Pass signs.

Line striping targets of the color shown on the Plans or directed by the Engineer shall be installed as described below or as directed by the Engineer.

For solid longitudinal pavement markings, line striping targets shall be placed at 10-foot intervals. For double centerline markings, line striping targets shall be paired. For dashed pavement markings, line striping targets shall be placed in groups of three spaced at 5 feet, with the groups separated by 30-foot spaces, or as determined by the Engineer.

Line striping targets shall not be used to delineate passing zones on two-lane non-divided highways.

Line striping targets shall be installed in accordance with the manufacturer's requirements. Line striping targets shall not be nailed to the surface.

Line striping targets in conjunction with Unsafe to Pass signs shall be used on wearing courses of pavement prior to applying permanent markings. Permanent markings shall be placed within 14 calendar days of the date the segment of wearing course pavement is placed, except that where centerline rumble strips have been installed and fog sealed, line striping targets may remain in place on the centerline for 21 calendar days after placement of the wearing course.

Unsafe to Pass signs shall be erected prior to traffic traveling through the work zone. The signs shall be erected on each side of the road 1,000 feet into the project limits, and subsequent signs placed at 2 mile intervals.

(d) Paint. Temporary paint applied on the base or intermediate courses of pavement shall have a minimum thickness of 8 mils. Type I optics shall be applied at a rate of 3 pounds per gallon.

All paint used for temporary markings shall be held to the same alignment and horizontal control standards as specified in Subsection 646.04.

646.13 COLORED PAVEMENT MARKINGS. Colored pavement markings shall consist of a green or other colored surface treatment in accordance with Subsection 754.06. Colored pavement markings shall be installed in accordance with the manufacturer's recommendations, Subsection 646.04, and the following requirements.

(a) Surface Preparation. Bituminous concrete pavement and Portland cement concrete pavement shall be in place a minimum of 28 calendar days prior to the installation of colored pavement markings. Joints and cracks shall be treated in accordance with the manufacturer's recommendations prior to installation. Existing pavement markings shall be removed prior to the placement of new markings, except that waterborne paint markings placed temporarily will not need to be removed. Vacuum-type equipment or equivalent shall be used to collect and contain debris generated by cleaning and marking removal. Adjacent and nearby features, including but not limited to pavement markings, shall be covered and protected as needed.

Following surface preparation, the Contractor shall broom the pavement surface and use compressed air cleaning to remove all residue and debris resulting from the preparation work.

(b) Application. Colored pavement markings shall not be applied on existing pavement markings or rumble strips. The Contractor shall remove colored pavement markings applied outside of the specified areas of application, including, but not limited to, material spilled or tracked onto other surfaces. Colored pavement markings shall not be installed temporarily unless otherwise specified.

(c) Protection. Colored pavement markings shall be protected from all traffic for a period of time as recommended by the manufacturer or until the marking is sufficiently cured to bear traffic without damage to the marking, tracking, or adhering to vehicle tires, whichever is longer.

646.14 OTHER RELATED MARKINGS.

(a) Pavement Marking Recess. Recessed pavement markings shall be installed as specified for permanent markings. The recess shall be a uniform depth across the width of the marking. The recess shall be controlled such that the depth meets the requirements of Table 646.14A.

TABLE 646.14A – PAVEMENT MARKING RECESS DEPTH

Marking Material	Recess Depth (mils)
Thermoplastic	140 – 160
Polyurea	90 –110
Epoxy	90 –110
Permanent tape	As recommended by the manufacturer

The bottom of the recess shall have a smooth, flat finished surface. The use of gang-stacked diamond cutting blades or polycrystalline diamond (PCD) is required for bituminous concrete pavement surfaces. The spacers between blade or PCD cuts shall be such that there will be less than a 10 mil rise in the finished groove between the blades.

Recesses shall be clean, dry, and free of laitance, oil, dirt, grease, paint, or any other foreign contaminants prior to application of the pavement markings. The Contractor shall re-clean grooves, as necessary, prior to application of any primer or permanent markings. Depth plates shall be provided by the Contractor to ensure that desired groove depth is achieved.

(b) Painted Curbs and Islands. Where a painted curb or painted island is called for, the existing curb or island shall be blast cleaned or wire brushed to remove scale, dirt, grass, etc. to the satisfaction of the Engineer, prior to painting. This cleaning work will not be paid for directly but will be considered incidental to the Painted Curb or Painted Island pay item.

Paint shall be applied at a rate of 100 to 115 square feet per gallon with glass beads applied at a rate of 6 pounds per gallon. All paint shall be applied within the manufacturer's allowable application temperatures.

Waterborne paint shall be applied by a method in which the liquid material is applied to the curb or island surface and the glass beads are immediately applied to the material and firmly embedded therein, and which shall provide a retroreflective marking, with a night visibility satisfactory to the Engineer. The material shall have a minimum wet film thickness of 15 mils, unless otherwise specified, and be applied in a smooth, uniform coat, free from thin areas or excessively thick films.

Type I optics shall be applied uniformly over the entire painted surface area at the specified rate.

646.15 SUBSTITUTION OF MARKING MATERIALS. If durable markings cannot be placed under suitable environmental conditions, paint shall be applied as specified in Subsection 646.06 at no cost to the Agency. Where it can be determined that, through no fault of the Contractor, durable markings cannot be applied under suitable environmental conditions, paint may be applied for durable marking of the types indicated on the Plans where appropriate and as directed by the Engineer.

Regardless of the circumstance under which paint is applied after an unsuitable environmental conditions determination, durable markings of the types indicated on the Plans shall be applied as soon as suitable environmental conditions permit during the following spring. These durable markings shall be measured and paid for in accordance with Subsection 646.18 and Subsection 646.19.

646.16 ALTERNATE MARKING MATERIALS. If the Contractor wishes to use pavement markings or markers that are not specified in this section, the Contractor shall submit samples, technical data, installation instructions and, if applicable, removal instructions to the Engineer for approval at least 30 calendar days before the date the markings or markers are to be placed.

The Engineer, after consultation with the Materials Manager, will approve or disapprove the use of the submitted products within the 30 calendar day period. The Contractor should be prepared to place approved markings on the proper date, even if the submittal is disapproved.

646.17 REMOVAL OF EXISTING PAVEMENT MARKINGS. Existing markings shall be obliterated in such a manner and by such means that a minimum of pavement scars are left and all the existing markings are removed, for example by grinding a square or rectangle on the pavement to remove a letter or arrow, or grinding a large rectangle to remove a word so that the outline of the letter, symbol, or word is not ground into the pavement and therefore still legible even though the marking has been removed. Painting over existing markings is not an acceptable method of removal.

The work shall be completed to the satisfaction of the Engineer. Masking of lines in intermediate duration activities shall be completed according to the Plans or as directed by the Engineer.

646.18 METHOD OF MEASUREMENT. The quantity of pavement marking edge lines and centerlines of the types and sizes specified to be measured for payment will be the number of linear feet applied in the complete and accepted work, as measured along the centerline of the pavement stripe. The number of linear feet of open spaces in a dashed or dotted line will not be measured for payment. Temporary pavement markings shall be installed on the pavement and removed in accordance with Subsection 646.04.

When, through no fault of the Contractor, durable markings could not be applied under suitable environmental conditions, and waterborne paint pavement markings were applied on the project as specified in Subsection 646.15, the quantity to be measured for payment will be the quantity determined per the measure for the durable pavement marking specified, multiplied by a factor of 1.5 to determine the accepted quantity for payment.

The quantity of Stop Bar of the type specified to be measured for payment will be the number of linear feet applied in the complete and accepted work, as measured along the centerline of the pavement stripe.

The quantity of Letter or Symbol of the type specified to be measured for payment will be the number of each unit applied in the complete and accepted work. A unit will consist of one letter or one symbol. For example, the six-letter word “SCHOOL” would be measured as six units, and a handicapped symbol would be measured as one unit. For arrow symbols, each arrow symbol and associated stem shall be paid as one unit.

The quantity of Crosswalk Marking of the type specified to be measured for payment will be the number of linear feet applied from curb-to-curb in the complete and accepted work, as measured along the center of the crosswalk.

The quantity of Railroad Crossing Symbol of the type specified to be measured for payment will be the number of each unit applied in the complete and accepted work. A unit will consist of three stop bars, two “Rs,” and one “X” for one traffic lane in one direction of travel.

The quantity of Line Striping Targets to be measured for payment will be the number of individual targets installed on the pavement and removed in accordance with Subsection 646.04.

The quantity of Painted Curb to be measured for payment will be the number of linear feet applied in the complete and accepted work, as measured along the centerline of the pavement stripe.

The quantity of Painted Island to be measured for payment will be the number of square feet of the top of an island painted in the complete and accepted work.

The quantity of Removal of Existing Pavement Markings to be measured for payment will be the number of square feet of markings removed or total area in square feet of symbol or letter removed in the complete and accepted work, as determined by the Engineer.

The quantity of Pavement Marking Mask to be measured for payment will be the number of square feet of existing markings masked in the complete and accepted work.

The quantity of Colored Pavement Markings and Colored Pavement Markings, Green to be measured for payment will be the number of square feet applied in the complete and accepted work.

646.19 BASIS OF PAYMENT. The accepted quantity of pavement marking edge lines and centerlines of the types and sizes specified will be paid for at the Contract unit prices per linear foot.

The accepted quantity of waterborne paint pavement markings of the types and sizes specified per Subsection 646.06 and measured for payment will be paid for at the corresponding Contract unit prices for Temporary Pavement Markings.

The accepted quantity of Stop Bar of the type specified will be paid for at the Contract unit price per linear foot.

The accepted quantity of Letter or Symbol of the type specified will be paid for at the Contract unit price per each unit.

The accepted quantity of Crosswalk Marking of the type specified will be paid for at the Contract unit price per linear foot.

The accepted quantity of Railroad Crossing Symbol of the type specified will be paid for at the Contract unit price per each unit.

The accepted quantity of Painted Curb will be paid for at the Contract unit price per linear foot.

The accepted quantity of Painted Island will be paid for at the Contract unit price per square foot.

Payment will be full compensation for furnishing, transporting, handling, assembling, and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The Contract unit price for recessed pavement marking items will also include all labor, equipment, tools, and incidentals necessary for the placement of the recess and any necessary cleaning, drying, or conditioning of the recess prior to placement of the marking.

The Contract unit price for liquid pavement marking items shall include all costs associated with Type I, Type II, and Type III optics. Reflective media will not be paid for directly but will be considered incidental to the pavement marking items in the Contract.

The Contract unit price for temporary pavement markings, including tape, paint, and line striping targets, as specified in Subsection 646.12, shall include all costs for maintaining marking capability for interim pavement markings, and all costs for removal.

The accepted quantity of Line Striping Targets will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing; transporting; handling; installing and removing the LSTs; installing and removing Unsafe to Pass signs, posts, and sleeves; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Line striping targets replaced at the direction of the Engineer within the first 14 calendar days, or 21 calendar days for centerline line striping targets in areas where centerline rumble strips were installed and fog sealed, shall be paid for at the Contract unit price for each. If line striping targets remain in place on the roadway for longer than 14 or 21 calendar days, as applicable, no payment will be made for the Contract item Line Striping Targets.

The accepted quantity of Removal of Existing Pavement Markings will be paid for at the Contract unit price per square foot. Payment will be full compensation for removing the markings and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Pavement Marking Mask will be paid for at the Contract unit price per square foot. Payment will be full compensation for obliterating existing markings with a masking material, for removing the masking material when it is no longer required as directed by the Engineer, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Colored Pavement Markings and Colored Pavement Markings, Green will be paid for at the Contract unit price per square foot. Payment will be full compensation for removal of existing pavement markings, surface preparation, furnishing, transporting, handling, assembling, and placing the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The Contractor is responsible for supplying necessary materials and equipment recommended by the manufacturer to determine the surface moisture condition of the pavement. The costs for supplying this material and equipment will be paid for under the appropriate Section 631 Contract item.

Payment will be made under:

Pay Item		Pay Unit
646.2010	4 Inch White Line, Waterborne Paint	Linear Foot
646.2111	4 Inch Yellow Line, Waterborne Paint	Linear Foot
646.2141	6 Inch White Line, Waterborne Paint	Linear Foot
646.2151	6 Inch Yellow Line, Waterborne Paint	Linear Foot

Pay Item		Pay Unit
646.2210	8 Inch White Line, Waterborne Paint	Linear Foot
646.2310	8 Inch Yellow Line, Waterborne Paint	Linear Foot
646.2410	12 Inch White Line, Waterborne Paint	Linear Foot
646.2510	12 Inch Yellow Line, Waterborne Paint	Linear Foot
646.2610	24 Inch Stop Bar, Waterborne Paint	Linear Foot
646.3010	Letter or Symbol, Waterborne Paint	Each
646.3110	Crosswalk Marking, Waterborne Paint	Linear Foot
646.3210	Railroad Crossing Symbol, Waterborne Paint	Each
646.4020	Durable 4 Inch White Line, Thermoplastic	Linear Foot
646.4030	Durable 4 Inch White Line, Epoxy Paint	Linear Foot
646.4040	Durable 4 Inch White Line, Polyurea	Linear Foot
646.4060	Durable 4 Inch White Line, Recessed Polyurea	Linear Foot
646.4071	Durable 4 Inch White Line, Recessed Type A Tape	Linear Foot
646.4072	Durable 4 Inch White Line, Recessed Type B Tape	Linear Foot
646.4080	Durable 4 Inch White Line, Recessed Thermoplastic	Linear Foot
646.4090	Durable 4 Inch White Line, Recessed Epoxy Paint	Linear Foot
646.4120	Durable 4 Inch Yellow Line, Thermoplastic	Linear Foot
646.4130	Durable 4 Inch Yellow Line, Epoxy Paint	Linear Foot
646.4140	Durable 4 Inch Yellow Line, Polyurea	Linear Foot
646.4160	Durable 4 Inch Yellow Line, Recessed Polyurea	Linear Foot
646.4171	Durable 4 Inch Yellow Line, Recessed Type A Tape	Linear Foot
646.4172	Durable 4 Inch Yellow Line, Recessed Type B Tape	Linear Foot
646.4180	Durable 4 Inch Yellow Line, Recessed Thermoplastic	Linear Foot
646.4190	Durable 4 Inch Yellow Line, Recessed Epoxy Paint	Linear Foot
646.4220	Durable 6 Inch White Line, Thermoplastic	Linear Foot
646.4230	Durable 6 Inch White Line, Epoxy Paint	Linear Foot
646.4240	Durable 6 Inch White Line, Polyurea	Linear Foot
646.4260	Durable 6 Inch White Line, Recessed Polyurea	Linear Foot
646.4271	Durable 6 Inch White Line, Recessed Type A Tape	Linear Foot
646.4272	Durable 6 Inch White Line, Recessed Type B Tape	Linear Foot
646.4280	Durable 6 Inch White Line, Recessed Thermoplastic	Linear Foot
646.4290	Durable 6 Inch White Line, Recessed Epoxy Paint	Linear Foot
646.4320	Durable 6 Inch Yellow Line, Thermoplastic	Linear Foot
646.4330	Durable 6 Inch Yellow Line, Epoxy Paint	Linear Foot
646.4340	Durable 6 Inch Yellow Line, Polyurea	Linear Foot

Pay Item		Pay Unit
646.4360	Durable 6 Inch Yellow Line, Recessed Polyurea	Linear Foot
646.4371	Durable 6 Inch Yellow Line, Recessed Type A Tape	Linear Foot
646.4372	Durable 6 Inch Yellow Line, Recessed Type B Tape	Linear Foot
646.4380	Durable 6 Inch Yellow Line, Recessed Thermoplastic	Linear Foot
646.4390	Durable 6 Inch Yellow Line, Recessed Epoxy Paint	Linear Foot
646.4420	Durable 8 Inch White Line, Thermoplastic	Linear Foot
646.4430	Durable 8 Inch White Line, Epoxy Paint	Linear Foot
646.4440	Durable 8 Inch White Line, Polyurea	Linear Foot
646.4460	Durable 8 Inch White Line, Recessed Polyurea	Linear Foot
646.4471	Durable 8 Inch White Line, Recessed Type A Tape	Linear Foot
646.4472	Durable 8 Inch White Line, Recessed Type B Tape	Linear Foot
646.4480	Durable 8 Inch White Line, Recessed Thermoplastic	Linear Foot
646.4490	Durable 8 Inch White Line, Recessed Epoxy Paint	Linear Foot
646.4520	Durable 8 Inch Yellow Line, Thermoplastic	Linear Foot
646.4530	Durable 8 Inch Yellow Line, Epoxy Paint	Linear Foot
646.4540	Durable 8 Inch Yellow Line, Polyurea	Linear Foot
646.4560	Durable 8 Inch Yellow Line, Recessed Polyurea	Linear Foot
646.4571	Durable 8 Inch Yellow Line, Recessed Type A Tape	Linear Foot
646.4572	Durable 8 Inch Yellow Line, Recessed Type B Tape	Linear Foot
646.4580	Durable 8 Inch Yellow Line, Recessed Thermoplastic	Linear Foot
646.4590	Durable 8 Inch Yellow Line, Recessed Epoxy Paint	Linear Foot
646.4620	Durable 12 Inch White Line, Thermoplastic	Linear Foot
646.4630	Durable 12 Inch White Line, Epoxy Paint	Linear Foot
646.4640	Durable 12 Inch White Line, Polyurea	Linear Foot
646.4660	Durable 12 Inch White Line, Recessed Polyurea	Linear Foot
646.4671	Durable 12 Inch White Line, Recessed Type A Tape	Linear Foot
646.4672	Durable 12 Inch White Line, Recessed Type B Tape	Linear Foot
646.4680	Durable 12 Inch White Line, Recessed Thermoplastic	Linear Foot
646.4690	Durable 12 Inch White Line, Recessed Epoxy Paint	Linear Foot
646.4720	Durable 12 Inch Yellow Line, Thermoplastic	Linear Foot
646.4730	Durable 12 Inch Yellow Line, Epoxy Paint	Linear Foot
646.4740	Durable 12 Inch Yellow Line, Polyurea	Linear Foot
646.4760	Durable 12 Inch Yellow Line, Recessed Polyurea	Linear Foot
646.4771	Durable 12 Inch Yellow Line, Recessed Type A Tape	Linear Foot
646.4772	Durable 12 Inch Yellow Line, Recessed Type B Tape	Linear Foot
646.4780	Durable 12 Inch Yellow Line, Recessed Thermoplastic	Linear Foot
646.4790	Durable 12 Inch Yellow Line, Recessed Epoxy Paint	Linear Foot

Pay Item		Pay Unit
646.4820	Durable 24 Inch Stop Bar, Thermoplastic	Linear Foot
646.4830	Durable 24 Inch Stop Bar, Epoxy Paint	Linear Foot
646.4840	Durable 24 Inch Stop Bar, Polyurea	Linear Foot
646.4860	Durable 24 Inch Stop Bar, Recessed Polyurea	Linear Foot
646.4871	Durable 24 Inch Stop Bar, Recessed Type A Tape	Linear Foot
646.4872	Durable 24 Inch Stop Bar, Recessed Type B Tape	Linear Foot
646.4880	Durable 24 Inch Stop Bar, Recessed Thermoplastic	Linear Foot
646.4890	Durable 24 Inch Stop Bar, Recessed Epoxy Paint	Linear Foot
646.4920	Durable Letter or Symbol, Thermoplastic	Each
646.4930	Durable Letter or Symbol, Epoxy Paint	Each
646.4940	Durable Letter or Symbol, Polyurea	Each
646.4960	Durable Letter or Symbol, Recessed Polyurea	Each
646.4971	Durable Letter or Symbol, Recessed Type A Tape	Each
646.4972	Durable Letter or Symbol, Recessed Type B Tape	Each
646.4980	Durable Letter or Symbol, Recessed Thermoplastic	Each
646.4990	Durable Letter or Symbol, Recessed Epoxy Paint	Each
646.5020	Durable Crosswalk Marking, Thermoplastic	Linear Foot
646.5030	Durable Crosswalk Marking, Epoxy Paint	Linear Foot
646.5040	Durable Crosswalk Marking, Polyurea	Linear Foot
646.5060	Durable Crosswalk Marking, Recessed Polyurea	Linear Foot
646.5071	Durable Crosswalk Marking, Recessed Type A Tape	Linear Foot
646.5072	Durable Crosswalk Marking, Recessed Type B Tape	Linear Foot
646.5080	Durable Crosswalk Marking, Recessed Thermoplastic	Linear Foot
646.5090	Durable Crosswalk Marking, Recessed Epoxy Paint	Linear Foot
646.5120	Durable Railroad Crossing Symbol, Thermoplastic	Each
646.5130	Durable Railroad Crossing Symbol, Epoxy Paint	Each
646.5140	Durable Railroad Crossing Symbol, Polyurea	Each
646.5160	Durable Railroad Crossing Symbol, Recessed Polyurea	Each
646.5171	Durable Railroad Crossing Symbol, Recessed Type A Tape	Each
646.5172	Durable Railroad Crossing Symbol, Recessed Type B Tape	Each
646.5180	Durable Railroad Crossing Symbol, Recessed Thermoplastic	Each
646.5190	Durable Railroad Crossing Symbol, Recessed Epoxy Paint	Each
646.6000	Temporary 4 Inch White Line	Linear Foot
646.6012	Temporary 4 Inch White Line, Type C Tape	Linear Foot
646.6020	Temporary 4 Inch White Line, Paint	Linear Foot
646.6100	Temporary 4 Inch Yellow Line	Linear Foot
646.6112	Temporary 4 Inch Yellow Line, Type C Tape	Linear Foot
646.6120	Temporary 4 Inch Yellow Line, Paint	Linear Foot

Pay Item		Pay Unit
646.6200	Temporary 6 Inch White Line	Linear Foot
646.6212	Temporary 6 Inch White Line, Type C Tape	Linear Foot
646.6220	Temporary 6 Inch White Line, Paint	Linear Foot
646.6300	Temporary 6 Inch Yellow Line	Linear Foot
646.6312	Temporary 6 Inch Yellow Line, Type C Tape	Linear Foot
646.6320	Temporary 6 Inch Yellow Line, Paint	Linear Foot
646.6400	Temporary 8 Inch White Line	Linear Foot
646.6412	Temporary 8 Inch White Line, Type C Tape	Linear Foot
646.6420	Temporary 8 Inch White Line, Paint	Linear Foot
646.6500	Temporary 8 Inch Yellow Line	Linear Foot
646.6512	Temporary 8 Inch Yellow Line, Type C Tape	Linear Foot
646.6520	Temporary 8 Inch Yellow Line, Paint	Linear Foot
646.6600	Temporary 12 Inch White Line	Linear Foot
646.6612	Temporary 12 Inch White Line, Type C Tape	Linear Foot
646.6620	Temporary 12 Inch White Line, Paint	Linear Foot
646.6700	Temporary 12 Inch Yellow Line	Linear Foot
646.6712	Temporary 12 Inch Yellow Line, Type C Tape	Linear Foot
646.6720	Temporary 12 Inch Yellow Line, Paint	Linear Foot
646.6800	Temporary 24 Inch Stop Bar	Linear Foot
646.6812	Temporary 24 Inch Stop Bar, Type C Tape	Linear Foot
646.6820	Temporary 24 Inch Stop Bar, Paint	Linear Foot
646.6900	Temporary Letter or Symbol	Each
646.6912	Temporary Letter or Symbol, Type C Tape	Each
646.6920	Temporary Letter or Symbol, Paint	Each
646.7000	Temporary Crosswalk Marking	Linear Foot
646.7012	Temporary Crosswalk Marking, Type C Tape	Linear Foot
646.7020	Temporary Crosswalk Marking, Paint	Linear Foot
646.7100	Temporary Railroad Crossing Symbol	Each
646.7112	Temporary Railroad Crossing Symbol, Type C Tape	Each
646.7120	Temporary Railroad Crossing Symbol, Paint	Each
646.7600	Line Striping Targets	Each
646.8100	Painted Curb	Linear Foot
646.8200	Painted Island	Square Foot
646.8500	Removal of Existing Pavement Markings	Square Foot
646.8600	Pavement Marking Mask	Square Foot
646.9000	Colored Pavement Markings	Square Foot
646.9001	Colored Pavement Markings, Green	Square Foot

SECTION 649 – GEOTEXTILE FABRIC

649.01 DESCRIPTION. This work shall consist of furnishing and placing geotextiles in underdrain trenches, under embankments, for embankment reinforcement, under riprap and stone fill, behind retaining structures, over roadbed subgrades, between railbed and roadbed subgrades, and beneath pavement overlays.

649.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Geotextile for Roadbed Separator.....720.02
Geotextile Under Railroad Ballast.....720.03
Geotextile Under Stone Fill.....720.04
Geotextile for Underdrain Trench Lining.....720.05

Geotextiles shall conform to the following:

(a) Where sewn seams are used, the Contractor shall furnish the manufacturer's wide strip tensile test results as part of the certification. The results must verify that the seam meets or exceeds the specified average minimum roll values for the grab tensile strength of the geotextiles, or wide strip tensile strength for reinforcement applications.

(b) Field seams, where used, shall be in accordance with the manufacturer's recommendations.

649.03 GENERAL REQUIREMENTS. The rolls of geotextile shall be protected against damage and deterioration until incorporated into the project. The geotextile shall be dry at the time of installation. The geotextile will be rejected if, at the time of installation, it has defects, deterioration, or damage as determined by the Engineer.

649.04 INSTALLATION.

(a) General Requirements. The surface receiving the geotextile shall be prepared to a smooth condition, free of obstructions, depressions, and debris, unless otherwise directed by the Engineer. The geotextile shall not be dragged on the ground or mishandled in any way. The geotextile shall be placed loosely and without wrinkles so that placement of the overlying material will not tear the geotextile. The geotextile shall be lapped as specified at the ends and sides of adjoining sheets.

In addition to the above general requirements, the following specific requirements shall be followed for the specified application:

(1) Geotextile Placement on Slopes. The geotextile sheets shall be placed with the machine direction oriented perpendicular to the slope. When the geotextile is placed on slopes steeper than 1:6 (V:H), the upper sheets shall lap over the top of the lower sheets. The laps shall be securely anchored to the ground surface with pins or stakes as necessary to prevent slippage and tearing of the geotextile.

As specified by the geotextile manufacturer or as directed by the Engineer, placement of fill material on the geotextile shall start at the toe of the slope and proceed upward.

(2) Geotextile Placement for Stream Bank Protection. Where geotextiles are placed under water, or in an area where water will flow, the geotextile shall be placed with its machine direction parallel to the direction of water flow. Successive geotextile sheets shall be overlapped in such a manner that the upstream sheet is placed over the top of the downstream sheet. The geotextile shall be adequately secured to prevent slippage.

As the geotextile is placed under water, the backfill material shall be placed on it to the required thickness. The geotextile placement shall not progress more than 50 feet ahead of the backfill placement.

(3) Underdrains. When a geotextile is specified to line an underdrain trench, the geotextile shall be placed to conform loosely to the shape of the trench.

(4) Geotextile Under Stone Fill. Geotextiles under riprap or stone fill shall be constructed in accordance with the details shown on the Plans and the following requirements. The Contractor shall demonstrate to the satisfaction of the Engineer that the combination of the stone fill drop height and the thickness of any sand cushion, when specified or required, are adequate so as not to puncture or damage the geotextile when placing the riprap or stone fill. Where a sand cushion is used, it shall be a minimum of 6 inches thick, unless otherwise directed by the Engineer. In addition, the stone fill drop height limits specified in Table 649.04A shall apply.

TABLE 649.04A – MAXIMUM STONE FILL DROP HEIGHT

Type of Stone Fill	Maximum Drop Height (in.)	
	Onto Geotextile	Onto Sand Cushion Blanket
Type I	36	36
Type II, Type III, Type IV, or riprap	0	12

After placement of the stone fill or riprap, all voids that allow the geotextile to be seen shall be satisfactorily backfilled so that the geotextile is completely covered.

(5) Roadbed Subgrade and Railroad Ballast Separation. The subgrade shall be prepared in accordance with Section 203. Construction vehicles shall be limited in size and weight such that rutting of the initial lift placed above the geotextile is no greater than 3 inches deep. Ruts shall not be graded off but shall be filled with material specified by the Engineer such that a minimum 8 inches of cover is kept over the geotextile. Turning of vehicles on the first lift of cover material shall not be permitted. The Contractor shall not use vibratory rollers on the first lift if pumping or distortion of the subgrade occurs, as determined by the Engineer.

(b) Protection of Geotextile. The Contractor shall not permit traffic or construction equipment to travel directly on the geotextile. The geotextile shall always be protected during construction operations from contamination by surface runoff and construction activities. The geotextile shall be covered with the specified cover material as soon as possible. Uncovered conditions shall not exceed 7 calendar days.

Specified cover material shall be placed on the geotextile in such a manner that the geotextile is not torn, punctured, or shifted. The minimum cover layer shall be 8 inches thick or twice the maximum aggregate size, whichever is thicker, before construction equipment is allowed over the area of the geotextile. The Contractor shall not permit end-dumping of aggregates from trucks directly on the geotextile.

(c) Repair of Geotextile. All geotextile that is torn, punctured, or contaminated during construction shall be repaired or replaced by the Contractor. The repair shall consist of a patch of the same type of geotextile placed over the affected area. The patch shall overlap the existing geotextile a minimum of 36 inches from the edge of any part of the rupture. Where geotextile seams are required to be sewn, all damaged sheets shall be repaired as required by the manufacturer's recommendations, unless otherwise shown in the Contract or as directed by the Engineer.

(d) Overlaps. The minimum overlap requirements for geotextiles shall be as specified Table 649.04B.

TABLE 649.04B – MINIMUM GEOTEXTILE OVERLAP DISTANCES

Geotextile Location	Minimum Overlap Distance (in.)
Underdrain trench lining	12
Under Type I and Type II stone fill	24
Under Type III and Type IV stone fill or riprap	36
Roadbed subgrade stabilization	36
Under railroad ballast	36

In the event the Engineer determines that the specified overlap is not sufficient, the overlap shall be increased to provide adequate coverage or the geotextile shall be sewn together in the field. If field-sewn, the requirements in Subsection 649.04(e) shall apply.

(e) Field Seams. Field seams shall be sewn with polymeric thread, consisting of polypropylene, polyester, or Kevlar, and shall be as resistant to deterioration as the geotextile being sewn. The thread shall be of a contrasting color with the geotextile being sewn, and the seams shall be made such that the stitches are exposed for inspection when the geotextile is placed.

(1) Stitching Equipment. The stitching equipment shall be such that it will provide an acceptable lock-type stitch, as recommended by the geotextile manufacturer and approved by the Engineer.

(2) Stitch Requirements. Two rows of lock-type stitching shall be used to make the seam. The two rows of stitching shall be 1/2 inch apart with a tolerance of ± 1/4 inch and shall not cross, except for re-stitching.

(3) Minimum Seam Allowance. The minimum required seam allowances (i.e. the minimum distance from the geotextile edge to the stitch line nearest to that edge) are specified in Table 649.04C.

TABLE 649.04C – MINIMUM GEOTEXTILE SEAM ALLOWANCES

Seam Type	Minimum Seam Allowance (in.)
Flat or prayer seam, Type SSa-1	1-1/2
J-Seam, Type SSa-1	1
Butterfly folded seam, Type SSd-1	1

(4) Seam Type. The Contractor shall obtain the geotextile manufacturer's recommendations for the type of seam and stitch to be used. If the manufacturer does not provide the foregoing technical information, then the Contractor shall use a J-seam with two passes of a lock-type stitch which places at least three stitches per 1 inch of sewn seam. This seam will be tested as required by these specifications. The prayer seam (flat) may be used for repair of damaged in-place geotextile.

649.05 METHOD OF MEASUREMENT. The quantity of Geotextile of the type specified to be measured for payment will be the number of square yards placed in the complete and accepted work. Slope measurements will be used in computing the area. Measurement will not be made for material used for repairs, seams, or overlaps. Measurement will not be made for material used to replace an installation of fabric that has become damaged, destroyed, lost, washed away, or otherwise ineffective unless authorized by the Engineer.

649.06 BASIS OF PAYMENT. The accepted quantity of Geotextile of the type specified will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, transporting, storing, handling, placing, repairing, and removing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Unless otherwise specified in the Contract, payment for the maintenance of Geotextile of the type specified will not be paid for directly, but will be considered incidental to the specific Contract item.

Payment will be made under:

Pay Item	Pay Unit
649.1100 Geotextile for Roadbed Separator	Square Yard
649.2100 Geotextile Under Railroad Ballast	Square Yard
649.3100 Geotextile Under Stone Fill	Square Yard
649.4100 Geotextile for Underdrain Trench Lining	Square Yard

SECTION 651 – TURF ESTABLISHMENT

651.01 DESCRIPTION. This work shall consist of the preparation of an area and the application of topsoil, grubbing material, sod, seed, soil amendments, and mulch.

651.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Stakes for holding sod shall be rounded or square wooden stakes at least 8 inches long and have a cross-sectional area of approximately one square inch. Stakes of other materials or designs may be used when authorized by the Engineer.

Grubbing material for use on stone fill along streams shall consist of grubbed or stripped earth material containing roots of native stream bank vegetation. Grubbing material for use on slopes shall consist of grubbed or stripped earth material containing roots (not necessarily from native stream bank vegetation) which will promote the growth of vegetation.

Grubbing material from outside of the project limits shall not contain any invasive plant material found on the state or federal noxious weed lists on file with the Vermont Agency of Agriculture, Food, and Markets.

651.03 GENERAL REQUIREMENTS. Turf establishment shall occur during the time periods specified in the Plans, unless otherwise authorized under applicable permits or directed by the Engineer.

All seeded areas shall be inspected by the Engineer for turf establishment within 14 calendar days of application. Areas not showing signs of sufficient growth shall be reestablished at the Contractor's expense.

651.04 PREPARATION OF AREA. Preparation of areas for turf establishment shall not take place when the area is frozen, excessively wet, or otherwise in a condition detrimental to the work, as determined by the Engineer. Areas receiving topsoil or sod shall have an allowance made for the depth of topsoil or thickness of sod if not accounted for on the Plans.

Surfaces shall be prepared with all breaks in grade well-rounded, to the satisfaction of the Engineer. All stones, lumps, roots, or other objectionable materials shall be removed.

(a) Native Material. For areas where native material is to be used for turf establishment, existing soil shall be loosened to a depth of 4 inches. Native material shall meet the requirements of Subsection 755.02 and shall also be soil tested in accordance with Subsection 755.02. Native material shall be reworked as necessary to meet the requirements of Subsection 755.02 and any amendments needed, as determined by soil testing, shall be added at the determined rates.

(b) Topsoil. For areas to receive topsoil, existing soil shall be loosened to a depth of 4 inches.

(c) Sod. For areas to receive sod, existing soil shall be loosened to a depth of 2 inches. Compost shall be uniformly incorporated into the loosened soil such it comprises a minimum of 25%, by volume, of the loosened soil. Fertilizer and limestone shall be applied to the entire area to receive sod in accordance with Subsection 651.08. Fertilizer and limestone shall be applied on the same day the area is sodded.

651.05 GROWTH MEDIUM. The growth medium shall be uniformly spread at the locations shown on the Plans. Spreading of growth medium shall not be done when the existing ground or growth medium is frozen, excessively wet, or otherwise in a condition detrimental to the work, as determined by the Engineer.

All stockpiles of growth medium shall be properly drained and all excess or unsuitable material removed and disposed of. When growth medium is stockpiled for 7 calendar days or more it shall be protected in accordance Subsection 651.07. When growth medium is stockpiled for 30 calendar days or more, it shall be seeded in accordance Subsection 651.06 and protected in accordance with Subsection 651.07. Stockpiling shall be done in accordance will all relevant permits.

(a) Topsoil. The Contractor shall have a soil analysis performed in accordance with Subsection 755.02 at a frequency of one analysis per 500 cubic yards for the first 1,000 cubic yards installed and one analysis per 1,000 cubic yards for all material installed thereafter, with a minimum of one analysis per project per source of composite material. The analysis shall be completed by a laboratory accredited by a nationally recognized accrediting body such as AASHTO. The analysis shall identify recommendations for soil additives to correct soil deficiencies and additives to accomplish the planting objectives specified. The Contractor shall incorporate all recommendations into the topsoil. The soil analysis and incorporation of all recommendations shall be completed prior to the material being delivered to the site. Topsoil shall be placed within one year of the soil analysis.

Topsoil shall be spread to a minimum depth of 4 inches, unless otherwise shown on the Plans. Topsoil shall be lightly compacted as heavy compaction will reduce the potential for seed-soil contact and germination success.

(b) Manufactured Topsoil. Manufactured topsoil shall be in accordance with Subsection 651.05(a). In addition, the Contractor shall submit the following information:

(1) Material Composition. A material description including all components with their percentage by weight.

(c) Grubbing Material. Grubbing material shall be spread to the depth shown on the Plans.

651.06 SEED AND AMENDMENTS. Seed and amendments, if needed, shall be spread uniformly at the locations shown on the Plans and shall not be applied when the existing ground or growth medium is frozen, excessively wet, or otherwise untillable, as determined by the Engineer. Hydroseeding shall not be performed when precipitation is forecast within 12 hours after application or when temperatures are below 40°F.

Seed may be applied by hand, mechanical, or hydroseeding methods.

Turf Establishment, General Seed shall be used in all permanent turf establishment areas unless noted otherwise. Turf Establishment, Specialty Seed shall be used to permanently establish vegetation in areas shown on the Plans with specific seed mixtures, as detailed on the Plans. Turf Establishment, Temporary Seed shall be used to establish a temporary cover of vegetation in areas where additional, subsequent disturbance will be occurring as part of the project's construction.

(a) Hand or Mechanical Seeding.

(1) Seed. Seed shall be spread at the rates shown on the Plans. Seed shall be incorporated into the top 1/4 inch of the growth medium. The seed mix design shall be furnished to the Engineer and the seed shall be labeled in accordance with Subsection 755.04.

(2) Fertilizer. The application rate for fertilizer shall be determined based on soil test results, or, if no soil tests are performed, shall be as specified on the Plans. Fertilizer shall not be applied within 50 feet of a water resource.

(3) Limestone. The application rate for limestone shall be determined based on soil test results, or, if no soil tests are performed, shall be as specified on the Plans. Limestone shall be applied with mechanical methods. Hand application will not be allowed.

(b) Hydroseeding. Hydroseeding shall consist of mixing and applying a slurry containing seed, fertilizer, limestone, hydraulic matrix, water, and other materials as required.

(1) Seed. Seed shall be spread at the rates shown on the Plans or as recommended by the hydroseeder manufacturer or seed supplier. The seed mix design shall be furnished to the Engineer and the seed shall be labeled in accordance with Subsection 755.04.

(2) Fertilizer. The application rate for fertilizer shall be determined based on soil test results, or, if no soil tests are performed, shall be as specified on the Plans. Fertilizer shall not be applied within 50 feet of a water resource.

(3) Limestone. The application rate for limestone shall be determined based on soil test results, or, if no soil tests are performed, shall be as specified on the Plans. Limestone application rates may be adjusted to be in accordance with the manufacturer's recommendations.

(4) Hydraulic Matrix. Hydraulic matrix shall be composed of tackifier and fiber mulch and shall be applied in in accordance with the manufacturer's recommendations.

(5) Water. Water shall be used in accordance with the recommendations of the hydraulic matrix manufacturer.

651.07 PROTECTION. Areas where seed and amendments are applied shall be protected in accordance with Subsection 653.07(a)(1), Subsection 653.07(a)(2), Subsection 653.07(a)(3), or Subsection 653.07(b)(1) for hay mulch, hydraulic mulch, straw mulch, or Type I rolled erosion control product, respectively. Protection of the type shown on the Plans shall be applied after, and on the same day, seed and amendments are applied and at the locations shown on the Plans. The Contractor shall maintain all protection measures through acceptance of the work. Type I rolled erosion control product may be substituted for mulch at the Contractor's discretion, with no additional compensation.

651.08 SODDING.

(a) Cutting and Transporting. Before cutting sod, the area from which it is to be removed shall be mowed to a height of approximately 2 inches and cleared of excess grass clippings and other foreign material.

The sod shall be cut into strips of uniform width having a minimum dimension of 12 inches in width and 18 inches in length and uniform thickness of approximately 2 inches, unless otherwise directed by the Engineer. The sod shall contain most of the feeding roots of the grasses.

The sod shall be transported in an unbroken condition to the area to be sodded. Unless otherwise directed by the Engineer, the sod shall be placed in its final position within 48 hours after cutting. When conditions require the sod to be stored, it shall be placed in stacks or piles for not more than 5 calendar days and shall be protected against drying from sun and wind.

(b) Placing. The sod shall be moist when placed on the prepared surface with the edges in close contact and alternate courses staggered. Any gaps shall be filled with sod plugs or topsoil.

Sod shall be staked at 2 foot intervals in both directions on grades steeper than 1:4 (V:H) and in drainage ditches, unless otherwise directed by the Engineer. The stakes shall be driven through the sod perpendicular to the surface so that the tops of stakes are flush with the top of the sod.

In ditches, the sod shall be placed with the longer dimension perpendicular to the flow of water. On slopes, starting at the bottom of the slope, the sod shall be placed with the longer dimension approximately parallel to the bottom of the slope.

After installation, sod shall be rolled with a lawn roller in order to create tight contact between the sod and the soil. Sod shall be thoroughly watered within an hour of placing. If any sections of sod turn brown or curl up, these areas shall be carefully cut out and new sod applied and watered, to create a uniform mat and appearance.

651.09 CARE DURING CONSTRUCTION. The Contractor shall be responsible for protecting and caring for sodded, seeded, and mulched areas until acceptance of the work. The Contractor shall repair and replace all areas where seed has failed to germinate or sod has failed to grow and any areas damaged by pedestrian or vehicular traffic or other causes at no cost to the Agency, except for conditions covered in Subsection 107.17. The Contractor shall maintain seeded areas to a height of no more than 18 inches in rural areas and 8 inches in urban areas through acceptance of the work. The Contractor shall be responsible for watering seeded or sodded areas sufficiently to promote continuous growth as needed for an acceptable stand of grass.

651.10 ACCEPTANCE. An acceptable stand of grass shall be reasonably thick and uniform, free from sizable areas of thin or bare spots, with a uniform count of at least 100 plants of the specified grass type per square foot.

651.11 METHOD OF MEASUREMENT. The quantity of Turf Establishment of the type specified to be measured for payment will be the number of square yards of turf established in the complete and accepted work, as determined using slope measurements.

The quantity of Topsoil to be measured for payment will be the number of cubic yards, including any compost added, used in the complete and accepted work, as measured in its final position using slope measurements for determining area.

The quantity of Grubbing Material of the depth specified to be measured for payment will be the number of square yards of grubbing material used in the complete and accepted work, as measured in its final position using slope measurements for determining area.

651.12 BASIS OF PAYMENT. The accepted quantity of Turf Establishment of the type specified will be paid for at the Contract unit price per square yard. Incorporating soil amendments will not be paid for separately but will be considered incidental to the applicable Turf Establishment item.

The accepted quantity of Topsoil, including any compost added, will be paid for at the Contract unit price per cubic yard.

The accepted quantity of Grubbing Material of the depth specified will be paid for at the Contract unit price per square yard.

Payment for these items will be full compensation for testing, furnishing, transporting, handling, and placing the material specified, including fertilizer, limestone, and tackifier when used, and for furnishing all labor, tools, equipment, maintenance, water necessary to promote growth, and incidentals necessary to complete the work. All work required for preparation of the area will not be paid for separately but will be considered incidental to other Contract items.

Payment will be made under:

Pay Item		Pay Unit
651.1500	Turf Establishment, General Seed	Square Yard
651.1600	Turf Establishment, Specialty Seed	Square Yard
651.1700	Turf Establishment, Temporary Seed	Square Yard
651.1800	Turf Establishment, Sod	Square Yard
651.3500	Topsoil	Cubic Yard
651.4000	Grubbing Material	Square Yard
651.4002	Grubbing Material, 2 Inch	Square Yard
651.4006	Grubbing Material, 6 Inch	Square Yard
651.4012	Grubbing Material, 12 Inch	Square Yard

SECTION 653 – EROSION PREVENTION AND SEDIMENT CONTROL

653.01 DESCRIPTION. This work shall consist of the design and modification of the erosion prevention and sediment control (EPSC) plan or furnishing, installing, monitoring, maintaining, removing, and disposing of erosion prevention and sediment control measures in accordance with these specifications.

653.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Coarse Aggregate for Concrete.....704.02
Dense Graded Crushed Stone for Subbase 704.06
Aggregate for Erosion Prevention and Sediment Control 704.17
Geotextile Under Stone Fill 720.04
Geotextile for Silt Fence 720.07
Barrier Fence.....727.03
Project Demarcation Fence 727.04
Hay Mulch .....755.10(a)
Wood Chip Mulch.....755.10(b)
Fiber Mulch.....755.10(d)
Hydraulic Matrix.....755.10(e)
Tackifier.....755.10(f)
Straw Mulch.....755.10(g)
Rolled Erosion Control Product, Type I .....755.11(a)
Rolled Erosion Control Product, Type II.....755.11(b)
Erosion Logs 755.14

Woven wire reinforcement shall be a minimum of 14-gauge mesh with a maximum mesh opening of 6 inches.

Posts for silt fence shall be wood, with minimum dimensions of 1 inch × 1 inch, or steel. Steel posts shall meet the requirements specified in *AASHTO M 281* or *AASHTO M 181*.

Filtering aggregate shall meet the requirements of Subsection 704.02 and Table 704.02C or Subsection 704.06.

653.03 EPSC PLAN. The Contractor shall be responsible for the development of an EPSC plan and shall become a co-permittee with the Agency on projects with associated permits.

(a) Development. The Contractor shall develop an EPSC plan. When an EPSC plan is included in the Contract the Contractor may use the included EPSC plan as a basis for making modifications. All Contractor submitted EPSC plans shall meet the requirements of the Agency's *Erosion Prevention and Sediment Control Plan Contractor Checklist* and all project permits.

When construction activities occur in phases requiring successive phases of the EPSC plan, those phases shall be included in the EPSC plan.

The preparer of the EPSC plan shall be a licensed professional engineer, a Certified Professional in Erosion and Sediment Control (CPESC) certified by EnviroCert or an equivalent as determined by the Engineer. The EPSC plan shall be stamped if prepared by a professional engineer and signed if prepared by a CPESC (or equivalent). This shall occur even if the EPSC plan included in the Contract is used unmodified.

The current EPSC plan and all manuals, checklists, forms, and other supporting documentation necessary to maintain compliance with associated permits shall be available to the Engineer and maintained on site by the Contractor.

(b) Submittals. The Contractor shall submit the EPSC plan and an updated risk evaluation as required by the permit and preparer certification, if necessary, to the Engineer to determine conformance. The EPSC plan shall be submitted in accordance with Subsection 105.06(c)(2).

The Engineer will provide a conformance memo or comments to the Contractor within 10 working days of the receipt of the EPSC plan. The Contractor shall submit a revised EPSC plan, addressing all comments, within 10 working days of receipt of comments. This cycle shall continue until a conformance memo has been issued for the EPSC plan. The submittal process will not be considered as an acceptable delay of the work under Subsection 108.11.

The EPSC plan, and each subsequent revision, which have demonstrated conformance, shall be forwarded to the Vermont Agency of Natural Resources as appropriate.

Construction activities shall not commence prior to issuance of a conformance memo for the EPSC plan by the Engineer. For projects where Vermont Agency of Natural Resources authorization is required, construction activities shall not commence until the conformance memo for the EPSC plan has been issued by the Engineer and authorized by the Vermont Agency of Natural Resources.

653.04 MONITORING EPSC PLAN. The Contractor shall be responsible for monitoring all EPSC measures in accordance with the conforming EPSC plan and Contract from installation of the EPSC measures through removal of the EPSC measures or acceptance of the project, whichever applies.

(a) On-Site Plan Coordinator. The Contractor shall designate an on-site plan coordinator (OSPC) that is responsible for monitoring the implementation of the EPSC plan on the project. The OSPC shall generally be on-site daily and shall have the authority to halt construction activities if necessary.

The OSPC shall have demonstrated experience in construction practices as they relate to erosion prevention and sediment control as well as a general understanding of state and federal environmental regulations and permits pertaining to the National Pollutant Discharge Elimination System construction program. The OSPC shall be proficient at reading and interpreting engineering and EPSC plans.

(b) Inspection. For Non-Jurisdictional and Low Risk Projects, inspections shall be conducted using the Agency's *EPSC Plan Inspection Report (Non-Jurisdictional and Low Risk Projects)*. For all other projects, inspections shall be done in accordance with permit requirements.

(1) Active Construction. Inspection shall occur once every 7 calendar days and within 24 hours of the end of a storm event that results in a discharge of stormwater from the site. Between October 15th and April 15th, inclusive, inspections shall occur daily for disturbed areas and at all areas that have not achieved permanent stabilization.

(2) Inactive Construction. Inspection shall occur at least once every 30 calendar days and within 24 hours of any storm or significant snow melt event that may cause stormwater runoff. The Contractor shall contact the Engineer prior to conducting any inspection. The Contractor shall provide, within 24 hours, the necessary personnel, equipment, and materials to repair or correct any deficiencies identified during inspection. All deficiencies and corrective measures taken shall be documented in the inspection reports.

653.05 MAINTENANCE OF EPSC PLAN. The Contractor shall provide all labor and equipment necessary for field maintenance of erosion prevention and sediment control items not included in the Contract, and providing materials and labor necessary for installing, monitoring, maintaining and, where necessary, removing additional measures needed to correct deficiencies that develop during construction that lessen the performance of the EPSC plan.

Erosion prevention and sediment control measures shall be maintained by the Contractor and removed when authorized by the Engineer. The Contractor shall establish vegetation in all areas disturbed during installation, maintenance and removal of the erosion prevention and sediment control measures.

Any maintenance required due to the failure of the Contractor to follow the conforming EPSC plan shall be performed at no additional cost to the Agency.

653.06 DELINEATION MEASURES.

(a) Barrier Fence. Barrier fence shall be installed as a visible barrier beyond which there shall be no construction activity by the Contractor or project personnel. Barrier fence shall be installed at the locations shown on the Plans, in accordance with the Contract and as directed by the Engineer.

Barrier fence shall be installed on W-shape steel posts. The fence shall have a minimum height of 4 feet. The posts shall be embedded a minimum of 2 feet into the ground, extend above the fabric, and be installed at a 5-foot spacing.

The Contractor shall install, inspect, and maintain barrier fence in accordance with the Contract or as directed by the Engineer.

The Contractor shall remove barrier fence from the project when deemed no longer necessary by the Engineer, and the barrier fence shall remain the property of the Contractor.

(b) Project Demarcation Fence (PDF). PDF shall be installed as a visible barrier beyond which there shall be no construction activity by the Contractor or project personnel. PDF shall be installed at the locations shown on the Plans, as per the Contract and as directed by the Engineer.

PDF shall be installed on hardwood stakes and shall have a minimum width of 3 inches. The stakes shall be 1 inch × 1 inch × 4 feet, shall be embedded 1 foot into the ground, extend above the fabric, and be installed at a 10-foot spacing.

The Contractor shall install, inspect, and maintain PDF in accordance with the Contract or as directed by the Engineer.

The Contractor shall remove the PDF from the project when deemed no longer necessary by the Engineer, and the PDF shall remain the property of the Contractor.

653.07 STABILIZATION MEASURES. Stabilization measures shall be used to prevent erosion of disturbed soils in accordance with the Contract. All stabilization measures described in this subsection, with the exception of Type II rolled erosion control product, are temporary erosion control measures.

(a) Mulch. Mulch shall be applied uniformly in accordance with the application rates specified herein and maintained by the Contractor during construction.

(1) Hay Mulch. Hay mulch shall be applied at a minimum rate of 2 tons per acre. Hay mulch shall only be used in areas with a slope flatter than 1:3 (V:H). Tackifier may be used with hay mulch, as determined by the Engineer, in areas where hay mulch will not stay in place.

(2) Hydraulic Mulch. Hydraulic mulch shall consist of applying a fiber mulch or hydraulic matrix with hydro-mulching equipment.

Fiber mulch shall be mixed in a hydraulic application machine and applied as a liquid slurry in accordance with the manufacturer's specified procedures and rates. Fiber mulch shall be applied from multiple directions and angles to ensure complete and proper coverage, and only when rainfall is not predicted for at least 12 hours. The fiber mulch shall be applied such that the entire area is covered to a depth of at least 1/8 inch.

Hydraulic matrix shall be hydraulically applied to the soil as a viscous mixture, creating a continuous three-dimensional blanket that adheres to the soil surface. Upon drying, the matrix shall form a high-strength, porous, and erosion-resistant mat that shall not inhibit the germination and growth of plants in and beneath the layer. The matrix shall retain its form despite re-wetting. Pedestrians or equipment shall not be permitted to enter areas where mixtures containing stabilizing emulsion have been applied until vigorous vegetation is established.

(3) Straw Mulch. Straw mulch shall be applied at a minimum rate of 2 tons per acre. Straw mulch shall only be used in areas with a slope flatter than 1:3 (V:H).

(4) Wood Chip Mulch. Wood chip mulch shall be applied to a depth of 1 inch.

(b) Rolled Erosion Control Product. Rolled erosion control products, of the type specified, shall be installed at the locations shown on the Plans or as directed by the Engineer.

The ground surface shall be shaped to the lines and grades shown on the Plans and be free of any depressions or objectionable material that would allow water to collect and flow beneath the matting or prevent the matting from maintaining contact with ground. Rolled erosion control products shall not be stretched or allowed to bridge over surface inconsistencies.

For areas where rolled erosion control products are to be installed and seed and amendments are also to be applied, all seed and amendments shall be applied prior to installation of the rolled erosion control products.

Rolled erosion control product and ground fasteners shall be installed in accordance with the Contract or the manufacturer's recommendations, whichever is more stringent.

(1) Rolled Erosion Control Product, Type I. Type I rolled erosion control product shall be used to provide temporary erosion control while vegetation is established in those areas where vegetation will provide permanent erosion protection.

Type I rolled erosion control product shall meet the requirements of Table 755.11A for the specific site properties as applicable.

Type I rolled erosion control product shall not be applied to grades steeper than 1:1 (V:H).

The Contractor shall maintain Type I rolled erosion control product through turf establishment in accordance with Section 651.

(2) Rolled Erosion Control Product, Type II. Type II rolled erosion control product shall be used to provide permanent erosion control where vegetation will not sustain expected flow conditions or provide sufficient long-term erosion protection.

Type II rolled erosion control product shall meet the requirements of Table 755.11B for the specific site properties as applicable.

The Contractor shall maintain Type II rolled erosion control product through acceptance of the project.

No vehicular traffic of any kind will be permitted over stabilization measures during or after placement. Damage or displacement of stabilization measures through the fault of the Contractor shall be replaced or repaired at the Contractor's expense.

653.08 RUNOFF CONTROL MEASURES. Runoff control measures shall be used to slow runoff in accordance with the Contract.

(a) Check Dams. Check dams shall be used for the primary purpose of reducing flow velocity and the secondary purpose of allowing sediment to settle. Check dams, of the type specified, shall be installed in the water flow path, as shown on the Plans, in accordance with the Contract and as directed by the Engineer.

(1) Check Dam, Type I. Type I check dams shall be placed in channels and on Geotextile Under Stone Fill meeting the requirements of Subsection 720.04.

Type I check dams shall be constructed of aggregate for erosion prevention and sediment control meeting the requirements of Subsection 704.17.

(2) Check Dam, Type II. Type II check dams shall be placed along curbs. Type II check dam structures shall vary in height, width, and length depending on site-specific conditions. They shall have a minimum height of 4 inches, a minimum width of 6 inches, and shall extend 1 foot in a direction perpendicular to the curb and 2 feet up gradient of the curb at an angle ranging from 30° to 60° from the curb face.

For slopes of 3% or less, Type II check dams shall be constructed of stone meeting the requirements of Subsection 704.02 and Table 704.02D.

For slopes greater than 3%, Type II check dams shall be constructed of stone meeting the requirements of Subsection 704.17.

(3) Check Dam, Type III. Type III check dams shall be installed in accordance with the Contract and the manufacturer's recommendations.

Type III check dams shall be one of the Type III check dam products on the Agency's *Approved Products List*.

The Contractor shall remove accumulated sediment when the depth of the sediment reaches half the height of the check dam, measured at the ditch flowline.

Check dams shall be removed from the project when deemed no longer necessary by the Engineer and shall remain the property of the Contractor.

(b) Silt Fence. Silt fence shall be installed in accordance with the Contract and shall be installed perpendicular to the water flow to intercept and collect sediment and associated pollutants by filtering and settling.

(1) Silt Fence, Type I. Type I silt fence shall be constructed of posts and geotextile meeting the requirements of Subsection 720.07.

(2) Silt Fence, Type II. Type II silt fence shall be constructed of posts, geotextile meeting the requirements of Subsection 720.07, and woven wire reinforcement.

The Contractor shall remove accumulated sediment when it reaches half the height of the silt fence above the existing ground.

The Contractor shall repair or replace damaged silt fence as ordered by the Engineer. Silt fence shall be removed from the project by the Contractor when deemed no longer necessary by the Engineer, and shall remain the property of the Contractor.

(c) Erosion Logs. Erosion logs shall be installed to intercept water flow and collect sediment and associated pollutants by settling and filtering. Erosion logs may be placed over bare or mulched soils or rolled erosion control products, around inlet and outlets, to slow runoff velocities in ditches, as slope interrupters on steep slopes, as perimeter control, and along stream banks as a base for plantings. The type of erosion log selected shall be designed for the intended application.

Prior to placing erosion logs, the ground surface shall be properly graded and compacted and free of depressions or obstructions such as tree roots, protruding stones, or other foreign matter.

Erosion logs shall be installed in accordance with the manufacturer's installation guidelines, staking pattern guide, and details based upon the intended use on the construction site.

The Contractor shall remove accumulated sediment when it has reached one half of the effective height of the log, or as directed by the Engineer. Erosion logs shall be maintained until the disturbed area above the device has been permanently stabilized and construction activities have ceased.

Erosion logs shall be removed from the project and disposed of when deemed no longer necessary by the Engineer. When fill material and netting are 100% biodegradable, erosion logs may be cut open, spread or graded flat, and left in place, in a manner to not cause concentration of surface runoff in the future.

653.09 TREATMENT MEASURES.

(a) Stabilized Construction Entrances. Stabilized construction entrances shall be constructed at each access point between the construction area and all public or private roads. The Contractor shall maintain any existing drainage and flow paths within the stabilized construction entrance.

Stabilized construction entrances shall be constructed of stone meeting the requirements of Subsection 704.17 and shall be placed on top of geotextile meeting the requirements of Subsection 720.04.

Stabilized construction entrances shall be maintained such that aggregate does not become clogged, resulting in tracking of sediment onto public rights-of-way. Additional aggregate may be added on top of the existing aggregate only to a point which a smooth transition between the road surface and construction area is maintained. When a smooth transition can no longer be maintained when adding aggregate, the stabilized construction entrance shall be removed in its entirety and replaced.

Stabilized construction entrances shall be removed from the project and disposed of when deemed no longer necessary by the Engineer.

(b) Inlet Protection Devices. Inlet protection devices shall be used for treating stormwater prior to entering a drainage structure. Inlet protection devices shall be constructed and installed such that flow is directed through the device and into the inlet. The Contractor shall remove accumulated sediment when it reaches half the height, at its lowest point, of inlet protection devices.

(1) Inlet Protection Device, Type I. Type I inlet protection devices shall be for use at drop inlets located outside of roadway surface and shall be installed in accordance with the Contract.

Block and stone devices shall be constructed of aggregate for erosion prevention and sediment control and concrete blocks approved by the Engineer.

Stake and fabric devices shall be constructed of geotextile meeting the requirements of Subsection 720.07 and stakes approved by the Engineer.

When deemed necessary by the Engineer, filtering aggregate shall be applied to the upstream surface of the Type I inlet protection device.

Type I inlet protection devices shall be removed from the project and disposed of when deemed no longer necessary by the Engineer.

(2) Inlet Protection Device, Type II. Type II inlet protection devices shall be for use at drop inlets located within the roadway surface and shall be installed in accordance with the Contract and the manufacturer's recommendations.

Type II inlet protection devices shall be one of the Type II inlet protection devices on the Agency's *Approved Products List*.

Type II inlet protection devices shall be removed from the project when deemed no longer necessary by the Engineer and shall remain the property of the Contractor.

(3) Inlet Protection Device, Type III. Type III inlet protection devices shall be for use at culvert inlets and shall be installed in accordance with the Contract.

Type III inlet protection devices shall be constructed of aggregate for erosion prevention and sediment control and shall be placed on top of geotextile meeting the requirements of Subsection 720.04.

When deemed necessary by the Engineer, filtering aggregate shall be applied to the upstream surface of the Type III inlet protection device.

Type III inlet protection devices shall be removed from the project and disposed of when deemed no longer necessary by the Engineer. Aggregate may be flattened along the channel upon approval of the Engineer. Geotextile shall be removed.

(c) Filter Bag. A filter bag is a device that may be used during dewatering pumping operations. The filter bag shall retain silt, sand, and fines while allowing filtered water to pass through.

Where possible, a filter bag shall be placed a minimum of 50 feet from any waters of the state and on a gradual slope in order that incoming water flows downhill through the bag. To increase the efficiency of filtration the filter bag shall be placed on a coarse aggregate or hay bale bed, unless otherwise directed by the Engineer or specified in the Contract.

The neck of the filter bag shall be strapped tightly to the discharge hose. A filter bag is full when it no longer can efficiently filter sediment or allow water to pass at a reasonable rate. Use of excessive flow rate or overfilling a filter bag with sediment will cause rupture of the bag or failure of the hose attachments and shall not be permitted under any circumstances.

Filter bags shall be one of the filter bags on the Agency's *Approved Products List*.

Filter bags shall be disposed of at an approved location as directed by the Engineer.

653.10 METHOD OF MEASURMENT. The quantity of EPSC Plan to be measured for payment will be on a lump sum basis for design and modification of an EPSC Plan in the complete and accepted work.

The quantity of Monitoring EPSC Plan to be measured for payment will be the number of hours, authorized by the Engineer, actually spent monitoring the EPSC Plan. Hours will be rounded to the nearest quarter hour. Travel time and other time not spent at the construction sites, or time not authorized by the Engineer, will not be measured for payment (e.g. travel expenses, clerical staff time, copying, miscellaneous expenses, overhead, etc.).

The quantity of Maintenance of EPSC Plan will be on a dollar basis for installation and maintenance of EPSC measures not otherwise included in the Contract.

The quantity of Barrier Fence, Project Demarcation Fence, Erosion Log, Silt Fence, Type I and Silt Fence, Type II to be measured for payment will be the number of linear feet used in the complete and accepted work.

The quantity of Hay Mulch and Straw Mulch to be measured for payment will be the number of tons used in the complete and accepted work.

The quantity of Hydraulic Mulch to be measured for payment will be the number of gallons used in the complete and accepted work.

The quantity of Rolled Erosion Control Product, of the type specified, to be measured for payment will be the number of square yards used in the complete and accepted work, as measured in its final position using slope measurements for determining area.

The quantity of Check Dam, Type I, Check Dam, Type II, Stabilized Construction Entrance, and Inlet Protection Device, Type III to be measured for payment will be the number of cubic yards of the stone specified used in the complete and accepted work.

The quantity of Check Dam, Type III, Inlet Protection Device, Type I, Inlet Protection Device, Type II and Filter Bag to be measured for payment will be for each used in the complete and accepted work.

Wood Chip Mulch will not be measured for payment separately but will be considered incidental to other Contract items.

653.11 BASIS OF PAYMENT. The accepted quantity of EPSC Plan will be paid for at the Contract lump sum price. Payment will be full compensation for the initial preparation of an EPSC Plan, modifications, submittals, and all incidentals necessary to complete the work. Subsequent modifications to the EPSC Plan during construction will be considered incidental.

The accepted quantity of Monitoring EPSC Plan will be paid for at the Contract unit price per hour. Payment will be full compensation for monitoring, reviewing, and reporting on the construction site, including waste, borrow, and staging areas or other support activities, as it relates to the EPSC Plan. Payment will not be made unless a report for the monitoring is submitted to the Engineer within 7 calendar days of the date of the inspection. Payment will not be made until the report has been accepted by the Engineer.

The accepted quantity of Maintenance of EPSC Plan will be paid for as specified for force account work in Subsection 109.06. Payment will be drawn against the Contract dollar amount. To provide a common proposal for all bidders, the Agency has entered an amount in the proposal to become part of the Contractor's total bid. Maintenance related to material supply and disposal areas shall be performed in accordance with Subsection 105.28.

The accepted quantities of delineation measures, stabilization measures, run-off control measures, and treatment measures will be paid for at the Contract unit price specified for each item. Payment shall be full compensation for furnishing, transporting, handling, placing, and removing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Geotextile, culverts, excavation, or any other items necessary to complete the work shall be considered incidental to the appropriate Contract item.

Unless otherwise specified in the Contract, payment for the maintenance of erosion prevention and sediment control measures will be incidental to the specific Contract item.

Payment will be made under:

Pay Item		Pay Unit
653.0100	EPSC Plan	Lump Sum
653.0200	Monitoring EPSC Plan	Hour
653.0300	Maintenance of EPSC Plan (N.A.B.I.)	Dollar
653.1000	Hay Mulch	Ton
653.1100	Hydraulic Mulch	Gallon
653.1200	Straw Mulch	Ton
653.2001	Rolled Erosion Control Product, Type I	Square Yard
653.2002	Rolled Erosion Control Product, Type II	Square Yard
653.2501	Check Dam, Type I	Cubic Yard
653.2502	Check Dam, Type II	Cubic Yard
653.2503	Check Dam, Type III	Each
653.3500	Stabilized Construction Entrance	Cubic Yard
653.4001	Inlet Protection Device, Type I	Each
653.4002	Inlet Protection Device, Type II	Each
653.4003	Inlet Protection Device, Type III	Cubic Yard
653.4500	Filter Bag	Each
653.4701	Silt Fence, Type I	Linear Foot
653.4702	Silt Fence, Type II	Linear Foot
653.5000	Barrier Fence	Linear Foot
653.5500	Project Demarcation Fence	Linear Foot
653.6000	Erosion Log	Linear Foot

SECTION 654 – STORMWATER TREATMENT PRACTICES

654.01 DESCRIPTION. This work shall consist of constructing stormwater treatment practices as shown on the Plans.

654.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Granular Borrow 703.04
Fine Aggregate for Concrete.....704.01
Coarse Aggregate for Concrete.....704.02
Gravel Filter for Slope Stabilization.....704.07
Drainage Aggregate 704.16
Stone Fill.....706.04
Corrugated Polyethylene Pipe (CPEP) 710.03
Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe.....710.04
Polyvinyl Chloride (PVC) Plastic Pipe.....710.05
Bar Reinforcement.....713.01
Iron Castings 715.01
Geotextile for Roadbed Separator.....720.02
Geotextile for Underdrain Trench Lining 720.05
Compost 755.05
Geomembrane Liner 760.07

Clay soil shall meet the requirements of Table 703.01A for group classification A-7-6.

Precast concrete shall meet the requirements of Section 540. Cast-in-place concrete shall meet the requirements of Section 541 for Concrete, Class B.

Bedding for gravel wetland shall conform to the requirements of Subsection 704.02. The layer of 1-1/2 inch bedding shall be in accordance with Table 704.02D. The layer of 3/8 inch bedding shall be in accordance with Table 704.02B.

Media filter drain soil shall consist of mineral aggregate, perlite, dolomite lime, and gypsum in the quantities shown in the *Vermont Stormwater Management Manual Rule and Design Guidance, Table 6-1*. The composition of perlite, dolomite lime, and gypsum shall meet the amendment requirements of the *Vermont Stormwater Management Manual Rule and Design Guidance, Table 6-1*. The mineral aggregate component shall meet the requirements of Table 704.02B.

Bioretention soil shall meet the requirements of Table 654.02A.

TABLE 654.02A – COMPOSITION OF BIORETENTION SOIL

Component	Min.	Max.
Sand	85%	88%
Silt	8%	12%
Clay	0%	2%
Organic matter in the form of compost	3%	5%

654.03 GENERAL REQUIREMENTS. The stormwater treatment practices, and the areas draining to them, shall be fully stabilized prior to allowing water to drain to them.

654.04 DRY SWALE AND DRY SWALE WITH UNDERDRAIN. Dry swales shall be constructed at the locations shown on the Plans. Geotextile fabric shall meet the material requirements of Subsection 720.05 and placement shall be performed in accordance with Section 649. Where required, underdrain shall be installed in accordance with Section 605.

Dry swale soils shall consist of natural or manufactured sand meeting the requirements of Subsection 704.01.

The Contractor shall not place dry swale soil directly from haul vehicles or by pushing material by bulldozers, graders, or other equipment.

654.05 GRAVEL WETLAND. Gravel wetlands shall be constructed at the locations shown on the Plans. Gravel wetlands shall be comprised of a network of underdrain pipes placed in a bedding of crushed stone and connected to an outlet structure, as shown on the Plans.

Bedding for gravel wetlands shall consist of a layer of 3/8 inch bedding on top of a layer of 1-1/2 inch bedding installed to the depths shown on the Plans.

Unless otherwise specified, the bottom and sides of the gravel wetlands shall be lined with either a clay soil, at a depth specified in the Plans, or geomembrane liner, as shown on the Plans. Geotextile for roadbed separator shall then be placed over the impermeable liner before placing the stone bedding.

Placement of geotextile fabric shall be performed in accordance with Section 649 and underdrain shall be installed in accordance Section 605, except as modified herein.

654.06 SURFACE SAND FILTER. Surface sand filters shall be constructed at the locations shown on the Plans. Placement of geotextile fabric shall be performed in accordance with Section 649. Where required, underdrain shall be installed in accordance with Section 605.

Surface sand filter soils shall consist of natural or manufactured sand meeting the requirements of Subsection 704.01.

The Contractor shall not place surface sand filter soil directly from haul vehicles or by pushing material by bulldozers, graders, or other equipment.

654.07 UNDERGROUND SAND FILTER. This work shall consist of designing and installing an underground precast or cast-in-place concrete sand filter as detailed and at the locations shown on the Plans.

Design drawings and calculations shall be submitted for review and approval in accordance with Subsection 105.06. For precast concrete, fabrication drawings shall be submitted for review and approval in accordance with Subsection 105.06.

Unless otherwise specified in the Contract, the design live load for all concrete elements shall be H-20 in accordance with the *AASHTO Standard Specifications for Highway Bridges*.

The underground sand filter media shall consist of natural or manufactured sand meeting the requirements of Subsection 704.01.

654.08 MEDIA FILTER DRAIN. Media filter drains shall be constructed at the locations shown on the Plans.

Placement of geotextile fabric shall be performed in accordance with Section 649. Underdrain shall be installed in accordance with Section 605.

The Contractor shall not place media filter drain soil directly from haul vehicles or by pushing material by bulldozers, graders, or other equipment.

654.09 BIORETENTION AREA. Bioretention areas shall be constructed at the locations shown on the Plans.

Geotextile shall be in accordance with Subsection 720.02 and placed in accordance with Section 649.

When the Plans require underdrain to be installed under the bioretention areas, the underdrain shall be installed prior to the bioretention area and in accordance with the respective underdrain pay item. For bioretention areas where underdrain is installed under the area, the Contractor shall conduct an available phosphorus soil test on the bioretention soil media using the modified Morgan Method, or approved equivalent, to ensure that the media will not leach phosphorus. The available phosphorus for the soil must be less than 0.2% phosphorus. Test results demonstrating compliance shall be obtained prior to placement of the bioretention soil media. The Contractor shall provide a record of the phosphorus test results to the Engineer for the Agency's use in subsequent design certification requirements.

654.10 STONE DIAPHRAGM. This work shall consist of furnishing and installing a stone trench for the purpose of providing initial stormwater treatment and distributing flows at the locations indicated on the Plans and as directed by the Engineer.

The stone diaphragm shall be comprised of a trench lined with geotextile meeting the requirements of Subsection 720.05 and filled with stone meeting the requirements of Subsection 704.16.

Trenches for stone diaphragms shall be excavated to the dimensions and grade shown in the Plans or as directed by the Engineer. The surface of the trench shall be prepared to a smooth condition free of debris, depressions, or obstructions which may damage the geotextile.

The geotextile fabric lining the trench shall be placed loosely with no wrinkles or folds. The upstream geotextile shall be overlapped over the downstream. Care shall be taken to ensure direct contact with the soil such that there are no voids between the geotextile and the trench. The geotextile lining shall be anchored by extending 12 inches beyond each side of the trench at a depth of 4 inches below finished grade.

Drainage aggregate shall be placed in layers of not more than 6 inches in thickness and compacted by use of air or mechanical tampers.

654.11 METHOD OF MEASUREMENT. The quantity of Dry Swale, Dry Swale with Underdrain, Media Filter Drain, and Stone Diaphragm to be measured for payment will be the number of linear feet installed in the complete and accepted work.

The quantity of Underground Sand Filter to be measured for payment will be the number of each installed in the complete and accepted work.

The quantity of Gravel Wetland, Surface Sand Filter, and Bioretention Area to be measured for payment will be the square yards installed in the complete and accepted work, measured based on the neat lines showing the finished surface area on the Plans.

654.12 BASIS OF PAYMENT. The accepted quantity of Dry Swale and Stone Diaphragm will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Dry Swale with Underdrain and Media Filter Drain will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified including underdrain, geotextile, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Gravel Wetland will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified including underdrain, impermeable liner, geotextile, and crushed stone bedding, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. The outlet structure, inlet and outlet pipes will be paid for separately under their respective Contract items.

The accepted quantity of Surface Sand Filter and Bioretention Area will be paid for at the Contract unit price per square yard. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified including underdrain and geotextile, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Landscape plantings, if specified, will be paid for separately under their respective Contract items.

Underdrain placed under bioretention areas will be paid for separately under the appropriate Contract pay item.

The accepted quantity of Underground Sand Filter will be paid for at the Contract unit price for each. Payment will be full compensation for designing, furnishing, fabricating, transporting, handling, and installing the materials specified, including, but not limited to, the trash rack, sand filter bedding, concrete vault, concrete top slab with lift rings, bar reinforcement, manhole covers and steps, debris screen, underdrain, geotextile, entrance grates, and drainage aggregate; any sheeting, bracing, dewatering and siltation control; preparing and submitting working drawings; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Catch basins, inlet and outlet pipes, and stone fill outlet protection attached to the Underground Sand Filter will be paid for under their respective Contract items.

For all stormwater treatment practices, excavation will be paid for under the appropriate excavation item included in the Contract. Topsoil, turf establishment, and mulch will be paid under their respective Contract items.

Payment will be made under:

Pay Item		Pay Unit
654.0010	Dry Swale	Linear Foot
654.0015	Dry Swale with Underdrain	Linear Foot
654.0020	Gravel Wetland	Square Yard
654.0030	Surface Sand Filter	Square Yard
654.0040	Underground Sand Filter	Each
654.0050	Media Filter Drain	Linear Foot
654.0060	Bioretention Area	Square Yard
654.0070	Stone Diaphragm	Linear Foot

SECTION 655 – WILDLIFE HABITAT FEATURES

655.01 DESCRIPTION. This work shall consist of providing and installing features for the protection, preservation, restoration, or management of wildlife habitat.

655.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Miscellaneous Hardware, Shapes, and Fabricated Materials.....709.01(h)
Nonstructural Lumber.....709.02
Timber Preservative.....726.01
Woven Wire Fence.....727.01
Chain-link Fence.....727.02
Snow Barrier Fence.....727.05
Plank Rail Fence.....727.06
Sign Posts.....750.01

Boulders shall be natural river material. The middle dimension of any boulder shall not be less than 16 inches. The middle dimension of at least half the boulders placed shall be at least 24 inches. Suitable boulders excavated during construction may be used.

655.03 STREAM HABITAT BOULDERS. This work shall consist of placing natural river boulders throughout the finished stream channel. The Contractor shall notify the Engineer a minimum of 7 calendar days prior to placement of the boulders.

Boulders shall be placed as directed by the Engineer at intervals defined in the Plans. Distribution of boulders shall be in a generally random fashion throughout the channel, except in locations to be identified by the Engineer at the time of construction, where boulders shall be either clustered or excluded.

The largest boulders shall be used at the toe of the slope (bottom 2 to 3 vertical feet), with no chinking stone used on the front face so that gaps remain between stones to provide improved aquatic habitat.

655.04 WILDLIFE GUIDE FENCES. This work shall consist of furnishing and installing wildlife guide or exclusionary fences at the locations indicated on the Plans and as directed by the Engineer. Fences shall be constructed in conformance with the Plans and Section 620.

655.05 WILDLIFE SHELF. This work shall consist of constructing a shelf within a culvert or under a bridge at the locations indicated in the Plans to facilitate animal passage. The shelf shall be constructed in conformance with the Plans and as directed by the Engineer.

655.06 WILDLIFE HABITAT COVER. This work shall consist of placing natural materials such as logs, brush, or stone to provide cover for wildlife at the entrances and exits of culverts and bridge structures. The type and arrangement of cover material shall be as shown on the Plans and as directed by the Engineer. Cover material may be sourced from the project site, if suitable.

655.07 NESTING BOX. This work shall consist of constructing bird nesting boxes with wooden or metal posts meeting the requirements of Subsection 750.01, or installing nesting boxes on existing structures or trees, at the locations indicated in the Plans. Entrance hole size and orientation and final box placement shall be as noted on the Plans and as directed by the Engineer.

655.08 BAT ROOSTING FEATURE. This work shall consist of constructing and installing bat houses or other roosting features to provide roosting opportunities for bats. The roosting features shall be constructed and installed as shown in the Plans and as directed by the Engineer.

655.09 WILDLIFE EXCLUSIONARY MEASURES. This work shall consist of installing measures that deter or prevent wildlife from inhabiting areas that will be disturbed during construction. The type and arrangement of exclusionary measures shall be as shown on the Plans and as directed by the Engineer.

655.10 METHOD OF MEASUREMENT. The quantity of Stream Habitat Boulders, Wildlife Habitat Cover, and Wildlife Exclusionary Measures to be measured for payment will be on a lump sum basis for the complete and accepted work.

The quantity of Wildlife Guide Fence and Wildlife Shelf to be measured for payment will be the number of linear feet installed in the complete and accepted work.

The quantity of Nesting Box to be measured for payment will be the number of each box installed in the complete and accepted work.

The quantity of Bat Roosting Feature to be measured for payment will be the number of each bat roosting feature installed in the complete and accepted work.

655.11 BASIS OF PAYMENT. The accepted quantity of Stream Habitat Boulder, Wildlife Cover Habitat, and Wildlife Exclusionary Measures will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work, including removal of features that are temporary, if indicated as such in the Plans.

The accepted quantity of Wildlife Guide Fence and Wildlife Shelf will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Nesting Box and Bat Roosting Feature will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified, including support bases, posts, and assembly hardware, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
655.0010	Stream Habitat Boulders	Lump Sum
655.0020	Wildlife Guide Fence	Linear Foot
655.0030	Wildlife Shelf	Linear Foot
655.0040	Wildlife Habitat Cover	Lump Sum
655.0050	Nesting Box	Each
655.0060	Bat Roosting Feature	Each
655.0070	Wildlife Exclusionary Measures	Lump Sum

SECTION 656 – PLANTING TREES, SHRUBS, AND VINES

656.01 DESCRIPTION. This work shall consist of furnishing, transporting, planting, and transplanting various sizes of trees, shrubs, vines, perennials, and ground cover plants.

656.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Barrier Fence.....727.03
Water.....745.01
Landscape Backfill.....755.01
Topsoil.....755.02
Compost.....755.05
Fertilizer.....755.06
Mycorrhizal Fungi Product.....755.07
Bark Mulch.....755.10(c)
Plant Materials.....755.12
Tree Watering Bags.....755.13

The sizes of evergreen and deciduous trees shall be as specified in Table 656.02A.

TABLE 656.02A – TREE SIZES

Size	Evergreen Trees	Deciduous Trees
Small	Less than 4 feet tall	Less than 1/2 inch caliper
Medium	4 feet to less than 6 feet tall	1/2 inch to less than 2 inch caliper
Large	6 feet tall or greater	2 inch caliper or greater

Live fascines shall consist of bundles 8 feet to 15 feet long and a minimum of 4 inches in diameter. The bundles shall contain cuttings from live stems no greater than 1 inch in diameter. The species used shall be native to Vermont. Live fascines shall be prepared from freshly cut dormant plants. No leaf buds shall have initiated growth beyond 1/4 inch and the cambium layer of each cutting shall be moist, green, and healthy.

