# STATE OF VERMONT
## AGENCY OF TRANSPORTATION

## STANDARD SPECIFICATIONS FOR CONSTRUCTION

# 2001

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# DIVISION 100

## GENERAL PROVISIONS

### SECTION 101 - DEFINITIONS AND TERMS

101.01 ABBREVIATIONS. Wherever the following abbreviations are used in these Specifications or on the Plans, they are to be construed the same as the respective expressions represented:

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|---|---|
| A | Ampere |
| ABS | Acrylonitrile-Butadiene-Styrene |
| ADA | Americans with Disabilities Act |
| AAN | Americans Association of Nurserymen |
| AAR | Association of American Railroads |
| AASHTO | American Association of State Highway Transportation Officials |
| ACI | American Concrete Institute |
| AGC | Associated General Contractors of America |
| AI | Asphalt Institute |
| AIA | American Institute of Architects |
| AISC | American Institute of Steel Construction |
| AISI | American Iron and Steel Institute |
| AITC | American Institute of Timber Construction |
| AMRL | AASHTO Materials and Reference Laboratory |
| ANR | Agency of Natural Resources |
| ANSI | American National Standards Institute |
| ARA | American Railway Association |
| AREA | American Railway Engineering Association |
| ASCE | American Society of Civil Engineers |
| ASLA | American Society of Landscape Architects |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| AWPA | American Wood-Preservers' Association |
| AWS | American Welding Society |
| AWWA | American Water Works Association |
| BIT CONC | Bituminous Concrete |
| CAAP | Corrugated Aluminum Alloy Pipe |
| CCRL | Cement and Concrete Reference Laboratory |
| CF | Cubic Foot |
| CFR | Code of Federal Regulations |
| CIP | Cast Iron Pipe |
| CM or $m^3$ | Cubic Meter |
| CPEP | Corrugated Polyethylene Pipe |
| CPM | Critical Path Method |
| CRSI | Concrete Reinforcing Steel Institute |
| CSP | Corrugated Steel Pipe |
| CWT | Hundredweight |
| CY | Cubic Yard |

| | |
|---|---|
| DIP | Ductile Iron Pipe |
| DN | Diameter nominal for metric pipes |
| EA | Each |
| FAA | Federal Aviation Administration, US Department of Transportation |
| FHWA | Federal Highway Administration, US Department of Transportation |
| FSS | Federal Specifications and Standards (General Services Administration) |
| G or g | Gram |
| HA or ha | Hectare |
| HDPE | High Density Polyethylene |
| Hz | Hertz |
| ISO | International Standards Organization |
| ISTEA | Intermodal Surface Transportation Efficiency Act of 1991, PL #102-240 |
| ITE | Institute of Transportation Engineers |
| J | Joule |
| KG or kg | Kilogram |
| KM or km | Kilometer |
| L | Liter |
| LF | Linear Foot |
| LS | Lump Sum |
| M or m | Meter |
| MC | Medium Curing |
| MFBM | Thousand Feet Board Measure |
| MGAL | Thousand Gallons |
| MUTCD | Manual on Uniform Traffic Control Devices for Streets and Highways |
| NBFU | National Board of Fire Underwriters |
| NEC | National Electric Code |
| NEMA | National Electrical Manufacturers Association |
| NHS | National Highway System |
| NIST | National Institute of Standards and Technology |
| NPS | Nominal Pipe Size |
| NSPE | National Society of Professional Engineers |
| PCA | Portland Cement Association |
| PCC | Portland Cement Concrete |
| PCCSP | Polymeric Coated Corrugated Steel Pipe |
| PCI | Precast/Prestressed Concrete Institute |
| PVC | Polyvinyl Chloride |
| RCP | Reinforced Concrete Pipe |
| RC | Rapid Curing |
| ROW or R.O.W. | Right-Of-Way |
| RT | Refined Tar |
| SAE | Society of Automotive Engineers |
| SF | Square Foot |
| SM or $m^2$ | Square Meter |

| | |
|---|---|
| SI | The International System of Units. The version of the metric system used in these Specifications. |
| sp gr | Specific Gravity |
| sp visc | Specific Viscosity |
| SY | Square Yard |
| UL | Underwriters' Laboratories, Inc. |
| USC or U.S.C. | United States Code |
| V | Volt |
| VAOT | Vermont Agency of Transportation |
| VCP | Vitrified Clay Pipe |
| VOSHA | Vermont Occupational Safety and Health Act |
| VSA or V.S.A. | Vermont Statutes Annotated |
| W | Watt |

All standard recognized abbreviations may be used in connection with the Contract.

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

ACCEPTANCE DATE - Date noted in the Completion and Acceptance memo on which designated responsible Agency personnel have accepted the completeness and quality of all materials and incorporated into the project.

ACT OF GOD - An "Act of God" means an earthquake, flood, cyclone, or other cataclysmic phenomena of nature, beyond the power of the Contractor to foresee or to make preparation in defense against.

ADDENDUM - A supplement to the proposal form as originally issued or printed, covering additions, corrections, or changes in the bidding conditions for the advertised work, that may be issued by the Agency to prospective bidders prior to the date set for opening of proposals.

ADVERTISEMENT - A public announcement, inviting bids for work to be performed and/or materials to be furnished.

AGENCY - Agency of Transportation, State of Vermont (VAOT).

AGGREGATE - Inert material such as sand, gravel, crushed gravel, broken stone, or crushed stone, or a combination thereof.

ARTERIAL HIGHWAY - A general term denoting a highway primarily for through traffic, usually on a continuous route.

AWARD - The acceptance by the Agency of a proposal by the lowest responsible bidder.

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

BIDDER - An individual, partnership, firm, or corporation, or any acceptable combination thereof, or a joint venture, submitting a proposal.

BOARD - State Transportation Board of the State of Vermont or its successors.

BRIDGE - A structure, including supports, erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads and having a clear span of more than 6.1 m (20 feet) [1.8 m (6 feet) on Non-Federal-Aid projects] measured along the center of the roadway between abutments or spring lines of arches or extreme ends of openings for multiple boxes, may include multiple pipes where the clear distance between openings is less than 50 percent of the smaller contiguous opening.

Length - The greater dimension of a structure measured along the center of the roadway between backs of abutment backwalls or between ends of bridge floor.

Width - The clear width of structure measured at right angles to the center of the roadway between the inner faces of parapet or railing.

CALENDAR DAY - Any day shown on the calendar, beginning and ending at midnight.

CHANGE IN DESIGN OR CONSTRUCTION - A form prepared to change original Plans or quantities or both.

CHANNEL - A natural or artificial water course.

CHIEF ENGINEER - See DIRECTOR OF PROJECT DEVELOPMENT.

CHIEF OF CONTRACT ADMINISTRATION - The Agency's authorized representative to enter into and administer the Contract on behalf of the Agency. This representative has the authority to make findings, determinations, and decisions with respect to the Contract and, when necessary, to modify or terminate the Contract.

CLEAR ZONE - The roadside border area starting at the edge of the traveled way, available for use by errant vehicles. Specified clear zones are indicated on roadway typical sections.

COLLUSION - A secret agreement between two or more persons for a deceitful or fraudulent purpose.

COMPLETION DATE - The calendar date by which the work contemplated shall be or is completed.

CONDUIT - A tube used for carrying and protecting electrical or other utilities.

CONSTRUCTION AREA - The "Construction Area" shall mean and include all of that portion of a project within the right-of-way and easement limits while under construction.

CONSTRUCTION EASEMENT - See EASEMENT.

CONSTRUCTION ENGINEER - The duly authorized representative of the Agency responsible for engineering supervision of the construction of a specific project, after the Contract has been executed and until project completion and acceptance.

CONTINGENT ITEM - Any pay item listed on the Plans, or called for in the Contract and included in the proposal merely for the purpose of obtaining a Contract price in case the item may be needed.

CONTRACT - The written agreement between the Agency and the Contractor setting forth the obligations of the parties thereunder, for the performance of the prescribed work.

The Contract includes the invitation for bids, proposal, Contract agreement and Contract bonds, Standard Specifications, Supplemental Specifications, General Special Provisions, Special Provisions, general and detailed plans, notice to proceed, and any supplementary agreements that are required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

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

CONTRACT DOCUMENTS - See CONTRACT.

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

CONTRACT TIME - The number of working days or calendar days allowed for completion of the Contract.

If a calendar date of completion is shown in the proposal in lieu of the number of working or calendar days, the Contract shall be completed by that date.

CONTRACTOR - The individual, partnership, firm, corporation, or any acceptable combination thereof or joint venture, which is a party to the Contract with the Agency, undertaking the execution of the work under the terms of the Contract and acting directly or through its agents or employees. The term "Contractor" is referred to as the prime Contractor as differentiated from a subcontractor.