Live stakes shall consist of branch cuttings from freshly cut dormant plants. The species used shall be native to Vermont. Live stakes shall be 1/2 inch to 2 inches in diameter and 3 feet to 4 feet long. No leaf buds shall have initiated growth beyond 1/4 inch and the cambium layer shall be moist, green, and healthy. The live stakes shall have side branches cleanly removed with the adjacent bark intact. The basal ends shall be cut at an angle for easy insertion into the soil and the top shall be cut square.

All plant material shall be the size and species specified in the Plans. Substitutions of plant materials will not be permitted unless authorized in writing by the Engineer, and then only when sufficient evidence is provided that the plant specified cannot be obtained. Plant substitutions shall be either the nearest available size of that variety or a similar variety with comparable form and function. An approved substitute plant shall be of a value at least equal to the specified plant for which the substitution is being made.

656.03 PLANTING SEASON. Unless otherwise specified on the Plans, plantings shall take place between April 1st and October 31st, inclusive. No planting shall be done in frozen ground, when snow covers the ground, or when the soil or weather is determined by the Engineer to be unsatisfactory for planting.

656.04 DELIVERY AND INSPECTION. Plants transported in open vehicles shall be covered by tarpaulins or other suitable covers securely tied to the body of the vehicle. Closed vehicles shall be adequately ventilated to prevent overheating of the plants.

The Engineer will make a preliminary inspection of all plants at the time of delivery on the project. Trees with multiple leaders will be rejected unless otherwise specified in the Contract. Trees with damaged or crooked leaders, broken terminal growth, bark abrasions, sun scald, disfiguring knots or other objectionable disfigurements, insect damage, disease, dead or dry wood, or cuts of limbs over 3/4 inch in diameter that are not completely closed will be rejected. Container grown plants that have stem girdling roots will be rejected. Balled and burlapped trees and shrubs with excessive soil on top of the root flare and an otherwise minimal root ball will be rejected. Thin, weak plants shall not be acceptable. Plant materials shall display the appearance of normal health and vigor.

The Engineer shall perform an inspection at the time of planting. Plants rejected by the Engineer at this inspection shall not be planted.

656.05 PROTECTION AND TEMPORARY STORAGE. The Contractor shall keep all plant material moist and protected from drying out. Temporary storage shall be limited to 45 calendar days from the time of delivery. Plants shall be protected when in transit, in temporary storage, and on the project site awaiting planting.

The Contractor shall exercise the utmost care in loading, unloading, and handling of plants to prevent injuries to the branches or to the roots of the plants. The solidity of balled and burlapped plants shall be carefully preserved.

Plants which are not scheduled for planting within 48 hours shall be kept in a moist condition and protected adequately by covering the roots with topsoil, wood chips, or other suitable material until removed for planting.

Failure to manage the storage of plant material as specified herein may be cause for rejection.

656.06 LAYOUT. Plant material locations and bed outlines shall be staked by the Contractor and approved by the Engineer.

656.07 EXCAVATION. Prior to performing excavation for plant pits and beds, the area shall conform to the lines and grades shown on the Plans. All sod, weeds, roots, and other objectionable material unsuitable for backfill shall be removed from the site and disposed of by the Contractor in a manner satisfactory to the Engineer.

Bare root, non-containerized seedlings, or transplants may be planted in the existing soil. The size of planting pits shall be as shown in the Contract.

The Contractor shall restore all areas disturbed by the planting operations at no cost to the Agency.

656.08 SETTING PLANTS. Plants shall be set at the locations shown on the Plans and in accordance with the Contract.

All plants shall be moved with the root ball intact, using mechanical methods if needed. If the root ball has been badly cracked or broken, the plant shall be rejected for use.

(a) Watering. All plant material shall be watered thoroughly at planting. Unless otherwise specified, the minimum number of waterings during the establishment period shall be twice weekly. At each watering, the soil around the plant shall be thoroughly saturated. The time interval between waterings may be increased or decreased by the Engineer to maintain adequate moisture levels. Trees shall receive a minimum of 10 gallons at each watering, shrubs a minimum of 5 gallons and vines and plants a minimum of 3 gallons. Natural rainfall will not be considered watering unless otherwise approved by the Engineer.

Tree watering bags may be used at the discretion of the Contractor. The installation and maintenance of the bags shall be in accordance with the manufacturer's recommendations. The bags shall be removed by the Contractor after final inspection. Replacement of watering bags during the establishment period shall be the responsibility of the Contractor.

The Contractor shall provide to the Engineer a weekly log to account for the frequency and amount of watering during the establishment period. When natural rainfall replaces a watering it shall be noted in the log as measured on site or as measured by the National Weather Service.

(b) Pruning. All broken, injured, or damaged branches shall be pruned before or immediately after planting in accordance with the *VTrans Technical Landscape Manual*.

(c) Mulching. Bark mulch material shall be applied as detailed in the Contract. Wood chip mulch shall not be used. The same type of material shall be used in all areas to provide visual uniformity.

(d) Antidesiccant Spray. The use of antidesiccant spray shall be at the discretion of the Contractor. The antidesiccant spray used shall be approved by the Engineer. Antidesiccant spray shall be applied per the manufacturer's recommendations unless otherwise specified in the Contract.

(e) Fertilizer and Mycorrhizal Fungi. The use of fertilizer and mycorrhizal fungi shall be at the discretion of the Contractor. Fertilizer and mycorrhizal fungi shall be applied per the manufacturer's recommendations unless otherwise specified in the Contract.

(f) Rodent Guards. Rodent guards may be used at the Contractor's discretion. The Engineer shall approve the type of rodent guard. If used, rodent guards shall be removed prior to acceptance of the project.

656.09 ESTABLISHMENT AND MAINTENANCE. The Contractor shall actively maintain the plants after planting. All mulched areas shall be kept weeded, neat, and maintained to the original layout lines. Saucers shall be maintained in accordance with the Contract until acceptance.

If the Contractor feels that spraying of the plant materials and mulched areas is necessary to prevent damage from insects or plant diseases, the material, application rate, number of applications, and any other data pertinent to the spraying shall be submitted to the Engineer for approval. The submittal shall also include a letter from the Vermont Agency of Agriculture, Food, and Markets approving the spraying.

Approximately four to six months following planting, the Engineer and Contractor shall inspect the plantings. Any dead, dying, or damaged plantings shall be replaced by the Contractor. Any replacement plantings shall be completed no more than 30 calendar days after inspection or as directed by the Engineer. This cycle shall continue until a 90% survival rate has been achieved to the satisfaction of the Engineer.

For live stakes and tubelings, following the initial inspection period, if the survival rate is less than 50%, the Contractor shall replace dead, dying, or damaged plantings in sufficient quantities to achieve 50% overall survival at the time of completion and acceptance of the project.

656.10 TRANSPLANTING. Transplanting shall be done in accordance with the requirements of Subsection 656.08 or as ordered by the Engineer.

Transplanted plant materials shall be maintained during establishment in accordance with the requirements of Subsection 656.09, except that on projects where only transplanting of existing plant materials is performed, the establishment period shall end on the Contract acceptance date.

656.11 TREE PROTECTION. The purpose of this item is to prevent damage to branches, stems, and root systems of existing individual trees to remain, and to ensure their survival. Provisions under this item include steps to minimize soil and root disturbance and to construct protection measures for trees close to construction areas. Prior to any earth disturbance, the Contractor shall install barrier fence to the drip line of existing trees or shrubs marked either "save" or "protect" or shown with a tree protection zone (TPZ) on the Plans. For trees with small, suppressed, or asymmetric crowns; or leaning trunks; or those with irregular rooting areas, the tree protection zone may be calculated from the trunk diameter in accordance with *ANSI A300* standards, or as directed by the Engineer. Barrier fence shall not be removed until the final project inspection.

There shall be no activity within the TPZ or the drip line of the tree except watering or installation of erosion prevention or sediment control measures where required. Only hand digging will be allowed within the TPZ when necessary. Manually spread wood chip mulch with a depth of 6 inches to 12 inches shall be used in accordance with *ANSI A300* standards for temporary tree protection when work must occur within the TPZ during construction. The Contractor shall avoid making root cuts during hot, dry weather. All tree protection shall be performed in accordance with the *VTrans Technical Landscape Manual*. The Engineer shall approve proposed tree protection methods and the schedule of work.

The following protection procedure shall apply when excavation is to be performed near trees or shrubs labeled "save" or "protect" or shown with a TPZ on the Plans:

(a) Care shall be taken to avoid breaking tree limbs and branches with construction equipment. Prior to construction, tree limbs of trees identified for protection and any other trees identified by the Engineer shall be pruned in accordance with the requirements of Subsection 656.08(b).

(b) Roots encountered during excavation work near a TPZ area shall be cleanly cut with no tearing of roots. Exposed tree roots shall be protected by a double layer of dampened burlap at all times until they can be covered with soil, at which time the dampened burlap shall be removed.

(c) Following excavation and during the construction season, water shall be provided to impacted trees at a minimum of 2-1/2 gallons per week per 1 inch caliper or as directed by the Engineer. The Contractor shall provide a log to document watering and natural rainfall to the Engineer.

If a tree is damaged due to the Contractor's negligence and the damage is determined to be non-repairable by the Engineer, the Contractor shall replace it at no additional cost to the Agency with a tree of equal value, or submit an alternative mitigation plan for review and acceptance by the Engineer. The value of the tree shall be determined by an arborist who has been certified by the International Society of Arboriculture. Replacement plantings shall be installed as specified herein.

656.12 METHOD OF MEASUREMENT. The quantity of Live Fascines to be measured for payment will be the number of linear feet used in the complete and accepted work.

The quantity of Live Stakes; Tubelings; Evergreen Trees, Small; Evergreen Trees, Medium; Evergreen Trees, Large; Evergreen Shrubs; Deciduous Trees, Small; Deciduous Trees, Medium; Deciduous Trees, Large; Deciduous Shrubs; Ground Covers and Vines; Perennials; Transplanting Trees; and Transplanting Shrubs, to be measured for payment will be the number of each of the specified types and sizes furnished and planted or transplanted in the complete and accepted work. Only living plants in healthy condition at the completion of the establishment and maintenance period, as defined in Subsection 656.09, will be accepted.

The quantity of Transplanting Ground Cover to be measured for payment will be the number of square yards of the specified types and sizes transplanted in the complete and accepted work. Only living plants in healthy condition at the completion of establishment and maintenance period, as defined in Subsection 656.09, will be accepted.

The quantity of Landscape Watering to be measured for payment will be the number of thousand gallons (MGAL) of water used in the complete and accepted work. The Contractor shall provide a written log meeting the approval of the Engineer for measuring the quantity of water applied.

The quantity of Landscape Backfill, Truck Measurement to be measured for payment will be the number of cubic yards used in the complete and accepted work, as determined by vehicle loads using three-dimensional measurement. All loads designated shall be leveled at the point of delivery when directed by the Engineer. A load ticket shall be furnished to the Engineer with each load delivered to the job site.

The quantity of Tree Protection to be measured for payment will be on a lump sum basis for the complete and accepted work.

656.13 BASIS OF PAYMENT. The accepted quantity of Live Fascines will be paid for at the Contract unit price per linear foot.

The accepted quantity of Live Stakes; Tubelings; Evergreen Trees, Small; Evergreen Trees, Medium; Evergreen Trees, Large; Evergreen Shrubs; Deciduous Trees, Small; Deciduous Trees, Medium; Deciduous Trees, Large; Deciduous Shrubs; Ground Covers and Vines; Perennials; Transplanting Trees; and Transplanting Shrubs will be paid for at the Contract unit price for each for the specified types, sizes, and kinds.

The accepted quantity of Transplanting Ground Cover will be paid for at the Contract unit price per square yard.

All seedlings, trees, shrubs, ground covers and vines, and perennials that have died, failed to grow, or otherwise have proven unsatisfactory to the Engineer during the establishment period shall be replaced with healthy stock of the same type or approved substitute at the Contractor's expense.

Payment for these items will be full compensation for testing, furnishing, transporting, handling, and placing plants, fertilizer, mycorrhizal fungi, mulch, wire rodent guards, and all incidental materials; for excavation, pruning, guying, staking, mulching, water basin formation, cleanup, restoration, and plant maintenance establishment work and care, including replacement; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Weed separator fabric, water bags, or any other item necessary to complete the work will be considered incidental to the appropriate Contract items.

Partial payments for these items will be made as follows:

(a) The initial 80% of the Contract unit price will be paid after the initial planting.

(b) The remaining 20% of the Contract unit price will be paid upon completion of the establishment and maintenance period, as defined in Subsection 656.09.

The accepted quantity of Landscape Watering will be paid for at the Contract unit price per thousand gallons (MGAL). When the Landscape Watering item is not specified as a separate pay item in the Contract, water applied during the plant establishment period will not be paid for directly but will be considered incidental to the other Section 656 items in the Contract. Water bags, when specified in the Contract, will not be paid for directly but will be considered incidental to Landscape Watering.

The accepted quantity of Landscape Backfill, Truck Measurement will be paid for at the Contract unit price per cubic yard. Payment will be full compensation for furnishing, mixing, testing, transporting, and placing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Tree Protection will be paid for at the Contract lump sum price. Payment will be full compensation for all tree protection measures including barrier fence, branch and root pruning, watering, and all incidentals necessary to complete the work.

The project will not be accepted until all dead, dying, or poorly-growing plants have been replaced to the satisfaction of the Engineer.

Payment will be made under:

Pay Item	Pay Unit
656.1000 Live Fascines	Linear Foot
656.1100 Live Stakes	Each
656.1200 Tubelings	Each
656.2001 Evergreen Trees, Small	Each
656.2002 Evergreen Trees, Medium	Each
656.2003 Evergreen Trees, Large	Each
656.2500 Evergreen Shrubs	Each
656.3001 Deciduous Trees, Small	Each
656.3002 Deciduous Trees, Medium	Each
656.3003 Deciduous Trees, Large	Each
656.3500 Deciduous Shrubs	Each
656.4000 Ground Covers and Vines	Each
656.4100 Perennials	Each
656.4500 Transplanting Trees	Each
656.5000 Transplanting Shrubs	Each
656.5500 Transplanting Ground Cover	Square Yard
656.6500 Landscape Watering	MGAL
656.8000 Landscape Backfill, Truck Measurement	Cubic Yard
656.8500 Tree Protection	Lump Sum

SECTION 662 – RAILROAD TRACK CONSTRUCTION

662.01 DESCRIPTION. This work shall consist of constructing new ballasted track with jointed or continuous welded rail (CWR); removing and replacing rail; removing and resetting track; removing and replacing ties; raising, aligning, and surfacing track; removing track; installing other track material (OTM) such as tie plates, anchors, and spikes as required; and de-stressing rail as required in accordance with the CWR program of the Operating Railroad.

662.02 MATERIALS. Materials shall meet the requirements of the following subsections:

662.03 SUBMITTALS.

(a) Pre-Construction Submittals. The following information shall be prepared and submitted for review and approval by the Engineer. Submittals shall meet the requirements of Subsection 105.06.

(1) Schedule of Materials. A complete schedule of the materials proposed for installation and the source of the material. Information to be provided on rail shall include the rail weight, rail section, rail wear, drilling pattern, typical rail length, date rolled, and the name of the mill where the rail was rolled.

(2) Ballast. Source for ballast and gradation analysis of a sample from the ballast source.

(3) Relay Rail Source. The source and classification of relay rail per *AREMA Chapter 4, Section 3.12*.

(4) Relay Rail Tests. Test results for relay rail as specified in Subsection 715.06(b)(3).

(5) Ties. Name and address of the facility proposed for disposal of wood ties.

(6) Tie Plug Material. Type of tie plug material.

(7) Certificate of Compliance. A manufacturer's certificate of compliance for all materials that are incorporated into the work.

(8) Rail Expansion Plan. Plan for rail expansion work inducing the proposed method of rail vibration and the type of mechanical vibratory equipment to be used.

(9) Thermite Weld Submittals.

a. The type and manufacturer of weld kits.

b. Detailed installation procedures showing proposed quick preheat, self-tapping thermite weld kit, and the method and detailed procedure for making field welds. If there are different types of welds in the Contract (e.g. different sizes or types of rail, compromise joints), a procedure shall be provided for each. Installation procedures submitted shall comply with these provisions and those of the weld kit manufacturer.

c. A detailed list of tools, equipment, and supplies required to make field welds.

d. Documentation that welders and all other field personnel involved in thermite welding have been trained by the welding kit manufacturer. The documentation shall include the name of the trainee, the location of the training, name of the instructor, and date of the training.

e. Qualification certification for each supervisor and field welder who will perform work under the Contract. Weld supervisors and welders shall be required, when requested by the Engineer, to submit their qualification certificates throughout the duration of the project.

f. The name of the independent testing entity and certification that the testing laboratory and the persons who will perform ultrasonic testing of field welds have previously tested a minimum of 250 welds.

g. Procedures for inspection and testing of qualification and in-track thermite welds.

1. For ultrasonic testing, a detailed test procedure and description of test equipment, including calibration blocks, that will be used in the testing process.

2. A form for documenting results of the ultrasonic testing. The form shall include, but not be limited to, identification of test equipment used, calibration, weld number and location, members of the test crew, date and time of test, description of defects, and a recommendation to accept or reject weld.

h. A form for recording field welds for the Contract.

(10) Rail Marking. The method of marking rail strings with a permanent method that identifies each rail.

(b) Post-Construction Submittals. No more than 2 working days following the completion of the work related to the submittal, the following information shall be prepared and submitted for review and approval by the Engineer. The following submittals by the Contractor shall meet the requirements of Subsection 105.06.

(1) Thermite Weld Submittals.

a. Documentation that the sample thermite welds have been tested and that welds meet or exceed the requirements specified herein.

b. A record of all welds installed under the Contract. This record shall be submitted on the approved Contractor created form and shall include, but not be limited to, the following information for each weld:

1. Weld number, location by track designation and station, and date and time the weld was made. Rail identification including section, rail strength and chemistry, heat number, and date rolled.

2. Kit manufacturer and identity of each mold and portion.

3. Weather conditions, and air and rail temperatures.

4. Rail gap.

5. Name of welder, weld supervisor, and Contractor's foreman.

6. General notes.

c. Certified ultrasonic inspection results for each field weld.

(2) CWR Strings. A record of all CWR strings laid. The record shall indicate the date, the string number, the weight of the rail, the manufacturer, the year, the temperature at which the rail was laid, the mileage location, and whether the string was the north or south rail (for east/west rail lines) or the east or west rail (for north/south rail lines).

(3) CWR Records and Forms. Agency and Operating Railroad CWR records and forms shall be submitted within 48 hours of the completion of work or upon the request of the Operating Railroad or Agency. Records shall be filled out on forms in accordance with the Operating Railroad's CWR plan.

662.04 REMOVAL OF TRACK. Existing rail, anchors, spikes, or other rail fastening devices, bolts, nuts, washers, joint bars, tie plates, concrete ties, wood cross ties, and wood switch ties shall be removed within the limits shown on the Plans.

(a) Removal.

(1) Rail. Rail meeting the requirements of relay rail set forth in Subsection 715.06(b) will be deemed to be fit for reuse and shall be stockpiled and protected from damage due to construction operations. The rail shall be reused at the locations indicated on the Plans.

When necessary, cutting of rail shall be performed as specified in Subsection 662.07(c)(10).

(2) Hardware. The Contractor shall remove joint bar bolts, spikes, rail anchors, and any other rail holding devices in a manner that does not damage any existing materials. Flame cutting of bolts to be removed will be permitted providing the joint bars and rails are not damaged.

Existing hardware shall include but not be limited to track spikes, rail anchors, joint bars, tie plates, and shim plates. The Engineer will determine which track hardware is fit for reuse.

(3) Ties. The Contractor shall excavate where necessary for the removal of the existing cross ties.

(b) Disposition of Materials.

(1) Stacking of Rails for Reuse on the Project.

a. Rails shall be stacked on approved sills a minimum of 6 inches above the ground.

b. Rails shall be stacked with the heads up and with the ends even.

c. Each layer shall be separated by at least three 2-inch by 4-inch wood strips evenly spaced along the length of the rail.

d. Rail shall be grouped by weight, section, drilling pattern, condition, length, and amount of wear.

e. The weight, section, drilling, and length shall be marked on one of the rails near the mid-height of the stack. These markings shall be painted neatly near one end of the rail. The Contactor shall mark rail ends in yellow designating fit relay rail. The Contractor shall also mark the centerline of each rail length on the rail head in yellow.

(2) Stacking of Joint Bars, Gage Rods, and Tie Plates for Reuse on the Project.

a. Joint bars, gage rods, and tie plates shall be sorted by section, punching, and condition.

b. Compromise joint bars shall be wired together in pairs, separate from other bars.

(3) Rail Anchors Fit for Reuse on the Project.

a. Rail anchors shall be sorted by type and size and placed in kegs, steel drums, or other approved containers.

b. Containers shall be labeled with the rail weight and section.

(4) Material to be Scrapped. Existing rail and track hardware removed and not fit for reuse, as determined by the Engineer, as well as any waste material, including ties, shall become the property of the Contractor and shall be removed from the site and disposed of properly at the Contractor's expense.

662.05 BALLAST HANDLING. The Contractor shall handle ballast in accordance with the requirements of *AREMA Chapter 1, Section 2.5* and the following.

Processed ballast shall be handled at the producing plant in such a manner that it does not segregate. Ballast shall be washed prior to loading. Ballast shall be loaded into rail cars or vehicles that are in good order and tight enough to prevent leakage and waste of material, and that are clean and free from rubbish, sand, dirt, or any substance that would foul or damage the ballast. Broken stone for ballast shall be delivered from the screens directly to the rail car (or other vehicle) or to clean bins provided for the storage of the output of the crusher.

662.06 BOTTOM BALLAST INSTALLATION. The depth of ballast required shall be as shown on the Plans.

(a) Inspection of Subbase. The Engineer will inspect and document the condition of the subbase surface upon which the track will be constructed. The Contractor shall remediate and correct any deficiencies as directed by the Engineer.

(b) Installation. Installation shall be performed in accordance with *AREMA Chapter 5, Section 4.1*. Bottom ballast shall be installed to the underside of the ties to the depths shown in the Contract.

To the extent practicable, ballast shall be unloaded for use with minimum redistribution and dressing. Care shall be taken when unloading ballast cars to ensure that they are completely unloaded.

Railroad ballast shall be distributed so that ample clearance below top of rail is provided for rolling equipment, switches are not fouled, and guard rails are unobstructed.

Care shall be taken when unloading and dressing ballast near open deck bridge approaches.

662.07 TRACK CONSTRUCTION. Ballasted track shall be constructed in accordance with the applicable sections of *AREMA Chapter 5, Part 4*; *AREMA Chapter 5, Part* 5; and as specified herein.

Ballasted track includes the rail, ties, fastenings, OTM, and ballast.

The Contractor shall connect new rail to existing rail sections as indicated on the Plans by the use of standard or compromise joint bars, or by the use of standard or compromise welds when connecting to existing CWR.

(a) Tie Installation. The Contractor shall transport and store cross ties in accordance with *AREMA Chapter 30, Section 3.5.11*.

(1) Ties shall be aligned as follows:

a. In double track or main track and passing siding locations, the Contractor shall align the ties with the outside (field) end of the tie used as a reference line to align the ties.

b. In single-track locations, the Contractor shall align the north or west end of the tie as a reference line unless otherwise designated by the Engineer.

(2) New cross ties shall be handled and placed with either a mechanical tie insertion device or tie tongs. The use of picks will not be permitted.

(3) The Contractor shall take special care and vigilance during handling and unloading of cross ties to avoid damage to the ties.

(4) New ties shall be placed with the heartwood face down, square with the line of the rails, not skewed and approximately centered about the centerline of track. Ties shall be spaced in accordance with the Contract.

(b) Tie Plates. Tie plates for timber ties shall be placed prior to setting the rail and shall be used on all ties. Tie plates shall not be placed directly under thermite welds.

(1) Tie plates shall be installed centered about the width of the tie, square with the rail, with the shoulders bearing firmly against the sides of the rail base. Under no circumstances shall the tie plate shoulder be allowed under any portion of the rail base. Care shall be taken to ensure that the tie plates are well seated on the ties and the rail properly seated on the tie plates. Canted tie plates shall be placed so as to cant the rail inward towards the gage side of the rail. Tie plates with different amounts of cant or flat plates shall not be intermixed except as directed by the Engineer. This requirement shall also apply to any surfacing within the limits of the project.

(2) Tie plates shall be free of any dirt and foreign matter when being installed. Stone dust and extraneous material shall be removed by blowing or brushing off the surface of the tie and tie plate to prevent damage and to ensure proper seating of the rail.

(3) Pre-plated timber ties may be used, in which case the Contractor shall demonstrate that the completed track gage is correct and within the specified limits in Subsection 662.07(c).

(c) Rail and Bolted Joint Installation. Rail and bolted joints for new track construction and for removal and replacement of rail shall be installed in accordance with the following requirements. When laying CWR strings or welding lengths of rail into CWR, bolted joints may be used for temporary works where applicable and as indicated in the Operating Railroad's CWR plan.

(1) If used, relay rail shall meet the requirements of Subsection 715.06(b). Relay rail shall be subject to inspection and acceptance by the Engineer.

(2) Rail shall not be dropped on uneven surfaces or left unevenly supported. The unloaded rail shall be placed so that it can be laid with as little handling as possible.

(3) The Contractor shall lay the rail and spike it to the proper gage. At a minimum, every fourth tie shall be gaged on tangents and every third tie shall be gaged on curves. The gage shall be 56-1/2 inches between points 5/8 inch below the top of the rail on the two inside edges of the rail.

(4) Existing track gage shall be at, or within, the limits specified in Table 662.07A. In the event the rail in existing track abutting the new rail is not at or within those limits, gaging shall be performed within existing track for a sufficient length to meet the limits specified in Table 662.07B for rate of change of track gage. The limits of gaging will be determined by the Engineer.

When correcting gage, all spike pulling and driving shall be done on the rail opposite the rail used for lining. Where spikes are pulled, the holes in the ties shall be plugged with tie plugging material meeting the requirements of Subsection 709.04(e). New spikes shall be driven as specified in Subsection 662.07(g).

TABLE 662.07A – EXISTING TRACK GAGE LIMITS

Minimum Gage (in.)	Maximum Gage (in.)
56-1/4	56-1/2

TABLE 662.07B – EXISTING TRACK GAGE RATE OF CHANGE LIMITS

Track Gage Parameter	Class of Track			
	1	2	3	4
The rate of change within 31 feet shall not exceed	1 in.	1 in.	3/4 in.	1/2 in.

(5) Joint bars shall be connected before the track is spiked. The fishing surfaces of joints and bolt threads shall be lubricated with an approved corrosion-resistant lubricant in accordance with the manufacturer's instructions before they are applied. When joint bars are used in temporary works prior to welding, they shall not be lubricated.

(6) Rail shall be fully supported on tie plates and bolted.

(7) The rail shall be slid into position with lining bars or lifted into place with rail tongs. The use of a hammer, maul, or other similar tools to drive the rail into position will not be permitted.

(8) Kinked, crooked, or surface-bent rails will not be permitted in the track.

(9) Rail shall be cut in accordance with *AREMA Chapter 5, Section 5.2.4.w*.

(10) When making bolt holes in the field, all holes shall be made with a rail drill and then chamfered. All chips and burrs shall be removed. Holes shall not be burned with a torch.

a. For rail sections specified in AREMA, the rail drilling pattern shall be as specified in *AREMA Chapter 4, Section 3.3*. Rail ends shall be drilled with three holes.

b. For rail sections not specified in AREMA, the rail drilling pattern shall match joint bars being utilized. If a rail end which is currently drilled requires drilling for another pattern, the Contractor shall not double drill the new pattern on the existing rail end. The Contractor shall crop off the rail end and then drill the new pattern.

c. When joint bars are used for temporary works prior to welding, the hole pattern shall be in accordance with the Operating Railroad's CWR plan.

(11) Rail joints shall be installed so that bars are not cocked between the base and head of rail. Joint bars shall be properly seated in the rail.

(12) The Contractor shall tighten bolts to the required torque, starting with the two bolts in the middle of the bar and working towards the ends. The Contractor shall strike both bars with a sledgehammer during the tightening process to help seat the bars properly. The Contractor shall then perform a final re-tightening of the two middle bolts. The Contractor shall torque the bolts as required by AREMA for the respective bolt size. All bolts shall be torqued with a mechanical bolt machine and set to apply the required torque. The Contractor shall not use this method to of striking the bars when installing insulated joint bars.

(13) The Contractor shall tamp all ties on which the newly laid rail does not have a full bearing with a mechanical tamper as specified in Subsection 662.07(i). Ties shall be tamped after rail is bolted and laid in tie plates and prior to gauging and spiking.

(14) Ties under compromise bars shall be spaced at 18 inches on center, with a tie directly under the rail end of the lighter of the two rail sections being joined. Hardwood ties meeting the requirements of *49 C.F.R. § 213.109* for non-defective crossties shall be used under compromise joints. When using temporary compromise joints as part of rail change-out or turnout change-out programs, it is permissible to use track shims to support the joint until the shims and compromise joints are removed the next day. The ties shall be tamped to support any permanent compromise joints left in the track. Shims to support permanent compromise joints will not be permitted.

(15) A minimum 12 foot stagger shall be maintained between bolted joints on opposite rails, unless otherwise indicated on the Plans.

(16) Bolted joints, including temporary joints in connecting strings of continuous welded rail, shall not be installed on bridges, nor shall they be installed on roadbed approaches within 300 feet of the ballast walls at either end of the bridge.

(17) Insulated joints shall have a 4-foot to 5-foot stagger.

(18) Any mismatched rail ends at joints which exceed 1/8 inch either vertically on the rail head or horizontally on the gage side of the rail head shall be corrected. The rail end mismatch shall be measured after the standard or compromise joints have been applied and tightened. If mismatched rail ends already contain rail end batter (due to the larger rail having been struck by wheels), the amount of rail end batter shall be taken into account when calculating the mismatch. Mismatches shall be corrected by changing joint bars and bolts, by being built-up with weld material on the offending rail, or by substituting a different piece of rail. The length of ramp required for this procedure will be calculated as the ramp slope, which shall be the rail end mismatch measurement (in thousandths of an inch) divided by 0.012.

(19) Additional requirements for laying and adjustment of CWR are specified in Subsection 662.07(d) and Subsection 662.07(e).

(d) Temperature Requirements for Laying CWR. CWR shall be laid within the preferred rail laying temperature (PRLT) range in accordance with the requirements of the Operating Railroad's CWR plan.

Laying and adjustment procedures for CWR will be dependent on the maximum and minimum rail temperatures expected.

If CWR is laid at rail temperatures above the maximum preferred rail laying temperature, the CWR shall be adjusted within 48 hours after being installed.

If CWR is laid at rail temperatures below the minimum preferred rail laying temperature, rail heaters shall be used to bring the rail temperature within the PRLT range.

The rail temperature of any CWR string laid shall be measured with an accurate and reliable rail thermometer placed on the base of the rail near the web. The thermometer shall be designed for measurement of rail temperature and shall be placed away from the wind and out of direct sunlight.

(e) Adjustment of CWR. CWR rails shall be laid without expansion gaps. To lay CWR which is below the minimum preferred rail laying temperature, the rail shall be heated to the preferred laying temperature with a propane rail heater. The rail shall be heated directly following it being laid or vibrated. The temperature of the rail will determine the amount of heat required.

On the base of the rail next to a tie plate which has been set to proper gage and spiked, the exact distance the rail will need to expand based on the difference between the current rail temperature and the PRLT shall be marked. The rail string shall be marked at each quarter point and at the end.

The rail shall be vibrated by a mechanical vibrator to ensure proper rail movement in accordance with the approved rail vibration plan. In no case will the Contractor be permitted to simultaneously apply mechanical vibrations and heat to perform rail expansion.

Under no circumstances shall the rail be vibrated by using spike mauls, sledgehammers, or other types of hammers or tools to strike the rail.

Equipment such as hydraulic rail pullers may be used to expand the rail to the proper PRLT equivalent length.

Adjustment of CWR shall occur after all work specified in Subsection 662.07(i) has been completed.

(f) Welding of Rail. Welding of CWR strings in the field shall be either by thermite welding or in-track electric flash-butt welding.

Electric flash-butt welding shall be performed in accordance with the requirements of *AREMA Chapter 4, Section 3.10* and *AREMA Chapter 4, Section 3.11*.

Thermite welding shall meet the requirements of *AREMA Chapter 4, Section 3.13* and Subsection 662.14.

Field welds shall be completed using in-track electric flash-butt welding to connect continuous welded rail strings, connect turnouts to adjacent rail strings, weld shop-fabricated rails containing bonded insulated joints into track, and weld shop-fabricated transition/compromise rails into track. Thermite welding shall be used within turnouts, for compromise welds, and at other locations noted on the Plans or designated by the Engineer.

Excessive rail grinding of the weld that causes a depression on the head and or gage face of the rail after a weld is completed will not be accepted. The weld shall be cut out beyond the heat affected zone and replaced.

The Engineer will visually inspect welds for visible defects, such as any incomplete portion or inclusions. The weld will be rejected and shall be replaced if it contains these defects.

(1) A minimum 12-foot stagger shall be maintained between welds and bolted joints unless otherwise specified.

(2) The end of a CWR string in one rail shall not vary from the end of a CWR string in the opposite rail by more than 100 feet.

(g) Track Spiking Requirements.

(1) Ties shall be pre-bored with a tie boring machine prior to installing spikes.

(2) Rail holding spikes shall be started with the head pointed toward the rail and driven vertically and square with the rail and driven so as to allow 1/8 inch to 3/16 inch in the space between the underside of the head of the spike and the top of the base of the rail. Opposite holes on the gage and field side of the rail shall be used for rail holding spikes. The rail holding spiking arrangement shall be in accordance with Table 662.07C unless otherwise specified in the Contract.

(3) Plate holding spikes shall be started with the head pointed toward the rail and driven vertically so the head has full bearing against the tie plate. Plate holding spiking arrangements shall be in accordance with Table 662.07C unless otherwise specified in the Contract.

TABLE 662.07C – TIE SPIKING TABLE

Degree of Curve		Tie Spiking Arrangement
Main and Siding Track	Yard and Industrial Track	
0°-00' to 2°-00'	0°-00' to 2°-00'	2 rail holding and 0 plate holding
2°-01' to 6°-00'	2°-01' to 13°-00'	2 rail holding and 1 plate holding – 1 field side
6°-01' and greater	13°-01' and greater	2 rail holding and 2 plate holding - 1 field side and 1 gage side

(4) On each tie, spikes on the gage side of the running rail shall be placed across from each other and spikes on the field side of the running rail shall be placed across from each other. Spikes on the field side shall be placed in the hole on the north or west side of the plate. The spiking pattern shall be held consistent through the limits of work.

(5) Spikes shall not be overdriven or straightened while driving. Spikes shall not be bent against the rail. Spikes which are bent while being driven shall be discarded and replaced. No spikes shall be driven against the end of joint bars. No spikes shall be driven in a slot in a rail joint.

(6) The Contractor shall not remove track spikes once driven, unless directed by the Engineer. If spikes are pulled, the ties shall be plugged with synthetic tie plugging material meeting the requirements of Subsection 709.04(e). Track spikes may be driven through tie plugging material. The Contractor shall remove and replace any tie where the tie plugging material is not completely and tightly filling the track spike hole or where the tie plugging material is not properly holding a driven track spike.

(7) Defective tie plates shall be culled by the Contractor.

(h) Rail Anchors. Rail anchors shall be applied in the pattern as shown in *AREMA Chapter 5, Section 5.4*.

The rail anchor pattern shall be spaced approximately uniformly along the rail length. To avoid tie skewing, the anchors shall be applied against the same tie on opposite rails.

Rail anchors shall have full bearing against a sound tie.

New rail anchors shall firmly grip the bottom of the rail to which they are applied to provide longitudinal rail restraint. Rail anchors shall not be installed at ties which support rail joints, where they will interfere with bond wire, boot legs, insulated joints, and other signal or track appliances.

Rail anchors shall be installed manually or with standard anchor machines.

For track constructed with jointed rail, rail anchors shall be installed immediately after rail is laid. All rail laid in a given day shall be fully anchored on that same day.

Unless otherwise specified, the Contractor shall anchor CWR in accordance with the following and the CWR program of the Operating Railroad:

(1) For the first and last 200 feet of each string, including connections as noted on the Plans, rail anchors shall be applied and boxed at every tie in both directions, including where joints are to be field welded. For the remainder of the string, rail anchors shall be applied and boxed at every second tie for restraint in both directions.

(2) Where CWR joins conventional jointed rail, all rail, except that supporting the rail joint, shall be box anchored for 200 feet in each direction.

(3) Anchored ties shall have four anchors per tie.

(4) If joints have been eliminated by field welding, it will be permissible to remove anchors on every second tie.

(5) Where CWR connects to jointed rail, the Contractor shall anchor the first six jointed rail lengths at every third tie in both directions.

(6) Through turnouts and other special track work connected to CWR, rails shall be anchored in accordance with the following:

a. On each side of the turnout every tie shall be box anchored wherever possible (i.e. when anchors are applied to one rail, anchors are also required on the opposite rail of the same side). Rail anchors shall be applied on the gage side of the rail except where insufficient clearance restricts the use of the anchor or application tool, in which case anchors may be applied from the field side of the rail where clearance permits.

b. In addition to the straight side, the diverging side shall be anchored a sufficient distance to prevent rail movement from disturbing the switch point and frog.

c. Every cross tie shall be box anchored for 200 feet ahead of the head block ties and 200 feet past the frog on each track on each side of the turnout.

(7) Every tie shall be box anchored for a distance of at least 300 feet back from the abutment at either end of a bridge.

(i) Ballasting, Surfacing, Aligning, Tamping, and Dressing of Track. The depth of ballast required shall be as shown on the Plans. Track shoulders shall be a minimum of 12 inches. Work shall be performed so that the track alignment, surface, and elevation will be maintained after tamping.

(1) Ballasting. Following the installation of the track on the compacted bottom ballast, ballast shall be distributed in advance of the track surfacing in sufficient quantity to properly surface, align, tamp, and dress the track to the required ballast cross section.

a. To the extent practicable, ballast shall be unloaded for use with minimum redistribution and dressing. Care shall be taken when unloading ballast cars to ensure that they are completely unloaded.

b. Railroad ballast shall be distributed so that ample clearance below the top of rail is provided for rolling equipment.

c. Care shall be taken when unloading and dressing ballast near open deck bridge approaches.

d. The Contractor shall avoid pulling sod, vegetation, and other foreign material onto the track structure or shoulders for the purpose of tamping or dressing the ballast sections. Any sod, vegetation or foreign matter inadvertently pulled in shall be removed by the Contractor prior to tamping.

(2) Surfacing and Aligning. The Contractor shall perform as many raising and surfacing passes as are needed to bring the track into the tolerances specified in Table 662.07D while meeting the following requirements. The Contractor shall consider overhead clearances where present.

a. Track surfacing shall be performed using methods that will prevent undue bending of the rail, straining of the joints, and damaging or loosening the fastenings. The amount of track lift in a single operation shall neither exceed 4 inches nor endanger the horizontal or vertical stability of the track. The track shall be raised such that the lift required to reach the final surface shall not be less than 1 inch nor more than 3 inches. The final raising and aligning operations shall fill cribs to the top of tie and the shoulders with ballast. A minimum of 2 inches of clearance shall be provided between metallic portions (non-rail) of the track structure and ballast. Particular attention shall be given to the tamping of ties not attached to the rails, to ensure that they maintain firm bearing against the base of the rail, without admitting ballast between the rail and tie. No portion of the tie plate shoulder, or stone, or any foreign material shall be permitted under the base of rail.

b. Any cross tie on which the tie plate is not tight against the rail base (down tie) shall be thoroughly cleaned of ballast in the rail seat area, the tie raised to firm bearing against the rail, and re-tamped until the tie plate is bearing firmly against the rail base.

c. Final surfacing and aligning shall bring the track to final grade and alignment and shall comply with the construction tolerances specified in Table 662.07D.

(3) Tamping. Tamping shall be accomplished using an electromatic squeeze-type vibratory tamping machine having at least sixteen tools, on traversing work heads, per tie. The work heads shall be capable of penetrating cemented or fouled ballast in the event that providing a smooth transition requires tamping existing track. A uniform squeeze shall be applied to all tools and the tools shall remain perpendicular to the tie during the entire tamping cycle. The tamping tools shall have sufficient length and head and face area, based on the manufacturer’s specifications, to compact the ballast under the tie. The tamper shall be capable of tamping both ballasted open track and ballasted special trackwork. The tamper shall be capable of automatic lift, level, and alignment of tangent and curved track, as well as turnouts.

a. All ties, including ties under a rail joint, shall receive a minimum of two separate insertions of the vibratory tamper. Tamping tools shall be inserted simultaneously inside and outside of both running rails on opposite sides of the same tie. The ballast under the tie shall be completely and uniformly tamped from 15 inches inside of the rail to the end of the tie. The tamping tools and limit switches shall be set to avoid damage to the track structure directly beneath the ballast layer.

b. The Contractor shall tamp the center of the tie only if approved by the Engineer. When the tamping operation is completed, all cribs shall be filled in.

(4) Dressing. After ballasting and surfacing operations are completed, the track work shall be dressed by utilizing a ballast regulator to provide the ballast section shown on the Plans. Following dressing, the ballast shall be flush with the top of tie and cribs shall be full. There shall be no ballast material left on the base of the rails, tie plates, or top of the ties.

(5) Damaged Track Spikes. If during the raising, aligning and surfacing operations any track spikes become damaged, loose, or are otherwise not functioning as intended, the Contractor shall remove damaged spikes, fill the resulting holes with synthetic tie plugging material specified in Subsection 709.04(e), and drive a new spike in accordance with Subsection 662.07(g).

(6) Damaged Ties. If during the raising, aligning, and surfacing operations any ties become damaged such that the ties are defective as defined in *49 C.F.R. § 213.109*, the damaged ties shall be removed and replaced with new ties and fastenings at no additional expense to the Agency.

(j) New Ballasted Track Construction Tolerances. Trackwork shall be constructed as shown on the Plans and meet the alignment of the existing tracks to which it will be connected. The final track alignment shall be continuous throughout and within the tolerances specified in this Subsection.

The actual centerline of track shall be within ± 1/4 inch of the locations indicated on the Plans. The top of rail elevation shall be within ± 1/4 inch of the elevations indicated on the Plans.

The Contractor shall perform a conventional survey to measure the horizontal and vertical alignment, track geometry, superelevation, and gage of the as-built track. The as-built alignment shall be compared to the design alignment indicated on the Plans. The track shall be within the tolerances shown in Table 662.07D. Any deviations above the allowable specified shall be corrected at no cost to the Agency.

TABLE 662.07D – TRACK SURFACE AND ALIGNMENT CONSTRUCTION TOLERANCES

Track Surface and Alignment Parameter	Maximum Allowable Construction Tolerance
Deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord shall not exceed	1/4 in.
Deviation from zero cross level at any point on tangents or the specified elevation on curves shall not exceed	1/8 in.
The difference in cross level between any two points less than 62 feet apart on tangents or curves shall not exceed	1/4 in.
Deviation from uniform alignment at the mid-ordinate of a 62-foot chord on tangent and curved track shall not exceed	1/4 in.

(k) Final Track Inspections. If the initial as-built survey indicates deviations in excess of those specified in Table 662.07D, the Contractor shall perform an additional conventional survey after corrective action has been performed to bring the track to within tolerances for final surface, alignment, gage, cross level, and superelevation.

Track inspections shall be performed in the presence of the Engineer. The Contractor shall notify the Engineer 7 calendar days in advance of requesting any track inspection.

Track deviations, as disclosed by the inspection described above, which exceed tolerances specified herein shall be corrected by the Contractor at no additional cost to the Agency. Additional inspections are required to ensure the corrections have been made.

Traffic shall not be permitted upon the newly installed track section until the track has been accepted by the Engineer.

662.08 REMOVE AND REPLACE RAIL. The Contractor shall remove existing jointed rail and furnish and install replacement jointed rail or CWR at locations shown in the Plans. The Contractor shall supply and install new joint bar bolts, washers, nuts, track spikes, and as many new joint bars, tie plates, rail anchors and welds as necessary to complete this work.

Relay rail shall be subject to inspection and acceptance by the Engineer prior to installation. Relay rail shall meet the requirements of Subsection 715.06(b).

Existing rail and track hardware shall be removed within the limits shown on the Plans. Existing rail and track hardware shall be removed and disposed of as specified in Subsection 662.04.

Any material damaged or lost due directly to the Contractor's operations shall be replaced at the Contractor's expense.

Sufficient ballast shall be removed from the cribs for adzing and anchor application. On ties that require adzing, the ties shall be adzed to get a full and even bearing for new tie plates. Excessive adzing shall be avoided. The adzed surface shall be parallel to the top of the ties.

All spike holes shall be plugged in accordance with Subsection 662.07(g)(6). All newly adzed surfaces shall be coated with a preservative meeting the requirements of *AWPA Standard M4* in accordance with Subsection 726.01.

The replacement rail and joint bar assemblies shall be installed in accordance with Subsection 662.07(c). Additional requirements for laying and adjusting CWR are specified in Subsections 662.07(d) and Subsection 662.07(e). Rail shall be laid on tie plates as specified in Subsection 662.07(b). Rail shall be spiked as specified in Subsection 662.07(g) and anchored as specified in Subsection 662.07(h). CWR shall be welded in accordance with Subsection 662.07(f) and Subsection 662.14.

After rail installation is completed, the ballast shall be dressed in accordance with Subsection 662.07(i)(4).

662.09 REMOVE AND RESET RAILROAD TRACKS. The Contractor shall remove and reset existing jointed rail track as shown in the Contract or as directed by the Engineer. The Contractor shall furnish new joint bars, joint bar bolts, washers, nuts, track spikes, and rail anchors.

Existing rail, ties, and track hardware shall be removed and stockpiled for reuse within the limits shown on the Plans in accordance with Subsection 662.04.

New ballast shall be installed as required in accordance with Subsection 662.05, Subsection 662.06, and Subsection 662.07. Track shall be reconstructed to the alignment and profile shown on the Plans using existing rail, ties, and new track hardware in accordance with Subsection 662.07. The Contractor shall surface, align, tamp, and dress the track as specified in Subsection 662.07(i).

662.10 REMOVE AND REPLACE CROSS TIES. The Contractor shall remove existing cross ties, properly dispose of all removed cross ties, and install new cross ties, including tie plates and tie attachment hardware, as detailed in the Contract and as directed by the Engineer. The size of the replacement ties shall be as indicated on the Plans.

The Contractor shall clean the tie surfaces sufficiently to permit the identification of defective cross ties. The Contractor shall remove only those cross ties designated by the Engineer as being defective.

Cross ties shall be removed in such a manner that the existing line and surface of the rails is not disturbed. The crib shall be excavated sufficiently to allow for the installation of the new cross tie without jacking or otherwise disturbing the rails.

New cross ties shall be installed in accordance with Subsection 662.07(a), except ties shall be spaced in accordance with the existing spacing, unless otherwise noted in the Contract.

Ties shall be plated as specified in Subsection 662.07(b). Existing rail anchors which affect the installation of a new tie plate shall be removed and reinstalled.

Ties shall be spiked as specified in Subsection 662.07(g) with the following additional requirements:

(a) All replacement ties shall be spiked to the existing track gage provided the existing gage is at, or within, the limits specified in Table 662.07A.

The Contractor shall be responsible for gaging if the existing track gage is not within the above limits. Limits of gaging shall extend to the limits of tie replacement in the Contract.

(b) Spiking shall be deferred until either of the following conditions is satisfied when a tie is to be installed on an existing joint:

(1) Where the rail joint requires a new rail joint assembly, the assembly shall be fully installed.

(2) Where the rail joint assembly requires bolt replacement, the bolts shall be replaced and fully tightened.

After the installation of the cross ties, tie plates, track spikes, and rail anchors, the Contractor shall replace the ballast that was removed for this operation. The Contractor shall tamp the ballast as specified in Subsection 662.07(i).

If the existing rail is CWR, the rail shall be thermally adjusted in accordance with Subsection 662.07(d) and Subsection 662.07(e).

662.11 REMOVE AND REPLACE BRIDGE TIES. The Contractor shall remove all existing bridge ties, properly dispose of all removed existing bridge ties, and install new timber bridge ties, including tie plates and tie attachment hardware, as detailed in the Plans and as directed by the Engineer.

Installation of new timber bridge ties required to complete the work shall be performed in accordance with *AREMA Chapter 7, Section 1.7.8*; *AREMA Chapter 7, Part 4*; and *AREMA Chapter 15, Section 8.3*.

Holes for bolts connecting bridge ties to stringer top flanges shall be drilled the same diameter as the bolt. Bridge tie to stringer top flange connectors shall be installed in accordance with the manufacturer's instructions.

All field cut ends and connection holes in timber members shall be treated with a field-applied preservative treatment meeting the requirements of *AWPA Standard M4* in accordance with Subsection 726.01.

Tie plates shall be installed on all new ties in accordance with Subsection 662.07(b).

662.12 RAISE, ALIGN, AND SURFACE TRACK. The Contractor shall raise, align, and surface track at the locations indicated in the Contract, or as directed by the Engineer.

The completed track section shall conform with Table 662.12A for the FRA class of track as defined in the Contract.

The track shall be raised in 2-inch maximum nominal lifts unless otherwise approved by the Engineer.

(a) Track Alignment. The track alignment shall be in conformance with Table 662.12A.

(b) Track Surface. The track surface shall be in conformance with Table 662.12A.

TABLE 662.12A – ALLOWABLE TRACK SURFACE AND ALIGNMENT MAINT. DEVIATIONS

Track Surface and Alignment Parameter	Class of Track			
	1	2	3	4
The runoff in any 31 feet at the end of a raise shall not exceed	2-5/8 in.	2-1/4 in.	1-1/2 in.	1-1/8 in.
Deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord shall not exceed	2-1/4 in.	2 in.	1-5/8 in.	1-1/2 in.
Deviation from zero cross level at any point on tangents or the specified elevation on curves shall not exceed	2-1/4 in.	1-1/2 in.	1-1/4 in.	1 in.
The difference in cross level between any two points less than 62 feet apart on tangents or curves shall not exceed	2-1/4 in.	1-5/8 in.	1-1/2 in.	1-1/4 in.
Deviation from uniform alignment at the mid-ordinate of a 62-foot chord on tangent and curved track shall not exceed	3-3/4 in.	2-1/4 in.	1-1/4 in.	1 in.

(c) Track Elevation. Superelevation and grade shall conform to the Plans.

(d) Ballast. Ballasting, surfacing, aligning, tamping, and dressing of track shall be performed in accordance with Subsection 622.07(i) with the following modifications:

(1) Where tie plates do not exist (only if permitted in Contract or as directed by the Engineer) the Contractor shall tamp the tie up tight so that it is in full contact with the base of the rail. No portion of the tie plate shoulder, stone, or any foreign material shall be permitted under the base of rail at these locations.

(2) The Contractor shall perform as many raising and surfacing passes as necessary to bring the track surface to the geometric parameters in Table 662.12A for the designated FRA class as indicated in the Contract.

(3) Final surfacing and aligning shall bring the track to final grade and alignment and shall comply with surface and superelevation tolerances specified in Table 662.12A for the designated class of track.

(4) In the event that the work required to comply with the designated FRA class of track results in a situation where there is greater than allowable deviations in the runoff of the top of rail elevations due to meeting the existing grade at a highway grade crossing, bridge, or turnout, the Contractor shall surface out of face consistent with designated FRA class of track requirements and tolerances or as directed by the Engineer. Such work shall be incidental to the Contract.

(e) Loose Joint Bolts. All loose joint bolts shall be tightened by mechanical means.

(f) Thermal Adjustment. If the existing rail is CWR, the rail shall be thermally adjusted in accordance with Subsection 662.07(d) and Subsection 662.07(e).

662.13 TEMPORARY RAIL CONNECTIONS. The Contractor shall furnish and install temporary connections between the new rail and existing rail to allow for the passage of a train (during work periods of non-exclusive and interruptible access) and at the end of an exclusive occupancy period. The closure rail shall be connected to the new rail by a compromise joint if the rails are of different sections. The connection rail shall have a full number of bolts and spikes.

(a) On tangents, the minimum length of the closure rail shall be 16 feet.

(b) On curves or spirals, the minimum length of the closure rail shall be 19-1/2 feet.

662.14 THERMITE WELDING.

(a) Quality Control. The thermite welding process shall be performed by trained and experienced personnel. The training shall include specific training provided by the welding kit manufacturer. Training shall include classroom and hands-on instruction with the course curriculum set by the manufacturer.

The Contractor shall provide for a representative of the welding kit manufacturer to be on call with 2 working days' notice to assist in case any unusual problems arise in the field. The welding kit manufacturer shall be prepared to provide for laboratory testing needed to solve a problem and shall have the capability of tracking their kit materials backward through the chain of production.

(1) Thermite Weld Qualification Inspection and Testing**.** Prior to performing thermite welding, the weld kit, weld procedure, and each welding crew shall be qualified as specified below. Welding crews shall prepare, in accordance with the approved method and procedure for thermite field welding, at least three samples of a thermite weld. Each welding crew shall perform at least one of each type of sample weld. Sample welds shall join two pieces of each type of running rail used in the Contract, each a minimum of 30 inches and a maximum of 36 inches in length.

Sample weld testing and inspection shall be performed by an approved certified independent testing laboratory. The Engineer may audit operations to ensure that inspection and tests are being performed in accordance with the specified procedures.

The Contractor shall test three sample welds. A manual ultrasonic test shall be performed on all sample welds from each type of rail as specified in Subsection 662.14(a)(2). Sample welds shall be ultrasonically inspected in accordance with *ASTM E164*. Acceptance criteria for this test shall be as specified in Subsection 662.14(a)(2)e. and Subsection 662.14(a)(2)g.

Approval of the weld kit, welding process, and welding crews will be contingent upon all sample welds satisfying the specified requirements. Should any sample weld fail to satisfy the specified requirements, the welding process, the welding crew, or both, will not be qualified for the work.

A supervisor shall be employed for each welding crew who has been trained and certified for performing thermite field welding by the manufacturer supplying the weld kits. Should the supervisor of the welding crew be replaced during the work, the welding crew shall be re-qualified under the new supervisor.

If the Contractor changes the manufacturer of the welding kits or welders during the work of the Contract, the sample weld testing shall be completed again.

(2) Field Weld In-Track Testing. During field welding, all field welds shall be hand tested and inspected as specified herein. All welds shall be ultrasonically tested by a certified testing laboratory as specified in this subsection.

Thermite welds shall be visually and dimensionally inspected as soon as the weld has been completed.

Manual ultrasonic testing of thermite welds in track designated as in-revenue service shall be completed within 24 hours of weld completion.

Manual ultrasonic testing of thermite welds in track designated as out-of-revenue service shall be completed within 30 days of the date of welding but in all cases prior to the resumption of train operations.

The ultrasonic testing calibration process shall be able to permit detection of defects of size, type, and location described under the acceptance criteria. The test procedure and equipment shall include, but not be limited to, the following:

a. Calibration.

1. Calibration shall be performed by the Contractor when starting work and at least every hour.

2. Recalibration shall be performed by the Contractor if there is a change in probes or cables.

b. Web Test.

1. The Contractor shall use two 45° probes placed on top of the rail in pitch-catch configuration.

2. The Contractor shall scan from the top to the bottom of the weld with both probes.

3. The Contractor shall scan the top and bottom edges of the weld with a single probe.

4. The Contractor shall scan from both sides of the weld.

c. Head Test.

1. The Contractor shall use two 45° probes placed on sides of the rail head in pitch-catch configuration.

2. The Contractor shall scan across the weld with both probes, angling them up and down to cover the entire cross-section of the weld.

3. The Contractor shall scan each vertical edge of the weld with a single probe.

4. The Contractor shall scan from both sides of the weld.

d. Base Test.

1. The Contractor shall use a 70° probe.

2. The Contractor shall place the probe on top of the base far enough back from the center of the weld so that the beam is following the path as defined in the approved test procedure.

3. The Contractor shall move toward and away from the weld, angling the probe from side to side.

4. The Contractor shall scan both sides of the base and from both sides of the weld.

5. The test crew shall fully document their findings on the approved Contract form.

e. Ultrasonic Acceptance Criteria.

1. Welds shall be free of defects. No defect in the weld of any size will be accepted in the head, web, or base of the rail.

2. The Engineer may perform random manual ultrasonic tests of field welds.

f. Physical Inspection.

1. The Contractor shall visually and dimensionally inspect each field weld to determine conformance with the alignment and finishing tolerances specified herein.

2. When the weld is made and the molds and risers are removed, the weld shall be checked for obvious failures such as an incomplete weld.

3. Once the weld has been ground and the weld temperature is less than 200°F, physical inspections shall be made by the Contractor to verify acceptance criteria.

g. Physical Acceptance Criteria. The welds shall meet the following criteria in order to be considered acceptable by the Engineer during the physical inspection.

1. The weld shall have no visible voids, rat holes, nicks, or gouges in surfaces which have been ground.

2. The weld collar in the web zone and base of the rail shall not be ground except to remove notches created by upset conditions. Sharp protrusions and gouges shall be blended into the rail and weld collar contour to eliminate possible stress risers.

3. Combined vertical offset and crown camber at top of rail, at rail temperature of 200°F or less, shall not exceed 0.060 inches. No dip camber will be allowed.

4. Combined horizontal offset and horizontal kink camber at the side of the rail head, at a rail temperature of 200°F or less, shall not exceed 0.060 inches.

5. A finished deviation of not more than + 0.010 inches or - 0.00 inches from the parent section of rail head surface will be allowed.

6. Weld straightness tolerances shall be as shown in *AREMA Chapter 4*.

h. Defective Welds. Defective welds shall be cut out and replaced with a 19-1/2 foot section of new or like relay rail, and welded in place, at no additional cost to the Agency.

i. Final Ultrasonic Testing. Final ultrasonic testing shall be performed by an on-track detector car.

(b) Thermite Welding.

(1) General Requirements. Thermite welds shall be made with approved weld kits. Thermite welds shall be made to join jointed rail or CWR. Thermite welds will be required in turnouts and in areas of bituminous concrete pavement crossings to eliminate rail joints.

The ends of rails to be welded shall be saw-cut. Torch cutting of rails will not be allowed.

If plug rails are required to meet the requirements, or to replace a defective weld, the minimum length of the plug rail shall be 19-1/2 feet.

Thermite welds shall not be located within the following areas in standard track work. In the case of special trackwork, some exceptions will be allowed with the approval of the Engineer.

a. Within 8 feet of the center of any bolted, bonded, or insulated joint.

b. Within 2 feet of a thermite weld in the opposite rail. Thermite welds shall be staggered a minimum of 4 tie cribs from any thermite or flash butt weld in the opposite rail.

c. Within 6 inches of any hole drilled in rail.

d. Within 9 inches of a weld which has been cut out.

e. Within 4 inches of a tie plate. If necessary, ties shall be spaced to provide this clearance prior to the welds being made.

f. Within 10 feet of the roadway surface of a grade crossing.

g. A minimum of 16 feet from any existing weld in the same rail on tangent (19-1/2 feet on curves) or as directed by the Engineer.

h. On open deck bridges or timber structures.

(2) Weld Quality. Weld quality shall be as specified in this section.

(3) Welding Requirements. The Contractor shall use approved kits that are self-tapping and require minimum preheating.

Rail ends shall be saw-cut at right angles to the rail. The surface of the rail shall be cleaned for a length of approximately 6 inches from each end, so that the surface of the rail is free of all grease, dirt, loose oxide, scale, and moisture. Burrs and lipped metal which would interfere with the proper fit of molds shall be removed.

Rails shall be aligned with respect to alignment prior to welding.

Proper rail end alignment shall be achieved by the use of an alignment device designed and manufactured for this purpose. In no case will the use of track jacks or track spikes be allowed for rail end alignment.

Striking of rail with blunt tools, such as a maul, is prohibited with the exception of brass hammers.

The Contractor shall ensure that rail ends are secured against longitudinal, vertical, lateral, or twisting movement during and immediately after the welding process. Rail pullers or expanders shall be used to prevent movement. Rail clips or anchors shall be installed if there is a chance of longitudinal movement.

At the time of field welding, the rail gap shall be as specified by the manufacturer of the weld kit. A hydraulic rail puller or expander shall be used to establish the proper rail end gap at all thermite weld locations.

Field welds shall not be made when the ambient temperature is below 40°F or during inclement weather such as rain, mist, sleet, or snow unless approved by the Engineer and in compliance with the Operating Railroad's CWR plan.

The weld shall not be subjected to a sudden strain by releasing hydraulic pressure too quickly. The rail puller or expander shall be left in place until the rail has cooled to below 500°F. Any movement of the rail before the weld has cooled to at least 500°F may result in the failure of the weld.

When welding rail in track on lines in service, sufficient time to complete welding shall be allowed so that the surface finish and temperature of the welded joint will permit safe operation of scheduled trains without delay to service. The temperature of the welded joint shall be 200°F or less before rail traffic is allowed to pass over the weld.

When welding rails in track on lines in service, the Contractor shall ensure that rail fastenings and anchors are properly installed prior to restoration of service.

Thermite field welds shall be made in accordance with and shall not deviate from the manufacturer's recommendations and *AREMA Chapter 4*.

a. The weld shall be trimmed and ground to meet the following requirements and as otherwise specified by the manufacturer:

1. The weld shall be finished to the tolerances specified.

2. A rail shear, specifically designed for the purpose, shall be utilized to remove weld upset. Use of a saw, cutting torch, or other handheld devices is prohibited.

3. A rail profile grinder specifically designed for the purpose shall be used to finish grind the top and sides of the weld. Use of a handheld grinder is prohibited.

4. The weld collar in the web zone and base of rail shall not be ground except to remove notches created by upset conditions, sharp protrusions, and gouges. These shall be blended into the rail and weld collar contour to eliminate possible stress risers. Defects visible to the unaided eye shall be removed by grinding. If removal by grinding cannot be accomplished without damaging rail, the weld shall be removed. Precautions shall be taken to avoid excessive pressure during grinding of a weld in order to prevent overheating of the rail surface.

5. Finish grinding shall only be performed when the weld temperature is less than 200°F.

6. Overheating of rail when grinding shall be avoided. Once the weld has cooled to below 200°F prior to grinding, the temperature rise due to grinding shall not exceed this temperature.

7. Welds shall be ground before the heat leaves the weld. Heat shall not be re-introduced into the sides of the weld where it will be ground.

8. Finish rail grinding on the top and sides of the weld shall be completed prior to the operation of trains over the weld.

(4) Weld Identification. Weld identification shall be marked on the field side of rail using a permanent metal marker and the required information shall be recorded in conformance with these specifications.

(5) Records. The Contractor shall prepare a record for each weld completed and submit the records as specified in Subsection 662.03.

662.15 METHOD OF MEASUREMENT. The quantity of Railroad Ballast to be measured for payment will be the number of tons placed in the complete and accepted work, as determined based on vehicle loads. A load ticket shall be furnished to the Engineer for each load delivered to the job site.

The quantity of Remove and Replace Bridge Ties of the size specified in the Contract to be measured for payment will be the number of existing bridge ties removed and replaced in the complete and accepted work.

The quantity of Remove and Replace Cross Ties of the size specified in the Contract and as directed by the Engineer to be measured for payment will be the number of existing cross ties removed and replaced in the complete and accepted work.

The quantity of Remove and Replace Switch Ties to be measured for payment will be the total linear feet of existing switch timbers removed and replaced in the complete and accepted work.

The quantity of Remove and Replace Jointed Rail to be measured for payment of the type specified will be the number of linear feet of rail installed in the complete and accepted work. Individual rails will be measured separately.

The quantity of Remove and Reset Jointed Railroad Track to be measured for payment will be the number of linear feet of track removed and reset in the complete and accepted work. Individual rails will not be measured separately. Measurement will be along the centerline of the track.

The quantity of Remove Railroad Track to be measured for payment will be the number of linear feet of track removed in the complete and accepted work. Individual rails will not be measured separately. Measurement will be along the centerline of the track.

The quantity of Ballasted Track Construction with Jointed Rail to be measured for payment will be the actual number of linear feet of track constructed to final grade in the complete and accepted work. Individual rails will not be measured separately. Measurement will be along the centerline of the track.

The quantity of Ballasted Track Construction with CWR to be measured for payment will be the actual number of linear feet of track constructed to final grade in the complete and accepted work. Individual rails will not be measured separately. Measurement will be along the centerline of the track.

The quantity of Remove Jointed Rail and Install CWR to be measured for payment of the type specified will be the number of linear feet of track installed in the complete and accepted work. Individual rails will not be measured separately. Measurement will be along the centerline of the track.

The quantity of Raise, Align, and Surface Track to be measured for payment will be the number of linear feet of track raised, aligned, and surfaced to final grade in the complete and accepted work. Individual rails will not be measured separately. Measurement will be along the centerline of the track. The Contractor shall perform as many raising and surfacing passes to achieve final grade or as directed by the Engineer to bring the track to the designated design standard as indicated in the Contract. Multiple passes will not be measured separately for payment.

The quantity of Gaging Track to be measured for payment will be the number of linear feet of track gaged. Measurement will be taken along the centerline of the track.

662.16 BASIS OF PAYMENT. The accepted quantity of Railroad Ballast will be paid for at the Contract unit price per ton. Payment will be full compensation for furnishing, transporting, handling, testing, placing, and tamping the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove and Replace Bridge Ties will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, and placing the material specified, including removal and disposal of old ties, furnishing and installing tie plates where required, furnishing new ties, spikes, and tie plugging material as required, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove and Replace Cross Ties will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, and placing the material specified, including excavation, removal, and disposal of old ties, furnishing and installing tie plates where required, furnishing new ties, spikes, and tie plugging material as required, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Railroad Ballast will be paid for separately.

The accepted quantity of Remove and Replace Switch Ties will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and placing the material specified, including excavation, removal, and disposal of old ties, furnishing and installing tie plates where required, furnishing new ties, spikes and tie plugging material as required, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Railroad Ballast will be paid for separately.

The accepted quantity of Remove and Replace Jointed Rail will be paid for at the Contract unit price per linear foot of rail. Payment will be full compensation for removing existing rail, tie plates, joint assemblies, track spikes, and rail anchors; furnishing, transporting, distributing, handling, and installing the materials specified, including jointed rail, tie plates, spikes, and other miscellaneous materials; and for furnishing all labor, tools, equipment, and incidental necessary to complete the work.

The accepted quantity of Remove and Reset Jointed Railroad Track will be paid for at the Contract unit price per linear foot of track. Payment will be full compensation for supplying new rail hardware, removing, handling, and resetting rail, ties, and rail hardware, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove Railroad Track will be paid for at the Contract unit price per linear foot of track. Payment will be full compensation for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Ballasted Track Construction with Jointed Rail will be paid for at the Contract unit price per linear foot of track. Payment will be full compensation for furnishing, transporting, distributing, handling, and installing the materials specified, including jointed rail, tie plates, spikes, and other miscellaneous materials, and for furnishing all labor, tools, equipment, and incidental necessary to complete the work. Railroad Ballast will be paid for separately.

The accepted quantity of Ballasted Track Construction with CWR will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, distributing, handling, and installing the materials specified, including CWR, tie plates, spikes, and other miscellaneous materials, and for furnishing all labor, tools, equipment, and incidental necessary to complete the work. The costs for thermite welding, all preparation and training activity will not be paid separately but shall be considered incidental to this item. Railroad ballast will be paid for separately.

The accepted quantity of Remove Jointed Rail and Install CWR will be paid for at the Contract unit price per linear foot. Payment will be full compensation for removing existing rails; installing new CWR; installing OTM such as tie plates, anchors, and spikes; scrapping of non-salvaged track materials; de-stressing rail as required; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. Thermite welding will be considered incidental to this item.

The accepted quantity of Raise, Align, and Surface Track will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work. Verification surveys, corrections of track deviations, and re-inspections shall be considered incidental to this item. Tightening of all loose bolts within the limits of this item shall be considered incidental to this item. Multiple passes will be considered incidental to the actual length of track feet raised, aligned, and surfaced to final grade. Railroad Ballast will be paid for separately.

The accepted quantity of Gaging Track will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work. Replacing missing spikes with new track spikes will be considered incidental to this item.

The cost of temporary rail connections will be considered incidental to the other Contract items of this section.

Payment will be made under:

Pay Item		Pay Unit
662.0010	Railroad Ballast	Ton
662.0110	Remove and Replace Bridge Ties	Each
662.0120	Remove and Replace Cross Ties	Each
662.0130	Remove and Replace Switch Ties	Linear Foot
662.0200	Remove and Replace Jointed Rail	Linear Foot
662.0250	Remove and Reset Jointed Railroad Track	Linear Foot
662.0300	Remove Railroad Track	Linear Foot
662.0350	Ballasted Track Construction with Jointed Rail	Linear Foot
662.0360	Ballasted Track Construction with CWR	Linear Foot
662.0400	Remove Jointed Rail and Install CWR	Linear Foot
662.0410	Raise, Align, and Surface Track	Linear Foot
662.0450	Gaging Track	Linear Foot

SECTION 663 – RAILROAD-HIGHWAY GRADE CROSSINGS

663.01 DESCRIPTION. This work includes rehabilitation of existing railroad-highway grade crossings and construction of new full depth bituminous concrete or precast concrete railroad-highway grade crossings, including furnishing all required materials and necessary incidentals in accordance with the Contract and as directed by the Engineer.

663.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Aggregate for Railroad Ballast 704.03
Cross Ties.....709.04(c)
Corrugated Polyethylene Pipe (CPEP) 710.03
Polyvinyl Chloride (PVC) Plastic Pipe.....710.05
New Rail .....715.06(a)
Relay Rail.....715.06(b)
Other Track Material (OTM) 715.08
Bituminous Concrete Mixtures 716.02
Geotextile under Railroad Ballast 720.03
Precast Concrete Grade Crossing Systems 781.01
Rubber Rail Seal 781.02

663.03 SUBMITTALS. The following information shall be prepared and submitted for review and approval by the Engineer. Submittals shall meet the requirements of Subsection 105.06.

(a) Work Plan. A site specific plan for work to be undertaken at each crossing, including construction staging, any proposed temporary paving or temporary detours, and material storage sites. The work shall comply with the approved traffic control plan.

(b) Shop Drawings. Shop drawings showing details of crossing surface and for other materials in related sections and production quality control documentation.

(c) Inspection Procedures. Procedures for inspection of track prior to placing it in service for train operation.

(d) Continuous Welded Rail (CWR) Maintenance Plan or Temperature Adjustment Plan. If construction affects existing CWR, the Contractor shall submit a plan (CWR Maintenance Plan) for maintenance of the Operating Railroad's neutral temperature in accordance with their CWR program or submit a plan to adjust the CWR to the Operating Railroad's neutral temperature.

(e) Layout Plan. A site-specific plan showing schematically the track layout, rail sections to be used, location of joints, location of welds, location of compromise joints or compromise welds, and connections to existing rails.

(f) Precast Concrete Panels.

(1) Fabrication drawings detailing cross tie spacing and placing prior to installation. The manufacturer shall submit fabrication drawings within 15 working days after onsite field measurements are taken by the manufacturer. Fabrication drawings shall show details of crossing surface, and for other materials in related sections and production quality control documentation. The fabrication drawings shall include a full cross section view of the panels on cross ties, a plan view of panels in the track, and a detail of the flangeways. The fabrication drawings shall also indicate data on panel weights, loading specifications, lifting eye specifications, and any other applicable information.

(2) Manufacturer's drawings showing mounting details for the existing or proposed precast concrete railroad grade crossing panels crossing surface, and for other materials in related sections and production quality control documentation.

(3) Manufacturer's printed installation instructions.

(4) Manufacturer's standard warranty.

(g) Rubber Rail Seal.

(1) Product data sheet.

(2) Manufacturer's installation requirements.

663.04 CONSTRUCTION REQUIREMENTS.

(a) General Requirements.

(1) The crossing shall be installed in accordance with *AREMA* and the *MUTCD*.

(2) Track work at highway crossings shall be closely coordinated with signal system installation and highway grading, drainage, and paving work, so that paving between tracks and adjacent to tracks can be accomplished in a single operation with highway paving.

(3) Where necessary to open crossings to highway traffic before final precast concrete panel installation and paving is completed, temporary panels or paving may be required. The Contractor shall ensure that temporary panels and pavement surfaces are properly maintained to avoid adverse highway traffic loads to the track structure. Any temporary paving shall be completely removed and the surfaces restored before final paving.

(b) Removal of Track. Track removal shall conform to Subsection 662.04.

(c) Underdrain. Underdrain shall be installed in accordance with Section 605 at the locations shown on the Plans.

Underdrain flushing basins shall be installed at the upstream end of the underdrain and at intermediate points as required to provide cleanout access points no more than 200 feet apart.

(d) Track Construction. Ballasted track shall be constructed in accordance with Section 662 and the following.

(1) All rail within grade crossings shall be CWR.

(2) Connections to existing rail sections shall be completed as shown on the Plans.

a. Standard joint bars shall be installed in accordance with Subsection 667.04.

b. Compromise joint bars shall be installed in accordance with Subsection 667.05.

c. Field welded joints shall be installed in accordance with Subsection 662.07(f). Welds that fall within the area of the rubber rail seal shall be ground down to the profile of the rail.

(3) Track construction within the limits of the crossing shall be completed, with track lined and surfaced to final horizontal and vertical location, and with ballast tamped and dressed, before the embedded rubber rail seal interface is installed. The embedded rubber rail seal shall be installed in accordance with the manufacturer's procedures and requirements.

(4) Where practical, track should be placed in service and as many train movements as possible allowed to traverse the crossing prior to establishing final line and surface, so as to attain the optimum ballast compaction in the crossing.

(e) Bituminous Concrete Pavement. The Contractor shall install bituminous concrete pavement in accordance with Section 406, as directed by the Engineer. The Contractor shall coordinate the installation of new pavement with the embedded rubber rail seal manufacturer's installation requirements.

(f) Precast Concrete Grade Crossing Panels. Precast concrete grade crossing panels shall be installed in accordance with *AREMA Chapter 5, Section 8.2*; *AREMA Chapter 5, Section 8.3*; and the manufacturer's recommendations.

(g) Rubber Rail Seals. Rubber rail seal shall be installed between the field and gage sides of the rail and the adjacent crossing surface and shall be compatible with the railroad grade crossing for which it is to be installed. The Contractor shall install rail seals level, in accordance with the manufacturer's recommendations and as directed by the Engineer.

The elastomeric interface shall provide a tight fit with the rail to minimize moisture infiltration and facilitate easy installation on both tangent and curved track. The ends of each piece of elastomeric interface shall be precision cut to ensure straight square ends.

(h) Install bituminous concrete pavement transitions at each end of the gage panels as indicated on the Plans.

663.05 PRECAST CONCRETE PANEL GRADE CROSSING REPAIR.

(a) This work shall consist of fastening existing precast concrete railroad grade crossing panels in accordance with the manufacturer's recommendations, including furnishing and installing all hardware required to reattach the existing panels at a railroad-highway crossing, at the location indicated in the Plans.

(b) This work includes fastening existing precast concrete railroad grade crossing panels that are loose, including the removal and resetting of the panel as necessary to complete the work per the manufacturer's recommendations. The Contractor shall be responsible for any damage to the existing panel, the elastomeric interface, and any other railroad facilities, and shall repair all damage caused by their operations at their own cost.

(c) The existing 1/8-inch elastomeric bearing pad shall be removed and reinstalled between the top of the timber cross tie and bottom of the concrete panels.

(d) The field side flangeway shall be 2-1/2 inches (± 1/4 inch) wide from the ball of rail to the panel. The filler shall be flush and level with the top of panel. The gage flangeway filler shall be 2-3/4 inches to 3 inches maximum from the ball of rail to concrete panel in standard 56-1/2-inch gage for tangent track.

663.06 METHOD OF MEASUREMENT. The quantity of Reconstruct Railroad-Highway Grade Crossing to be measured for payment will be on a lump sum basis for each crossing installed in the complete and accepted work.

The quantity of Precast Concrete Panel Grade Crossing System to be measured for payment will be on a lump sum basis for each crossing installed in the complete and accepted work.

The quantity of Precast Concrete Panel Grade Crossing Surface Repair at the location specified to be measured for payment will be for each precast panel repaired in the complete and accepted work.

The quantity of Rubber Rail Seal to be measured for payment will be the number of linear feet of rail seal installed in the complete and accepted work. Field and gage side seals will be considered a single installation unit and will not be measured separately.

663.07 BASIS OF PAYMENT. The accepted quantity of Reconstruct Railroad-Highway Grade Crossing at the location specified will be paid for at the Contract lump sum price. Payment will be full compensation for removal and disposal of existing materials; excavation; furnishing, transporting, handling, and installing the materials specified including rubber rail seal, spikes, tie plates, other track material, underdrain, geotextile; temporary paving on roadways; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Where required, underdrain carrier pipe and all appurtenances, such as joints, bends, and caps, underdrain flushing basins, material used for backfilling voids created by the removal of unsuitable material below subgrade, all associated excavation, backfill, geotextile fabric, and outletting of underdrain to the existing drainage swale will not be paid for directly but will be considered incidental to Reconstruct Railroad-Highway Crossing.

Restoring roadway surfaces, emulsified asphalt used in the treatment of surfaces prior to placing permanent pavement, and furnishing and placing final roadway pavement will be paid for separately under the appropriate Contract items.

The accepted quantity of Precast Concrete Panel Grade Crossing System at the location specified will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified, including precast concrete panels with elastomeric flangeway filler, elastomeric bearing pads, and other track material; and for furnishing all labor, tools, equipment, and incidentals to complete the work.

The accepted quantity of Precast Concrete Panel Grade Crossing Surface Repair at the locations specified will be paid for at the Contract price for each panel. Payment will be full compensation for furnishing the necessary hardware, removing, and installing the panel with the associated materials specified, including the protection and reuse of the elastomeric flangeway filler, elastomeric bearing pads, and other track material; and for furnishing all labor, tools, equipment, and incidentals to complete the work.

Where not incidental to Reconstruct Railroad-Highway Grade Crossing, the accepted quantity of Rubber Rail Seal will be paid for at the Contract unit price per linear foot. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
663.0100	Reconstruct Railroad-Highway Grade Crossing	Lump Sum
663.0200	Precast Concrete Panel Grade Crossing System	Lump Sum
663.0250	Precast Concrete Panel Grade Crossing Surface Repair	Each
663.0270	Rubber Rail Seal	Linear Foot

SECTION 664 – RAILROAD SIGNALS

664.01 DESCRIPTION. This work includes designing, furnishing and installing new railroad-highway active warning systems with new metered power services, traffic preemption interconnection where indicated on the Plans, and testing of equipment, material, hardware, and all necessary appurtenances specified or required to provide a safe and operating automatic highway crossing warning systems (AHCWS) as specified in this section and as indicated on the Plans.

664.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Sand Borrow and Cushion 703.03
Dense Graded Crushed Stone for Subbase 704.06
Electrical Conduit 752.06
Automatic Highway Crossing Warning System (AHCWS) 781.03

664.03 SUBMITTALS.

(a) Pre-Installation Submittals. The following information shall be prepared and submitted for review and approval by the Engineer. Submittals shall meet the requirements of Subsection 105.06.

(1) Catalog Cut Sheets. Catalog cut sheets and descriptive literature for all material as specified herein.

(2) Working Drawings. Working drawings, including, but not limited to, the following:

a. Fabrication drawings for the assembly of automatic highway crossing warning layout, including detailed bills of material. Fabrication drawings shall include detailed drawings of signal masts, cantilever gates, shelters and cases, and their respective foundations.

b. Design calculations in accordance with the *AREMA C&S Manual* for signal masts, cantilever gates, and their respective foundations.

c. Detailed installation drawings for each layout indicating the location and sizes of the new wiring.

d. Drawings showing the proposed size and equipment layout of the housing, including rack, lighting, convenience outlet arrangement, and exhaust fan mounting and location.

e. Drawings showing the location, size, and mounting arrangement of the manual control box.

f. Drawings showing the manual control panel face plate configuration, including types of buttons, plugs, levers, terminals, and lights that have been proposed to be furnished.

g. Drawings of the grounding arrangement.

h. Drawings of the battery trays and racks.

i. Drawings of the sizes and types of internal wire that the Contractor proposes to furnish and install.

j. Design drawings showing the control of the specified equipment for each newly circuited location. Design drawings will be used to generate the as-built drawings. As-built drawings shall meet the requirements specified in Subsection 664.03(b)(2).

k. Drawings of each instrument and entrance rack showing the arrangement and description of the mounted equipment and their proposed method of inter- and intra-rack wiring.