DETOUR - A temporary route to carry vehicular traffic.

DIAMETER NOMINAL - The metric version of nominal pipe size (NPS), applying to all plumbing, gas, oil, drainage, and miscellaneous piping used in building and heavy construction.

DIRECTOR OF PROJECT DEVELOPMENT - Director of all personnel of the Agency of Transportation in the areas of project design and construction.

Wherever the terms "Chief Engineer," "Director of Engineering and Construction," or "Director of Construction and Maintenance" appear on the Plans, in any Specification, or in the Contract Documents, they shall be read as, and shall mean, "Director of Project Development."

DISTRICT TRANSPORTATION ADMINISTRATOR - The person assigned as representative of the Agency for a subdivision of the State who is responsible for maintenance, force account construction, and liaison between the Agency and Towns, Cities, and Villages.

DRAINAGE - The system of pipes, drainage ways, ditches and structures by which surface or subsurface waters are collected and conducted from the construction area.

EASEMENT (RIGHT-OF-WAY) - 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 fill section situated between the existing ground and the subgrade.

ENCROACHMENT - Illegal use of highway right-of-way or easement.

ENGINEER - The Director of Project Development of the Agency, acting directly or through the Director's duly authorized representatives, who are responsible for engineering supervision of the construction. Where the term "Director" is used, it shall mean the Director of Project Development in person.

EQUIPMENT - All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and the tools and apparatus necessary for the proper construction and acceptable completion of the specified work.

ESCROW - An account that allows the Contractor to gain interest on retained monies in accordance with Title 19 VSA Section 11c.

EXTRA WORK - An item of work not provided for in the Contract as awarded but found by the Engineer essential to the satisfactory completion of the Contract within its intended scope. Extra Work shall be performed at agreed prices or on a force account basis as provided elsewhere in these Specifications.

EXTRA WORK ORDER - A special form used which concerns the performance of work or furnishing of materials involving Extra Work.

FEDERAL HIGHWAY ADMINISTRATION - An agency within the US Department of Transportation, Washington, D.C.

FINAL ACCEPTANCE DATE - Date on which the Secretary of the Vermont Agency of Transportation signs the final estimate. It shall apply to acceptance of the Contract quantities and amount.

FINAL ESTIMATE - A summary of quantities prepared upon completion of the Contract, stating the whole amount of work done by the Contractor and the value of such work.

FORCE ACCOUNT - Prescribed work paid for on the basis of actual costs including appropriate extras as defined under Subsection 109.06.

FRONTAGE STREET (OR ROAD) - A local street or road auxiliary to and located on the side of an arterial highway for service to abutting property and adjacent areas and for control of access.

GENERAL SPECIAL PROVISIONS - Approved additions and revisions to the Standard Specifications.

GRADE SEPARATION - A crossing of two or more transportation facilities at different elevations.

HIGHWAY - A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

HOLIDAYS - In the State of Vermont, "Holidays" occur on:

| | |
|---|---|
| New Years Day | January 1 |
| M.L. King's Birthday | Third Monday in January |
| Washington's Birthday | Third Monday in February |
| Town Meeting Day | First Tuesday in March |
| Memorial Day* | Both May 30 (State of Vermont) and the last Monday in May (Federal Government) |
| Independence Day | July 4 |
| Bennington Battle Day | August 16 |
| Labor Day | First Monday in September |
| Columbus Day | Second Monday in October |
| Veteran's Day | November 11 |
| Thanksgiving Day | Fourth Thursday in November |
| Christmas Day | December 25 |

* These dates may coincide.

If a Holiday falls on a Sunday, the following Monday shall be considered the Holiday, or if a Holiday falls on a Saturday, the Friday, immediately preceding, shall be considered the Holiday.

INSPECTOR - The authorized representative of the Engineer assigned to make detailed inspections of Contract performance.

INVITATION FOR BIDS - The advertisement for proposals for all work or materials on which bids are required. Such advertisement will indicate with reasonable accuracy the quantity and location of the work to be done or the character and quantity of the material to be furnished and the time and place of the opening of proposals.

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

LIQUIDATED DAMAGES - The charge assessed against the Contractor by the State because of failure of the Contractor to complete the Contract within the Contract time or by the Contract completion date.

MASS - In these Specifications, the words "mass" and "weight" are used interchangeably. Mass must be converted to force (by multiplying by gravity) before computing structural reactions, shears, moments, or internal stresses. See also WEIGHT.

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

MATERIALS AND RESEARCH ENGINEER - The duly authorized representative of the Agency responsible for the supervision, research, and approval of materials specified in contracts or to be added to the approved products list.

MEDIAN - The portion of a divided highway separating the traveled ways for traffic in opposite directions.

METRIC TON - A unit of measure equivalent to 1000 kg. See also TON.

NON-PARTICIPATING - As used in the Contract for Federal-Aid projects, designates work in which the cost is not shared by the Federal Government.

NOTICE TO PROCEED - Written notice to the Contractor stipulating the date on which it is expected the Contractor will begin on-project construction and from which date Contract time will be charged.

PAY ITEM - See CONTRACT ITEM.

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.

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

PLANT INSPECTOR - The authorized representative of the Agency assigned to make detailed inspections of methods and materials at bituminous and concrete plants and responsible for signing the ticket.

PROFESSIONAL ENGINEER - A qualified registered Professional Engineer licensed in the State of Vermont or eligible to practice engineering in the State of Vermont under the transient practice provisions of Title 26 VSA Section 1181a.

PROGRAM MANAGER - The authorized representative of the Engineer assigned to review and approve the Contractor's drawings, details, and plans for a specific project, to

determine feasibility and conformance with the Plans and Specifications, and to approve of any changes from the original Contract Documents.

PROFILE GRADE - The trace of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal centerline. Profile grade means either elevation or gradient of such trace according to the context.

PROJECT - The specific section(s) of the transportation facility on which work is to be performed under one or more contracts.

PROPOSAL - The offer of a bidder, on the prescribed form, to perform stated construction work at the prices quoted.

PROPOSAL FORM - The prescribed form on which the offer of a bidder is to be submitted.

PROPOSAL GUARANTY - The security furnished with a bid to ensure that the bidder enters into the Contract if the bidder's offer is accepted.

QUESTIONNAIRE - The approved form or forms upon which the Contractor shall furnish the information as to financial ability, adequacy of plant and equipment, organization, prior experience, and such other pertinent and material facts having bearing upon the Contractor's ability to perform the work and to finance the work.

REGIONAL CONSTRUCTION ENGINEER - The duly authorized representative of the Chief Engineer in each of the regional divisions that the State is divided into for the purposes of administering construction contracts.

RESIDENT ENGINEER - The duly authorized representative of the Director of Project Development responsible for engineering supervision of a specific project.

RIGHT-OF-WAY - A general term denoting land, property, or interests therein, acquired for or devoted to transportation purposes.

ROAD - See HIGHWAY.

ROADBED - The graded surface prepared as a foundation for the pavement structure and shoulders, also called subgrade.

ROADSIDE - A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

ROADWAY - The portion of a highway within limits of construction.

SACK - A standard unit of dry powder cement with a mass (weight) of 42.64 kg (94 pounds).

SCHEDULE OF WORK - The approved CPM or other work schedule, prepared and submitted by the Contractor.

SECRETARY - The appointed head of the Agency of Transportation of the State of Vermont.

SELECTMEN - The elected or appointed board authorized to make transactions for the Town.

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.

SLOPES - The inclined graded areas extending from the shoulders to the natural undisturbed 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 - Additions and revisions to the Standard Specifications and Supplemental Specifications, or General Special Provisions applicable to an individual contract.

SPECIALTY ITEM - Specialty items shall be construed to be limited to work that requires highly specialized knowledge, ability or equipment not ordinarily available in contracting organizations qualified to bid on the Contract as a whole and in general are to be limited to minor components of the overall Contract.

SPECIFICATIONS - The compilation of provisions and requirements for the performance of prescribed work including the Standard Specifications, Supplemental Specifications, General Special Provisions, and Special Provisions.

STANDARD PLANS - Agency approved drawings used for repetitive use, showing details to be used where appropriate.

STANDARD SPECIFICATIONS - See STANDARD SPECIFICATIONS FOR CONSTRUCTION.

STANDARD SPECIFICATIONS FOR CONSTRUCTION - The book entitled *Standard Specifications for Construction*, as approved for general application and repetitive use.

STATE - The State of Vermont, acting through its authorized representative.

STREET - A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

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 (vertical:horizontal) slope to the intersection with the existing ground.

STRUCTURES ENGINEER - The duly authorized representative of the Agency responsible for structural engineering supervision of a specific project. Also the Structures Program Manager.

STRUCTURE - Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, headwalls, buildings, sewers, service pipes, underdrains, foundation drains, and other features which may be encountered in the work and not otherwise classified in these Specifications.

SUBBASE - The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base or surface course.

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

SUBGRADE - The graded surface prepared as a foundation for the pavement structure and shoulders, also called roadbed.

SUBSTANTIAL COMPLETION DATE - Substantial completion date shall be the date when, in the opinion of the Engineer, the work under the Contract has been sufficiently completed, to enable use of the project or facilities by the Agency for the purpose originally intended.

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; including 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, excluding the approach slabs.

SUPPLEMENTAL AGREEMENT - A written agreement made and entered into by and between the Contractor and the Agency covering work not otherwise provided for, revisions in or amendments to the terms of the Contract, or conditions specifically prescribed in these Specifications as requiring supplemental agreements. Such supplemental agreement becomes a part of the Contract when approved and properly executed.

SUPPLEMENTAL SPECIFICATIONS - Specifications for sections not included in the Standard Specifications or sections rewritten subsequent to publication of this edition.

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.

SURFACE COURSE - The uppermost component of a pavement structure, also called the wearing course.

TON - In these Specifications, the word "ton" by itself is a unit of measure equivalent to 2000 pounds. See also METRIC TON.

TOWN, CITY, OR VILLAGE - A subdivision of the State used to designate or identify the location of the proposed work.

TRAFFIC DESIGN ENGINEER - (Formally the Traffic and Safety Engineer) The duly authorized representative of the Agency responsible for the supervisions of traffic design and safety of a specific project.

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

UNIT PRICE - The Contract price for one unit of work, as defined by these Specifications.

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, storm water, not connected with highway drainage, and other similar commodities, including 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.

WEIGHT - In these Specifications, the words "weight" and "mass" are used interchangeably. See also MASS.

WEIGHTS AND MEASURES - Vermont Department of Agriculture, Division of Weights and Measures.

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 - A calendar day during which normal construction operations could proceed for a major part of the daylight shift, as determined by the Engineer, normally excludes Saturdays, Sundays, Holidays, and the period between December 1 and April 15.

WORKING DRAWINGS - Supplemental design sheets or similar data which the Contractor is required to submit to the Engineer such as stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, and bending diagrams for reinforcing steel.

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

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

(b) Informs the Contractor of work that is not being accomplished according to the Plans and these Specifications, and directs corrective action.

(c) Documents quantities to be paid for designated Contract items.

(d) Brings to the Contractor's attention any other information or concerns that the Engineer may wish to emphasize.

101.03 INTENTION OF TERMS. In order to avoid cumbersome and confusing repetition of expressions in these Specifications, it is provided that whenever anything is, or is to be, done, if, as, or, 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 understood as if the expression were followed by the words "by the Engineer" or "to the Engineer."

When the phrases, "as ordered by the Engineer," "as directed by the Engineer," or those implied herein are used in these Specifications, it shall be understood that these phrases are to provide the Engineer latitude to meet field conditions, but in no case shall these phrases be construed to permit changing the intent of these Specifications.

The words "furnish," "provide," or words of like import when used in relation to the "Contractor," shall mean at the Contractor's expense, unless specifically included in a Contract item.

## SECTION 102 - BIDDING REQUIREMENTS AND CONDITIONS

102.01 INVITATION FOR BIDS. The invitation for bids contains a description of the proposed work to be performed or materials to be furnished. It will indicate within reasonable accuracy the quantity of work to be done or the character and quantity of the material to be furnished, and the time and date of opening of proposals.

Information will be shown as to the access to proposal forms, the Plans and these Specifications, the amount and nature of the proposal guaranty, prequalification requirements for the proposed work, and the reservation of the right of the Agency to reject any and all bids and waive any and all technicalities.

Pertinent data included in the above information is published in newspapers and trade publications in advertisement form.

The Agency prepares an engineer's estimate for each project. This estimate is a confidential document. To assist prospective bidders in determining if they are

prequalified to bid on a proposal, the Agency will classify each invitation for bid according to the following:

| Engineer Estimate | Category |
|---|---|
| Less than $250,000 | A |
| $250,000 to $500,000 | B |
| $500,000 to $1,000,000 | C |
| $1,000,000 to $2,500,000 | D |
| $2,500,000 to $5,000,000 | E |
| $5,000,000 to $10,000,000 | F |
| Over $10,000,000 | G |

102.02 PREQUALIFICATION (COMPETENCY OF BIDDERS). Proposals will be issued only to prequalified bidders.

A contractor who is not prequalified and who intends to bid on construction work advertised by the Agency, must file, at least five days prior to the time of receipt of bids, a questionnaire and confidential statement on forms furnished by the Agency, unless otherwise stated in the "Invitation for Bids."

A contractor who has been disqualified from participation in Agency contracts in accordance with the "Policy and Procedures on Debarment" adopted by the Agency will not be issued proposal forms.

Where limited participation of debarred firms is allowed, the participation shall be in accordance with the Agency's "Policy and Procedures on Debarment."

Any participation of a suspended or debarred firm or individual relative to a Federal-Aid project will be in accordance with Part 29, Title 49 CFR, which prohibits the company, the individual, and any firm from participation as a contractor or subcontractor, or as a supplier or provider of labor, materials, or services to any contractor or subcontractor in such programs for the duration of the suspension or debarment periods.

102.03 CONTENTS OF PROPOSAL FORMS. Upon request, the qualified bidders will be furnished by the Agency with proposal forms which will state the location and description of the work to be done, completion date, and approximate quantities and kinds of work to be performed, materials to be furnished, Special Provisions, General Special Provisions, Supplemental Specifications, the amount of the proposal guaranty (which must accompany the proposal), and the date, time, and place of the opening of proposals. All papers bound with or attached to the proposal form are a necessary part thereof and must not be detached.

The Agency reserves the right to revise the Plans, these Specifications, and proposal form for any project at any time prior to the date set for opening the proposals. Revisions will be made by a dated addendum, subject to the following provisions:

(a) When an addendum is to be issued, each prospective bidder who has received a proposal form prior to the date of the addendum will be contacted by telephone

and receive the addendum by certified mail, express mail, or other mail or courier service which provides a written record of the time and date of receipt and a written signature of the recipient. Each proposal form issued after the date of an addendum will have the addendum attached thereto.

(b) If the revisions made by an addendum require considerable change or reconsideration on the part of the bidder, the date set for opening the proposals may be postponed, in which case the addendum will include an announcement of the new date set for opening proposals.

(c) Each bidder shall acknowledge receipt of each addendum, when not issued with the proposal form, by returning one copy of the issued addendum with the recipient's signature and the date of receipt thereon.

(d) Each bidder shall also acknowledge the receipt of all addenda, by entering the number and date of each addendum, and signing in the designated place on the face of the bid envelope.

(e) Additionally, each holder of the Plans, Special Provisions, or sample proposal forms will receive the addendum by certified or other mail or courier service mail. Each set of the Plans, Special Provisions, and sample proposal forms issued after the date of an addendum will be accompanied by a copy of the addendum. Holders of the Plans, Special Provisions, and sample proposal forms will not be notified by telephone and will not be required to acknowledge receipt of each addendum.

(f) When a change is made only to the proposal and does not affect the project Special Provisions or the Plans, the addendum will be sent only to the prospective bidders who have received a proposal form.

102.04 INTERPRETATION OF APPROXIMATE ESTIMATE. The bidder's attention is called to the fact that the estimate of quantities of work to be done and materials to be furnished under these Specifications, as shown on the proposal form is approximate and is given only as a basis of calculation upon which the award of the Contract is to be made. Therefore, the Agency disclaims any responsibility that the aforementioned quantities shall be less than, equal to, or greater than the quantities used in the actual construction of the work. The Contractor shall not plead misunderstanding or deception because of such estimate of quantities or of the character, location, or other conditions pertaining thereto. The Agency reserves the right to increase or diminish any or all of the above-mentioned quantities of work or to omit any of them as the Agency may deem necessary.

102.05 EXAMINATION OF PLANS, SPECIFICATIONS, PROPOSAL FORMS, AND SITE OF WORK. The bidder shall examine carefully the site of the work contemplated and the Plans, Specifications, and proposal forms. It will be the responsibility of the bidder or Contractor to investigate and to become aware of the conditions to be encountered, as to the character, quality, and quantities of the work to be performed and materials to be furnished, and as to the requirements of the Plans, Specifications, proposal, and Contract forms.

To assist in the preparation of the design for a project, the Agency normally by means of borings, test pits, sampling, testing, and classification makes investigations of subsoils, foundation conditions, and potential sources of material for: character, quality, and quantity. Normally, information concerning these investigations will appear in the Contract Documents.

Boring logs and other subsurface information contained in the Contract or made available to bidders were obtained with reasonable care and recorded in good faith by the Agency for design and estimating purposes. The Agency and Contractor mutually agree and understand that supplying this information as part of the Contract is a voluntary act and not done in compliance with any legal or moral obligation on the part of the Agency.