(3) Test Documentation. Documentation that all required factory tests of systems, subsystems, assemblies, subassemblies, and components supplied under the Contract have been performed. All test records shall be submitted to the Engineer before the equipment is delivered to the site.

(4) Training Classes. Outline of training classes to be given by the Contractor to familiarize railroad maintenance personnel with the initial setup, troubleshooting, and maintenance procedures for any Style C, motion sensor system, or crossing predictor system furnished under the Contract.

(5) Manuals. Six installation and maintenance manuals for each type of AHCWS equipment.

(6) Vital Signal Cable Pre-Qualification.

a. General Requirements. All cable manufacturers supplying cable for the Contract shall be pre-qualified by the Engineer. The Contractor shall provide all the data required for the Engineer's evaluation and shall make the arrangements for any required demonstrations and tests.

b. Qualifications. Qualifications shall be based on the following criteria:

1. Past Performance and Experience. The cable manufacturers must demonstrate previous successful experience in supplying cable to the railway industry for use as vital signal control cables. A list of such installations shall be provided for each cable manufacturer to be considered.

2. Quality Assurance Program. The manufacturer of cables in accordance with the requirements of this specification shall be in compliance with a quality assurance program that meets the intent of *ASQ/ANSI/ISO 9001*. Prime concern must be focused on the necessary formal assurance requirements to ensure that cable failure cannot be attributed to actions or lack of actions by the manufacturer.

3. Technical Data. The Contractor shall provide full technical data which demonstrates compliance with the requirements of this specification for each specified cable type the Contractor intends to supply.

4. Warranty. The manufacturer shall certify compliance with the following warranty prior to selection:

i. The manufacturer warrants that the design, material, and workmanship incorporated in each item of cable shall be of the highest grade and consistent with the established and generally accepted standards for aerial and underground cable for vital railroad signal, communication, and power circuits; and that each such item and every part and component thereof shall comply with this specification.

ii. The manufacturer agrees that this warranty shall commence with the acceptance of each item of the cable, whether the defect is patent or latent, and shall continue for a period of two years after initial satisfactory operation of the item or four years after acceptance of the item, whichever is shorter.

iii. The warranty covering any length of cable that shall be replaced by the manufacturer under the above conditions shall be reinstated for a period of two years, effective as of the day when said replacement is effected. If the failure is found to be of major importance and affects any other item of cable, the reinstatement of the warranty shall then be extended to cover the item so affected as well, and shall start as of the date of such replacement. The warranty reinstatement provided herein shall apply only to the first replacement or repair of any such item and, in the case of failure of major importance, to the first extension of the said warranty to said affected items.

iv. The foregoing warranties are exclusive and in lieu of all other warranties, written, oral, implied, or statutory (except as to title and freedom from lien). In no event shall the manufacturer be liable by reason of breach of warranty for special or consequential damages.

(7) Vital Signal Cable Quality Assurance.

a. The Contractor shall submit the following to the Engineer for approval prior to shipment of the cable:

1. List of the cable manufacturer's railway signal installations.

2. Each cable manufacturer's quality assurance program.

3. Full technical data for each type of cable which the cable manufacturer intends to supply.

b. The Contractor shall submit two certified copies of the following to the Engineer for approval:

1. Cable test reports for all factory tests.

2. Test reports of cable tests conducted in the field in accordance with the approved testing procedures.

3. Certification that each cable supplied complies with the requirements of these specifications.

4. Information to be supplied by certified cable test reports shall include the following:

   i. Report number.

   ii. Date and location of test.

   iii. Description of test and test conditions.

   iv. Complete cable or wire description.

   v. Lot, batch, or reel identification number.

   vi. Quantitative test results.

   vii. Summary of test results.

   viii. Information on the components of the cable tested, to include batch numbers and physical and electrical properties.

(b) Post-Installation Submittals. Upon acceptance of the AHCWS, the following information shall be prepared and submitted for review and approval by the Engineer. Submittals shall meet the requirements of Subsection 105.06.

(1) Documentation that all required specified field tests have been performed and that the installed system and equipment has successfully passed the test. All test records shall be submitted to the Engineer upon acceptance of the AHCWS.

(2) As-built drawings meeting the following requirements:

a. Drawings shall be provided to the Contractor which are representative only of the general principles and concepts upon which the Contractor shall base the design and location of the proposed system and equipment.

b. Five copies bound in a protective covering of the as-built drawings for the work shall be provided by the Contractor to the Engineer no more than 10 calendar days after the work is complete and in-service. The Contractor shall furnish to the Engineer a copy of the as-built drawings in MicroStation DGN and PDF format.

c. Working drawings shall be in accordance with the industry standards for AHCWS circuit design and detail design. Approval of the working drawings shall be at the discretion of the Engineer. The drawings shall conform to the following:

1. Use of AREMA standard symbols and nomenclature.

2. Conformance with specifications.

3. Logical grouping and arrangement of subject matter.

4. Drawings shall not be crowded or cluttered but shall be arranged for easy reading for troubleshooting and maintenance.

5. Complete, well described circuits shall be shown on each drawing insofar as possible. A minimum of circuit continuations shall be used. When continuations are used, they shall be clear and specific and shall include the identity of the continuation sheet. Circuitry shall be presented on the drawing with a minimum of crossed or offset lines.

6. The arrangement of circuitry shall be in such a manner that no more than two wires shall be shown connected to a single terminal or contact pin. A uniform method of 0.10 inch right or left 45° angle, as drawn in the MicroStation DGN file, shall be used to indicate the actual location of double wire connections. Wires shall be shown at the actual point of termination.

7. Circuits shall not be drawn as schematics but shall be drawn to reflect the actual wiring of the circuits.

8. Circuit drawings shall provide sufficient information by means of contact and terminal numbering to easily enable the tracing and testing of such circuits.

9. A minimum distance of 0.40 inches shall be maintained between lines representing circuit wiring. Lettering or printing shall be at least 0.10 inches high. All spacing shall be in multiples of tenths of inches.

10. Circuits shall be arranged to geographically match the track layout.

11. Relay nomenclature shall appear at the top of the contact and at the top of the coil.

12. Local circuits shall be drawn with relay coils, timers, motors, or other operated devices shown near the right or left border of the drawing wherever practical. Where there is a choice, the right border shall be favored. Contacts in circuits shall be laid out in geographical succession insofar as possible and practical.

13. Relay contacts shall line up with the controlling coil and other contacts of the same relay insofar as practicable. Different relay contacts and coils shall not line up. Stick contacts shall line up under the coil of controlling relay.

14. A cover sheet with the name of the crossing, mile post, and DOT number shall be included.

15. An index sheet listing the sheets included in the working drawings shall be included.

16. Track and cable plan showing the proposed crossing layout and cables to field appurtenances shall be included.

d. As-built drawings shall include fabrication drawings as specified in Subsection 664.03(a).

e. The Contractor shall submit with the as-built drawings a detailed bill of materials. This list shall include the part number of all materials used on the project.

664.04 DELIVERY, STORAGE, AND HANDLING.

(a) All equipment shipped within AHCWS shelters shall be properly fastened and braced to prevent damage during transit. Any equipment damaged during transit shall be replaced at no additional cost to the Agency.

(b) Batteries shall be shipped wet, filled to the correct level, and in a fully charged state. Each battery shall be equipped with transit plugs or rubber stoppers to prevent spillage of the electrolyte. Batteries shall be shipped separately from the housings in which they are to be used.

(c) Vital relays shall be shipped separately from the wired racks in which they are to be used. They shall be packaged individually, each in a sturdy corrugated cardboard carton with the drawing number of the relay printed on the outside of the carton. Relays shall be stored in a protected area until tested and installed.

(d) All cable shall be shipped on reels and adequately protected from damage in shipment, including the hazard of reels moving obliquely against each other, by heavy wrapping or wood lagging. The manufacturer shall also be responsible for any change in the shape of the cable occurring in normal transit which results in an increase in the maximum diameter beyond that specified. The external protective wrapping on reels shall be secured by at least two steel bands to ensure damage-free shipment.

(e) Each length of cable shall be wound on a separate reel. Reels shall be substantial to withstand handling and shall be so designed that the inner end of the cable will be secured and accessible but protected from injury. If the inner end of the cable projects through the flange of the reel, the inner end shall be protected by a suitable cover of metal having rounded ends and sides and securely fastened in place to protect the cable end. Both ends of cable on reel will be secured in place, to prevent their becoming loose in transit or handling of reel. The diameter of the reel drum shall be at least 14 times the cable diameter to prevent damage to the cable during reelings. The arbor hole shall admit a spindle 2-1/2 inches in diameter without binding. The reels shall be designated and constructed as non-returnable when drum size and cable weight and volume permit. The maximum width of the reel shall not exceed 48 inches unless otherwise specified.

(f) After passing factory tests, cable shall be effectively sealed against the entrance of moisture. Both ends of each length of cable shall be protected by wrappings of rubber tape and plastic tape, an effective boot taped or sealed into place, or other suitable means approved by the Engineer. The use of friction tape, other than as external mechanical protection over an adequate rubber or plastic tape, will not be accepted. The cable end protection shall be adequate to protect the cable in shipment and prolonged external storage in the weather if not immediately employed without regard to the position of the reel while so stored.

(g) Cable shall be closely and tightly wound, in a uniform manner, in each layer on reels. An arrow shall be painted on one head of each reel pointing the opposite direction from the outer end of the cable with the words “roll this way” employing letters not less than 3/4-inch high and an arrow not less than 6 inches in length and 1/2 inch in width.

(h) LED units shall be packaged separately from flashing light units in which they are to be used.

664.05 DESIGN CRITERIA.

(a) Fail Safe Design Criteria.

(1) Vital circuits shall be designed on fail-safe design principles, which is to say that broken wires, damaged or dirty contacts, a relay failing to respond when energized, or a loss of power supply energy shall not result in unsafe conditions.

(2) Component or system failures which are not self-detecting shall not cause unsafe conditions. Even if added to other failures, any number of simultaneous component or system failures attributable to the same cause or related causes shall not cause unsafe conditions. Any component or wire becoming grounded or any combination of such grounds shall not cause unsafe conditions.

(3) The articles or units submitted by the Contractor must be in production and must have had a previous, satisfactory in-service performance record of at least two years on Class I or Class II railroads. The manufacturer shall provide proof of performance statements upon request. Articles or units that do not meet this requirement shall be made available for type acceptance testing.

(4) Type acceptance testing shall be conducted by the Contractor. The Engineer and the Operating Railroad shall be notified prior to testing.

(5) All vital circuits shall be double-break, except within a signal instrument house or case, after the entering or leaving circuits are double-broke.

(6) All vital repeater relay circuits shall be designed on the cascade principle. The paralleling of vital repeater relays will not be permitted.

(7) Repeater relay contacts shall be assigned so that safety will not be compromised by the failure of any repeater relay to energize.

(8) Highway crossing warning start circuits shall provide initiation of the warning equipment from both sides of the crossing and shall also include separate island circuits with 5 seconds minimum loss-of-shunt.

(9) AHCWS total warning times and approach circuit distance calculations shall be provided on the crossing track plan. Total warning time shall be calculated as follows:

$$T_{TW} = T_{MW} + T_B + T_{ER} + T_C + T_P$$

where:

T_{TW} = Total warning time (seconds)

T_{MW} = Minimum warning time (seconds)

T_B = Buffer time (seconds)

T_{ER} = Equipment response time (seconds)

T_C = Clearance time (seconds)

T_P = Preemption time (seconds)

The value of each variable shall be determined as follows:

a. The minimum warning time shall be the FRA minimum time of 20 seconds.

b. The buffer time shall be 10 seconds for crossings equipped only with flashing light signals and 15 seconds for crossings equipped with automatic flashing lights and gates.

c. Equipment response time shall be provided per the manufacturer's recommendation.

d. Clearance time shall be provided for locations with multiple track crossings, skewed angle crossings, or wide travel surfaces. Clearance times for wide crossings are shown on the Plans and shall be verified and submitted to the Engineer for approval prior to completion of the design.

e. Preemption time shall be added for advanced traffic preemption.

(10) Vital relays shall be included for the gate control relay (GCR), emergency control stick relay (ECSR), preemption relay (PER) and other vital circuits included in the Contractor's design.

a. The GCR shall be controlled by an output from a vital logic gate delay unit, used to control the gates.

b. The PER shall be driven by an output of the motion sensor unit. The PER relay shall be equipped with heavy duty contacts and shall be a four-wire double break circuit to the traffic controller in advance of the start of the flasher signals.

c. The ECSR will be used to disable the crossing and will include the emergency cutout switch and control of a red LED, indicating that the crossing is out-of-service.

d. The LED shall be located on the side of the shelter.

(b) Control Circuits.

(1) Control circuits shall be in accordance with the *AREMA C&S Manual* recommended practices where such practices do not conflict with these specifications.

(2) Where means are provided for cutting out the warning devices during intervals when trains make regular operating stops or perform switching operations on approach circuits, the following requirements shall be met:

a. Controls shall be designed to ensure that warning devices are operating before the train enters the crossing.

b. Automatic control of the warning devices actuated by approaching trains other than the train that has stopped or is performing switch operations shall take precedence over any cut-out features.

c. Hand throw switches equipped with circuit controllers shall not cause the warning devices to operate without trains within the approach circuits when the switch is reversed.

(3) Warning devices shall operate until the rear of the train clears the crossing for trains operating in either direction.

(c) Modular Design.

(1) Modular design shall be used throughout the system. Electrical and mechanical components shall be organized in plug-in assemblies or modules whenever practical and shall be shelf-mounted, unless noted otherwise.

(2) Components mounted on printed circuit (PC) cards and weighing more than one-half ounce or with a displacement of more than 1/2 cubic inch shall have a mechanical attachment to the card which is separate from any electrical connection.

(3) The Contractor shall organize the printed circuit wiring so that wires serving the same function shall be connected to the same terminal of PC cards. PC cards containing the same circuitry shall be interchangeable between subsystems.

(4) The design and construction of PC cards of the same subsystem shall be the same. Cards of different subsystems shall be of the same design and construction wherever practicable.

(5) Adjustable components for electronic equipment shall be avoided wherever possible by the use of appropriate circuitry, stable components, and high-tolerance circuits. Adjustable components, where used, shall have locking devices or shall be self-locking to prevent inadvertent operation or drift. Whenever practical, two or more points of adjustment which are required during the same tune-up operation shall be located within 12 inches of each other and in such a way that they can be operated by one person. Interacting adjustments will not be acceptable. The replacement of a component or PC card with a spare shall not require compensating adjustments to other components or modules.

(6) Test points shall be provided for checking essential voltages and wave forms and for injecting test signals. Test points shall permit detection of defective PC boards and equipment modules without the disconnection of wires. All test points shall be readily accessible when the equipment is in the normal operating position and shall be clearly labeled. Test points shall be capable of accepting probes and connectors used with standard test equipment such as voltmeters and oscilloscopes.

(7) When built-in indicators or meters are associated with adjustments, the adjustment point shall be sufficiently close to the associated indicator so that the adjustments may be manipulated and the indicator observed simultaneously by one person. Built-in indicators or meters shall be provided when frequent observation or adjustments are necessary or when portable test equipment will not provide the necessary information or accuracy.

(d) Environment.

(1) All equipment housed in signal equipment housings or cases shall function in accordance with these specifications and within an operating temperature range of -40°F to +158°F at a relative humidity of 5% to 95% non-condensing, per *AREMA C&S Manual, Part 11.5.1* for Class C environment requirements.

(2) Signal equipment installed outside of the signal housing shall be designed to operate satisfactorily in all weather conditions such as rain, snow, temperature, and humidity variations. This shall be determined by the climatic conditions from data published by NOAA for the Vermont area. In addition, the recommendations of the *AREMA C&S Manual, Part 11.5.1,* shall be followed to minimize condensation and frost buildup.

(3) The electrical environment that the signal equipment will be exposed to shall be determined by the Contractor. Design, construction, and field application of the signal system shall prevent interference by the site environment from affecting the signal system operation. Possible sources of interference include, but are not limited to, 60 Hz AC electricity, rotating machinery, poor ballast conditions, and lightning.

(e) Quality Assurance.

(1) The design and workmanship of the apparatus will comply in every respect with the requirements of *49 C.F.R. Part 236*.

(2) Unless otherwise specified herein, all items furnished or installed shall be in accordance with the applicable standards, practices, and recommendations of the Agency, Operating Railroad, AREMA, NEMA, and the Institute of Electrical and Electronic Engineers, and the requirements of *49 C.F.R. Part 234* and *49 C.F.R. Part 236*.

(5) All apparatuses, including the signal junction boxes and all other miscellaneous components that form a complete system, shall be furnished completely factory wired and tested.

(6) The Contractor shall verify the testing and inspection of the equipment prior to shipment in accordance with the approved factory test as specified in Subsection 664.07(b) and inspection as specified in Subsection 664.07(a)(3).

(7) All miscellaneous components and products shall be new, free of manufacturing defects, and clearly and permanently labeled with value or type identification.

(8) All electrical components shall be rated to operate at power, voltage, current, and temperature levels exceeding by 20% those which the components will be subject to in service, unless otherwise specified herein.

(9) The AHCWS shall be designed to meet the requirements of the *MUTCD*.

(f) AHCWS Materials.

(1) The Contractor shall ensure proper integration of components into a complete highway crossing signal layout. In the event the Contractor's proposed equipment does not fit the vital design specified, it will be the Contractor's responsibility to modify the design and submit an alternate design for approval.

(2) Highway crossing warning equipment shall meet the requirements established by *AREMA C&S Manual, Part 3.3.1* and *AREMA C&S Manual, Part 3.1.15*, except where such instructions and requisites conflict with this specification.

(3) The active warning system configurations shall be as shown on the Plans.

664.06 INSTALLATION OF AHCWS.

(a) General Requirements. All work shall be accomplished in a manner that will protect the crossing throughout the prosecution of work and ensure the safety of workers, pedestrians, and vehicular traffic.

(b) Excavation and Backfill.

(1) Excavation of Pavements. Excavation of pavements for the installation of signal conduit shall be performed in accordance with Subsection 203.07. Cuts in the pavement shall be made with a concrete saw to a minimum depth of 2 inches along the neat lines of the area to be removed.

(2) Excavation for Conduit and Buried Cable. Trenches necessary for placing conduit and buried cable shall be excavated in accordance with Section 204. The bottom of conduit trench shall be graded to a pitch of not less than 3 inches per 100 feet.

(3) Excavation for Signal Foundations. Excavation for signal foundations shall be performed in accordance with Section 204.

(4) Backfill. Backfill shall be placed and compacted as specified in Subsection 204.05.

(5) Buried Cable. All buried cable shall be marked with 6-inch wide yellow plastic marking tape as specified in Subsection 781.03(j)(31). The tape shall be placed in the backfill 12 inches below finished grade.

(c) Installation.

(1) General Requirements.

a. AHCWS equipment shall be installed in accordance with the approved working drawings.

b. AHCWS equipment shall be mounted in such a manner as to provide for easy access to test points, indicators, and adjustments.

c. Track termination diodes and shunts shall be installed in accordance with the manufacturer’s standard and at locations shown on the approved working drawings.

d. Electrical work and materials shall be subject to inspection and approval of the state or municipal electrical inspector, as applicable.

e. All work shall meet the requirements of the *National Electrical Code* and the *National Electrical Safety Code*.

(2) Foundations and Cribbing.

a. At all locations where precast or cast-in-place concrete foundations are installed, a crushed stone base as specified in Subsection 704.06 shall be placed and compacted on the accepted subgrade to a total depth of not less than 4 inches after compaction.

b. When placing foundations, the Contractor shall exercise care to ensure that anchor bolts are not bent or the threads damaged. All anchor bolt threads, washers, and nuts shall be protected by applying friction tape until such time as the unit to be supported is installed. Anchor bolts requiring leveling nuts shall be of sufficient length and size for the load application and have the necessary concrete coverage to ensure that it does not push out under compression or pull out under tension.

c. Foundations and pads shall be installed level and plumb.

d. Finishing of foundations exposed to view shall be in accordance with Subsection 541.14.

e. After backfilling foundations, the Contractor shall ensure that the foundation is plumb and level. The top of foundation shall be at the same elevation as the crown of the roadway and no more than 4 inches above the final top of grade.

f. Cribbing shall be installed as shown on the Plans. Each tier of timber cribbing shall be drift bolted to the one upon which it rests with 3/4-inch galvanized drift bolts of sufficient length to extend through two tiers and not less than 4 inches into the third tier. Concrete or steel cribbing shall be installed in accordance with the manufacturer's instructions.

g. The filling of the interior of the crib shall closely follow the erection of the successive tiers and at no time shall the cribbing be laid up higher than 3 feet above the backfilled portion.

h. The cribbing shall be installed so as to have a minimum perimeter walkway around the case or signal of 6 feet.

(3) Flashing Light Signal Installation.

a. The flashing light signal mast shall be securely fastened within the split base in a manner such as the distance between the split halves of the base shall be equal. The heads of the bolts in the base assembly shall be squared with each other and facing oncoming highway traffic.

b. The base shall be securely fastened to the concrete foundation with the hardware provided for that purpose. The mast shall be plumb when the base assembly is fastened to the foundation. Shims, spacers, or other filler devices shall not be used to level and plumb flashing light signal equipment.

c. A hole shall be factory-drilled in the mast for the bottom cross-arm. The center line of the hole shall be located so that, when the cross-arm with light unit is attached thereto, the lowest part of the light assembly shall be between 7-1/2 feet and 9-1/2 feet above the crown of the roadway. Holes for additional cross-arms, when required, shall be located and drilled in the field after the bottom cross-arm has been secured to the mast. The centerline of the additional light units shall be 23 inches above the centerline of the lower light unit.

d. Electronic bells shall be installed on the top of the mast of the flashing light unit as shown on the Plans. If a bell is not specified, then a pinnacle shall be provided.

e. Underground cables shall be installed in the split base junction box. The cables shall be pot headed, tagged, and terminated. No. 10 AWG wire shall be run to the cross-arm junction box in a manner as specified in the *AREMA C&S Manual, Part 10.4.1*.

1. Wiring for the flashing light units and the bell shall be 37 strand, No. 10 AWG.

2. Where additional light units are used, wiring for these units shall be run from the corresponding terminals in the next lowest cross-arm junction box.

3. Wiring for bells shall go directly from the bottom cross-arm junction box to the bell.

4. Terminations for flasher unit and bell wiring shall be solderless compression type terminals as specified in Subsection 781.03(j)(13).

f. With AC power off and standby battery in a fully charged condition, the lamp voltage shall be adjusted to 9.5 volts for LED lights (measured at the lamp) by varying the resistor for the flasher unit.

g. The front lights of the flashing light unit shall be focused to provide maximum visibility for oncoming highway traffic. The back lights of the flashing light unit shall be focused to provide close up visibility for oncoming highway traffic from the opposite direction.

(4) Cantilever-Gate Combination Installation.

a. The base of the cantilever shall be securely fastened to the concrete foundation with the hardware provided for that purpose. The mast shall be plumb when the base assembly is fastened to the foundation. Shims, spacers, or other filler devices shall not be used to level and plumb cantilever layouts. Leveling nuts shall be installed prior to installation of the signal.

b. The railroad crossing sign and ENS sign for the cantilever arm shall be securely fastened with the hardware provided for that purpose as per the manufacturer's recommendation.

c. Installation of the cantilever shall provide a minimum clearance of 17-1/2 feet above the roadway.

d. Gate mechanisms and gate arms shall be installed per the manufacturer's instructions. The Contractor shall install light units, gate arm deflectors, high wind gate arm supports, off set conversions brackets and all equipment required for a complete assembly.

(5) Automatic Highway Crossing Warning Gate Installation.

a. The gate arm tip light shall be steadily illuminated and the other gate arm lights shall flash in unison with the mast or cantilever mounted lights.

b. Sidewalk gate tip lights shall be steadily illuminated.

c. Gate lights shall be adjustable for installations not perpendicular to the tracks.

d. Gate arm counterweights shall be adjusted in accordance with the manufacturer's standards for the length of gate arm specified.

e. Ground mount gate masts shall be securely fastened within the junction box base in a manner such that the distance between the split halves of the base shall be equal when tightened.

f. The base shall be securely fastened to the concrete foundation with the hardware provided for that purpose.

g. The mast shall be plumb when the base assembly is fastened to the foundation. Shims, spacers, or other fillers shall not be used to level and plumb highway crossing warning gates.

h. Gate operating mechanism, including counterweight arms, shall be securely fastened to the mast with the hardware provided for that purpose.

i. The mechanism shall be located on the pole in a position that shall allow for the gate arms, when in the down position, to be not more than 4-1/2 feet, nor less than 3-1/2 feet, above the crown of the roadway.

j. Underground cables shall be installed in the split base junction box. The cables shall be pot headed, tagged, and terminated.

(6) Cable Installation.

a. General Requirements.

1. The installation of wire and cable shall conform to *AREMA C&S Manual, Part 10.4.1*, except as modified herein.

2. Prior to the installation of underground cables, a sand bed, using material in accordance with Subsection 703.03, shall be compacted to a depth of not less than 3 inches on the accepted subgrade. Following the installation of the cables, sand backfill shall be placed and compacted with hand tools around and over the cables in 4-inch to 6-inch layers, to a uniform depth not less than 8 inches without damage to the cables.

3. The Contractor shall provide sufficient slack in cable conductors at all terminating posts to enable three re-terminations of the conductor due to broken eyelets without re-servicing or re-pot heading the cable.

4. Cables shall not be bent to a radius less than 10 times the diameter of the cable during installation, or as finally installed.

5. All cable runs shall be continuous without splices between cable terminating locations.

6. Tags to identify cables shall be of plastic material. Tags shall be lettered to correspond with the cable destination and the number of conductors in the cable. The type of tag to be used shall be as specified in Subsection 781.03(j)(14).

7. All cables shall be terminated in conductor order. Individual cable conductors shall be identified at each cable termination with plastic tags as specified herein. All spare conductors in each cable shall be terminated and identified.

8. All cable entrance openings in equipment enclosures and junction boxes shall be sealed with a pliable sealing compound after the cable is in place. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in accordance with *AREMA C&S Manual, Part 15.2.15*.

9. A suitable lubricating medium, non-injurious to the cable insulation, shall be used when pulling cables into conduit or pipe.

10. Wherever multiple conductor cables are terminated, the outer sheath of the cable shall be carefully removed to the point of cable entrance. At the end of the cable sheath or covering, two layers of plastic electrical tape shall be applied.

11. When paralleling the tracks, cable shall be buried at a minimum depth of 30 inches below finished earth or ballast. Cable shall be laid loosely in the trench with a sand bed and backfill as specified. When passing under tracks, cable that is not protected in conduit shall be buried a minimum depth of 48 inches below the top of tie.

12. Upon request, and only under extreme circumstances and because of installation hardship, the Engineer may allow installation of a to a depth of less than 30 inches. The cable shall be protected in a manner as approved by the Engineer.

13. Whenever any signal cable is to pass under pavement or a roadway, if existing conduit is not provided, the cable shall be installed in a 4-inch galvanized steel conduit, as specified in Subsection 752.06, and the conduit shall extend 20 feet beyond the edges of the pavement.

14. Where cable leaves the ground at locations other than buildings or in foundations, it shall be protected by a bootleg or other covering extending above the ground line. The top of such protective coverings shall be filled with a sealing compound in accordance with *AREMA C&S Manual, Part 15.2.15*.

15. The Contractor shall install polyethylene cable marking tape at a depth of approximately 12 inches below final grade while backfilling each cable trench. This tape shall be as specified in Subsection 664.06(b)(5).

16. The pot heading of buried cabled shall be applied whenever cable is terminated in signal equipment and such termination is within 2 feet of the grade level. This neoprene end seal pot head shall be installed in accordance with the manufacturer's instructions.

(7) Rail and Turnout Bonding Installation.

a. Non-Insulated Joint Bars. All non-insulated joint bars in the crossing circuited territory shall be bonded with one bond installed on the field side of the joint bars.

b. Turnouts. All turnouts within the crossing approach shall be furnished with fouling wires and switch heel bonds. Track switch, frog fouling bonds, and track circuit connections shall plug-type rail web bonds.

c. Exothermically Welded Rail Head.

1. The surfaces of the rails where the bond is to be applied shall be ground clean with a reinforced grinding wheel, of a type recommended by the bonding material manufacturer. Vitrified grinding wheels shall not be used. After grinding, the surface shall be cleaned with an approved non-toxic solvent to remove all traces of grease and dirt. After the surface has been ground and cleaned, it shall be heated to drive out any moisture. The bond wire shall then be welded to the rail in a manner to ensure a thorough mechanical and electrical connection.

2. The Contractor shall ensure that each bond connection is thoroughly welded to the rail. The Engineer reserves the right to require a test of each weld.

3. The Contractor shall demonstrate that the bonding is in accordance with the requirements of this section and as specified in *AREMA C&S Manual, Part 8.1.20*, *AREMA C&S Manual, Part 8.1.30*, and *AREMA C&S Manual, Part 8.6.40*.

d. Plug-Type Rail Web Track Circuit Connections.

1. Track circuit connectors shall be furnished and installed in accordance with *AREMA C&S Manual, Part 8.1.20* and *AREMA C&S Manual, Part 8.1.25* for Type 2 plugs. The opposite end of the connectors shall have a 7-inch length of turned bond strand with a compression sleeve installed for connection to bond strand wires.

2. Rail shall be drilled in accordance with *AREMA C&S Manual, Part 8.6.25*. Rail shall be drilled with an approved 3/8-inch bonding drill bit and drill normally used for this purpose to permit the application of the bond to the rail web.

3. No hole shall be drilled through the rail brand. Holes shall be drilled within ± 3/16 inch of the neutral axis of the rail. All holes shall be clean and deburred. Bond wires shall be installed on the same day as the hole is drilled. In the event that bond wires cannot be installed on the same day, the bond hole shall be protected against the elements with a suitable plug.

4. Plugs shall be driven with a hammer approximately three pounds in weight, and when in-place shall be tight to provide the best possible contact throughout the web of the rail.

5. Track circuit connectors shall be furnished and installed with insulated bond strand cable. The bond strand shall have a nominal diameter of 0.200 inch and be jacketed with 3/32-inch rubber compound. The bond strand shall be connected to the solid No. 6 AWG insulated twisted track wire with compression sleeves and taped and insulated to prevent corrosion. The connection between track wire and bond strand shall be housed in rubber water hosing to prevent damage from ballast and frost in the ground.

6. The underground cable shall be stripped back a sufficient distance for the exposed conductor to be fully inserted into the compression sleeve. The sleeve shall then be compressed with the type of compression tool designed for that purpose. The sleeve shall then be covered with two layers of vinyl plastic electrical tape.

7. A 24-inch piece of hose, as specified in Subsection 781.03(j)(17)b.1., shall be located beneath the rail base and sealed with sealing compound in accordance with the *AREMA C&S Manual, Part 15.2.15*.

8. Any track circuit connection installed by the Contractor that is found to be defective prior to acceptance shall be removed and a new track circuit connection installed at no additional cost to the Agency.

9. Care shall be taken to avoid excessive slack in the bond conductor to prevent vandalism. A connector sleeve shall be used on the base of the rail.

e. Plug-Type Rail Web Turnout Bonding.

1. Turnout bonding connectors shall be furnished and installed in accordance with *AREMA C&S Manual, Part 8.1.20* and *AREMA C&S Manual, Part 8.1.25* for Type 2 plugs.

2. Rail shall be drilled in accordance with *AREMA C&S Manual, Part 8.6.25*. Rail shall be drilled with an approved 3/8-inch bonding drill bit and drill normally used for this purpose to permit the application of the bond to the rail web.

3. No hole shall be drilled through the rail brand. Holes shall be drilled within ± 3/16 inch of the neutral axis of the rail. All holes shall be clean and deburred. Bond wires shall be installed on the same day as the hole is drilled. If bond wires cannot be installed on the same day, the bond hole shall be protected against the elements with a suitable plug.

4. Plugs shall be driven with a hammer approximately three pounds in weight, and when in-place shall be tight to provide the best possible contact throughout the web of the rail.

5. Fouling bond wires for all turnouts within the crossing approach shall be installed as close as practicable to the transposition joints. The holes for bond wires shall be located 2-1/2 inches apart and centered above a tie bay.

6. The fouling wires shall be installed so as to allow for the plug end of the one wire to be placed on the outside of the far rail and the other end of the inside of the opposite far rail. The second wire installation shall be the reverse of the first wire.

7. Fouling wire shall be stapled to separate ties, 1-1/2 inches below the top of tie, opposite each other in the same tie bay. The fouling wires shall be installed to avoid touching the tie plates. Fouling wires shall be left exposed to allow visual inspection.

8. Any bond, weld, or connection installed by the Contractor that is found to be defective prior to acceptance shall be removed and a new bond installed at no additional cost to the Agency.

f. Existing Bonding. If existing rail bonding is in place on the approach circuits, then the Contractor shall inspect and verify that all such bonding, including track switches, is in accordance with these specifications. If additional rail bonding, or rail bonding corrections, is required then the Contractor shall correct any such deficient existing rail bonding at no cost to the Agency in accordance with these specifications, or as directed by the Engineer. Final determination of bonding requirements shall be approved by the Engineer and Railroad.

(8) Installation of AHCWS Shelters and Cases.

a. Each AHCWS shelter shall be mounted level and plumb using the foundation leveling system provided as part of the shelter.

b. Cable entrance pipes shall be installed through the cable knockout holes provided in the floor of the house behind the terminal boards.

c. The AHCWS shelter or case shall be grounded as specified in Subsection 781.03(g)(9) and Subsection 781.03(j)(22).

d. Cables shall enter shelters by entrance knockouts and fittings and entrance pipes provided. Cables shall be dressed, pot headed, tagged, and terminated as specified in Subsection 664.06(c)(6).

e. Relays shall be installed on the relay plug-boards corresponding to the relay nomenclature and securely fastened in place with the hardware provided.

f. Batteries shall be installed on battery trays. Battery posts shall be coated with approved grease and battery connectors shall be securely fastened to the battery posts.

g. Manual control boxes shall be mounted and wired in accordance with the approved working drawings.

h. Grade crossing predicator, motion sensor, or similar solid-state equipment, as shown on the approved working drawings, shall be shelf mounted with rubber matting under the units.

i. AHCWS shelters and cases, if of sheet steel construction, shall be painted as specified in Subsection 781.03(g)(12).

(9) Metered Power Service Grounding. Power service equipment grounding shall be installed in accordance with the *National Electrical Code* and the power company's requirements.

(10) Signs. Two signs shall be mounted to the AHCWS masts, one on each side of the crossing on the right-hand side of the driver approaching the crossing. One sign shall be mounted on the signal house or case. All signs shall be mounted in a manner approved by the Engineer. The signs shall conform to the applicable Standard Drawings.

(11) Retirement and Disposal of Existing Equipment. All retired existing AHCWS equipment or passive crossing warning devices shall be removed by the Contractor and transported to a site designated by the Engineer.

(12) Protective Service Costs. Following the date of in-service operation, all railroad flagging and related crossing protection expense, during periods that the warning system fails to operate as specified in this section, shall be borne by the Contractor at no additional cost to the Agency until the system is accepted by the Agency.

664.07 TESTING OF AHCWS.

(a) Quality Assurance Testing Procedures.

(1) All test procedures and inspection procedures shall be subject to the approval of the Engineer and shall comply with all FRA rules and regulations.

(2) Test equipment of the proper type, capacity, range, and accuracy shall be supplied by the Contractor to perform the required tests and inspections. This equipment shall be in good working order and properly calibrated at the time the tests or inspections are conducted.

(3) Each component and unit of the AHCWS shall have an inspection performed at its point of manufacture, and evidence of this inspection and acceptability shall be indicated on the item where practicable.

(5) All approved system and subsystem tests to demonstrate that the installation meets these specifications and design requirements shall be completed prior to any operational testing of systems or subsystems.

(6) No more than 3 days prior to placing in service, the Contractor shall adjust all rectifiers and DC power supplies for maximum output for a period of 24 hours. Following this operation, the Contractor shall adjust the output in excess of the load requirements in accordance with the battery manufacturer's recommendations.

(7) The Engineer and the Operating Railroad will have the right to witness any or all field tests conducted. The Engineer and the Operating Railroad shall be notified in writing at least 48 hours prior to each field test. No part of the AHCWS shall be placed in service without an authorized representative of the Agency and the Operating Railroad being present and witnessing the in-service tests, unless otherwise agreed by the Engineer.

(8) The work shall include all tests required to ensure the proper and safe operation of all systems and subsystems and to prove the adequacy and acceptability of the total installation specified herein. The tests to be performed shall cause each system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions to prove that the installation complies with all specified fail-safe requirements.

(9) In the event that the system does not meet the requirements of this section, all deficiencies shall be corrected and retested to prove compliance, at no additional cost to the Agency.

(b) Factory Test Procedures.

(1) Confirmation shall be provided by the Contractor that all required factory tests of systems, subsystems, assemblies, subassemblies, and components supplied under this Contract have been performed. These tests shall verify design and name-plate ratings and adequate and proper performance.

(2) All vital systems, subsystems, and equipment shall be inspected and tested.

(3) Non-vital components, those not related to fail-safe circuits, may be tested on a sampling basis. An approved number of randomly selected components or units from the manufacturing process shall be tested to ensure the adequacy and acceptability of all components and units produced.

(4) When test results are not recorded on a test-data plate affixed to the equipment or unit, certified test reports shall be furnished for each item at the time of delivery in a form and format suitable for regular office file record keeping.

(c) Factory Tests and Instructions.

(1) Vital Relay Tests. All DC vital relays shall be factory tested and inspected in accordance with the *AREMA C&S Manual, Part 6.4.1*.

(2) Wired AHCWS Shelters and Cases.

a. Operational and Wiring Verification Test. Each AHCWS shelter and case shall be wired complete at the point of assembly, with all equipment installed. An operational and wiring verification test shall be made in accordance with the approved design drawings. Functions external to the housing shall be simulated where required.

b. Energy Distribution Tests. Energy distribution tests shall include, but not be limited to, the following:

1. All fuses shall be removed and circuit breakers placed in the open position.

2. All over-current devices shall be of the sizes shown on the approved design drawings.

3. All energy distribution shall be checked using a resistance test instrument to verify agreement with the approved design drawings.

4. All wire gauges shall be verified as matching that called for on the approved design drawings. All incorrect wire sizes shall be replaced with the proper size wire.

5. Each energy bus shall be tested to all other energy buses to ensure that no crosses exist.

6. During energy distribution breakdown, a wire count on each terminal, relay contact, etc. shall be taken to ensure that only the number of wires called for on the approved design drawings are present at each terminal, relay contact, etc. Any discrepancies found shall be corrected and excess wires, if found, shall be removed.

7. Tags shall be verified for proper nomenclature and terminal location.

8. All power supplies shall be checked for correct setting and quantities.

c. Wiring Verification Test. All circuitry shall be checked for accuracy against the approved design drawings. Tests may be done with energy on or off and shall verify the following:

1. Point to point wiring.

2. During wire verification test, a wire count on each terminal, relay contact, etc. shall be taken to ensure that only the number of wires called for on the approved design drawings is present at each terminal, relay contact, etc. Any discrepancies found shall be corrected.

3. Tags and nomenclature where applicable.

4. That all components, relays, resistors, etc. are the same as called for on the approved circuit drawings and are located in the proper positions.

d. Vital Circuit Tests.

1. Tests shall be conducted with energy on during simulation testing.

2. All vital circuits shall be tested to ensure that the opening of each contact in a control circuit cuts off the control current under the conditions shown on the approved design drawings following through all multiple circuits and cut arounds. When a circuit is broken by a relay contact twice or when it is broken by some other relay contact, whose coil circuit is opened by opening the relay, the wires in the circuit shall be disconnected in addition to opening the relay.

3. Adjustments and corrections of defects in the housing wiring shall be made as necessary to obtain proper operation.

4. All design changes found necessary to obtain proper operation shall be submitted to the Engineer for approval.

e. Other Factory Tests. Factory tests and inspections of other components, products, and subsystems shall be as specified elsewhere in this section.

(d) Field Test Procedures.

(1) The field tests performed shall cause each installed system and subsystem to be sequenced through its required operations, including the imposition of simulated conditions, to demonstrate that the installation complies with all specified fail-safe design requirements and operational functions.

(2) The quality of the installation shall be demonstrated by field tests for continuity, insulation resistance, resistance of ground connections, circuit breakdown, visual inspection, and any other tests required by this section. These tests shall be performed prior to any operational testing of systems or subsystems.

(3) The Contractor's test procedures shall consist of pre-printed data sheets or inspection sheets for each test. When completed by the field test personnel and checked for accuracy and completeness, the sheet shall be submitted as the test report.

(4) When tests require specific meter or test instrument readings, the pre-printed data sheet shall show the allowable range of values for each part of the test. The test report shall also contain a check-off system for each action and a blank space adjacent to the expected value in which to record the test readings.

(5) The test report shall also contain a final description sheet on which the Contractor shall record discrepancies found and action taken. This document shall be furnished to the Engineer.

(6) All test reports shall be dated and signed by the responsible employee of the Contractor or subcontractor on the day the test is performed. Space shall also be provided for the signature of those witnessing the test, including the Engineer and Operating Railroad inspector.

(7) The report shall show the specific test instruments used on each test, with the instruments identified by name, type, serial number, and calibration due date.

(8) Should an error be discovered during field testing due to field wiring and connections that do not agree with the approved design drawings, the Contractor may correct such errors without prior approval of the Engineer. The Contractor shall not, however, make any changes which affect the safety of operation of the approved circuits as designed without prior written approval of the Engineer.

(9) The Engineer will make all final determinations as to whether only a part, or the whole test, shall be rerun when any specific field test does not meet the requirements specified for the test.

(10) Any changes made after completion of the test procedure shall be retested in accordance with the applicable test procedure.

(e) Field Tests and Inspection.

(1) General Field Tests. General field tests shall include, but not be limited to, the following:

a. Ground verification test.

b. Power racks – energy distribution system and failure alarm checks.

c. Breakdown test of all vital circuitry.

d. Wiring verification of all non-vital circuitry.

e. Vital function tests.

f. Operating tests.

g. All applicable tests prescribed by *AREMA C&S Manual, Part 2.4.1*, where the AREMA inspections and tests do not conflict with the requirements of these specifications.

(2) Specific Field Tests.

a. Ground Resistance Testing.

1. Testing. The Contractor shall perform testing of all signal locations using a ground resistance direct-reading single test meter using the alternating current fall-of-potential method and two reference electrodes.

2. Test Procedure.

i. The ground electrode to be tested and the two reference electrodes shall be oriented in a straight line spaced a minimum of 50 feet apart.

ii. The two reference electrodes shall be driven 5 feet deep.

iii. The maximum resistance value goal of the main ground for wayside outdoor locations shall be within a range of 1 ohm to 5 ohms. If it is found that the resistance value of the main ground exceeds this range, the Contractor shall install additional ground rods, up to a maximum of 4. Additional ground rods shall be spaced no less than 10 feet apart. If, after additional ground rods are installed, excessive resistance readings persist, the Contractor shall notify the Engineer.

iv. The Contractor may propose an alternate method to the fall-of-potential method for approval by the Engineer in consultation with the Operating Railroad. Any such alternate method shall be supported by documentation that validates that the resultant measurement readings are analogous.

b. Insulation Resistance Tests. The procedure for testing insulation resistance shall include tests to verify the following:

1. All wire and cable installed for vital circuits along the right-of-way and wire and cable entering or leaving wayside instrument housings shall be tested after installation to ensure that insulation of wires and cable and connected equipment meet the specified resistance value. A direct reading instrument, having a 0-megohm to 200-megohm-scale range and a self-contained DC power supply rated 500 volts minimum to 1,000 volts maximum, shall be used to measure the insulation resistance. Resistance between conductors and ground shall not be less than that specified in *49 C.F.R. § 234.267*.

2. The insulation resistance of each conductor to ground and between each conductor and all other conductors in each multi-conductor cable shall be tested. Power sources, made grounds, and connections to the rails shall be disconnected from the circuits during testing.

3. The point used as ground shall be the most convenient ground available.

4. Insulation resistance test values shall be recorded on approved insulation resistance record forms and turned over to the Engineer upon their acceptance of this test requirement.

c. Vital Relays.

1. All DC vital relays shall be tested for pick-up and drop-away values. These values shall be in accordance with field requirement values stated in the *AREMA C&S Manual, Part 6.4.1, Table 641-1*.

2. These measured values shall be recorded on the approved relay record forms and turned over to the Engineer upon their acceptance of this test requirement.

3. These tests shall be performed after the housing has been set.

d. Energy Distribution.

1. Energy-Off Tests. With all power to AHCWS instrument shelters or case off, the following checks and tests shall be performed. These tests shall include but not be limited to:

i. Verifying that circuit breaker size compares to that of the approved design drawings.

ii. All energy distributions shall be checked using a resistance test instrument to verify agreement with the approved fabrication drawings.

iii. Wire gauges shall be compared with those called for on the approved circuit drawings. All discrepancies in wire sizes shall be replaced with the proper size wire.

iv. Terminal board tags shall be verified for proper nomenclature and terminal location.

v. Each energy bus shall be tested to all other energy buses to ensure that no crosses exist.

2. Energy-On Tests. Upon completion of the energy-off tests, the following checks and tests shall be performed. These tests shall include, but not be limited to, the following:

i. Inserting circuit breakers for power supply feeds and verifying proper size according to the approved circuit drawings.

ii. Turning on energy feeds and testing operation of power transfer for proper operation.

iii. Measuring and recording each AC voltage input.

iv. Measuring and recording each power supply or charger output voltage.

v. Verifying that the proper voltage is present at all distribution points.

vi. Checking circuit power failure alarms, and all other alarms that indicate to Central Control.

vii. Checking battery water level and specific gravity of all cells.

3. Circuit Continuity Tests. All wire and cable installed by the Contractor shall be tested to verify the continuity of each conductor and that each conductor is connected to the proper terminal as shown on the approved drawings. Where parallel circuits exist, each parallel path shall be tested independently to verify the continuity of each path.

4. Circuit Wiring Verification. All vital and non-vital circuit wiring shall be checked for accuracy against the approved design drawings. Tests may be performed with energy on or off and shall verify, but not be limited to, the following:

i. Point to point wiring.

ii. A wiring count of all field installed wires shall be conducted for each terminal, relay contact, etc. to ensure that only the number of wires called for on the approved designed drawings is present at each terminal, relay contact, etc. Any discrepancies found shall be corrected.

iii. Tags and nomenclature where applicable.

iv. That all components, relays, resistors, etc. are the same as called for on the approved circuit drawings and are located in the proper positions.

5. Breakdown of Control Circuits.

   i. All vital relay circuits shall be tested in their entirety for the correct operation of and response to each contact on each circuit element, such as relays and contactors. Where parallel paths exist, the tests shall validate each path, and circuits shall be opened when required to ensure the proper tests.

   ii. Each circuit shall be tested by simulating all operating conditions to verify that the circuit operates in accordance with these specifications and approved submittals.

6. Power Tests. The following power tests shall be performed and recorded:

   i. The voltage of the main power feeders shall be measured and recorded.

   ii. A check of all circuit breakers shall be performed for correct size and type.

   iii. All power supplies, battery chargers, and batteries shall be checked for correct setting and quantities.

   iv. Bus-to-bus checks shall be made to determine that no shorts, crosses, or grounds exist.

7. AHCWS Operational Tests.

   i. A test train shall be used to verify that any AHCWS motion sensor or predictor equipment installed under this Contract has the specified warning time at each highway grade crossing.

   ii. Tests of the AHCWS shall be performed in both directions at various speeds to the satisfaction of the Engineer.

   iii. As an alternative to test train operation, the Contractor may propose a field train simulation test procedure for the approval of the Engineer. Any such alternate procedure proposed shall be accompanied by verification documentation of such field tests performed by the Contractor for similar AHCWS installation projects.

664.08 TRAINING FOR SYSTEMS. The Contractor shall provide a qualified field engineer to instruct maintenance personnel on recommended initial setup, troubleshooting, and maintenance procedures for predictor, motion sensor, or Style C systems. This training course shall be conducted on the Operating Railroad's property and will be limited to two 8-hour days of instruction. The Contractor shall submit a request for the Agency to arrange the training 14 calendar days in advance of the proposed date.

664.09 METHOD OF MEASUREMENT. The quantity of Railroad-Highway Crossing Active Warning System to be measured for payment will be on a lump sum basis for each system installed in the complete and accepted work.

664.10 BASIS OF PAYMENT. The accepted quantity of Railroad-Highway Crossing Active Warning System at the location specified will be paid at the Contract lump sum price. Payment will be full compensation for designing, furnishing, transporting, handling, placing, and testing and placing in service the materials and equipment specified, including all new equipment, as-built signal circuits for placement in the shelter, insulated joints, and traffic pre-emption interconnection; concrete, backfill, permanent number signs, excavation, trench excavation, trench pavement replacement, and removal of existing signal lights; resurfacing or other restoration work; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
664.1000 Railroad-Highway Crossing Active Warning System	Lump Sum

SECTION 665 – RAILROAD TURNOUT CONSTRUCTION

665.01 DESCRIPTION. This work shall consist of providing new welded railroad turnouts, including a complete timber switch tie set; connecting the turnout to the existing track, including realignment of existing track, installation of new rail, welds, and compromise welds, as required; raising, aligning, and surfacing turnouts and crossovers; and the removal of turnouts and crossovers.

665.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Aggregate for Railroad Ballast 704.03
Switch Ties.....709.04(d)
Tie Plugging Material .....709.04(e)
New Rail .....715.06(a)
Railroad Turnouts 715.07
Other Track Material (OTM) 715.08

New turnouts shall be of the rail section and weights shown on the Plans.

Ballast shall be of the type shown on the Plans.

665.03 SUBMITTALS. The following information shall be prepared and submitted for review and approval by the Engineer. Submittals shall meet the requirements of Subsection 105.06.

(a) Fabrication drawings shall be submitted in accordance with the requirements of Subsection 105.06. All details, dimensions, quantities, parts, specifications, and sections necessary to fabricate and assemble the turnout shall be included in the submittal.

(b) A complete schedule of the materials proposed for installation and the source of the material. Information to be provided on the rail shall include rail weight, rail section, drilling pattern, typical rail length, date rolled, and the name of the mill where the rail was rolled.

(c) Sub-assembly component and bolt certificates of origination.

(d) Source for ballast and gradation analysis of a sample from the ballast source.

(e) Manufacturer’s certificate of compliance for all materials that are incorporated into the work.

(f) Manufacturer’s cut sheet of lubricant or graphite for application to switch plates following the cleaning of the plates.

665.04 TURNOUT CONSTRUCTION REQUIREMENTS. The Contractor shall take special care and precautions when unloading, handling, and installing a turnout package. Care shall be taken to prevent rail bending, switch ties splitting, and loss or damage to associated switch materials.

Removal of existing track necessary to install the new turnout shall be performed in accordance with Subsection 662.04.

The Contractor shall handle ballast in accordance with Subsection 662.05 and shall install bottom ballast in accordance with Subsection 662.06.

Turnout installation shall be performed as follows:

(a) Turnout Layout. Pre-plated switch ties, turnout rails, switch, frog, and guard rail (or turnout panels if furnished as such) shall be placed in accordance with the fabrication drawings.

(b) Switch Tie Installation. The Contractor shall transport and store switch ties in accordance with *AREMA Chapter 30, Section 3.5.11*.

(1) New switch ties shall be handled and placed with either a mechanical tie insertion device or tie tongs. The use of picks will not be permitted.

(2) The Contractor shall take special care and vigilance during handling and unloading of switch ties to avoid damage to the ties. Any switch ties damaged during handling or installation shall be replaced by the Contractor at no expense to the Agency.

(3) New switch ties shall be placed with the plate side up, square with the line of the rails along the straight route side of the turnout and not skewed. Switch ties shall be spaced in accordance with the fabrication drawings.

(c) Rail and Temporary Bolted Joint Installation. Rail and temporary bolted joints shall be installed in accordance with the following requirements:

(1) Rail layout and joint locations shall be in accordance with the fabrication drawings.

(2) Rail shall not be dropped on uneven surfaces or left unevenly supported. The unloaded rail shall be placed so that it can be laid with as little handling as possible.

(3) Tie plates and switch plates shall be free of any dirt and foreign matter prior to rail being installed. Stone dust and extraneous material shall be removed by blowing or brushing off the surface of the tie plate to prevent damage and to ensure proper seating of the rail.

(4) When placing rail, regular tie plates shall be square with the rail and switch plate orientation shall be per the fabrication drawings. The shoulders of both tie and switch plates (where located) shall bear firmly against the sides of the rail base. Under no circumstances shall the tie plate or switch plate shoulder be allowed under any portion of the rail base. Care shall be taken to ensure that the rail is fully supported and properly seated on the tie and switch plates.

(5) Temporary joint bar assemblies shall be installed with four bolts, as furnished from the fabricator. Joints to be field welded shall be located as specified in Subsection 715.07(a). Temporary joint bar assemblies shall not be lubricated.

(6) Insulated joints shall be located as specified in Subsection 715.07(h).

(7) Rail joints shall be installed so that bars are not cocked between the base and head of rail. Joint bars shall be properly seated in the rail.

(8) The Contractor shall tighten bolts to the required torque, starting with the two bolts in the middle of the bar and working towards the ends. The Contractor shall strike both bars with a sledgehammer during the tightening process to help seat the bars properly. The Contractor shall then perform a final re-tightening of the two middle bolts. The Contractor shall torque the bolts as required by AREMA for the respective bolt size. All bolts shall be torqued with a mechanical bolt machine and set to apply the required torque. The Contractor shall not use this method to of striking the bars when installing insulated joint bars.

(9) Rail clips shall be installed to fasten the rail to the tie plates. Clips shall be driven until there is an approximately 3/8-inch gap between the edge of the tie plate and the inner edge of the rear arch of the clip. Clips shall not be overdriven.

(10) Rail anchors shall not be installed at tie locations which utilize spring clips to fasten the rail to the tie plates.

(d) Ballasting, Surfacing, Aligning, Tamping, and Dressing of Turnout. Ballasting, surfacing, aligning, tamping, and dressing of the turnout shall be performed in accordance with Subsection 662.07(i) with the following exceptions and additions:

(1) The ballast under the switch ties shall be completely and uniformly tamped outward 15 inches from the gage and field sides of each rail. The head block ties supporting the switch stand shall be tamped completely to the end of the tie.

(2) Upon completion of surfacing, aligning, and tamping, the regular tie plates and various types of switch plates shall bear fully on the tie and the rail, switch points, and frog shall bear fully on the plates. No portion of the various plate shoulders, or stone or any foreign material, will be permitted under the base of rail, switch points, frog, or guard rails. In no case shall the gap between the base of the switch point and the top of the plate exceed 1/16-inch.

(3) The guard rail flangeway, switch point, frog flangeway, and switch point rod areas shall be cleaned and dressed to allow component parts to function properly. Tie cribs that contain switch rods shall be kept open to provide drainage and prevent build-up of snow and ice in the winter.

(4) If, during the installation process, any screw spike becomes damaged, bent, loose, is found to not meet the proper alignment or designated head contact, or is otherwise not functioning as intended, the Contractor shall remove damaged screw spikes. The resulting holes shall be filled with a synthetic tie plugging material as specified in Subsection 709.04(e) and new screw spikes shall be installed. Driving of timber screw spikes with a sledgehammer or spike maul is prohibited. Use of track spikes will not be permitted.

(5) The tie cribs shall be dressed such that the ballast does not extend higher than 2-inches below the top of tie elevation within the limits of the first switch tie ahead of the point of switch to the tie behind the heel. All tie cribs with switch rods shall be dressed such that the ballast does not extend higher than 6-inches below top of tie elevation. The profile of the ballast in the vicinity of the switch stand shall not extend higher than 6-inches below the top of tie elevation. The ends of the switch ties extending from the first switch tie ahead of the point of switch to the tie behind the heel shall be dressed such that the ballast does not extend higher than 2-inches below the top of tie elevation.

(e) Post-Surfacing Adjustments. After all turnout surfacing work has been completed, the Contractor shall check and make any adjustments necessary to turnout gage, frog guard rail facing limits, switch points and stock rails, the switch stand, and the connecting rod tension.

(1) Graphite or other lubricant as specified in Subsection 715.07(k) shall be applied to all switch plates following cleaning of the plates.

(2) The Contractor shall tighten all loose joints and frog bolts by mechanical means to manufacturer recommendations.

(f) Temporary Joints. The Contractor shall thermite weld temporary turnout joints in accordance with Subsection 662.14.

(g) Construction Tolerances. The new turnout shall be constructed within the tolerances shown in Table 665.04A.

TABLE 665.04A – TRACK SURFACE AND ALIGNMENT CONSTRUCTION TOLERANCES

Track Surface and Alignment Parameter	Maximum Allowable Construction Tolerance
Deviation from uniform profile on either rail at the mid-ordinate of a 62-foot chord shall not exceed	1/4 in.
Deviation from zero cross level at any point on tangents shall not exceed	1/8 in.
The difference in cross level between any two points less than 62 feet apart on tangents or curves shall not exceed [1]	1/4 in.
Deviation from uniform alignment at the mid-ordinate of a 62-foot chord on tangent and curved track shall not exceed	1/4 in.

[1] An exception to this tolerance is the allowable rate of change of elevation within spirals which shall be between 3/8 inch and 1/2 inch over 40 feet.

The Contractor shall raise, align, and surface the adjacent existing track to tie into the turnout as specified in Subsection 662.12.

The Contractor shall weld the new turnout rails to existing continuous welded rail in accordance with Section 662, installing new rail as required. Rail anchors shall be installed as specified in Section 662.

665.05 RAISE, ALIGN, AND SURFACE TURNOUTS AND CROSSOVERS. The Contractor shall raise, align, and surface turnouts and crossovers at the locations indicated in the Contract, or as directed by the Engineer.

Turnouts and crossovers shall be raised in 2-inch maximum nominal lifts unless otherwise approved by the Engineer. The completed turnout or crossover section shall conform with Table 665.04A.

(a) Turnout and Crossover Alignment. Turnout and crossover alignment shall be in conformance with Table 665.04A.

(b) Turnout and Crossover Surface. Turnout and crossover surface shall be in conformance with Table 665.04A. Each end of the turnout or crossover shall be surfaced a minimum of 100 feet in each direction.

(c) Turnout and Crossover Elevation. The grade shall conform to the Plans. No superelevation shall be added within the limits of the turnout or crossover, unless otherwise shown on the Plans.

(d) Ballast. Ballasting, surfacing, aligning, tamping, and dressing of track shall be performed in accordance with Subsection 665.04(d) and the following:

(1) The Contractor shall perform as many raising and surfacing passes as necessary to bring the turnout or crossover surface to the geometric parameters in Table 665.04A.

(2) Final surfacing and aligning shall bring the turnout or crossover to final grade and alignment and shall comply with surface tolerances specified in Table 665.04A. The limit of surfacing shall extend at least 100 feet beyond the switch points and at least 100 feet beyond the last long timber on both the straight and diverging track.

(e) Post-Surfacing Adjustments. Post-surfacing adjustments shall be performed as specified in Subsection 665.04(e).

665.06 REMOVAL OF TURNOUTS AND CROSSOVERS. Existing turnouts and crossovers shall be removed within the limits shown on the Plans. All materials removed shall become the property of the Contractor and shall be removed from the project site and properly disposed of, unless otherwise stated in the Contract.

665.07 METHOD OF MEASUREMENT. The quantity of Railroad Turnout; Railroad Turnout, No. 8; and Railroad Turnout, No. 10 to be measured for payment will be the number of each turnout installed in the complete and accepted work.

The quantity of Removal of Railroad Turnout to be measured for payment will be the number of each turnout removed in the complete and accepted work.

The quantity of Remove and Reset Railroad Turnout to be measured for payment will be the number of each turnout removed and reset in the complete and accepted work.

The quantity of Raise, Align, and Surface Turnout and Raise, Align, and Surface Crossover to be measured for payment will be the actual number of turnouts or crossovers aligned and surfaced in the complete and accepted work.

665.08 BASIS OF PAYMENT. The accepted quantity of Railroad Turnout; Railroad Turnout, No. 8; and Railroad Turnout, No. 10 will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing and installing the turnout, including all required welding, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Removal of Railroad Turnout will be paid for at the Contract unit price per each. Payment will be full compensation for removing the existing turnout, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove and Reset Railroad Turnout will be paid for at the Contract unit price per each. Payment will be full compensation for removing and resetting the existing turnout, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Raise, Align, and Surface Turnout and Raise, Align, and Surface Crossover will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work. All loose joints and frog bolts shall be tightened by mechanical means and included in the item for Raise, Align, and Surface Turnout or Raise, Align, and Surface Crossover.

Geotextile, subballast, and ballast will be paid for separately under the appropriate Contract items.

Payment will be made under:

Pay Item		Pay Unit
665.0100	Railroad Turnout	Each
665.0108	Railroad Turnout, No. 8	Each
665.0110	Railroad Turnout, No. 10	Each
665.0200	Removal of Railroad Turnout	Each
665.0300	Remove and Reset Railroad Turnout	Each
665.0500	Raise, Align, and Surface Turnout	Each
665.0550	Raise, Align, and Surface Crossover	Each

SECTION 667 – OTHER TRACK MATERIAL

667.01 DESCRIPTION. This work shall consist of removing and replacing joint bar sets, installing compromise rail joint assemblies to connect two abutting rails of differing sizes, installing conventional poly or bonded insulated joints, and removing and replacing tie plates.

667.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Other Track Material (OTM) 715.08

667.03 SUBMITTALS. The following information shall be prepared and submitted for review and approval by the Engineer. Submittals shall meet the requirements of Subsection 105.06.

(a) Fabrication drawings of all track material components. For joint bars and compromise joint bars, the fabrication drawings shall indicate all bolt hole locations.

(b) Manufacturer's certificate of compliance for all materials that are incorporated into the work.

(c) For insulated joints, the following submittals are required:

(1) Catalog cuts or other manufacturer's descriptive literature on insulated joints and fasteners.

(2) Manufacturer's field installation (to include bolt torque) and test procedures.

(3) Locations where rail cutting and welding is required for insulated joints.

(4) Fabrication drawings, including fabrication details, for insulated joints.

(d) Shop drawings and catalog cuts for all assembly hardware for bridge tie connections.

667.04 JOINT BAR SETS. All defective joint bar sets identified by the Engineer shall be removed and acceptable similar replacement bar sets (assemblies) installed. If one or both joint bars are defective, both joint bars shall be replaced.

Joint bars may be deemed defective and rejected by the Engineer for the following reasons:

(a) Cracks, breaks, or other flaws that impair the proper functioning of the bar or where integrity of the bar has been compromised.

(b) Bolt holes with wear which prevents a snug fit of the bolt assembly.

(c) Excessive deterioration from rust, scale, or brine.

(d) Any vertical movement of either rail when all the bolts are tight.

All existing bolts, nuts, and washers shall be replaced.

All the bolts for a joint bar assembly shall have a washer and a nut and shall be tightened in accordance with *AREMA Chapter 5, Section 5.5*.

667.05 COMPROMISE JOINTS. Compromise joints shall be installed so opposite rail joints are staggered by at least 4 feet 11 inches. When joining rails of differing sizes with a compromise rail joint assembly, it shall be fitted so that the top of rail surface and the gage face of the rails to be connected are held in alignment. Bars shall be stamped with markings indicating the field side and gage side of the bars and shall be installed accordingly.

The Contractor shall install bolt sets in all assembly bolt holes. Driving of bolts will not be permitted. The Contractor shall tighten all bolts in accordance with *AREMA Chapter 5, Section 5.5*.

If there are fewer existing bolt holes in the rail than there are bolt holes in the compromise joint bar, the Contractor shall provide additional bolt holes by drilling with a rail drill of the appropriate size. No other method will be permitted.

667.06 INSULATED JOINTS.

(a) Inspection. Insulated joints shall be inspected for conformance with the manufacturer's material specifications before installation of track. Insulated joints shall be inspected after installation to ensure conformance with the approved manufacturer's field installation and test procedures.

(b) Installation of Insulated Joints. Insulated joints shall be installed in accordance with the manufacturer's fabrication drawings, the applicable requirements of *AREMA C&S Manual Part 8.6.35*, and the Plans.

Insulated joints shall be installed at signal locations in track as shown on the Plans. The location of insulated joints may be adjusted to match field conditions where directed by the Engineer.

At each location requiring two insulated joints, the insulated joints shall have a maximum stagger in compliance with *AREMA C&S Manual, Part 2.1.20A* through *AREMA C&S Manual, Part 2.1.20D*.

The Contractor shall install all insulated joints as suspended joints. In ballasted track, the Contractor shall re-space existing cross ties to achieve this requirement.

Field welding of bonded insulated joints into the running rail shall be in accordance with Section 662.

The Contractor shall secure all insulated joints by box anchoring 200 feet of each side of an insulated joint.

Bolts shall alternate so that all nutlocks are not on one side of the joint unless otherwise specified by the manufacturer.

667.07 TIE PLATES. Existing defective tie plates shall be removed and replacement tie plates installed on the ties indicated on the Plans or where directed by the Engineer.

The Contractor shall plug spikes holes, adze ties, place new tie plates, and spike new tie plates in accordance with Subsection 662.08, Subsection 662.10(b), and Subsection 662.11.

667.08 METHOD OF MEASUREMENT. The quantity of Remove and Replace Joint Bar Sets to be measured for payment will be the number of joint bar sets (consisting of two joint bars, and all necessary bolts, nuts, and washers) installed in the complete and accepted work.

The quantity of Compromise Joint Bar Sets to be measured for payment will be the number of compromise rail joint bar sets (consisting of two joint bars, and all necessary bolts, nuts, and washers) assemblies installed in the complete and accepted work.

The quantity of Insulated Joints to be measured for payment will be the number of insulated joints installed in the complete and accepted work.

The quantity of Remove and Replace Tie Plates to be measured for payment will be the actual number of tie plates furnished and installed in the complete and accepted work.

667.09 BASIS OF PAYMENT. The accepted quantity of Remove and Replace Joint Bar Sets will be paid for at the Contract unit price per each joint assembly. Payment will be full compensation for removing existing joint bars; furnishing and installing new joint bars, bolts, nuts, and washers, labor; and furnishing all tools, equipment, materials, and incidentals necessary to complete the work.

The accepted quantity of Compromise Joint Bar Sets will be paid for at the Contract unit price per each joint assembly. Payment will be full compensation for installing a properly fitted compromise rail joint assembly, complete with new properly tensioned bolts, nuts, and washers, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete work.

The accepted quantity of Insulated Joints will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Plug rails for bonded insulated joints will not be paid separately but will be considered incidental to Insulated Joints. Field welding for the installation of bonded insulated joints will not be paid for separately but will be considered incidental to Insulated Joints.

The accepted quantity of Remove and Replace Tie Plates will be paid for at the Contract unit price per each. Payment will be full compensation of all labor, material, including track spikes and tie plugs, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
667.0010	Remove and Replace Joint Bar Sets	Each
667.0015	Compromise Joint Bar Sets	Each
667.0020	Insulated Joints	Each
667.0100	Remove and Replace Tie Plates	Each

SECTION 675 – TRAFFIC SIGNS

675.01 DESCRIPTION. This work shall consist of constructing, furnishing, and installing sign post foundations, sign posts, traffic signs, removing existing signs, setting salvaged sign posts, and resetting signs.

675.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Concrete shall conform to the requirements of Section 541 for Concrete, Class B.

675.03 GENERAL REQUIREMENTS. Foundation components, sign posts and traffic signs shall always be handled to prevent damage. Damaged foundations, sign posts, or traffic signs will be rejected. Signs shall be installed with adequate sight distance in accordance with the *MUTCD*.

675.04 FOUNDATIONS. Foundations, of the size and type specified, shall be constructed at the locations shown on the Plans. The Contractor shall excavate to depths and dimensions as required and shall construct the foundation in accordance with the Contract. Stub posts or steel pipe, whichever applies, shall be placed in position, plumbed, leveled, and braced prior to the construction of the foundation, and projection above final grade shall be as shown in the Contract. Care shall be taken during construction of foundations to ensure that minimum shimming between the post and foundation is required.

Forms and braces shall not be removed and posts shall not be mounted on foundations until the concrete has cured in accordance with the requirements of Section 541. It shall be the Contractor's responsibility to ensure that all foundations, stub posts, and steel pipes are oriented such that when posts are mounted to the foundation the applicable sign post faces will be in the same plane, as required by the Contract. Foundations shall be backfilled with material approved by the Engineer and compacted in layers of not more than 6 inches by use of a mechanical tamper.

675.05 SLIP BASES. Slip bases shall be installed on sign posts at the locations shown on the Plans. Slip bases shall be compatible with the type and size of sign post on which they are to be installed. Slip bases shall meet the requirements of *NCHRP Report 350* or *MASH*. The Contractor shall provide the type of slip base and the corresponding FHWA eligibility letter to the Engineer for approval prior to installation.

675.06 SIGN POSTS. Sign posts, of the size and type specified, shall be installed at the locations shown on the Plans. Sign posts shall be installed on foundations, in anchors, or directly in the ground as specified in the Contract. Sign posts shall be erected plumb and level and shall remain plumb and level after the installation of the traffic sign, bracing or the sign itself will not be used to maintain sign posts plumb and level. When installed on foundations, minimum shimming will be allowed between a foundation and sign post at the discretion of the Engineer.

When two or more sign posts are required for a single-sign installation, they shall be oriented such that the sign post faces which the signs will be attached to, will be in the same plane, the plane shall be as required by the Contract. The tops of all posts in a single-sign installation shall be the same elevation and shall not extend above the sign.

For posts that do not require foundations and are set into a dug hole, holes shall be backfilled with material approved by the Engineer and compacted in layers of not more than 6 inches by use of a mechanical tamper.

Unless otherwise specified in the Contract all required modifications to posts shall be incidental to other Traffic Sign items.

675.07 TRAFFIC SIGNS. Traffic signs, of the design specified, shall be installed at the locations and on the post types as shown on the Plans.

(a) General Requirements. All traffic signs shall conform to the requirements of the Contract and the *MUTCD*.

All new signs installed, excluding double-sided signs, shall include a decal on the back of the sign with the following information, in 1-inch numbers and text, and as shown in this example:

Ownership: (Town or VTrans)

Date Fabricated: (MM/YY)

Route: (US ##, VT ##, or TH ##)

Decals shall remain intact and legible during the life of the sign, at least 15 years.

Ownership shall refer to the entity owning the sign. Generally, signs on state highways and U.S. routes, as well as stop signs and legal load signs on town highways at the intersection with a state or US route, belong to VTrans. All other signs on Class 1, Class 2, and Class 3 town highways belong to the town.

The date fabricated shall be the month and year of sign fabrication in MM/YY date format.

The route shall be the designation of the route the sign is located on. Note that in the case of stop and legal load signs at the intersection of a town highway and a state highway, the owner will be VTrans and the route will be US ## or VT ##.

(b) Sign Substrate. Unless otherwise specified on the Plans, signs with an area of 20 square feet or less shall be fabricated from flat sheet aluminum, and signs with an area greater than 20 square feet shall be fabricated from extruded aluminum panels.

The surfaces of sign substrate shall be flat and free of buckles, warps, dents, burrs, open cracks, open splits, open joints, or other defects. All edges shall be true and smooth with no tears, cracks, burrs, or other defects.

(1) Flat Sheet Aluminum. Fabrication of the flat aluminum sheets, including cutting to size, shall be completed prior to degreasing, etching or treating, and application of the retroreflective sheeting. Flat sheet aluminum may be sheared, blanked, sawed, or milled. No flame cutting will be permitted. Field drilling or punching of holes will be allowed as needed.

(2) Extruded Aluminum Panels. Extruded aluminum panels shall be of the butting type, 12 inches wide and of the lengths shown on the Plans. The moment of inertia of a panel shall not be less than 0.765 $in.^4$ and the panel shall be designed to carry a wind load of 30 psf.

All signs fabricated from extruded aluminum panels shall have extruded aluminum molding on the two vertical sides. The color shall be the same as the parent sign.

Fabrication, including punching or drilling holes and cutting to length, shall be completed prior to metal degreasing, treating, and application of the background material. Flame cutting will not be permitted. The panels shall be fabricated for horizontal mounting. Each panel shall extend the full width of a sign and shall be bolted at least every 24 inches to each adjacent panel.

(c) Retroreflective Sheeting. All sheeting shall be retroreflective. Retroreflective sheeting shall be of the color and type shown in the Contract or in accordance with the *MUTCD*, whichever applies. The face of a sign shall be completely covered by the retroreflective sheeting when used as a background. All panels of a multi-panel sign shall be of uniform background color and brilliance during both day and night.

Sign substrate shall be prepared and retroreflective sheeting applied in accordance with the retroreflective sheeting manufacturer's recommendations for the respective sign substrate. Retroreflective sheeting components shall be sourced from the same manufacturer and shall be designed or approved to work as a system.

(d) Mounting. Signs shall be mounted as tightly to the posts, frame, or the horizontal supporting members as shown on the Plans. For permanent installations of flat sheet aluminum signs to frames or posts, a nylon-insert locking nut and two washers shall be used. One washer shall be installed under the head of the bolt against the sign sheeting face and the second washer shall be installed under the nut. The minimum outside diameter of the washers shall be no less than the diameter of the bolt head. For all sign types, if bolts are used for mounting, the installed bolt shall be at least flush with the nut.

Horizontal and vertical supporting members required to hold together the separate extruded aluminum panels forming a multi-panel sign and to attach the sign to the posts, shall be either standard steel or aluminum structural shapes meeting the same requirements as for sign posts in accordance with the Plans. After a multi-panel sign is mounted, the individual panels shall be joined together as shown on the Plans to ensure a smooth, flat sign face, free of deflection.

675.08 REMOVING SIGNS. The Contractor shall remove signs as shown on the Plans. Unless otherwise shown on the Plans, removal shall include foundations to a minimum depth of 12 inches below finished grade, and anchors, sleeves, sign posts, traffic signs, frames, overhead supports, hardware, all other incidentals, as applicable, and filling holes and returning the area to a condition consistent with the adjacent areas.

Foundations shall not be removed when signs are to be set or reset on them. Except for where signs that are to be removed are also to be salvaged or reset, sign faces shall be defaced, including decal, so as not to be reused. Defacing shall be done using paint or to the satisfaction of the Engineer. Unless otherwise shown on the Plans, all material removed shall become the property of the Contractor.

Signs shown on the Plans that are to be removed and salvaged, including anchors, sleeves, sign posts, frames, traffic signs, and hardware, as applicable, shall be removed as specified herein and delivered to the locations identified in the Contract. Mounting hardware shall be in a sealed container and clearly marked with its contents. Components damaged during removal or salvaging, through the fault of the Contractor as determined by the Engineer, shall be replaced at no cost to the Agency.

Signs shown on the Plans that are to be removed and reset, including anchors, sleeves, sign posts, frames, traffic signs, and hardware, as applicable, shall be removed as specified herein and stored as necessary until they are to be reset. Components damaged during removal or storage, through the fault of the Contractor as determined by the Engineer, shall be replaced at no cost to the Agency.

675.09 RESETTING SIGNS. Signs that are to be reset, including anchors, sleeves, sign posts, sign frames and mounting hardware, as applicable, shall be reset to the location shown on the Plans.

The Contractor shall be responsible for transporting and stockpiling all anchors, sleeves, sign posts, sign frames and mounting hardware, as applicable, to and from the stockpiling location. The Contractor shall supply new mounting hardware, as required, to reset signs.

Anchors, sleeves, sign posts, frames, and traffic signs damaged through the fault of the Contractor, as determined by the Engineer, shall be replaced at no additional cost to the Agency.

675.10 METHOD OF MEASUREMENT. The quantity of Traffic Sign, Flat Sheet Aluminum and Traffic Sign, Extruded Aluminum to be measured for payment will be the number of square feet of the type specified, installed in the complete and accepted work. The measured quantities of traffic signs for signs with retroreflective sheeting on both sides shall be multiplied by a factor of 1.5.

The quantity of Square Tube Sign Post and Anchor to be measured for payment will be linear feet measured from the top of the post to the bottom of the anchor, installed in the complete and accepted work. No additional measurement will be made for required sleeves, anchors or overlap of posts.

The quantity of W-Shape Steel Sign Post and Tubular Steel Sign Post to be measured for payment will be the number of pounds of each type of post installed in the complete and accepted work, as determined by the lengths and the standard weight per linear foot of the specified material. No additional measurement will be made for required anchors, slip bases, or breakaway features.

The quantity of Foundation for W-Shape Steel Post, Foundation for Tubular Steel Post, Soil Bearing Slip Base, Erecting Salvaged Signs, and Setting Salvaged Posts to be measured for payment will be the number of each installed in the complete and accepted work.

The quantity for Sign Removal, Flat Sheet Aluminum; Sign Removal, Extruded Aluminum; and Resetting Signs to be measured for payment will be the number of each sign removed or reset in the complete and accepted work.

675.11 BASIS OF PAYMENT. The accepted quantity of Traffic Sign, Flat Sheet Aluminum and Traffic Sign, Extruded Aluminum will be paid for at the Contract unit price per square foot. Payment will include frames, supports, tee bars, and mounting hardware as required.

The accepted quantities for Square Tube Sign Post and Anchor will be paid for at the Contract unit price per linear foot. Anchors, sleeves, and other required hardware will not be paid for directly but will be considered incidental to the respective sign post item.

The accepted quantities for W-Shaped Steel Sign Post and Tubular Steel Sign Post will be paid for at the Contract unit price per pound. Payment will include anchors, slip bases, breakaway features, and other hardware as required.

Foundation for W-Shaped Steel Post, 24-Inch Diameter, Foundation for W-Shaped Steel Post, 30-Inch Diameter, and Foundation for Tubular Steel Post will be paid for at the Contract unit price per each. Payment will include concrete, reinforcing steel, anchor bolts, stub posts, steel pipe, breakaway features, and other hardware as required.

Soil Bearing Slip Base, Setting Salvaged Posts, Sign Removal, Flat Sheet Aluminum; Sign Removal, Extruded Aluminum; and Resetting Signs will be paid for at the Contract unit price per each.

Removal of sign posts and foundations will be considered incidental to the item Removing Signs, as applicable.

The cost of attachment hardware, including vandal-proof hardware when required, will be considered incidental to the pay item for the particular sign being used.

Payment will be full compensation for furnishing and erecting, fabricating, transporting, handling, applying, and installing the materials specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Excavation and backfill will not be paid for separately but will be considered incidental to the Contract unit prices for other items in the Contract.

Payment will be made under:

Pay Item		Pay Unit
675.2000	Traffic Sign, Flat Sheet Aluminum	Square Foot
675.2100	Traffic Sign, Extruded Aluminum	Square Foot
675.3100	W-Shape Steel Sign Post	Pound
675.3300	Tubular Steel Sign Post	Pound
675.3410	Square Tube Sign Post and Anchor	Linear Foot
675.3500	Soil Bearing Slip Base	Each
675.4100	Foundation for W-Shape Steel Post, 24 Inch Diameter	Each
675.4200	Foundation for W-Shape Steel Post, 30 Inch Diameter	Each
675.4300	Foundation for Tubular Steel Post	Each
675.5000	Sign Removal, Flat Sheet Aluminum	Each
675.5100	Sign Removal, Extruded Aluminum	Each
675.6000	Resetting Signs	Each
675.6100	Setting Salvaged Posts	Each

SECTION 676 – DELINEATORS

676.01 DESCRIPTION. This work shall consist of removing or furnishing and installing reflector units or delineators consisting of new or salvaged posts, reflectors, and plaques.

676.02 MATERIALS. Materials shall meet the requirements of the following subsections:

676.03 INSTALLATION. Delineator posts shall be set to the heights and at the locations shown on the Plans. They shall be set vertically facing the direction shown on the Plans or as directed by the Engineer.

Posts set in the ground shall be driven either by hand or by mechanical devices using a suitable driving cap and shall be set in the ground to the satisfaction of the Engineer. Hand tamping will be permitted. Posts set on the roadway surface shall have the base securely fastened to the surface. Delineators to be attached to bridge rail shall be consistent with the design shown on the Plans and securely fastened to the railing as shown on the Plans or as directed by the Engineer. Delineator assemblies and plaques, when required, shall be attached after the posts are set.

Delineators shall consist of flat sheet aluminum substrate and completely covered by retroreflective sheeting of the color and type shown in the Contract.

The replacement of delineators on existing posts that are to remain shall be as shown on the Plans or as directed by the Engineer.

676.04 METHOD OF MEASUREMENT. The quantity of Delineators with Steel Post, Removal of Existing Delineator and Post, Remove and Replace Delineator, and Delineator with Flexible Post to be measured for payment will be the number removed, installed, or replaced in the complete and accepted work.