Soil classifications have been made from laboratory tests of samples extracted or collected. Rock descriptions, engineering properties, or classifications are from visual inspection and tests of cores or 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. Insofar as such disclosure is made, the information may only approximately represent existing conditions and the Agency claims no responsibility or warranties, express or implied, as to the completeness or accuracy of the information. Such disclosure is not intended as a substitute for personal investigations, interpretations, or judgements by the bidder. It shall be the responsibility of the bidders or subcontractors to satisfy themselves through their own independent investigations as to the conditions and materials to be encountered.

The Agency accepts no liability for any of the aforementioned information, should it be found to be erroneous, or should actual conditions or materials vary from the data appearing in the Contract.

It is the bidder's responsibility to convey all information relative to Contract requirements to any proposed suppliers, fabricators, or subcontractors.

102.06 DIFFERING SITE CONDITIONS.

(a) During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those specified 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 they are disturbed and before the affected work is performed.

(b) Upon written notification, the Engineer will investigate to determine if the conditions materially differ and will cause an increase or decrease in the cost or time required for the performance of any work under the Contract. The Contractor will be notified of the Engineer's determination, whether or not an adjustment of the Contract is warranted. If an adjustment is warranted, the

Contract will be modified in writing accordingly. Any adjustment made will exclude loss of anticipated profits.

(c) 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 Contract adjustment will be allowed under this clause for any effects caused on unchanged work.

102.07 PREPARATION OF PROPOSAL. Proposals shall be made by the Contractor on proposal forms furnished by the Agency. Each proposal form must be completely filled out and executed with the written signature of the individual authorized to sign legal documents for the Contractor. All blank spaces under the page heading "Schedule of Prices" must be filled in with ink or typewriter in both words and figures indicating the unit price for each respective bid item.

In case of a discrepancy between the unit prices written in words and those entered in figures, the unit price in written words shall govern.

When proposals have unit cost bid items submitted for a fractional cent, the total cost for the quantity of the item shall be determined by carrying unit price computations out through the fourth digit after the decimal point. The fifth digit shall be dropped with no rounding off onto the fourth digit. All bid results shall be computed on this basis for purposes of determining the low bidder.

When "Optional Bid Items" are indicated in the proposal, the Contractor shall bid on only one pay item in each group of options, leaving the other pay items in the group without a unit bid price. In case the bidder enters more than one unit price bid in a group of options, only the lowest unit price will be considered as the basis of calculation for determining the low bidder.

When "Alternate Bid Items" are indicated in the proposal, the Contractor must bid on all pay items in each such Alternate. Failure to bid on all of the "Alternate Bid Items" in the proposal will result in rejection of the bid.

When the Schedule of Prices for this project contains one or more pay items which have a quantity of one and a unit price and total price entered, this identifies pay items for which the Agency has set a unit price in the event the items are used on the project. If the items are needed, as determined by the Engineer, the work will be performed by the Contractor according to these Specifications at the unit prices listed.

When it is specified in the Contract Documents that payment or costs of work and/or materials are incidental to all other Contract items (but not to specific other items), such incidental costs shall be included by the bidder in the price bid for the Contract item Mobilization.

If the proposal is made by an individual, the individual's name and post office address must be shown. If made by a firm or partnership, the names and post office addresses of each member of the firm or partnership must be shown, and whether or not the partnership is registered to do business in the State of Vermont. If made by a

corporation, the person signing the proposal must show the name of the State under the laws of which the corporation is chartered, the location of its principal office, the amount of the paid up capital stock, and whether or not the corporation is authorized to do business under the laws of the State of Vermont, and must be an official authorized to sign for the corporation (provide the signer's position in the corporation and the official address of the corporation).

The Contractor must complete the Debarment and Non-Collusion Affidavit included in the furnished proposal form prior to submitting a bid. This affidavit, which is a sworn statement executed by, or on behalf of, the person, firm, association, or corporation to whom a contract may be awarded, certifies that such person, firm, association, or corporation has not either directly or indirectly entered into any agreement, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in conjunction with such contract and has not been suspended, indicted, convicted, or had a civil judgement rendered against them within the past three years. The statement must be sworn to before a person who is authorized to administer oaths.

The completed affidavit must remain in, and be submitted with, the proposal.

102.08 REJECTION OF PROPOSALS. Proposals may be rejected if they show any alteration of form, omissions or additions not called for, lack of proper signature, conditional bids, alternate bids unless so requested in the proposal form, irregularities of any kind, changes of printed content, submission on forms not furnished by the Agency, incompleteness, or inclusion of a clause in which the bidder reserves a right to accept or reject the Contract award.

Proposals submitted without a completed Debarment and Non-Collusion Affidavit will be rejected.

The Agency shall decide whether any bid prices are unbalanced above or below a reasonable cost analysis value determined by the Director of Project Development. Proposals in which bid prices are obviously unbalanced may be rejected.

102.09 PROPOSAL GUARANTY. No proposal will be considered unless accompanied by a proposal guaranty of the character and amount indicated on the cover sheet of the proposal form, made payable to the Treasurer, State of Vermont, when the Agency is the awarding entity, or to the Treasurer of the awarding entity if other than the Agency.

A bid bond, on a form furnished by the Agency, will be accepted as a proposal guaranty when in the amount indicated on and in the proposal form. A bid bond on forms not furnished by the Agency will not be acceptable.

102.10 DELIVERY OF PROPOSALS. Each proposal must be submitted to the address indicated on the proposal form in a sealed envelope bearing on the outside the name of the awarding entity, the name of the bidder complete with the bidder's address, the name and number of the project for which the bid is submitted, and the scheduled opening date of the proposal. Any proposal received after the time for submittal of bids will be returned to the bidder unopened.

102.11 WITHDRAWAL OR REVISION OF PROPOSALS. A bidder's proposal may be withdrawn or revised by that bidder after it has been deposited but prior to the time set for submitting proposals, provided a request for withdrawal or revision is received by the Chief of Contract Administration. Once the time set for submitting proposals has passed, a bidder will not be permitted to withdraw the submitted proposal unless a written request stating the specific reason(s) for the withdrawal had been received and approved by the Chief of Contract Administration prior to the time set for submitting proposals.

102.12 COMBINATION PROPOSALS AND CONDITIONAL PROPOSALS. If the Agency so elects, proposals may be issued for projects in combination and/or separately, so that bids may be submitted either on the combination or on separate units of the combination. The Agency reserves the right to make awards on combination bids or separate bids to the best advantage of the Agency. No combination of bids, other than those specifically set up in the proposals by the Agency, will be considered. Separate contracts will be written for each individual project included in the combination.

Conditional proposals will be considered only when so stated in the special provisions.

102.13 PUBLIC OPENING OF PROPOSALS. Proposals will be opened publicly and read aloud at the time and place specified in the proposal form and the "Invitation for Bids" sheet. Bidders, their authorized agents, and other interested parties are invited to be present. The time of receiving and opening bids may be postponed due to emergencies or unforeseen conditions. When circumstances arise which necessitate changing the opening date, the prospective bidders will be notified by issuance of an addendum in accordance with Subsection 102.03.

102.14 DISQUALIFICATION OF BIDDERS. Bidders may be disqualified for various reasons such as:

(a) More than one proposal for the same work from an individual, firm, or corporation under the same or different names.

(b) Evidence of collusion among bidders or any other cause for suspension or debarment as detailed in the Agency's debarment procedures referred to in Subsection 102.02.

102.15 MATERIAL GUARANTEE. The successful bidder may be required to furnish a complete statement of the origin, composition, and manufacture of any or all materials to be used in the construction of the work together with samples; which samples may be subjected to the tests provided for in these Specifications to determine their quality and fitness for the work.

102.16 FAMILIARITY WITH LAWS. The bidder has the responsibility to be familiar with all Federal, State, and local laws, ordinances, and regulations which in any manner affect those engaged or employed in the work, or the materials or equipment or haul roads used in or upon the work, or in any way affect the conduct of the work, and no plea of misunderstanding will be considered on account of ignorance

thereof. If the bidder or Contractor shall discover any provision in the Plans, proposal, Specifications, or Contract which is contrary to or inconsistent with any such laws, bylaws, ordinance, or regulation, the bidder or Contractor shall forthwith report it to the Secretary in writing. The State shall assume no responsibility or liability for any cause of action that may arise against the State of Vermont because of the failure of the bidder or Contractor to give the Secretary notice in writing of any error or inconsistency in the Plans, proposal, Specifications, or Contract.

102.17 ESCROW ACCOUNTS. The bidder has the option to have any funds retained by the Agency under this Contract deposited into an escrow account, pursuant to Title 19 VSA Section 11c. The bidder must indicate the desire to escrow or to not escrow retained funds by checking the appropriate box on the proposal form.

The successful low bidder shall return the filled out escrow agreement to the Agency within 21 calendar days following the date of the letter transmitting the blank escrow agreement. The Contractor shall fill out the escrow agreement, sign it, and have it signed by the Contractor's bank and the Contractor's surety before returning it to the Agency.

## SECTION 103 - AWARD AND EXECUTION OF CONTRACT

103.01 CONSIDERATION OF PROPOSALS. After the proposals are opened and read, they will be compared on the basis of the summation of the products of the quantities shown in the bid schedule multiplied by the unit bid prices. The results of such comparisons will be immediately available to the public. In the event of a discrepancy between unit bid prices and extensions, the unit bid price shall govern.

The right is reserved to reject any or all proposals, to waive technicalities or to advertise for new proposals, if in the judgment of the awarding authority the best interests of the Agency will be promoted thereby.

103.02 AWARD OF CONTRACT. Award of the Contract, if it be awarded, will be made to the lowest responsible bidder whose proposal shall comply with all the provisions required to render it formal. If the bidder is a corporation, its authority to do business under the laws of Vermont shall be in conformity with Subsection 103.07. No award will be made until all necessary investigations are made as to the responsibility of the low bidders.

The successful bidder will be notified by letter, mailed to the address shown on the submitted proposal, that its specific bid has been accepted subject to execution and approval of the Contract as required by law.

When a bidder is aggrieved by the proposed award of a contract to an apparent low bidder, the bidder may appeal in writing to the Secretary. Oral notice of the intent to appeal must be given to the Chief of Contract Administration by 4:30 p.m. of the day of bid opening. The written appeal must be received within seven calendar days following the bid opening of the project in question and shall outline the nature of the grievance and include appropriate documentation supporting the bidder's position. The

Secretary shall render a decision to the bidder within 14 calendar days of the bid opening.

103.03 RETURN OF PROPOSAL GUARANTIES. Proposal guaranties of the two lowest responsible bidders will be retained until the Contract and bonds have been fully executed. Proposal guaranties of all other bidders will be returned as soon as possible.

Should no award be made within 30 calendar days, all proposals may be rejected and all guaranties may be returned.

103.04 REQUIREMENT OF CONTRACT BONDS. The successful bidder entering into a contract for any portion of the work will be required to provide the Agency sufficient surety in the form of a labor and materials bond and a compliance bond, each bond in a sum equal to 100 percent of the contract awarded. The form of bond shall be that provided by the Agency, and the surety shall be acceptable to the Secretary. These bonds shall be procured from an insurance company registered and licensed to do business in the State of Vermont. The bonds shall guarantee the execution, faithful performance, and completion of the work to be done under the Contract, and the payment in full of all bills and accounts for material and labor used in the work.

103.05 EXECUTION OF CONTRACT. The individual, partnership, firm, or corporation to whom or to which the Contract has been awarded shall sign the necessary agreements and return them to the office of the Agency at Montpelier within 15 calendar days from the date notice is mailed that the Contract is ready for execution. The mailing date of the letter of award of the Contract shall be considered the date that the Contract is ready for execution. No contract shall be considered as effective until it has been fully executed by all of the parties thereto.

The Agency reserves the right to cancel the award of any contract at any time before the execution of said contract by all parties without any liability against the Agency.

Upon execution of the Contract, the Contractor will, upon request, be supplied by the Agency with two copies of the *Standard Specifications for Construction*. The Contractor will also be supplied with the Plans in accordance with Subsection 105.03.

103.06 FAILURE TO EXECUTE CONTRACT. Failure to comply with any of the requirements of the Contract Documents, or failure to furnish the required surety within 15 calendar days after notice of award, as specified, shall be just cause for the annulment of the award, or of the Contract if executed, and it is understood by the bidder, in the event of the annulment of the award or of the Contract, that the proposal guaranty accompanying the proposal shall become the property of the State, not as a penalty but as liquidated damages.

Award may then be made to the next lowest responsible bidder, or the work may be readvertised and constructed under contract or otherwise, as the Agency may decide.

103.07 AUTHORITY TO CONTRACT. The Contractor shall be registered with the Vermont Secretary of State to do business in the State of Vermont if the Contractor is a domestic or foreign corporation, or is a resident co-partner or resident member of a co-partnership or association, or is a non-resident individual or individuals doing business

in this State in its or their individual capacity, or under any name other than the Contractor's own personal name. Any foreign corporation or non-resident co-partnership, partnership, association, or any non-resident individual or individuals doing business either in their own name or under some other name shall notify the Vermont Secretary of Transportation of the name of the individual designated as process agent prior to the execution of the Contract.

If the Contractor is a corporation, a signed copy of the minutes of said corporation shall be furnished the Agency for each Contract showing delegation of authority to the officer or officers executing the Contract on behalf of the corporation.

As required by law (Title 32 VSA Section 3113), the Contractor, by signing the Contract, hereby certifies, under the pains and penalties of perjury, that the Contractor is in good standing with respect to, or in full compliance with a plan to pay, any and all taxes due the State of Vermont as of the date the Contractor signs the Contract.

The Contractor, by signing the Contract, agrees to comply with the Americans with Disabilities Act of 1990 and to ensure that individuals with disabilities have equitable access to the services, programs, and employment activities/opportunities offered by the Contractor under the Contract.

The Contractor, by accepting and signing the Contract, agrees to fully comply with the provisions of Title 19 VSA Chapter 12, also referred to as S-51 of 1991 or the Prompt Payment Act, in all actions relating to the performance of the Contract.

103.08 CONSTRUCTION EQUIPMENT TAX. The Contractor agrees that all construction equipment tax as assessed under Title 32 VSA Section 3603, for machinery and other personal estate either in the State on April 1 or brought into the State between April 1 and December 1, shall be paid, and the terms for Title 32 VSA Section 3603, are by reference, made a part hereof.

103.09 WITHHOLDING OF TAXES. The Contractor agrees that the requirements of subchapter 4 of Chapter 151 of Title 32 VSA relating to the withholding of taxes from employees shall be complied with and that all taxes withheld pursuant to subchapter 4 shall be reported and paid to the Commissioner of Taxes.

103.10 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 (see Vermont Sales and Use Tax Regulations No. 226-2 and 226-7) and used exclusively in the conduct of its business or purpose; 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.

103.11 INSURANCE. Insurance obtained by the Contractor to cover the below-listed requirements shall be procured from an insurance company registered and licensed to do business in the State of Vermont. Before the Contract is executed, the Contractor

shall file with the Agency a certificate of insurance, in duplicate, executed by an insurance company or its licensed agent(s), on form satisfactory to the Agency, stating that with respect to the Contract awarded, the Contractor carries insurance in accordance with the following requirements:

(a) Workers Compensation Insurance. With respect to all operations performed, the Contractor shall carry Workers Compensation Insurance in accordance with the laws of the State of Vermont. The Contractor shall also ensure that all subcontractors carry Workers Compensation Insurance for all work performed by them.

(b) Contractor's Public Liability and Property Damage Insurance. With respect to all operations performed by the Contractor and subcontractors, the Contractor shall carry Public Liability and Property Damage Insurance providing all major divisions of coverage including, but not limited to:

Premises - Operations
Independent Contractor's Protective
Products and Completed Operations
Personal Injury Liability
Contractual Liability applying to the Contractor's obligations under Subsection 107.16, Broad Form Property Damage
Collapse and Underground (CU) Coverage
Explosion (X) Coverage, unless this requirement is waived in writing by the Agency of Transportation

(1) If the Public Liability Coverages are provided under a Commercial General Liability Policy, coverage shall be provided on an "Occurrence" form. Limits of Coverage shall be not less than:

| | |
|---|---|
| $1,500,000 | Each Occurrence |
| $2,000,000 | General Aggregate applying, in total, to this project only |
| $2,000,000 | Products/Completed Operations Aggregate |
| $ 250,000 | Fire Damage |

(2) If the Public Liability Coverages are provided under a Comprehensive General Liability Policy, Limits of Coverage shall be not less than:

| | |
|---|---|
| Bodily Injury: | $1,000,000 Each Occurrence, $1,000,000 Aggregate |
| Property Damage: | $ 500,000 Each Occurrence, $1,000,000 Aggregate |

OR

| | |
|---|---|
| Combined Single Limit: | $2,000,000 Each Occurrence, $2,000,000 Aggregate |

(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. Limits of Coverage shall be not less than:

| | |
|---|---|
| Bodily Injury: | $ 500,000 Each Person,<br>$1,000,000 Each Occurrence |
| Property Damage: | $ 500,000 Each Occurrence |

OR

| | |
|---|---|
| Combined Single Limit: | $1,500,000 Each Occurrence |

(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 and by the Contractor's subcontractors, Railroad Protective Liability Insurance in form and amount as required by the railroad company and as specified in the Special Provisions and Supplemental Specifications for the project. If not available from insurance companies registered and licensed to do business in the State of Vermont, this insurance may be procured from Eligible Surplus Lines Companies approved by the Vermont Department of Banking and Insurance.