676.05 BASIS OF PAYMENT. The accepted quantity of Delineators with Steel Post, Removal of Existing Delineator and Post, Remove and Replace Delineator, and Delineator with Flexible Post will be paid for at the Contract unit price for each. Payment will be full compensation for removing or furnishing, fabricating, transporting, handling, and installing the materials specified, including plaques when required, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
676.1000	Delineator with Steel Post	Each
676.1200	Removal of Existing Delineator and Post	Each
676.1500	Remove and Replace Delineator	Each
676.2000	Delineator with Flexible Post	Each

SECTION 677 – OVERHEAD TRAFFIC SIGN SUPPORTS

677.01 DESCRIPTION. This work shall consist of furnishing and installing overhead traffic sign supports and removing and disposing of existing overhead traffic sign supports, including the concrete footings.

677.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Mortar, Type IV .....707.01(e)
Aluminum Filled Silicone Sealant 707.11
Bar Reinforcement 713.01
Carbon Steel Bolts, Nuts, and Washers 714.04
High-Strength Structural Bolts and Assemblies, 120 ksi.....714.05
Anchor Bolts for Traffic Signals, Lighting, and Overhead Signs.....714.09
Steel Tubing 714.11
Grounding Electrodes 752.11

The sign support shall be constructed of the materials shown on the Plans.

The sign support design may be a cantilever structure or a multi-support structure (tubular beam, tri-chord, or box truss).

All design details, quality of work, procedure, materials, etc., shall be in accordance with the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Concrete shall conform to the requirements of Section 541 for Concrete, Class B.

All welding shall be performed in accordance with the provisions of Section 506.

677.03 GENERAL REQUIREMENTS. Overhead traffic sign supports shall be constructed in accordance with the details shown on the Plans.

The design of mast arm and overhead sign support foundations shall be performed in accordance with *MREI 10-01*.

Prior to installation, the Contractor shall submit fabrication drawings in accordance with Subsection 105.06, which shall include a complete list of materials.

High-strength bolts, nuts, and washers shall be tensioned in accordance with Subsection 506.18. Field verification testing for direct tension indicators is not required.

Anchor bolts shall be pre-tensioned in accordance with the following procedure:

(a) Verify that the nuts can be turned onto the bolts past the elevation corresponding to the bottom of each in-place leveling nut and be backed off by the effort of one person on a 12-inch long wrench or equivalent (i.e. without employing a pipe extension on the wrench handle).

(b) Clean and lubricate the exposed threads of all anchor bolts. Clean and lubricate the threads and bearing surfaces of all leveling nuts. Re-lubricate the exposed threads of the anchor bolts and the threads of the leveling nuts if more than 24 hours have elapsed since earlier lubrication, or if the anchor bolts and leveling nuts have become wet since they were first lubricated.

(c) Turn the leveling nuts onto the anchor bolts and align the nuts to the same elevation.

(d) Place structural washers on top of the leveling nuts, with one washer corresponding to each anchor bolt. Install the base plate atop the leveling nuts and place structural washers on top of the base plate with one washer corresponding to each anchor bolt. Turn the top nuts onto the anchor bolts.

(e) Tighten the top nuts to a snug-tight condition in a star pattern. Snug-tight is defined as the maximum nut rotation resulting from the full effort of one person on a 12-inch long wrench or equivalent. A star tightening pattern is one in which the nuts on opposite or near-opposite sides of the bolt circle are successively tightened in a pattern resembling a star. For example, for an 8-bolt circle with bolts sequentially numbered 1 to 8, tighten the nuts in the following bolt order: 1, 5, 7, 3, 8, 4, 6, 2.

(f) Tighten leveling nuts to a snug-tight condition in a star pattern.

(g) Before final tightening of the top nuts, mark the reference position of each top nut in a snug-tight condition with suitable marking on one flat with a corresponding reference mark on the base plate at each bolt. Then incrementally turn the top nuts using a star pattern until achieving the required nut rotation specified below. Turn the nuts in at least two full tightening cycles (passes). After tightening, verify the nut rotation.

(h) Top nuts for *ASTM F1554*, Grade 55 anchor bolts shall be tightened to 1/3 turn beyond snug-tight condition for bolts less than or equal to 1-1/2 inch diameter and 1/6 turn beyond snug-tight condition for bolts greater than 1-1/2 inch diameter. The tolerance for nut rotation is + 20°. A beveled washer shall be used if the nut is not in firm contact with the base plate or if the outer face of the base plate is sloped steeper than 1:40 (V:H).

Tightening requirements for all other bolted connections shall be specified on the fabrication drawings.

Concrete footings shall be backfilled by placing and compacting uniform layers of approved material not exceeding 6 inches in depth.

Where aluminum alloys come in contact with other materials, the contacting surfaces shall be separated with a fabric pad 1/8 inch in thickness or cleaned and thoroughly coated with an aluminum filled silicone sealant.

The space between the top of the concrete footing and metal base of the support shall be sealed with a stainless steel wire cloth. The wire cloth shall be stainless steel standard grade, with a 1/4 inch maximum opening and a minimum wire diameter of No. 16 AWG with a 2-inch lap. It shall be secured with 3/4 inch stainless steel banding after anchor bolts are fully tightened.

Where existing overhead traffic sign supports are to be removed, the Contractor shall remove and dispose of the entire sign assembly, including concrete footings, to a depth of 18 inches below existing grade. Areas of ground disturbance shall be restored to the satisfaction of the Engineer.

677.04 GROUNDING. All posts used in overhead sign supports shall be grounded in accordance with Section 678.

677.05 METHOD OF MEASUREMENT. The quantity of Overhead Traffic Sign Support, of the type specified, to be measured for payment will be the number of each installed in the complete and accepted work.

The quantity of Remove and Reset Overhead Traffic Sign Support to be measured for payment will be the number of each removed and reset in the complete and accepted work.

The quantity of Remove Existing Overhead Sign Assembly of the type specified to be measured for payment will be the number of each assembly removed in the complete and accepted work.

677.06 BASIS OF PAYMENT. The accepted quantity of Overhead Traffic Sign Support, of the type specified, will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified, including the concrete footings, excavation, and backfilling and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove and Reset Overhead Traffic Sign Support will be paid for at the Contract unit price for each. Payment will be full compensation for removing the existing sign support, including all excavation, removal of the existing base as required, furnishing, placing, and compacting all necessary backfill, all necessary disconnections and modifications to existing wiring, construction of a new base as required, grading all areas disturbed by the work, turf establishment in those areas if turf establishment is not otherwise included in the Contract and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove Existing Overhead Sign Assembly of the type specified will be paid for at the Contract unit price per each. Payment will be full compensation for removing and disposing of assembly components, including concrete footings; for performing any excavation necessary; for restoring areas of ground disturbance; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Costs associated with providing traffic control or Flaggers for performing the work will be paid under the appropriate Contract items.

Payment will be made under:

Pay Item		Pay Unit
677.1200	Overhead Traffic Sign Support, Cantilever	Each
677.1300	Overhead Traffic Sign Support, Multi-Support	Each
677.2200	Overhead Traffic Sign Support, Cantilever with Lighting	Each
677.2300	Overhead Traffic Sign Support, Multi-Support with Lighting	Each
677.2500	Remove and Reset Overhead Traffic Sign Support	Each
677.3000	Remove Existing Overhead Sign Assembly, Cantilever	Each
677.3500	Remove Existing Overhead Sign Assembly, Multi-Support	Each

SECTION 678 – TRAFFIC SIGNALS

678.01 DESCRIPTION. This work shall consist of furnishing, installing, or modifying a traffic signal, including all items necessary to provide a complete and operational system.

678.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Granular Backfill for Structures.....704.08
Mortar, Type IV.....707.01(e)
Aluminum Filled Silicone Sealant.....707.11
Paint for Traffic Control Signals.....708.06
Bar Reinforcement.....713.01
Carbon Steel Bolts, Nuts, and Washers.....714.04
High Strength Structural Bolts and Assemblies, 120 ksi.....714.05
Anchor Bolts for Signals, Lighting, and Overhead Signs.....714.09
Galvanizing.....726.06
Retroreflective Sheeting.....750.04
Pedestal Posts and Bases.....752.01
Traffic Signal Assembly.....752.02
Traffic Signal Heads.....752.03
Traffic Signal Controllers and Cabinets.....752.04
Aerial Flashing Beacons.....752.05
Electrical Conduit.....752.06
Traffic Signal Conductor Cable.....752.07
Vehicle Detectors.....752.08
Junction Boxes and Pull Boxes.....752.09
Accessible Pedestrian Signals.....752.10
Grounding Electrodes.....752.11
Pan-Tilt-Zoom Camera.....752.12
Emergency Vehicle Preemption System.....752.13

Concrete shall conform to the requirements of Section 541 for Concrete, Class HPA.

Steel reinforcement shall conform to the requirements of Section 507.

678.03 GENERAL REQUIREMENTS. Traffic signals shall be installed as shown on the Plans and as specified in the Contract.

All design details, submittals, materials, installation, and wiring shall be performed in accordance with the applicable documents listed below, and other industry standards as appropriate.

(a) *National Electrical Code*

(b) *National Electrical Safety Code*

(c) *NEMA TS 2*

(d) *MUTCD*

(e) *Americans with Disabilities Act*

(f) *AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*

(g) *MREI 10-01*

678.04 SUBMITTALS. The Contractor shall submit working drawings in accordance with Subsection 105.06. All submittals shall indicate, on the drawings or in the cover letter, that the Contractor has reviewed the submittals and that they are in conformance with the Contractor's proposed installation procedures.

(a) References. All submittals shall indicate conformance with the applicable documents listed in Subsection 678.03 and the Contract.

(b) Contractor Qualifications. Documentation shall be provided to the Engineer prior to commencing signal work that the work will be performed under the supervision of a licensed master electrician with IMSA Traffic Signal Construction Technician Level II certification.

(c) Required Submittals.

(1) Traffic Signal Controller. Fabrication drawings shall be provided identifying the following:

a. Manufacturer, model, and type

b. Controller programming data

(2) Controller Cabinet. Fabrication drawings shall be provided identifying the following:

a. Manufacturer, model, and type

b. Dimensions

c. Ancillary Equipment

d. Finish (coating and color)

(3) Bench Test Results. Successful bench testing results, using the approved controller programming data, shall be provided for new controller cabinets. When a new controller is

being installed with a new cabinet, they shall be tested together. When a salvaged controller is being installed in a new cabinet, the cabinet shall be tested using the same model controller running the proposed timings.

Bench testing shall be performed by an independent third-party testing entity. The test shall be performed or supervised by a licensed professional engineer or technician with IMSA Traffic Signal Bench Technician Level II certification.

A report shall be provided with the following information:

a. Testing entity and location of testing

b. Testing date and begin and end time

c. Controller settings used

d. Equipment serial numbers

e. Name, credentials, and signature of individual responsible for the test results

Controllers or cabinets shipped prior to Agency approval of the bench test results shall be at the sole risk of the Contractor. The Contractor shall be responsible for any costs related to a rejected controller or cabinet.

(4) Traffic Signal and Pedestrian Heads. Fabrication drawings shall be provided identifying the following:

a. Manufacturer and model

b. Material specifications and dimensions

c. Wiring

d. Housing dimensions, material, and color

e. Lens material and color

f. Mounting bracket

g. Visor shape and color

h. Backplates (if applicable)

(5) Traffic Signal Assembly.

a. Design calculations shall include the following:

1. The design axial and shear forces and bending and torsional moments acting at the top of the foundation

2. The design axial, bending, and shear stresses and the combined stress ratio

3. Vibration and fatigue calculations as set forth in the required AASHTO standard listed

4. The allowable axial, bending, and shear stresses

5. The calculations required in Subsection 678.04(c)(5)a.1., Subsection 678.04(c)(5)a.2., and Subsection 678.04(c)(5)a.4. shall be shown for each group loading and for the basic wind load applied to the two cases outlined in the AASHTO standard listed

b. Fabrication drawings shall include the following:

1. Detailed drawings of each component of the structure

2. Material specification for each component of the structure, either by complete specification or reference to the applicable ASTM standard

3. The project name, project number, Contract number, route number, and structure number on each sheet

4. Details for location of signs or signals and attachment hardware for the support structure

5. All elevation and dimensions necessary to provide a complete set of record plans

6. Dead load deflection and vertical rise information

7. Welding details and procedures for all welds

8. Bolt tensioning requirements

9. Finish (coating and color)

(6) Pedestal Posts. Fabrication drawings shall be provided identifying the following:

a. Dimensions and connection details

b. Material specifications

c. Finish (coating and color)

d. Foundation

(7) Vehicle Detection System. Fabrication drawings shall be provided identifying all components of the vehicle detection system including, but not limited to, the following:

a. Manufacturer, model, and type

b. Processing hardware

c. Wiring

d. Proposed installation locations

e. Documentation that installation locations and mounting hardware are in conformance with the manufacturer's recommendations

(8) Emergency Vehicle Preemption System. Fabrication drawings shall be provided identifying all components of the emergency preemption system including, but not limited to, the following:

a. Manufacturer, model, and type

b. Processing hardware

c. Wiring

d. Proposed installation locations.

e. Documentation that installation locations and mounting hardware are in conformance with the manufacturer's recommendations.

(9) Ancillary Equipment. Fabrication drawings shall be provided identifying all required ancillary equipment including, but not limited to, the following:

a. Manufacturer, model, and type

b. Functions

678.05 CONSTRUCTION REQUIREMENTS.

(a) Incidental Work. Unless otherwise shown in the Contract, the Contractor shall perform all excavations, backfilling, and resurfacing work, including removal and replacement of curbs, sidewalks, paved surfaces, and any other materials necessary to complete the work in accordance with the applicable sections of the specifications.

All pavement surfaces to be removed shall be saw-cut to the full pavement depth along the neat lines of the area to be removed.

All landscaping and underground utility systems that have been disturbed during construction shall be restored to their original condition upon the completion of the work.

Backfill of suitable material shall be placed and compacted in layers not exceeding 6 inches. Backfill for footings shall meet the requirements of Subsection 704.08.

(b) Foundations. Foundations shall be designed in accordance with the Contract. All foundations shall meet the following requirements:

(1) A minimum embedment depth of five feet shall be used for all spread footing foundations, measured from the ground surface elevation to the bottom of footing elevation.

(2) For drilled shaft foundations, concrete shall be poured against undisturbed soil unless a permanent casing is designed for, and appropriate supporting calculations are provided. The top two feet of soil shall be neglected for design purposes. A disposable circular concrete form, if used, shall not be placed deeper than two feet, in order to not reduce the friction between the soil and the concrete.

(3) As an alternative to the drilled holes, footings may be poured in excavated holes using the proper forms, which shall be removed. The excavated holes shall be at least two feet clear of the foundation sides and one foot deeper than the foundation. Care shall be taken to avoid excavating around the top of the foundation. The backfill material shall be compacted as described in Section 204. The same design limits as for drilled footings apply.

(4) Any backfill placed adjacent to the footing shall be granular material meeting the requirements of Subsection 704.08. It shall be compacted as described in Section 204.

(5) Concrete for the foundation shall conform to the requirements of Section 541. If a different class of concrete is required for drilled shaft foundations, it shall be included in the submittal.

(6) Reinforcing steel for mast arm pole foundations shall be in accordance with Section 507.

(7) Steel piles, if used, shall meet the requirements of Section 505.

(8) When the design depth of a foundation cannot be obtained due to unforeseen field conditions, the Contractor shall notify the Engineer and resubmit the foundation design.

(c) Electrical Conduit Sleeves. Electrical conduit sleeves shall be installed in accordance with Subsection 625.04(b).

The Contractor shall seal the ends of conduit sleeves with a material that will not decompose prior to backfilling the sleeve.

(d) Conduit. Electrical conduit shall be installed in accordance with Subsection 625.04(c).

Unless otherwise specified, the conduit shall be laid in a straight line with no bends except preformed bends and at the entrance to a pull box, junction box, or a concrete base.

For metal conduit, all couplings shall be tightened until the ends of the conduit are together. Any cutting of the conduit shall be made squarely so that the resulting ends will butt together over their full area. The ends of conduits shall be reamed and have threaded connections. Slip joints or running threads shall not be used for couplings. The exposed ends for all types of conduits shall be capped with standard conduit caps until wiring starts, at which time they shall be replaced with approved bushings.

Either elbows or sweeps may be used for entering concrete bases, but elbows shall be used at the base of a service pole on the street quarter of the pole.

All unused conduit and void space in wired conduit that terminates in a traffic signal cabinet, mast arm pole, junction box, or pull box shall be plugged with steel wool and capped with a standard conduit cap.

(e) Junction Box. Junction boxes shall be installed in accordance with Subsection 625.04(e).

(f) Grounding. Each traffic signal system shall be grounded. The ground shall consist of the following:

(1) An internal ground lug opposite the hand hole.

(2) A No. 6 AWG minimum soft drawn copper grounding electrode conductor.

(3) A 5/8 inch × 8 foot minimum copper clad grounding electrode. The resistance to ground shall be 25 ohms or less.

Additional grounding electrodes may be required, with a minimum spacing of 6 feet. When a power service meter and disconnect are attached to a pole, there shall be a continuous ground wire from the meter and disconnect, which may run internal to the upright, through the 1/2 inch flexible tubing in the concrete base to the required grounding electrodes. The ground wire from the pole grounding lug, controller cabinet, or luminaire may attach to this continuous grounding electrode from the service meter and disconnect.

The Contractor shall perform a resistance to ground test on the continuous grounding electrode from the service meter and disconnect and provide a submittal to the Engineer from a master electrician certifying that the grounding electrode is continuous from the service meter and disconnect and the resistance to ground is 25 ohms or less. If the resistance is greater than 25 ohms, at least one additional ground rod will be required until the resistance is brought down to 25 ohms or less.

(g) Grounding Electrodes and Couplings. Each metal pole that is part of the traffic signal system shall be grounded.

The grounding electrodes shall be driven vertically until the top of the rod is at least 4 inches below the finished ground at a location one foot from the pole foundation.

The grounding electrode coupling and grounding electrode shall be compliant with Subsection 752.11. Grounding electrodes shall be connected to the post or pole base using grounding conductors in accordance with Subsection 752.11(c). The grounding electrode coupling shall be attached to the grounding electrode by an exothermic welding process or UL listed mechanical clamp.

(h) Power Drop Stanchion. Power drop stanchions shall meet the requirements of Section 625.

(i) Traffic Signal Assembly. Traffic signal assemblies shall be installed as shown on the Plans or as directed by the Engineer.

(1) Erection of Posts and Poles. All posts and poles shall be erected on concrete foundations at the locations shown on the Plans or as directed by the Engineer. The space between the top of the concrete footing and metal base of the support shall be sealed with wire screen.

All poles shall be level and plumb in the final loaded condition. In the erection of posts and poles, leveling nuts shall be provided for installation between the bases and concrete foundation. When aluminum alloys encounter other materials, the contacting surfaces shall be thoroughly cleaned and coated with a silicone sealant that will adhere to aluminum and concrete. Before erecting the pole, the Contractor shall clean the top of the foundation of any laitance, oils, grease, or any other deleterious materials.

The Contractor shall not install mast arm poles until the foundation has achieved 85% of the specified 28-day concrete strength based on field cured cylinders.

(2) Fabrication. All mast arms, mast arm poles, foundations, and miscellaneous hardware shall be fabricated in accordance with the Contract. All components for mast arms and mast arm poles shall be obtained from the same fabricator. Each mast arm pole shall include a pole tag. The information shall be stamped on a metal tag riveted to the pole near the hand hole. The tag shall include the following information:

a. Mast Arm Poles.

1. Diameter

2. Height

3. Yield strength

4. Gauge

b. Mast Arms.

1. Diameter

2. Length

3. Yield strength

4. Gauge

All components shall be protected from damage during shipping and handling by wrapping or other effective methods. Wrappings shall be removed no more than 5 calendar days after receipt of components, or immediately if the wrappings become saturated. Failure to comply with these requirements may lead to damage of the coating system and will be cause for the rejection of the component. Any component that is determined to be damaged beyond repair by the Engineer shall be replaced at no additional cost to the Agency.

(3) Protective Coating. All steel components, except concrete reinforcing, shall be hot dipped galvanized. The assemblies shall be designed and fabricated to permit galvanizing on all interior and exterior surfaces and shall be free of pockets and other structural obstructions that will not permit proper deposition of zinc coating. Galvanizing and repairs to damaged galvanized surfaces shall be in accordance with Subsection 726.06.

(4) Screen Installation. The Contractor shall install a wire screen covering the gap between the bottom of the base plate and the top of the concrete foundation. The wire screen shall be in full contact with the top of the mast arm pole foundation and the mast arm pole base plate. The wire cloth shall be stainless steel with a 1/4 inch maximum opening and a minimum wire diameter of No. 16 AWG with a 2 inch lap. It shall be secured with 3/4 inch stainless steel banding after anchor bolts are fully tightened.

(5) Anchor Bolts. Anchor bolts shall conform to Subsection 714.09 and shall be tightened in accordance with Subsection 677.03. After installation, a minimum of two threads on the bolt shall be exposed above the nut.

(6) Flange Bolts. All flange bolts, hex nuts, and washers shall conform to Subsection 714.05. The flange bolts shall be capable of resisting 133% of the full design stress of the tube at its yield strength stress. Flange bolts shall be tensioned in accordance with Subsection 506.18. Direct tension indicators are required.

(7) U-Bolts. U-bolts and associated hardware shall conform to Subsection 714.04. All U-bolts and hardware shall be galvanized in accordance with Subsection 726.06.

(8) Welding. Any welds shall be at least as strong as the materials being welded. Any welds shall be performed in accordance with Subsection 506.10.

High strength bolts, nuts and washers shall be tensioned in accordance with Subsection 506.18. Field verification testing for direct tension indicators is not required.

All materials greater than 1/2 inch thick shall meet the Charpy V-notch impact requirements for the specified material. Testing and sampling shall be in accordance with *AASHTO T 243*.

Horizontal members shall be cambered as specified on the Plans.

(j) Cabinet Assembly. The cabinet shall be installed at the location shown on the Plans or as directed by the Engineer. The cabinet shall be oriented so that the door opens away from the intersection or roadway and does not block a sidewalk or passageway.

The cabinet assembly shall consist of a traffic controller, ancillary equipment (including monitors, load switches, flasher, flash transfer relay, power supplies), and other equipment wired into a controller cabinet to make a complete and operational assembly. All cabinet assemblies shall provide functionality that meets or exceeds operational characteristics, including NTCIP support, as described in *NEMA TS 2*. All wiring shall be neat and secured and comply with all necessary electrical codes.

The cabinet shall be ground mounted unless otherwise specified on the Plans. Ground mounted cabinets shall be installed on a level, concrete foundation in conformance with Section 541. Ground mounted cabinets shall be sealed at their base with aluminum filled silicone sealant in conformance with Subsection 707.11. If the Plans specify that the cabinet be installed on an extended base, the area where the extended base meets the cabinet assembly and where it meets the concrete foundation shall be sealed with aluminum filled silicone sealant in conformance with Subsection 707.11.

The cabinet shall be supplied with signal layout sheets, wiring diagrams, pin assignment chart, conductor phase assignments, and manuals for circuits and components. These documents shall be stored in the cabinet in a resealable, weatherproof container, with the signal sheet laminated. All equipment installed within the cabinet shall be labeled on the cabinet shelving. The turn-on or switch-over date shall be labeled inside the cabinet door.

The traffic signal controller and auxiliary equipment shall be installed within the traffic signal cabinet as specified on the Plans.

All equipment installed in the traffic signal cabinet shall be in accordance with Section 752. The Contractor shall provide an electronic copy of the final controller configurations prior to acceptance of the traffic control signal system.

(k) Signal Heads. Signal heads shall be placed as shown on the Plans unless otherwise directed by the Engineer. Horizontal spacing of the signal heads and vertical clearances shall meet the requirements of the *MUTCD* and the Plans.

All signal head wires shall be continuous runs from the signal head to the controller cabinet. A separate neutral circuit shall be wired and returned to the controller cabinet from each phase. All terminal blocks shall be installed behind the red signal housing.

Where traffic signals are installed and not put into service immediately, or placed out-of-service temporarily, signal heads shall be covered in order to conceal them. The Contractor shall conceal the signal heads by securely placing burlap bags or other coverings approved by the Engineer. The covering shall be open at the bottom to prevent the buildup of condensation.

(l) Wiring. All wiring shall be performed in accordance with the *National Electrical Code*. Splices shall only be made at pull boxes, junction boxes, or pole bases. All splices shall be electrically and mechanically secure and shall be insulated for 600 volts. The completed splice shall be watertight and shall test electrically equal to or greater than the cable. All splices shall be soldered, using rosin core solder, and then be fully sealed using a method approved by the Engineer.

Unless otherwise shown on the Plans, each cable shall have a minimum of 3 feet of slack in each box or base.

Where shown on the Plans, wired conduit may be either pre-wired before the conduit is installed or the wire may be installed after the conduit is installed. The Contract item for wired conduit includes both the conduit and the wires contained within the conduit, however, the wires and the conduit shall not be attached to each other and the wires shall be readily pulled from the conduit for replacement without excessive effort.

Except when otherwise shown on the Plans, the minimum size for installed conduit shall be nominal 2-inch inside diameter conduit or it shall match the size of the existing conduit to which it is to be attached. In either case, the installed conduit shall be of sufficient inside diameter to contain wiring of a size such that the voltage drop in the secondary circuits will not exceed 3%.

Wiring conduits shall have a sufficient inside diameter such that the combined cross-sectional area of the wiring does not exceed the percentage of conduit fill specified in the *National Electrical Code*. Conduits shall, in accordance with the other requirements of this subsection, contain all the wiring necessary to make the completed system or subsystem functional.

Where electrical wiring is shown on the Plans, the Contractor shall remove the existing wiring, if such exists, from the existing conduit, strain pole, streetlight pole, or bracket arm and shall install new wiring meeting all code and specification requirements. The wiring shall be of a size such that the voltage drop in the secondary circuits will not exceed 3% and the wiring shall contain only the number of conductors necessary to make the completed system or subsystem function.

The minimum wire sizes for circuits shall be as specified in Table 678.05A.

TABLE 678.05A – MINIMUM SIGNAL WIRE SIZES

Service	AWG
From supply to disconnect	No. 6
Ground	No. 6
Disconnect to controller or flasher	No. 6
Controller to signals or beacons	No. 14
Controller to pavement units	No. 14
Controller to push button	No. 14
Interconnect figure 8	No. 12 (solid)

There shall be a neutral wire for every eight or fewer ungrounded conductors.

The Contractor shall furnish and install sufficient cable and wire to operate the system properly as shown on the Plans and as specified and shall provide at least two spare conductors in all signal and interconnect cable runs, including emergency and railroad preemption cables.

Where practicable, the Contractor shall wire the system in accordance with the color-coding system specified in Table 678.05B.

TABLE 678.05B – SIGNAL WIRE COLOR-CODING

Wire Color	Application
Red	Red light
Orange	Yellow light
Green [1]	Green light
White	Common ground for all signals and exposed metal parts
Blue	Arrows
Remaining	Push buttons and spare

[1] Green wires shall be tagged NOT GROUNDED WIRES

When wiring vehicle signal heads, the Contractor shall install a minimum of one No. 14 AWG 7-conductor signal cable from the controller cabinet to the mast arm pole base for each phase. For vehicle signal heads, the Contractor shall install a minimum of one No. 14 AWG 7-conductor cable for each signal phase to the base of the mast arm pole wired in parallel. For pedestrian signal heads, the Contractor shall install a minimum of one No. 14 AWG 5-conductor signal cable from the controller cabinet to each pedestrian head installation (no more than 3 wires per terminal) and push button location to operate either one or two pedestrian signal heads. Pedestrian buttons shall use "home run" wiring back to the signal cabinet with no more than 2 wires per terminal per phase.

Colored electrical tape intended to denote what phase the wiring is associated with shall be wrapped around the corresponding wire within the cabinet as specified in Table 678.05C.

TABLE 678.05C – ELECTRICAL TAPE COLOR-CODING

Phase	Electrical Tape Color
Phase 1	1 blue stripe
Phase 2	1 green stripe
Phase 3	1 yellow stripe
Phase 4	1 red stripe
Phase 5	2 blue stripes
Phase 6	2 green stripes
Phase 7	2 yellow stripes
Phase 8	2 red stripes
Pedestrian	Orange stripe with associated phase stripes

(m) Vehicle Detection System. The vehicle detection system shall be as specified on the Plans. All work associated with the vehicle detection system shall be completed prior to testing and turn-on of the traffic signal system.

All equipment shall be installed and wired in a neat and orderly manner in conformance with the manufacturer's instructions. All of the vehicle detection system components shall be current production equipment produced by the same manufacturer for system operation compatibility purposes unless otherwise specified.

The Contractor shall install the detector to achieve the desired fields of detection as shown on the Plans or as directed by the Engineer.

Routing of the detector cable shall provide a drip loop for protection of the detector and connector. The detector cable shall be installed as a continuous run with no splices from the detector to the processor in the traffic control cabinet unless specified otherwise by the manufacturer.

The Contractor shall be responsible for furnishing all training, labor, materials, cables, connectors, tools, equipment, shipping, and incidental items necessary to complete the installation and make the vehicle detection system fully operational.

(n) Pan-Tilt-Zoom Cameras. All pan-tilt-zoom cameras shall be installed as specified on the Plans or as directed by the Engineer. The camera shall be installed in a location with optimal view of the intersection per the manufacturer's guidance.

(o) Pedestrian Equipment. All pedestrian equipment shall be placed at the locations shown on the Plans or as directed by the Engineer. A pedestrian actuation sign shall be included with each push button assembly. Tactile arrows shall be aligned parallel with the direction of the crossing.

(p) Pedestal Post Assembly. All pedestal post assemblies shall be installed at the locations shown in the Plans or as directed by the Engineer. Pedestal post assemblies shall consist of a pole, transformer base, and concrete foundation. All grounding shall meet the requirements of Subsection 678.05(f).

(q) Aerial Flashing Beacon. Aerial flashing beacons shall be installed as specified on the Plans or as directed by the Engineer. Work shall consist of furnishing and installing flashing beacon signal heads, including poles, mounting equipment, signal cable, flash relay, and enclosure at the locations shown on the Plans or as directed by the Engineer.

The Contractor shall notify the Engineer a minimum of 48 hours prior to replacing existing or installing new aerial flashing beacons. A uniformed traffic officer shall be present to maintain traffic while the work is being performed as directed by the Engineer.

All existing flashing beacon signal heads to be replaced shall be replaced with new LED flashing beacon signal heads at the locations shown on the Plans or as directed by the Engineer. All existing flashing beacon signal heads and mounting equipment replaced shall be disposed of by the Contractor.

(r) Emergency Vehicle Preemption System. All equipment shall be installed and wired in a neat and orderly manner in conformance with the manufacturer's instructions. All emergency vehicle preemption system components shall be current production equipment produced by the same manufacturer for system operation compatibility purposes unless otherwise specified.

All traffic signal installations shall be supplied with a single emergency vehicle preemption receiver for each mainline approach to the intersection as noted in the major list of equipment or as directed by the Engineer.

Emergency vehicle preemption system receiver and confirmation strobe locations shall be determined by the Contractor in accordance with the manufacturer's guidance, if available.

Confirmation strobes shall serve to validate to the driver of the emergency vehicle that the traffic signal has recognized the preemption call and will initiate the proper preemption sequence. The confirmation strobes shall be illuminated whenever any emergency vehicle triggered preemption green is on. The confirmation strobes shall have a red lens.

The emergency vehicle preemption system shall have full ID and logging capabilities. Programming of the emergency vehicle preemption system shall be via a PC-based computer using unit-specific software. A hard copy of final programming data shall be left in the controller cabinet. The Contractor shall supply a complete set of interface cables for laptop connection in each controller cabinet.

The Contractor shall coordinate with local emergency services to test the emergency vehicle preemption system prior to the beginning of the 30 calendar day test period.

(s) Turn-On and Testing. Prior to turn-on and testing, all construction of the signal system shall be complete.

(1) Turn-On. The traffic signal shall not operate without the pavement markings and signal related signing in place. Full operation for a new installation or switch-over for replacement signals shall not be initiated except in the presence of the Project Manager, Traffic Signal Operations Engineer, or a designated representative. A uniformed traffic officer shall be required at every turn-on.

a. Existing Signals. Any locations that require a switch-over from one traffic signal system to another do not require a flash period.

b. New Signals. Traffic signals installed at locations that were previously unsignalized shall be operated in flash mode for a minimum of 48 hours prior to being put into full operation.

(2) Testing. Once all equipment is installed and the traffic signal has been turned on, an inspection to start the 30 calendar day test period shall be scheduled. Each traffic control signal system shall successfully complete a minimum 30 calendar day test period. The required 30 calendar day test period for the signal system shall not begin until all construction of the signal system has been completed and the Engineer has received notice from the responsible Agency parties that all paperwork, including fabrication drawings, materials certifications, bench test reports, etc., related to the signal equipment and installation have been completed to the satisfaction of the Agency.

a. The Contractor shall submit a request to the Engineer to begin the 30 calendar day test period.

b. An in-depth inspection including the Project Manager and the Traffic Signal Operations Engineer, or their representatives, will be conducted to start the 30 calendar day test period. A written punch list of items will be provided to the Contractor to correct by the end of the 30 calendar day test period.

c. The test period for the traffic signal shall be at least 30 calendar days of continuous, satisfactory operation.

If a component or system fails or shows unsatisfactory performance, the condition shall be corrected and the test restarted until 30 calendar days of continuous satisfactory operation have been completed.

The traffic signal will not be accepted until successful completion of the test period.

Once the 30 calendar day test period has been successfully completed, the Engineer will notify the Project Manager and the Traffic Signal Operations Engineer that the above criteria have been met and that the Agency is now responsible for the maintenance of the traffic control signal system. The name of the power company and the account number on the power bill shall be included for the District Transportation Administrator's records.

(t) Maintenance of New and Existing Equipment. The Contractor shall be responsible for all maintenance costs for new and existing signals and beacons, starting from the installation of construction approach signing and lasting until project acceptance. This period shall include any winter shutdowns during the Contract period. Replacement of poles, cabinets, or controllers will not be considered maintenance costs unless the loss is due to the Contractor's negligence.

At the discretion of the Engineer, the Contractor may be required to replace poles and cabinets or controllers that are lost or damaged due to an accident, or to perform routine repairs to existing signals that are not necessitated by the Contractor's operations. If required, such work will be considered extra work under Subsection 109.06 and additional payment will be allowed. Any equipment that is defective or damaged prior to the beginning of the Contract shall be maintained in at least as good condition until it is replaced as part of the Contract.

678.06 METHOD OF MEASUREMENT. The quantity of Removal of Existing Traffic Control Signal System to be measured for payment will be the number of each traffic control signal system removed in the complete and accepted work.

The quantity of Cabinet Assembly; Mast Arm Pole Foundation; Pedestal Post Assembly; Pedestrian Signal Assembly; Traffic Signal Assembly; Traffic Signal Head Assembly; Flashing Beacon, Aerial Mounted; Vehicle Detection System; Pan-Tilt-Zoom Camera; and Emergency Vehicle Preemption System to be measured for payment will be the number of each installed in the complete and accepted work.

678.07 BASIS OF PAYMENT. The accepted quantity of Removal of Existing Traffic Control Signal System will be paid for at the Contract unit price per each. Payment will be full compensation for removing and handling the existing traffic control signal system components as specified in the Contract and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Cabinet Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all training, labor, materials, tools, equipment, wiring, and any incidentals necessary to complete the work.

The accepted quantity of Mast Arm Pole Foundation will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Pedestal Pole Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for providing the pedestal pole; transformer base including grounding lugs and related mounting hardware; concrete foundation, leveling shims, corrosion prevention; and all training, labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Pedestrian Signal Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing pedestrian signal heads, mounting hardware, all training, labor, materials, wiring, tools, equipment, and incidentals necessary to complete the work. The pedestal pole assembly will be paid separately.

The accepted quantity of Traffic Signal Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all training, labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Traffic Signal Head Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all training, labor, materials, tools, equipment, wiring, and incidentals necessary to complete the work.

The accepted quantity of Flashing Beacon, Aerial Mounted will be paid for at the Contract unit price per each at each designated location. Payment will include strain poles, span wire, attachment hardware, beacon heads, and all other materials necessary for a fully operational flashing beacon system. Sign posts and panels will be paid for under the applicable Contract items.

The accepted quantity of Vehicle Detection System will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all training, labor, materials, tools, equipment, wiring, and incidentals necessary to complete the work. Removal and disposal or salvage of existing detection systems will be considered incidental to other Contract items.

The accepted quantity of Pan-Tilt-Zoom Camera will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all training, labor, materials, tools, equipment, wiring, and incidentals necessary to complete the work.

The accepted quantity of Emergency Vehicle Preemption System will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing all training, labor, materials, tools, equipment, wiring, and incidentals necessary to complete the work. Removal and disposal of existing emergency vehicle preemption systems will be considered incidental to other Contract items.

(a) Partial payments for Flashing Beacon, Aerial Mounted will be made as follows:

(1) The first payment of 90% of the Contract unit price will be made upon receipt by the Engineer of notice from all responsible Agency parties that all paperwork related to the beacon installation has been completed to the satisfaction of the Agency, and upon installation of a functioning system as indicated by a successful continuous 24-hour operation test period.

(2) The remaining 10% of the Contract unit price will be paid upon successful completion of the 30-day test control period.

(b) Partial payments for Cabinet Assembly; Mast Arm Pole Foundation; Pedestal Post Assembly; Pedestrian Signal Assembly; Traffic Signal Assembly; Traffic Signal Head Assembly; Vehicle Detection System; Pan-Tilt-Zoom Camera; and Emergency Vehicle Preemption System will be made as follows:

(1) The first payment of 35% of the Contract unit price will be made upon receipt by the Engineer of notice from all responsible Agency parties that all submittals related to the signal installation have been completed to the satisfaction of the Agency.

(2) The second payment of 40% of the Contract unit price will be made upon installation of a functioning system as indicated by a successful continuous 24-hour operation test period.

(3) The third payment of 15% of the Contract unit price will be paid upon successful completion of the 30 calendar day test period.

(4) The remaining 10% of the Contract unit price will be paid upon project acceptance.

Payment will be made under:

Pay Item		Pay Unit
678.1000	Removal of Existing Traffic Control Signal System	Each
678.2005	Cabinet Assembly	Each
678.2010	Mast Arm Pole Foundation	Each
678.2015	Pedestal Post Assembly	Each
678.2020	Pedestrian Signal Assembly	Each
678.2025	Traffic Signal Assembly	Each
678.2030	Traffic Signal Head Assembly	Each
678.2035	Flashing Beacon, Aerial Mounted	Each
678.2040	Vehicle Detection System	Each
678.2045	Pan-Tilt-Zoom Camera	Each
678.2050	Emergency Vehicle Preemption System	Each

SECTION 679 – STREET LIGHTING

679.01 DESCRIPTION. This work shall consist of removing, furnishing, and installing the street lighting components and other illumination elements necessary to provide a complete and operational system.

Street light assemblies shall consist of light pole foundations, transformer bases, light poles, bracket arms and luminaires.

679.02 MATERIALS. Materials shall meet the requirements of the following subsections:

679.03 GENERAL REQUIREMENTS. Street lights shall be installed as specified in the Contract.

Street lights shall be designed to withstand a 100 mph wind load with an allowable angular deflection of 70 arc minutes or less.

Street lighting design shall conform to the *AASHTO Standard Specifications for the Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

All wiring shall meet the requirements of the *National Electrical Code*.

679.04 SUBMITTALS. The Contractor shall submit fabrication drawings in accordance with Subsection 105.06. The submittal shall contain the following information, at a minimum:

(a) Wiring. Conductor material, insulation type, voltage rating, and temperature rating.

(b) Light Pole Foundations.

(1) Dimensions and material specifications for all hardware used to mount the transformer base to the light pole foundation.

(2) For precast light pole foundations, complete design details and material specifications shall be supplied.

(c) Transformer Bases.

(1) Dimensions for bottom and top of transformer base, height of transformer base, transformer base door dimensions, bolt pattern for mounting the transformer base to the light pole foundation and type of transformer base. The submittal shall include documentation indicating the transformer base meets the AASHTO standards.

(2) Dimensions and material specifications for all hardware used to mount the light pole to the transformer base.

(d) Light Poles.

(1) Dimensions for pole height, mounting height, pole diameter (top and bottom), handhole (size and location), anchor base, bolt circle, and mounting bolt size.

(2) Dimensions for the bolt pattern for mounting the light pole to the transformer base.

(3) Material specifications for all components of the light pole.

(4) Welding information in accordance with Subsection 506.10.

(5) The welding process and procedures and the materials used to make the two continuous circumferential welds, one attaching the top of the anchor base to the pole shaft and the other attaching the bottom of the pole shaft to the inside of the shoe base.

(6) Special features as shown on the Plans, such as finish or color.

(e) Bracket Arms.

(1) Dimensions for bracket arm length and diameter.

(2) Details for connection of bracket arm to light pole. The details shall be specific to the light pole material on which the arm is to be mounted.

(3) Welding information in accordance with Subsection 506.10.

(4) Material specifications for bracket arm and mounting hardware.

(f) Bolted Connections. Tightening requirements for all bolted connections shall be specified on all fabrication drawings where shown.

(g) Luminaires.

(1) Luminaire Data.

a. Manufacturer

b. Model number

c. Wattage

d. Lamp type, with number of LEDs

e. Any other features, such as finish, special wire access, etc.

f. BUG rating

g. Operating amperage

h. Street lighting control device

(2) Photometric Data. Photometric data shall be supplied when a street lighting design is not included in the Plans or when changes to the Plans are proposed

a. IES Distribution type

b. Utilization curve

c. Iso-lux curve

d. Mounting height factor

e. Maintenance factor

679.05 BRACKET ARM. Bracket arms shall be free of defects and burrs. Bracket arms shall be able to withstand a vertical load of 100 pounds and a horizontal load of 50 pounds without fracture or permanent deformation and shall be installed as shown in the Contract.

Bracket arms installed on aluminum posts shall be in accordance with Subsection 753.04(a). Bracket arms installed on steel or wood posts shall be in accordance with Subsection 753.04(b).

The length and mounting height of bracket arms shall be as shown on the approved drawings. The bracket arm shall be mounted perpendicular to the centerline of roadway, unless otherwise specified. The bracket arm shall be provided with a 2-inch slip-fit mounting of sufficient length to accommodate the luminaire.

All welds shall conform to the requirements of Subsection 506.10. No field welds will be allowed.

679.06 LUMINAIRE. Luminaires shall meet the requirements of the *Vermont Agency of Transportation Lighting Design Guide* unless otherwise specified on the Plans.

679.07 STREET LIGHT ASSEMBLY. Street light assemblies shall be installed as shown in the Contract and shall include the following:

(a) Light Pole Foundation. Light pole foundations shall be installed as shown in the Contract. Excavation and backfill shall be in accordance with Section 203.

(b) Transformer Bases. Transformer bases shall be installed on light pole foundations as shown in the Contract.

The bottom plate of the transformer base shall have a grounding bolt and nut, easily accessible from the transformer base door. Transformer bases, and all wiring contained in the transformer bases, shall meet the requirements of the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* for breakaway features.

(c) Light Poles. Light poles shall be mounted on transformer bases as shown in the Contract.

The anchor base shall be attached to the light pole shaft by two continuous welds, one inside the base at the end of the shaft and the other on the outside at the top of the anchor base. All welds shall conform to the requirements of Subsection 506.10. No field welding shall be allowed.

Light poles shall be plumb and level. A 4 inch × 6 inch handhole, complete with cover and hardware, shall be located approximately 18 inches above the top of the transformer base directly above the transformer base door. A lip shall be provided around the handhole opening to prevent the cover from tipping and falling inside the hole. A grounding bolt and nut, easily accessible from the handhole, shall be located inside the light pole shaft.

The light pole cap shall be securely held in place.

(d) Bracket Arms. Bracket arms shall be as specified herein.

(e) Luminaires. Luminaires shall be as specified herein.

679.08 ERECTION OF LIGHT POLES. All light poles shall be erected on concrete bases at the locations shown on the Plans.

In the erection of light poles, leveling nuts shall be provided for installation between the bases and the foundation to aid in plumbing.

Anchor bolts shall be tightened in accordance with Subsection 677.03.

Where aluminum alloys come in contact with other materials, the contacting surfaces shall be separated with a fabric pad 1/8 inch in thickness or cleaned and thoroughly coated with an aluminum filled silicone sealant.

679.09 REMOVE STREET LIGHT ASSEMBLY. The Contactor shall remove the entire street light assembly as identified in the Plans, including the light pole foundation, transformer base, light pole, bracket arm, luminaire, wiring and all other incidentals.

The street light assembly shall become property of the Contractor. All components of the street light assembly shall be removed from the project and properly disposed of by the Contractor.

All voids resulting from this work shall be backfilled in accordance with Section 203.

679.10 REMOVE AND RESET LIGHT POLE. The Contractor shall remove, store, and reset the transformer base, light pole, bracket arm, luminaire, wiring, and other incidentals as shown in the Plans. All light poles shall be carefully separated from the light pole foundation on which they are mounted.

Light poles shall be completely removed from the light pole foundation, transported, and stored at locations specified in the Contract or as ordered by the Engineer and reset on the light pole foundation at the original location.

679.11 REMOVE AND RESET PRIVATE LIGHT ASSEMBLY. The Contractor shall coordinate all light removal and relocation activities with the property owners, and as directed by the Engineer, and shall lock out breakers and panels as needed to safely perform the work. Care shall be taken in the removal and handling of the lights and appurtenances during relocation. Any components damaged due to Contractor negligence shall be replaced with new components at the Contractor's expense, and as directed by the Engineer.

The Contractor shall reuse all existing materials to the greatest extent possible for the resetting of lights. If wiring or conduit is damaged by the Contractor during removal, the Contractor shall supply new materials of similar size and type that conform to the *National Electric Code* and as needed to complete the work to the satisfaction of the Engineer. The Contractor shall provide new conduit and wiring as needed to relocate the lights to the new location.

679.12 STREET LIGHTING CONTROL DEVICES. An astronomical clock shall be provided for each wired group of street lights and installed at the power drop stanchion for each group, unless otherwise specified on the Plans.

Astronomical clocks shall have two-circuit scheduling, at least 20 set points for individual programs for each day of the week, be capable of Daylight Saving Time adjustments, have a manual override, and a power outage backup system with permanent schedule retention and memory module.

All astronomical clocks shall be placed in an enclosure meeting the requirements of *ANSI/NEMA 250*, Type 3R and all shall be the same for the project. A mix of clocks will not be allowed for new installations.

Astronomical clocks will not be required for single installations of street light assemblies. Other types of control devices will be allowed for single installations.

679.13 POWER DROP STANCHION. Power drop stanchions shall conform to the requirements of Section 625.

679.14 ELECTRIC WIRING. All wiring shall be in accordance with the *National Electrical Code* and Section 678.

All current carrying conductors shall have a fusible disconnect in the base of each light pole accessible from the hand hole or breakaway base.

Conductors shall not have any unnecessary kinks or bends. End caps, when necessary, of the appropriate size for the service conductors shall be installed at all termination points in pull boxes, junction boxes, and light pole bases.

679.15 FINISH. All transformer bases, light poles, bracket arms, and luminaires shall have either a powder coating or anodized aluminum finish. All finishes shall be factory-applied.

Anodized aluminum coatings shall have a minimum coating thickness of 1.0 mils.

Powder coatings shall be a thermosetting material, with a minimum film thickness of 4.0 mils. The powder coating process shall have pre-treatment steps that ensure complete cleaning and adherence of the coating materials, including at least the following steps: hot alkaline wash, rinse, hot phosphoric acid etching, and final rinse. It shall be free of blisters, cracks, stains, and similar defects.

679.16 ACCEPTANCE. Acceptance of street lighting systems shall be based on the following conditions:

(a) Prior to acceptance of the street lighting system the system shall successfully complete a test period. The street lighting systems shall be completely operable and energized for 30 consecutive calendar days without any defects in the system for successful completion of the test period. All required adjustments to the street lighting control device, if required, shall be completed to the satisfaction of the Engineer prior to acceptance.

(b) The Contractor shall be responsible for all power costs through project acceptance.

679.17 TEMPORARY STREET LIGHTING.

(a) General Requirements. Temporary street lighting shall be installed by the Contractor at the locations shown on the Plans or directed by the Engineer.

Temporary street lighting is not work zone lighting, which shall instead meet the requirements of Section 641.

The temporary street lighting system installed at the designated location shall include all necessary existing or Contractor-provided materials and equipment shown on the Plans, including, but not limited to, light poles, bracket arms, luminaires, conduit, control devices, transformer bases, and foundations.

(b) Materials. The temporary street lighting equipment shall conform to the requirements of *AASHTO Standard Specifications for the Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and the *National Electrical Code* but is not required to be new.

(c) Installation. The components of the temporary street lighting shall be installed in accordance with this section with the following modifications:

(1) Concrete bases will not be required for temporary street lighting installations.

(2) The Contractor shall correct all deficiencies found in the temporary street lighting system and shall repair or replace defective equipment at no cost to the Agency.

(3) Removal of the temporary street lighting system in its entirety and restoration of the disturbed areas shall constitute the completion of the Contract item.

(4) The Contractor shall be responsible for all permits and costs associated with providing electrical power to the temporary street lighting system and operation.

(5) The Contractor shall notify the Engineer and town or city officials at least 48 hours prior to deactivating the temporary street lighting system.

679.18 METHOD OF MEASUREMENT. The quantity of Remove Street Light Assembly to be measured for payment will be the number of each street light assembly removed in the complete and accepted work.

The quantity of Remove and Reset Light Pole to be measured for payment will be the number of each light pole removed, stored, and reset in the complete and accepted work.

The quantity of Remove and Reset Private Light Assembly to be measured for payment will be the number of light assemblies removed and reset in the complete and accepted work.

The quantity of Street Light Assembly to be measured for payment will be the number of each street light assembly installed in the complete and accepted work.

The quantity of Bracket Arm to be measured for payment will be the number of each bracket arm installed in the complete and accepted work.

The quantity of Luminaire to be measured for payment will be the number of each luminaire installed in the complete and accepted work.

The quantity for Street Lighting Control Device to be measured for payment will be the number of each street lighting control device installed in the complete and accepted work.

The quantity of Temporary Street Light Assembly to be measured for payment will be the number of each temporary assembly installed in the complete and accepted work.

679.19 BASIS OF PAYMENT. The accepted quantity of Remove Street Light Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for removing and disposing of a street light assembly, including light pole foundation, transformer base, light pole, bracket arm, luminaire, wiring and other incidentals, and for all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove and Reset Light Pole will be paid for at the Contract unit price per each. Payment will be full compensation for removing, storing, and installing a salvaged light pole, including transformer base, light pole, bracket arm, luminaire wiring, and for all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove and Reset Private Light Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for removing the light, light pole, and foundation; installing wiring and conduit; transportation, handling, and resetting lightings at locations indicated in the Plans or as directed by the Engineer; providing any new conduit, wiring, hardware, bulbs, and accessories; performing any necessary excavation, backfilling, electrical connections, and testing; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Street Light Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, and placing the light pole foundation, transformer base, light pole, bracket arm luminaire, wiring within the Street Light Assembly, and for all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Bracket Arm will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, and placing the bracket arm, wiring within the bracket arm, hardware required to mount the bracket arm to the light pole, and for all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Luminaire will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, and placing the luminaire housing, ballasts, lamps, control device, and for all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Street Lighting Control Device will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, placing, and installing a fully functional street lighting control device and for all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Temporary Street Light Assembly will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing, transporting, handling, and placing the temporary street light assembly and for all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Circuit testing and connections to power sources will not be paid for separately but will be considered incidental to the Contract items that include the costs of wiring.

The cost of furnishing and installing electrical conduit, wired conduit, electrical wiring, electrical conduit sleeve, pull boxes, and junction boxes, when not covered under Section 678, shall be considered incidental to the items in this section.

Payment will be made under:

Pay Item		Pay Unit
679.2400	Remove Street Light Assembly	Each
679.2500	Remove and Reset Light Pole	Each
679.2600	Remove and Reset Private Light Assembly	Each
679.4600	Street Light Assembly	Each
679.4700	Bracket Arm	Each
679.5000	Luminaire	Each
679.5400	Street Lighting Control Device	Each
679.7000	Temporary Street Light Assembly	Each

SECTION 680 – TRAVEL INFORMATION SIGNS

680.01 DESCRIPTION. This work shall consist of furnishing, erecting, and maintaining travel information signs and information plazas.

680.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Drainage Aggregate 704.16
Structural Timber and Lumber.....709.01
Nonstructural Lumber.....709.02
Timber Preservative.....726.01
Sign Posts.....750.01
Retroreflective Sheeting.....750.04
Assembly Hardware.....750.05

All materials shall be in conformance with the requirements of the Vermont Travel Information Council.

The colors used for specific signs, symbols, and plaques shall be as shown on the Plans and shall provide an acceptable match to the appropriate color chip in *SAE AMS-STD-595* as specified in Table 680.02A.

TABLE 680.02A – SIGN COLORS

Color	Black	White	Magenta	Brown	Orange	Gray
Chip No.	17038	17875	11158	10100	12501	16373

The color of retroreflective material shall be silver-white No. 2.

Concrete shall conform to the requirements of Section 541 for Concrete, Class B.

680.03 PLANS. Plans for travel information signs, associated components, and work required will consist of assembly drawings of information plazas, Standard Drawings, location and site plan, and order forms detailing the work to be performed at each specified location.

680.04 SIGN POSTS. The installation of steel and aluminum sign posts shall conform to the requirements of Section 675. Posts shall be set to the depth shown on the Plans.

680.05 SIGNS. Travel and business information signs shall be prepared and installed according to the requirements of Section 675, except as modified by this subsection.

All lettering, mileage numerals, and directional arrows shall be formed from retroreflective sheeting. Basic travel information symbols for use on sign boards carrying only travel information symbols shall be reflectorized either by silk-screening the background color on retroreflective sheeting or by applying reflective symbols on acrylic material of the appropriate color. All other travel information symbols and background material shall be non-reflectorized and shall be of the colors shown on the Plans.

Commercial logos, furnished by others, shall be applied to certain signs as shown on the Plans.

680.06 INFORMATION PLAZAS. Information plazas shall be constructed at locations shown on the Plans or directed by the Engineer. The information plaza shall be constructed from materials shown on the Plans. The information plaza shall be erected as shown on the Plans and in conformance with the *State of Vermont Travel Information Council Standards Manual*.

The area in which the information plaza is erected shall be reasonably level and unobstructed to provide for easy circulation by pedestrians. In areas subject to vehicular traffic, an 8-foot length of curbing shall be installed parallel to the axis of the structure for the separation of vehicular and pedestrian traffic. Pedestrian traffic areas shall be excavated and surfaced with 12 inches of drainage aggregate.

The relocation of an existing information plaza shall consist of removing the information plaza from its present location and reinstalling it on new posts or concrete bases at the location specified. The reinstallation shall be made as shown on the Plans and shall include the necessary electrical connections, grading, and curb installation if necessary. Removal and disposal of the original mounting posts and curb, if any, and any necessary cleanup of the original site shall also be included in the relocation item.

An information plaza that is damaged during its removal and resetting due to negligence on the part of the Contractor shall be repaired or components replaced by the Contractor at no additional cost to the Agency.

If lighting is called for, the plazas shall be lit during the hours of darkness under the control of a suitably designed photoelectric device. Information plaza lighting and electrical circuitry shall be as shown on the Plans. All electrical materials and installation methods shall conform to the provisions of the *National Electrical Code* and all electrical work shall be in accordance with state and local regulations.

680.07 MAGNETIC PLAZA INFORMATION PLAQUES. When indicated in the Contract, the Contractor shall furnish magnetic plaques of the sizes and types indicated on the *Application for Official Business Directional Signs (OBDS)*, complete with the legend provided on the order form.

Plaques shall have space reserved for the application of a commercial logo to be furnished by others. The plaques shall be installed by others.

The graphics shall be white on a square panel of magnetic vinyl in the color specified. Graphics shall be on plaques 6 inches square, with 48-point lettering for headings, 18-point lettering for text, and logos 1-1/2 inches square.

680.08 SYMBOLS. When called for in the Contract, the Contractor shall furnish travel information symbols as ordered by the Engineer. The symbols shall consist of a self-adhesive acrylic background with the appropriate symbol superimposed, all of the size and color specified. The symbols shall be installed by others.

680.09 METHOD OF MEASUREMENT. The quantity of Travel Information Sign and Business Directional Sign to be measured for payment will be the number of square feet of signs installed in the complete and accepted work.

The quantity of Travel Information Plaza and Relocate Information Plaza to be measured for payment will be the number of each plaza installed or relocated in the complete and accepted work.

The quantity of 6 Inch Magnetic Information Plaque, Travel Information Symbol, and Overlay for Travel Information Signs will be measured for payment as the number of plaques, symbols, and overlays furnished in the complete and accepted work.

680.10 BASIS OF PAYMENT. The accepted quantity of Travel Information Sign and Business Directional Sign will be paid for at the Contract unit price per square foot. Payment will be full compensation for furnishing the sign, complete with letters and symbols, installing the sign as part of a unit at the location specified, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work. Sign posts will be paid for at the Contract unit price for the appropriate item for sign posts under Section 675.

The accepted quantity of Travel Information Plaza will be paid for at the Contract unit price per each. Payment will be full compensation for excavation, preparation, and grading of the area; furnishing and placing backfill material; furnishing and placing protective curb where required; the information plaza complete with electrical service; and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Relocate Information Plaza will be paid for at the Contract unit price per each. Payment will be full compensation for disassembly of the plaza; disposal of the original posts; cleanup of the original area; reinstallation of the plaza on new posts or a new base at the location specified, complete with prepared, graded, and curbed area and electrical service; and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of 6 Inch Magnetic Information Plaque and Travel Information Symbol will be paid for at the Contract unit price per each. Payment will be full compensation for furnishing the materials specified with the required text or symbols superimposed and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Overlay for Travel Information Sign will be paid for at the Contract unit price per each. Payment will be full compensation furnishing the acrylic background of the color specified, placing the required text on the background, installation of the overlay on the sign panel at the location specified, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item		Pay Unit
680.2000	Travel Information Sign	Square Foot
680.2500	Business Directional Sign	Square Foot
680.3000	Travel Information Plaza	Each
680.4000	Relocate Information Plaza	Each
680.6500	6 Inch Magnetic Information Plaque	Each
680.7000	Travel Information Symbol	Each
680.7200	Overlay for Travel Information Sign	Each

SECTION 681 – ANCILLARY WORK

681.01 DESCRIPTION. This work shall consist of removing and relocating existing landscaping items; furnishing and installing bicycle racks; removing existing parking meters, posts, and sleeves; furnishing, and installing new parking meters, posts, and sleeves; resetting parking meters; and other miscellaneous work, as shown on the Plans.

681.02 MATERIALS. Materials shall meet the requirements of the following subsections:

Crushed Gravel for Subbase 704.05
Dense Graded Crushed Stone for Subbase 704.06
Bicycle Rack Systems.....715.05
Galvanizing.....726.06

All materials for landscaping items shall be approved by the Engineer prior to use.

Concrete shall meet the requirements of Section 541 for Concrete, Class B.

Parking meters shall be of the type specified on the Plans and shall be accompanied by a warranty for satisfactory operation for a period of 6 months following project acceptance.

Parking meter posts and sleeves shall be standard steel pipe conforming to *ASTM A53*, Type E, Grade B or *ASTM A53*, Type S, Grade B. The posts shall accommodate attachment of the existing or new parking meters.

Parking meter posts and post sleeves shall be galvanized in accordance with Subsection 726.06 and powder coated in accordance with *ASTM D7803*. The color shall be as specified on the Plans.

681.03 REMOVE AND RELOCATE LANDSCAPE ITEMS. Landscape items to be removed or removed and relocated may include planters, walkways, monuments, steps, stone edging, boulders, flag poles, lawn ornaments, and other similar objects. The Contractor shall use caution when removing and relocating landscape items. Any items damaged will be repaired or replaced in-kind at the Contractor's expense. Replacement items and final relocations shall be as shown on the Plans, or as directed by the Engineer.

681.04 BICYCLE RACKS. Bicycle racks shall be installed at the locations shown on the Plans and in accordance with the manufacturer's recommendations.

681.05 PARKING METERS.

(a) Installing New Parking Meters. Parking meters shall be installed as shown on the Plans or in accordance with the manufacturer's recommendations.

(b) Removing Existing Parking Meter Post and Sleeve. When existing sidewalk is not being replaced, the existing post shall be removed by saw-cutting an 18-inch square around the base of each post and removing the concrete sidewalk and post base. The excavated area shall be filled and compacted with crushed gravel for subbase or dense graded crushed stone for subbase to the depth of the bottom of the existing sidewalk. Concrete shall be placed and finished on top of the crushed gravel for subbase or dense graded crushed stone for subbase.

(c) Installing New Parking Meter Post and Sleeve. Where a new parking meter post and sleeve are to be installed in existing sidewalk, an 18-inch square area of existing concrete sidewalk shall be saw-cut and removed. Existing crushed gravel for subbase or dense graded crushed stone for subbase under the sidewalk shall be removed to a depth of 12 inches below the grade of the existing sidewalk. The new post sleeves will be installed in the locations specified on the Plans with at least 2 inches of the sleeve extending above the grade of the sidewalk. The entire excavated area shall then be filled with concrete to the grade of the existing sidewalk.

The Contractor shall ensure that the new post sleeve will allow for the plumb installation of the actual meter post and not require bending of the post to achieve plumbness. The new parking meter post shall extend 36 inches above the grade of the sidewalk. Once placed, the post shall be welded around the full circumference of the post sleeve.

(d) Remove and Reset Parking Meter. Parking meters shall be removed and reset as shown in the Plans. The Contractor shall coordinate with the municipality to allow time for the town to remove money from the meter housings. The Contractor shall be responsible for the removal, safe storage, and re-installation of the existing parking meter on a new post and sleeve. Prior to resetting, the Contractor shall clean the parking meter to the satisfaction of the Engineer.

(e) Repair of Damage. Any damage caused to the sidewalk during construction will be repaired as directed by the Engineer at the Contractor's expense.

681.06 METHOD OF MEASUREMENT. The quantity of Remove and Relocate Landscape Items to be measured for payment will be the number of each removed and relocated in the complete and accepted work.

The quantity of Remove Landscape Items to be measured for payment will be the number of each removed in the complete and accepted work.

The quantity of Bicycle Rack, Parking Meter, and Parking Meter Post and Sleeve to be measured for payment will be the number of each installed in the complete and accepted work.

The quantity of Remove and Reset Parking Meter to be measured for payment will be the number of each removed and reset complete and accepted work.

The quantity of Remove Parking Meter Post and Sleeve to be measured for payment will be the number of each removed in the complete and accepted work.

681.07 BASIS OF PAYMENT. The accepted quantity of Remove and Relocate Landscape Items will be paid for at the Contract unit price for each. Payment will be full compensation for removing and relocating landscape items as required; performing any excavation required; furnishing, transporting, storing, and installing; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove Landscape Items will be paid for at the Contract unit price for each. Payment will be full compensation for removing landscape items as required; performing any excavation required; transportation and disposal; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Bicycle Rack will be paid for at the Contract unit price for each. Payment will be full compensation for installing a complete bicycle rack system in accordance with the Contract, and for furnishing all labor, materials, equipment, tools, and incidentals necessary to complete the work, furnishing, transporting, and installing; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Parking Meter will be paid for at the Contract unit price for each. Payment will be full compensation for providing and installing new parking meters and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove and Reset Parking Meter will be paid for at the Contract unit price for each. Payment will be full compensation for removing existing concrete sidewalk as required; performing any excavation required; backfilling with crushed gravel for subbase or dense graded crushed stone for subbase; furnishing and placing concrete; cleaning, transporting, and resetting the parking meter; furnishing, transporting, and installing a new post and sleeve; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Parking Meter Post and Sleeve will be paid for at the Contract unit price for each. Payment will be full compensation for removing existing concrete sidewalk as required; performing any excavation required; furnishing, transporting, and installing the post and sleeve; backfilling with crushed gravel for subbase or dense graded crushed stone for subbase; welding; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Remove Parking Meter Post and Sleeve will be paid for at the Contract unit price for each. Payment will be full compensation for removing existing concrete sidewalk as required; performing any excavation required; backfilling with crushed gravel for subbase or dense graded crushed stone for subbase; furnishing and placing concrete; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Pay Item		Pay Unit
681.1010	Remove and Relocate Landscape Items	Each
681.1020	Remove Landscape Items	Each
681.2010	Bicycle Rack	Each
681.3010	Parking Meter	Each
681.3020	Remove and Reset Parking Meter	Each
681.3030	Parking Meter Post and Sleeve	Each
681.3040	Remove Parking Meter Post and Sleeve	Each

SECTION 690 – COMMODITY PRICE ADJUSTMENTS

690.01 DESCRIPTION. This specification contains price adjustment provisions for commodities used by the Contractor during construction. These price adjustment provisions will provide for either additional compensation to the Contractor, or a payment to the Agency, based upon changes in the retail price of a commodity between the time of bidding and the time when the work was performed.

690.02 GENERAL CONDITIONS.

(a) Decreased Quantities. It shall be understood by the Contractor that a price adjustment increase may cause the Agency to decrease the quantities of the pay items subject to adjustment under these provisions. Provisions providing for decreased quantities and item cancellation in this paragraph are separate and take precedence, notwithstanding any other provisions of the Contract.

(b) No Adjustment After Completion Date. No price adjustment will be computed for work performed after the Contract completion date, as modified by change order, if applicable.

(c) No Extension of Time. Any increase in the total Contract amount due to price adjustments will not be justification for an extension of time under Subsection 108.11.

(d) Price Adjustments Based on Estimated Quantities. If estimated quantities are used to determine estimated price adjustments throughout the duration of the Contract, reconciliation of those estimated adjustments will be made upon the determination of actual final quantities. Final adjustments to the total final quantity will be made by prorating those estimated adjustments over the applicable adjustment periods previously paid. Reconciliation of any price adjustments will only be performed in those instances where the actual final quantity differs by more than 5% from the total estimated quantity. Payments owed to either the Contractor or the Agency will not be subject to any applicable interest claims.

(e) Pay Items Added by Change Order. Pay items added by change order will be subject to price adjustment provided that all other criteria for that type of price adjustment are met.

(f) Index Price. Prior to advertising for bids, an index price per unit of the commodity will be established by the Agency. This price will be specified in the Contract and will be the basis from which commodity price adjustments for pay items included in the original awarded Contract are computed, including pay items where the total quantity is later increased by change order.

For pay items added by change order, the index price will be the posted price at the time that the Contractor and the Agency agree to the unit prices of the pay items to be added. This index price will be specified in the change order and will be the basis from which commodity price adjustments for pay items added in that change order are computed.

(g) Posted Price. For the duration of the Contract, the posted price for the commodity will be established monthly by the Agency. The posted price will be established in the same manner as the index price and may be found on the Agency's website. The posted price used to calculate the adjustment will be the price for the month in which the work was performed.

690.03 ASPHALT PRICE ADJUSTMENT.

(a) General Requirements. All asphalt binder and emulsified asphalt incorporated into the work, including that incorporated under Special Specification pay items or pay items added by change order, will be subject to adjustment under this specification.

(b) Calculation.

(1) Quantity of Asphalt.

a. Asphalt from Asphalt Binder.

1. Bituminous Mixtures Produced at Batch Plants or Foamed Asphalt. The quantity of asphalt from asphalt binder (Q_{AAB}) will be the cumulative amount of virgin asphalt binder for each applicable item as reported on the batch or load ticket.

2. Bituminous Mixtures Produced at Drum-Mix or Continuous Mix Plants. The quantity of asphalt from asphalt binder (Q_{AAB}) will be calculated using the following equation:

$$Q_{AAB} = Q_M \times F_{AB}$$

where:

Q_{AAB} = Quantity of asphalt from asphalt binder (tons)

Q_M = Quantity of mix (tons)

F_{AB} = Asphalt binder factor

The asphalt binder factor will be the percentage of virgin asphalt binder incorporated into the mixture, expressed as a decimal. In the event of multiple asphalt binder contents, the accepted quantity of mix at each asphalt binder content will be determined, and the total quantity of asphalt used will be calculated accordingly. The accumulated asphalt binder total reported by the plant automation may be checked and verified by Agency personnel for each mix.

b. Asphalt from Emulsified Asphalt. The quantity of asphalt from emulsified asphalt (Q_{AEA}) will be calculated using the following equation:

$$Q_{AEA} = 0.05 \times Q_{EA} \times F_{AC}$$

where:

Q_{AEA} = Quantity of asphalt from emulsified asphalt (tons)

Q_{EA} = Quantity of emulsified asphalt (hundredweight)

F_{AC} = Asphalt content factor

The quantity of emulsified asphalt will be determined in accordance with the method of measurement for the specification under which it was placed.

The asphalt content factor will be the residual asphalt content percentage of the emulsified asphalt, expressed as a decimal and determined as follows:

1. The asphalt content factor will be the minimum residual asphalt content required by the specification under which the emulsified asphalt was placed.

2. If the specification does not require a minimum residual asphalt content, the asphalt content factor will be the minimum residual asphalt content required by Subsection 702.02 for the grade of emulsified asphalt used.

3. If the specification does not require a minimum residual asphalt content and the emulsion type used in the work is not covered by Subsection 702.02, the asphalt content factor will be the average residual asphalt content as determined from Agency test results.

(2) Asphalt Price Adjustment Quantity. The quantity of asphalt price adjustment will be calculated using the following equation:

$$PA_A = (Q_{AAB} + Q_{AEA}) \times (PP_A - IP_A)$$

where:

PA_A = Price Adjustment, Asphalt (dollars)

Q_{AB} = Quantity of asphalt from asphalt binder for the month (tons)

Q_{AEA} = Quantity of asphalt from emulsified asphalt for the month (tons)

PP_A = Posted price of asphalt for the month the work was performed (dollars/ton)

IP_A = Index price of asphalt cement (dollars/ton)

690.04 FUEL PRICE ADJUSTMENT.

(a) General Requirements. For the purposes of this specification, it is assumed that all fuel used by the Contractor is diesel fuel. Fuel price adjustment will only be computed for a pay item if all of the following criteria are met:

(1) The pay item is listed in Table 690.04A or is identified as being subject to fuel price adjustment in the Special Provisions or a change order. No other pay items will be subject to adjustment.

TABLE 690.04A – ITEMS, FUEL USAGE FACTORS, AND THRESHOLD QUANTITIES

Work Category	Eligible Pay Item Numbers	Fuel Usage Factor (F_{FU})	Threshold Quantity for Work Category
Earth Excavation	203.1500, 203.1700, 203.2000, 203.2500, 203.2700, 204.2000, 204.2500, 208.3000	0.319 gal/CY	40,000 CY
Aggregates Paid for by the Cubic Yard	203.3500, 204.3000, 301.1500, 301.2500, 301.2600, 301.3500, 401.1000, 401.1500, 629.0500	0.558 gal/CY	25,000 CY
Aggregates Paid for by the Ton	301.2800, 402.1200, 414.5100, 415.5100, 662.0010	0.413 gal/ton	30,000 tons
Bituminous Concrete Pavement	406.0110, 406.0120, 406.0130, 406.0210, 406.0220, 406.0230, 406.0310, 406.0320, 406.0330, 406.0410, 406.0420, 406.0430, 406.1410, 406.1420, 406.1430, 406.2400	2.827 gal/ton	5,000 tons
Bonded Wearing Course	407.0100, 407.0200, 407.0300	0.115 gal/SY	115,000 SY
Cold Central Plant Recycling	415.0200, 415.0250, 415.0300, 415.0350, 415.0400, 415.0450, 415.0500	0.140 gal/SY	95,000 SY

(2) The total Contract quantity for a given work category, being the total quantity for all eligible pay items in the work category across all projects in the Contract, equals or exceeds the threshold quantity specified in Table 690.04A. For determining which items are subject to fuel price adjustment for a given month, the total Contract quantity will be the quantity, as adjusted by change order, on the last calendar day of the month.

Pay items belonging to a work category which had a total Contract quantity that was less than the threshold quantity will become subject to fuel price adjustment if additional pay items are added, or the quantities of existing pay items are increased, by change order such that the total quantity for the work category equals or exceeds the threshold quantity. However, only work performed during or after the month in which the change order was processed will be subject to fuel price adjustment. Work that was already performed in prior months will not be subject to retroactive fuel price adjustment.

Pay items belonging to a work category which had a total Contract quantity that was greater than the threshold quantity will no longer be subject to fuel price adjustment if pay items are removed, or the quantities of existing pay items are decreased, by change order such that the total quantity for the work category no longer equals or exceeds the threshold quantity. However, only work performed during or after the month in which the change order was processed will not be subject to fuel price adjustment. Work that was already performed in prior months will still be subject to fuel price adjustment.

(b) Calculation.

(1) Index Price to Posted Price Ratio. The ratio of the posted price to the index price will be calculated using the following equation:

$$R = \frac{PP_F}{IP_F}$$

where:

R = Ratio of the posted price to the index price

PP_F = Posted price of diesel fuel for the month the work was performed (dollars/gallon)

IP_F = Index price of diesel fuel (dollars/gallon)

(2) Fuel Price Adjustment Quantity. The quantity of fuel price adjustment will be computed using the appropriate equation below. If multiple items are eligible for fuel price adjustment, the fuel price adjustment for each individual item will be calculated and the resulting values summed to generate one fuel price adjustment for the month.

For R < 0.95

$$PA_F = F_{FU} \times Q \times [PP_F - (0.95 \times IP_F)]$$

For 0.95 ≤ R ≤ 1.05

$$PA_F = 0$$

For R > 1.05

$$PA_F = F_{FU} \times Q \times [PP_F - (1.05 \times IP_F)]$$

where:

R = Ratio of the posted price to the index price

PA_F = Price Adjustment, Fuel (dollars)

F_{FU} = Fuel usage factor (gallons/unit)

Q = Quantity of the item placed in the month (varying units)

PP_F = Posted price of diesel fuel for the month the work was performed (dollars/gallon)

IP_F = Index price of diesel fuel (dollars/gallon)

690.05 METHOD OF MEASUREMENT. The quantity of Price Adjustment, Asphalt (N.A.B.I.) will be the number of dollars calculated in accordance with Subsection 690.03.

The quantity of Price Adjustment, Fuel (N.A.B.I.) will be the number of dollars calculated in accordance with Subsection 690.04.

690.06 BASIS OF PAYMENT. Payment for Price Adjustment, Asphalt (N.A.B.I.) will be debited or credited against the Contract dollar price for Price Adjustment, Asphalt (N.A.B.I.).

Payment for Price Adjustment, Fuel (N.A.B.I.) will be debited or credited against the Contract dollar price for Price Adjustment, Fuel (N.A.B.I.).

Payment will be made under:

Pay Item		Pay Unit
690.0300	Price Adjustment, Asphalt (N.A.B.I.)	Dollar
690.0400	Price Adjustment, Fuel (N.A.B.I.)	Dollar

SECTION 698 – ID/IQ AND JOC PAY ITEMS

698.01 DESCRIPTION. This work shall be as specified in the Contract. This section is a placeholder for ID/IQ and JOC pay items.

698.02 METHOD OF MEASUREMENT. The quantity of Lump Sum Project, ID/IQ to be measured for payment will be on a lump sum basis for the complete and accepted work.

The quantity of Lump Sum Project, JOC to be measured for payment will be on a lump sum basis for the complete and accepted work.

698.03 BASIS OF PAYMENT. The accepted quantity of Lump Sum Project, ID/IQ will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Lump Sum Project, JOC will be paid for at the Contract lump sum price. Payment will be full compensation for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
698.1000 Lump Sum Project, ID/IQ	Lump Sum
698.2000 Lump Sum Project, JOC	Lump Sum

SECTION 699 – FAA PAY ITEMS

699.01 DESCRIPTION. This work shall be as specified in the Aviation Technical Specifications included in the Contract. This section is a placeholder for FAA pay items on aviation Contracts.

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DIVISION 700

MATERIALS

SECTION 701 – HYDRAULIC CEMENT

701.01 GENERAL REQUIREMENTS. Hydraulic cement shall meet the following general requirements:

(a) Protection from Moisture. The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which, for any reason, has become partially set or which contains lumps or is caked shall be rejected.

(b) Storage of Different Brands and Types. Storage of hydraulic cement shall be by the brand, type, and mill. Cements of different brands and types or from different mills shall not be mixed.

701.02 PORTLAND CEMENT. Portland cement shall meet the requirements of *AASHTO M 85,* Type II and *ASTM C150,* Type II, unless otherwise shown on the Plans or directed by the Engineer.

701.03 HIGH EARLY-STRENGTH PORTLAND CEMENT. High early-strength Portland cement shall meet the requirements of *AASHTO M 85,* Type III and *ASTM C150,* Type III.

701.04 PORTLAND-POZZOLAN CEMENT. Portland-pozzolan cement shall meet the requirements of *AASHTO M 240* and *ASTM C595,* Type IP.

701.05 PORTLAND-LIMESTONE CEMENT. Portland-limestone cement shall meet the requirements of *AASHTO M 240* and *ASTM C595,* Type IL.

701.06 PORTLAND BLAST-FURNACE SLAG CEMENT. Portland blast-furnace slag cement shall meet the requirements of *AASHTO M 240* and *ASTM C595,* Type IS.

701.07 TERNARY BLENDED CEMENT. Ternary blended cement shall meet the requirements of *AASHTO M 240* and *ASTM C595,* Type IT.

SECTION 702 – BITUMINOUS MATERIALS

702.01 PERFORMANCE-GRADED ASPHALT BINDER. Performance graded asphalt binder shall come from an approved source that participates in the AASHTO Product Evaluation & Audit Solutions Asphalt Binder Suppliers program, in accordance with the Agency's *Bituminous Concrete Policy Manual*. Asphalt binder shall be homogenous, uniformly mixed, and blended liquid bituminous materials that are free of contaminants such as water, fuel oils, or other solvents, and shall not foam when heated to 350°F. Neat asphalt binder shall be asphalt prepared solely by the refining of crude petroleum.

Asphalt binder may be modified only with the addition of SBS polymer modifiers and low temperature modifiers. All asphalt binder shall conform to the requirements of *AASHTO M 332,* except requirements for J_{nrdiff} are waived. In addition, traffic level designation H, V, and E binder shall meet the requirements of *AASHTO R 92,* and after 40-hours of aging have a ΔT_c value greater than -5.0°C when measured in accordance with *AASHTO PP 113*. Asphalt binder shall not contain re-refined engine oil bottoms, vacuum tower asphalt extenders or other modifiers produced from recycled petroleum products. For modified binders, the certificate of analysis and bill of lading shall include the modifier types.

The asphalt binder manufacturer or supplier shall furnish a certificate of analysis and bill of lading representing each delivery in accordance with the requirements of *AASHTO R 26*. The certificate of analysis shall include the binder's specific gravity, and rotational viscosity for each shipment. Asphalt binder that is not modified during the initial refining process shall constitute neat binder and shall be labeled appropriately.

The asphalt binder shall be manufactured and handled in accordance with the manufacturer or supplier's quality systems manual. The manufacturer or supplier shall remain in compliance with the quality systems manual, including all notification, sampling, testing, and reporting requirements. The grades and traffic designations of asphalt binder specified in the Plans shall be as follows:

(a) 58S-28.

(b) 58H-28.

(c) 58V-28.

(d) 58E-28.

(e) 58S-34.

(f) 58H-34.

(g) 58V-34.

(h) 58E-34.

702.02 EMULSIFIED ASPHALT. Emulsified asphalts shall be homogeneous. They shall show no separation of asphalt at the time of use and shall be used within 30 calendar days after delivery from the manufacturer or supplier.

Emulsified asphalts shall not be allowed to freeze.

Emulsified asphalt for tack coats shall comply with the type and class of emulsion specified, but the grade shall be allowed to extend from the intermediate to the hard grade for penetration.

Diluted emulsified asphalts shall meet the requirements of the specified emulsion type and shall be diluted in a 1:1 ratio with water or a compatible surfactant solution. The resulting diluted product shall be a fluid, homogenous mixture capable of being sprayed evenly by a pressure distributor. The minimum residual content of the final diluted product shall be 50% of the residual content required for the undiluted emulsified asphalt.

(a) Anionic Emulsified Asphalt. Anionic emulsified asphalts shall meet the requirements of *AASHTO M 140* and shall be one of the following types:

(1) RS-1.

(2) RS-1h.

(3) MS-2h.

(4) HFMS-2.

(5) HFMS-2h.

(6) HFMS-2s.

(7) SS-1.

a. SS-1 Diluted.

(8) SS-1h.

a. SS-1h Diluted.

(b) Cationic Emulsified Asphalt. Cationic emulsified asphalts shall meet the requirements of *AASHTO M 208* and shall be one of the following types:

(1) CRS-1.

(2) CRS-1h.

(3) CMS-2h.

(4) CSS-1.

a. CSS-1 Diluted.

(5) CSS-1h.

a. CSS-1h Diluted.

(c) Polymer-Modified Emulsified Asphalt. Polymer-modified emulsified asphalts shall meet the requirements of *AASHTO M 316* and shall be one of the following types:

(1) CRS-1P.

702.03 WARM-MIX ASPHALT TECHNOLOGIES. Warm-mix asphalt (WMA) technologies used for the purposes of lowering the mixing or compaction temperatures of bituminous concrete mixtures shall be listed on the *NEAUPG Qualified WMA Technologies* list. WMA technologies that also act as an anti-strip agent, and are dosed to abate stripping, shall also meet the requirements of Subsection 702.04.

702.04 ANTI-STRIP ADDITIVES. Anti-strip additives shall be capable of improving the bonding properties of the performance-graded asphalt binder to the aggregates in the presence of moisture and shall also be capable of reducing film stripping.

(a) General Requirements. Anti-strip additives shall be heat stable for all temperature ranges prescribed for the performance-graded asphalt binder. They shall not change the grade of the asphalt binder. Anti-strip additives shall be capable of being thoroughly dispersed in the asphalt binder and of remaining stable in the asphalt binder, in storage, and at the temperatures specified for the mix, without losing effectiveness. The percentage of anti-strip additive included in the mixture shall be as recommended by the anti-strip additive manufacturer.

(b) Performance Requirements. Bituminous concrete mixtures containing anti-strip additive shall demonstrate no loss of adhesion of the performance-graded asphalt binder to the aggregate when tested in accordance with *ASTM D3625*.

702.05 HOT RECYCLING AGENTS. Hot recycling agents shall be petroleum-based agents used to recondition the materials in hot in-place recycling.

(a) Recycling Agents. Recycling agents shall be Grade RA25 in accordance with *ASTM D4552*, except as modified below.

(1) Flash Point. The flash point of residue from distillation shall be a minimum of 419°F as determined in accordance with *AASHTO T 48*.

(b) Emulsified Recycling Agents. Emulsified recycling agents shall be recycling agents meeting the requirements of Subsection 702.05(a) which have been emulsified and shall also meet the requirements of Table 702.05A.

TABLE 702.05A – EMULSIFIED RECYCLING AGENT REQUIREMENTS

Property	Test Method	Min.	Max.	Other Requirements
Specific gravity	*AASHTO T 228*	--	--	Report value
Viscosity, Saybolt Furol (25ºC, sec.)	*AASHTO T 59*	15	85	--
Storage stability (24 hours, %)	*AASHTO T 59*	--	1.0	--
Sieve (%)	*AASHTO T 59*	--	0.1	--
Cement mixing (%)	*AASHTO T 59*	--	2.0	--
Asphalt content by evaporation (%)	*AASHTO T 59*	65.0	--	--

SECTION 703 – SOILS AND BORROW MATERIALS

703.01 CLASSIFICATION OF SOILS. Based upon their field performance, soils shall be classified into seven groups that are designated as A-1, A-2, A-3, A-4, A-5, A-6, and A-7. This classification shall be based upon the results of tests made in accordance with *AASHTO M 145*, as specified in Table 703.01A.

TABLE 703.01A – CLASSIFICATION OF SOILS

General Classification	Granular Materials			Silt-Clay Materials								
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 [1]	A-7-6 [2]
Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves											
No. 10 (2.00 mm)	≤ 50	--	--	--	--	--	--	--	--	--	--	--
No. 40 (0.425 mm)	≤ 30	≤ 50	≥ 51	--	--	--	--	--	--	--	--	--
No. 200 (0.075 mm)	≤ 15	≤ 25	≤ 10	≤ 35	≤ 35	≤ 35	≤ 35	≥ 36	≥ 36	≥ 36	≥ 36	≥ 36
Property	Characteristics of the Fraction Passing the No. 40 (0.425 mm) Sieve											
Liquid Limit	--		--	≤ 40	≥ 41	≤ 40	≥ 41	≤ 40	≥ 41	≤ 40	≥ 41	
Plasticity Index	≤ 6		NP [3]	≤ 10	≤ 10	≥ 11	≥ 11	≤ 10	≤ 10	≥ 11	≥ 11 [1, 2]	
Usual Types of Soil	Gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clay soils		

[1] The plasticity index of the A-7-5 subgroup is equal to or less than the liquid limit minus 30.

[2] The plasticity index of the A-7-6 subgroup is greater than the liquid limit minus 30.

[3] NP = Non-plastic

Begin the classification procedure by taking the required data and proceeding from left to right in Table 703.01A. The correct group will be found by the process of elimination. The first group from the left into which the test data will fit is the correct classification.

Where the Unified Soil Classification System (USCS) is referenced in the Contract, it shall be based on the soil classification chart in *ASTM D2487*.

703.02 EARTH BORROW. Earth borrow shall be material of a quality approved by the Agency as meeting the requirements for the particular embankment, backfill, or other use for which the material is intended, and shall show evidence of satisfactory compaction when placed in embankments.

The natural moisture content shall be less than the laboratory optimum moisture content as determined in accordance with *AASHTO T 99, Method C*.

703.03 SAND BORROW AND CUSHION. Sand borrow and cushion shall consist of material reasonably free from silt, loam, clay, or organic matter and shall meet the requirements of Table 703.03A as determined in accordance with *AASHTO T 27*.

TABLE 703.03A – GRADATION OF SAND BORROW AND CUSHION

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
2 inch (50.0 mm)	100
1-1/2 inch (37.5 mm)	90 – 100
1/2 inch (12.5 mm)	70 – 100
No. 4 (4.75 mm)	60 – 100
No. 100 (0.150 mm)	0 – 20
No. 200 (0.075 mm)	0 – 8

703.04 GRANULAR BORROW. Granular borrow shall consist of stone and sand reasonably free from loam, silt, clay, and organic material and shall meet the requirements of Table 703.04A as determined in accordance with *AASHTO T 27*.

TABLE 703.04A – GRADATION OF GRANULAR BORROW

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
No. 4 (4.75 mm)	20 – 100
No. 200 (0.075 mm)	0 – 12

703.05 ROCK BORROW. Rock borrow shall consist of blasted rock broken into various sizes that will form a compact embankment with a minimum of voids. The maximum size shall be 36 inches in its widest dimension and that size which may be incorporated in a 24 inch layer of rock embankment.

SECTION 704 – AGGREGATES

704.01 FINE AGGREGATE FOR CONCRETE. Fine aggregate for concrete shall consist of natural sand, manufactured sand, or stone screenings washed in an approved manner or a combination thereof.

Fine aggregate shall consist of clean, hard, durable grains, uniformly graded from coarse to fine, shall be free from detrimental amounts of organic matter or other harmful substances, and shall be obtained from approved sources.

(a) Grading. Fine aggregate for concrete shall meet the gradation requirements of Table 704.01A as determined in accordance with *AASHTO T 27*.

TABLE 704.01A – GRADATION OF FINE AGGREGATE FOR CONCRETE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
3/8 inch (9.50 mm)	100
No. 4 (4.75 mm)	95 – 100
No. 16 (1.18 mm)	50 – 80
No. 30 (0.600 mm)	25 – 60
No. 50 (0.300 mm)	10 – 30
No. 100 (0.150 mm)	2 – 10

The fineness modulus on that portion of material passing the 3/8 inch (9.50 mm) sieve shall be determined by laboratory sieve tests. The fineness modulus is defined as the summation of the percentages of sand retained on the No. 100 (0.150 mm), No. 50 (0.300 mm), No. 30 (0.600 mm), No. 16 (1.18 mm), No. 8 (2.36 mm), and No. 4 (4.75 mm) sieves, divided by 100.

The minimum and maximum fineness moduli shall be 2.30 and 3.10, respectively. Fine aggregate from any one source for any one designated mix having a variation in fineness modulus greater than ± 0.20 from the fineness modulus of a representative sample proposed for use may be rejected.

(b) Organic Impurities. Fine aggregate for concrete shall have an organic plate number of two or less as determined in accordance with *AASHTO T 21*.

(c) Compressive Strength of Mortar. When sand or a combination of stone screenings and sand is mixed with Portland cement in the proportion of one part of cement to three parts of sand (or of the combination of stone screenings and sand) by mass (weight), according to the standard method of making 2 inch cubes, the resulting mortar at the ages of 3 days and 7 days shall have a compressive strength of at least 100% of that developed in the same time by mortar of the same proportions and flow, made of the same cement and graded Ottawa sand, when tested in accordance with *AASHTO T 106*.

(d) Soundness. A soundness test shall be performed on the aggregate in accordance with *AASHTO T 104*. The weighted average percentage of loss shall be not more than 8% by mass (weight) when subjected to five cycles of the sodium sulfate soundness test.

704.02 COARSE AGGREGATE FOR CONCRETE. Coarse aggregate for concrete shall consist of clean, hard, crushed stone or washed crushed gravel free of deleterious material. Crushed stone and crushed gravel shall not be blended in the stockpile. It shall be obtained from approved sources and shall meet the following requirements:

(a) General Requirements. Coarse aggregate for concrete shall meet the requirements of Table 704.02A.

TABLE 704.02A – COARSE AGGREGATE FOR CONCRETE PROPERTIES

Property	Test Method	Requirement
Percent wear (igneous)	*AASHTO T 96*	50% max.
Percent wear (all other)	*AASHTO T 96*	35% max.
Flat and elongated particles (1:5 ratio)	*ASTM D4791*	10% max.
Soundness (5 cycles, sodium sulfate solution)	*AASHTO T 104*	8% max.
Angularity (one fractured face)	*AASHTO T 335*	100% min.
Angularity (two fractured faces)	*AASHTO T 335*	50% min.

(b) Coarse Aggregate for Concrete, 3/8 Inch. The gradation of 3/8 inch coarse aggregate for concrete shall meet the requirements of Table 704.02B as determined in accordance with *AASHTO T 27*.

TABLE 704.02B – GRADATION OF COARSE AGGREGATE FOR CONCRETE, 3/8 INCH

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1/2 inch (12.5 mm)	100
3/8 inch (9.50 mm)	85 – 100
No. 4 (4.75 mm)	10 – 30
No. 8 (2.36 mm)	0 – 10
No. 16 (1.18 mm)	0 – 5

(c) Coarse Aggregate for Concrete, 3/4 Inch. The gradation of 3/4 inch coarse aggregate for concrete shall meet the requirements of Table 704.02C as determined in accordance with *AASHTO T 27*.

TABLE 704.02C – GRADATION OF COARSE AGGREGATE FOR CONCRETE, 3/4 INCH

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1 inch (25.0 mm)	100
3/4 inch (19.0 mm)	90 – 100
3/8 inch (9.50 mm)	20 – 55
No. 4 (4.75 mm)	0 – 10
No. 8 (2.36 mm)	0 – 5

(d) Coarse Aggregate for Concrete, 1-1/2 Inch. The gradation of 1-1/2 inch coarse aggregate for concrete shall meet the requirements of Table 704.02D as determined in accordance with *AASHTO T 27*.

TABLE 704.02D – GRADATION OF COARSE AGGREGATE FOR CONCRETE, 1-1/2 INCH

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
2 inch (50.0 mm)	100
1-1/2 inch (37.5 mm)	95 – 100
3/4 inch (19.0 mm)	35 – 70
3/8 inch (9.50 mm)	10 – 30
No. 4 (4.75 mm)	0 – 5

704.03 AGGREGATE FOR RAILROAD BALLAST. Aggregate for railroad ballast shall be granite, traprock, or quartzite, free of carbonates and slag, and meet the requirements of *AREMA Chapter 1, Section 2.3*. and *AREMA Chapter 1, Section 2.4*. Aggregate for railroad ballast shall meet the following gradation requirements in accordance with *AREMA Table 1-2-1* for the respective size number:

(a) Aggregate for Railroad Ballast, Type 3. Type 3 aggregate for railroad ballast shall be size number 3.

(b) Aggregate for Railroad Ballast, Type 4. Type 4 aggregate for railroad ballast shall be size number 4.

(c) Aggregate for Railroad Ballast, Type 5. Type 5 aggregate for railroad ballast shall be size number 5.

704.04 GRAVEL FOR SUBBASE. Gravel for subbase shall consist of material reasonably free from silt, loam, clay, and organic matter. It shall be obtained from approved sources and shall meet the following requirements:

(a) Grading. Gravel for subbase shall meet the gradation requirements of Table 704.04A as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.04A – GRADATION OF GRAVEL FOR SUBBASE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
No. 4 (4.75 mm)	20 – 60
No. 100 (0.150 mm)	0 – 12
No. 200 (0.075 mm)	0 – 6

(b) Percent of Wear. The percent of wear shall not be more than 50% when tested in accordance with *AASHTO T 96*.

704.05 CRUSHED GRAVEL FOR SUBBASE. Crushed gravel for subbase shall be produced from gravels or crushed quarried rock and shall be a reasonably free from silt, loam, clay, or organic matter. It shall be obtained from an approved source and shall meet the following requirements:

(a) General Requirements.

(1) Percent of Wear. The maximum percent of wear shall be 40% as determined in accordance with *AASHTO T 96*.

(2) Fractured Faces. At least 50% by mass (weight) of the material coarser than the No. 4 (4.75 mm) sieve shall have at least one fractured face as determined in accordance with *AASHTO T 335*.

(b) Crushed Gravel for Subbase, Fine Graded. Fine graded crushed gravel for subbase shall meet the gradation requirements of Table 704.05A as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.05A – GRADATION OF CRUSHED GRAVEL FOR SUBBASE, FINE GRADED

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
2 inch (50.0 mm)	100
1-1/2 inch (37.5 mm)	90 – 100
No. 4 (4.75 mm)	30 – 60
No. 100 (0.150 mm)	0 – 12
No. 200 (0.075 mm)	0 – 6

(c) Crushed Gravel for Subbase, Coarse Graded. Coarse graded crushed gravel for subbase shall meet the gradation requirements of Table 704.05B as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.05B – GRADATION OF CRUSHED GRAVEL FOR SUBBASE, COARSE GRADED

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
4 inch (100 mm)	95 – 100
No. 4 (4.75 mm)	25 – 50
No. 100 (0.150 mm)	0 – 12
No. 200 (0.075 mm)	0 – 6

704.06 DENSE GRADED CRUSHED STONE FOR SUBBASE. Dense graded crushed stone for subbase shall consist of product resulting from the mechanical crushing of quarried bedrock, boulders, or cobbles. It shall be sufficiently free from dirt, deleterious material, and pieces that are structurally weak, shall be obtained from approved sources, and shall meet the following requirements:

(a) Grading. Dense graded crushed stone for subbase shall meet the gradation requirements of Table 704.06A as determined in accordance with the requirements of *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.06A – GRADATION OF DENSE GRADED CRUSHED STONE FOR SUBBASE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
3-1/2 inch (87.5 mm)	100
3 inch (75.0 mm)	90 – 100
2 inch (50.0 mm)	75 – 100
1 inch (25.0 mm)	50 – 80
1/2 inch (12.5 mm)	30 – 60
No. 4 (4.75 mm)	15 – 40
No. 200 (0.075 mm)	0 – 6

(b) Percent of Wear. The percent wear shall not be more than 40% when tested in accordance with *AASHTO T 96*. When the aggregate is composed of crushed igneous rock, the percent of wear shall be not more than 50% when tested in accordance with *AASHTO T 96*.

(c) Flat and Elongated Particles. Not more than 30% by mass (weight) of the material coarser than the No. 4 (4.75 mm) sieve shall consist of flat and elongated particles in accordance with the requirements of *ASTM D4791*.

(d) Filler Material. Filler material shall consist of clean, hard, uniform graded, crushed stone or stone screenings produced by the crushing process. The material shall consist of hard, durable particles sufficiently free from dirt, organic material, structurally weak pieces, and other deleterious materials and shall comply with the requirements of Subsection 704.06(b) and Subsection 704.06(c).

Filler material shall meet the gradation requirements of Table 704.06B as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.06B – GRADATION OF FILLER MATERIAL

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
3/4 in (37.5 mm)	100
1/2 in (12.5 mm)	70 – 100
No. 4 (4.75 mm)	50 – 90
No. 100 (0.150 mm)	0 – 12
No. 200 (0.075 mm)	0 – 6

704.07 GRAVEL FILTER FOR SLOPE STABILIZATION. Gravel filter for slope stabilization shall consist of stone and sand that is reasonably free from loam, silt, clay, and organic material and shall meet the requirements of Table 704.07A as determined in accordance with *AASHTO T 27*.

TABLE 704.07A – GRADATION OF GRAVEL FILTER FOR SLOPE STABILIZATION

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1/2 inch (12.5 mm)	100
No. 4 (4.75 mm)	20 – 80
No. 200 (0.075 mm)	0 – 12

704.08 GRANULAR BACKFILL FOR STRUCTURES. Granular backfill for structures shall consist of granular material reasonably free from loam, silt, clay, and organic material and shall meet the gradation requirements of Table 704.08A as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.08A – GRADATION OF GRANULAR BACKFILL FOR STRUCTURES

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
3 inch (75.0 mm)	100
No. 4 (4.75 mm)	45 – 75
No. 100 (0.150 mm)	0 – 12
No. 200 (0.075 mm)	0 – 6

704.09 BACKFILL FOR MUCK EXCAVATION. Backfill for muck excavation shall consist of granular material or blasted rock broken into various sizes that will form a compact embankment with a minimum of voids.

When granular material is used, it shall meet the requirements of Subsection 703.04.

704.10 AGGREGATE FOR BITUMINOUS CONCRETE MIXTURES. The aggregate for bituminous concrete mixtures shall come from approved sources and be free from dirt, deleterious material, and pieces which are structurally weak.

Coarse aggregate shall mean that portion of material coarser than the No. 8 (2.36 mm) sieve. Coarse aggregate for bituminous concrete mixtures shall consist of clean, hard, crushed stone or crushed gravel and be uniformly graded.

Fine aggregate shall mean that portion of material finer than the No. 8 (2.36 mm) sieve. Fine aggregate for bituminous concrete mixtures shall consist of stone screenings or a combination of stone screenings, screened natural sand or manufactured sands, and other fine aggregates, such that at least 95% of any individual stockpile of the fine aggregate will pass the 3/8 inch (9.50 mm) sieve.

At the discretion of the Agency, aggregates identified as prone to stripping will require testing to determine stripping potential, and those with stripping shall require the use of an anti-strip additive meeting the requirements of Subsection 702.04.

Aggregate for bituminous concrete mixtures shall meet the following requirements:

(a) Coarse Aggregates for Superpave. Coarse aggregates for Superpave bituminous concrete pavement shall meet the requirements of Table 704.10A.

TABLE 704.10A – SUPERPAVE COARSE AGGREGATE PROPERTIES

Property	Test Method	Traffic Volume (ESALs)	Requirement
Percent wear (igneous)	*AASHTO T 96*	All	50% max.
Percent wear (all other)	*AASHTO T 96*	All	35% max.
Flat and elongated particles (1:5 ratio)	*ASTM D4791*	All	10% max.
Soundness (5 cycles, sodium sulfate solution)	*AASHTO T 104*	All	12% max.
Angularity (one fractured face)	*AASHTO T 335*	< 30,000,000	95% min.
		≥ 30,000,000	100% min.
Angularity (two fractured faces)	*AASHTO T 335*	< 30,000,000	90% min.
		≥ 30,000,000	100% min.

(b) Fine Aggregates for Superpave. Fine aggregates for Superpave bituminous concrete pavement shall meet the requirements of Table 704.10B.

TABLE 704.10B – SUPERPAVE FINE AGGREGATE PROPERTIES

Property	Test Method	Traffic Volume (ESALs)	Requirement
Angularity (uncompacted voids)	*AASHTO T 304, Method A*	All	45% min.
Soundness (5 cycles, sodium sulfate solution)	*AASHTO T 104*	All	12% max.
Sand equivalent (clay content)	*AASHTO T 176*	< 30,000,000	45% min.
		≥30,000,000	50% min.

(c) Coarse Aggregates for Bonded Wearing Course. Coarse aggregates for bonded wearing course shall meet the requirements of Table 704.10C.

TABLE 704.10C – BONDED WEARING COURSE COARSE AGGREGATE PROPERTIES

Property	Test Method	Requirement
Percent wear (igneous)	*AASHTO T 96*	50% max.
Percent wear (all other)	*AASHTO T 96*	35% max.
Angularity (one fractured face)	*AASHTO T 335*	95% min.
Angularity (two fractured faces)	*AASHTO T 335*	90% min.
Flat and elongated particles (1:3 ratio)	*ASTM D4791*	25% max.
Soundness (5 cycles, sodium sulfate solution)	*AASHTO T 104*	12% max.
Clay lumps and friable particles	*AASHTO T 112*	2% max.

(d) Fine Aggregates for Bonded Wearing Course. Fine aggregates for bonded wearing course shall meet the requirements of Table 704.10D.

TABLE 704.10D – BONDED WEARING COURSE FINE AGGREGATE PROPERTIES

Property	Test Method	Requirement
Angularity (uncompacted voids)	*AASHTO T 304, Method A*	45% min.
Soundness (5 cycles sodium sulfate solution)	*AASHTO T 104*	12% max.
Sand equivalent (clay content)	*AASHTO T 176*	60% min.
Clay lumps and friable particles	*AASHTO T 112*	2% max.
Methylene blue	*AASHTO T 330*	10 mg/g max.

(e) Mineral Filler. Mineral filler may be used to aid in meeting the gradation requirements for bituminous concrete mixtures. Mineral filler shall consist of approved limestone dust, talc dust, hydrated lime, or Type I Portland cement. Mineral filler shall meet the requirements of Table 704.10E.

TABLE 704.10E – GRADATION OF MINERAL FILLER

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
No. 30 (0.600 mm)	100
No. 200 (0.075 mm)	75 – 100

704.11 AGGREGATE FOR BITUMINOUS SURFACE TREATMENTS. Aggregate that is used for bituminous surface treatments shall meet the following requirements:

(a) Sand Cover. Sand cover shall be a silica-free aggregate meeting the gradation requirements of Table 704.11A as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.11A – GRADATION OF SAND COVER

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
No. 8 (2.36 mm)	100
No. 16 (1.18 mm)	50 – 85
No. 30 (0.600 mm)	25 – 60
No. 50 (0.300 mm)	5 – 30
No. 200 (0.075 mm)	0 – 10

704.12 AGGREGATE FOR SURFACE COURSES AND SHOULDERS. Aggregate for surface courses and shoulders shall consist solely of crushed gravel or crushed stone. It shall be obtained from approved sources, be reasonably free from deleterious materials, and shall meet the following requirements:

(a) Aggregate Surface Course.

(1) Grading. Aggregate surface course shall be uniformly graded and shall meet the gradation requirements of Table 704.12A as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.12A – GRADATION OF AGGREGATE SURFACE COURSE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1-1/2 inch (37.5 mm)	100
1 inch (25 mm)	95 – 100
No. 4 (4.75 mm)	45 – 65
No. 100 (0.150 mm)	10 – 15
No. 200 (0.075 mm)	8 – 12

(2) Percent of Wear. The percent of wear shall not be more than 40% when tested in accordance with *AASHTO T 96*.

(3) Fractured Faces. When crushed gravel is used, at least 50% by mass (weight) of the material coarser than the No. 4 (4.75 mm) sieve from each stockpile shall have at least two fractured faces as determined in accordance with *AASHTO T 335*.

(4) Plasticity Index. The plasticity index (PI) shall be between 4 and 8 when determined in accordance with *ASTM D4318*.

(b) Aggregate Surface Course, Paths and Trails. Aggregate surface course for paths and trails shall consist of clean, hard, crushed stone. It shall be reasonably free from dirt, deleterious material, and pieces that are structurally weak. The material shall be uniformly graded and shall meet the requirements of Table 704.12B as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.12B – GRADATION OF AGGREGATE SURFACE COURSE, PATHS AND TRAILS

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
3/8 inch (9.50 mm)	100
No. 4 (4.75 mm)	75-90
No. 8 (2.36 mm)	55 – 80
No. 16 (1.18 mm)	35 – 50
No. 30 (0.600 mm)	25 – 50
No. 200 (0.075 mm)	6 – 15

(c) Aggregate Shoulders.

(1) Grading. Aggregate for aggregate shoulders shall be uniformly graded and shall meet the gradation requirements of Table 704.12C as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.12C – GRADATION OF AGGREGATE SHOULDERS

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1 inch (25.0 mm)	100
3/4 inch (19.0mm)	90 – 100
No. 4 (4.75 mm)	35 – 65
No. 200 (0.075 mm)	9 – 15

(2) Fractured Faces. At least 50% by mass (weight) of the material coarser than the No. 4 (4.75 mm) sieve from each stockpile shall have at least two fractured faces as determined in accordance with *AASHTO T 335*.

(d) Aggregate Shoulders, RAP. RAP for aggregate shoulders shall meet the requirements of Subsection 704.22(a) and 100% of the material shall pass the 1-1/2 inch (37.5 mm) sieve prior to placement.

704.13 SAND FOR CEMENT MORTAR. Sand for cement mortar shall consist of clean, hard, durable grains. It shall be uniformly graded from coarse to fine and shall be free from detrimental amounts of organic matter or other harmful substances.

(a) Grading. Sand for cement mortar shall meet the gradation requirements of *AASHTO M 45* as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

(b) Organic Impurities. The sand shall show a color of not greater than two when determined in accordance with *AASHTO T 21*.

(c) Soundness. Soundness tests shall be performed on the aggregate in accordance with *AASHTO T 104*. The weighted average percentage of loss shall be not more than 8% by mass (weight) when subjected to five cycles of the sodium sulfate soundness test.

704.14 LIGHTWEIGHT COARSE AGGREGATE FOR CONCRETE. Lightweight coarse aggregate for concrete shall be clean, hard, and uniformly graded. It shall be reasonably free from dirt, deleterious material, and pieces that are structurally weak and shall meet the requirements of *AASHTO M 195* and *ASTM C330*. The Contractor shall submit the results of *AASHTO M 195, Section 4.1.2*; *AASHTO M 195, Section 5.2*; *ASTM C330, Section 5.1.2*; and *ASTM C330, Section 6.2* testing performed within the last 5 years.

(a) Organic Impurities. The aggregate shall show a color of not greater than two when determined in accordance with *AASHTO T 21*.

(b) Percent of Wear. The percent of wear shall not be more than 50% when tested in accordance with the requirements of *AASHTO T 96*.

(c) Flat and Elongated Particles. The flat and elongated particles shall conform to the requirements specified in Subsection 704.02(a).

(d) Soundness. Soundness shall meet the requirements of Subsection 704.01(d).

(e) Density. The density of lightweight aggregate shall not differ by more than 10% from the density submitted on the approved mix design.

704.15 AGGREGATE FOR SHOTCRETE. Aggregate for shotcrete shall conform to the requirements of *AASHTO M 80*.

(a) Grading. Aggregate for shotcrete shall meet the gradation requirements of Table 704.15A as determined in accordance with *AASHTO T 27* and *AASHTO T 11*.

TABLE 704.15A – GRADATION OF AGGREGATE FOR SHOTCRETE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1/2 inch (12.5 mm)	100
3/8 inch (9.50 mm)	90 – 100
No. 4 (4.75 mm)	70 – 85
No. 8 (2.36 mm)	50 – 70
No. 16 (1.18 mm)	35 – 55
No. 30 (0.600 mm)	20 – 35
No. 50 (0.300 mm)	8 – 20
No. 100 (0.150 mm)	2 – 10

(b) Percent of Wear. The percent of wear shall not be more than 50% when tested in accordance with *AASHTO T 96*.

(c) Soundness. The weighted average percentage of loss shall be not more than 12% by mass when subjected to five cycles of sodium sulfate solution in accordance with *AASHTO T 104*.

704.16 DRAINAGE AGGREGATE. Drainage aggregate shall be produced from gravels or crushed quarried rock, shall be obtained from approved sources, and shall consist of clean, hard, sound, and durable material.

(a) Grading. Drainage aggregate shall be uniformly graded from coarse to fine and shall meet the gradation requirements of Table 704.16A as determined in accordance with *AASHTO T 27*.

TABLE 704.16A – GRADATION OF DRAINAGE AGGREGATE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
1 inch (25 mm)	100
3/4 inch (19.0)	90 – 100
3/8 inch (9.5 mm)	20 – 55
No. 4 (4.75 mm)	0 – 10
No. 8 (2.36 mm)	0 – 5

(b) Percent of Wear. The percent of wear shall not be more than 40% when tested in accordance with *AASHTO T 96*.

(c) Soundness. Soundness shall conform to the requirements of Subsection 704.01(d).

704.17 AGGREGATE FOR EROSION PREVENTION AND SEDIMENT CONTROL. Aggregate for erosion prevention and sediment control (EPSC) shall consist of clean, hard, crushed stone or crushed gravel and shall be reasonably free from dirt and deleterious material. It shall be uniformly graded and meet the gradation requirements of Table 704.17A as determined in accordance with *AASHTO T 27*.

TABLE 704.17A – GRADATION OF AGGREGATE FOR EPSC

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
6 inch (150 mm)	100
4 inch (100 mm)	80 – 100
3 inch (75.0 mm)	40 – 60
2 inch (50.0 mm)	0 – 20

704.18 SELECT BACKFILL FOR MSE STRUCTURES. Select backfill for mechanically stabilized earth (MSE) structures shall be substantially free from organic matter and otherwise deleterious materials and shall meet the following requirements:

(a) Grading. Select backfill material used in MSE structures shall conform to the gradation limits in Table 704.18A as determined by *AASHTO T 27*.

TABLE 704.18A – GRADATION OF SELECT BACKFILL FOR MSE STRUCTURES

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
4 inch (100 mm)	100
3 inch (75.0 mm)	75 – 100
No. 40 (0.425 mm)	0 – 60
No. 200 (0.075 mm)	0 – 12

(b) Soundness. Select backfill material shall be substantially free of shale or other soft particles with poor durability characteristics. The material shall have a sodium sulfate soundness loss of less than 8% after five cycles, as determined in accordance with *AASHTO T 104*.

(c) Plasticity Index. The plasticity index (PI), as determined by the requirements of *AASHTO T 90*, shall not exceed 6.

(d) Electrochemical Requirements.

(1) Metallically Reinforced Systems. Select backfill material for metallically reinforced systems shall conform to the requirements of Table 704.18B.

TABLE 704.18B – BACKFILL FOR METALLICALLY REINFORCED SYSTEMS

Property	Test Method	Requirement
Resistivity at 100% saturation	*AASHTO T 288*	3,000 ohm-cm min.
pH	*AASHTO T 289*	5 – 10
Sulfates	*AASHTO T 290*	200 ppm max.
Chlorides	*AASHTO T 291*	100 ppm max.
Organic content	*AASHTO T 267*	< 1%

(2) Geosynthetically Reinforced Systems. Select backfill material for geosynthetically reinforced systems shall conform to the requirements of Table 704.18C.

TABLE 704.18C – BACKFILL FOR GEOSYNTHETICALLY REINFORCED SYSTEMS

Base Polymer Type	Test Method	Requirement
Polyester (PET)	*AASHTO T 289*	$3 < pH \leq 9$
Polyolefin (PP & HDPE)	*AASHTO T 289*	$3 < pH$

(e) Uniformity Coefficient. Select backfill material shall have a minimum uniformity, C_U, of 4.

704.19 LIGHTWEIGHT FINE AGGREGATE FOR CONCRETE. Lightweight fine aggregate for concrete shall be clean, hard, and uniformly graded. It shall be reasonably free from dirt and deleterious material and shall meet the requirements *AASHTO M 195* and *ASTM C330*. *AASHTO M 195, Section 4.1.2*; *AASHTO M 195, Section 5.2*; *ASTM C330, Section 5.1.2*; and *ASTM C330, Section 6.2* testing will not be required.

(a) Organic Impurities. The aggregate shall show a color of not greater than two when determined in accordance with *AASHTO T 21*.

(b) Soundness. Soundness shall meet the requirements of Subsection 704.01(d).

(c) Density. The density of lightweight aggregate shall not differ by more than 10% from the density submitted on the approved mix design.

704.20 PROCESSED GLASS AGGREGATE. Materials used to produce processed glass aggregate (PGA) shall consist of recycled glass food or beverage containers. PGA materials listed on the Agency's *Approved Products List* shall meet the following requirements:

(a) Grading. PGA shall be a crushed and screened material meeting the grading requirements of *AASHTO M 318, Section 5.2* and *AASHTO M 318, Section 5.5*.

(b) Deleterious Content. Small amounts (less than 5% total) of china dishes, ceramics, plate (window or mirror) glass, or other glass products will be allowed in PGA. The PGA material shall not contain more than trace amounts of screw tops, plastic cap rings, or other contaminants. Amounts of contaminants greater than 1% by weight shall be grounds for rejection of the entire PGA batch.

(c) Hazardous Materials. Glass cullet shall be free of TV or other cathode ray tubes, fluorescent lightbulbs, and shall not meet the definition of hazardous waste given in *42 U.S.C. § 6903* or in the state or local jurisdiction. Glass containers containing, or having contained, toxic or hazardous materials will not be allowed, and, when present, shall be grounds for rejecting the entire stockpile of PGA or PGA blends.

(d) Process Control. PGA materials shall be subjected to process control testing. Process control tests shall be performed at a minimum frequency of one test per 2,500 cubic yards of material produced by a stable process and shall demonstrate conformance with the requirements of Subsection 704.20(a), Subsection 704.20(b), and Subsection 704.20(c). A copy of each test result shall be made available to the Engineer upon request.

704.21 RECYCLED CONCRETE AGGREGATE. Recycled concrete aggregate (RCA) shall consist of recycled concrete that has been crushed. RCA materials listed on the Agency's *Approved Products List* shall meet the requirements of *AASHTO M 319* and the following exceptions:

(a) Grading. RCA shall be crushed to aggregate dimensions of 6 inches or less.

(b) Deleterious Content. Small amounts of brick, block or mortar may be present in the RCA at a level not to exceed a total of 5% by weight. The RCA material shall not contain more than trace amounts of wire, steel or plastic that were associated with the original placement of the concrete, bituminous material, or unreacted cementitious materials. No additional wire, steel or plastic may be added to the RCA. No discernable amounts of oils, fats, soaps, surfactants, or organic contaminants shall be present in the RCA.

(c) Hazardous Materials. The recycled concrete aggregate shall not meet the definition of hazardous waste given in *42 U.S.C. § 6903* or in the state or local jurisdiction. Concrete structures used to contain hazardous materials will not be allowed, and, when present, shall be grounds for rejection of the entire stockpile of RCA or RCA blends.

(d) Process Control. RCA materials shall be subjected to process control testing. Process control tests shall be performed at a minimum frequency of one test per 2,500 cubic yards of material produced by a stable process and shall demonstrate conformance with the requirements of Subsection 704.21(a), Subsection 704.21(b), and Subsection 704.21(c). A copy of each test result shall be made available to the Engineer upon request.

704.22 RECYCLED ASPHALT MATERIALS. Recycled asphalt materials (RAM) include recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS).

The bitumen component of RAM shall be asphalt binder and shall be free of significant contents of solvents, tars, and other volatile organic compounds or foreign substances that will make the RAM unacceptable for recycling as determined by the Agency.

(a) Recycled Asphalt Pavement. RAP shall consist of crushed or milled bituminous concrete pavement. The Contractor may blend, crush, or prepare the RAP into one or more homogenous stockpiles. RAP used in Superpave bituminous concrete pavement shall meet the requirements of Subsection 704.10(a) and Subsection 704.10(b).

(b) Recycled Asphalt Shingles. RAS materials shall come from an approved producer, and meet the following requirements:

(1) Material. RAS shall consist of manufactured shingle waste or postconsumer shingles that comply with the provisions of *AASHTO M 350*.

(2) Process Control. RAS materials shall be subjected to process control testing. Process control tests shall be performed at a minimum frequency of one test per 2,500 cubic yards of material produced by a stable process and shall demonstrate conformance with the requirements of Subsection 704.22(b)(1). A copy of each test result shall be made available to the Agency upon request.

SECTION 705 – MASONRY UNITS

705.01 BRICK. Brick masonry units shall meet the following requirements:

(a) Manhole Brick. Manhole brick shall be in accordance with *ASTM C32*, Grade MS.

(b) Sewer Brick. Sewer brick shall be in accordance with *ASTM C32*, Grade SM.

(c) Pedestrian Paving Brick. Pedestrian paving brick shall be in accordance with *ASTM C902*, Class SX, Type I.

(d) Vehicular Paving Brick. Vehicular paving brick shall be classified as Application PS in accordance with *ASTM C1272*, unless otherwise specified.

(1) Mortar Bedded. Vehicular paving brick to be set in mortar, with a concrete or bituminous base, shall be in accordance with *ASTM C1272*, Type R.

(2) Aggregate Bedded. Vehicular paving brick to be set in aggregate shall be in accordance with *ASTM C1272*, Type F.

705.02 CONCRETE MASONRY BLOCKS. Concrete masonry blocks shall be in accordance with *ASTM C139*.

705.03 PRECAST DROP INLETS, CATCH BASINS, AND MANHOLES. Precast drop inlets, catch basins, and manholes shall be in accordance with *AASHTO M 199*.

SECTION 706 – STONE FOR MASONRY, RIPRAP, AND OTHER PURPOSES

706.01 STONE FOR MASONRY. Stone for masonry shall be quarry stone, field stone, or rock fragments approximately rectangular in shape and of a hard, sound, and durable quality acceptable to the Engineer. The stone shall be free from structural defects or imperfections that would tend to compromise its resistance to the weather.

At least 80% of the individual stones in a unit shall have a thickness of not less than 8 inches and a width of not less than 150% of the thickness. The minimum size of the other stones in the unit shall have a thickness of not less than 4 inches and a width of not less than 150% of the thickness.

706.02 STONE FOR MASONRY FACING. Stone for masonry facing shall be irregularly shaped or roughly rectangular quarried granite, marble, or another quarried stone approved by the Engineer.

Stone for capping shall conform to the dimensions shown on the Plans unless changes are ordered in writing by the Engineer.

The stone shall be of approved quality, tough, sound, and durable, resistant to weathering action, uniform in color, free from seams, cracks, laminations, pyrite inclusions, and minerals or other structural defects which, by weathering, would cause discoloration or deterioration, and shall be thoroughly cleaned of any iron or rust particles. Stone shall be of such character that it can be wrought to such lines and surfaces, whether curved or plane, as required. Any stone having defects that have been repaired with cement or other materials will be rejected.

The stone shall be kept free from dirt, oil, and any other detrimental material that may prevent the proper adhesion of the mortar or detract from the appearance of the exposed surfaces.

The front face of the facial stone, including capstones when required, shall be smooth, quarry-split, free from drill holes in the exposed face, with no projections or depressions greater than 1 inch measured from the vertical plane of the face of the stone.

The capstone shall have a top surface sawed to an approximately true plane. The front and back arris lines of the capstones shall be pitched straight and true.

706.03 STONE FOR RIPRAP. Stone for riprap shall be approved, rough, unhewn quarry stone, as nearly rectangular in section as practical. The stones shall be hard, sound, and resistant to the action of water and weathering. They shall be of a rock type other than serpentine rock containing the fibrous variety chrysotile (asbestos) and suitable in every respect for the purpose intended.

(a) Riprap, Heavy Type. The individual stones shall have a depth equal to the thickness of the course of riprap. At least 75% of the volume of the riprap shall consist of stones that have a minimum volume of 16 cubic feet.

(b) Riprap, Light Type. The individual stones shall have a depth equal to the thickness of the course of riprap and shall have a minimum volume of 1/2 cubic foot.

706.04 STONE FILL. Stone for stone fill shall be approved, hard, blasted, angular rock other than serpentine rock containing the fibrous variety chrysotile (asbestos). The least dimension of the stone shall be greater than 33% of the longest dimension. The stone fill shall be reasonably well graded from the smallest to the maximum size stone specified to form a compact mass when in-place.

(a) Stone Fill, Type I. The longest dimension of the stone shall vary from 1 inch to 12 inches, and at least 50% of the volume of the stone in-place shall have a minimum dimension of 4 inches.

(b) Stone Fill, Type II. The longest dimension of the stone shall vary from 2 inches to 36 inches, and at least 50% of the volume of the stone in-place shall have a minimum dimension of 12 inches.

(c) Stone Fill, Type III. The longest dimension of the stone shall vary from 3 inches to 48 inches, and at least 50% of the volume of the stone in-place shall have a minimum dimension of 16 inches.

(d) Stone Fill, Type IV. The longest dimension of the stone shall vary from 3 inches to 60 inches, and at least 50% of the volume of the stone in-place shall have a minimum dimension of 20 inches.

706.05 ENVIRONMENTAL STONE FILL. Environmental stone (E-stone) fill shall be hard, blasted, angular rock other than serpentine rock containing the fibrous variety chrysotile (asbestos). E-stone fill material of the type specified shall be defined as follows:

(a) E-Stone Fill, Type I. The longest dimension of the stone shall be at least 18 inches, and at least 50% of the volume of the stone in place shall have a least dimension of 12 inches, and at least 25% of the particles shall have a maximum dimension of 2 inches and be well graded material.

(b) E-Stone Fill, Type II. The longest dimension of the stone shall be at least 24 inches, and at least 50% of the volume of the stone in place shall have a least dimension of 18 inches, and at least 25% of the particles shall have a maximum dimension of 2 inches and be well graded material.

(c) E-Stone Fill, Type III. The longest dimension of the stone shall be at least 36 inches, and at least 50% of the volume of the stone in place shall have a least dimension of 24 inches, and at least 25% of the particles shall have a maximum dimension of 2 inches and be well graded material.

(d) E-Stone Fill, Type IV. The longest dimension of the stone shall be at least 48 inches, and at least 50% of the volume of the stone in place shall have a least dimension of 36 inches, and at least 25% of the particles shall have a maximum dimension of 2 inches and be well graded material.

SECTION 707 – JOINT MATERIALS

707.01 MORTAR. Mortar shall be a hydraulic-cement grout meeting the following requirements:

(a) General Requirements. Mortar shall be composed of cement in accordance with Subsection 701.02, sand in accordance with Subsection 704.01 or Subsection 704.13, and water in accordance with Subsection 745.01, unless otherwise specified.

Chemical admixtures shall be in accordance with Subsection 725.02 and mineral admixtures shall be in accordance with Subsection 725.03 for the respective admixture used, as required.

Masonry cement shall be in accordance with *ASTM C91* for the type specified.

Hydrated lime shall be in accordance with *ASTM C207*.

Contractor blended mortars shall be proportioned on site with sufficient water to form a stiff plastic composition. Packaged pre-blended mortars shall be prepared and installed in accordance with the manufacturer's recommendations.

Mortar shall not be re-tempered after it has begun to set.

(b) Mortar, Type I. Type I mortar shall be composed of 1 part cement, 2 parts sand, and sufficient water to form a plastic composition.

(c) Mortar, Type II. Type II mortar shall meet one of the following requirements:

(1) A packaged pre-blended dry mortar in accordance with *ASTM C1714*, Type S; or

(2) A Contractor blended mortar composed of 1 part cement, 2-1/2 parts sand, and 1/2 part hydrated lime; or

(3) A Contractor blended mortar composed of 1 part Type S masonry cement and 2-1/2 parts sand.

(d) Mortar, Type III. Type III mortar is generally used as a grout to fill around slope stabilization nails. It may also be used for rock slope stabilization rock dowels, rock anchors, shear keys and rock nails. It shall be a neat material meeting the following requirements:

(1) Compressive Strength. Type III mortar shall have a minimum compressive strength of 1,500 psi at 3 days and a minimum compressive strength of 3,500 psi at 28 days as determined in accordance with *AASHTO T 106*.

(e) Mortar, Type IV. Type IV mortar shall be a non-shrink hydraulic-cement grout with resistance to rapid freezing and thawing exhibiting no more than an 8% loss in mass (weight) after 300 cycles as determined in accordance with *AASHTO T 161, Procedure A*, and meeting one of the following requirements:

(1) Pre-Packaged. A packaged, dry, hydraulic-cement grout in accordance with *ASTM C1107*, at standard conditions, and one of the products listed on the Agency's *Approved Products List*; or

(2) Ready Mixed. A ready mixed, hydraulic-cement grout with an approved mix design conforming to *ASTM C1107* for compressive strengths and height change of hardened hydraulic-cement mortar.

Mix designs for Type IV mortar shall be submitted to the Structural Concrete Engineer for approval and shall include the following:

a. Mortar Type.

b. Aggregates.

1. Source

2. Moisture condition (SSD or dry weight)

3. Gradation

4. Specific gravity

5. Absorption

c. Cement.

1. Cementitious type (Type II or Type III)

2. Cementitious weight

i. Cement weight

ii. Pozzolan weight (if applicable)

d. Volumetric Quantities.

1. Volumetric quantities of each material

2. Target water volume

3. Maximum water-cementitious ratio

e. Admixtures.

1. Type

2. Product name

3. Dosage

i. Liquid or dry

ii. Volume or weight as applicable

f. Test Data.

1. Compressive strengths at 3, 7, and 28 days

2. Height changes at 1, 3, 14, and 28 days

3. Freeze-thaw durability

Testing shall be performed by a laboratory accredited in the respective test methods.

The Structural Concrete Engineer will provide a response to the submitted mix design within 14 calendar days of receipt.

Approved mix designs will be allowed consecutive re-approval if no material proportions or material sources have changed from the previous year's approved mix design and the mix design is submitted with updated aggregate properties and volumes adjusted accordingly. The aggregate properties shall be tested within 14 months of the mix design submission. The properties to be tested shall include, but not be limited to, specific gravity and absorption.

(f) Mortar, Type V. Type V mortar shall meet one of the following requirements:

(1) A packaged pre-blended dry mortar in accordance with *ASTM C1714*, Type N; or

(2) A Contractor blended mortar composed of 1 part cement, 2-1/2 parts sand, and 1 part hydrated lime; or

(3) A Contractor blended mortar composed of 1 part Type N masonry cement, 2-1/2 parts sand, and sufficient water to form a stiff plastic composition.

(g) Mortar, Type VI. Type VI mortar shall meet one of the following requirements:

(1) A packaged pre-blended dry mortar in accordance with *ASTM C1714*, Type M; or

(2) A Contractor blended mortar composed of 1 part cement, 2-1/2 parts sand, and 1 part hydrated lime; or

(3) A Contractor blended mortar composed of 1 part Type M masonry cement, 2-1/2 parts sand, and sufficient water to form a stiff plastic composition.

707.02 JOINT SEALER, POURABLE. Pourable joint sealer shall meet the following requirements:

(a) Joint Sealer, Hot Poured. This material shall consist of a hot applied, single-component, low-modulus, elastic sealant meeting the requirements of *ASTM D6690,* Type II or Type IV as specified in the Contract.

(b) Joint Sealer, Cold Poured. This material shall consist of a cold applied, two-component, low-modulus, elastic sealant capable of 200% elongation at -20°F when placed in a typical joint configuration.

(c) Backer Rod. Backer rod shall be 100% watertight, closed-cell, non-gassing, polyethylene, polyolefin, or other suitable material that does not react chemically with the sealant. It shall be compatible with the sealant applied at temperatures up to 410°F, shall remain stable down to a temperature of -20°F, and shall not cause bubbling of the sealant bead. The backer rod shall be approximately 1/8 inch larger in diameter than the width of the joint in which it is used.

707.03 JOINT SEALER, POLYURETHANE. Polyurethane joint sealer shall consist of a single component or two-component, cold-applied, polyurethane, elastomeric compound for use in expansion joints with widths of up to 6 inches. The sealer shall be suitable for installation at temperatures above 45°F and below 80°F, self-leveling where used in horizontal joints, capable of filling the joint completely without the formation of air holes or other discontinuities, and non-sagging or not subject to flow when placed in vertical or inclined joints.

The sealer shall cure by chemical reaction between the two components or by reaction with moisture from the atmosphere.

(a) Primer. When recommended by the manufacturer, a primer system shall be used to ensure adhesion to steel, concrete, epoxy, epoxy mortar, or granite under all conditions. The primer system shall be furnished by the sealer manufacturer.

(b) Filler Material. A foam spacer (backing) or filler material shall be used where shown on the Plans. The foam spacer shall be a closed-cell polyethylene or PVC foam, recommended by the manufacturer of the joint sealer and acceptable to the Engineer.

(c) Bond Breaker. A suitable bond breaker shall be applied to those surfaces shown on the Plans. The bond breaker shall be polyethylene-coated tape or other substitute acceptable to the Engineer.

(d) Proportioning and Mixing. When required, proportioning and mixing shall be accomplished strictly according to the manufacturer's instructions.

(e) Packaging. The joint sealer materials shall be delivered to the project in suitable containers for handling and shall be sealed or otherwise protected from contamination.

The containers shall be clearly labeled with the following information:

(1) Name and address of the manufacturer

(2) Name of the product or component identification

(3) Batch number

(4) Date of manufacture

The manufacturer shall furnish to the Engineer complete instructions for the storage, proportioning, mixing, handling, joint preparation, joint installation procedures, and complete SDS information for each shipment.

(f) Performance Requirements for Two-Component Materials. The joint sealer system, consisting of sealer and primer, shall meet the requirements of *ASTM C920*.

(g) Performance Requirements for Single-Component Materials. The joint sealer system shall meet the requirements of *ASTM C920*.

707.04 JOINT SEALER, PREFORMED NEOPRENE. Preformed neoprene joint sealer shall conform to the requirements of *ASTM D2628*. The lubricant-adhesive shall be of the formulation recommended by the manufacturer for the kind of material adjacent to the joint sealer. The Contractor shall furnish representative samples of joint sealer, lubricant-adhesive, or other components at no additional cost to the Agency for laboratory testing, when requested by the Engineer.

Any material not conforming to this subsection at the time of application or which has been improperly stored or which has exceeded the stated shelf life will be rejected. Lubricant-adhesive shall not be used beyond one year following its date of manufacture or if the container has been previously opened.

707.05 PREFORMED FABRIC MATERIAL. Preformed fabric material shall be a multi-layered sheet composed of multiple plies of 15 ounces per square yard (± 5%) polyester fabric laminated with butadiene acrylonitrile, and vulcanized to form an integral laminate.

The physical properties of the laminate shall meet the material requirements in Table 707.05A.

TABLE 707.05A – PREFORMED FABRIC PROPERTIES

Property	Number of Plies		
	2	3	5 – 8
Min. mass (weight) per unit area (lbs/ft^2)	0.75	0.85	4.00
Min. thickness (in.)	1/8	5/32	3/4
Min. ultimate tensile strength (lbs/in. of width)	800	1,200	2,000
Max. elongation at ultimate tensile strength (%)	30	30	30
Max. elongation at 10% of ultimate tensile strength (%)	3	3	3

707.06 PREFORMED JOINT FILLER, CORK, AND ASPHALT-TREATED FELT. Preformed cork joint filler shall conform to the requirements of *AASHTO M 153,* Type II unless otherwise specified. Asphalt-treated felt shall conform to *AASHTO M 213* unless otherwise specified.

707.07 PREFORMED JOINT FILLER, CLOSED-CELL FOAM. Preformed joint filler shall be a closed-cell polyethylene, polypropylene, or PVC foam, pre-molded to a semi-rigid consistency and meeting the performance requirements of *ASTM D7174*, Type I when tested in accordance with *ASTM D545*.

707.08 POLYVINYL CHLORIDE (PVC) WATERSTOP. PVC waterstop shall be manufactured from virgin PVC resin with the addition of only those plasticizers, stabilizers, or other materials needed to ensure that, when the material is compounded, it will meet the requirements of this subsection. No reclaimed, scrap, or reprocessed PVC shall be used.

The finished waterstop shall conform to the requirements of Table 707.08A.

TABLE 707.08A – PVC WATERSTOP PROPERTIES

Property	Test Method	Min.	Max.
Tensile strength (psi)	*ASTM D638*, Type IV	1,400	--
Ultimate elongation (%)	*ASTM D638*, Type IV	250	--
Low temperature brittleness	*ASTM D746*	[Note 1]	--
Durometer hardness – Shore Type A	*ASTM D2240*	60	80
Stiffness in flexure (psi)	*ASTM D747*	400	--
Alkali resistance (10% NaOH) mass (weight) change (%)	*ASTM D543*	-0.10	+0.25
Durometer hardness change	--	-5	+5

[1] No cracking or chipping shall be permitted on three specimens at -20°F.

707.09 RUBBER GASKETS. Rubber gaskets for culvert pipe joints shall conform to *ASTM C990*.

707.10 JOINT SEALER, BUTYL RUBBER TAPE. Butyl rubber tape joint sealer shall be a flexible plastic gasket conforming to the requirements of *ASTM C990*. The sealant shall be in roll form with release paper backing dimensioned to the width and thickness specified.

707.11 ALUMINUM FILLED SILICONE SEALANT. Aluminum filled silicone sealant is generally used to protect the surfaces of aluminum alloy in contact with other metals, wood, or Portland cement concrete. The compound shall be filled with aluminum flake or powder, be electrically conductive, and shall be of such consistency and have such properties that it can be readily applied with a trowel, putty knife, or caulking gun without pulling or drawing. Aluminum filled silicone sealant shall meet the approval of the Engineer.

707.12 PREFORMED JOINT FILLER. Preformed joint filler shall have the following properties:

(a) Preformed Joint Filler, Bituminous Type. Bituminous type preformed joint filler shall conform to the requirements of *AASHTO M 33* or *AASHTO M 213*.

(b) Preformed Joint Filler, Closed-Cell Polypropylene Type. Closed-cell polypropylene type preformed joint filler shall conform to the requirements of Table 707.12A.

TABLE 707.12A – CLOSED-CELL POLYPROPYLENE JOINT FILLER PROPERTIES

Property	Test Method	Requirement
Water absorption (volume)	*ASTM D545*	< 1.0%
Compression strength (to 50%)	*ASTM D545*	35 – 50 psi
Compression recovery (from 50%)	*ASTM D545*	> 80%
Extrusion (at 50%)	*ASTM D545*	< 0.1 in.
Density	*ASTM D545*	> 3.5 lbs/ft^3
Heat resistance at 392°F ± 5°F (shrinkage)	*ASTM D5249*	< 1.0%
UV weathering (1,000 hours, Cycle A - 340 nm)	*ASTM D4329*	No observable change or cracking
Freeze-thaw resistance (300 cycles)	*ASTM C666*	No visual change, less than 10% tensile strength change

707.13 ASPHALTIC PLUG JOINTS FOR BRIDGES. Asphaltic plug joints for bridges shall be single or multiple layer systems consisting of asphaltic binder, aggregate, closed cell foam expansion joint filler, and steel bridging plate, as applicable. Asphaltic plug joints shall be in accordance with *ASTM D6297* and shall be one of the products listed on the Agency's *Approved Products List*.

707.14 CONCRETE BONDING SYSTEMS. Concrete bonding systems shall conform to the requirements of *ASTM C881*.

707.15 ASPHALTIC PLUG JOINT BINDER. Asphaltic plug joint binder shall be a thermoplastic polymeric-modified asphalt in accordance with *ASTM D6297* and shall be one of the products listed on the Agency's *Approved Products List*.

707.16 JOINT SEALANT, ELASTOMERIC. Elastomeric joint sealants shall be Type S, Grade NS, and Class 100/50 in accordance with *ASTM C920*. The sealant shall exhibit no staining as determined in accordance with *ASTM C1248* for the applicable porous substrate.

707.17 JOINT SEALANT, LATEX. Latex joint sealants shall be Type OP, Grade -18°C, in accordance with *ASTM C834*. Sealants shall be ozone, ultraviolet, mildew, mold, and snow resistant.

SECTION 708 – COATINGS, STAINS, AND TRAFFIC MARKING MATERIALS

708.01 GENERAL REQUIREMENTS.

(a) Qualities and Characteristics. All paints shall be ready-mixed in accordance with the specific formulas from ingredients that meet the requirements described below. The paints shall be free of coarse particles, skins, water, and other foreign and objectionable matter except where tolerances have been allowed. The paints shall not skin over, thicken, liver, settle out excessively, or cake in the container in storage and shall be readily broken up with a paddle into a smooth, uniform consistency.

No rosin or rosin derivatives shall be added to the paints, but beneficial agents such as antioxidants or wetting aids may be added.

Ready-mixed paints that have hardened on standing or otherwise deteriorated to any extent will not be acceptable.

All paints shall be suitable for use in airless spray equipment.

(b) Packaging. Ready-mixed paints shall be shipped in strong, new, airtight containers. All containers of paint shall be clearly labeled with the following information:

(1) Name and address of the manufacturer

(2) Manufacturer's batch number

(3) Date of manufacture

(4) Vermont paint number, name, and color

(5) Volume of contents

Containers shall be clearly marked to indicate any hazards connected with the use of the paint and the protective measures that should be provided to prevent injury to the health of workers.

(c) Approval. No paint or stain shall be used until it has been approved by the Agency's Materials Testing and Certification Section.

(d) Identification. To provide a means of identification for paints, the applicable identification number and name taken from the following list shall be printed on all test reports and container labels:

(1) Coatings for Structural Steel and Other Metals. For structural steel coatings, the identification number and the name for the coating used shall be the manufacturer's name, the manufacturer's name for the coating, and the manufacturer's lot number.

a. VT 1.01 – Structural Steel Prime Coat

b. VT 2.01 – Structural Steel Intermediate Coat

c. VT 3.01 – Structural Steel Top Coat

(2) Wood Coatings.

a. VT 4.01 – Dark Brown Oil Base Stain

(3) Traffic Sign Paint.

a. VT 5.01 – Black Enamel

b. VT 5.02 – Blue Enamel

c. VT 5.03 – Green Enamel

d. VT 5.04 – Red Enamel

e. VT 5.05 – White Enamel

f. VT 5.06 – Yellow Enamel

g. VT 5.07 – Brown Enamel

h. VT 5.08 – Orange Enamel

(4) Traffic Control Signal Paint.

a. VT 6.01 – Flat Black Enamel

b. VT 6.02 – Yellow Enamel

(5) Pavement Marking Paint.

a. VT 7.01 – White Traffic Paint

b. VT 7.02 – Yellow Traffic Paint

c. VT 7.05 – White Traffic Paint, Fast Dry

d. VT 7.06 – Yellow Traffic Paint, Fast Dry

708.02 POWDER COATING SYSTEMS. Protective coatings shall be applied to metals as a free-flowing, dry powder using a dry finishing process to cure the coating onto the substrate.

(a) General Requirements. Systems shall be exterior grade powders consisting of two coats from a single manufacturer. Coats shall be compatible and per the manufacturer's recommendations.

The first coat may be applied to bare metal or galvanized metal in accordance with the Contract. When applied to bare metal, the first coat shall be an epoxy zinc rich primer. When applied over galvanizing, the first coat of powder shall be recommended for use over galvanizing by the powder manufacturer.

The topcoat shall be a urethane or polyester powder.

(b) Material Properties. Material properties shall be in accordance with Table 708.02A.

TABLE 708.02A – POWDER COATING MATERIAL PROPERTIES

Property	Test Method	Test Requirement
Abrasion resistance	*ASTM D4060* (CS-10 abrasive wheel, at 1,000 cycles)	100 mg weight loss (max.)
Adhesion	*ASTM D3359, Method A* or *ASTM D3359, Method B*	5A or 5B
Water resistance	*ASTM B4585* or *ASTM D2247* (100°F minimum, 2,000 hours)	No blister or film failure, no cracking or delamination
Salt spray resistance	*ASTM B117, ASTM D1654* (1,000 hours)	Unscribed – No blisters or visual defects Scribed – 0 inches to 1/64 inch

(c) Color. The color shall be in accordance with Subsection 708.03(b).

708.03 STRUCTURAL STEEL COATING SYSTEMS. Acceptable structural steel coating systems shall be one of the systems listed on both the Agency's *Approved Products List* and on the *NEPCOAT Qualified Products List B*, and shall meet the following requirements:

(a) System. The structural steel coating system shall be a three-coat system with a prime, intermediate, and top coat. Components of different systems shall not be intermixed.

(b) Color. Individual coats shall have contrasting colors. The finish color of the top coat shall be green, black, or brown as specified in the Contract, and shall conform to *SAE AMS-STD-595* for the respective chip number as specified in Table 708.03A.

TABLE 708.03A – COLORS FOR STRUCTURAL COATING SYSTEMS

Color	Chip Number
Green	14062
Black	27038
Brown	20059

(c) Damage. Damage to structural steel coating systems shall be repaired with a compatible structural steel coating system as specified herein.

708.04 GREASE RUSTPROOFING COMPOUND. Grease rustproofing compound shall be a soft film type material made from petroleum combined with special additives to enhance its moisture displacing capabilities.

Grease rustproofing compound shall contain effective rust inhibitors and have properties that conform to the requirements of Table 708.04A.

TABLE 708.04A – GREASE RUSTPROOFING COMPOUND PROPERTIES

Property	Requirement
Appearance (color)	Brown-green
Flash (COC)	150°F min.
Melting point (*ASTM D127*)	145°F min.
Thinner	20% by weight max.
Density at 60°F	7.00 lbs/gal min.
Approximate NLGI grease grade	No. 2 before solvent evaporation, No. 5 after solvent evaporation

708.05 COATINGS FOR WOOD.

(a) VT 4.01 Dark Brown Oil Base Stain. Dark brown oil base stain is used as a protective coating for wood surfaces. The stain shall conform to the requirements of Table 708.05A and the pigment shall consist of pure mineral pigments combined in the proportions necessary to match the specified color.

TABLE 708.05A – DARK BROWN OIL BASE STAIN PROPERTIES

Stain Component	Property	Min.	Max.
Vehicle	Heavy bodied linseed oil (%)	15	--
	Mineral spirits (%)	--	85
Stain	Pigment (%)	15	--
	Vehicle (%)	--	85
	Density (lbs/gal)	7.5	--
	Drying time, dry to recoat (hours)	--	24
	Fineness of grind (Hegman scale)	4	--

(b) Insecticide/Fungicide. Insecticide/fungicide coatings for interior applications shall be water/ glycol-based solutions per the manufacturer's specifications. Acceptable coatings shall be those on the Agency's *Approved Products List*.

(c) Fire Retardant. Fire retardant coatings for interior and exterior applications shall be non-toxic, non-hazardous, and water-based solutions meeting the requirements of *ASTM E84/NFPA 255/UL 723*. Acceptable coatings shall be those on the Agency's *Approved Products List*.

708.06 PAINT FOR TRAFFIC CONTROL SIGNALS. Paint for traffic control signals shall consist of ready-mixed enamels suitable for exterior use on primed metal surfaces. Paint colors used for traffic control signals shall conform to the requirements of *MPI #8, MPI #9,* or *MPI #94*. The *SAE AMS-STD-595* standard shall be used to determine the acceptable color match for black and yellow traffic control signal paints.

(a) VT 6.01 Flat Black Enamel. The color shall conform to the requirements of *MPI #8, MPI #9,* or *MPI #94*. The color shall be an acceptable match to Chip No. 37038 in *SAE AMS-STD-595*.

(b) VT 6.02 Yellow Enamel. The color shall conform to the requirements of *MPI #8, MPI #9,* or *MPI #94*. The color shall be an acceptable match to Chip No. 13538 in *SAE AMS-STD-595*.

708.07 PAINT FOR PAVEMENT MARKINGS. Ready-mixed traffic paint suitable for marking on either bituminous or Portland cement concrete pavements shall conform to the following requirements:

(a) Polyurea Pavement Markings. Approved polyurea marking materials shall be one of the markings listed on the Agency's *Approved Products List*.

(b) Epoxy Paint. Epoxy paint shall be one of the epoxy paints on the *Approved Products List*.

(c) Waterborne Traffic Paint. Waterborne traffic paint shall consist of properly formulated pigment and vehicle to give the desired results. The paint shall show the proper capillary action at the bead surface to provide anchorage, refraction, and reflection when beads are applied at the standard rate of 8 pounds per gallon of paint.

(1) Materials.

a. Pigments. The pigments used shall be those designated, which shall conform to the stated requirements.

b. Titanium Dioxide. Titanium dioxide shall be of the rutile type and shall meet the requirements specified in *ASTM D476*, Type II.

c. Vehicle. The vehicle shall be water.

(2) Composition. The waterborne paint binder shall be a 100% acrylic binder, as determined by infrared analysis according to the requirements of *ASTM D2621* or other standard ASTM methods designated herein. The composition of the paint shall comply with Table 708.07C.

TABLE 708.07C – WATERBORNE TRAFFIC PAINT COMPOSITION

Property	Test Method	White	Yellow/Blue/Green
Pigment content (% by mass)	*ASTM D3723*	58% min., 62% max.	58% min., 62% max.
Vehicle content (% by mass)	--	38% min., 42% max.	38% min., 42% max.
VOC content	*ASTM D3960*	1.25 lbs/gal (150 g/L) max.	1.25 lbs/gal (150 g/L) max.
Lead content	--	0.005% max.	0.005% max.
Yellow pigment	--	N/A	Yellow #65 or Yellow #75
Titanium dioxide, rutile Type II	*ASTM D1394*	1.00 lbs/gal (120 g/L) max.	0.21 lbs/gal (25 g/L) max.
Total non-volatile content (% by mass)	*ASTM D2369*	76.0% min.	76.0% min.
Total volatile content (% by mass)	*ASTM D2369*	25.0% max.	25.0% max.
Total non-volatile content, by volume	*ASTM D2697*	62.0% min.	62.0% min.
Density	*ASTM D1475*	14.0 ± 0.33 lbs/gal (1.68 ± 0.04 kg/L)	13.6 ± 0.33 lbs/gal (1.63 ± 0.04 kg/L)
Paint pH	--	9.6 min.	9.6 min.
Close cup flash point	*ASTM D3278*	140°F (60°C) min.	140°F (60°C) min.
Viscosity	*ASTM D562*	78 Krebs min., 95 Krebs max.	78 Krebs min., 95 Krebs max.
Dry time	*ASTM D711*	10 minutes max.	10 minutes max.

708.08 THERMOPLASTIC PAVEMENT MARKINGS.

(a) Thermoplastic Pavement Markings, Type A. Type A thermoplastic pavement markings shall be one of the thermoplastic pavement markings on the Agency's *Approved Products List*. Thermoplastic pavement markings shall comply with the requirements of *AASHTO M 249*.

Thermoplastic pavement markings shall have a lead content less than 0.005% by weight.

(b) Thermoplastic Pavement Markings, Type B. Type B thermoplastic pavement markings shall be one of the preformed thermoplastic pavement markings on the Agency's *Approved Products List*.

708.09 TEMPORARY DELINEATION SYSTEMS.

(a) Line Striping Targets. Acceptable line striping targets shall be one of the line striping targets on the Agency's *Approved Products List*.

(b) Pavement Marking Mask. Acceptable pavement marking mask shall be one of the masking marking tapes on the Agency's *Approved Products List*.

SECTION 709 – LUMBER AND TIMBER

709.01 STRUCTURAL LUMBER AND TIMBER. Structural lumber and timber shall conform to the species and stress-grades specified in the Contract and shall be acceptable to the Engineer.

(a) Grading. Structural lumber and timber shall be graded in accordance with *AASHTO M 168*. Lumber ordered in multiple lengths shall be graded after having been cut to length.

(b) Moisture Content.

(1) Untreated Lumber and Timber. The maximum moisture content of untreated lumber and timber material being incorporated into the work shall be 19%.

(2) Treated Lumber and Timber. The maximum moisture content of treated lumber and timber material prior to treatment shall be 19%. Material treated with water-borne preservatives in accordance with AWPA standards shall be dried after treatment to a moisture content not exceeding 19% and shall be maintained at a moisture content of 19% or less until it is incorporated into the work.

(c) Minimum Stress Requirements. Unless otherwise specified in the Contract, lumber and timber shall meet the allowable unit stress requirements for No. 1 Grade or better material as specified in the *AASHTO LRFD Bridge Design Specifications*.

(d) Lumber Dimensions.

(1) Full-Sawn Lumber. Minimum full-sawn lumber sizes are nominal dimension sawn sizes after seasoning. Pieces shall be sawn to obtain the full nominal dimensions specified with only occasional slight variation permitted. Thickness and width dimensions are somewhat variable depending upon the sawmill equipment used.

(2) Rough-Sawn Lumber. Rough dry-sized lumber is minimally 1/8 inch larger in each dimension than standard (seasoned) dressed-sized lumber. Thickness and width dimensions are somewhat variable depending upon the sawmill equipment used.

(3) Dressed Lumber. Dressed lumber sizes are the finished planed dimensions of material after seasoning. Minimum net finished dimensions for dressed lumber shall be 1/2 inch less than the nominal dimension, except that the minimum net width of dressed lumber exceeding 6 inches shall be 3/4 inch less than the nominal dimension.

(e) Lumber Finish. Lumber finishes shall be as specified per the requirements of *AASHTO M 168* for manufacturing classifications (e.g. rough lumber or dressed lumber).

(f) Soundness. Lumber material shall be sound and free from any incipient or advanced form of decay.

(g) Preservative Treatment. Preservative treatment of lumber and timber materials shall conform to the requirements of Subsection 726.01 and *AWPA Standard U1*.

(h) Miscellaneous Hardware, Shapes, and Fabricated Materials.

(1) Structural steel shapes and metal fabricated materials shall conform to the requirements of the Contract and the material requirements specified in Section 714 and Section 715.

(2) Unless otherwise specified, bolts, studs, threaded rods, nuts, and washers shall conform to the requirements of *ASTM A307*, Grade A. Carbon steel nuts, unless otherwise specified, shall conform to the requirements of *ASTM A563*.

(3) Nails and spikes shall conform to the requirements of *ASTM F1667*.

(4) Lag screws shall be of low to medium carbon steel and shall be of good commercial quality.

(5) Unless otherwise specified, all steel hardware and fabricated materials shall be galvanized in accordance with *AASHTO M 111* or *AASHTO M 232*, as applicable.

709.02 NONSTRUCTURAL LUMBER. Material furnished under this subsection shall be for non-load–carrying structural applications with a maximum nominal thickness of 2 inches (e.g. boarding, siding, trim, etc.). Lumber shall be seasoned or kiln dried spruce, eastern white pine, eastern hemlock, southern pine, or western fir, unless otherwise specified in the Contract.

(a) Grade. The grade classification of yard lumber, whether common or select, shall be as specified in the Contract. Structural lumber meeting the requirements of Subsection 709.01 and nominal 2-inch thickness may be used for nonstructural lumber applications. Except with the written permission of the Engineer, lumber which has not been grade classified or stress-graded shall not be used for nonstructural lumber.

(b) Moisture Content. The moisture content of nonstructural lumber shall be as specified in Subsection 709.01(b).

(c) Dimensions.

(1) Full-Sawn. When required in the Contract, lumber shall be furnished to the minimum full-sawn (nominal) dimensions specified.

(2) Dressed. Unless otherwise specified, all lumber shall be surfaced four sides (S4S).

(d) Finish. Rough lumber or dressed lumber shall be finished per the requirements of *AASHTO M 168* manufacturing classifications.

(e) Soundness. Nonstructural lumber shall be sound and free from any incipient or advance form of decay.

(f) Preservative Treatment. Preservative treatment of lumber shall conform to the requirements of Subsection 726.01 and *AWPA Standard U1*.

(g) Hardware, Shapes, and Fabricated Materials. Hardware, shapes, and fabricated materials shall be as specified in Subsection 709.01(h).

709.03 STRUCTURAL GLUED LAMINATED TIMBER.

(a) Material. Unless otherwise specified, structural glued laminated (glulam) timber shall be fabricated from southern pine, coastal Douglas fir, western hemlock, or western larch and shall meet the requirements of *AASHTO LRFD Bridge Construction Specifications, Section 16*.

Adhesives used in the lamination process shall be for wet-use conforming to the requirements of *ASTM D2559* and shall comply with all other requirements of *ANSI/AITC A190.1*.

Unless otherwise specified, the appearance grade of the finished glulam products shall be industrial.

(b) Seasoning. Unless otherwise specified, all material shall have a moisture content not exceeding 16% at the time of gluing laminations.

(c) Preservative Treatment. Unless otherwise specified, all glued laminated timber shall be treated in accordance with *AWPA Standard U1*. Also, unless otherwise specified, all material shall be shop-fabricated prior to treatment. Any field treatment required by the Engineer shall be performed in accordance with *AWPA Standard M4*.

(d) Miscellaneous Hardware, Shapes, and Fabricated Materials.

(1) Structural steel shapes and metal fabricated materials shall conform to the requirements of the Contract and the material requirements specified in Section 714 and Section 715.

(2) Unless otherwise specified, bolts, studs, threaded rods, nuts, and washers shall conform to the requirements of *ASTM A307*, Grade A. Stainless steel fasteners shall conform to the requirements of *ASTM F593*, Alloy Group 1, Condition AF, Alloy 304 and its supplementary requirements for S5, with nuts conforming to the requirements of *ASTM F594*.

(3) All welding shall conform to the requirements of Subsection 506.10.

(4) Nails and spikes shall conform to the requirements of *ASTM F1667*.

(5) Lag screws shall be of low to medium carbon steel and shall be of good commercial quality.

(6) Unless otherwise specified, all steel hardware and fabricated materials shall be galvanized in accordance with *AASHTO M 111* or *AASHTO M 232*, whichever is applicable.

(e) Dimensions. The designated dimensions for glued laminated timber shall be taken as the actual net dimensions.

(f) Handling. Glued laminated timber shall be carefully handled to avoid damaging the edges and surfaces. The handling, transit, and erection procedures shall meet the requirements of *AITC 111*.

709.04 RAILROAD TIES.

(a) General Requirements.

(1) Preservative Treatment. Railroad ties shall be preserved in accordance with *AREMA Chapter 30, Section 3.6*; *AREMA Chapter 30, Section 3.7*; and one of the following:

a. *AWPA P1/P13*

b. *AWPA P2*

c. *AWPA P3*

d. *AWPA P60*

(2) Field-Applied Preservative Treatment. Field-applied preservative treatment shall meet the requirements of Subsection 726.01.

(3) Anti-Splitting Devices. Railroad ties shall be furnished with anti-splitting devices in accordance with *AREMA Chapter 30, Section 3.1.6* and *AREMA Chapter 30, Section 3.1.7*.

(b) Bridge Ties. Bridge ties shall be No. 1 Grade or better solid sawn oak in accordance with *AREMA Chapter 7, Section 1.7* and meet the following requirements:

(1) Surface. Bridge ties shall be surfaced two sides, top and bottom, and dapped (notched) for stringer flanges on the bottom side as shown on the Plans. The heartwood side shall be the bottom side for dapped ties.

(2) Dimensions. Bridge tie dimensions shall be as shown on the Plans.

(c) Cross Ties. Cross ties shall be solid sawn treated timber from mixed hardwoods, in accordance with *AREMA Chapter 30, Section 3.1*.

(1) Cross Ties, Type A. Type A cross ties shall be 6-inch grade cross ties, 6 inches × 8 inches in cross section.

(2) Cross Ties, Type B. Type B cross ties shall be 7-inch grade cross ties, 7 inches × 9 inches in cross section.

(d) Switch Ties. Switch ties shall be solid sawn treated timber from mixed hardwoods, in accordance with *AREMA Chapter 30, Section 3.2*. Switch ties shall be 7-inch grade switch ties, 7 inches × 9 inches in cross section.

(e) Tie Plugging Material. Tie plugging material shall meet the requirements of *AREMA Chapter 30, Section 3.1.5*. Liquid tie plug material shall be non-foaming, polymer-based synthetic polyurethane tie plugging compound.

SECTION 710 – CULVERTS, STORM DRAINS, AND SEWER PIPES, NONMETAL

710.01 REINFORCED CONCRETE PIPE. Reinforced concrete pipe shall conform to the requirements of *AASHTO M 170* with the following notes or exceptions:

(a) Design Requirements. The circular reinforcement specified in *AASHTO M 170, Table 3* for 24-inch, Class III, Wall B pipe shall be 0.1 square inch per foot of pipe wall. Elliptical reinforcement shall not be used in circular pipes.

All pipes 24 inches in diameter or smaller shall be of the bell-and-spigot type. Pipes larger than 24 inches in diameter may be either of the tongue-and-groove or bell-and-spigot types.

710.02 REINFORCED CONCRETE PIPE END SECTIONS. Reinforced concrete pipe end sections shall conform to the requirements of Subsection 710.01. Where two cages of reinforcement are required in accordance with *AASHTO M 170*, they shall be placed in the barrel of the end section only. Reinforcement of the apron section shall be equal in area to the inner cage of the barrel reinforcement.

710.03 CORRUGATED POLYETHYLENE PIPE (CPEP). CPEP shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions work plan for *Evaluation of HDPE (High Density Polyethylene) Thermoplastic Drainage Pipe Manufacturers* and in compliance with the AASHTO Product Evaluation & Audit Solutions audit program for thermoplastic pipe. CPEP shall be one of the products listed on the Agency's *Approved Products List* for the respective material specification.

(a) Corrugated Polyethylene Pipe, Unlined.

(1) Small Diameter. CPEP, unlined, with a nominal diameter of 3 inches to 10 inches, inclusive, shall be in accordance with *AASHTO M 252*, Type C.

(2) Large Diameter. CPEP, unlined, with a nominal diameter of 12 inches to 60 inches, inclusive, shall be in accordance with *AASHTO M 294*, Type C.

(b) Corrugated Polyethylene Pipe, Smooth Lined.

(1) Small Diameter. Smooth lined CPEP with a nominal diameter of 3 inches to 10 inches, inclusive, shall be in accordance with *AASHTO M 252*, Type S.

(2) Large Diameter. Smooth lined CPEP with a nominal diameter of 12 inches to 60 inches, inclusive, shall be in accordance with *AASHTO M 294*, Type S.

(c) Corrugated Polyethylene Pipe, Perforated. Perforated CPEP shall be in accordance with *AASHTO M 252*, Type CP or Type SP.

Large diameter CPEP may be made of virgin materials, recycled materials, or a blend of both in accordance with *AASHTO M 294*.

710.04 ACRYLONITRILE-BUTADIENE-STYRENE (ABS) PLASTIC PIPE. ABS pipe shall conform to the requirements of *ASTM D2680*.

710.05 POLYVINYL CHLORIDE (PVC) PLASTIC PIPE. PVC pipe shall conform to the requirements of Table 710.05A.

TABLE 710.05A – PVC PIPE MATERIAL REQUIREMENTS

Pipe Type	Pipe Dimensions	Standard
Smooth wall, perforated or un-perforated	4 – 16 inches (100 – 375 mm)	*AASHTO M 278*
	18 – 28 inches (450 – 700 mm)	*ASTM F679* [1]
Corrugated, with smooth interior	All sizes	*ASTM F949, ASTM F794*

[1] Pipe with other cell classifications that meet or exceed the performance requirements of *ASTM D3034* will be permitted if the wall thickness is not less than 94% of that in *AASHTO M 278*.

710.06 CORRUGATED POLYPROPYLENE PIPE (CPPP). CPPP shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions work plan for *Evaluation of Polypropylene Drainage Pipe Manufacturers* and in compliance with the AASHTO Product Evaluation & Audit Solutions audit program for thermoplastic pipe. CPPP shall be one of the products listed on the Agency's *Approved Products List* for the respective material specification.

(a) Corrugated Polypropylene Pipe, Unlined. Unlined CPPP shall be in accordance with *AASHTO M 330*, Type C.

(b) Corrugated Polypropylene Pipe, Smooth Lined. Smooth lined CPPP shall be in accordance with *AASHTO M 330*, Type S.

SECTION 711 – CULVERTS, STORM DRAINS, AND SEWER PIPES, METAL

711.01 CORRUGATED STEEL PIPE, PIPE ARCHES, AND UNDERDRAINS. Corrugated steel pipe, elbows, end sections, reducer units, pipe arches, underdrain, risers, flushing basins, and coupling bands shall conform to the requirements of *AASHTO M 36*. Material furnished under this subsection shall be formed from sheet material coated in accordance with *AASHTO M 218, AASHTO M 274*, or *AASHTO M 289*.

(a) Coupling Bands. Coupling bands shall conform to the requirements of *AASHTO M 36*, with the following modifications:

(1) Coupling bands and their connections shall be of such dimensions as required to meet the Erodible Special Joint category criteria of *AASHTO Standard Specifications for Highway Bridges, Section 26*. Structural steel for band connections shall meet the requirements of *ASTM A36*.

a. The only approved method of connection and connection details at the ends of the bands shall be 2 inch × 2 inch × 3/16 inch galvanized steel angles extending the full width of the band as detailed in *Standard Drawing D-4*.

b. 12-gauge die-cast angles shall be used with a configuration that provides at least the same section modulus as the 2 inch × 2 inch × 3/16 inch angle, extending the full width of the band.

c. A minimum of two bolts shall be used for 7 inch wide coupling bands, three bolts shall be used for 12 inch wide coupling bands, and five bolts shall be used for 24 inch wide coupling bands. All bolts shall be uniformly spaced.