The Contractor shall file the original Railroad Protective Policy and one duplicate policy with the Agency of Transportation. The Agency will transmit the original Railroad Protective Policy to the Chief Engineer of the railroad concerned.

The Railroad Protective Policy shall remain in force until all work required to be performed on railroad property is completed to the satisfaction of the Chief Engineer of the railroad and of the Director of Project Development of the Agency.

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

(e) General Insurance Conditions. The insurance specified under parts (a), (b), and (c) above shall be maintained in force until acceptance of the project by the Agency.

Under part (b) above, Products and Completed Operations Coverage shall be maintained in force for at least one year from the date of acceptance of the project.

The contractual liability insurance requirements detailed in the Contract Documents, including Subsection 107.16, are to indemnify, defend, and hold harmless the Agency and its officers, agents, representatives, and employees, with respect to any and all claims, causes of action, losses, expenses, or damages resulting in death, bodily injury, or property damage resulting from the actions, inactions, errors, omissions, malfeasances, or misfeasances of the Contractor.

Each policy shall name the Vermont Agency of Transportation as an additional insured for the possible liabilities resulting from the Contractor's actions or omissions.

Umbrella Excess Liability Policies may be used in conjunction with primary policies 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 insurance company shall agree to investigate and 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:

> *Anything herein to the contrary notwithstanding, no cancellation, termination, or alteration of this policy by the company or the assured shall become effective unless and until notice of cancellation, termination, or alteration has been given by registered mail to the Director of Project Development of the Vermont Agency of Transportation, National Life Building, Montpelier, Vermont 05633-5001, at least 30 calendar days before the effective cancellation, termination, or alteration date unless all work required to be performed under the terms of the Contract is satisfactorily completed as evidenced by the formal acceptance by the Agency.*

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, but the cost thereof shall be considered included in the general cost of the work.

## SECTION 104 - SCOPE OF WORK

104.01 INTENT OF CONTRACT. The intent of the Contract is to provide for the construction and completion in every detail 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 Plans, Specifications, and terms of 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; and in locations. Such alterations will not constitute a change in the Specifications, a waiver of any condition of the Contract, or invalidate any of the provisions of the Contract Documents.

Payment for work occasioned by changes or alterations will be made according to Subsections 109.04 and 109.05. If the altered or added work is of sufficient magnitude as to require additional time in which to complete the project, such time adjustment may be made according to Subsection 108.11.

104.03 EXTRA WORK. The Contractor shall perform extra or unforeseen work, for which there is no quantity and price included in the Contract whenever it is deemed necessary or desirable in order to complete the work as contemplated. Such work shall be performed according to these Specifications or as directed by the Engineer, and will be paid for as provided under Subsection 109.06.

104.04 MAINTENANCE OF TRAFFIC. All roadways to be used by the traveling public, including such temporary highways, bridges, and approaches as necessary to accommodate the traffic diverted from the roadway undergoing improvements, shall be provided and maintained, in a safe and passable condition by the Contractor.

As a minimum, one-way traffic will be maintained during working hours. Working hours will be limited to the period between sunrise and sunset. As a minimum, one-way traffic highway facilities shall be open to the unrestricted two-way flow of traffic, unless otherwise shown on the Plans or directed by the Engineer.

When the Plans contain an Agency designed traffic control plan that includes, but is not limited to, references to standard sheets, the Contractor may submit an alternate traffic control plan for the project. This alternate plan may be for the entire traffic control plan of the project or for one or more phases of the Agency's design in the Plans, including the specific location of the lanes where the traffic will be maintained.

The submitted alternative must include complete construction details, including all facets of traffic control, to the same extent as provided in the Agency design.

The Contractor shall allow the Agency 30 calendar days to review the proposed alternative before it is to be implemented.

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, they shall be constructed and maintained by the Contractor and no compensation will be made except as provided in the Contract. If the Contractor elects to construct a temporary bridge on detours contiguous to the work, over which traffic is to be maintained while a culvert or bridge is being constructed, this temporary bridge shall be constructed according to Section 528. The expense of the construction, maintenance, and removal of this temporary bridge and its approaches and all incidental work pertaining thereto shall be included in the cost of the Contract items involved in the structure whenever Maintenance of Traffic for Bridge Projects or Temporary Bridge is not included as a bid

item in the Contract. The Contractor is completely 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, and flaggers required in accordance with Subsections 107.09 and 107.10.

If conditions on active projects (not closed down for the winter) are such that snowplowing, sanding, or salting of the highway including temporary highways, detours, and bridges are necessary, the Contractor shall perform such snowplowing, sanding, and salting. The costs for snowplowing and sanding will be paid for under the Contract item Roadway Patrol Maintenance, and salting will be paid for under the Contract item Dust and Ice Control with Calcium Chloride.

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 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 in no way relieves the Contractor of any other responsibilities regarding public convenience and safety as specified in this Section, from the liabilities as specified in Subsection 107.13, 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 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 necessary measures to satisfactorily remedy the situation immediately, the Engineer may cause the work to be performed and deduct the cost for same from any monies due or to become due to the Contractor.

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, and warning signs throughout the length of the project as directed by the Engineer. These temporary installations shall conform to requirements for the permanent items except that approved, used material may be substituted. They shall be removed when the Engineer indicates they are no longer required. The installation, maintenance and removal of temporary guardrail, guide posts, barricades, and warning signs will not be paid for directly, but will be considered incidental to other items in the Contract.

When the Contract specifies that the base course or the binder course of pavement be placed prior to suspension of work for the winter season, permanent, rather than temporary, guardrail shall be installed in accordance with the Plans. No payments will be made for any adjustments necessary to these permanent installations in order to accomplish work when construction resumes in the spring.

If construction is suspended on any project before the completion, acceptance, and termination of the Contractor’s responsibility as defined under Subsection 108.15,

regardless of the cause, it shall be the responsibility of the Contractor to take precautions against injury or damage to the work and for reinstallation of damaged work as specified under Subsection 107.18.

All maintenance of traffic procedures shall conform to the applicable requirements indicated in the MUTCD.

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

Unless otherwise provided, all salvageable material being removed shall become the property of the Contractor and shall be disposed of as authorized by the Engineer. Salvage generated by utility relocation shall remain the property of the applicable utility.

104.06 USE OF MATERIALS FOUND IN THE ROADWAY. The Contractor, with the written approval of the Engineer, may use on the project such stone, gravel, sand, or other materials as found in the excavation for other construction items provided the materials meet the requirements of these Specifications.

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

Whenever any material except granular borrow is removed from 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 then no deductions will be made for material used for other items.

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

The Contractor shall not excavate or remove any material that is not within the excavation as shown on the Plans, slope, and grade lines without written authorization from the Engineer.

104.07 FINAL CLEANING UP FOLLOWING COMPLETION OF PROJECT. Upon completion of the work and before acceptance and final payment shall 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 unsightly material.

The Contractor shall in an acceptable manner restore, 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, and leave the waterways unobstructed and

the construction area in a neat and presentable condition, satisfactory to the Engineer, throughout the entire length of the work under contract.

The removal and disposal of silt, debris, and other material from drainage structures and ditches, whether deposited prior to or during construction under this Contract, shall be accomplished as ordered by the Engineer prior to acceptance of the project. No added compensation will be made to the Contractor for this work.

Material supply and disposal areas shall be closed in accordance with Subsection 105.28.

## SECTION 105 - CONTROL OF THE WORK

105.01 AUTHORITY OF THE ENGINEER. The Engineer shall decide all questions which may arise as to the quality and acceptability of materials furnished, the work performed, the manner of performance and rate of progress of the work, and compliance with the requirements of the Contract, and shall decide all questions which may arise as to the interpretation of the Contract.

The Engineer shall determine the amount and quantity of the several kinds of work performed and materials furnished, which are to be paid for under the Contract. The Engineer shall have executive authority to enforce and make effective such decisions and orders as 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 shall have the authority to reject the materials or to suspend the work until the question at issue can be referred to and decided by the Director of Project Development. The Engineer is not authorized to revoke, alter, enlarge, relax, or release any requirements of these Specifications. The Engineer has the authority to suspend the work or withhold payment of all estimates due the Contractor when necessary to secure proper compliance with these Specifications.

In case of the failure on the part of the Contractor to carry on any work ordered by the Engineer, the Engineer may, upon written notice, proceed to carry on such work as deemed necessary and the cost thereof will be deducted from any monies due or which may become due the Contractor under this Contract.