Bolts, nuts, and other threaded items used with coupling bands shall be coated by the electroplating process as specified in *ASTM B633,* Class Fe/Zn 25, the zinc coating process as specified in *AASHTO M 232*, or the mechanical zinc coating process as specified in *ASTM B695*, Class 25.

d. Angles shall be connected to bands by one of the following methods:

1. Spot welds spread over full width of the band

2. Stitch-welds over the full width of the band

3. Attached by rivets

(2) The minimum coupling band thickness shall be 1/16 inch, and bands shall be no more than two nominal sheet thicknesses thinner than the wall thickness of the culvert or unit being connected. Coupling bands and die-cast angles may be formed from any one of the three types of sheet material specified above.

(3) The use of projection pipe coupling (dimpled) bands or preformed channel bands is not allowed.

(4) The Contractor may submit alternate coupling bands for approval to the Agency and shall allow 30 days for evaluation. Coupling bands shall not be shipped to projects until the Contractor has been notified that the coupling proposed band has been approved by the Agency.

(5) For attaching metal end sections to corrugated steel pipe, the Contractor may supply 1 inch wide × 12-gauge galvanized straps connected by a 1/2 inch galvanized bolt and nut for 12 inch through 24 inch diameter round pipes, and for 28 inch × 20 inch pipe arches and smaller.

(b) End Sections. Materials used in the manufacture of end sections shall conform to the requirements of *AASHTO M 36*, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.

(c) Reducer Units. Materials used in the manufacture of concentric metal reducer units shall conform to the requirements of *AASHTO M 36*, except that the maximum and minimum diameters, dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.

(d) Underdrain. Perforated underdrain including all lateral and special connections shall conform to the requirements of *AASHTO M 36*. The required minimum sheet metal thickness shall be 0.052 inch for 6-inch diameter underdrain and 0.064 inch for 8-inch diameter underdrain and larger.

(f) Underdrain Risers and Flushing Basins. Underdrain risers and flushing basins, including all connectors, fittings, and covers shall conform to the requirements of *AASHTO M 36*, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract. Underdrain risers and flushing basins shall not be perforated.

(g) Marking. All material furnished under this subsection shall be clearly marked in an approved manner with the name or trademark of the pipe fabricator and the sheet metal thickness.

711.02 CORRUGATED ALUMINUM ALLOY PIPE, PIPE ARCHES, AND UNDERDRAINS.

(a) Coupling Bands. Coupling bands shall conform to the requirements of *AASHTO M 196.*

(1) Coupling bands and their connections shall be of such dimensions as required to meet the Erodible Special Joint category criteria of the *AASHTO Standard Specifications for Highway Bridges, Section 26*.

(2) Coupling band connections shall meet the following parameters:

a. Coupling bands connections shall have either 2 inch × 2 inch × 1/4 inch aluminum angles that meet the requirements of *ASTM B221,* Alloy 6063-T6 or 12-gauge minimum die-cast aluminum angles. Angles shall extend the full width of the band.

b. Coupling bands connections shall have a minimum shear strength capacity of 6.3 kips.

c. Connections shall be made with a minimum of two bolts for 7 inch wide coupling bands, three bolts for 12 inch wide coupling bands, and five bolts for 24 inch wide bands. Bolts shall be uniformly spaced across the width of the band. Bolts, nuts, and other threaded items shall be coated in accordance with Subsection 711.01(a)(1)c.

d. Coupling bands connections shall have angles attached to the bands by stitch-welding over the full width of the band or by rivets uniformly spaced across the width of the band.

(3) The minimum coupling band thickness shall be 0.06 inch, and bands shall be no more than two nominal sheet thicknesses thinner than the wall thickness of the culvert being connected.

(4) Alternate coupling bands may be submitted for approval as specified in Subsection 711.01(a)(5).

(b) End Sections. Materials used in the manufacture of end sections shall conform to the requirements of *AASHTO M 196,* except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.

(c) Reducer Units. Materials used in the manufacture of concentric reducer units shall conform to the requirements of *AASHTO M 196,* except that the maximum and minimum diameters, dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.

(d) Underdrain Risers and Flushing Basins. Underdrain risers and flushing basins, including all connectors, fittings, and covers shall conform to the requirements of *AASHTO M 196*, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract. Underdrain risers and flushing basins shall not be perforated.

(e) Marking. All material furnished under this subsection shall be clearly marked in an approved manner with the name or trademark of the pipe fabricator and the sheet metal thickness.

711.03 POLYMERIC COATED CORRUGATED STEEL PIPE AND PIPE ARCHES. Polymeric coated corrugated steel pipe, elbows, reducer units, and pipe arches shall conform to the requirements of *AASHTO M 245*. Polymeric coating shall conform to the requirements of *AASHTO M 246*, Grade 250/250.

(a) Coupling Bands. Coupling bands shall conform to the requirements of Subsection 711.01(a) modified as follows:

(1) Coupling bands and die-cast angles shall be formed from sheet material coated in accordance with *AASHTO M 218*, *AASHTO M 245*, *AASHTO M 274*, or *AASHTO M 289*.

(2) Coupling bands formed from *AASHTO M 274* or *AASHTO M 289* material shall be not more than one nominal sheet thickness thinner than the wall thickness of the culvert or unit being connected.

(3) Coupling bands formed from *AASHTO M 245* material shall be not more than two nominal sheet thicknesses thinner than the thickness of the culvert or unit being connected. Angles must be attached to the band by rivets.

(4) Coupling bands formed from *AASHTO M 218* material shall be the same nominal sheet thickness as the culvert or units being connected. Angles must be attached to the band with rivets or by stitch-welding over the full width of the band.

(b) End Sections. Materials used in the manufacture of end sections shall conform to the requirements of Subsection 711.01(b).

(c) Reducer Units. Materials used in the manufacture of concentric reducer units shall conform to the requirements of *AASHTO M 245*, except that the maximum and minimum diameters, dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.

(d) Marking. All material furnished under this subsection shall be clearly marked in an approved manner with the name or trademark of the pipe fabricator and the sheet metal thickness.

711.04 COAL-TAR BASED COATING. Coal-tar based coating used to repair damaged areas of polymeric coating shall meet the requirements of *AASHTO M 243*.

711.05 STRUCTURAL PLATES, BOLTS, AND NUTS. Structural steel plates, bolts, and nuts for pipe, pipe-arches, arches, and box culverts shall conform to the requirements of *AASHTO M 167*.

Structural aluminum alloy plate, bolts, and nuts for pipe, pipe-arches, arches, and box culverts shall conform to the requirements of *AASHTO M 219*.

(a) Dimensions. The thickness of the plates or sheets and the radius of curvature shall be as specified in the Contract. Each plate or sheet shall be curved to one or more circular arcs.

(b) Fabrication. Plates shall be formed to provide lap joints. The bolt holes shall be punched so that all plates having like dimensions, curvature, and the same number of bolts per foot of seam shall be interchangeable. Each plate shall be curved to the proper radius so that the cross-sectional dimensions of the finished structure will be as specified in the Contract.

Bolt holes along those edges of the plates that form longitudinal seams in the finished structure shall be in two rows. Bolt holes along those edges of the plates that form circumferential seams in the finished structure shall provide for a bolt spacing of not more than 12 inches. The minimum distance from center of hole to edge of the plate shall not be less than 1.75 times the diameter of the bolt. The diameter of the bolt holes in the longitudinal seams shall not exceed the diameter of the bolt by more than 1/8 inch.

Cut edges shall be free from oxide and burrs. Legible identification numerals shall be placed on each plate to designate its proper position in the finished structure.

Unless otherwise specified in the Contract, plate pipes shall be elongated so that the finished pipe is elliptical in shape with the vertical diameter approximately 5% greater than the nominal diameter of the pipe. Pipe arches shall not be elongated.

SECTION 713 – CONCRETE REINFORCING MATERIALS

713.01 BAR REINFORCEMENT. Bar reinforcement shall be Grade 60 deformed bar unless otherwise specified herein.

(a) Reinforcing Steel. Reinforcing steel shall be in accordance with *AASHTO M 31*, Type S, including supplementary requirements. Reinforcing steel shall not have corrosion protection.

(b) Low-Alloy Reinforcing Steel. Low-alloy reinforcing steel shall be in accordance with *AASHTO M 31*, Type W.

(c) Epoxy-Coated Reinforcing Steel. Epoxy-coated reinforcing steel shall have an electrostatically applied epoxy protective coating which has been prequalified, fabricated, tested, and installed in accordance with the requirements of *ASTM A775*. Steel reinforcing bars to be coated shall be in accordance with *ASTM A615* or *ASTM A706*.

(d) Dual-Coated Reinforcing Steel. Dual-coated reinforcing steel shall be in accordance with *ASTM A1055*, Type I or Type II. Steel reinforcing bars to be coated shall be in accordance with *ASTM A615* or *ASTM A706*.

(e) Continuous Galvanized Reinforcing Steel. Continuous galvanized reinforcing steel shall be in accordance with *ASTM A1094*. Steel reinforcing bars to be coated shall be in accordance with *ASTM A615* or *ASTM A706*.

(f) Low-Carbon, Chromium, Steel. Low-carbon, chromium, steel shall be in accordance with *AASHTO M 334* and UNS designation K81550, Grade 100.

(g) Hot-Dipped Galvanized Reinforcing Steel. Hot-dipped galvanized reinforcing steel shall be in accordance with *ASTM A767*, Class 1 coating. Steel reinforcing bars to be coated shall be in accordance with *ASTM A615* or *ASTM A706*. Chromate treatment will not be required.

(h) Solid Stainless Reinforcing Steel. Solid stainless reinforcing steel shall be in accordance with *ASTM A955* with a UNS designation of S24100, S31653, S32101, S32205, or S32304. Different designations shall not be mixed within the same project.

Elongation requirements for solid stainless reinforcing steel shall be the same as for the equivalent size and grade of *AASHTO M 31*, Type S reinforcing steel.

713.02 MECHANICAL SPLICES FOR BAR REINFORCEMENT. Mechanical splices for bar reinforcement shall develop, in tension or compression, a minimum of 125% of the specified yield strength of the bar intended to be spliced. Mechanical splices shall be installed in accordance with the manufacturer's recommendations or as ordered by the Engineer.

713.03 WELDED WIRE REINFORCEMENT. Welded steel wire reinforcement for concrete structures shall be in accordance with *AASHTO M 336*, including supplementary requirements.

713.04 PRESTRESSING STRAND AND POST-TENSIONING STRAND.

(a) Prestressing Strands. Prestressing strands shall be strands of the diameter shown on the Plans and shall be in accordance with *AASHTO M 203*, Grade 270.

(b) Post-Tensioning Strands. Post-tensioning strands shall conform to the requirements of *AASHTO M 203* or *AASHTO M 204*.

713.05 FIBER REINFORCEMENT. Fiber reinforcement shall be Type I, Type II, Type III, Type IV, or Type V high tensile strength deformed steel fibers in accordance with *ASTM A820* except as modified below.

(a) Length. Fibers shall have a length of 1.0 inch to 1.5 inches with an aspect ratio (length divided by minimum width or diameter) between 40 and 80.

(b) Tensile Strength. Fibers shall have a minimum tensile strength of 120,000 psi as determined in accordance with *ASTM A820*.

SECTION 714 – STRUCTURAL STEEL

714.01 GENERAL REQUIREMENTS. Structural steel and other related materials shall conform to the requirements specified in this section. All main load carrying members and components of rolled or welded sections subject to tensile stress or the reversal of stresses, as well as any other members or components identified in the Contract as requiring CVN testing, shall meet the longitudinal Charpy V-notch impact requirements specified in *AASHTO M 270* for non-fracture critical steel and fracture critical steel, for Zone 2. Impact test sampling and testing procedures shall be in accordance with *AASHTO T 243*.

All steel bolts, nuts, and washers furnished for Agency projects shall be manufactured in the United States only. All bolts, nuts, and washers furnished for a particular application shall be furnished by a single supplier.

All bolts, nuts, and washers shall have identifiable manufacturer's markings on each piece.

Nuts for galvanized fasteners shall be over-tapped a minimum amount to ensure fastener assembly.

All galvanized nuts shall be lubricated with a lubricant containing a visible dye that will provide visual verification of the lubricant during installation. Black bolts shall be oily to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

714.02 STRUCTURAL STEEL. Structural carbon steel shall conform to the requirements of *AASHTO M 270,* Grade 36.

714.03 HIGH-STRENGTH LOW-ALLOY STRUCTURAL STEEL. High-strength low-alloy structural steel with a 50 ksi minimum yield point up to 4 inches in thickness shall conform to the requirements of *AASHTO M 270,* Grade 50 or Grade 50W as required.

714.04 CARBON STEEL BOLTS, NUTS, AND WASHERS. Carbon steel bolts shall conform to the requirements of *ASTM A307,* Grade A. Carbon steel nuts shall conform to the requirements of *ASTM A563*. Carbon steel washers shall conform to the requirements of *ASTM F844*.

714.05 HIGH-STRENGTH STRUCTURAL BOLTS AND ASSEMBLIES, 120 KSI. High-strength bolts shall meet the requirements of *ASTM F3125,* Grade A325, including rotational capacity testing, for each lot of fasteners. Heavy hex nuts shall conform to the requirements of *ASTM A563,* Grade DH. Hardened steel washers shall conform to the requirements of *ASTM F436*.

Bolts installed in coated structural components shall be Type 1 and shall be provided with appropriate nuts and washers, as required. The combination of bolt, nut, and washer shall be mechanically galvanized in accordance with *ASTM B695,* Class 55, Type 1.

Bolts installed in uncoated weathering steel structural components shall be Type 3 and shall be provided with appropriate nuts and washers, as required.

714.06 HIGH-STRENGTH STRUCTURAL BOLTS AND ASSEMBLIES, 150 KSI. High-strength bolts shall meet the requirements of *ASTM F3125,* Grade A490, including rotational capacity testing, for each lot of fasteners. Heavy hex nuts shall conform to the requirements of *ASTM A563,* Grade DH. Hardened steel washers shall conform to the requirements of *ASTM F436*.

Bolts installed in coated structural components shall be Type 1 and shall be provided with appropriate nuts and washers, as required. The combination of bolt, nut, and washer shall be mechanically galvanized in accordance with the requirements of *ASTM B695,* Class 55, Type 1.

Bolts installed in uncoated weathering steel structural components shall be Type 3 and shall be provided with appropriate nuts and washers, as required.

714.07 ANCHOR BOLTS FOR BRIDGE RAILING. Bridge railing anchor bolts shall conform to the requirements of *ASTM A449,* Type 1. Bridge railing nuts shall conform to the requirements of *ASTM A563,* Grade DH. Bridge railing washers shall conform to the requirements of *ASTM F436*.

714.08 ANCHOR BOLTS FOR BEARING DEVICES. Anchor bolts for bearing devices shall conform to the requirements of *ASTM F1554,* Grade 36, unless otherwise specified. Nuts for bearing devices shall be of the heavy hex type and conform to the requirements of *ASTM A563*. Washers for bearing devices shall conform to the requirements of *ASTM F436* and the style shall be extra thick washer, unless otherwise noted on the Plans.

When the bolts furnished under this subsection are required to be galvanized, the bolts, nuts, and washers furnished shall meet the requirements of *ASTM B695,* Class 55 for mechanically galvanized fasteners or *ASTM F2329* for hot-dipped galvanized fasteners.

Anchor bolts shall be swedged or threaded and shall conform to the shape, length, and diameter specified in the Contract.

714.09 ANCHOR BOLTS FOR SIGNALS, LIGHTING, AND OVERHEAD SIGNS. Anchor bolts for traffic signals, lighting, and overhead sign structures shall conform to the requirements of *ASTM F1554*, Grade 55, unless otherwise specified. Nuts shall be heavy hex type and conform to the requirements of *ASTM A563,* Grade DH. Washers shall conform to the requirements of *ASTM F436* and the style shall be extra thick washer, unless otherwise indicated on the Plans. All components shall be galvanized in accordance with *ASTM F2329*.

Anchor bolts shall be swedged or threaded unless otherwise specified on the Plans.

714.10 WELDED STUD SHEAR CONNECTORS. Welded stud shear connectors shall conform to the requirements of the *AASHTO LRFD Bridge Construction Specifications* and *ANSI/AASHTO/AWS D1.5*.

714.11 STEEL TUBING. Steel tubing shall conform to the requirements of *ASTM A500*, Grade B, unless otherwise specified.

714.12 DIRECT TENSION INDICATORS. Direct tension indicators (DTIs) shall be compressible-washer-type direct tension indicators conforming to the requirements of *ASTM F959*. DTIs shall be of the type corresponding to the bolt specification with which they will be used.

714.13 TENSION CONTROL ASSEMBLIES. Tension control assemblies shall be twist off type tension control structural bolt/nut/washer assemblies conforming to *ASTM F3125*, Grade F1852 or Grade F2280. Heavy hex nuts shall conform to the requirements of *ASTM A563*, Grade DH. Hardened steel washers shall conform to the requirements of *ASTM F436*.

Bolts installed in coated structural components shall be Type 1 and shall be provided with appropriate nuts and washers, as required. The combination of bolt, nut, and washer shall be mechanically galvanized in accordance with the requirements of *ASTM B695*, Class 55, Type 1.

Bolts installed in uncoated weathering steel structural components shall be Type 3 and shall be provided with appropriate nuts and washers, as required.

SECTION 715 – MISCELLANEOUS METALS

715.01 IRON CASTINGS. Iron castings shall meet the following requirements:

(a) General Requirements. Castings shall conform to the requirements of *AASHTO M 306*. Castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended.

Castings shall be boldly filleted at angles and the arises shall be sharp and perfect. The surfaces shall have a blemish-free finish.

All castings shall be blast-cleaned or otherwise effectively cleaned of scale and sand to present a smooth, clean, and uniform surface. The dimensions of the frames and covers shall substantially conform to the dimensions for cast iron covers and frames as shown in the Contract.

The covers shall be flush with the upper surface of the frame when seated. The seatings shall be machined or made quiet using a gasket cushioning insert or supported by a three-point triangular suspension. The minimum depth of insertion of the cover into the frame shall be no less than 2 inches.

As a minimum, the covers and frames shall meet the HS-20 loading requirements of AASHTO and the proof load requirements of *AASHTO M 306*.

Covers shall be identified by the words “STORM SEWER,” “WATER,” “SEWER,” “ELECTRIC,” or others as applicable, in raised cast letters as indicated in the Contract or as directed by the Engineer.

(b) Gray Iron Castings. Gray iron castings shall conform to the requirements of *AASHTO M 105,* Class No. 35B, unless otherwise specified.

(c) Ductile Iron Castings. Ductile iron castings for frames and covers shall conform to the requirements of *ASTM A536,* Grade 80-55-06.

715.02 ALUMINUM ALLOY. Aluminum alloy material shall be fabricated from Alloy 6061-T6.

(a) Sheet and Plate. Sheet and plate shall be in accordance with *ASTM B209*.

(b) Drawn Seamless Tubes. Drawn seamless tubes shall be in accordance with *ASTM B210*.

(c) Bars, Rods, and Wire. Bars, rods, and wire shall be in accordance with *ASTM B211*.

(d) Extruded Bars, Rods, Shapes, and Tubes. Extruded bars, rods, shapes, and tubes shall be in accordance with *ASTM B221*.

(e) Seamless Pipe and Seamless Extruded Tube. Seamless pipe and seamless extruded tube shall be in accordance with *ASTM B241*.

(f) Welding Rods and Electrodes. Welding rods and bare electrodes shall be in accordance with AWS requirements.

(g) Standard Structural Shapes. Standard structural shapes, rolled or extruded, shall be in accordance with *ASTM B308*.

(h) Extruded Structural Pipe and Tube. Extruded structural pipe and tube shall be in accordance with *ASTM B429*.

(i) Sand Castings. Sand casting shall be in accordance with *ASTM B26*.

(j) Permanent Mold Castings. Permanent mold castings shall be in accordance with *ASTM B108*.

(k) Rivets. Rivets shall be in accordance with *ASTM B316*.

(l) Bolts, Nuts, and Screws. Bolts, nuts, and screws shall be made from rod conforming to the requirements of *ASTM B211*. Bolt heads shall conform to the requirements of American standard heavy hexagon, *ANSI B18.2.1/ANSI B18.2.3.6M*. Nuts shall conform to the requirements of *ANSI B18.2.4.6M* in accordance with the requirements of *ANSI B18.2.1* and *ANSI B18.2.2/ANSI B18.2M*. Bolt threads shall conform to the requirements of *ANSI B1.1/ANSI B1.13M*. Both bolts and nuts shall be given an anodic coating at least 0.2 mils in thickness with a dichromate or boiling water seal.

(m) Washers and Shims. Aluminum alloy washers shall be made from aluminum alloy sheet conforming to the requirements of *ASTM B209*. Aluminum alloy shims shall be made from aluminum alloy sheet or plate conforming to the requirements of *ASTM B209* or *ASTM B221*.

715.03 STEEL FOR CORRUGATED METAL FORMS. Steel for corrugated metal forms and form supports shall be in accordance with *ASTM A653,* Coating Designation G165. Fabrication shall be in conformance with the requirements of *ASTM A924*.

715.04 ROOFING SYSTEMS. Roofing systems shall consist of the rafters, roof deck, underlayment materials, roofing panel system, flashing and trim.

(a) Rafters. Rafters shall be white oak in accordance with Subsection 709.01.

(b) Roof Deck. Roof deck shall be V-groove tongue and groove pine in accordance with Subsection 709.02.

(c) Underlayment Materials.

(1) Felt Underlayment. Felt underlayment shall be asphalt-saturated organic felt in accordance with *ASTM D226*, Type II (No. 30 asphalt felt) or as recommended by the manufacturer.

(2) Rosin Paper. Slip sheet shall be per the manufacturer's recommendation and of the type required for the application.

(d) Roofing Panel Systems. Roofing panel systems shall consist of roof panels, panel clips, and all other hardware. Systems shall be structural standing seam steel roof panel systems in accordance with *ASTM E1514*.

Roofing panel systems shall have an uplift rating of UL 90 as determined in accordance with *UL 580* and shall accommodate thermal movements for ambient temperature changes of 120°F.

(1) Roof Panels. Roof panels shall be zinc-coated 24-gauge steel sheet in accordance with *ASTM A653*, Coating Designation G90 with a minimum nominal thickness of 0.0239 inches (16 ounce). Roof panels shall have a two-coat finish consisting of a fluoropolymer top coat and compatible primer in accordance with *ASTM A755* on the exposed side of the panel. The top coat shall be green and approved by the Engineer prior to installation. Roof panels shall have a polyester washcoat in accordance with *ASTM A755* on the unexposed side of the panel.

(2) Panel Clips. Panel clips shall be zinc-coated steel sheet in accordance with *ASTM A653*, Coating Designation G90. Clips shall have a minimum nominal thickness of 0.064 inches. Panels clips shall be concealed and mechanically connect panels to supports.

(3) Miscellaneous Hardware and Accessories. Miscellaneous hardware and accessories shall be all components required by the manufacturer for the roofing panel system not otherwise specified herein. Miscellaneous hardware and accessories shall be in accordance with the manufacturer's recommendations.

Roof panel systems shall have a minimum 2 year manufacturer's warranty on all components of a roof panel system, a 20 year manufacturer's warranty on panel finishes, and a 20 year manufacturer's warranty on weathertightness. All warranties shall be effective from the date of installation and demonstrate the manufacturer agrees to repair or replace the defective component.

Manufacturers shall provide a standard warranty agreement form for each warranty. Standard warranty agreements shall include the owner's name, building type, building location, roofing system model, roofing system type, date of completion, Contract amount of material and installation, warranty type, warranty terms and conditions, and signature blocks (for the manufacturer, roofing contractor, and owner).

(e) Flashing and Trim. Flashing and trim shall be in accordance with Subsection 715.04(d)(1).

715.05 BICYCLE RACK SYSTEMS. Bicycle rack systems shall be U-shaped, surface mounted, one of the products listed on the Agency's *Approved Products List*, and meet the following requirements:

(a) Construction. Bicycle rack systems shall be constructed steel pipe.

(b) Finish. Bicycle rack systems shall have a galvanized, powder coated, or stainless steel finish as specified on the Plans.

715.06 RAIL. Rail shall be continuous welded or jointed carbon steel rail.

(a) New Rail.

(1) General Requirements.

a. Length of Rail. New rail shall be furnished in 80-foot sections wherever possible. In no case shall new rail be furnished in lengths of less than 39 feet unless approved by the Engineer. The acceptable amount and lengths of short rails shall be as specified in *AREMA Chapter 4, Section 2.1.11*.

b. End Condition. Rail ends shall be square and shall be cut with an approved abrasive rail saw. Torch cut rails will not be accepted.

1. Running rail ends that are not welded shall be drilled with six holes. Drilling shall be uniform with holes drilled and dressed per *AREMA Chapter 4, Section 2.1.12*. Rail drillings shall be as specified in *AREMA Chapter 4, Section 3.3*.

2. Rail that will be field welded shall have blank ends or only the rear hole drilled.

3. Rail that will be plant welded shall have blank ends.

(2) New Rail, Standard Strength. Standard strength rail shall be in accordance with *AREMA Chapter 4* for standard strength rail.

(3) New Rail, High Strength. High strength rail shall be in accordance with *AREMA Chapter 4* for high strength rail.

(b) Relay Rail.

(1) Relay rail shall meet the requirements of *AREMA Chapter 4, Section 3.12,* except as modified herein.

(2) The required relay rail section shall be as indicated in the Contract.

(3) Each length of rail shall be ultrasonically tested in accordance with *AREMA Chapter 4, Section 4.5* to verify that no internal rail defects are present. Each length of rail shall have an attached label with certification information including the rail test date.

(4) Relay rail shall be supplied in uniform lengths and shall not be less than 33 feet in length.

(5) Relay rail for jointed rail track construction shall have bolt holes drilled. Rail drillings shall be as specified in *AREMA Chapter 4, Section 3.3* for current AREMA rail sections. For other rail sections, drilling shall be uniform and match the punching pattern of the joint bars. All holes shall be drilled.

(6) Rail ends shall be square and shall be cut with an approved abrasive rail saw. Torch cut rails will not be accepted.

(7) Relay rail having bolt hole cracks or breaks, broken bases, breaks, crushed heads, detail fractures, engine burn fractures, head-web separation, piped rail, horizontal split heads, vertical split heads, torch cut rail ends, torch cut bolt holes, or compound or transverse fissures will not be accepted. Relay rail shall be free of shelly spots, head checks, corrugations, bends or kinks, and any other visual defects.

(8) Relay rail wear shall not exceed the limits from its original dimensions as specified in *AREMA Chapter 4, Section 3.12*. Limits will be based on the specific AREMA rail section and class of track in which the rail is to be installed. Relay rail shall only have wear on one side of the head. Rail with wear on both sides of the head will be rejected.

For non-AREMA rail sections, wear limits shall be as specified in the Contract.

The following limits shall also apply to relay rail:

a. End batter shall not exceed 1/16 inch

b. Base and web thickness wear shall not exceed 1/16 inch

715.07 RAILROAD TURNOUTS.

(a) General Requirements.

(1) Turnouts shall conform to the *AREMA Portfolio of Trackwork Plans*.

(2) All rail used for turnout and closure rails, switch points, stock rails, frogs and guard rails shall be new high strength rail in accordance with Subsection 715.06(a). The required rail section shall be as indicated on the Plans and all steel work shall use the same rail section.

(3) All turnout materials shall be new and conform with the requirements of *AREMA Portfolio Plan 100.*

(4) Turnout geometry shall be in accordance with *AREMA Portfolio Plan 910.* The type of turnout as designated by frog number shall be as specified on the Plans.

(5) Rail and joint layout shall be in accordance with *AREMA Portfolio Plan 911* except rail and joint layout shall be modified as required to meet the requirements of Subsection 715.07(d) and Subsection 715.07(h) and all joint locations shall clear tie plates by a minimum of 4 inches to allow for field welding. Additional modifications to joint layout may be required as indicated in the Contract.

(6) Lengths and quantities of timber switch ties shall be in accordance with *AREMA Portfolio Plan 912* except that head block ties shall be 14-feet long when used with low switch stands 24-inches high and 3-foot long connecting rods, and 16-feet long when used with high switch stands and 6-foot connecting rods.

(7) All single-rail tie plates, switch, gage, frog, guard rail, transition, and turnout plates shall utilize timber screw spikes to secure all plates. Elastic rail clips shall be utilized to fasten the rail to the plates. Use of track spikes will not be accepted. Each plate shall utilize a minimum of four screw spikes. The gage plates shall have all hole positions spiked.

(8) Turnouts shall be fully insulated unless otherwise specified in the Contract.

(9) New turnout packages shall include the following:

a. Turnout and closure rails

b. Switch points

c. Stock rails

d. Bolted heel block assemblies unless otherwise specified in the Contract

e. Vertical, adjustable insulated switch rod and clip assemblies

f. Adjustable, boltless stock rail brace assemblies

g. Insulated gage plates

h. Switch plates

i. Turnout plates

j. Transition plates

k. Frog plates

l. Elastic spring clips, tie plates and screw spikes

m. Temporary joint bar assemblies used for shop assembly and installation in the field prior to field welding

n. Timber switch ties

o. Bonded insulated joint assemblies

p. Rail bound manganese steel frog

q. Frog guard rails and guard rail plates

r. Switch stand, target, and connecting rod

s. Any other materials and hardware required for a complete, functional turnout assembly

(10) The turnout shall be color coded with all switch ties tagged and match marked to the rail with 1/2-inch-wide marks locating both sides of each tie. All rail joints shall be match marked on the head of the rail. Turnouts shall be completely shop assembled for inspection by the Engineer at the manufacturer's facility. Following the inspection and any corrective work required as a result of the inspection, the turnout shall be dismantled. The switch portion shall be shipped as a panel with remaining switch ties pre-plated and bundled in groups of four unless otherwise specified in the Contract.

(b) Frogs. Frogs shall be rail bound manganese steel, explosive hardened, and shall conform to *AREMA Portfolio Plan 600* and *AREMA Portfolio Plan 621*.

Frogs and frog plates shall be in accordance with *AREMA Portfolio Plan 622* for No. 8 frogs and *AREMA Portfolio Plan 623* for No. 10 frogs.

(c) Frog Guard Rails. Frog guard rails shall be tee rail and allow for adjustment of the flangeway width. Frog guard rail assemblies and guard rail plates shall conform to *AREMA Portfolio Plan 502* and *AREMA Portfolio Plan 504*, except the separator and end blocks shall be designed to allow for the adjustment of the flangeway width by use of removable shims. When used with unworn rails, the width of the flangeway shall be adjustable in a range from 1-1/2 inches to 1-7/8 inches.

(d) Switch. The switch portion of the turnout shall be a 16-1/2 foot straight split switch with graduated risers for screw spikes in accordance with *AREMA Portfolio Plan 112.* Switch points shall be in accordance with *AREMA Portfolio Plan 112* and *AREMA Portfolio Plan 221, Detail 5100.* Stock rails shall be in accordance with *AREMA Portfolio Plan 112* and *AREMA Portfolio Plan 221.*

The stock rail extensions ahead of the point of switch shall be modified as follows: the straight stock rail shall extend 12-feet ahead of the point of switch and the bent stock rail shall extend 6-feet ahead of the point of switch.

Bolted heel block assemblies shall be in accordance with *AREMA Portfolio Plan 221, Detail 1125*.

Vertical, adjustable, insulated switch rod and clip assemblies shall be in accordance with *AREMA Portfolio Plan 222*.

Adjustable, boltless stock rail brace assemblies shall be in accordance with *AREMA Portfolio Plan 224*.

Insulated gage plates shall be used at the point of switch and on the first and third ties ahead of the point of switch. Gage plates shall be in accordance with *AREMA Portfolio Plan 112* and *AREMA Portfolio Plan 223*. Switch plates shall be in accordance with *AREMA Portfolio Plan 112* and *AREMA Portfolio Plan 224*. Turnout plates shall be in accordance with *AREMA Portfolio Plan 112*. Transition plates shall incorporate 1:80 rail cant and be used where rail transitions from 1:40 cant to no cant.

(e) Switch Stands, Targets and Connecting Rods. Switch stands shall be extra heavy duty and rated for unrestricted use. All switch stands shall be supplied complete with a connecting rod assembly and both the stand and the connecting rod assembly shall meet the requirements of *AREMA Portfolio Plan 251*.

Inside switches shall be low mast with trihandle and the target shall be yellow/green. Mainline switches shall be high mast with trihandle and the target shall be red/green.

The switch stand and connecting rod assembly, including bolts, nuts, washers, and cotter pins, shall be of the proper size to fit the switch and switch stand.

(f) Rail. New high strength rail shall conform to Subsection 715.06(a). The Contractor shall furnish the rail section compatible with the frog and switch points used. At field weld locations, rails shall be furnished with only the hole furthest from the end of the rail drilled.

(g) Joint Bar Assemblies. Joint bars, bolts, nuts, and spring washers shall conform to Subsection 715.08(f).

(h) Insulated Joints. Bonded insulated joint assemblies shall conform to Subsection 715.08(h). Insulated joints shall be located so as to be suspended within the tie cribs and have a stagger distance between the two insulated joints that is a minimum of 32 inches and a maximum of 56 inches.

(i) Spring Clips with Associated Tie Plates and Screw Spikes. Elastic spring clips, single-rail tie plates and screw spikes shall conform to Subsection 715.08(e). Spring clips for use at temporary (to be welded in the field) and insulated joints need not be identical in design to those used on a standard rail. Clips used at joint bars shall have similar performance characteristics, shall be made by the same manufacturer, and shall be capable of being installed into identical shoulders as the standard rail clip. All switch ties shall be pre-drilled with a pilot hole prior to installing screw spikes. Driving of timber screw spikes with a sledgehammer or spike maul is prohibited.

(j) Timber Switch Ties. Timber switch ties shall conform to Subsection 709.04(d). All switch ties shall come furnished pre-plated from the fabricator unless otherwise specified in the Contract.

(k) Lubricant for Application to Switch Plates. The graphite or lubricant applied to switch plates shall be specifically manufactured for this application.

715.08 OTHER TRACK MATERIAL (OTM).

(a) Tie Plates.

(1) New Tie Plates. New tie plates shall be in accordance with *AREMA Chapter 5, Part 1*.

a. Type A. Type A tie plates shall be Plan Number 7 in accordance with *AREMA Figure 5-1-5*, with Punching A – 8 Spike Holes.

b. Type B. Type B tie plates shall be Plan Number 11 in accordance with *AREMA Figure 5-1-7*, with Punching A – 8 Spike Holes.

(2) Relay Tie Plates.

a. Relay tie plates will be acceptable providing they fit and are compatible with the rails to be connected and have no defects.

b. Relay tie plates shall be punched to fit the base of the rail on which they will be used. Each plate shall have 8 holes punched for 5/8-inch track spikes. Four of the holes shall be punched for rail holding spikes and four holes punched for the use of plate holding spikes.

c. The minimum size of relay tie plates shall be 13 inches × 7-3/4 inches.

d. Relay tie plates shall be subject to inspection and acceptance by the Engineer. In addition to being judged defective due to improper fit, they may be deemed defective for any of the following reasons:

1. Rounded or worn shoulders.

2. Rounded or otherwise excessively worn spike holes.

3. Wear of the rail seat.

4. A crack, bend, or other flaw in the plate.

6. Excessive deterioration from rust, scale, or brine.

(b) Shim Plates. Shim plates for use under tie plates shall be *ASTM A36* or *ASTM A709*, Grade 36 steel and shall have the same plan area and spike hole configuration as the tie plates.

(c) Track Spikes. Track spikes shall be new and 5/8 inch × 6 inch long spikes with a reinforced throat. Spikes shall meet the dimensional requirements of *AREMA Chapter 5, Section 2.2*. The material of the spikes shall meet the requirements of *AREMA Chapter 5, Section 2.1*.

(d) Rail Anchors.

(1) Rail anchors shall be approved new spring type or drive-on type. Anchors shall conform to the requirements of *AREMA Chapter 5, Part 7.*

(2) Relay rail anchors will be acceptable provided that they are re-formed, fit, and are compatible with the rails to be connected and have no defects such as pitting or excessive rust.

(e) Spring Clips with Associated Tie Plates, and Screw Spikes.

(1) New elastic spring clips, tie plates, and screw spikes shall be designed for use on timber ties, meet the requirements of *AREMA Chapter 30, Appendix 30-A-2* and shall have a successful service history of at least 20 years on either commuter rail, intercity passenger rail, or freight rail within the United States.

(2) Elastic spring clips shall be threadless, be constructed from alloy spring steel, and be capable of being driven and removed parallel to the rail manually with a sledgehammer, a specially purposed tool for installing and removing the clips, or through mechanical means.

(3) The clip shall apply a toe load on the base of the rail through spring and torsion action to provide longitudinal restraint and resistance to rail rollover. The nominal toe load applied shall be 2,750 pounds with a working deflection of 7/16 of an inch. The surface area in contact with the rail shall be 0.82 square inches. The rail seat clamping force with two clips installed on one tie plate shall be 5,500 pounds.

(4) Bars shall have a diameter of 0.79 inches. The clip shall consist of a center leg which is inserted into the tie plate shoulder, rear arch, heel which bears with the field side of the tie plates, front arch, and toe which bears on the rail base.

(5) Tie plates shall be manufactured from rolled steel, specifically designed to accommodate the spring clips, with raised rail shoulders to prevent lateral movement of the rail. Tie plates shall meet the requirements of *AREMA Chapter 5, Section 1.1*. Plates shall incorporate 1:40 cant. Tie plates shall be suited for 5-1/2 inch or 6-inch rail bases as applicable. Tie plates shall contain four 1-inch round holes located at the corners of the plate and two 11/16-inch square holes, one each on the gage and field sides of the plate centered between the round holes.

(6) Screw spikes shall be square head, 15/16-inch diameter × 6 inches in length conforming to *AREMA Chapter 5, Section 10.1* and *AREMA Chapter 5, Section 10.2*.

(f) Joint Bar Assemblies.

(1) Joint bars shall be of the size, shape, and punching pattern to fit the rail being joined.

(2) New joint bars shall meet the requirements of *AREMA Chapter 4, Section 3.4*.

(3) New nuts, bolts and washers shall be properly sized to fit the bolt holes in which they will be installed. Joint bar bolts and nuts shall meet the material requirements of *AREMA Chapter 4, Section 3.5*.

(4) Spring washers shall meet the material requirements of *AREMA Chapter 4, Section 3.6*.

(5) Relay joint bars will be acceptable providing they fit and are compatible with the rails to be connected and have no defects.

(g) Compromise Joint Bar Assemblies.

(1) Compromise joint bars shall be new or relay, 6-hole unless otherwise required by the rail section, as indicated in the Contract, and be of proper design for the rail sections to be connected.

(2) If new compromise rail joint assemblies are to be furnished, they shall meet the material requirements of *AREMA Chapter 4, Section 3.4*.

(3) If relay compromise rail joint assemblies are furnished, they will be acceptable, providing they fit properly, are premanufactured and are compatible with both rails which are to be connected. Relay bars will be subject to inspection and approval by the Engineer.

(4) All compromise joint bars shall have a specific hand and rail weight designation that fits the rail exactly. No-hand joint bars and 4-hole joint bars will not be acceptable unless approved by the Engineer.

(5) Due to the many slight variations in railroad rail and appurtenances, a preliminary inspection and acceptance of compromise rail joint assemblies by the Engineer shall always be conditioned upon the fact that the final acceptance cannot be given until the assembly is installed in its final position. In addition to being deemed defective due to improper fit, compromise rail joint assemblies may be deemed defective for the following reasons:

a. Cracks, breaks or other flaws that impair their proper functioning.

b. Bolt holes with excessive wear.

c. Excessive deterioration from rust or scale.

d. If they permit any vertical movement of either rail when all the bolts are tight.

(6) Bolts set shall be new and of the proper design and size for the two rail sections to be connected.

(7) Compromise joint bar bolts and nuts shall meet the material requirements of *AREMA Chapter 4, Section 3.5*.

(8) Spring washers shall meet the material requirements of *AREMA Chapter 4, Section 3.6*.

(h) Insulated Joints.

(1) Conventional (Bolted) Poly Insulated Joints. Conventional poly insulated joints shall consist of two joint bars of same general configuration as 6-hole standard joint bars conforming to the dimensional requirements of the selected rail section. Insulated joint bars shall have a rolled, heat-treated steel core surrounded by uniform, single pour, polymeric insulation material and be designed for use in installations requiring insulated signal joints.

Bar, end post, and bushing insulation material shall be impervious to oil, grease, and water, and with electrical resistance characteristics equal to or greater than fiber insulation meeting the requirements of *AREMA Chapter 4*, *Section 3.9*. Insulated joints shall be resistant to abrading, cracking, cutting, spalling, and fatigue failure under impact loads, and shall exhibit deflection characteristics comparable to standard steel rail joints.

Insulated joints shall be complete with bars, 3/16-inch end posts, bushings, and washer plates and high strength bolts.

Bolts, nuts, and flat washers shall conform to the chemical and mechanical requirements of *ASTM F3125*, Grade A490 and having Class 2A and Class 2B thread fit. A positive means for maintaining the tension in the bolts through in-service vibrations shall be provided by a prevailing lock nut complying with *ASME B18.16.6* and *IFI-101*. Bolt holes shall be located and sized in conformance with the rail drilling pattern specified in AREMA or as directed by the Engineer. Flat washers, if required, shall be hardened *ASTM F3125*, Grade A325 or Grade A490, and tempered carbon steel.

Insulated joints shall be suspended. Tie plates for supported insulated joints shall be polymer.

(2) Bonded Insulated Joints. Bonded insulated joints shall be shop fabricated into plug rails totaling 19-1/2 feet in length (minimum length of one side of the plug rail is 8 feet) and conforming to the dimensional requirements of the selected rail section. Rail shall meet the requirements of Subsection 715.06.

Joint bars shall be fabricated from quenched carbon steel conforming to *AREMA Chapter 4*.

Joint bars shall be full contact bars conforming to the dimensional requirements of the selected rail section. Joint bars shall be smooth and straight. The inside face of joint bars shall be coated with pre-bonded insulating material, smooth, with no branding or stamping. The Contractor shall supply end posts and high strength bolts.

Fabrication tolerances shall be in accordance with *AREMA Chapter 4, Section 3.8*.

Insulating material shall be of a high pressure, laminated design, impervious to oil, grease, and water, with electrical resistance characteristics equal to or greater than fiber insulation, and meeting the requirements of *AREMA Chapter 4, Section 3.9*. The end posts shall project 1/4 inch (± 1/16 inch) below the base of rail and shall be 3/16 inch thick.

Bonded insulated joints joined together with adhesive and with six high-strength, 1 inch diameter bolts. Bolts, nuts, and flat washers shall conform to chemical and mechanical requirements of ASTM *F3125*, Grade A490 and having Class 2A and Class 2B thread fit. A positive means for maintaining tension in bolts through in service vibrations shall be provided by a prevailing lock nut complying with *ASME B18.16.6*. The bolt hole location and size shall conform to drilling for rail as specified in AREMA. Flat washers, if required, shall be hardened ASTM *F3125*, Grade A325 or Grade A490, and tempered carbon steel.

(i) Bridge Tie Connection Hardware.

(1) General Requirements. Any threaded rod, bolts, washers, nuts, or other connection hardware required for installation of new timber shall meet the requirements of *AREMA Chapter 7, Section 1.6*. All connection hardware shall be galvanized in accordance with *ASTM A153* unless otherwise noted.

(2) Bridge Tie to Stringer Top Flange Connectors.

a. Bridge tie to stringer top flange connectors shall be either:

1. Bridge tie anchors with 3/4-inch diameter *ASTM A307* hex-head bolts with nuts and washers.

2. *ASTM A307* hook bolts, 3/4 inch in diameter, with washer nuts and spring washers.

b. Bridge tie anchors and hook bolts shall be capable of fastening track crossties to steel open deck stringers. Bridge tie anchor and hook bolt dimensions shall be as indicated on the Plans.

c. Bridge tie anchors and hook bolts shall be hot rolled and cold finished. They shall be free from burrs and cracks of any size and shall have a workmanlike finish.

d. Bridge tie anchors shall be alloy spring steel conforming to *ASTM A29*, Grade 5160. The Brinell hardness of bridge tie anchors shall be greater than 390 and less than 430 when tested using *ASTM E10*. No cracks of any size in the steel macrostructure will be allowed. Tie anchors shall have a slotted bolt hole to accommodate variations in the thickness of the top flange.

e. Hook bolts shall be a one-piece forging with fins. The hook shall be 2 inches in length.

f. Washer nuts shall be a one-piece integrally manufactured washer and nut. Nuts shall be formed with an integral flat washer provided with a hole in the washer to permit nailing it to track crossties. The integral washers of the nuts shall be capable of retaining the nuts in place when the bolts are tightened and provide an even bearing surface on the track crossties.

g. Additional requirements for assembly hardware shall be as shown in the Contract. Connection assemblies shall have a successful in-track service record on freight railroads within the United States of at least 20 years.

(j) Other Bridge Tie Accessories. Steel tie spacing bars, timber spacing blocks, walkways, and associated attachment hardware shall be in accordance with *AREMA Chapter 7, Section 1.7.8* and as specified in the Contract.

SECTION 716 – BITUMINOUS CONCRETE MIXTURES

716.01 GENERAL REQUIREMENTS. Bituminous concrete mixtures shall be produced in accordance with an Agency approved mix design, using aggregates and asphalt binder from Agency approved sources, at an approved bituminous concrete production facility.

Asphalt binder for bituminous concrete mixtures shall meet the requirements of Subsection 702.01. WMA technologies and anti-strip additives, if used, shall meet the requirements of Subsection 702.03 and Subsection 702.04, respectively.

Aggregates for bituminous concrete mixtures and recycled asphalt materials (RAM) shall meet the requirements of Subsection 704.10 and Subsection 704.22, respectively.

716.02 BITUMINOUS CONCRETE MIXTURES.

(a) General Bituminous Concrete Mixture Design Requirements. Mix designs for all mixtures covered in this subsection shall be submitted in accordance with the Agency's *Bituminous Concrete Policy Manual*. No paving of a mix design shall be started until the Contractor has submitted, and the Agency has approved the mix design, including cold feed gradations, mixing times, the percentage of each ingredient, including asphalt binder, the job mix formula (JMF) from such a combination, and the optimum mixing and compaction temperatures. The design shall also include the control limits for quality control.

A copy of all design test data used in developing the mix design, including graphs, may be required with the submittal of the mix design or at any time when directed by the Agency.

The stockpile gradation data shall be derived by wet sieve analysis. Coarse aggregates for Superpave shall be furnished with at least three stockpiles for mixes with a nominal maximum aggregate size (NMAS) greater than or equal to 1 inch (25.0 mm), two stockpiles for mixes with a NMAS greater than or equal to 1/2 inch (12.5mm) and greater than 3/8 inch (9.5 mm), and one stockpile for mixes with a NMAS less than or equal to 3/8 inch (9.5 mm).

No change in the JMF may be made without Agency approval. The Agency may approve changes in the design's JMF or discontinue use of the design if placement, finishing, or compaction characteristics are determined to be unsatisfactory.

At the time that the mix design is submitted, the Contractor shall provide batched asphalt mixture to the Agency, for determining asphalt ignition oven calibration, in accordance with the Agency's *Bituminous Concrete Policy Manual*.

A minimum of 21 calendar days shall be allowed for the testing and evaluation of the submitted mix design. Once a mix design is approved, the JMF will be valid until a change is made in aggregate source, RAM source, or asphalt binder grade. If a change is made in aggregate source or asphalt binder grade, a new mix design shall be submitted and a minimum 21 calendar day evaluation period shall be allowed prior to resuming production. If a change in the asphalt binder supplier is proposed, it shall be from an approved supplier and be in accordance with the Agency's *Bituminous Concrete Policy Manual*.

If aggregates prone to stripping are used in the mixture, an anti-strip additive meeting the requirements of Subsection 702.04 may be required as specified in Subsection 704.10.

(b) Superpave Mixtures.

(1) Design Ranges and Values. The gradation of the coarse aggregate, fine aggregate, and recycled asphalt materials (if used) shall be such that, when combined, the composite aggregate will meet the gradation requirements of Table 716.02A for the applicable bituminous concrete mixture type. The process of blending the coarse aggregate, fine aggregate, and recycled asphalt materials (if used) shall be accomplished using separate bins. Blending in the stockpile will not be permitted.

For each mix type, the JMF target value for each sieve shall be within the ranges specified in Table 716.02A, and the JMF target value for other mixture properties shall meet the requirements specified in Table 716.02B.

The value of N_{design} will be determined by the Agency based on Design Lane/Design Life ESALs and shall be as specified on the Plans. The values of $N_{initial}$ and N_{max} shall be as specified in Table 716.02C for a given value of N_{design}.

If the value of N_{design} is not specified on the Plans, it shall be determined based on the number of Design Lane/Design Life ESALs as specified in Table 716.02C. If both the Design Lane/Design Life ESALs and the number of gyrations at N_{design} are not specified in the Plans, then N_{design} shall be 65, except for Type IS mixtures, where N_{design} shall be 50.

The asphalt binder grade and traffic designation shall be as listed on the Plans. If the asphalt binder grade and traffic designation are not specified on the Plans, then paver placed pavement shall use grade 58E-28, and material used for surface preparation, temporary pavement, and non-paver placed pavement shall use grade 58S-28.

TABLE 716.02A – GRADATION DESIGN RANGES

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves (Minimum – Maximum)				
	Type IS	Type IIS	Type IIIS	Type IVS	Type IVSB
2 inch (50.0 mm)	--	--	--	--	--
1-1/2 inch (37.5 mm)	100	--	--	--	--
1 inch (25.0 mm)	93 – 100	100	--	--	--
3/4 inch (19.0 mm)	X – 87	93 – 100	100	--	--
1/2 inch (12.5 mm)	--	X – 87	93 – 100	100	100
3/8 inch (9.50 mm)	--	--	X – 87	93 – 100	93 – 100
No. 4 (4.75 mm)	--	--	--	X – 87	X – 87
No. 8 (2.36 mm)	21 – 43	25 – 47	30 – 56	34 – 65	34 – 65
No. 16 (1.18 mm)	--	--	--	--	--
No. 30 (0.600 mm)	--	--	--	--	--
No. 50 (0.300 mm)	--	--	--	--	--
No. 100 (0.150 mm)	--	--	--	--	--
No. 200 (0.075 mm)	1.5 – 6.5	2.5 – 7.5	2.5 – 9.5	2.5 – 9.5	2.5 – 9.5

TABLE 716.02B – OTHER MIXTURE PROPERTY DESIGN RANGES AND VALUES

Property	Type IS	Type IIS	Type IIIS	Type IVS	Type IVSB
Nominal maximum aggregate sieve size	1 inch (25.0 mm)	3/4 inch (19.0 mm)	1/2 inch (12.5 mm)	3/8 inch (9.50 mm)	3/8 inch (9.50 mm)
Air voids	4.0%	4.0%	4.0%	4.0%	3.0%
Voids in mineral aggregate	13.0% min.	14.0% min.	15.0% min.	16.0% min.	16.0% min.
Dust proportion range (dry sieve)	0.50 – 1.20	0.50 – 1.20	0.50 – 1.00	0.50 – 1.00	0.50 – 1.00

TABLE 716.02C – NUMBER OF GYRATIONS BY TRAFFIC LEVEL

Design Lane/ Design Life ESAL Value	ESALs < 300,000	300,000 ≤ ESALs < 3,000,000	ESALs ≥ 3,000,000
$N_{initial}$	6	7	8
N_{design} [1]	50	65	80
N_{max}	75	115	160

[1] All Type IS mixtures shall have an N_{design} value of 50 gyrations. All Type IVSB mixtures shall have an N_{design} value of 65 gyrations.

(2) Use of Recycled Asphalt Materials. The Contractor may choose to use RAM, consisting of RAP or RAS used either individually or in combination, as aggregate in Superpave bituminous concrete pavement mixtures. The amount of RAM used, expressed as a percentage of the total weight of aggregate in the mixture (including the RAM), shall not exceed the limits specified in Table 716.02D.

TABLE 716.02D – MAXIMUM ALLOWABLE AMOUNT OF RAM BY MIX TYPE

Property	Type IS	Type IIS	Type IIIS	Type IVS	Type IVSB
Maximum RAS content [1]	3%	3%	3%	3%	0%
Maximum combined RAP and RAS content	50%	25%	20%	20%	0%

[1] RAS shall not be used in the wearing course.

When RAM is used, the following conditions shall apply:

a. For Type IS, only 75% of the total RAM binder content shall be credited toward the design asphalt binder content.

b. When any amount of RAP is used, an analysis of the RAP material, including the extracted aggregate gradation, coarse aggregate specific gravity, fine aggregate specific gravity, and asphalt content shall be provided in the mix design.

c. When any amount of RAS is used, an analysis of the RAS material containing the extracted aggregate gradation, coarse aggregate specific gravity, fine aggregate specific gravity, asphalt content, and extracted binder performance grade shall be provided in the mix design.

Additionally, all provisions of *AASHTO R 114* shall apply when developing the mix design. Asphalt binder shall specifically meet the quality requirements of *AASHTO R 114, Section 7.1* through *AASHTO R 114, Section 7.3*, with the extracted binder having a ΔT_c value greater than -5.0°C when measured in accordance with *AASHTO PP 113* and meeting the grades and traffic designations of asphalt binder specified on the Plans. The use of recycling agents or rejuvenators is not permitted.

d. Any change in the amount or combination of recycled materials shall require a new mix design unless otherwise approved by the Agency.

e. Should the characteristics of any proposed recycled material be such that an acceptable mixture cannot be produced or maintained, the recycled material will not be allowed for use on the Contract.

(3) Superpave Mixture Design Process. *AASHTO R 35* will be the method used to develop a mix that will meet the specified design criteria in accordance with *AASHTO M 323*, unless otherwise noted.

The Superpave mixture shall be designed using the following methodology:

a. Select materials (aggregate, asphalt binder, additives).

b. Select design aggregate structure.

c. Select design asphalt binder content.

d. Evaluate moisture sensitivity and rutting susceptibility using the Hamburg wheel tracker test (HWTT) in accordance with *AASHTO T 324* to ensure the criteria outlined in Table 716.02E are met. Specimen fabrication, conditioning, and procedures for the HWTT shall be in accordance with the Agency's *Bituminous Concrete Policy Manual*. The HWTT will not be applicable to material used non-paver placed pavement, surface preparation, temporary pavement, curbs, gutters, or sidewalks.

TABLE 716.02E – HAMBURG WHEEL TRACKER TEST REQUIREMENTS

Traffic (ESALs)	Maximum Rut Depth	Minimum Number of Passes	Minimum Stripping Inflection Point (SIP)
All	12.5 mm (1/2 in.)	20,000 passes	15,000 passes

e. Determine the cracking tolerance index (CT-Index) using the indirect tensile cracking test in accordance with *ASTM D8225*. Specimen fabrication, conditioning, and procedures for determination of the CT-Index shall be in accordance with the Agency's *Bituminous Concrete Policy Manual*. The indirect tensile cracking test will not be applicable to material used non-paver placed pavement, surface preparation, temporary pavement, curbs, gutters, or sidewalks.

f. For mixes containing stripping prone aggregate, determine if anti-stripping additive is needed, and if so the correct dosage, using *ASTM D3625*.

(4) Superpave Job Mix Formula. The job mix formula for each mixture shall contain all of the following information:

a. A single percentage of aggregate passing each sieve identified in Table 716.02A.

b. When applicable, a single percentage of RAP and a single percentage of RAS in the mixture.

c. A single percentage of asphalt binder to be added to the aggregate.

d. When applicable, a single percentage for every additive in the mixture. Each additive shall be identified by name and purpose (e.g. anti-strip, WMA technology).

e. A single percentage for air voids.

f. A single percentage for voids in mineral aggregate.

g. The values of $N_{initial}$, N_{design}, and N_{max}.

h. The mixing temperature.

i. The design compaction temperature.

The Contractor's mix design may specify either hot mix asphalt (HMA), or warm-mix asphalt (WMA). WMA shall be produced with a warm-mix asphalt technology meeting the requirements of Subsection 702.03 and at a lower mixing temperature.

(5) Control Limits. Each mix design shall establish an upper and lower control limit (as applicable) for every JMF parameter to determine when action should be taken or production should be suspended.

(c) Bonded Wearing Course Mixtures.

(1) General Requirements. Bonded wearing course (BWC) mixtures shall not contain any RAM, and WMA technology additives shall not be incorporated unless the additive also acts as an anti-strip agent and is dosed to abate stripping in accordance with Subsection 702.04.

The gradation of the coarse and fine aggregate shall be such that, when combined, the composite aggregate will meet the gradation requirements of Table 716.02F for the applicable bonded wearing course mixture type. The process of blending the coarse and fine aggregate shall be accomplished using separate bins. Blending in the stockpile will not be permitted.

For each mix type, the JMF target value for each sieve shall be within the ranges specified in Table 716.02F, and the JMF target value for asphalt binder content shall be within the ranges specified in Table 716.02G.

The asphalt binder grade and traffic designation shall be as listed on the Plans. If the asphalt binder grade and traffic designation are not specified on the Plans, then it shall be grade 58E-28.

TABLE 716.02F – GRADATION DESIGN RANGES

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves (Minimum – Maximum)		
	Type A	Type B	Type C
3/4 inch (19.0 mm)	--	--	100
1/2 inch (12.5 mm)	--	100	87 – 100
3/8 inch (9.50 mm)	100	87 – 100	48 – 83
No. 4 (4.75 mm)	41 – 54	25 – 37	25 – 40
No. 8 (2.36 mm)	22 – 31	22 – 31	22– 32
No. 16 (1.18 mm)	17 – 25	17– 22	16 – 25
No. 30 (0.600 mm)	13 – 17	13 – 17	12 – 19
No. 50 (0.300 mm)	9 – 12	9 – 12	9 – 15
No. 100 (0.150 mm)	6 – 9	6 – 9	6 – 9
No. 200 (0.075 mm)	4.0 – 6.0	4.0 – 6.0	4.0 – 6.0

TABLE 716.02G – ASPHALT BINDER CONTENT DESIGN RANGES

Property	Type A	Type B	Type C
Asphalt binder content design range	4.9% – 5.8%	4.8% – 5.6%	4.6% – 5.6%

(2) Bonded Wearing Course Mixture Design Process. Bonded wearing course mixture shall be designed using the following methodology:

a. Select materials (aggregate, asphalt binder, additives).

b. Select design aggregate structure.

c. Select design asphalt binder content.

d. Conduct drain-down in accordance with *AASHTO T 305*. The loose mixture shall not exceed 0.10% drain-down when tested at a temperature equal to the mixing temperature plus 60°F, but not exceeding 360°F.

(3) Bonded Wearing Course Job Mix Formula. The job mix formula for each mixture shall contain all of the following information:

a. A single percentage of aggregate passing each sieve specified in Table 716.02F. Sieves that do not have a specified design range for a given mix type do not need to be included.

b. A single percentage of asphalt binder to be added to the aggregate.

c. When applicable, a single percentage for every additive in the mixture. Each additive shall be identified by name and purpose (e.g. anti-strip).

d. The design mixing temperature.

e. The design compaction temperature.

(4) Control Limits. Each mix design shall establish upper and lower control limits (as applicable) for every JMF parameter, to determine when action should be taken or production should be suspended.

716.03 BITUMINOUS MIXING PLANT AND LABORATORY. Bituminous concrete mixtures shall come from approved producers, and shall be made in accordance with an approved plant QC plan. The requirements for plant QC plans are detailed in the Agency's *Bituminous Concrete Policy Manual*.

The bituminous mixing plant and laboratory shall meet the requirements detailed in the Agency's *Bituminous Concrete Policy Manual*.

716.04 PREPARING AND MIXING BITUMINOUS CONCRETE MIXTURES. Bituminous concrete mixtures shall be prepared and mixed in accordance with *AASHTO M 156* and the following:

(a) Preparation of Asphalt Binder. The asphalt binder shall be uniformly heated to the temperature specified in the approved mix design. A continuous supply of the asphalt binder at a uniform temperature shall be provided to the mixer at all times.

(b) Preparation of Aggregates. The aggregates for the mixture shall be dried and heated at the mixing plant before being placed in the mixer. Flames used for drying and heating shall be properly adjusted to avoid damage to the aggregate and to avoid depositing soot or unburned fuel on the aggregate.

Mineral filler may be added to meet gradation requirements. The method of introducing the mineral filler into the mix shall be approved by the Agency.

For batch plants, immediately after heating, the aggregates shall be screened and conveyed into separate bins ready for batching and mixing with asphalt binder.

(c) Mixing. The dried aggregates shall be combined in the mixer at the appropriate proportions required to meet the JMF and thoroughly mixed prior to adding the asphalt binder. All plants shall have a means of preventing oversized and foreign material from being incorporated into the mixer. For mix designs containing RAM, the dry and wet mixing times shall be adjusted to ensure that moisture from the RAM is completely dissipated prior to adding the liquid asphalt binder.

The quantity of asphalt binder introduced into the mixer shall be the percentage specified in the accepted JMF. The mass or percentage of asphalt binder in the mix shall be specified on the weigh slip or demand ticket.

After the required amounts of constituent material have been introduced into the mixer, the materials shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the asphalt binder throughout the aggregate is obtained. If complete and uniform coating of the particles is not achieved, the wet mixing time shall be adjusted as approved by the Agency. The mixture, when discharged from the mixing unit, shall be at the temperature specified on the approved mix design unless otherwise approved by the Agency.

SECTION 719 – EPOXY RESIN MATERIALS

719.01 EPOXY BONDING SYSTEMS. Epoxy bonding systems shall be a grade and class adhesive conforming to the requirements of *AASHTO M 235*. Systems shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions committee work plan for *Evaluation of Epoxy Resin Based Adhesive Bonding Systems*, be one of the products listed on the Agency's *Approved Products List*, and meet the following requirements:

(a) Epoxy Bonding System, Type IV. Type IV systems shall conform to the requirements of *AASHTO M 235* for Type IV adhesives. Type IV systems shall be for use in load-bearing applications for bonding hardened concrete to hardened concrete and other materials and as a binder for epoxy mortars and concretes.

(b) Epoxy Bonding System, Type V. Type V systems shall conform to the requirements of *AASHTO M 235* for Type V adhesives and shall bond freshly mixed concrete to steel. Type V systems shall be for use in load-bearing applications for bonding freshly mixed concrete to hardened concrete and freshly mixed concrete to steel.

(c) Epoxy Bonding System, Type VI. Type VI systems shall conform to the requirements of *AASHTO M 235* for type VI adhesives. Type VI systems shall be for bonding and sealing segmental precast elements, as in segment-by-segment erection and for span-by-span erection when temporary post tensioning is applied.

Elongation at break will not be required.

SECTION 720 – GEOTEXTILES

720.01 GENERAL REQUIREMENTS. Geotextiles shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions work plan for *Geotextile Product Evaluation and Facility Audits* and in compliance with the AASHTO Product Evaluation & Audit Solutions audit program for geotextiles. Geotextiles shall be one of the products listed on the Agency's *Approved Products List* for the respective material specification.

720.02 GEOTEXTILE FOR ROADBED SEPARATOR. Geotextile for roadbed separator shall conform to *AASHTO M 288, Table 1*, Class 1 for Geotextile Strength Property Requirements, and shall conform to *AASHTO M 288, Table 3* for Separation Geotextile Property Requirements, except as modified below.

(a) Permittivity. Permittivity shall be a minimum of 0.2 sec^{-1} as determined in accordance with *ASTM D4491*.

720.03 GEOTEXTILE UNDER RAILROAD BALLAST. Minimum average roll values (MARV) for geotextile under railroad ballast shall be as required in Table 720.03A.

TABLE 720.03A – MARV FOR GEOTEXTILE UNDER RAILROAD BALLAST

Property	Test Method	MARV
Elongation criteria at failure [1]	*ASTM D4632*	50% min.
Grab strength (lbs)	*ASTM D4632*	225
Tear strength (lbs)	*ASTM D4533*	115
Puncture strength (lbs)	*ASTM D6241*	850
Permittivity (s^{-1})	*ASTM D4491*	0.70
Apparent opening size (mm)	*ASTM D4751*	0.212 max. (No. 70 Sieve)
UV resistance (% strength retained)	*ASTM D4355*	70% at 500 hours of exposure
Structure	N/A	Nonwoven only

[1] Elongation corresponds to maximum grab tensile strength as measured in accordance with *ASTM D4632*.

720.04 GEOTEXTILE UNDER STONE FILL. Geotextile under stone fill shall conform to *AASHTO M 288, Table 1*, Class 1 for Geotextile Strength Property Requirements, and shall conform to *AASHTO M 288, Table 5* for Stabilization Geotextile Property Requirements. Geotextile structure shall not be slit film.

720.05 GEOTEXTILE FOR UNDERDRAIN TRENCH LINING. Geotextile for underdrain trench lining shall conform to *AASHTO M 288, Table 1*, Class 3 for Geotextile Strength Property Requirements, with a minimum elongation of 20%. Geotextile for underdrain trench lining shall conform to *AASHTO M 288, Table 2* (> 50% of in situ soil passing the No. 200 (0.075 mm) sieve) for Subsurface Drainage Geotextile Requirements. Geotextile structure shall be nonwoven and shall not be slit film.

720.06 GEOTEXTILE FOR FILTER CURTAIN. Minimum average roll values (MARV) for geotextile for filter curtain shall be as required in Table 720.06A.

TABLE 720.06A – MARV FOR GEOTEXTILE FOR FILTER CURTAIN

Property	Test Method	MARV
Elongation criteria at failure [1]	*ASTM D4632*	20% max.
Grab strength (lbs)	*ASTM D4632*	200
Tear strength (lbs)	*ASTM D4533*	50
Puncture strength (lbs)	*ASTM D6241*	430
Permittivity (s^{-1})	*ASTM D4491*	0.28
Apparent opening size (mm)	*ASTM D4751*	0.212 max. (No. 70 Sieve)
UV resistance (% strength retained)	*ASTM D4355*	70% at 500 hours of exposure
Structure	N/A	Woven only

[1] Elongation corresponds to maximum grab tensile strength as measured in accordance with *ASTM D 4632*.

720.07 GEOTEXTILE FOR SILT FENCE. Geotextile for silt fence shall conform to *AASHTO M 288, Table 8* for Temporary Silt Fence Property Requirements. Geotextile structure shall be woven.

SECTION 725 – CONCRETE CURING MATERIALS AND ADMIXTURES

725.01 CONCRETE CURING MATERIALS. Concrete curing materials shall meet the following requirements:

(a) White Burlap-Polyethylene Sheet. White burlap-polyethylene sheet shall conform to the requirements of *ASTM C171*.

(b) Burlap Cloth. Burlap cloth shall conform to the requirements of *AASHTO M 182*. Worn burlap cloth with holes, or burlap cloth reclaimed from uses other than that of curing concrete, will not be permitted. The burlap cloth shall be free of any ingredients that may damage or be detrimental to concrete.

(c) White Polyethylene Sheeting. White polyethylene sheeting (film) shall conform to the requirements of *ASTM C171*.

(d) Liquid Membrane-Forming Compounds. Liquid membrane-forming compounds shall be one of the products listed on the Agency's *Approved Products List* and shall meet the following requirements:

(1) Liquid membrane-forming compounds shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions work plan for *Evaluation of Concrete Curing Compounds*.

(2) Liquid membrane-forming compounds shall conform to the requirements of *ASTM C309*, Type 1-D or Type 2, Class B.

(3) Liquid membrane-forming compounds shall not be allowed to freeze.

725.02 CHEMICAL ADMIXTURES.

(a) General Requirements. Non-bulk quantities of chemical admixtures shall be delivered in the manufacturer's original containers marked with the manufacturer's name and product name. Bulk quantities shall be accompanied by a delivery slip indicating both the manufacturer's name and the product name. Chemical admixtures, excluding anti-washout admixtures, shall be one of the products listed on the Agency's *Approved Products List* for the respective material specification, and shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions work plan for *Evaluation of Concrete Admixtures*. Chemical admixtures shall meet the requirements of the respective material specification below.

(b) Air-Entraining Admixtures. Air-entraining admixtures shall conform to the requirements of *AASHTO M 154*.

(c) Retarding Admixtures. Retarding admixtures shall conform to the requirements of *AASHTO M 194* and *ASTM C494*, Type B.

(d) Latex Admixtures. Latex admixtures shall conform to the requirements of *ASTM C1438*, Type II. Latex admixture shall be stored in suitable enclosures which will protect it from dampness, freezing, and from prolonged exposure to temperatures higher than 86°F. If no shelf life is specified by the manufacturer, the admixture shall not be used after two years from the date of manufacture.

(e) Water-Reducing Admixtures. Water-reducing admixtures shall conform to the requirements of *AASHTO M 194* and *ASTM C494*, Type A.

(f) Water-Reducing and Retarding Admixtures. Water-reducing and retarding admixtures shall conform to the requirements of *AASHTO M 194* and *ASTM C494*, Type D.

(g) Water-Reducing, High Range Admixtures. Water-reducing, high range admixtures shall conform to the requirements of *AASHTO M 194* and *ASTM C494*, Type F.

(h) Water-Reducing, High Range, and Retarding Admixtures. Water-reducing, high range, and retarding admixtures shall conform to the requirements of *AASHTO M 194* and *ASTM C494*, Type G.

(i) Accelerating Admixtures. Accelerating admixtures shall conform to the requirements of *AASHTO M 194* and *ASTM C494*, Type C.

(j) Water-Reducing and Accelerating Admixtures. Water-reducing and accelerating admixtures shall conform to the requirements of *AASHTO M 194* and *ASTM C494*, Type E.

(k) Specific Performance Admixtures. Specific performance admixtures that provide desired performance characteristics, including but not limited to shrinkage reduction, alkali-silica reaction mitigation, and viscosity, shall conform to the requirements of *AASHTO M 194* and *ASTM C494*, Type S.

(l) Anti-Washout Admixtures. Anti-washout admixtures shall conform to the requirements of the U.S. Army Corps of Engineers *CRD-C 661*.

725.03 MINERAL ADMIXTURES. Mineral admixtures shall be stored in a manner so as to protect them from contamination with foreign materials.

(a) Pozzolans. Pozzolans and fly ash shall conform to the requirements of *AASHTO M 295*, Class F.

Fly ash shall contain 10% or less total calcium content, expressed as calcium oxide (CaO). Fly ash containing any oil shall be rejected. The mixing of the same type of fly ash from different sources will not be permitted.

(b) Silica Fume. Silica fume shall conform to the requirements of *AASHTO M 307* and be one of the products listed on the Agency's *Approved Products List*. Silica fume shall be delivered in containers clearly labeled with the manufacturer's name, mass (weight) of the silica fume, if densified or undensified, and if wet or dry.

(c) Ground Granulated Blast-Furnace Slag (GGBFS). GGBFS shall conform to the requirements of *AASHTO M 302*.

(d) Ground Glass Pozzolans. Ground glass pozzolans shall conform to the requirements of *ASTM C1866*.

725.04 COLORING ADMIXTURES. Coloring admixtures shall be pigments for integrally colored concrete in accordance with *ASTM C979*.

SECTION 726 – PROTECTIVE COATINGS AND WATERPROOFING MATERIALS

726.01 TIMBER PRESERVATIVE. Preservatives and pressure treatment processes for lumber and timber shall conform to the requirements of *AASHTO M 133* or *AWPA Standard U1*.

Wood components shall be treated in accordance with *AWPA Standard U1* to the requirements of the applicable use category as specified in Table 726.01A.

TABLE 726.01A – AWPA PRODUCT USE CATEGORIES AND COMMODITY SPECIFICATIONS

Component	AWPA Use Category	AWPA Commodity Specification
Sawn guardrail post	UC4B	A
Sawn bollard, marker post, guide post, sign post, or fence post	UC4A	A
Sawn structural lumber and timber	UC4B	A
Sawn nonstructural lumber	UC4A	A
Sawn timber cribbing	UC4B	A
Structural glued laminated timber	UC4B	F
Round fence post	UC4A	B
Round timber pole	UC4B	D

Any field treatment required by the Engineer shall be performed in accordance with the provisions of *AWPA Standard M4*. Prior to the delivery of preservative material, a copy of the safety data sheet for the product shall be provided to the Engineer.

726.02 MINERAL SPIRITS. Mineral spirits shall conform to the requirements of *ASTM D235*.

726.03 WATERPROOFING PITCH. Waterproofing pitch shall conform to the requirements of *ASTM D450,* Type II.

726.04 WOVEN COTTON FABRIC. Bitumen-saturated woven cotton fabric shall conform to the requirements of *ASTM D173*.

726.05 WOVEN GLASS FABRIC. Coated woven glass fabric shall conform to the requirements of *ASTM D1668*.

726.06 GALVANIZING. Surfaces to be galvanized shall be zinc-coated in conformance with *AASHTO M 111* or, when applicable, *AASHTO M 232*.

Zinc coating that has been damaged shall be repaired in accordance with *ASTM A780, Annex A2*. The paint used in the repair shall be organic rich, containing a minimum of 92% zinc by weight in the dry film. The paint shall be applied per the manufacturer's recommendations to a thickness equivalent to the surrounding zinc coating.

726.07 METALIZING. Surfaces to be metalized shall be prepared and coated in accordance with *AASHTO/NSBA S8.2, SSPC-PA 18*, and the following:

(a) The coating shall be zinc with a minimum purity of 99.9%.

(b) All surfaces to be thermal sprayed shall be blast-cleaned to white metal immediately prior to metalizing. The final surface appearance shall be equivalent to *SSPC-SP 5* supplemented by *SSPC-VIS 1*. All surfaces shall also have a uniform surface profile of 3.5 mils to 5.5 mils. If the profile requirements of the coating manufacturer are more restrictive, the fabricator shall advise the Structural Steel Fabrication Engineer and comply with the more restrictive requirements.

The surface profile produced by the fabricator's surface preparation procedures shall be determined by replica tape and spring micrometer at the beginning of the work, and each day that the surface preparation is performed. The replica tape shall be attached to the daily inspection records. Areas having unacceptable measurements shall be further tested to determine the limits of the deficient area and subsequently corrected to meet specification requirements.

(c) Thermal spray coating (TSC) shall be applied within six hours of completing blast cleaning. If this time is exceeded, or rust appears on the surface, the steel surface shall be properly prepared again. A thermal spray coating 8 mils to 12 mils thick shall be applied to all exterior surfaces. Internal surfaces shall have a coating with a minimum thickness of 2 mils.

(d) Exterior surfaces (except faying surfaces) shall be sealed with an approved sealant conforming to the sealant manufacturer's recommendations for the TSC applied. The sealant name, manufacturer, and product data sheets shall be included with the submittal for the metalizing procedure. Unless otherwise specified in the Contract, a top coat will not be applied over the seal coat, and therefore the seal coat shall be ultraviolet resistant. The dry film thickness of the sealant shall be 1 mil to 2 mils. The sealant shall be applied within 8 hours of completing the TSC application.

(e) In addition to the requirements above, the following shall also apply:

(1) QA witnessing of job reference standards is required, when applicable.

(2) Companion coupons shall be used in lieu of destructive testing on the work piece, except when a test failure occurs. If more than one thermal spray equipment setup is to be used in production, the frequency requirements apply to each one.

(3) Bend tests shall be performed for each thermal spray unit. The tests shall meet the requirements of *AWS C2.23*.

(f) Inaccessible areas, as well as metalizing that has been damaged in the field, shall be repaired in accordance with Subsection 726.06. The repair coating shall be brush applied.

726.08 WATERPROOFING MEMBRANE SYSTEMS. Waterproofing membrane systems shall be one of the products listed on the Agency's *Approved Products List* and shall meet the following requirements for the respective material specification:

(a) Waterproofing Membrane System, Type I. Type I waterproofing membrane system shall be a Type I cold applied elastomeric system in accordance with *ASTM D6153*.

(b) Waterproofing Membrane System, Type II. Type II waterproofing membrane system shall be a Type II hot applied elastomeric system in accordance with *ASTM D6153*.

(c) Waterproofing Membrane System, Type III. Type III waterproofing membrane system shall be a preformed sheet system intended for below-grade applications and shall meet the following requirements:

(1) Permeability. Permeability shall meet the requirements of *ASTM D6153*, *Table 1*.

(2) Adhesion. The system shall be self-adhering.

726.09 ANTI-GRAFFITI COATING. Anti-graffiti coatings shall be concrete, masonry, or natural stone coatings that aid in the removal of graffiti. Anti-graffiti coating for concrete shall be in accordance with *ASTM D7089*, Cleanability Level 1.

726.10 WATER REPELLENT, SILANE. Silane water repellent shall be in accordance with *AASHTO M 244* and shall be one of the products listed on the Agency's *Approved Products List*.

(a) Type I. Type I silane water repellent shall have a minimum active silane content of 40%.

(b) Type II. Type II silane water repellent shall have an active silane content of 100%.

SECTION 727 – FENCING MATERIALS

727.01 WOVEN WIRE FENCE. Woven wire fence shall meet the following requirements:

(a) Woven Wire Fabric for Fencing and Gates. Woven wire fabric shall be Design Number 939-6-11 or Design Number 939-6-12 1/2 in accordance with *AASHTO M 279*, Grade 60. Woven wire fabric shall have a Type A coating or Type Z Class 3 coating and may have a hinge joint or continuous stay fixed knot joint.

(b) Barbed Wire. Barbed wire shall be Design Number 12-4-5-14R in accordance with *AASHTO M 280*. Barbed wire shall have a Type A coating or a Type Z coating.

(c) Wood Posts and Braces. Round wood posts shall be seasoned red (Norway) pine or southern pine, straight, sound, and cut from live timber.

If round posts are used, they shall conform to the diameter and length shown on the Plans. In all cases, they shall be not less than 4-1/2 inches in diameter at the small end after removal of the bark. They shall be shaved to an even surface and be free from bark or skin.

If sawn posts are used, they shall be rough-sawn and conform to the requirements of Subsection 728.01. The nominal dimensions shall be at least 4 inches square and of the length shown on the Plans.

The types of wood to be used for bracing shall be similar to those required for the posts. The braces shall conform to the dimensions shown on the Plans.

All wood posts and braces shall be pressure treated in accordance with Subsection 726.01. Any cut portions shall receive a field application in accordance with *AWPA Standard M4*.

(d) Steel Posts and Braces. Line posts shall be standard commercial T-type steel posts conforming to the requirements of *AASHTO M 281*.

End posts, corner posts, pull posts, bracing, and anchor plates shall conform to the requirements of *AASHTO M 281*.

Intermediate posts or line posts shall be provided with an anchor plate having a length or width of 4 inches to 5 inches with a net area of not less than 20 square inches.

All posts, braces, anchors, plates, and other metal fittings shall be zinc coated on all inner and outer surfaces in accordance with the requirements of *AASHTO M 111* or *AASHTO M 232*, whichever is applicable.

(e) Gates. Frames, diagonal tie bars, braces, and hardware for gates shall be zinc-coated on all inner and outer surfaces in accordance with the requirements of *ASTM A53, AASHTO M 111*, or *AASHTO M 232*, whichever is applicable. Woven wire fabric used for gates shall be of the same material used in fences.

(f) Miscellaneous Hardware. Miscellaneous hardware such as, but not limited to, wire, clips, nails, bolts, nuts, washers, hinges, latches, and staples shall be of low to medium carbon steel, galvanized, and shall be of good commercial quality. Staples shall be 0.1483-inch diameter (9-gauge) galvanized wire at least 1-1/2 inches long.

Galvanizing shall be in accordance with the requirements of *AASHTO M 232*, where applicable. Galvanized wire and clips produced from galvanized wire shall have a Class 1 coating in accordance with *AASHTO M 279*.

727.02 CHAIN-LINK FENCE. Chain-link fence shall conform to the requirements of *AASHTO M 181* and shall be one of the products listed on the Agency's *Approved Products List*.

(a) Fabric. Chain-link fence fabric shall be 0.1483-inch diameter (9-gauge) wire woven into a 2-inch mesh.

(1) Chain-Link Fence Fabric, Galvanized. Galvanized chain-link fence fabric shall be Type I, Class D in accordance with *AASHTO M 181*.

(2) Chain-Link Fence Fabric, PVC Coated. PVC coated chain-link fence fabric shall be Type IV, Class B in accordance with *AASHTO M 181*. PVC coating shall be black unless otherwise noted in the Contract.

(b) Posts. Posts shall be Grade 1 or Grade 2 round pipe in accordance with *AASHTO M 181* and conform to the following requirements:

(1) Gate Posts. Gate posts shall conform to the requirements of Table 727.02A.