Any advice that the Engineer may give the Contractor shall in no manner be construed as binding the Agency in any way, or releasing the Contractor from the fulfillment of the terms of the Contract.

105.02 DIRECTOR OF PROJECT DEVELOPMENT TO BE REFEREE. It is mutually agreed by both parties to this Contract that the Director of Project Development shall act as referee in all questions of dispute arising under the terms of the Contract unless appealed as hereinafter provided. In the event that the Contractor is aggrieved by the decision of the Director of Project Development, the Contractor may appeal in writing to the Transportation Board via the Director of Project Development completely outlining the nature and extent of the question or questions appealed together with any supported documentation.

All appeals shall be made within 30 calendar days of the decision to which the Contractor is aggrieved, and not thereafter.

105.03 PLANS AND WORKING DRAWINGS. A complete description of the work requires both the Plans, which are furnished to the Contractor by the Agency, and working drawings, which are submitted to the Agency by the Contractor or the Contractor's suppliers. The Plans and drawings will be provided as follows:

(a) Contract Plans. The Agency will furnish plans, consisting of general drawings and details that are necessary to give a comprehensive idea of the construction contemplated. The Plans will show general features of all structures, alignment, grades, typical cross-sections, and specific cross-sections.

The Agency will furnish the prime Contractor one copy of the signed set of the Plans, two complete full size sets of the Plans, and four complete half scale sets of the Plans.

Additional full sets or partial sets requested by the Contractor, subcontractor, fabricator, or supplier will be furnished at the standard current rates charged by the Agency. The Contractor shall keep one set of complete plans available on the project at all times.

(b) Working Drawings. Certain items and construction procedures require plans, drawings, and other information for documented Agency approval of the Contractor's proposed plan for conformance with Contract requirements.

Drawings and details shall be submitted sufficiently in advance of the anticipated work to allow for review and corrections.

The cost of furnishing drawings and details shall be included in the Contract unit price for the item involved.

Plans and details submitted for review and approval shall be addressed to the responsible Program Manager.

Address all submittals to the Vermont Agency of Transportation, National Life Building, Drawer 33, Montpelier, Vermont 05633-5001.

The Contractor or fabricator shall not begin work on the activity or fabrication involved without approval of the details and procedures. One set of "approved" or "approved as noted" drawings or procedures will be returned to the Contractor or fabricator. Agency approval of drawings and procedures indicates concurrence with the information presented and does not relieve the Contractor or fabricator of compliance with all specifications and code requirements. The Agency assumes no responsibility for error(s) and/or omission(s) of details.

Drawings and procedures identified "approved as noted" indicate that specific clarification or conditional changes have been identified and take precedence over submitted information. Withholding of approval by the Agency for selected

details or procedures shall not constitute a basis for delay of performance of a non-related item or work that has approval to proceed.

After approval of the drawings, details, and procedures, no changes shall be made without written approval of the Engineer. The Contractor or fabricator shall assume all risk for materials ordered or work performed prior to approval by the Engineer.

Working drawings to be submitted fall into two categories:

(1) Fabrication Drawings. 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 Plans and these Specifications to define dimensions, sizes, procedures, and materials necessary for complete fabrication and installation or erection of the work specified.

Unless otherwise specified, five sets of drawings and procedures will be required for approval. For projects of normal complexity, the fabricator or supplier shall anticipate a review time of four weeks.

Drawing and detail sheets shall be a maximum of 841 mm (36 inches) horizontal by 594 mm (22 inches) vertical in size. A 30 mm (1 1/2 inch) margin shall be provided on the left and 15 mm (1/2 inch) margins on the remaining three sides. A title block shall be provided in the lower right hand corner and shall include the following:

Town(s) in which project is located
Project name and number
Route number and location information
Prime contractor or fabricator's name and address
Sheet title or identification of details shown
Name of supervisor in charge
Detailer's and checker's name
Date
Sheet number _____ of _____.

Original fabrication drawings shall become the property of the Agency upon completion of the project. Prior to processing the final estimate, the drawings shall be transmitted to the responsible Program Manager. Original drawings shall be on tracing cloth, polyester film, or other acceptable permanent quality material (paper vellum is not acceptable). Drawings in pencil shall be coated with an acceptable protective spray. All "approved as noted" changes must be transferred to the originals prior to transmittal to the Agency.

The following Sections require fabrication and shop drawings:

| Section | Forward To |
|---|---|
| 506 Structural Steel | Structures Engineer |
| 508 Shear Connectors* | Structures Engineer |
| 510 Precast Concrete | Structures Engineer |
| 516 Expansion Devices | Structures Engineer |
| 522 Lumber and Timber (Structural Timber as required) | Structures Engineer |
| 525 Railings | Structures Engineer |
| 526 Bin-Type Retaining Wall | Structures Engineer |
| 531 Bearing Devices | Structures Engineer |
| 616 Curbs and Gutters (Bridge Curb only) | Structures Engineer |
| 677 Overhead Traffic Sign Supports | Structures Engineer |
| 678 Traffic Control Signals | Traffic Design Engineer |
| 679 Street Lighting | Traffic Design Engineer |

* Shear connector details shall be shown on the drawings for structural steel. The drawings shall indicate whether the connectors are to be shop or field applied.

(2) Construction Drawings. For an item or element of work that permits the Contractor optional details, procedures, and materials that affect structural capacity, safety, and/or the results of the work, the Contractor shall prepare for the Agency's review and approval detailed drawings and procedures of how it is proposed to perform and adequately control the work.

Unless otherwise specified, three sets of drawings and procedures will be required for approval. For work of normal complexity, the Contractor shall anticipate a review time of two weeks.

Drawings shall conform to ISO Designation A-1 or A-4 (8 1/2 × 11 inches or 36 × 22 inches) in size and shall have appropriate scale and detail, and shall convey sufficient information for successful prosecution and inspection of the proposed work. Each sheet shall include a title block with the same information as specified for fabrication drawings.

The following Sections require construction drawings:

| Section | Forward To |
|---|---|
| 501 Structural Concrete (e.g., form work - when shown on the Plans or directed by the Engineer) | Construction Engineer |
| 502 Shoring Superstructure | Structures Engineer |
| 506 Structural Steel (Field Welding Procedures) | Structures Engineer |
| 528 Temporary Bridge | Construction Engineer |

105.04 CONFORMITY WITH PLANS AND ALLOWABLE DEVIATIONS. The work shall be performed in reasonably close conformity with the lines, grades, cross-sections, dimensions, and material requirements, including tolerances, shown on the

Plans or specified in these Specifications. Any deviation from the Contract as required will be determined by the Engineer and authorized in writing.

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.

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.

105.05 COORDINATION OF PLANS, STANDARD SPECIFICATIONS, SUPPLEMENTAL SPECIFICATIONS, SPECIAL PROVISIONS, AND GENERAL SPECIAL PROVISIONS. These Standard Specifications, the Supplemental Specifications, the Plans, Special Provisions, General Special Provisions, and all supplemental documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. In case of discrepancy, precedence of the Contract Documents will be determined in the following order:

Contract Document Precedence

(a) Special Provisions
(b) Detail Plans
    (1) Calculated Dimensions
    (2) Scaled Dimensions
(c) General Special Provisions
(d) Standard Plans
    (1) Calculated Dimensions
    (2) Scaled Dimensions
(e) Supplemental Specifications
(f) Standard Specifications

The Contractor shall take no advantage of any apparent error or omission in the Contract Documents.

In the event that the Contractor discovers such error or omission, the Contractor shall immediately notify the Engineer. The Engineer will then make such corrections and interpretations as deemed necessary for fulfilling the intent of the Plans and these Specifications.

When there is an apparent absence of mention of any detail or an apparent omission of a detailed description relative to any point or feature in the Plans, Standard Specifications, Supplemental Specifications, Special Provisions, and General Special Provisions, the meaning to be regarded shall be that the best general engineering and construction practice is to be used and interpretation is to be made on this basis.

Other specifications cited by reference shall become effective only if the work or material covered by them is not included in these Specifications, the Supplemental Specifications, Special Provisions, and General Special Provisions. Specifications so referenced shall be the latest revision in effect on the date of advertisement for bids.

105.06 COOPERATION BY CONTRACTOR. The Contractor shall have available on the project at all times during the prosecution of the work one copy each of the Plans and Specifications. The Contractor shall have on the project at all times a competent and reliable English-speaking representative, authorized to receive orders and to act for the Contractor.

The Contractor shall 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, authorized to receive orders and to issue binding directions concerning safety to all persons associated with the project, whether employed by the Contractor, subcontractors or material suppliers, except Agency representatives.