TABLE 727.02A – ZINC-COATED STEEL MATERIAL FOR GATE POSTS

Nominal Width of Gate [1]	Grade	Outside Diameter (in.)	Weight Per Foot (lbs)
6 feet and less	Grade 1	2.875	5.80
	Grade 2	2.875	4.64
Over 6 feet to 13 feet	Grade 1	4.00	9.12
	Grade 2	3.50	5.71
Over 13 feet to 18 feet	Grade 1 or Grade 2	6.625	18.99
Over 18 feet	Grade 1 or Grade 2	8.625	28.58

[1] Nominal width of gate is for a single gate or one leaf of a double gate.

(2) End, Corner, and Pull Posts. End, corner, and pull posts shall conform to the requirements of Table 727.02B.

TABLE 727.02B – ZINC-COATED STEEL MATERIAL FOR END, CORNER, AND PULL POSTS

Chain-Link Fence Fabric Height	Grade	Outside Diameter (in.)	Weight Per Foot (lbs)
Less than 6 feet	Grade 1	2.375	3.65
	Grade 2	2.375	3.12
6 feet and greater	Grade 1	2.875	5.80
	Grade 2	2.875	4.64

(3) Line Posts. Line posts shall conform to the requirements of Table 727.02C.

TABLE 727.02C – ZINC-COATED STEEL MATERIAL FOR LINE POSTS

Chain-Link Fabric Height	Grade	Outside Diameter (in.)	Weight Per Foot (lbs)
Less than 6 feet	Grade 1	1.90	2.72
	Grade 2	1.90	2.28
6 feet and greater	Grade 1	2.875	5.80
	Grade 2	2.375	3.12

(c) Gate Components. Gate components shall be in accordance with *AASHTO M 181*.

(1) Gate Frame. Gate frames shall be Grade 1 or Grade 2 round pipe in accordance with *AASHTO M 181* and conform to the requirements of Table 727.02D.

TABLE 727.02D – ZINC-COATED STEEL MATERIAL FOR GATE FRAMES

Nominal Width of Gate [1]	Grade	Outside Diameter (in.)	Weight Per Foot (lbs)
6 feet and less	Grade 2	1.660	1.84
Over 6 feet to 13 feet	Grade 1	1.90	2.72
	Grade 2	1.90	2.28
Over 13 feet to 18 feet	Round	6.625	18.97

[1] Nominal width of gate is for a single gate or one leaf of a double gate.

(2) Brace Rod. Brace rods shall be Grade 1 or Grade 2 round pipe in accordance with *AASHTO M 181* and conform to the requirements of Table 727.02E.

TABLE 727.02E – ZINC-COATED STEEL MATERIAL FOR BRACE RODS

Grade	Outside Diameter (in.)	Weight Per Foot (lbs)
Grade 1	1.660	2.27
Grade 2	1.660	1.84

(3) Truss Rod. Truss rods shall be 0.375 inch steel round rods with a turnbuckle.

(d) Miscellaneous Hardware and Fittings. Miscellaneous hardware and fittings shall be steel in accordance *AASTHO M 181* and meet the following requirements as applicable:

(1) Tension Bar. Tension bars shall be flat steel, 0.25 inch × 0.625 inch for fabric heights 6 foot and less or 0.25 inch × 0.75 inch for fabric heights over 6 foot.

(2) Tension Wire. Tension wire shall be 0.1770 inch diameter (7 gauge), Class 1 in accordance with *AASTHO M 181*.

727.03 BARRIER FENCE. Barrier fence shall be fluorescent yellow or orange, ultraviolet stabilized, high density polyethylene mesh or grid that will not sag, corrode, rot, or conduct electricity.

727.04 PROJECT DEMARCATION FENCE. Project demarcation fence shall be non-adhesive, ultraviolet stabilized, fluorescent yellow or orange vinyl-coated polyester mesh or polyethylene plastic tape that will not sag or tear over time due to natural weather conditions.

727.05 SNOW BARRIER FENCE. Snow barrier fence shall conform to the requirements of *AASHTO M 181* and to the design, dimensions, and details shown on the Plans.

(a) Snow Barrier Fabric. Snow barrier fabric shall meet the requirements of Subsection 727.02(a) as modified below.

(1) Snow barrier fabric shall be woven into a 1-inch mesh.

(b) Posts. Posts shall meet the requirements of Subsection 727.02(b).

(c) Miscellaneous Hardware. Miscellaneous hardware shall meet the requirements of Subsection 727.02(d).

727.06 PLANK RAIL FENCE. The plank for rail fence shall be seasoned red (Norway) pine or southern pine, planed on four sides, and of the dimensions shown on the Plans. Wood shall be pressure treated in accordance with Subsection 726.01.

Miscellaneous hardware for plank rail fence such as spikes, lag screws, bolts, nuts, and washers shall conform to the dimensions shown on the Plans. Hardware shall be of low- to medium-carbon steel, galvanized, and shall be of good commercial quality. The metal brackets shall be fabricated from 1/4 inch steel plate and shall be galvanized after fabrication.

SECTION 728 – ROADSIDE SAFETY BARRIER MATERIALS

728.01 POSTS.

(a) Wood Posts. Posts shall be straight, sound wood meeting one of the following:

(1) Red (Norway) Pine. No. 1 Stress Grade red (Norway) pine as determined in accordance with the Northeastern Lumber Manufacturers Association; or

(2) Southern Pine. No. 2 Stress Grade southern pine as determined in accordance with the Southern Pine Inspection Bureau.

Wood posts shall be treated in accordance with Subsection 726.01 for sawn guardrail posts after fabrication.

Inspection, quality control, handling, storage, field fabrication, and field treatment shall be in accordance with *AWPA Standard M2*, *AWPA Standard M3*, and *AWPA Standard M4*.

(b) Steel Posts and End Post Caps. Posts and caps shall be structural steel in accordance with *AASHTO M 270*, Grade 36. Posts shall be galvanized in accordance with *AASHTO M 111* after fabrication.

728.02 BEAM AND CABLE ELEMENTS.

(a) Cable. Cable shall be wire rope in accordance with *AASHTO M 30*, Type I, Class A Coating.

(b) W-Beam and Thrie Beam. Beam shall be corrugated sheet steel W-beam in accordance with *AASHTO M 180*, Type II.

(1) Standard Beam. Standard beam shall be Class A in accordance with *AASHTO M 180*.

(2) Heavy Duty Beam. Heavy duty beam shall be Class B in accordance with *AASHTO M 180*.

(c) Box Beam. Beam shall be square steel structural tubing in accordance with Subsection 714.11. Beams shall be galvanized in accordance with *AASHTO M 111* after fabrication.

(d) Steel-Backed Timber Beam.

(1) Timber. Timber shall have a minimum allowable bending stress of 1,450 psi.

(2) Steel Backing and Splice Plates. Steel backing and splice plates shall be in accordance with *AASHTO M 270*, Grade 50. Steel backing and splice plates shall be galvanized in accordance with *AASHTO M 111* after fabrication.

(e) End Sections. End sections shall be sheet steel in accordance with *AASHTO M 180*, Type II.

728.03 HARDWARE.

(a) Cable, W-Beam, and Thrie Beam Guardrail Hardware. Hardware shall be galvanized in accordance with *AASHTO M 232*.

(1) Cable-Beam Connectors.

a. Bolts. Bolts shall be in accordance with *ASTM A307*, Grade A.

b. Washers. Washers shall be in accordance with *ASTM F436* and *ASTM F844*.

c. Nuts. Nuts shall be in accordance with *ASTM A563*.

(2) Cable Fittings. Anchor angles, cable end assemblies, and splices shall be in accordance with *AASHTO M 30*.

(b) Box Beam Guardrail Hardware.

(1) Splice Plates and Brackets. Splice plates and brackets shall be structural steel in accordance with *AASHTO M 270*, Grade 36. Splice plates and brackets shall be galvanized in accordance with *AASHTO M 111* after fabrication.

(2) Post-Bracket-Beam Connectors. Post-bracket-beam connectors shall be galvanized in accordance with *AASHTO M 232*.

a. Bolts. Bolts shall be in accordance with *ASTM A307*, Grade A.

b. Washers. Washers shall be in accordance with *ASTM F436*.

c. Nuts. Nuts shall be in accordance with *ASTM A563*.

(3) Rail-Splice Connectors. Bolts, washers, and nuts shall be in accordance with Subsection 714.05, except that rotational capacity, proof load, and wedge tests will not be required.

(c) Steel-Backed Timber Guardrail Hardware. Hardware shall be galvanized in accordance with *AASHTO M 232*.

(1) Bolts and Lag Screws. Bolts and lag screws shall be in accordance with *ASTM A307*, Grade A.

(2) Washers. Washers shall be in accordance with *ASTM F844*.

(3) Nuts. Nuts shall be in accordance with *ASTM A563*.

728.04 OFFSET BLOCKS.

(a) Composite Offset Blocks. Composite offset blocks shall have an FHWA eligibility letter and shall be one of the products on the Agency's *Approved Products List*.

(b) Wood Offset Blocks. Wood offset blocks shall be in accordance with Subsection 728.01(a).

728.05 CONCRETE ANCHORS. Concrete anchors may be precast or cast-in-place in accordance with the Contract requirements for the respective anchor.

(a) Concrete. Concrete shall have a minimum 28-day compressive strength of 4,000 psi as determined in accordance with *AASHTO T 22*.

Concrete shall be cured in accordance with *AASHTO M 199* for sufficient time to develop the minimum 28-day compressive strength.

(b) Bar Reinforcement. Bar reinforcement shall be in accordance with Subsection 713.01.

728.06 MANUFACTURED TERMINAL SECTIONS. Manufactured terminal sections (MTS) shall have an FHWA eligibility letter demonstrating the respective *MASH* test level, be one of the products on the Agency's *Approved Products List*, and meet the following requirements:

(a) W-Beam. MTS shall be compatible with w-beam guardrail and meet the following requirements:

(1) Flared. Flared MTS shall gradually increase the offset from the edge of pavement from the end of the guardrail installation to the end of the MTS installation.

a. TL-2. MTS TL-2 shall be a minimum of Test Level 2 in accordance with *MASH*.

b. TL-3. MTS TL-3 shall be a minimum of Test Level 3 in accordance with *MASH*.

(2) Tangent. Tangent MTS shall maintain a consistent offset from the edge of pavement from the end of the guardrail installation to the end of the MTS installation.

a. TL-2. MTS TL-2 shall be a minimum of Test Level 2 in accordance with *MASH*.

b. TL-3. MTS TL-3 shall be a minimum of Test Level 3 in accordance with *MASH*.

(b) Box Beam. Box beam MTS shall be compatible with box beam guardrail and meet the following requirements:

(1) Flared. Flared MTS shall gradually increase the offset from the edge of pavement from the end of the guardrail installation to the end of the MTS installation.

a. TL-2. MTS TL-2 shall be a minimum of Test Level 2 in accordance with *MASH*.

b. TL-3. MTS TL-3 shall be a minimum of Test Level 3 in accordance with *MASH*.

(2) Tangent. Tangent MTS shall maintain a consistent offset from the edge of pavement from the end of the guardrail installation to the end of the MTS installation.

a. TL-2. MTS TL-2 shall be a minimum of Test Level 2 in accordance with *MASH*.

b. TL-3. MTS TL-3 shall be a minimum of Test Level 3 in accordance with *MASH*.

728.07 ENERGY ABSORPTION ATTENUATORS. Energy absorption attenuators shall have an FHWA eligibility letter demonstrating the respective *MASH* test level, be one of the products on the Agency's *Approved Products List*, and meet the following requirements:

(a) Type I. Type I attenuators shall be temporary and meet the following requirements:

(1) TL-2. TL-2 attenuators shall be a minimum of Test Level 2 in accordance with *MASH*.

(2) TL-3. TL-3 attenuators shall be a minimum of Test Level 3 in accordance with *MASH*.

(b) Type II. Type II attenuators shall be permanent and meet the following requirements:

(1) TL-2. TL-2 attenuators shall be a minimum of Test Level 2 in accordance with *MASH*.

(2) TL-3. TL-3 attenuators shall be a minimum of Test Level 3 in accordance with *MASH*.

728.08 TEMPORARY TRAFFIC BARRIER. Temporary Traffic barrier, and corresponding connections, shall be Test Level 3 longitudinal barrier with a corresponding FHWA eligibility letter demonstrating the test level. Test level criteria shall be in accordance with Table 728.08A.

TABLE 728.08A – TEMPORARY TRAFFIC BARRIER TEST LEVEL CRITERIA

Date of Manufacture	Test Level Criteria
Prior to January 1, 2020	*NCHRP Report 350* or *MASH*
January 1, 2020 or later	*MASH*

SECTION 729 – CURB MATERIALS

729.01 VERTICAL GRANITE CURB. Vertical granite curb shall consist of hard, durable, quarried granite. It shall be gray in color, free from seams, cracks, or other structural defects, and shall be of a smooth splitting character. The curb may contain natural color variations that are characteristic of the granite source. Granite curb shall meet the requirements of *ASTM C615*.

(a) Source. The Contractor shall submit for approval the name of the quarry that is the proposed source of the granite for curb materials. Such submission shall be made sufficiently in advance of ordering so that the Engineer may have an opportunity to judge the stone, both as to quality and appearance. Samples of curbing shall be submitted for approval only when requested by the Engineer.

(b) Finish and Surface Dimensions. The individual curb stones shall be of the dimensions shown on the Plans and shall be of uniform thickness in any continuous run. The individual curb stones shall be furnished in minimum lengths of 6 feet.

The top surface of the curb stones shall be sawed to an approximately true plane and shall have no projection or depression greater than 1/8 inch. The bottom surface may be sawn or split.

The top front arris line shall be rounded to a 1/2 inch radius as shown in the Contract. The exposed arris lines shall be pitched straight and true, with no variations from a straight line greater than 1/8 inch.

The front face shall be at right angles to the plane of the top and shall be smooth quarry split or sawn for the full depth. Drill holes in the exposed part of the face shall not be permitted. The front face shall have no projections greater than 1 inch or depressions greater than 1/2 inch, measured from the vertical plane of the face through the top arris line for 8 inches down from the top. For the remaining distance, there shall be no projections or depressions greater than 1 inch measured in the same manner.

The back surface of the curb stones shall have no projection for 3 inches down from the top which would fall outside of a plane having a batter of 3:1 (V:H) from the back arris line.

The ends of all curb stones shall be square with the planes of the top and front face, and so finished that when the stones are placed end to end as closely as possible, no space more than 1 inch shall show in the joint for the full width of the top or down on the face for 8 inches. The remainder of the end may break back a maximum of 6 inches from the plane of the joint.

Curbing stones to be set on a radius of 80 feet or less shall be cut to the curve required, and their ends shall be cut on radial lines.

729.02 GRANITE SLOPE EDGING. Granite slope edging shall consist of hard, durable, quarried granite. It shall be gray in color, free from seams, cracks, or other structural defects, and shall be of smooth splitting character. The edging may contain natural color variations that are characteristic of the granite source. Granite slope edging shall meet the requirements of *ASTM C615*.

(a) Source. The Contractor shall submit for approval the name of the quarry that is the proposed source of the granite for edging materials. Such submission shall be made sufficiently in advance of ordering so that the Engineer may have an opportunity to judge the stone, both as to quality and appearance. Samples of edging shall be submitted for approval only when requested by the Engineer.

(b) Finish and Surface Dimensions. The individual edging stones shall be of the dimensions shown on the Plans and shall be of uniform thickness in any continuous run. The individual edging stones shall be furnished in minimum lengths of 2 feet.

The tops and bottoms shall be not under the square more than 4 inches, or over the square at the back more than 1 inch, when so tested.

The exposed face shall be smooth quarry-split or sawed. Drill holes will be permitted on the exposed face, but only along the bottom edge and extending no more than 3 inches upward from the edge. The exposed face shall have no projections or depressions greater than 1 inch, measured from a 24-inch long straightedge placed as closely as possible on any part of the face.

The ends of all edging stones shall be square with the plane of the exposed face and so finished that when the stones are placed end to end as closely as possible, no space more than 1 inch shall show in the joint for the full depth of the face. The arris lines at the ends shall be pitched with no variation from the plane of the face more than 1/4 inch.

729.03 PRECAST REINFORCED CONCRETE CURB. Precast reinforced concrete curb shall be solid, precast, reinforced units of uniform quality and appearance. All curb shall be cast in steel or concrete forms which will produce a satisfactory surface requiring no further finishing, rubbing, or patching after the forms are removed, except for the removal of flash or excess material along the edges.

Precast reinforced concrete curb shall conform to the following requirements:

(a) Dimensions. The individual precast curb units shall be of the dimensions shown on the Plans and shall be cast in lengths of not less than 3 feet or greater than 10 feet. Random lengths of curb of not less than 3 feet in length may be obtained by sawing regular precast curb, if the Engineer determines it is necessary to meet field conditions. All curbs to be set on a radius of 160 feet or less shall be precast to fit the curve as required.

(b) Marking. Each pour shall be identified with a six-digit registration number (indicating in order the year, month, and day of month) cast in the curb, as well as the name or trademark of the manufacturer and the date of manufacture. A pour shall be considered one day's production.

(c) Materials. The concrete shall conform to the requirements of Section 540, and when sampled and tested in accordance with *AASHTO T 22*, shall have a minimum compressive strength of 5,000 psi. Bar reinforcement shall conform to the requirements of Subsection 713.01.

(d) Curing. The precast curb units shall be subjected to any one of the curing methods specified in *AASHTO M 199*, for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less.

729.04 BITUMINOUS CONCRETE CURB. Bituminous concrete curb shall consist of blended aggregate, polyester fiber, performance-graded asphalt binder, and mineral filler if required.

(a) Bituminous Concrete Curb Mixture. The bituminous concrete curb mixture shall meet the requirements of Subsection 716.02 for Type IVS bituminous concrete pavement, with the following modifications and requirements:

(1) Performance-Graded Asphalt Binder Content. The asphalt binder content shall be between 7.0% and 9.0%.

(2) Asphalt Binder Grade. The asphalt binder shall be grade 58-28 of any traffic level designation.

(3) Number of Gyrations. The value of N_{design} shall be 50 gyrations.

(4) Volumetric Requirements. The percent air voids shall be between 0.0% and 4.0%. All other volumetric requirements are waived.

(b) Polyester Fiber. Polyester fiber shall meet the requirements specified in Table 729.04A.

TABLE 729.04A – POLYESTER FIBER PROPERTIES

Property	Test Method	Requirement
Denier	*ASTM D1577*	4.5 ± 1.5
Length (in.)	--	0.25 ± 0.02
Minimum tensile strength (psi)	*ASTM D2256*	70,000
Specific gravity	--	1.36 ± 0.04
Minimum melting temperature (°F)	--	475

729.05 TREATED TIMBER CURB. Treated timber curb and stakes shall be either seasoned red (Norway) pine, eastern white pine, or southern pine, straight, sound, and cut from live timber. Material shall be fabricated prior to treatment in conformance with the dimensions and details shown on the Plans. The sides of the planks may be either surfaced or rough-sawn. Treatment shall be performed, inspected, tested, and reported in accordance with Subsection 726.01.

All spikes, fasteners, U-bolts, nuts, and washers for treated timber curb shall conform to the dimensions shown on the Plans. They shall be of low- to medium-carbon steel, either galvanized or corrosion-resistance treated, and shall be of good commercial quality.

SECTION 730 – PILING

730.01 STEEL PILING. Steel piling shall be rolled steel sections of the weight and shape shown on the Plans. Piles, splice plates, and point reinforcement shall be new material conforming to the requirements of *ASTM A572*, Grade 345 (Grade 50). When cast steel shoes are used, they shall conform to the requirements of *AASHTO M 103*, Grade 485-275 (Grade 70-40) or *ASTM A148*, Grade 550-275 (Grade 80-40).

730.02 STEEL SHEET PILING. Steel sheet piling shall be rolled steel sections of the type, shape, and weight shown on the Plans and shall be capable of being interlocked so that a continuous wall is formed when individual pieces are driven side by side. Permanent steel sheet piling shall be new material conforming to the requirements of *AASHTO M 202*.

730.03 STEEL CASING FOR DRILLED SHAFTS. Permanent steel casing for drilled shafts shall conform to the requirements of *ASTM A36* or *ASTM A252*, Grade 2.

SECTION 731 – BEARING PADS FOR STRUCTURES

731.01 BEARING PADS. Bearing pads shall be manufactured from all-new materials comprised of high-quality elastomer with a random distribution of synthetic fibers in proper proportion to maintain strength and stability. The finished product shall withstand a compressive load perpendicular to the plane of laminations of 7,000 psi. The surface shall have a hardness of 80 (± 10) using a Shore A durometer, in accordance with the requirements of *ASTM D2240*.

731.02 ELASTOMERIC MATERIAL. Elastomeric material shall conform to the *AASHTO LRFD Bridge Construction Specifications, Section 1*8 and *AASHTO M 251,* Durometer Grade 50, Low Temperature Brittleness Grade 4, unless otherwise specified. Elastomeric material shall have a shear modulus of 110 psi, unless otherwise specified. The resulting product shall be free of porous areas, weak sections, bubbles, foreign matter, or other defects affecting serviceability.

Testing of elastomeric material will be waived for bearings that will be encased in concrete in the final work.

731.03 STAINLESS STEEL. Stainless steel shall conform to the requirements of the *AASHTO LRFD Bridge Design Specifications, Section 14* and the *AASHTO LRFD Bridge Construction Specifications, Section 18*.

Stainless steel used as a mating surface with polytetrafluoroethylene (PTFE) material and incorporated in bearing devices shall conform to the requirements of *ASTM A240,* Type 304.

731.04 PTFE MATERIAL. Polytetrafluoroethylene (PTFE) material incorporated in bearing devices shall be all-new material with a minimum thickness of 1/8 inch and conforming to the requirements of the *AASHTO LRFD Bridge Design Specifications, Section 14.7.2* and the *AASHTO LRFD Bridge Construction Specifications, Section 18*.

SECTION 732 – RAILING MATERIALS

732.01 METAL HAND RAILING. Material for metal hand railing and sleeves shall conform to the requirements of *ASTM A53* or *ASTM A500*, Grade B.

732.02 ALUMINUM BRIDGE RAILING.

(a) Aluminum Alloy. Aluminum alloy for aluminum bridge railing, including hand railing, shall conform to the requirements of Subsection 715.02.

(b) Stainless Steel Bolts, Nuts, Washers, and Set Screws. Bolts and washers for post, railing, and offset block connections shall conform to the requirements of *ASTM F593*, Alloy Group 1, Condition AF, Alloy 304 and its supplementary requirements for S5.

Nuts shall conform to the requirements of *ASTM F836M*, Property Class A1-50, Condition AF, Alloy 304 and *ASTM F594*, Alloy Group 1, Condition AF, Alloy 304.

Stainless steel set screws for use in aluminum bridge railing connections shall conform to the requirements of *ASTM F880*, Property Class A1-70, Condition CW, Alloy 304 and *ASTM F880*, Alloy Group 1, Condition CW, Alloy 304.

Stainless steel anchor bolts and washers shall conform to the requirements of *ASTM F593*, Alloy Group 1, Condition CW, Alloy 304. Heavy hex stainless steel nuts for stainless steel anchor bolts shall conform to the requirements of *ASTM F836M*, Property Class A1-70, Condition CW, Alloy 304 and *ASTM F594*, Alloy Group 1, Condition CW, Alloy 304.

(c) Structural Carbon Steel. Structural carbon steel for anchor channel bars, approach railing posts, offset brackets, and anchor bolt sleeve bases shall conform to the requirements of *AASHTO M 270*, Grade 250 (Grade 36) or *ASTM A36*.

(d) Steel Pipe. Steel pipe for anchor bolt sleeves shall conform to the requirements of Subsection 740.04.

(e) Anchor Bolts, Nuts, and Washers. Anchor bolts, nuts, and washers shall conform to the requirements of Subsection 714.07.

(f) Fabric Pads. Fabric pads for aluminum posts shall conform to the requirements of Subsection 731.01 or Subsection 731.02.

(g) Aluminum Impregnated Caulking Compound. Aluminum filled silicone sealant shall conform to the requirements of Subsection 707.11.

732.03 GALVANIZED BOX BEAM BRIDGE RAILING.

(a) Structural Steel Tubing. Tubing for posts, railings, and railing splices shall conform to the requirements of *ASTM A500,* Grade B, except as modified below.

(1) The manufacturer shall test both welded and formed tubular material for the physical properties specified. Results of all tests shall be submitted with material certifications.

(2) Welds shall be sound, free from defects, and have no repairs. Transverse mill welds will not be permitted.

(3) Longitudinally-welded tubing shall have a tensile strength of 58,000 psi when tested in accordance with *ASTM E8*.

(4) A traceable identification number shall be placed on each piece of material in a form that can be read after the galvanizing process. Quantities of the same item made from the same heat numbers are allowed to be packaged together with a single identification.

(5) Posts and railings shall be CVN tested in accordance with *AASHTO T 243*, Frequency H testing. Full size 3/8 inch × 3/8 inch specimens shall be used whenever thickness permits. Sub-size specimens may be used when material thickness is less than 3/8 inch. The average energy absorbed by a sub-sized specimen shall be prorated for the actual thickness of the specimen. The average energy absorbed by a full-size specimen shall be not less than 15 foot-pounds of force at 0°F.

(b) Structural Carbon Steel (Non-Tubular).

(1) Structural carbon steel for posts, baseplates, and railing splices shall meet the requirements of *ASTM A572,* Grade 50 or *AASHTO M 270,* Grade 345 (Grade 50). Posts and baseplates shall be CVN tested in accordance with *AASHTO T 243,* Frequency H testing. Full size 3/8 inch × 3/8 inch specimens shall be used whenever thickness permits. Sub-size specimens may be used when material thickness is less than 3/8 inch. The average energy absorbed by a sub-sized specimen shall be prorated for the actual thickness of the specimen. The average energy absorbed by a full-size specimen shall be not less than 15 foot-pounds of force at 40°F.

(2) Structural carbon steel for anchor plates shall conform to the requirements of *AASHTO M 270,* Grade 250 (Grade 36) or *ASTM A36*.

(3) Structural carbon steel for angles shall conform to the requirements of *AASHTO M 270,* Grade 345 (Grade 50) or *ASTM A572,* Grade 50.

(c) Bolts, Nuts, and Washers. High-strength bolts shall conform to the requirements of *ASTM F3125*, Grade A 325, Type 1, or *ASTM A449*, Type 1. High-strength nuts shall conform to the requirements of *ASTM A563*, Grade DH. High-strength washers shall conform to the requirements of *ASTM F436*. Lock washers shall be high-carbon heat-treated spring steel conforming to the requirements of *ASME D18.21.1*.

(d) Anchor Bolts, Nuts, and Washers. Anchor bolts, nuts, and washers shall conform to the requirements of Subsection 714.07.

732.04 STEEL BEAM BRIDGE RAILING.

(a) Beam Guardrail. Beam guardrail for bridge railing shall conform to the requirements of Subsection 728.02. The beam guardrail shall be Class B type.

(b) Steel Tubing. Tubular steel backing material for steel beam bridge railing shall conform to the requirements of *ASTM A500*, Grade B. Splice material shall conform to Subsection 732.04(c).

(c) Steel Posts and Components. Posts, baseplates, offset blocks, brackets, washers, and other steel components shall be structural carbon steel conforming to the requirements of *AASHTO M 270*, Grade 345W (Grade 50W); *ASTM A588*; *ASTM A572*, Grade 345 (Grade 50); or *AASHTO M 270*, Grade 345 (Grade 50). Posts, baseplates, and post mounting brackets or components shall be CVN tested for impact properties in accordance with *AASHTO T 243*, Frequency H testing. Full size 3/8 inch × 3/8 inch specimens shall be used whenever thickness permits. Sub-size specimens may be used when material thickness is less than 3/8 inch. The average energy absorbed by a sub-sized specimen shall be prorated for the actual thickness of the specimen. The average energy absorbed by a full-size specimen shall be not less than 15 foot-pounds force at 40°F.

(d) Steel Pipe. Steel pipe for anchor bolt sleeves shall conform to the requirements of Subsection 740.04.

(e) Anchor Bolts, Nuts, and Washers. Anchor bolts, nuts, and washers shall conform to the requirements of Subsection 714.07.

SECTION 735 – INSULATING MATERIALS

735.01 POLYSTYRENE INSULATION BOARD. Polystyrene insulation board shall conform to the requirements of *AASHTO M 230*. It shall be furnished in nominal 2-foot × 8-foot boards and shall be of the thickness, compressive strength, and density shown on the Plans.

735.02 BLANKET INSULATION MATERIAL. Blanket insulation material shall consist of mats of fiberglass, rock wool, balsam wool, or other approved insulating materials completely enclosed on all sides within weatherproof facings of reinforced, coated Kraft paper or polyethylene sheeting.

The thermal conductivity of the blanket insulation material shall not exceed 0.27 BTU-inch per hour per square foot per degree Fahrenheit at a mean temperature of 75°F.

SECTION 740 – WATER LINES AND APPURTENANCES

740.01 PLASTIC PIPE, FLEXIBLE. Flexible plastic pipe shall be polyethylene plastic pipe suitable for the transportation of potable water and shall conform to the requirements of *ANSI/AWWA C901*. The material grade selected shall be capable of withstanding a minimum sustained water pressure of 160 psi at 73°F. The pipe shall be inside-diameter controlled. Fittings may be either nylon, copper, or bronze. Clamps shall be stainless steel.

740.02 PLASTIC PIPE, RIGID (PVC). Rigid PVC plastic pipe shall be suitable for the transportation of potable water and shall conform to the requirements of *ANSI/AWWA C900*. The material grade selected shall be capable of withstanding a minimum sustained water pressure of 160 psi at 73°F. Fittings shall be PVC plastic conforming to the requirements of *ANSI/AWWA C907*.

740.03 COPPER TUBE, SEAMLESS. Seamless copper water tube shall conform to the requirements of *ASTM B88,* Type K.

740.04 STEEL PIPE, GALVANIZED. Galvanized steel pipe shall be suitable for the transportation of potable water and shall be the standard weight class conforming to the requirements of *ASTM A53*.

740.05 DUCTILE IRON PIPE, CEMENT LINED. Ductile iron pipe shall be cement lined and centrifugally cast in metal- or sand-lined molds. The pipe shall conform to the requirements of *ANSI/AWWA C151/A 21.51* and the cement mortar lining shall conform to the requirements of *ANSI/AWWA C104/A21.4*. The class of pipe shall be as specified in the Contract.

740.06 PIPE INSULATION. Thermal insulation for pipes shall be preformed to fit standard pipe sizes and may be supplied as either hollow cylindrical shapes (split in half lengthwise) or as curved segments. Insulation shall include all accessories complete with proper jackets or facings as required by the conditions. Multilayer insulation is acceptable provided the inside and outside diameters of each layer will ensure proper nesting.

The thermal conductivity of the insulation material shall not exceed 0.27 BTU-inch per hour per square foot per degree Fahrenheit at a mean temperature of 75°F as determined in accordance with *ASTM C177* or *ASTM C518*.

The thickness and jackets shall be as specified in the Contract.

Pipe insulation used as bond breakers for structures shall meet the requirements of *ASTM C534*.

SECTION 742 – DISINFECTANTS

742.01 CHLORINE SOLUTION. Chlorine solution used for disinfecting springs, wells, and other water systems shall consist of a solution of water and liquid chlorine, sodium hypochlorite, calcium hypochlorite, or chloride of lime.

Liquid forms of chlorine or sodium hypochlorite and powder forms of calcium hypochlorite or chloride of lime shall be used according to the instructions supplied by the manufacturer and as recommended by the Vermont Department of Health.

If sodium hypochlorite is already in solution as a laundry bleach containing 5.25% sodium hypochlorite, it shall be used at the rate of one part per 12,000 parts of water to be disinfected. The dosage should be sufficient to produce a chlorine taste in the water.

742.02 SPACE DEODORIZER. Space deodorizer shall consist of a commercial liquid concentrate that, when applied at the dilution ratio recommended by the manufacturer, will suppress the obnoxious odors produced by the material to which it is applied. The deodorizer shall be non-corrosive to the material to which it is applied. The deodorizer shall be nontoxic and nonirritating. It shall be approved by the Engineer before use.

SECTION 745 – WATER

745.01 WATER. All water used shall be clear and free of harmful amounts of oil, salt, acids, alkalis, sugar, organic matter, or other substances injurious to the finished product, plant life, or the establishment of vegetation.

Where the source of water is relatively shallow, the intake shall be maintained at such a depth and so enclosed as to exclude silt, mud, grass, and other foreign materials.

No formal tests of water will be made unless the Engineer questions the quality of the water. Water known to be of potable quality may be used without tests.

Mixing water for concrete or mortar shall meet the requirements of *ASTM C1602*.

SECTION 746 – CALCIUM CHLORIDE

746.01 CALCIUM CHLORIDE. Calcium chloride shall conform to the requirements of *AASHTO M 144*.

(a) Solid Calcium Chloride. Solid calcium chloride shall be Type S, Grade N1 or Grade N2 in accordance with *ASTM D98*.

(b) Liquid Calcium Chloride. Liquid calcium chloride shall be Type L, a true solution not reconstituted from flake calcium chloride, in accordance with *ASTM D98*, and meet the requirements of Table 746.01A.

TABLE 746.01A – LIQUID CALCIUM CHLORIDE REQUIREMENTS

Property	Value
Calcium chloride	35% ± 1%
Alkali chloride as NaCl	2% max.
Magnesium as MgCl	0.1%

746.02 CALCIUM CHLORIDE FOR FULL DEPTH RECLAMATION. Calcium chloride for full depth reclamation shall be in accordance with Subsection 746.01(b) and meet the requirements of Table 746.02A.

TABLE 746.02A – CONCENTRATION OF LIQUID CALCIUM CHLORIDE

Component	Concentration (lbs/gal.)
Calcium chloride	5.050
Sodium chloride	0.200
Magnesium chloride	0.004
Calcium sulfate	0.004
Water	6.002
Total	11.260

SECTION 750 – TRAFFIC SIGNS

750.01 SIGN POSTS.

(a) Steel Posts and Anchors. Steel posts and anchors shall conform to the following requirements:

(1) Structural steel tubing shall conform to the requirements of Subsection 714.11. Steel posts consisting of standard rolled steel structural shapes shall conform to the requirements of *AASHTO M 270,* Grade 250 (Grade 36). After fabrication, these posts shall be galvanized in accordance with *AASHTO M 111*.

(2) Steel posts consisting of flanged channels shall conform to the mechanical requirements of *ASTM A499,* Grade 60 and the chemical requirements of *ASTM A1,* 85 to 114 lbs/yard Rail Class. Steel posts shall conform to the details indicated on the Plans as to size, shape, weight, hole punching, hole drilling, and other details. After fabrication, these posts shall be galvanized in accordance with *AASHTO M 111*.

(3) Steel posts and anchors consisting of welded mechanical square tubes formed from hot-rolled carbon steel sheet shall conform to the mechanical and chemical requirements of *ASTM A1011,* Grade 380 (Grade 55) or Grade 245 (Grade 40). They shall conform to the details indicated on the Plans as to size, shape, weight, hole punching, hole drilling, strength, and other details.

The posts shall be fabricated in accordance with *ASTM A787,* Type 2, and shall be galvanized with a G140 Coating in accordance with *ASTM A653*. Alternatively, the posts shall be fabricated in accordance with *ASTM A787,* Type 3, and shall be galvanized in accordance with *AASHTO M 111*.

(b) Wood Posts. Wood posts shall be seasoned, straight, and sound sawn timber comprised of either oak, cedar, spruce, western fir, or other approved wood. The posts shall conform to the dimensions and grade shown on the Plans or requirements specified in the Contract.

All wood posts shall be pressure-treated with preservative as specified in Subsection 726.01. All cut ends or notches shall be field-treated in in accordance with *AWPA Standard M4*. Depending on size and location, wood posts may have to be drilled as shown on the Plans.

(c) Sleeves. Sleeves for sign posts consisting of structural tubing shall conform to the requirements of *ASTM A501*. They shall conform to the details shown on the Plans as to size, shape, and weight, and they shall be punched or drilled as shown on the Plans. After fabrication, all steel sleeves shall be galvanized in accordance with *AASHTO M 111*.

750.02 EXTRUDED ALUMINUM PANELS. Extruded aluminum panels shall conform to the requirements of *ASTM B221*. Alloy 6063-T6 shall be used when reflective sheeting is to be applied to the face of the sign.

750.03 FLAT SHEET ALUMINUM. Flat sheet aluminum shall conform to the requirements of *ASTM B209* for either Alloy 6061-T6 or Alloy 5052-H38. Aluminum components shall not be in direct contact with treated wood posts.

750.04 RETROREFLECTIVE SHEETING. Retroreflective sheeting is a material that redirects light back to the source of the light. Retroreflective sheeting shall be evaluated in accordance with the applicable AASHTO Product Evaluation & Audit Solutions work plan, be one of the products listed on the Agency's *Approved Products List*, conform to *AASHTO M 268*, and meet the following requirements:

(a) Type III. Retroreflective sheeting, Type III shall conform to *ASTM D4956*, Type III.

(b) Type IV. Retroreflective sheeting, Type IV shall conform to *ASTM D4956*, Type IV.

(c) Type V. Retroreflective sheeting, Type V shall conform to *ASTM D4956*, Type V.

(d) Type VI. Retroreflective sheeting, Type VI shall conform to *ASTM D4956*, Type VI.

(e) Type VII. Retroreflective sheeting, Type VII shall conform to *ASTM D4956*, Type VII.

(f) Type VIII. Retroreflective sheeting, Type VIII shall conform to *ASTM D4956*, Type VIII.

(g) Type IX. Retroreflective sheeting, Type IX shall conform to *ASTM D4956*, Type IX.

(h) Type X. Retroreflective sheeting, Type X shall conform to *ASTM D4956*, Type X.

(i) Type XI. Retroreflective sheeting, Type XI shall conform to *ASTM D4956*, Type XI.

750.05 ASSEMBLY HARDWARE. Unless otherwise shown on the Plans, the assembly hardware used to fasten and support traffic sign components shall conform to the designs and sizes used in standard commercial practices for the materials involved.

(a) Bolts, Nuts, and Washers. Bolts and washers shall be stainless steel conforming to the requirements of *ASTM F593*, Alloy Group 1, Condition AF, Alloy 304, and its supplementary requirements for S5. Nuts shall be stainless steel conforming to the requirements of *ASTM F594*, Alloy Group 1, Condition AF, Alloy 304, and its supplementary requirements for S5.

(b) Rivets. Rivets shall be aluminum conforming to the requirements of *ASTM B316*, Alloy 6053-T61.

(c) Clips. Clips used to fasten extruded aluminum panels to the supporting posts shall be aluminum conforming to the requirements of *ASTM B108*, Alloy 356-T6.

SECTION 751 – DELINEATORS

751.01 STEEL DELINEATORS.

(a) Steel Posts and Anchors. Steel posts, anchors, and sleeves shall be galvanized in accordance with the requirements of *AASHTO M 111* after fabrication, and shall conform to the following additional requirements:

(1) Steel posts fabricated as flanged channels shall conform to the mechanical requirements of *ASTM A499,* Grade 60 and the chemical requirements of *ASTM A1,* 85 lbs/yard to 114 lbs/yard Rail Class.

(2) Steel posts and anchors fabricated as welded mechanical square tubes formed from hot-rolled carbon steel sheet shall conform to the mechanical and chemical requirements of *ASTM A1011,* Grade 380 (Grade 55) or Grade 245 (Grade 40). The posts may be fabricated in accordance with the requirements of *ASTM A787,* Type 2, and galvanized with a G140 Coating in accordance with *ASTM A653.* Alternatively, the posts may be fabricated in accordance with the requirements of *ASTM A787,* Type 3.

(b) Sleeves. Sleeves for sign posts consisting of structural tubing shall conform to the requirements of *ASTM A501*.

(c) Assembly Hardware. Assembly hardware shall conform to the following requirements:

(1) Bolts and Nuts. Bolts and nuts shall be fabricated from aluminum conforming to the requirements of *ASTM B211,* Alloy 2024-T4. Both bolts and nuts shall be given another coating at least 0.2 mil in thickness with dichromate or boiling water seal.

(2) Washers. Washers shall be fabricated from aluminum conforming to the requirements of *ASTM B209,* Alloy 2024-T4.

751.02 FLEXIBLE DELINEATORS. Flexible delineators shall be surface mounted delineators in accordance with the *MUTCD* for tubular markers for use on high-speed highways or nighttime use. Flexible delineators shall be *MASH* compliant with self-certification from the manufacturer and be one of the products listed on the Agency's *Approved Products List*.

751.03 DETECTABLE WARNING SURFACE. Detectable warning surfaces shall be in accordance with *AASHTO M 333*. Detectable warning surfaces shall be cast iron, mechanically anchored, cast-in-place, and one of the products listed on the Agency's *Approved Products List.*

Detectable warning surfaces shall not be colored unless otherwise specified in the Contract. If coloring is specified it shall be applied by the manufacturer.

SECTION 752 – TRAFFIC SIGNALS

752.01 PEDESTAL POSTS AND BASES. Steel posts shall use cast iron bases and aluminum posts shall use cast aluminum bases.

(a) Pedestal Posts. Pedestal posts shall have no taper and shall be threaded at the lower end to fit the base.

(1) Steel Posts. Steel posts shall consist of 4-1/2 inch outside diameter galvanized steel pipe conforming to the dimensional requirements of *ASTM A501* or *ASTM A53*, Type S, Grade B standard weight. Galvanizing shall be in accordance with *AASHTO M 111*.

(2) Aluminum Posts. Aluminum posts shall consist of 4-1/2 inch outside diameter aluminum structural pipe conforming to the requirements of *ASTM B429*, Alloy 6063-T6.

(b) Bases.

(1) Cast Iron Bases. Cast iron bases shall conform to the requirements of *AASHTO M 105*, Class 20 or higher. Galvanized cast iron bases shall conform to the requirements of *ASTM A126*, Class A. Galvanizing shall be in accordance with *AASHTO M 111*.

(2) Cast Aluminum Bases. Cast aluminum bases shall conform to the requirements of *ASTM B26* or *ASTM B108*, Alloy SG70A-T6.

752.02 TRAFFIC SIGNAL ASSEMBLY.

(a) Steel Poles and Baseplates. Steel poles shall consist of tapered tubular shafts. Tapered tubular shafts for cantilevered overhead signal structures shall meet the applicable requirements of *ASTM A595*, Grade A; *ASTM A1011*, Grade 50; or *ASTM A572*. Tapered tubular shafts for non-cantilevered overhead signal structures shall meet the applicable requirements of *ASTM A500*, Grade B or *API 5L*, Grade X42.

Steel properties shall conform to the requirements of the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. After fabrication, the shafts shall have a minimum yield strength of 48 ksi. The metal thickness shall be not less than 0.25 inches. The steel poles shall be capable of withstanding the stringing tension of the span wire with its signal load without exceeding a deflection of 6 inches and a bending stress limit of 66% of the yield strength.

The tapered shafts shall be formed, welded, and longitudinally cold-rolled under sufficient pressure to flatten the weld and form a smooth, tapered tube.

A reinforced handhole at least 4 inches in width and 6 inches in height, complete with cover, shall be provided in the pole approximately 18 inches above the base and located at 90° to the span wire on the side away from approaching traffic. Stainless steel machine screws shall be provided for attaching the handhole cover.

A steel cap shall be provided for the top of each pole with provision for an overhead wire entrance when needed. Stainless steel machine screws shall be provided for securely fastening the cap to the top of the pole.

A 2 inch blind half-coupling shall be welded through the side of the pole 6 inches to 12 inches below the span wire attachment height. A grounding nut shall be located inside the pole easily accessible from the handhole.

The baseplate shall consist of a steel plate conforming to the requirements of *ASTM A36*. The baseplate shall be attached to the shaft by two continuous welds, one inside and one outside the base. The design shall be such that the welded connection shall develop the full strength of the adjacent shaft section. An eight-anchor bolt pattern shall be used, unless otherwise shown on the Plans.

After fabrication, the shaft and baseplates shall be galvanized in accordance with *AASHTO M 111* and shall have a flat black powder coat finish applied in accordance with Subsection 708.02 unless otherwise specified on the Plans.

(b) Cantilever Mast Arms. Material for the mast arms shall conform to the requirements of Subsection 752.02(a). Mast arms shall be fabricated as tapered tubes with a minimum metal thickness of 0.1793 inches (7-gauge). A flange plate shall be welded to the end for attaching to the vertical pole. A removable cap shall be securely attached to the end. Wire outlets with rubber grommets shall be provided for each indicated signal location.

752.03 TRAFFIC SIGNAL HEADS. Traffic signal heads shall be self-contained assemblies that are modular and adjustable. The signal heads may contain one or more signal faces as shown on the Plans.

Each traffic signal face shall consist of a specific number of signal sections rigidly fashioned together in such a manner as to be watertight and dustproof.

The components of the signal head shall be polycarbonate with a smooth outer surface and shall be capable of holding the optical units securely in place.

The housings, doors, visors, optical units (lenses, reflectors, lamp sockets, and lamps), wiring, trunnions, and brackets of the signal head shall conform to the performance specifications of the *Equipment and Material Standards of the Institute of Transportation Engineers* for vehicle traffic control signal heads as well as the following additional requirements:

(a) Housing. The housing of each section shall be a one-piece polycarbonate resin material with front, sides, top, and bottom integrally molded. Two sets of internal bosses shall be provided in each section for mounting terminal strip facilities. The terminal bosses shall have threaded inserts sonically welded into each boss. Signal housings shall be flat black unless otherwise specified in the Plans.

(b) Housing Door. The housing door of each signal section shall be of the same material and color as the housing.

(c) Optical System. The optical system shall be an LED with a polycarbonate lens (red, yellow, or green) having a nominal diameter of 12 inches unless otherwise specified on the Plans. The optical system shall include dimming capabilities and shall comply with the applicable ITE signal supplement or signal module.

The manufacturer's name, trademark, serial number, and other necessary identification shall be permanently marked on the back of the module.

(d) Wiring. Terminal blocks shall be located behind the red LED unless otherwise specified, and shall be a five-position, ten-terminal, barrier-type strip with the terminal designations clearly marked R-A-G-RC-AC. The terminal blocks shall be secured on both ends.

(e) Visors. Each signal door shall be equipped with a tunnel polycarbonate visor securely fastened at four points to the door. Visors shall be colored flat black unless otherwise specified on the Plans.

(f) Backplates. All backplates shall be louvered and be colored flat black with a 2 inch high-visibility yellow retroreflective tape border meeting the requirements of Subsection 750.04.

(g) Mounting Brackets. The traffic signal head mounting brackets shall be aluminum, enclose all wiring internally, be capable of 360° rotation, and be designed to facilitate the mounting of any size signal to any size mast arm or pole.

752.04 TRAFFIC SIGNAL CONTROLLERS AND CABINETS.

(a) General Requirements. The manufacturer or distributor shall have bench testing performed by an independent testing company which shall certify that such tests have been made and that the traffic signal controller functions properly. Copies of all test results and descriptions of all changes and repairs shall be submitted with the certification. A copy of the controller settings used for the test shall be included in the bench test results. These settings shall be retained in the controller through shipment and installation.

Traffic signal equipment design and performance shall meet or exceed all requirements of the NEMA standards for traffic control systems. Operation of the equipment shall be consistent with the *MUTCD*. The controller along with all auxiliary equipment shall be capable of producing the timing plans and coordination shown on the Plans.

(b) Controller. All traffic signal controllers shall meet the requirements of *NEMA TS 2*, Type 2, be actuated, solid-state, menu-driven, with keyboard entry, and be compliant with *ATC 5201 v06A*. They shall have a minimum of 16 phases with dual maximum capabilities, and an internal time-based coordinator capable of providing at least four cycle lengths with multiple programs per cycle. All controllers shall have all necessary hardware and software for ethernet communications. All controllers shall be connected vehicle compatible. All controllers shall have a minimum of two USB ports. Controllers shall have remote communications capability unless otherwise specified on the Plans.

Each installation shall include the following:

(1) Malfunction Management Unit. A 16 channel malfunction management unit (MMU) with stop-timing function, liquid crystal display, and sufficient recording storage capacity for at least nine events. The MMU and the controller shall be wired to ensure that the events logged by MMU and the controller indications at the time of failure can be uploaded directly to a computer. The MMU shall be flashing yellow arrow compatible and IP addressable.

(2) Switches and Relays. Sufficient load switches and flash transfer relays for all 16 phases.

(3) Load Switches. LED-display load switches on the input side and labeled on the cabinet wall.

(4) Remote Flasher. Remote flasher shall be included.

(c) Cabinet. The controller and all auxiliary equipment shall be enclosed within a pre-wired, rainproof P44 controller cabinet meeting the requirements of *ANSI/NEMA 250*, Type 3R. Unless otherwise specified on the Plans, the cabinet shall have a flat black finish and be mounted on a 15 inch base extension. The cabinet shall be sized to provide ample space for housing all equipment necessary to provide the timings shown on the Plans. Each cabinet shall have a weatherproof plastic envelope of sufficient size, at least 18 inches × 24 inches, to store wiring diagrams, program manuals, and other documents.

The cabinet shall have a main door within which a police door (auxiliary door) shall be placed. The police door shall house a compartment with switches for Flash-Automatic; Power, On-Off; and Signal, On-Off. A metal plaque listing ownership and emergency telephone numbers shall be attached to the outside of the cabinet. The design and configuration of the plaque shall be as shown on the Plans.

The cabinet shall include an external generator plug and transfer switch capable of running the signal system off a standard portable generator which can be connected to the cabinet without opening the cabinet doors. The transfer switch shall toggle the cabinet between AC line service and generator supplied power.

The cabinet shall contain two suitably designed vent fans and thermostat with a range of 120°F to 160°F. The thermostat shall be initially set to 120°F.

The controller cabinet shall contain a strong mounting table, sliding track, and a hinged, adjustable fixed or folding support of such construction that it will permit the controller or other equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting normal operation of the controller.

An LED lamp capable of illuminating all areas of the cabinet, two convenience outlets, ground fault interruption protection, and surge protection shall be provided. Six non-ground fault outlets for equipment power shall be provided on the left side of the cabinet to be fed from the load side of the main breaker.

A wiring panel shall be included in each cabinet mounted in such a way as to provide visibility and accessibility. The lowest row of terminals shall be at least 3 inches from the bottom of the cabinet.

The main door lock of the cabinet shall be a No. 2 tumbler-type lock as recommended by the manufacturer of the equipment. Two keys shall be furnished for the lock. A different style of lock that is appropriate for the application shall be provided for the police door.

(1) Spare Equipment. In addition to equipment furnished to provide a functional signal system, the Contractor shall supply the following spare parts in each cabinet:

a. One flasher unit (independent of the controller).

b. One transfer relay.

c. One flash drive, USB 2.0 or later, containing controller data.

d. One cabinet lamp LED.

e. One filter for the ventilation system.

f. One flash transfer relay.

g. One bus interface unit (BIU) in a protected container.

h. Six additional load switches.

(2) Relays. Relays shall not be used in connection with any automatic non-flashing red, yellow, or green indications without the approval of the Engineer. All relays shall be jack-mounted.

(3) Snap Switch. Each controller shall be equipped with a snap switch that will disconnect the timing mechanism and signal lights from all outside sources of electrical power.

(4) Lightning Arrester. Each controller shall be equipped with a suitable effective lightning arrester that filters lightning or high voltages to ground, protecting the internal components of the controller.

(5) Flasher. Each controller shall be equipped with a flashing mechanism capable of providing flashing operation at a rate of not less than 50 or more than 60 flashes per minute, part of which may be yellow and part red, or all red, as directed by the Engineer. The illuminated period of each flash shall not be less than 50% nor more than 67% of the total cycle.

Flashing mechanisms shall be in an encapsulated cube style configuration, shall be adequately housed and protected from the weather, and shall be of such design as to be accessible for inspection, cleaning, and adjustment without disconnecting any part. The flasher shall be capable of flashing two inductive or tungsten loads and shall operate within a line voltage range of 95 volts AC to 135 volts AC. The flashing operation shall begin automatically if the controller malfunctions and when called for by the timing plan. In addition, flashing shall be capable of being manually controlled by a switch in the police door. The controller itself need not be present to operate the signals in flashing mode.

752.05 AERIAL FLASHING BEACONS. The applicable portions of Subsection 752.04 shall apply in addition to the following specific functional requirements:

(a) Flasher. The controller shall be equipped with a flashing mechanism which meets the requirements of Subsection 752.04(c)(5).

(b) Cabinets. The complete flashing mechanism and related interference filters shall be enclosed within a rainproof, cast aluminum cabinet meeting the requirements of *ANSI/NEMA 250*, Type 3R. The cabinet shall be sized to provide ample space for housing the flashing mechanism, filters, and fuse panel.

The cabinet shall have a main door and lock. The lock shall be a No. 2 tumbler-type lock as recommended by the manufacturer of the equipment. Two keys shall be furnished for the lock.

The cabinet shall contain a suitably designed vent.

(c) Aerial Flashing Beacon Signal Heads. Flashing beacon signal heads shall be self-contained assemblies that are expandable, adjustable, and may contain one or more signal faces as shown on the Plans.

The housings, doors, visors, optical units (lenses, reflectors, lamp sockets, and lamps), wiring, trunnions, and brackets comprising the signal head shall conform to the requirements of the *Equipment and Material Standards of the Institute of Transportation Engineers* and the applicable portions of Subsection 752.03 unless otherwise specified.

752.06 ELECTRICAL CONDUIT. Electrical conduit shall conform to the following requirements:

(a) Rigid Polyvinyl Chloride (PVC) Electrical Conduit. Rigid PVC electrical conduit shall be schedule 80 and shall meet or exceed the requirements of *ASTM D1784.*

(b) High-Density Polyethylene (HDPE) Electrical Conduit. High-density polyethylene (HDPE) electrical conduit shall be schedule 80 and shall meet or exceed the requirements of *ASTM D3350.*

(c) PVC Coated Rigid Metal Conduit (RMC).

(1) Conduit. Conduit shall be galvanized steel RMC in accordance with *UL 6* and *ANSI C80.1*. RMC shall have an external 40 mil PVC coating and a 2 mil internal urethane coating in accordance with *NEMA RN 1*. The PVC coating shall be verified for adhesion performance in accordance with *ETL PVC-001*.

(2) Elbows, Nipples, and Couplings. Elbows, nipples, and couplings shall be galvanized steel RMC in accordance with *UL 6* and *ANSI C80.1*. Elbows, nipples, and couplings shall have an external 40 mil PVC coating and a 2 mil internal urethane coating in accordance with *NEMA RN 1*.

(3) Fittings. Fittings shall be in accordance with *UL 514B*.

752.07 TRAFFIC SIGNAL CONDUCTOR CABLE.

(a) Polyethylene-Insulated, Polyvinyl Chloride (PVC) Jacketed Signal Cable. Polyethylene-insulated, PVC-jacketed signal cable shall conform to the requirements of *IMSA 19-1*.

(b) Polyethylene-Insulated, Polyethylene-Jacketed Communication Cable. Polyethylene-insulated, polyethylene jacketed communication cable shall conform to the requirements of *IMSA 20-1*.

(c) Polyethylene-Insulated, Polyvinyl Chloride (PVC) Jacketed, Integral Messenger Signal Cable. Polyethylene-insulated, PVC jacketed signal cable with integral supporting span wire for aerial installation shall conform to the requirements of *IMSA 19-3*.

(d) Polyethylene-Insulated, Polyethylene-Jacketed, Integral Messenger Communication Cable. Polyethylene-insulated, polyethylene-jacketed communication cable with integral supporting span wire for aerial installation shall conform to the requirements of *IMSA 20-3*.

752.08 VEHICLE DETECTORS. Vehicle detectors used for actuating traffic signal controllers shall use radar presence detection or the method shown on the Plans.

The vehicle detectors shall have at least a 90° field of view and a detection range of 140 feet. The vehicle detectors shall be capable of detecting in real-time the presence of both stopped and moving vehicles and bicyclists. The vehicle detectors shall be remotely accessible to allow for traffic monitoring and sensor management.

The configurations and installation of the vehicle detectors shall be in accordance with the manufacturer's recommendations. The vehicle detectors shall be located at locations per the manufacturer's recommendations.

752.09 JUNCTION BOXES AND PULL BOXES.

(a) Junction Boxes

(1) Material. Junction boxes shall be constructed of precast monolithic polymer concrete.

(2) Cover Gasket. A sufficient cover gasket shall be provided to reduce the inflow of fluids.

(3) Junction Box Covers. Junction box covers shall be flush with the boxes and frames. All junction box covers shall be skid resistant.

Junction box covers shall have a logo punched, formed, or stamped into a flat rectangular area. The minimum letter height shall be 1/2 inch and the minimum depth shall be 1/16 inch. The logo on the covers shall read "TRAFFIC SIGNAL" unless otherwise noted on the plans.

(4) Interior Dimensions. Junction boxes shall be a minimum of 21-1/4 inches long, 11-3/4 inches tall, and 12 inches deep.

(5) Enclosure Integrity. Junction boxes shall meet the requirements of *ANSI/SCTE 77*, Tier 22 for underground enclosure integrity.

(b) Pull Boxes

(1) Material. Pull boxes shall be constructed of Concrete, Class B.

(2) Cover Gasket. A sufficient cover gasket shall be provided to reduce the inflow of fluids.

(3) Pull Box Covers. Pull box covers shall be flush with the boxes and frames. All pull box covers shall be skid resistant.

Pull box covers shall have a logo punched, formed, or stamped into a flat rectangular area. The minimum letter height shall be 1/2 inch and the minimum depth shall be 1/16 inch. The logo on the covers shall read "TRAFFIC SIGNAL" unless otherwise noted on the Plans.

(4) Interior Dimensions. Single pull boxes shall be a minimum of 16 inches long and 16 inches wide. Double pull boxes shall be a minimum of 16 inches long and 38 inches wide. The depth for both single and double pull boxes will depend on installation location and depth needed for conduit.

(5) Enclosure Integrity. Pull boxes shall meet the requirements of *ANSI/SCTE77*, Tier 22 for underground enclosure integrity.

752.10 ACCESSIBLE PEDESTRIAN SIGNALS. Accessible pedestrian signals (APS) shall be in accordance with the *MUTCD*.

(a) Pedestrian Pushbutton Assemblies. Pedestrian pushbutton assemblies shall meet all *Americans with Disabilities Act* requirements. The plunger head shall have a minimum diameter of 2 inches and the force required to operate the plunger shall not exceed 5 pounds. The pushbutton shall activate both the walk interval and the APS.

(1) Color. The color of the pushbutton shall contrast visually with the housing or mounting.

(2) Locator Tone. The pushbutton assembly shall include an integral locator tone. The locator tone shall have a duration of 0.15 seconds or less and shall repeat at 1 second intervals. The locator tone shall be 2 dB minimum and 5 dB maximum above ambient noise levels and shall be responsive to ambient noise levels.

(3) Tactile Features. The pushbutton assembly shall incorporate a raised arrow. The arrow shall be raised a minimum of 1/32 inch and shall have a minimum length of 1-1/2 inches. The arrow color shall contrast with the background. The pushbutton shall vibrate to indicate that the walk interval is in effect.

(4) Audible Features. The APS shall include an audible indication of the walk interval by either tone or voice and shall be audible from the near side of the associated crosswalk. If the tone for the walk interval is the same as the locator tone of the pushbutton, it shall have a faster repetition rate than the associated locator tone.

The audible features shall have automatic volume adjustment based on the ambient noise levels. Audible features shall be no more than 5 dB louder than ambient sound up to a maximum volume of 89 dB measured at 36 inches from the device. When voice messages are used, they shall include a clear message that the walk interval is in effect and shall indicate to which crossing it applies. Audible features may be integral to the pedestrian pushbutton assembly or produced through a separate speaker housing.

(b) Pedestrian Signal Heads. Pedestrian signal heads shall meet or exceed the requirements of *MIL-STD-810F, Method 506.4, Procedure I*.

(1) Controller Compatibility. Pedestrian signal heads shall be compatible with traffic signal controllers meeting the requirements of *NEMA TS 2*, Type 2.

(2) Signal Face Dimensions. The pedestrian signal head face shall be 17.7 inches wide and 16.0 inches tall.

752.11 GROUNDING ELECTRODES. Grounding electrodes shall include grounding rods and grounding conductors.

(a) Grounding Rods. Grounding rods shall be copper-clad steel rods with a diameter of 5/8 inch and a minimum total length of 8 feet, conforming to the requirements of *UL 467*.

(b) Grounding Braid. Grounding braid shall conform to the requirements of *UL 467*.

(c) Grounding Conductors. Grounding conductors shall be installed throughout the system back to the power source. The earth shall not be used as the sole equipment-grounding conductor. Grounding conductors shall be No. 6 AWG soft copper or stranded copper conductors.

752.12 PAN-TILT-ZOOM CAMERA. Pan-tilt-zoom cameras shall be suitable for outdoor use.

(a) Video Quality. Pan-tilt-zoom cameras shall provide a minimum video resolution of 1080p.

(b) Zoom Capability. Pan-tilt-zoom cameras shall be capable of a minimum of 40X optical zoom, 12X digital zoom, and a total of 480X zoom.

(c) Pan/Tilt Capability. Pan-tilt-zoom cameras shall be capable of 360° pan and a minimum of 220° tilt.

(d) Lens. Pan-tilt-zoom cameras shall have an autofocus, auto-iris lens.

(e) Memory. Pan-tilt-zoom cameras shall have a minimum of 1024 MB of RAM and 512 MB of flash memory.

752.13 EMERGENCY VEHICLE PREEMPTION SYSTEM. All components of the emergency vehicle preemption system shall be new equipment produced by the same manufacturer.

(a) Signal detection range. The emergency vehicle preemption system's receiver shall have a minimum detection range of 2,500 feet.

(b) Field of view. The emergency vehicle preemption system's receiver shall have a minimum field of view of 13°.

(c) Weather resistance. The emergency vehicle preemption system receiver's enclosure shall be suitable for all-weather use and have a weep hole allowing for moisture to escape.

752.14 POWER DROP STANCHION. Power drop stanchions shall comply with the *National Electrical Code*, the requirements of the utility company providing the power source, and the Standard Drawings.

SECTION 753 – HIGHWAY ILLUMINATION

753.01 LIGHT POLE FOUNDATIONS.

(a) Concrete. Concrete shall conform to the requirements of Section 541 for Concrete, Class B.

(b) Reinforcing Steel. Reinforcing steel for light pole bases shall conform to the requirements of Section 507 for Level I reinforcing steel.

(c) Electrical Conduit. Electrical conduit for light pole bases shall conform to the requirements of Subsection 752.06(a).

(d) Anchor Bolts. Anchor bolts for light pole bases shall be per the transformer base manufacturer's recommendation and conform to the requirements of Subsection 714.09.

(e) Grounding Electrodes. Grounding electrodes for light pole bases shall conform to the requirements of Subsection 752.11.

753.02 TRANSFORMER BASES.

(a) Transformer Bases. Transformer bases and transformer base doors shall consist of a one-piece aluminum casting conforming to the requirements of *ASTM B26* or *ASTM B108,* Alloy SG70A-T6, 356-T6. Galvanized bolts, nuts, washers, and other hardware shall be provided to attach the transformer base to the anchor base of the light pole. Galvanizing for bolts, nuts, washers, and other hardware shall conform to the requirements of Subsection 726.06.

(b) Mounting Hardware. Hardware for mounting the transformer base door to the transformer base shall be stainless steel.

753.03 LIGHT POLES.

(a) Anchor Bases. Anchor bases shall consist of a one-piece aluminum casting conforming to the requirements of *ASTM B26* or *ASTM B108,* Alloy SG70A-T6, 356-T6.

(b) Pole Shafts. Pole shafts shall be fabricated from tapered one-piece seamless aluminum tubes conforming to the requirements of *ASTM B221,* Alloy 6063-T6, Alloy 6061-T6, or Alloy 6005-T5. The minimum wall thickness shall be 0.125 inch for mounting heights of less than 20 feet and 0.188 inch for mounting heights of 20 feet or more.

(c) Pole Caps. Pole caps shall consist of a one-piece aluminum casting conforming to the requirements of *ASTM B26* or *ASTM B108,* Alloy SG70A-T6, 356-T6.

753.04 BRACKET ARMS.

(a) Bracket Arms, Aluminum. Single member bracket arms and the main member of truss-type arms shall be fabricated from seamless aluminum tube conforming to the requirements of *ASTM B221*, Alloy 6063-T6 or Alloy 6061-T6. Other members of truss-type arms shall conform to the requirements of *ASTM B221*, Alloy 6063-T6. All screws, nuts, bolts and other hardware for mounting bracket arms to the light pole shall be stainless steel, unless otherwise specified.

(b) Bracket Arms, Steel. Components of single member and truss-type bracket arms shall be fabricated from standard steel pipe meeting the requirements of *ASTM A53* or *ASTM A501*.

753.05 LUMINAIRES. All luminaires shall be 120 volt and shall be one of the products listed on the Agency's *Approved Products List*.

753.06 HIGHWAY ILLUMINATION CONDUCTOR CABLE. Highway illumination conductor cables shall be conductors of stranded, soft-drawn copper with a moisture and heat resistant thermoplastic insulation. Cables shall be rated for 600 volt service at 167°F for either dry or wet locations.

The single conductors shall conform to the requirements of the *National Electrical Code* for the intended wire use and existing field conditions. The wire size shall be such that no more than a 3% voltage drop will occur anywhere in the secondary circuit. All wiring shall be color-coded.

All conductors within the streetlight pole and bracket arm shall be No. 10 AWG stranded copper wire. Street lighting conductors within strain poles or mast arm poles shall also be No. 10 AWG stranded copper wire. UF cable will be allowed in the bottom of the pole below the handhole.

753.07 FINISH OF HIGHWAY ILLUMINATION COMPONENTS.

(a) Powder Coating. Powder coating shall be in accordance with Subsection 708.02 with a black finish.

(b) Anodized Aluminum. Anodized aluminum coatings shall be in accordance with *ASTM B137*, *ASTM B244*, *ASTM B580*, Type A or Type B, and *ASTM B680*.

SECTION 754 – PAVEMENT MARKING MATERIALS

754.01 OPTICS. Optics shall be beads or elements incorporated into pavement markings to produce reflectorized pavement markings. Optics shall be one of the products listed on the Agency's *Approved Products List* for the respective material specification and shall meet the following requirements:

(a) Optics, Type I. Type I optics shall be standard optics consisting of glass beads free from carbon residue. Type I optics shall conform to the requirements of *AASHTO M 247*, Type 1, except as modified below.

(1) Roundness. Roundness shall be a minimum of 80% true spheres, as determined in accordance with *ASTM D1155*.

(2) Moisture Resistance. Optics shall be moisture resistant in accordance with *AASHTO M 247*.

(3) Chemical Resistance. Optics shall be resistant to hydrochloric acid, water, calcium chloride, and sodium sulfide in accordance with *Federal Specification TT-B-1325, Section 4.3*.

(b) Optics, Type II. Type II optics shall be modified optics consisting of virgin glass beads or a mixture of virgin glass beads and direct melt glass beads, with a maximum of 50% direct melt glass beads. All glass beads shall be free from carbon residue. Type II optics shall conform to the requirements of *AASHTO M 247*, Type 2, Type 3, Type 4, or Type 5, except as modified below.

(1) Roundness. Roundness shall be a minimum of 80% true spheres, as determined in accordance with *ASTM D1155*.

(2) Refractive Index.

a. The refractive index shall be 1.5 to 1.7, inclusive, as determined in accordance with *AASHTO T 346*; or

b. The refractive index shall be above 1.7 with all beads above the No. 18 (1.00 mm) sieve having an average hardness of C70.5 as determined in accordance with the Rockwell C scale method, with a minimum sampling of 100 glass beads.

(3) Moisture Resistance. Optics shall be moisture resistant in accordance with *AASHTO M 247*.

(4) Chemical Resistance. Optics shall be resistant to hydrochloric acid, water, calcium chloride, and sodium sulfide in accordance with *Federal Specification TT-B-1325, Section 4.3*.

(c) Optics, Type III. Type III optics shall be wet reflective optics consisting of a composite material. Pavement markings containing Type III optics shall demonstrate retroreflective properties in accordance with Section 646, for the respective pavement marking material type.

754.02 PAVEMENT MARKING TAPE. Pavement marking tape is a white or yellow preformed retroreflective tape. Pavement marking tape shall be evaluated in accordance with the applicable AASHTO Product Evaluation & Audit Solutions pavement marking materials work plan, with a minimum of one year of data for permanent tape and a full data set for temporary tape, shall be listed on the Agency's *Approved Products List* for the respective material specification, and meet the following requirements:

(a) Pavement Marking Tape, Type A. Type A pavement marking tape shall be a high performance and extended service life pavement marking tape in accordance with *ASTM D4505*. The tape shall have continuous wetting properties and meet the following requirements:

(1) Skid Resistance. Skid resistance shall be Skid Resistance Level A in accordance with *ASTM D4505*.

(2) Adhesive. Adhesive shall be Class I, Class II, or Class III in accordance with *ASTM D4505*.

(3) Durability. Initial durability shall be 10 and three-year durability shall be a minimum of 7 as determined in accordance with *ASTM D913*.

(4) Retroreflectivity.

a. Dry. Initial dry retroreflectivity shall be Reflectivity Level I in accordance with *ASTM D4505*. Three-year retroreflectivity shall be a minimum of 150 mcd/m^2/lx for white and 100 mcd/m^2/lx for yellow as determined in accordance with *ASTM E1710*.

b. Wet. Initial wet retroreflectivity shall be a minimum of 250 mcd/m^2/lx for white and 200 mcd/m^2/lx for yellow. Three-year wetness retroreflectivity shall be a minimum of 150 mcd/m^2/lx for white and 75 mcd/m^2/lx for yellow as determined in accordance with *ASTM E2177*.

c. Wet Continuous. Wet continuous retroreflectivity shall be a minimum of 150 mcd/m^2/lx for white and 100 mcd/m^2/lx for yellow in accordance with *ASTM E2832*.

(b) Pavement Marking Tape, Type B. Type B pavement marking tape shall be a standard performance pavement marking tape in accordance with *ASTM D4505*.

(1) Skid Resistance. Skid resistance shall be Skid Resistance Level A in accordance with *ASTM D4505*.

(2) Adhesive. Adhesive shall be Class I, Class II, or Class III in accordance with *ASTM D4505*.

(3) Durability. Initial durability shall be 10 and three-year durability shall be a minimum of 7 as determined in accordance with *ASTM D913*.

(4) Retroreflectivity. Initial dry retroreflectivity shall be Level II in accordance with *ASTM D4505*.

(c) Pavement Marking Tape, Type C. Type C pavement marking tape shall be a temporary pavement marking tape in accordance with *ASTM D4592* and the following requirements:

(1) Retroreflectivity. Initial wet retroreflectivity shall be a minimum of 250 mcd/m^2/lx for white and 200 mcd/m^2/lx for yellow.

754.03 THIS SUBSECTION RESERVED.

754.04 THIS SUBSECTION RESERVED.

754.05 THIS SUBSECTION RESERVED.

754.06 COLORED SURFACE TREATMENT. Colored surface treatment shall be a skid resistant and pigmented system consisting of a methyl methacrylate (MMA) resin binder, catalyst, and aggregate. The treatment shall be one of the products listed on the Agency's *Approved Products List* and shall meet the following requirements:

(a) General Requirements.

(1) Retroreflectivity. The treatment shall be non-retroreflective.

(2) Color. The treatment shall be green in accordance with the FHWA *Interim Approval for Optional Use of Green Colored Pavement for Bike Lanes (IA-14)* and FHWA *Interpretation Letter 9(09)-86(I) – Chromaticity Requirements for Green-Colored Pavement*.

(3) Skid Resistance. The treatment shall have a minimum skid resistance of 60 BPN, as determined in accordance with *ASTM E303*.

(b) MMA Resin Binder. Binder shall meet the requirements of Table 754.06A.

TABLE 754.06A – MMA RESIN BINDER PROPERTIES

Property	Test Method	Test Requirement
Ultimate tensile strength	*ASTM D638*, Type IV	400 psi min.
Tensile elongation at break	*ASTM D638*, Type IV	20% min.
Durometer hardness – Shore Type D	*ASTM D2240*	50 min.
Tensile bond strength	*ASTM C1583* or *ASTM D4541*	250 psi min.

(c) Aggregate. Aggregate shall be clean, dry, and have a minimum hardness of 7.0 Mohs as determined in accordance with the Mohs hardness scale. Aggregate shall be from the same manufacturer and as recommended as the MMA resin binder manufacturer.

SECTION 755 – LANDSCAPING AND EPSC MATERIALS

755.01 LANDSCAPE BACKFILL. Landscape backfill shall consist of approximately 50% topsoil in accordance with Subsection 755.02, 25% compost in accordance with Subsection 755.05, and 25% native soil, all measured by volume. Landscape backfill shall be uniformly mixed prior to placement. Native soil conforming to Subsection 755.02 may be substituted for topsoil.

755.02 TOPSOIL. Topsoil shall be a screened, workable soil free of refuse, roots, stones (larger than 1 inch), brush, noxious weeds, and other debris detrimental to plant growth.

(a) Natural Topsoil. Natural topsoil shall conform to the requirements of *ASTM D5268.*

(b) Manufactured Topsoil. Manufactured topsoil shall conform to the requirements of *ASTM D5268*, except as modified below:

(1) pH. The pH shall be 5.5 to 8.5.

(2) Organic Matter. Organic matter content (including, but not limited to, short paper fiber and biosolids) shall be in accordance with *ASTM D5268*. Short paper fiber and biosolids shall meet the following requirements:

a. Short Paper Fiber. Short paper fiber shall be in accordance with the Vermont Agency of Natural Resources *Comprehensive Short Paper Fiber Management Procedure*.

b. Biosolids. Biosolids shall be Exceptional Quality biosolids in accordance with the Vermont Agency of Natural Resources *Solid Waste Management Rules, Subchapter 13*.

(3) Per- and Polyfluoroalkyl Substances (PFAS). The composite manufactured topsoil shall have maximum PFAS screening values as specified in Table 755.02A when tested in accordance with *EPA Method 1633*.

TABLE 755.02A – PFAS SOIL-TO-GROUNDWATER SCREENING VALUES

PFAS Analyte	Chemical Abstract Service (CAS) Number	Soil to Groundwater Screening Value (µg/kg)
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.84
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.38
Perfluorononanoic acid (PFNA)	375-95-1	0.44
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	3.40
Perfluorooctanic acid (PFOA)	335-67-1	1.60

755.03 SOD. Sod shall be live, fresh, and of suitable character for the soil in which it is placed. Sod shall be of a firm, even texture, show good root development, be free from noxious weeds, disease, and insect problems, and shall have a compact growth of vigorous, dark green grass.

Sod shall be machine-cut with a uniform soil thickness of 0.5 inches to 2 inches (not including shoot growth or thatch). The thickness of the soil, thatch, and canopy shall be at least 1.5 inches when compressed, with a thatch layer no greater than 0.5 inches.

The sod shall be approved by the Engineer prior to being cut and again before it is laid.

755.04 SEED. Seed shall be furnished in new, clean, sealed, and properly labeled containers, either separately or mixed, as appropriate, and shall conform to the seed formula shown on the Plans. Seed that has become wet, moldy, or otherwise damaged will not be accepted. Seed that is a year or more past its sell by date, or seed that has not been tested for more than one year, will not be accepted.

(a) Testing. The seed shall conform to all state and federal regulations.

(b) Labels. Labels shall conform to all state and federal regulations and shall be clearly marked with the following information:

(1) Seed name

(2) Seed species and percentage

(3) Lot number

(4) Germination percentage

(5) Purity percentage

(6) Weed seed content percentage

(7) Sell by date

(8) Origin

755.05 COMPOST. Compost shall be free of weed seeds, shall comply with U.S. Environmental Protection Agency requirements for compost, and shall meet the definition of compost in *10 V.S.A. § 6001(33)*.

The compost shall have a loose and granular texture with the characteristics and properties specified in Table 755.05A.

TABLE 755.05A – COMPOST MATERIAL REQUIREMENTS

Property	Requirement
Organic matter content	30% – 60%
Total Kjeldahl nitrogen content	0.5% – 2.0%
pH	6.5 – 7.5
Maximum particle size	1 inch
Maximum soluble salt content	5 mmhos/cm
Moisture content	35% – 55%

The compost shall possess no objectionable odors and shall not resemble the raw material from which it was derived.

At least 14 calendar days prior to delivery and use, the Contractor shall provide a compost analysis to the Engineer. The analysis shall be performed by a facility employing the *Test Method for the Examination of Composting and Compost*.

755.06 FERTILIZER. Fertilizer shall be a standard commercial grade dry fertilizer and shall conform to the requirements of all state and federal regulations and to the standards of AOAC International.

The fertilizer composition shall be as shown on the Plans. Of the available nitrogen, 50% shall be in a slow-release form, as is found in certain urea form products or natural organic forms, or a combination of both.

The fertilizer shall be furnished in new, clean, sealed, and properly labeled bags not weighing more than 100 pounds each. Caked or otherwise damaged fertilizer will not be accepted.

Labels shall be clearly marked with the following information:

(a) Manufacturer’s name

(b) Type

(c) Weight

(d) Guaranteed analysis

755.07 MYCORRHIZAL FUNGI PRODUCT. Mycorrhizal fungi product shall be of granular form and shall include mycorrhizae spores to enhance root growth, nutrient uptake, and reduce transplant shock.

Mycorrhizal fungi shall be one of the mycorrhizal fungi listed Agency’s *Approved Products List*.

755.08 AGRICULTURAL LIMESTONE. Agricultural limestone shall be a calcitic or dolomitic ground limestone containing not less than 85% of total (calcium or magnesium) carbonates. The limestone shall conform to the requirements of all state and federal regulations and to the standards of AOAC International.

(a) Packaging. The limestone shall be furnished in new, clean, sealed, and properly labeled bags not weighing more than 100 pounds each. Caked or otherwise damaged limestone will not be accepted.

Labels shall be clearly marked with the following information:

(1) Manufacturer's name

(2) Type

(3) Weight

(4) Guaranteed analysis

(b) Gradation. Agricultural limestone shall meet the gradation requirements of Table 755.08A, as determined in accordance with *AASHTO T 27*.

TABLE 755.08A – GRADATION OF AGRICULTURAL LIMESTONE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
No. 10 (2.00 mm)	100
No. 100 (0.150 mm)	40 – 100

755.09 LIQUID LIME. Liquid lime shall be a commercially formulated calcium carbonate lime mixture. Labels shall be clearly marked with the following information:

(a) Manufacturer's name

(b) Type

(c) Weight

(d) Guaranteed analysis

755.10 MULCH MATERIALS. Mulch materials shall conform to the following requirements:

(a) Hay Mulch. Hay mulch shall consist of mowed and properly cured grass or legumes, reasonably free from swamp grass, weeds, twigs, debris, invasive species, or other deleterious material, and free from rot or mold. It shall be in an air-dry condition suitable for placing with mulch blower equipment and shall be acceptable to the Engineer.

(b) Wood Chip Mulch. Wood chip mulch shall consist of hardwood chips having a nominal thickness of 1/8 inch to 1/4 inch and with 50% having an area of not less than 1 square inch or more than 6 square inches.

All wood chip mulch shall be reasonably free from materials that are injurious to plant growth.

(c) Bark Mulch. Mulch material used for landscape plantings shall consist of well composted shredded cedar, pine, or spruce bark, 1/8 inch to 1/4 inch nominal thickness, with 50% having an area of not less than 1 square inch or more than 6 square inches.

All bark mulch shall be reasonably free from leaves, twigs, shavings, insect pests, eggs, larvae, or other material that is injurious to plant growth.

(d) Fiber Mulch. Fiber mulch shall be produced from natural or recycled (pulp) fiber, such as wood chips or similar wood materials or from newsprint, chipboard, corrugated cardboard, or a combination of these processed materials. Fiber mulch shall be free of synthetic or plastic materials, weed seed, and growth or germination inhibiting substances and shall be nontoxic to plant or animal life.

Fiber mulch shall have a water-holding capacity by mass of not less than 900% and shall be of such character that the fiber will disperse into a uniform slurry when mixed with water. The water content of the fiber before mixing into slurry shall not exceed 12% (± 3%) of the dry mass of the fiber. The moisture content of the fiber shall be marked on the package.

Fiber mulch shall be colored to contrast with the area on which it is to be applied and shall not stain concrete or painted surfaces.

Fiber mulch shall be one of the fiber mulch products listed on the Agency's *Approved Products List*.

(e) Hydraulic Matrix. The hydraulic matrix shall consist of a mix of long strand, residual, wood fibers and a high-strength bonding agent. The matrix shall be 100% biodegradable over time, nontoxic to fish and wildlife, and it shall not contain any synthetic fibers. The hydraulic matrix shall be colored to contrast with the area on which it is to be applied, and shall not stain concrete or painted surfaces.

Hydraulic matrix shall be one of the hydraulic matrices listed on the Agency's *Approved Products List*.

(f) Tackifier. Tackifier for hay mulch shall be guar based organic tackifier, starch based-agricultural tackifier or another type of mulch binder as approved by the Engineer. Tackifier for stabilization of bare soils, without mulch or other fiber incorporated, shall use materials and quantities specified by the manufacturer based on the results of soils, water, and site assessment. Tackifiers shall be nontoxic to plant or animal life and non-staining to concrete or painted surfaces. Tackifiers shall be water soluble, linear, and non-cross-linked. Tackifiers shall be non-combustible and shall not change the soil pH.

Tackifier shall be one of the tackifier products listed on the Agency's *Approved Products List*.

(g) Straw Mulch. Straw mulch shall consist of threshed plant residue of oats, wheat, barley, rye, or rice from which the grain has been removed. The material shall be free of noxious weeds, undesirable grasses and plants, and rot or mold, and shall be approved by the Engineer prior to use.

755.11 ROLLED EROSION CONTROL PRODUCT.

(a) Rolled Erosion Control Product, Type I. Type I rolled erosion control product shall conform to one of the specifications and corresponding properties found in Table 755.11A. Type I rolled erosion control product shall be used in temporary applications where natural vegetation will provide permanent erosion protection. Type I rolled erosion control product may be either mulch control netting or erosion control blankets, which are defined as follows:

(1) Mulch control netting is a temporary biodegradable rolled erosion control product (RECP) composed of planar woven natural fiber.

(2) Erosion control blanket is a temporary all-natural biodegradable rolled erosion control product composed of processed fibers mechanically bound together to form a continuous matrix.

TABLE 755.11A – ROLLED EROSION CONTROL PRODUCT, TYPE I SPECIFICATIONS

Product Description	Material Composition	Longevity (months)	Slope Applications [1]		Channel Applications [1]	Min. Tensile Strength (lbs/ft) [7]
			Max. Gradient (V:H)	C Factor [2, 3]	Max. Shear Stress (lbs/ft^2) [4, 5, 6]	
Mulch control nets	All-natural biodegradable mesh or woven netting	3	1:5	≤ 0.10	0.25	5
		12	1:5	≤ 0.10	0.25	5
		24	1:5	≤ 0.10	0.25	25
Netless rolled erosion control blankets	All-natural biodegradable fibers mechanically interlocked together to form a continuous matrix	3	1:4	≤ 0.10	0.50	5
		12	1:4	≤ 0.10	0.50	5
Single-net erosion control blankets	All-natural processed, biodegradable fibers mechanically bound together by a single net of yarn or twine woven into a continuous matrix	3	1:3	≤ 0.15	1.5	50
		12	1:3	≤ 0.15	1.5	50
Double-net erosion control blankets	All-natural processed, biodegradable fibers mechanically bound together between two nets of yarn or twine woven into a continuous matrix	3	1:2	≤ 0.20	1.75	75
		12	1:2	≤ 0.20	1.75	75
		24	1:1.5	≤ 0.25	2.00	100
		36	1:1	≤ 0.25	2.25	125

[1] The C factor and shear stress for mulch control nettings shall be obtained with netting used in conjunction with pre-applied mulch material.

[2] The C factor is calculated as ratio of soil loss from RECP protected slope (tested at specified or greater gradient, V:H) to the ratio of soil loss from the unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions using *ECTC Test Method #*2.

[3] Acceptable large-scale test methods may include *ASTM D6459*, *ECTC Test Method #2*, or other independent testing deemed acceptable by the Engineer.

[4] Required minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (> 0.5 inch soil loss) during a 30-minute flow event in large-scale testing. These performance test values shall be supported by periodic bench scale testing under similar test conditions and failure criteria using *ECTC Test Method #3*.

[5] The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 to 0.05.

[6] Per the Engineer's discretion. The recommended acceptable large-scale testing protocol may include *ASTM D6460, ECTC Test Method #3* or other independent testing deemed acceptable by the Engineer.

[7] Minimum average roll values, machine direction using ECTC modified *ASTM D503*5.

(b) Rolled Erosion Control Product, Type II. Type II rolled erosion control product shall be a turf reinforcement mat (TRM) composed of ultraviolet stabilized, non-degradable, synthetic fibers, filaments, nettings, or wire mesh processed into three-dimensional reinforcement matrices conforming to one of the specifications and corresponding properties found in Table 755.11B. Type II rolled erosion control product shall be used in permanent applications where vegetation alone will not provide sufficient long-term erosion protection.

All categories of TRM shall have a minimum thickness of 0.25 inches and meet the requirements of *ASTM D6525*. TRMs shall also have an ultraviolet stability of 80% per the requirements of *ASTM D4355* for 500 hours of exposure. For TRMs containing degradable components, all property values shall be obtained on the nondegradable portion of the matting alone.

TABLE 755.11B – ROLLED EROSION CONTROL PRODUCT, TYPE II SPECIFICATIONS

Type	Product Description	Material Composition	Slope Applications	Channel Applications	Minimum Tensile Strength (lbs/ft) [3, 4]
			Max. Gradient (V:H)	Maximum Shear Stress (lbs/ft^2) [1, 2]	
A	TRM	Non-degradable synthetic fibers, filaments, nets, wire mesh or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness [5]	1:0.5	6.0	125
B	TRM		1:0.5	8.0	150
C	TRM		1:0.5	10.0	175

[1] Required minimum shear stress TRM (fully vegetated) can sustain without physical damage or excess erosion (> 0.5 inch soil loss) during a 30-minute flow event in large scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using *ECTC Test Method #3*.

[2] Acceptable large-scale testing protocol may include *ASTM D6460*, *ECTC Test Method #3*, or other independent testing deemed acceptable by the Engineer.

[3] Minimum average roll values, machine direction only for tensile strength determination using *ASTM D6818*

[4] Field conditions with high loading or high survivability requirements may warrant the use of a TRM with a tensile strength of 3,000 pounds per foot or greater.

[5] TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment, and provide long-term functionality by permanently reinforcing vegetation during and after maturation. TRMs are typically used in hydraulic applications, such as high-flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.

755.12 PLANT MATERIALS. Plant materials shall conform to the following requirements:

(a) Quality of Plant Material. All plants shall be first-class representatives of their normal species or varieties, unless otherwise specified.

All plant materials shall be nursery grown stock that have been transplanted or root-trimmed two or more times, according to the kind and size of plants. They shall have average or normal, well-developed branches, together with vigorous root systems.

The plant supplier shall certify that all plant materials were grown in a hardiness zone that is the same or colder than the project site's hardiness zone as established by the *USDA Plant Hardiness Zone Map*. The certification shall be identified in such a manner as to be directly traceable to the individual shipment. Plants that are not certified to have been grown under the designated hardiness zone conditions will not be accepted.

(b) Plant Names. All scientific and common plant names of the items specified shall be names accepted by the *Integrated Taxonomic Information System*. All plant materials delivered shall be true to name and legibly tagged with the names and sizes of materials.

(c) Grading Standards. Grading of plant materials shall be accomplished according to the requirements of *ANSI Z60.1*. All plant measurements shall be made in conformance with the standard measurement methods in *ANSI Z60.1*.

Unless designated as multi-stemmed, the trunk of each tree shall be a single trunk growing from a single unmutilated crown of roots. The tree trunks shall be free from sunscald, frost cracks, or wounds resulting from abrasions, fire, or other causes. No pruning wounds having a diameter exceeding 2 inches shall be present and all allowable pruning wounds must show vigorous bark on all edges.

Trees shall not be pruned prior to delivery. No trees with double-leaders or twin-heads shall be acceptable without the written approval of the Engineer. The Contractor shall reject such plants at time of delivery by the supplier unless such plants were previously selected by the Engineer as marked by tags and seals.

The height and spread of each shrub shall correspond to the specifications for Type 0 through Type 3 as referenced in *ANSI Z60.1*. Single stemmed or thin plants will not be accepted. The side branches shall be generous, well-twigged, and the plant as a whole well-branched to the ground. The plants shall be in a moist vigorous condition, free from dead wood, bruises, or other root or branch injuries. Plants shall not be pruned prior to delivery.

Vines, perennials, and ground cover plants shall be of the size, age, and condition listed on the Plans. Plants shall be healthy and free of insects and diseases. Ground cover plants shall be potted or in soil.

Container grown stock shall have been grown in a container long enough for the root system to have developed sufficiently to hold its soil together, firm and whole. No plants shall be loose in the container. No plants shall be root-bound in the container. Such plants shall be rejected.

Plants delivered by truck and plants requiring storage on-site shall be properly wrapped and covered to prevent wind-drying and desiccation of branches, leaves, or buds. Plant balls shall be firmly bound, unbroken, and reasonably moist to indicate watering prior to delivery and during storage. Tree trunks shall be free from fresh scars and damage in handling. No plant material from cold storage will be accepted.

Evergreens shall be quality evergreens with a well-balanced form complying with the relationship requirements of *ANSI Z60.1*.

(d) Nursery Inspection and Plant Quarantine. All plant materials shall be free from plant diseases and insect pests. All shipments of plants shall comply with all nursery inspection and plant quarantine regulations of the state of origin and the state of Vermont, as well as with federal regulations governing interstate movement of nursery stock. A certificate of inspection shall accompany each package, box, bale, or carload of plant materials delivered and shall be provided to the Engineer upon request.

(e) Balled and Burlapped Plants. Balled and burlapped (B&B) plants shall be dug to retain as many fibrous roots as possible and shall come from soil which will form a firm ball. The soil in the ball shall be the original and undisturbed soil in which the plant has been grown. The plant shall be dug, wrapped, transported, and handled in such manner that the soil in the ball will not be so loosened that it would cause stripping of small and fine feeding roots, or cause the soil to drop away from such roots.

All plants shall be moved with the root systems as solid units with balls of earth firmly wrapped with untreated burlap, Class 2, 8 ounces per square yard, firmly held in place by a stout cord or wire. The diameter and depth of the balls of earth shall be sufficient to encompass the fibrous and root feeding system necessary for the healthy development of the plant and in accordance with *ANSI Z60.1*.

No plant shall be accepted when the ball of earth surrounding its roots has been badly cracked or broken preparatory to the process of planting or after the burlap, staves, ropes, or platform required in connection with its transplanting have been removed. The plants and balls shall remain intact during all operations. All plants that cannot be planted at once shall be heeled in by setting in the ground and covering the balls with soil and then watering them.

755.13 TREE WATERING BAGS. Tree watering bags are available in varying sizes and can be used together to accommodate tree trunk diameters. These waterproof bags are made of reinforced, ultraviolet treated polyethylene, reinforced with nylon webbing and are secured to the tree using heavy duty zippers located on each side of the bag. The adjustable drip holes at the base allow for water to flow at varying rates for specific needs.

Tree watering bags shall be one of the tree watering bags listed on the Agency's *Approved Products List*.

755.14 EROSION LOGS. Erosion logs are available in varying diameters. The Contractor shall follow the manufacturer's recommendations for the material type and size based on the intended use.

Erosion logs shall be composed of weed-seed-free coir, straw, excelsior, compost, or other biodegradable filtering medium encased in a biodegradable netting or mesh.

Netting shall have openings of 1/2 inch to 1 inch, except for compost filled logs, which shall have openings of 1/8 inch to 3/8 inch or as recommended by the manufacturer and accepted by the Engineer.

Anchors for erosion logs shall be wooden stakes, U-shaped wire or earth anchors, or rebar stakes. The size and length of the anchors shall be as recommended by the manufacturer.

Compost shall meet the requirements of Table 755.05A, with the exception that 99% of the particle size shall be 2 inches or less and a maximum of 30% shall be less than 3/8 inch.

SECTION 760 – SLOPE STABILIZATION MATERIALS

760.01 SLOPE STABILIZATION NAILS. Solid bars, bearing plates, and nuts shall be galvanized in accordance with *ASTM A767*.

(a) Bars. Bars shall be of the grade, size, and length specified in the Contract.

(1) Solid. Solid bars shall be all thread bars in accordance with *ASTM A615*.

(2) Hollow. Hollow bars shall be all thread bars in accordance with *ASTM A29*.

(b) Bearing Plates. Bearing plates shall be steel plates in accordance with *ASTM A36*. Bearing plates shall be of the size and design in the Contract.

(c) Nuts. Nuts shall be in hexagonal steel nuts in accordance with *ASTM A563*, Grade B.

760.02 SHOTCRETE. Shotcrete shall be a concrete mix with a maximum chloride ion content of 0.10%, in each component, as determined in accordance with *AASHTO T 260*. Shotcrete shall have an air content of 5.5% to 8.5% prior to application, as determined in accordance with *AASHTO T 152*. Shotcrete shall have an absorption of less than 8% as determined in accordance with *ASTM C642*. Shotcrete shall have a minimum 3-day compressive strength of 2,000 psi and minimum 28-day compressive strength of 4,000 psi as determined in accordance with *AASHTO T 106* and shall be one of the following:

(a) Dry Mix Shotcrete. Dry mix shotcrete shall be a prepackaged dry concrete mix where water is added to the mix at the nozzle.

(1) Air Entrainment. Dry mix shotcrete shall have a minimum plastic air content of 2.5% as determined in accordance with *AASHTO T 152*, using rodding as the consolidation method.

(b) Wet Mix Shotcrete. Wet mix shotcrete shall be a bulk-produced concrete mix where all components are mixed, including water, before introduction to the delivery hose. Wet mix shotcrete shall be batched in accordance with *AASHTO M 157* or *ASTM C94*. Wet mix shotcrete shall meet the following requirements:

(1) Portland Cement. Portland cement shall meet the requirements of Subsection 701.02. The cement content shall be 600 pounds per cubic yard or greater. The water/cement ratio shall not exceed 0.45.

(2) Aggregates. Aggregate shall meet the requirements of Subsection 704.15.

(3) Water. Water shall meet the requirements of Subsection 745.01.

(4) Admixtures. Chemical admixtures shall meet the requirements of Subsection 725.02 for the respective type of chemical admixture used. Mineral admixtures shall meet the requirements of Subsection 725.03 for the respective type of mineral admixture used.

(5) Air Entrainment. Wet mix shotcrete shall have a minimum plastic air content of 6% as determined in accordance with *AASHTO T 152*, as sampled from the discharge of the mixing equipment.

When shotcrete is required to be reinforced, reinforcement shall be in accordance with Subsection 713.05. Reinforced shotcrete shall have a minimum 7-day flexural strength of 650 psi and a minimum 28-day flexural strength of 900 psi.

When coloring is specified in the Contract, colored admixture for integrally colored concrete conforming to *ASTM C979*, *ASTM C494*, and *AASHTO M 194* shall be used. Colored admixture shall consist of a colored, water-reducing admixture containing no calcium chloride, with coloring agents that are lime-proof and ultraviolet light-resistant. Colored admixture shall be in powdered form.

760.03 SLOPE DRAINAGE.

(a) Strip Drain. Strip drains shall consist of a drainage core encapsulated in a geotextile. Strip drains shall have a minimum flow rate of 4.8 gallons per minute per foot of width as determined in accordance with *ASTM D4716* with a 10 psi applied load, 1.0 gradient, and a 100-hour seating period.

(1) Drainage Core. The drainage core shall consist of long chain synthetic polymers composed of a minimum of 85%, by mass, polypropylenes, polyester, polyamine, polyvinyl chloride, polyolefin, or polystyrene. Drainage cores shall have a minimum compressive strength of 40 psi as determined in accordance with *ASTM D1621, Procedure A*.

(b) Sheet Drain. Sheet drains shall be prefabricated drains consisting of geotextiles attached to one side of a drainage core. Sheet drains shall have a maximum flow rate of 21 gallons per minute per foot of width as determined in accordance with *ASTM D4716* with a 25 psi applied load and a 1.0 gradient.

(1) Drainage Core. Drainage cores shall consist of a 3-dimensional polystyrene core formed with dimples.

(2) Geotextile. Geotextile shall be a nonwoven geotextile.

(c) PVC Drain. PVC drains shall be PVC pipes in accordance with *ASTM D1785*. PVC drains shall be a minimum of 1.5 inches in diameter and a minimum of schedule 80. PVC pipe shall have two rows of uniformly spaced slots or three rows of uniformly spaced perforations.

760.04 WIRE MESH FACING. Wire mesh facing shall be a diamond pattern high-tensile steel wire mesh made from high strength wire of the diameter specified on the Plans with a minimum tensile strength of 256,000 psi. Wire mesh facing shall be provided with corrosion protection as specified by the manufacturer. Fasteners, spike plates, boundary ropes, and component materials such as wire rope clips, clamps, or any other connectors needed for the design shall be hot dipped galvanized for corrosion protection in accordance with *ASTM A767* and meeting the system manufacturer's specifications.

760.05 PRECAST CONCRETE RETAINING WALL SYSTEMS. Precast concrete retaining wall systems shall include gravity, semi-gravity, and prefabricated modular walls. Precast concrete retaining wall systems shall be one of the systems on the Agency's *Approved Products List* as approved by the Geotechnical Engineering Manager.

760.06 MECHANICALLY STABILIZED EARTH (MSE) WALL SYSTEMS. Mechanically stabilized earth retaining wall systems shall be systems using soil reinforcements mechanically connected to concrete facing panels. MSE wall systems shall be one of the systems on the Agency's *Approved Products List* as approved by the Geotechnical Engineering Manager and shall meet the following requirements:

(a) Reinforcing Mesh Elements. Reinforcing mesh elements shall be shop fabricated from cold drawn steel rod conforming to the requirements of *ASTM A1064*, Grade 65 minimum, and shall be welded at the junctions between longitudinal and transverse wires in accordance with *AASHTO M 336*. Galvanizing shall be applied after mesh fabrication and shall conform to the minimum requirements of *AASHTO M 111*. The galvanizing thickness shall be determined and specified based on the design life requirements of the structure.

(b) Loop Embeds. Loop embeds shall be fabricated from cold drawn steel rod conforming to *ASTM A1064*. Loop embeds shall be welded in accordance with *AASHTO M 336* and galvanized in accordance with *AASHTO M 111*.

(c) Reinforcing Strips. Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. At a minimum, their physical and mechanical properties shall conform to *ASTM A572*, Grade 65. Galvanizing shall conform to the minimum requirements of *AASHTO M 111* with a minimum application rate of 0.125 pounds per square foot. The actual galvanizing thickness shall be determined and specified based on the design life requirements of the structure.

(d) Tie Strips. Tie strips shall be shop fabricated from hot rolled steel conforming to the minimum requirements of *ASTM A570*, Grade 50 (*ASTM A1101*, Grade 50 minimum) or equivalent. Galvanizing shall conform to *AASHTO M 111*. The minimum galvanizing application rate shall be 0.125 pounds per square foot.

(e) Fasteners. Fasteners shall consist of galvanized hexagonal cap screw bolts and nuts conforming to the requirements of *ASTM F3125*, *ASTM A449*, or equivalent. Fasteners shall be galvanized in accordance with *AASHTO M 232* with a minimum application rate of 0.125 pounds per square foot and achieve 3.4 mils of galvanization on all surfaces of the fasteners.

(f) Bearing Pads. Bearing pads shall be preformed ethylene propylene diene monomer rubber pads conforming to *ASTM D2000*, Grade 2, Type A, Class A with a durometer hardness of 60 (± 5).

760.07 GEOMEMBRANE LINER. Geomembrane liner shall be an impervious liner consisting of virgin PVC resins, plasticizer, and stabilizers that prevents or minimizes the infiltration of water and deicing salts into the substrate below the liner. Geomembrane liners shall have a minimum thickness of 0.03 inches and shall meet the requirements of Table 760.07A.

Individual widths of geomembrane liners shall be fabricated into larger sections by dielectric seaming into a single piece, or into a minimum number of panels, as required to fit the application, unless otherwise specified in the Contract. Lap joints with a minimum joint width of 0.75 inches shall be used.

TABLE 760.07A – PHYSICAL REQUIREMENTS FOR GEOMEMBRANE

Property	Test Method	Requirement
Thickness	*ASTM D1593*	0.03 in. ± 5%
Specific gravity	*ASTM D792*	1.23 min.
Tensile strength (breaking factor)	*ASTM D882*	2,300 psi min. (835.3 lbs/ft width min.)
Elongation at break	*ASTM D882*	350% min.
Modulus at 100% elongation	*ASTM D882*	1,000 psi min. (363.2 lbs/ft width min.)
Tear resistance	*ASTM D1004*	3630.28 lbs/ft min. (9.07 lbs min.)
Low temperature brittle failure point	*ASTM D1790*	-28°C max.
Dimensional stability (100°C, 15 min.)	*ASTM D1204*	3.5% change max.
Water extraction loss change	*ASTM D3083*	0.35% max.
Volatility loss	*ASTM D1203*	0.70% max.
Resistance to soil burial loss	*ASTM D3083*	-5% max.
Tensile strength change, elongation at break, modulus at 100% elongation	*ASTM D3083*	20% max.
Hydrostatic resistance	*ASTM D751*	85 psi min.
Bonded seam strength (factory seam, breaking factor) [1]	*ASTM D3082 (Modified)*	668 lbs/ft width
Puncture resistance	*ASTM D4833*	32 lbs min.

[1] Factory bonded seam strength is the responsibility of the fabricator.

SECTION 780 – REPAIR MATERIALS

780.01 CONCRETE REPAIR MATERIALS. Concrete repair material shall be a prepackaged material and shall be one of the products listed on the Agency's *Approved Products List*.

(a) Concrete Repair Material, Type I. Type I concrete repair material shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions work plan for *Evaluation of Rapid Set Concrete Patching Materials for Portland Cement Concrete*, be a neat (having less than 5% aggregate retained on the 3/8 inch (9.50 mm) sieve) overhead and vertical repair material, and meet the following requirements:

(1) Compressive Strength. The neat material shall have a minimum 7-day compressive strength of 2,000 psi and a minimum 28-day compressive strength of 4,000 psi as determined in accordance with *AASHTO T 106*.

(2) Bond Strength by Direct Tension. The material shall have a minimum bond strength of 150 psi as determined in accordance with *ASTM C1583* at 28 days, or sooner.

(3) Freeze-Thaw Durability. The material shall have a minimum durability factor of 80, after 300 cycles, as determined in accordance with *AASHTO T 161, Procedure A.*

(4) Length Change. The material shall meet the performance requirements of *ASTM C928* as determined in accordance with *AASHTO T 160*.

(5) Chloride Ion Penetration. The material shall exhibit a chloride ion penetrability of Low, or less, as determined in accordance with *AASHTO T 277* or *AASHTO T 358* at 28 days, or sooner.

(b) Concrete Repair Material, Type II. Type II concrete repair material shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions work plan for *Evaluation of Rapid Set Concrete Patching Materials for Portland Cement Concrete*, be a horizontal rapid setting repair material, and meet the requirements of Subsection 780.01(a) except as modified below.

(1) Compressive Strength. The neat material shall have a minimum 3-hour compressive strength of 1,200 psi and a minimum 7-day compressive strength of 5,000 psi as determined in accordance with *AASHTO T 106*.

(c) Concrete Repair Material, Type III. Type III concrete repair material shall be evaluated in accordance with the AASHTO Product Evaluation & Audit Solutions work plan for *Evaluation of Rapid Set Concrete Patching Materials for Portland Cement Concrete*, be a horizontal rapid setting repair material, and meet the requirements of Subsection 780.01(a) except as modified below.

(1) Compressive Strength. The neat material shall have a minimum 3-hour compressive strength of 1,200 psi, a minimum 1-day compressive strength of 2,900 psi, and a minimum 7-day compressive strength of 5,000 psi as determined in accordance with *AASHTO T 22*.

(2) Aggregate. The material shall contain greater than 5% coarse aggregate (aggregate contained on the 3/8 inch (9.50 mm) sieve). Coarse aggregate may be contained in the prepackaged material (extended), or material of the type and quantity specified by the manufacturer may be added to the prepackaged material (extendable).

(d) Concrete Repair Material, Type IV. Type IV concrete repair material shall be an overhead, vertical, or horizontal polymer repair material meeting the following requirements:

(1) Compressive Strength. The neat material shall have a minimum 3-hour compressive strength of 1,200 psi and a minimum 7-day compressive strength of 5,000 psi as determined in accordance with *ASTM C579*.

(2) Bond Strength by Direct Tension. The material shall have a minimum bond strength of 150 psi as determined in accordance with *ASTM C1583* at 28 days, or sooner.

(3) Linear Shrinkage. The material shall have a maximum linear shrinkage of 0.15% as determined in accordance with *ASTM C531*.

(4) Chloride Ion Penetration. The material shall exhibit a chloride ion penetrability of Low, or less, as determined in accordance with *AASHTO T 277* at 28 days, or sooner.

SECTION 781 – RAILROAD CROSSING MATERIALS

781.01 PRECAST CONCRETE GRADE CROSSING SYSTEMS. Precast concrete grade crossing systems shall consist of concrete, bar reinforcement, steel angle, rubber rail seal, fasteners, hardware, and all other components required for the system. Systems shall be one of the systems listed on the Agency's *Approved Products List*.

781.02 RUBBER RAIL SEAL. Rubber rail seal shall be a single high quality, homogenous elastomeric compound that is ultraviolet, ozone, weathering, and chemical resistant. The compound shall not permanently deform under loading and shall be free of porosity, defects, and dimensional irregularities.

Seals shall be designed for the use between the field and gage sides of the rail and the adjacent pavement. The seal shall provide vibration dampening and protection from thermal expansion and contraction and shall allow for normal rail deflection without transferring force to the roadway pavement. Seals shall be in accordance with the *Americans with Disabilities Act*.

781.03 AUTOMATIC HIGHWAY CROSSING WARNING SYSTEM (AHCWS).

(a) Crossing Lamp Controller Units.

(1) General Requirements. Crossing lamp controller units shall be a solid-state interface between the train detection unit and the flasher crossing warning lamps.

(2) Hardware Design. Crossing lamp controllers shall be designed for mounting in a B1 type relay base and installed in the relay rack.

(3) Operation.

a. Lamp driver circuits shall be capable of sinking up to 20 amps continuously from the flasher crossing warning lamps. Alternate flashing lamp and bell outputs shall energize no more than 1.0 second after control inputs are de-energized.

b. The alternate lamp flashing rate shall be 55 pulses per minute (± 20%).

c. Where gate control is not provided, flashing lamp and bell outputs shall de-energize no more than 1.0 seconds after the control unit is energized.

d. Flashing and steady lamp voltages shall remain within 2% of preset levels under normal conditions.

e. Means shall be provided to manually energize either side of the flashing lamp circuit continuously, with the other side off, for lamp voltage adjustment under actual operating conditions. If provided, de-energizing control input (on approach of a train) shall flash one or both sets of lamps to provide warning indication and override manual control.

f. Means shall be provided to synchronize multiple units for use at locations requiring additional lights exceeding the 20-amp limit.

(4) Control Inputs. Control inputs shall require 12.0 volts DC into a load resistance of 500 ohms to maintain warning device drive in a clear condition. Control input resistance shall be 250 ohms to 1,000 ohms. Control input voltage of less than 3.0 volts DC shall result in activation of the crossing warning devices. Multiple vital and gated control inputs shall be provided integrally or as an accessory.

(5) System Outputs. The system shall provide the following outputs to drive the crossing warning devices:

a. Three-wire alternately flashing lamp drives that shall provide a minimum of 12.0 volts DC to operate the nominal 10-volt DC signal lamps with a load rating as specified by the manufacturer.

b. Steady energy lamp drives from two wires of the three-wire flashing lamp circuit, which shall provide a minimum of 12.0 volts DC to operate the nominal 10-volt DC gate arm tip lamps with load rating specified by the manufacturer.

c. Warning bell drives shall provide 3.0 amps at a minimum 11.0 volts DC to operate mechanical type crossing warning bells, and a minimum of 0.25 amps at a minimum of 11.0 volts DC to operate electronic type bells.

(6) Fallback Mode. In the event of a failure that would impair the system from operating properly, the highway crossing warning device, in response to control input signals, shall have a fallback mode that shall assure the following minimum operating capabilities when the control input signal is de-energized:

a. Flashing lamp power is applied at 12.0 volts DC to at least one of each lamp pair, with either flashing or steady energy.

b. Bell control output is energized at 11.0 volts DC.

c. Operation meets the operating criteria specified for the primary controller operating system.

(b) Motion Sensor Track Circuits. The motion sensor system shall be microprocessor-based and shall meet the following minimum requirements:

(1) The design and equipment furnished shall be modular in design, utilizing plug-in type modules, and compatible with the types of track circuits currently used for control of adjacent or overlapping crossing warning systems within the limits of this Contract.

No motion sensor system frequencies shall be selected that will preclude the use of former GE Transportation (now Alstom Signaling) Electrocode or Alstom Signaling Genrakode track circuits, or future 91-2/3 Hz to 100 Hz cab signaling, unless otherwise approved by the Engineer.

(2) The motion sensor system for the automatic highway crossing warning location shall be furnished and installed as a complete redundant solid-state system. Redundancy shall be achieved by adding backup modules to the system.

Motion sensor system equipment shall have a high degree of immunity to adjacent high tension AC power lines or AC or DC propulsion systems and its operation shall not be affected by electromagnetic or inductive interference from such sources.

Equipment layout design shall be such as to mitigate interference from other equipment or apparatus installed within the same instrument housing.

(3) The motion sensor system ethernet processor shall allow the user to access, download, set up and diagnose the system with a standard web browser. This shall be done locally or through a standard IP network.

The motion sensor system shall be provided with two ethernet connections that can operate at 10 Mbps or 100 Mbps. These interfaces shall auto-negotiate with the connected network device for speed selection and auto-detect whether the connecting cable is a cross-over cable or is a straight connection.

Motion sensor system equipment shall have provisions for expansion to wireless crossing control and prediction capabilities.

(4) The motion sensor system shall be programmable for all frequencies from 86 Hz to 979 Hz.

(5) The motion sensor system shall activate the AHCWS devices without a delay exceeding 500 milliseconds with a train occupying any portion of the island circuit. The island circuit shall be defined by the distance between transmit and receive track connections to the rails. The island circuit shall be an independent AC circuit with a method of randomized modulation using frequencies of 4.0 kHz, 4.4 kHz, 4.9 kHz, 5.4 kHz, 5.9 kHz, 6.4 kHz, 7.1 kHz, 7.7 kHz, or 8.0 kHz.

Internal circuit logic shall be so designed that a momentary shunt applied to the island circuit while the approach is occupied shall not allow the crossing warning system to cease operation (clear).

(6) The motion sensor system shall have continuous cycling of internal solid-state self-check circuitry.

(7) The motion sensor system voltage requirement shall be 12.0 volts DC nominal with a range of 9.5 volts DC to 16.5 volts DC and shall be provided with complete internal and external surge suppression equipment for rail and battery connections for single-track usage.

Each output driver shall be capable of energizing a 12-volt DC relay with a resistance of 500 ohms.

(8) The motion sensor system shall provide the ability to synchronize approach track circuits in a master/slave configuration. Turning off a slave unit shall not affect the operation of the master or other slave units.

(9) The system shall select redundant operation, frequency, and system configuration through the local display unit or web graphic user interface that is accessible via a laptop computer which shall display all necessary microprocessor statuses and allow for configuration.

(10) A method for securing set-up parameters and verifying local presence of maintenance personnel shall be provided. Verification shall take place before an application program is selected or vital safety adjustments to the setup parameters can be made.

(11) Motion sensor systems shall be provided with a method of false shunt detection to detect a sudden shunt in the approach without the presence of a train.

(12) Track ballast conditions, defective track bonds, or defective bypass shunts shall not cause unsafe warning time for the AHCWS equipment.

(13) The apparatus shall be equipped with LED status and fault memory lights that will be illuminated to indicate the current status of related circuits. These shall include the status of the system, track circuits, inputs, and outputs.

(14) Track termination shunts, including wide or narrow band, shall be furnished in accordance with the manufacturer's standard. All shunts shall be NBS-1 type.

Adjustable loss of shunt protection shall be provided. The means of adjustment for warning loss-of-shunt time shall be such that once set it cannot inadvertently be changed by maintenance personnel.

(15) The motion sensor system shall be designed to detect forward motion of a train within the limits of the approach and activate the warning devices. If, after the system has activated the warning devices, the train ceases approaching or recedes from the crossing, the system shall deactivate the warning devices within a pre-determined time.

(16) Multiple motion sensor units shall be capable of operating at a different compatible frequency on each track monitored and shall operate properly without the need of any external relays to prevent tail ring (ring-off). Tail rings, ring-bys, and short warning times will not be acceptable.

(17) The motion sensor system shall be capable of operating in constant warning time mode or motion-sensing mode.

(18) Motion sensor system warning time and advanced traffic preemption time shall be installed to achieve the designated times shown on the Plans. Advanced traffic preemption shall be provided by a separate output of the motion sensor.

(19) Motion sensor systems shall, insofar as practicable, be designed so that in event of failure of any component part, a minimum of 20 seconds warning time will be provided.

(20) Dummy loads to balance uneven approach lengths, or in a unidirectional application that requires the unit to be set up in a bi-directional manner, shall be furnished in accordance with the manufacturer's standard.

(21) In the event of a loss of local parameters, the motion sensor unit shall only default to the frequency assigned to that application, or to 0 Hz. All other local parameters shall default to the parameters set for that application, or to the most restrictive state.

(22) Where insulated joints are within the approaches of crossings controlled by motion sensor systems, the Contractor shall design and furnish a means of bypassing the insulated joints using coupling devices as recommended by the motion sensor system manufacturer to ensure complete approach distance required for the designed warning time.

The motion sensor unit shall be capable of remote activation when insulated joints located within the crossing approaches cannot be bypassed.

(23) Lightning and surge protection shall be to the manufacturer's standard.

(24) The motion sensor unit shall be capable of maintaining a train record log of the entire crossing approach length with joints located in the approach and remote activation being used. The internal crossing recorder shall be capable of maintaining such functions as date and time, average train speed, actual warning time, and diagnostic and supervisory information.

The recorder shall be capable of recording and storing data for a minimum of 400 train moves. The data shall be displayed on a digital readout and be transferable to a laptop computer or master recording device via a serial or ethernet connector. All recorded events shall be capable of being printed trackside and in the office.

(25) The motion sensor unit's operating program shall be field programmable.

(26) The motion sensor unit shall be rack, wall, or shelf mountable.

(c) Flashing Light Signal Equipment.

(1) The Contractor shall furnish mast mounted flashing light signals where required and as shown on the Plans. The flashing light signal layout shall be equipped with a standard railroad crossing sign, ENS sign, flashing light units and, where required, bells, as specified herein.

(2) The flashing light signal shall be 12-inch LED type in accordance with these specifications and shall also conform to the *AREMA C&S Manual, Part 3.2.5, AREMA C&S Manual Part 3.2.35* and the *AREMA C&S Manual Part 3.2.50*.

(3) Flashing light signal assemblies shall consist of various configurations of back-to-back and single-direction flashing light signals as indicated on the Plans. In accordance with the *MUTCD* and the *AREMA C&S Manual*, 30-inch spacing is required. Additional mounting hardware may be required in some instances.

(4) Each lamp housing shall be constructed of a rigid material which is not affected by atmospheric conditions or by changes in temperature as defined by Class B in the *AREMA C&S Manual, Part 11.5.1*. A protective finish shall be applied to housings made of materials susceptible to corrosion, weathering, degradation from ultraviolet rays, or other elements identified in Class B in the *AREMA C&S Manual, Part 11.5.1*. The housing shall be equipped with a door with front access, hinged at one side with a weatherproof seal. A ventilation opening shall be provided at the bottom of the housing and covered with brass, or copper, wire screen. A sidelight shall be provided on both sides of the lamp housing complete with gasket, lens, and retainer.

(5) Typical crossing masts for supporting flashing light signals only shall be a minimum of 16 feet tall, of aluminum construction, and complete with pinnacle cap and aluminum split base junction box. A pinnacle cap will not be required when bell is used.

The Contractor shall verify that the crossing masts supplied are of sufficient height to maintain the recommended minimum clearances with the multiple light configurations shown on the Plans and the multiple signs specified in this subsection.

A strip of white Type III or Type V retroreflective material, as specified in *ASTM D4956*, and not less than two inches in width, shall be used on each mast for the full length of the front and back of the mast, from the crossbuck sign or number of tracks sign to the junction box base.

(6) LED flashing light units shall conform to the following:

a. The LED signal module shall be 12 inches in size, and, as indicated on the Plans, shall have either a clear or red lens. White LED sidelights shall be included. Any gasket or similar sealing provisions shall be made of a material in accordance with the *AREMA C&S Manual, Part 15.2.10*.

b. The LED signal module shall operate over an ambient temperature range of -40ºF to 158ºF in accordance with the *AREMA C&S Manual, Part 11.5.1*. It shall be protected against dust and moisture intrusion in accordance with the requirements of *ANSI/NEMA 250*, Type 4.

c. The LED signal module shall meet mechanical vibration and shock requirements in accordance with the *AREMA C&S Manual, Part 11.5.1*, and the lens shall be UV stabilized.

(7) The electronic bell shall be provided with a weatherproof housing constructed of cast aluminum. The bell shall conform to the *AREMA C&S Manual, Part 3.2.61*. Normal operating voltage shall be 10 volts DC.

(8) Cross-arms for flashing light units shall be constructed of cast aluminum in accordance with *AREMA C&S Manual, Part 3.2.50*.

(9) Railroad crossing signs (crossbuck, *MUTCD* designation R15-1) shall be white retroreflective sheeting on flat sheet aluminum with the words “RAILROAD CROSSING” in black letters, and a 5-inch reflective stripe on the rear, in accordance with the *MUTCD*.

(10) Flashing light signal assemblies shall be of the type indicated on the Plans.

(d) Cantilever-Gate Combination Flashing Light Signals.

(1) Cantilever structures at highway-rail grade crossings shall meet or exceed the recommended guidelines in the *AREMA C&S Manual, Part 3.2.5*.

(2) The cantilever structure shall be an aluminum, non-rotatable, walkout type. The structure assembly shall be of the type indicated on the Plans.

(3) The cantilever shall be designed to withstand a wind velocity of 100 mph with gusts of 130 mph with a maximum horizontal deflection of 3° 15′, and be capable of supporting a 500-pound load at the end of the arm.

(4) The structure shall be equipped with a ladder, ladder guard, and walkway. The walkway shall be equipped with handrails on both sides and shall be a minimum of 20 inches wide, constructed of expanded metal to provide good footing and prevent ice or snow build up. The handrails shall consist of a top handrail 36 inches above the walkway and an intermediate handrail 18 inches above the walkway.

(5) The mast shall be constructed of 12-inch aluminum pipe with a solid base. The structure shall be a single mast structure for arm lengths up to 26 feet and double mast for arms over 26 feet. A pole mounted junction box shall be furnished with provisions for terminating all cable wires on terminals conforming to the *AREMA C&S Manual*. The junction box shall be equipped with a gasket and front door provided with a means for being secured by an approved padlock.

(6) Cantilever flashing light layouts shall be equipped with an aluminum cantilever structure, standard railroad crossing sign, flashing light signal units, crossarms, visors, backgrounds and, where required, bells. Where the Plans do not require a bell, the cantilever mast shall have a pinnacle and multiple track signs where appropriate.

(7) Gate mechanisms shall mounted be on the cantilever with a minimum of two mounting clamps and a mast mounted support bracket.

(8) Gate arms shall be mounted on the track side of the cantilever.

(9) Components or structures shall be mounted or installed in a manner which will not interfere with gate arm operation.

(10) Gate arm deflectors shall be provided, adjusted, and mounted on the cantilever to prevent the gate arm from coming in contact with cantilever arm mounted flashing lights.

(11) High wind gate arm support shall be provided and offset from the main mast.

(12) An offset conversion bracket shall be provided for gate assemblies as specified in the *AREMA C&S Manual, Part 3.2.10*. Conversion brackets shall not exceed 36 inches in length from centerline of mast to centerline of gate.

(13) Breakaway gate arm adapters shall be included and conform to the *AREMA C&S Manual, Part 3.2.21*. The design shall allow the gate to assume a vertical position.

(14) Counterweights shall be distributed over both counterweight support arms.

(15) Counterweight arms shall not prevent access to the junction box in any position.

(16) All gates over 30 feet in length shall be equipped with buffer legs to minimize the sagging effect associated with long gates. Buffer legs shall be of the type specified on the Plans.

(e) Automatic Highway Crossing Warning Gates.

(1) The Contractor shall install automatic highway crossing warning signals complete with gate mechanism, gate keepers, gate arm, counterweights, LED gate arm lights, high-wind brackets, mast mounted flashing light units, railroad crossing signs, extension brackets for signs, and, where required, bells. Where the Plans do not require a bell, the signal mast shall have a pinnacle and number of tracks signs, together with all necessary hardware as specified herein, in accordance with the *AREMA C&S Manual, Part 3.2.15*, and as shown on the Plans.

(2) The ground-mounted mast for supporting a gate mechanism shall be constructed of 5 inch aluminum pipe, 16 feet long and include a cast aluminum double split base junction box. Junction boxes shall be provided with terminals conforming to the *AREMA C&S Manual*, gaskets, and provisions for padlocking both sides. All special gate hardware for cantilever supported gates shall be ordered with the cantilever assembly as manufactured by the cantilever supplier.

(3) The gate mechanisms shall be supplied with an internal wiring diagram protected by a plastic laminate and shall be fastened to the inside of mechanism cover. Binding posts, nuts, washers, and insulators shall conform to the *AREMA C&S Manual, Part 14.1.11*.

(4) The highway crossing gate mechanism shall be of the type specified on the Plans. The mechanism shall include a nominal 115 volt AC heater element to prevent the formation of frost on controller contacts.

(5) The general design, painting and striping of the gate arm shall conform to the *AREMA C&S Manual, Part 3.2.20* or the *AREMA C&S Manual, Part 3.2.24*. The striping shall consist of 16-inch alternate reflectorized red and white stripe on both sides of the arm. The arm shall be constructed of non-conductive fiberglass and be designed to ensure reasonable durability and rigidity to prevent undue sway or whipping. The clearance between the gate arm and any fixed portion of the assembly shall be a minimum of two inches.

(6) The highway crossing gate arms shall be of sufficient length to extend to within one foot of the centerline of the roadway, but in no case less than 90% of the roadway width, and provide a minimum clearance of two feet from overhead wire and cable. All gates over 30 feet in length shall be equipped with buffer legs to minimize the sagging effect associated with long gates. Buffer legs shall be of the type specified on the Plans.

(7) All roadway gates shall be equipped with high wind support devices. The wind support devices shall be as specified in the *AREMA C&S Manual, Part 3.2.22*.

(8) All roadway gates 32 feet in length or less, except those mounted on cantilevers, shall be equipped with self-restoring gate arm devices. The self-restoring gate arm devices shall be as specified in the *AREMA C&S Manual, Part 3.2.23*. The gate arm devices shall be of the type specified on the Plans.

(9) Weatherproof, 10 volt, bi-directional LED gate arm lights with highway crossing red lenses shall be provided in accordance with the *AREMA C&S Manual, Part 3.2.40*. Gate arm lights shall be adjustable to permit focusing of lights at gate installations parallel to the tracks but not perpendicular to the roadway.

(10) A mechanism support shall be furnished with each gate mechanism. The mechanism support shall provide a base upon which the gate mechanism rests and shall support the weight of the mechanism when it is necessary to swing the mechanism and gate for repairs. Mechanism support shall be of the type specified on the Plans. The mechanism support shall be complete for mounting on a 5-inch pipe.

(11) Crossarms for flashing light units shall be in accordance with the *AREMA C&S Manual, Part 3.2.51*.

(12) Gate access platforms shall be provided at locations shown on the Plans to provide safe access to the gate assemblies and rear of the gate mechanisms.

(13) Gate access platforms shall be of the type specified on the Plans.

(14) Platforms shall be a minimum of 7-1/2 feet long and 5-2/3 feet wide with railings on the sides and rear of platform. Railings shall be a minimum of 45 inches in height.

(15) Each gate access platform will be provided with a leveling plate with cable access cutouts.

(16) Platforms shall be constructed so that no part of the platform interferes with the operation of the gate or obstructs the flashing lights.

(f) AHCWS Shelters and Cases.

(1) Shelters and cases shall be of the type specified on the Plans.

(2) Shelters shall be constructed of 0.09-inch thick aluminum sheeting with a 0.125-inch thick aluminum floor and access to underground and aerial cable knockout entrances behind the main terminal rack. The top and sides shall be fully lined with fire insulating material complying with a flame spread of 0-20 and a fire rating of 7 in accordance with *ASTM E84*. Roof and floor ventilation openings for the size of the shelter shall be provided. Hoist bars shall be provided to facilitate the movement of the shelter.

(3) Shelters shall be equipped with a ratchet style adjustable foundation system.

(4) Shelters shall be equipped with a side personnel entrance and a rear cable entrance door. In each door, there shall be a minimum of two ventilating openings covered with fine mesh stainless steel, copper, or bronze screening. The exterior of the ventilated openings shall be hooded to minimize the entrance of precipitation. The interior of the ventilation opening shall be equipped with a sliding steel plate to allow the adjustment of airflow. Each door shall be hinged and gasketed so that they will provide a dustproof and weatherproof seal. Doors shall be provided with cast iron handles connected to a three-point locking device which will ensure that the door cannot be locked until it is in the fully closed position. Doors shall be provided with a two-position retaining device to secure the door when open.

(5) Hinges shall be separate castings that are welded to the housing and door. The hinges shall be equipped with bronze hinge pins and shall be lubricated by the manufacturer before the shelter is shipped.

(6) Shelters shall be equipped with electric lights as required to provide complete illumination for all passages and sides and operated from a switch conveniently placed near the entrance door. A minimum of three ground fault circuit interrupter (GFCI) convenience outlets (duplex receptacles) shall be provided in each wall about 36 inches from the floor. A GFCI receptacle shall be provided near each door.

(7) A thermostatically controlled roof or side mounted vent exhaust fan operated from 120 volts AC and fused separately shall be provided in the shelter or case. The fan, if side mounted, shall be of the centrifugal type, sized to mount through a standard aerial cable outlet knockout. The thermostat that activates the fan control shall be adjustable with an on control operable between 65°F and 75°F.

(8) A thermostatically controlled 2,000-watt minimum wall-mounted heater operated from 240 volts AC and fused separately shall be provided in the shelter.

(9) Shelters shall be provided with a grounding bus of hard-drawn pure copper. The minimum dimensions of this bus shall be 8 inches × 8 inches × 1/2-inch. The bus shall be located on the lower left section of the terminal board and as near the cable entrance as possible. A minimum of twelve 3/8-inch holes shall be drilled and tapped in the bus and twelve 3/8-inch × 1/2-inch long hex head bronze studs with one washer each shall be furnished.

(10) The free floor space shall be covered by a removable mat as specified.

(11) Equipment layout design shall be such as to mitigate interference from other equipment or apparatus installed within the same instrument housing.

(g) Components and Equipment for Shelters and Cases.

(1) Equipment Racks. Racks shall be the manufacturer's standard for the type of equipment furnished and shall be sized to fit the shelter. Equipment racks shall include all necessary supports for wire and equipment.

(2) Relay Plug-boards. Plug-boards shall be designed for insertion of removable type contacts. The wires shall be attached to the removable contacts using solderless connections. Unless otherwise approved by the Engineer, or proven by type acceptance testing, the plug-board shall be designed so that the removable contact will have a direct connection with the contact and coil prongs. The plug-boards shall be in accordance with the applicable sections of the *AREMA C&S Manual, Part 6.2.2*. All wires shall be of sufficient length to permit them to be moved to any contact on the same relay. The plug-boards for vital relays shall be equipped with a registration plate to prevent relays of the wrong type, contact arrangement, or operating characteristics from being inserted.

(3) Relay and Component Mounting.

a. In designing the detail layout of the racks, panels, and other equipment within the AHCWS shelter or case, the Contractor shall group the rows of racks and the instruments thereon so that similar types of equipment or functions of a similar nature will be together.

b. Relays for track circuits shall be mounted in the upper half of the relay rack.

c. Relays or components shall be mounted at a height of no more than 6 feet or less than 1 foot from the floor of the room. The overall height of the rack shall not exceed 7-1/3 feet.

d. Shelves shall be provided for mounting any required solid-state equipment such as electronic track circuits, grade crossing predictors, motion sensors, or related solid-state equipment. Shelves shall be mounted such that equipment is not more than 6 feet nor less than 1 foot from the floor. Shelves shall be provided with rubber matting in accordance with these specifications.

(4) Identification.

a. A white identification number shall be stenciled at the top of the frames of each rack or panel.

b. There shall be an identifying nameplate for each relay, or other instrument mounted on the rack or panel.

c. The relay plug-boards shall be equipped with a tag as specified herein. This tag shall indicate the nomenclature of the relay.

d. The contact numbering system shall be uniform for each type of relay used.

e. The wiring to each removable contact shall be identified with a wraparound tag as specified herein. This tag shall indicate the relay contact number assigned to the wire.

f. Wire and cable conductor identification tags for terminal board mounting shall be as specified herein.

g. External identification of the manual control (MC) box shall be provided.

(5) Cable Entrance Racks.

a. Cable entrance racks shall be made of 3/4-inch Type AB exterior grade plywood, mounted on a standard equipment rack where required.

b. Cable entrance racks shall be located in the immediate proximity of the cable entrance facilities of the shelter. The Contractor shall determine the physical size of the terminal boards necessary to meet the requirements of the Contract.

c. Multiple-unit terminal blocks for wire and cable conductors shall be in accordance with the *AREMA C&S Manual, Part 14.1.6*.

d. Lightning arresters shall be as specified in Subsection 781.03(j)(12).

e. An additional 10% spare terminals and lightning arresters shall be provided.

f. Provisions shall be made to locate spare wire conductors on dedicated terminal posts or lightning arresters, in line with the working conductors of any one cable.

g. Wire-wound resistors mounted on the terminal board shall be spaced with 1/2-inch clearance between adjacent resistors.

(6) Apparatus Boards. A full complement of apparatus boards shall be furnished on the sides of shelter and shall be made of 3/4-inch Type AB exterior grade plywood securely fastened to the walls in such a manner to permit mounting of battery charging equipment, transformers, terminals, fuses, etc.

(7) Battery Trays. The Contractor shall furnish wood battery trays mounted on steel racks of a design and size for the batteries supplied by the Contractor. Alternative designs of polyethylene may be submitted for consideration. Unless otherwise approved, the design shall provide for batteries to be mounted on battery racks having a single tier.

(8) Cable Entrance Pipes. Cable entrance pipes shall be as specified herein.

(9) Grounding. A 3/8-inch high-tensile strength, silicon manganese bronze stud bolt for externally grounding the case shall be provided. Perforations of the shelter will not be permitted. The internal ground bus arrangement shall be as specified in Subsection 781.03(f)(9).

(10) Wiring. Internal wiring for vital circuits shall be in accordance with the applicable provisions of the *AREMA C&S Manual*, unless otherwise specified herein.

No. 16 AWG 19-strand flexible wire shall be used for all circuits, except that No. 10 AWG, or larger, flexible stranded shall be used for signal lighting, track connections to the main terminal board and rectifier bus circuits. No. 6 AWG shall be used for battery connections. Wiring for lights, fan control, switch and convenience outlets shall be insulated No. 12 AWG, flexible, THHN wire installed in EMT. Wiring for the wall-mounted heater shall be insulated No. 10 AWG, flexible, THHN wire installed in EMT.

Solderless terminals, for stranded wire, shall be as specified in Subsection 781.03(j)(13). Solid terminal connectors shall be used for all short terminal jumpers.

(11) Wiring Raceway. All internal case wiring shall be contained within surface mounted plastic raceway. The raceway shall be of a polycarbonate, low smoke type with a solid snap-on cover and flexible side walls. The side walls shall be of finger type construction allowing for insertion and removal of wire runs with terminations attached. Sizes shall be determined by the manufacturer. Fill capacity shall not exceed 40%.

(12) Painting.

a. The interior of non-aluminum housings shall be painted according to the manufacturer's standard.

b. The terminal and apparatus boards and shelves shall be painted gray *ANSI 61*.

c. The exterior of non-aluminum housings shall be painted in accordance with the *AREMA C&S Manual, Part 1.5.10*. The finish color shall be aluminum. The steel bottom of the shelter shall be treated with a corrosion resistant undercoating.

d. The battery trays shall be painted with two coats of acid-resistant black paint.

e. All paint shall be fire retardant.

(13) Power Off and Status Indication Light.

a. The Contractor shall furnish and install a power off and equipment status indication light, above the manual control box, on the highway crossing side of each AHCWS shelter. The circuit control for this light shall include contacts of the power-off relay. The light shall be lit when the power is on.

b. A 2-inch diameter hole shall be cut in the shelter on the side facing the highway. A polycarbonate lens, with a gasket or seal, shall be installed to weatherproof the hole.

c. A 12-volt, 18-watt lamp and base shall be mounted inside the crossing shelter behind the lens.

d. The lamp shall be wired as shown on the Plans or the approved fabrication drawings.

(14) Manual Control Box.

a. The Contractor shall furnish and install a manual control (MC) box, mounted on the roadway side of the shelter as indicated on the Plans.

b. The MC box shall be of cast iron or cast aluminum construction, complete with a hinged and gasketed door to provide a dustproof and weatherproof seal.

c. The method of mounting the MC box on the side of the shelter shall include a gasket to provide a weatherproof seal between the back of the MC box and the side of the shelter. A pipe nipple with locknuts and bushings, or similar approved means, shall be provided between the inside of the shelter and the inside rear of the MC box to house and protect the flexible internal wiring between the shelter and the terminals on the control switch within the MC box.

d. An approved means of securing and locking the door with a standard padlock shall be provided.

e. A pocket shall be provided on the inside of the MC box door to house the crossing test record booklet.

f. The MC box shall be fitted complete with an internal face-plate panel marked "Manual Control".

g. A knife switch and all internal wiring shall be provided.

h. The wire terminations on the switch within the MC box shall be identified with tags, as specified in Subsection 781.03(j)(14). These tags shall indicate the nomenclature of the wire.

(15) Event Recorder.

a. The Contractor shall furnish and install an event recorder system at each crossing location. The event recorder shall be of the type specified on the Plans.

b. Event recorders shall be designed for installation at highway crossings to monitor and report activities associated with signal equipment operation.

c. Event recorders shall also provide data analysis capabilities internal to the event recorder which through user defined application logic can interpret the stored information.

d. Event recorders shall be capable of reporting digital information such as relay contact closures and analog information such as relay battery voltage, gate battery voltage, and AC lamp voltage.

e. The event recorders shall use solid-state microprocessor technology and base unit networked with expansion modules via RS485 to scale to larger I/O intensive applications.

f. The event recorders shall use a user interface that allows easy navigation through menus and fast access to stored data and system functions. The user interface shall be accessed using a built-in display and keypad or remotely through the communication options.

g. The event recorder shall receive inputs from the various signal relays and voltage sources and shall process outputs to battery backed up memory for storage with a date and time stamp.

h. Event recorders shall conform to the *AREMA C&S Manual, Part 3.1.29* on event recorder design and operation.

i. Event recorders shall be installed in accordance with standard *AREMA* temperature ranges for field installed equipment.

j. Event recorders units shall be provided as follows:

    1. Each input and output port shall be equipped with an illuminated status indicator. The indicator shall light when the respective port is energized.

    2. Each unit shall be equipped with a built-in interface for connection of a printer and modem to download from memory. Event recorders shall be capable of storing up to 24,000,000 events and equipped with a minimum of four relay outputs front-back-heel contacts used for general-purpose control interface.

k. The operating voltage of event recorders shall be 8.0 volts DC to 36.0 volts DC, isolated ground.

l. Units shall be configured for wall mounting. Units shall be bound in a secure enclosure with wiring connections protected from accidental contact when passing by.

(16) Shelter and Case (Power).

a. AC Power Supply. Shelters shall be provided with single phase, three wire, 120/240 volt AC, 100 amp, 24 circuit panelboards. The capacity rating for each panel board shall be sized by the Contractor for the projected loads and shall be rated for not less than 100 amps. Panel boards shall contain 25% spare circuit breaker spaces. Two double pole circuit breakers shall be provided for future use, in addition to the 25% spare circuit breaker spaces. Circuit breakers provided shall be of the thermal magnetic, molded case type, sized by the Contractor in accordance with the approved power calculations.

b. External Connection.

1. The Contractor shall design and furnish a new metered power service at each crossing location to replace the existing service. The Contractor shall obtain all permits, licenses and agreements with the supplying power company and be responsible for coordination with the power company and railroad and all user installation costs that the power company requires.

2. Actual power conductor size shall be calculated to suit distances and loads. Conductor sizes and cable makeup shall be detailed for application of the Contractor's final design. The sizing of the conductors shall allow no more than a 5% voltage drop between the power source and the load under maximum calculated load conditions.

3. All power service materials and equipment installed shall conform to all applicable state and local ordinances pertaining to electrical power installations and the *National Electrical Code*.

4. The Contractor shall provide and install cable for connection of the 240 volt AC, three-wire feed from the meter service to the utility tapping point.

c. Lighting. Shelters shall be provided with lamp holders and bulbs at each door, front and rear.

d. Branch Circuit Wiring. Branch circuit wiring for shelter utilities shall be installed in EMT conduit. Wire sizes, EMT conduit, and liquid tight flexible conduit shall be sized in accordance with the *National Electrical Code*. Wiring for lights and convenience outlets shall be a minimum of No. 14 AWG, flexible, THHN wire installed in EMT.

(h) Foundations.

(1) Precast Concrete Foundations. Precast concrete foundations shall be made of concrete with an average compressive strength of 5,000 psi and be in accordance with the applicable drawing section of the *AREMA C&S Manual, Part 14* for the type of precast foundation required. Precast concrete foundations shall be steel reinforced. Reinforcing steel shall be in accordance with the *AREMA C&S Manual, Part 14.4* and shall be not less than one inch from any outside surface.

(2) Bolts, Nuts, and Hardware. Bolts, nuts, and washers shall be galvanized in accordance with the *AREMA C&S Manual, Part 15.3.1*. Bolts, nuts, and threads shall be in accordance with the *AREMA C&S Manual, Part 14.6.20.*

Plain washers shall be in accordance with the *AREMA C&S Manual, Part 14.6.21*. Steel shall be in accordance with the *AREMA C&S Manual, Part 15.1.4, Section 1*.

(i) Signs. For each crossing, the Contractor shall furnish three new I-13a emergency notification signs. Signs shall be in accordance with *MUTCD* requirements.

(j) Miscellaneous Products and Components.

(1) Printed Circuit Cards.

a. Printed circuit (PC) cards shall be of glass epoxy construction. Card material shall meet the requirements of *ANSI/NEMA IM 60000*, Type FR-4 and meet or exceed the Class 2 requirements of *IPC-A-610F*. Cards shall have sufficient thickness to permit easy insertion and removal and shall be physically keyed to protect against incorrect interchange. Circuits shall be formed by etching. Conductor material shall be copper and shall be protected from exposure to air.

b. PC cards containing components that may be damaged in the event a plug connector or plug-in unit is removed while the equipment is energized shall be clearly marked or labeled with a warning note and means provided to remove power to the PC cards.

c. Stacking or piggybacking of printed circuit card sections in order to accomplish changes or modifications to wiring or components on printed circuit cards will not be allowed.

(2) Printed Circuit Card Connectors. Connectors shall have gold plating with a minimum thickness of 0.000050 inches.

(3) Circuit Breakers.

a. Circuit breakers shall be of suitable capacities to protect the various pieces of signal apparatus from the effects of short circuits or overloads.

b. The circuit breakers shall be the correct size and rating for circuit current interruption and shall protect the electrical equipment and circuits from short-term and long-term overloads.

c. In DC branch circuits, where fusing is impractical, a protective resistance unit shall be furnished. All fuses shall be centrally located on the power distribution panel and power racks.

d. Fuse clips shall be so constructed that they shall retain their resilience under all installation and service conditions to assure a positive contact between the clips and fuse.

(4) Diodes. All diodes to be furnished shall carry a JEDEC number or shall be available from more than one manufacturer and shall be used within the published specifications for such number. All diodes shall be of the silicon type.

(5) Resistors. All resistors, other than those required for electronic circuits, shall be in accordance with the *AREMA C&S Manual, Part 14.2.15*. Resistors for electronic circuits shall be in accordance with the applicable requirements of the *AREMA C&S Manual, Part 11.5.1*.

(6) Reactors. All reactors, other than those required for electronic circuits, shall be in accordance with the *AREMA C&S Manual, Part 14.2.20*. Reactors for electronic equipment shall be in accordance with the applicable requirements of the *AREMA C&S Manual, Part 11.5.1*.

(7) Capacitors. Capacitors for electronic circuits shall be in accordance with the applicable requirements of the *AREMA C&S Manual, Part 11.5.1*.

(8) Signal Terminal Connectors. Signal system terminal connectors shall be in accordance with the applicable requirements of the *AREMA C&S Manual, Part 14.1.15*.

(9) Signal Terminal Binding Posts. AHCWS terminal board binding posts, required for supervisory control circuits, shall be in accordance with the *AREMA C&S Manual, Part 14.1.10*.

(10) Terminal Post Insulators. All terminal posts located on terminal boards in the crossing instrument shelters used to terminate 55.0 volt or greater AC or DC circuits shall be provided with a protective insulator. The type of insulator shall be individual for each terminal post and shall be fire-resistant.

(11) Insulated Test Link. Insulated test links shall be of the type specified on the Plans.

(12) Lightning Arresters and Equalizers. Lightning arresters and equalizers shall be mounted on three or four post porcelain or other approved types of bases and shall be in accordance with the *AREMA C&S Manual, Part 14.1.9.*

(13) Terminals for Wires and Cables.

a. All solderless terminals shall be in accordance with the *AREMA C&S Manual, Part 14.1.1*, or as specified herein.

b. Terminals shall be of the solderless crimp-on type. Samples of all solderless terminals shall be submitted for approval.

c. All stranded copper wire shall be fitted with an approved type of terminal at all points where the wires are to be terminated on terminal binding posts.

d. The terminating means shall be of five types:

1. A lug for terminating heavy wires or signal power wires.

2. A solderless insulated 1/4 inch stud circular ring terminal for terminating No. 16 and No. 14 AWG stranded wires.

3. A solderless insulated 1/4 inch stud circular ring terminal for terminating No. 12 through No. 10 AWG insulated wires.

4. A solderless insulated 1/4 inch stud circular ring terminal for terminating other stranded vital circuit No. 20 through No. 16 AWG insulated wires having a maximum diameter of 0.200 inches.

5. A solderless insulated circular ring terminal shall be furnished for No. 8 studs and 1/4 inch studs for non-vital circuit No. 22 AWG though No. 16 AWG insulated stranded wires having a maximum diameter of 0.125 inches.

e. Solderless insulated circular ring flag-type terminals shall be used where required. The Contractor shall be responsible for ensuring that the proper terminals are selected based on wire gauge and stud size.

f. The terminals shall be for attaching to the ends of the conductor in such a manner that the flexibility of the conductor will not be destroyed and the possibility of breakage at the terminal will be reduced to a minimum.

g. Terminals shall be for attaching to the wire with a tool made by the manufacturer of the terminal and recommended by the manufacturer for the terminals being furnished.

h. The tool shall be equipped with a ratchet device that will ensure proper indentation of the terminal and which will not release until proper indentation is complete.

(14) Tagging For Cables, Wire, and Equipment.

a. General Requirements. Except as otherwise specified in this subsection, both ends of each cable and each cable wire and all single wires that terminate in the cases, junction boxes, gate mechanisms, instrument housings on entrance racks, and any equipment of the AHCWS outside of such locations shall be permanently identified with a tag. Tags shall not obscure connecting links used between terminal binding posts. Tags shall be installed so that they may be read with a minimum of disturbance of the tags and wiring. Each conductor of the cable shall be rung out and identified before applying the tag.

b. Identification Tags. Tags for wire and cable identification and for identification of transformers, resistors, reactors, and other components shall meet the following requirements:

1. Sleeve Type Tags. Tags for identification of individual cable conductors and field-installed wires within the cases and AHCWS instrument shelters, base of signal junction boxes, and similar applications shall be of the type specified on the Plans. The application of the conductor nomenclature shall be in accordance with the manufacturer’s instructions and shall result in a permanently bonded and legible identification.

2. Flat Plastic Tags.

   i. Tags for identification of vital relay plug boards, individual transformers, resistors, reactors, terminals, and other miscellaneous components within the cases or AHCWS instrument shelters shall be the flat plastic laminated type.

   ii. Identification tags shall be 1-1/2 inches long × 3/4 inches wide with one 5/16-inch hole located in the center of the width. The distance from the edge of the tag to the hole shall be approximately 9/32 of an inch. The untreated tag shall be milk white in color and composed of nontoxic, thermoplastic, acid-resistant vinyl resins.

   iii. The identifying nomenclature space shall allow for three rows of lettering, and the tag material shall be capable of receiving typed-on characters by conventional means. The height of the lettering shall be not less than 1/8 inch. Hand-written tags shall not be allowed.

   iv. After lettering, both the face and back side of the tag shall be covered with a clear plastic coating, or nontoxic, thermoplastic, acid-resistant vinyl resin coating, shall have a minimum thickness of 0.01 inch.

   v. The nomenclature applied to tags to go on entrance racks and boards shall show the terminal post identification on the top line. The functional nomenclature shall appear on the bottom line, or, if required, on the middle and bottom lines. The terminal posts shall be identified by geometry coordinates, such as rack, row, and post number.

3. Wrap Around Tags. Tags for identification of the individual wires of plug-in relays, within the AHCWS instrument shelter and the wayside cases, shall be of the wrap around, self-adhesive type.

4. Flag Marker Tags. Tags for identification of individual wires of shelf-mounted relays, and wires and conductors in junction boxes, shall be flag marker tags of the miniature locking type.

(15) Pressure-Sensitive Labels.

a. The rows and columns on entrance racks shall be identified by pressure-sensitive labels bearing the geometric coordinates.

b. Wires on plug-in vital relays shall be identified by the contact to which they are applied. These tags shall be of the wrap-around self-adhesive type.

(16) Hardware. All mounting hardware exposed to the elements and used for signal equipment, cases, conduit, hangers, brackets, clamps, etc., shall be hot-dip galvanized.

All lock-washers shall be cadmium plated. All nuts, bolts, and washers used for the mounting of equipment within finished enclosures shall be cadmium plated or stainless steel.

a. Galvanizing. Hot-dip galvanizing shall be in accordance with Subsection 726.06. All galvanized mounting hardware nicked or damaged during construction shall be repaired in accordance with Subsection 726.06 and coated when dry with a non-oxide grease to prevent corrosion.

b. Cadmium Plating. Cadmium plating shall be an impervious, dense, hard, fine grained, continuous, closely adhering coating of commercially pure cadmium, free from capillaries and shall completely cover the surface of the part in a smooth, bright layer. Plating on raised or prominent portions shall show no evidence of blackness or loose crystalline structure. It shall have a minimum thickness of 0.0006 inches and shall withstand the salt spray test for at least 1,000 hours.

(17) Conduit.

a. Rigid Conduit. Rigid conduit shall be used at locations as specified herein and as shown on the Plans. The types of rigid conduit shall be as follows:

1. Steel conduit shall be made of the best grade standard weight steel pipe protected inside and outside by a coat of hot-dip galvanizing. Where elbows are used, they shall be the long radius type. Steel conduits shall be protected in shipping and handling by approved thread protectors.

2. PVC conduit shall be schedule 80 and shall meet or exceed the requirements of *ASTM D1784*.

b. Flexible Conduit and Hose.

1. Hose for track circuit leads shall be a braided rayon, vari-purpose hose, or internal tube neoprene cover.

2. When the Engineer permits the use of metallic flexible conduit, it shall be Type UA.

c. Fittings.

1. Approved PVC fittings shall be used for PVC conduit. All fittings for rigid steel conduit shall be of cast malleable iron and shall be protected by hot-dip galvanizing.

2. Expansion joints for PVC conduit shall be required where shown on the Plans.

(18) Padlocks and Keys. Signal padlocks and keys shall be furnished and installed for all housing or case doors and covers of signal equipment installed under the Contract. Switch padlocks shall be furnished and installed for manual control boxes requiring access by train crews. The Contractor shall obtain through the Engineer the proper ordering references for the Operating Railroad's signal and switch padlocks.

(19) Sealing Compound. Sealing compound for use in sealing cable entrances shall be in accordance with the *AREMA C&S Manual, Part 15.2.15*.

(20) Cable Entrance Pipes. Cable entrance pipes for ground-mount AHCWS instrument shelters shall be 6-inch schedule 40 PVC pipe, 3 feet long, with a bell housing on one end.

(21) Paint and Finish. All paint and painting procedures shall be in accordance with applicable requirements given in the *AREMA C&S Manual, Part 1.5.10*.

(22) Ground Rods, Clamps, and Wire.

a. Ground rods shall be copper-clad steel of the non-rusting type. The rod shall be at least 8 feet in length and at least 5/8-inch in diameter.

b. Ground rod clamps shall be made of a cast bronze clamp body with non-ferrous set screws.

c. Internal ground wire from the equipment to the ground bus shall be insulated No. 6 AWG or No. 10 AWG stranded copper wire. Insulated ground wire shall be colored green.

(23) Rubber Mats. Rubber mats shall be furnished for installation in the crossing shelter. Rubber mats shall meet the requirements of the applicable sections of ANSI and NEMA standards.

(24) Rail and Turnout Bonds.

a. Non-insulated rail joints shall be bonded with an exothermically welded rail head bond installed on the field side of the joint bars.

b. Rail head bonds shall be furnished and installed in accordance with the *AREMA C&S Manual, Part 8.1.20, AREMA C&S Manual, Part 8.1.30,* and *AREMA C&S Manual, Part 8.6.40.*

c. Bonds shall be 5/16-inch tab style with a nominal length of 7 inches.

d. For all turnouts within the crossing approach, fouling wires and switch heel bonds shall be furnished and installed in accordance with the *AREMA C&S Manual, Part 8.1.20* and *AREMA C&S Manual, Part 8.1.25* (Type 2 plugs).

(25) Signal Transformers.

a. General Requirements. Signal transformers shall be in accordance with the *AREMA C&S Manual, Part 14.2.10* for single-phase transformers, where the requirements do not conflict with any requirements of this subsection.

b. General Signal Transformers.

1. General signal transformers shall be provided with sufficient primary and secondary voltage taps to adjust between 85% and 110% for varying feeder voltages. All transformers shall be rated to carry 125% of the total load continuously.

2. The primary and secondary taps shall be brought to terminals mounted inside the transformer case, and a connection for each secondary tap and at least two connections for the primary winding shall be brought out of the transformer to terminals conforming to the requirements of the *AREMA C&S Manual*. All terminals shall be identified.

c. Signal Lighting Transformers. Signal lighting transformers shall be equipped with taps to provide output voltage adjustment in one-volt steps, from 6 volts to 15 volts. The primary excitation voltage shall be 120 volts AC at 60 Hz.

(26) Batteries and Charging Equipment.

a. Design Requirements.

1. Two 12-volt battery banks and charging equipment shall be included in the design. One bank shall be used for electronic track circuits (MB12) and a separate bank shall be used for signal lighting and gates (XB).

2. Battery charging equipment shall be of a microprocessor-based design for continuous operation, shall provide constant current and constant voltage charge, and shall meet the requirements of the *AREMA C&S Manual, Part 9.2.5.*

3. Battery charging equipment shall be designed to deliver rated outputs with an input voltage of 100 volts AC to 130 volts AC at 60 Hz, single phase, two-wire input.

4. Battery charging equipment shall have a reserve capacity at least 25% above the calculated requirements. Locations using gates shall be provided with a 40-amp minimum XB rectifier.

5. Each charger shall be provided with an adjustment device to change the rate of output current.

6. Terminal markings for AC and DC terminals shall be permanent.

b. Track Battery Chargers. Track battery chargers shall provide constant current and constant voltage charge and shall meet the requirements of the *AREMA C&S Manual, Part 9.2.5*. Chargers shall have a selectable float voltage to match supplied battery manufacturers requirements of the type as specified on the Plans.

c. Battery Bank Chargers. Battery bank chargers shall be fully adjustable rectifiers of the type specified on the Plans.

The Contractor shall furnish DC battery bank chargers for operating all equipment required to operate the connected equipment.

The charger shall provide a stabilized output voltage, with output current limiting. The capacity of the battery charger shall be determined by the Contractor and approved by the Engineer. The charger shall adjust its output current automatically according to the load and to the demand on the battery.

d. Storage Batteries.

1. The Contractor shall furnish storage batteries for all applications except as otherwise approved by the Engineer.

   Low maintenance railroad signal batteries, of the type specified on the Plans, will be used by the Operating Railroad as a standby source of power for highway crossing warning devices, signal control systems, and other similar uses.

   The batteries shall operate, with a high degree of reliability, at -40°F to 160°F in a harsh environment, enclosed only in a relay house or raised concrete battery box.

   The batteries shall not be capable of exploding under any condition, including a short circuit discharge.

2. Batteries shall meet the requirements of the *AREMA C&S Manual, Part 9.1.3*, where they do not conflict with any requirements of this subsection.

3. The following is a guide to minimum storage battery size. The Contractor shall calculate the loads based upon the equipment that the Contractor proposes to furnish. All batteries shall be sized for a minimum 24-hour standby capacity at an ambient temperature of 40°F.

   i. 80 amp-hour (minimum) – DC steady energy track battery

   ii. 340 amp-hour (minimum) – Local MB12 battery

   iii. 340 amp-hour (minimum) – Local XB battery

4. The physical construction shall conform to the following:

   i. Polypropylene container and cover.

   ii. Projected design life of 20 years at 80% rated capacity.

   iii. Individual cells (multiple cell groups or modules are not allowed).

   iv. The battery shall be low maintenance, meaning no overcharge will be required.

(27) Vital Relays.

a. General Requirements.

1. Vital relays shall meet the requirements of the *AREMA C&S Manual, Part 6.2.1*.

2. All relays and equipment specified shall be capable of rated performance through an operating temperature range of -40°F to 158°F.

3. All relays shall be in dust-proof enclosures, except a provision shall be made for ventilation where required for heat dissipation.

4. Arc suppression for vital relays shall be built into the relay or into its plug-board.

5. Contact arrangements shall be identical for similar types of relays, except special function relays.

6. All vital plug-in relays, except vital time-element relays and special application relays, shall be equipped with front current testing facilities.

7. Vital plug-in relays shall be equipped with a registration plate to prevent relays of the wrong style, contact arrangement, or operating characteristics, from being inserted into the plug-board.

8. Vital relays shall be shipped separately from the wired racks in which they are to be used. They shall be packaged individually, each in a sturdy corrugated cardboard carton with the drawing number of the relay printed on the outside of the carton. Relays shall be stored in a protected area until tested and installed.

9. The factory testing of each relay shall be to the manufacturer’s standard.

10. Vital relays, with a nominal operating voltage of 10 volts to 16 volts, shall be capable of operating continuously without resultant damage, with a minimum voltage range of 7 volts to 21 volts, inclusive, applied to their operating circuits.

11. Biased neutral vital relays shall be designed so that gravity alone will prevent the armature from picking up if the permanent magnet is de-energized or if no current is applied to the coil due to interruption of the normal magnetic circuit. Biased neutral vital relays shall be designed so that up to at least 50 times working energization applied for two seconds at both normal and reverse polarity will not affect their operating characteristics by more than 2%, and will not pick up their armature on reverse polarity.

12. Each vital relay shall have a minimum of four dependent front-back contacts, two independent front contacts, and one independent back contact. All front contacts shall be silver-to-metalized carbon, except for heavy duty, extra heavy duty, or special application relays.

b. Flasher Relays.

1. Flasher rates for AHCWS shall be provided by solid-state flashers.

2. The flashing rate shall not be less than 35 times per minute nor more than 65 times per minute and shall be in accordance with the *AREMA C&S Manual, Part 3.2.55.*

c. Timers and Time Element Relays.

1. Timers used for loss of shunt protection or special applications shall be of the vital solid-state type.

2. Any interruption of power shall cause an immediate reset to the beginning of the selected time delay. The timer shall be accurate to within ± 0.1% over the entire temperature range of -40°F to 158°F.

(28) Shunt Enhancement Systems.

a. Shunt enhancement systems shall meet the requirements of the *AREMA C&S Manual, Part 3.1.17.*

b. Shunt enhancement systems shall be used to improve shunting characteristics by providing a DC whetting voltage to break down rust and contaminants on the rail. Shunt enhancement systems shall be of the type specified on the Plans.

c. The shunt enhancement systems shall meet the following requirements:

1. The system shall provide a DC voltage in a range between 6.0 volts and 7.5 volts to the rails.

2. The system shall monitor the DC voltage to the rails and provide a system check output of 12.0 volts to 15.0 volts DC for the use of activating the crossing if the shunt enhancement system fails.

3. The system shall operate from an external 12-volt DC power source and 120-volt AC line. The system shall automatically switch to DC voltage in the event of AC power failure.

d. The equipment shall be wall or rack mountable.

(29) Audio Frequency Overlay Track Circuits.

a. Audio frequency overlay (AFO) track circuit control system equipment shall meet the requirements of the *AREMA C&S Manual, Part 8.2.1*.

b. AFO track circuit control equipment for island and approach control of automatic highway crossing warning systems shall be of the type as specified on the Plans.

c. The equipment shall meet the following requirements:

1. The transmitter, receiver, and transceiver units of the audio frequency track circuits shall be system engineered by one manufacturer. The Contractor shall furnish documentation that their selection of audio frequencies and location of equipment will not introduce harmonic interference to other audio frequency assemblies (including motion sensor assemblies) or false and spurious inductive currents within adjacent audio frequency cable conductors or track circuits.

2. The audio frequency overlay track circuit shall be designed to detect a shunt of 0.25 ohms, or greater, rail-to-rail resistance.

3. The transmitter shunting sensitivity shall have a maximum range of twenty feet using a 0.06-ohm shunt. The receiver post shunt shall be a maximum of ten feet using a 0.06-ohm shunt.

d. Lightning protection devices shall be the manufacturer's standard and shall be system compatible with the proposed type of audio frequency overlay track circuit subsystem.

e. The maximum effective range of the audio-frequency overlay track circuit shall be 8,000 feet.

f. The track circuit module shall be capable of operation from an external 12-volt DC power source. The module shall be provided with built-in battery and lightning surge protection.

g. The internal wiring shall be brought out to terminals conforming to the *AREMA C&S Manual, Part 14.1.10* and the *AREMA C&S Manual, Part 14.1.11*.

(30) Vital Signal Cables.

a. Vital signal cable shall meet the requirements of the *AREMA C&S Manual, Part 10.3.17* and shall be rated for minimum life expectancy of 40 years. These cables shall be suitable for use in the environment to be encountered on a railroad signal system and shall be certified for continuous operation at 167°F in wet or dry locations with no conductor failing in continuity or with loss of insulation to cross or ground less than one meg-ohm.

b. Actual conductor size shall be calculated to suit distances and loads. Conductor sizes and cable makeup shall be detailed for application of the Contractor's final design. The Contractor shall submit voltage drop calculations and size conductors to provide minimum voltages as specified in the *AREMA C&S Manual, Part 3.2.15*, *AREMA C&S Manual, Part 3.2.35*, and, as applicable, the *AREMA C&S Manual, Part 3.2.60* or the *AREMA C&S Manual, Part 3.2.61* under maximum calculated load conditions. Sizing for conductors in remaining circuits shall allow no more than a 5% voltage drop between the power source and the load under maximum calculated load conditions.

c. Multiconductor distribution cable containing more than two conductors shall contain a minimum of 10% spare conductors or two spare conductors, whichever is greater, except that two conductor cables shall not require spare conductors.

(31) Trench Marker Tape. The Contractor shall furnish trench marker tape for signal cable. The tape shall be bright yellow, 6 inches wide, and continuously coded in black lettering with the following legend:

CAUTION	CAUTION	CAUTION
BURIED	SIGNAL	CABLE

(k) Site Test Equipment and Materials.

(1) All test instruments and equipment necessary to conduct the tests specified herein shall be available and ready for use at least 48 hours in advance of the test being required. Ready for use shall mean properly matched for test parameters, properly calibrated, and sufficiently supplied with leads, probes, adapters, stands, and other accessories necessary to conduct the particular test in a completely professional manner.

(2) All temporary or interim test-related materials, special tools, connections, jumpers, etc. shall be furnished and available in advance of the test being required.

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INDEX OF PAY ITEMS

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