The Contractor shall furnish to the Engineer a list of addresses and telephone numbers of the Contractor's personnel who may be reached in case of emergency during hours when no work is being performed. On weekends and during storms, the Contractor shall alert certain personnel to stand by and shall inform the Engineer of all arrangements therefore.

The Contractor shall provide all reasonable facilities and furnish the information, assistance, and samples required by the Engineer or Inspector for proper inspecting or testing of materials and quality of work. The Contractor shall also cooperate in setting and preserving stakes, bench marks, and other control points, used in laying out the work.

105.07 COOPERATION WITH UTILITIES. The Agency will notify all utility companies, pipeline owners, or 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.

Water lines, gas lines, wire lines, service connections, water and gas meter boxes, water and gas valve boxes, light standards, 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.

It is understood and agreed that the Contractor at the time of bid submission has already considered all of the permanent and temporary utility appurtenances in their present or relocated positions as shown on the Plans and as evident on the site and that no additional compensation will be allowed for any delays, inconvenience or damage sustained by the Contractor due to any interference from said utility, appurtenances, or the operation of moving them.

Should the Contractor desire temporary changes of location of any utility 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 traffic. The Contractor shall make its own request to the utility or other parties affected by such relocation work. Such relocation work shall be made solely at the Contractor's expense.

105.08 COOPERATION BETWEEN CONTRACTORS. 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.

When separate contracts are let within the limits of any one 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.

Each contractor involved shall assume all liability, financial or otherwise, in connection with its own contract and shall 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.

105.09 CONSTRUCTION STAKES. Unless other methods of placing stakes are provided in the Contract, the Engineer will set sufficient points to establish the initial location, alignment and elevation of the proposed work, except as provided herein. When it is time for the Contractor to fine-grade the subgrade, the Engineer will rerun the centerline from which the Contractor can set working stakes. It is the Contractor's responsibility to check the location, alignment, and elevations to ensure that they are correct. Any mistakes or errors shall be brought immediately to the attention of the Engineer, and adjustments shall be made immediately. After the Contractor has set the working stakes at the outer limits of the subbase course, the Engineer will reestablish the finished centerline grades. Again, it shall be the Contractor's responsibility to check the grades and, as before, bring any mistakes or errors to the attention of the Engineer for correction. The Contractor shall be held responsible for the preservation of all stakes and marks, and if, as determined by the Engineer, any of the survey stakes or marks have been carelessly or willfully destroyed or disturbed by the Contractor, the cost of replacing them will be charged against the Contractor and will be deducted from the payment for the work. No claim will be entertained on account of alleged inaccuracies unless the Contractor notifies the Engineer of the inaccuracies in writing in time for the Engineer to verify or check such stakes or marks before the work is commenced.

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.

The Contractor shall stake out the work and make known the immediate plan or procedure of the next work contemplated 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, in a timely manner, will be responsible for maintaining a sufficient number of grade stakes so the Engineer can monitor and regulate the alignment and elevations of cut and embankment slopes. The cost of the aforementioned work shall be considered as incidental work pertaining to the project as a whole, and shall be included in the unit price bid for the various items involved.

105.10 AUTHORITY AND DUTIES OF RESIDENT ENGINEER. As the direct representative of the Director of Project Development, the Resident Engineer has immediate charge of the engineering details of each construction project. The Resident Engineer with delegated commensurate authority is responsible for the administration and satisfactory completion of the project. The Resident Engineer has the authority to reject defective material and to suspend any work that is being improperly performed and withhold payment until defective work has been corrected.

105.11 AUTHORITY AND DUTIES OF THE INSPECTOR. Inspectors employed by the Agency will be authorized to inspect all work done and materials furnished and perform other duties as directed by the Engineer. Such inspection may extend to all or any part of the work and to the preparation, fabrication, or manufacture of the materials used. The Inspector is not authorized to alter or waive the provisions of the Contract, to issue instructions contrary to the Contract Documents, or to act for the Contractor.

105.12 INSPECTION OF WORK. The Engineer or designated representative shall be allowed access to all parts of the work at all times and shall be furnished such information and assistance by the Contractor as required to make a complete and detailed inspection.

The Contractor shall furnish such reasonable amount of help as the Engineer may desire for ascertaining whether or not the work is performed in accordance with the requirements and the intent of the Contract.

The Contractor, if the Engineer requests, shall remove or uncover such portion of the finished work as the Engineer may direct before the acceptance of the work. After the examination, the Contractor shall restore the portion of the work to the standard required by these Specifications. If the work thus exposed or examined proves acceptable, the expenses of uncovering or removing, and the replacing of the parts removed, shall be paid for as Extra Work, but if the work so exposed or examined is unacceptable, the expenses of uncovering or removing, and the replacing of same in accordance with these Specifications, shall be borne by the Contractor.

The Agency will not be required to pay for any work done or materials used without supervision or inspection by the Engineer or the Inspector. Such inspection may include project, mill, plant, or shop inspection, and any material furnished under these Specifications is subject to such inspection.

When any unit of government or of a public or private company is to pay a portion of the cost of the work covered by this Contract, its respective representatives shall have the right to inspect that portion of the work. Such inspection shall in no sense make

any such entity a party to this Contract, and shall in no way interfere with the rights of either party hereunder.

105.13 REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK. 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 105.04.

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.

No work shall be done without lines and grades having been given by the Engineer. Work done contrary to the instructions of the Engineer; beyond the lines shown on the Plans, except as herein specified; or any extra work done without authority, will be considered as unauthorized and will not be paid for under the provisions of the Contract. Work so done may be ordered removed or replaced at the Contractor's expense.

Upon failure on the part of the Contractor to comply forthwith with any order of the Engineer made 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, and in either case, to deduct the costs from any monies due or to become due the Contractor.

Any expense incurred by the Agency in making these 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 the Contract Bonds.

105.14 SUNDAY AND HOLIDAY WORK. The Contractor shall not carry on construction operations on Sunday except as authorized by the Engineer.

The Engineer reserves the right to require the Contractor to cease construction operations on Holidays, the day before if the Holiday falls on Tuesday, and the day after if the Holiday falls on Friday, if the Contractor's operations are of such a nature, the project is so located, or traffic is of such volume, that the Engineer deems it is expedient to do so.

The above limitations will not apply for the purposes of maintenance, emergency repairs, and proper protection of the work, which includes, but is not limited to, the curing of concrete and for the repairing and servicing of equipment.

The above limitations in no manner whatsoever relieve the Contractor of any responsibility for the work involved as set forth in Subsection 107.18, or in any other applicable requirement.

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

105.16 LOAD RESTRICTIONS. The Contractor shall comply with all legal load restrictions specified in Title 23 VSA § 1392, in the hauling of equipment or material on public roads beyond the limits of the project. The application for and obtaining of a hauling permit will not relieve the Contractor of liability for damage that may result from the moving of equipment.

The operation of equipment of such mass (weight) or so loaded as to cause damage to structures, the roadway, or to any other type of construction will not be permitted. Hauling of materials over the base course, surface course, or structure during construction shall be limited as directed. No loads will be permitted on a concrete pavement, cement treated base course, or concrete structure prior to expiration of the curing period and until the concrete reaches its specified 28-day compressive strength. In no case will vehicles exceeding the load restrictions cited in Title 23 VSA § 1392 be permitted on a structure. The Contractor shall be responsible for all damage done by the Contractor's hauling equipment.

Prior to placement of the wearing surface, vehicle travel speed over any structure shall not exceed 15 km/h (10 miles per hour) and an acceptable transition ramp shall be constructed at any expansion joint that projects above the deck surface.

Each vehicle entering or leaving the project limits must either be within the legal load limit for the roadways and structures being traveled or be within the load limit imposed by a current overload permit for those roadways and structures. Should any vehicle not meet either of these requirements, the difference in mass (weight) between the legal load limit and the gross vehicle mass (weight) shall be converted to the appropriate measurement quantity for the item involved, and this amount shall be deducted from the quantity of the item to be paid the Contractor.

The Contractor shall provide copies of the permits to the Engineer prior to beginning hauling. Copies of permits provided after hauling has begun will not be considered to be in effect for this project prior to the date that the Engineer receives the required copy.

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

These requirements, including the overload penalty, 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 PROJECT DURING CONSTRUCTION. The Contractor shall maintain the work during construction and until the work is finally accepted. This maintenance shall constitute continuous and effective work prosecuted day by day, with adequate equipment and forces to the end that the roadway, structures or other portions of the project are kept in satisfactory condition at all times.

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

In the event that the Contractor's work is ordered shut down for failure to comply with the provisions of the Contract, the Contractor shall maintain the project, as provided herein, and provide such ingress and egress for local residents as necessary during the period of suspended work or until the Contract has been declared in default.

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

105.19 FINAL ACCEPTANCE AND FINAL INSPECTION. None of the work shall be accepted until all of the work required by the Contract has been satisfactorily completed.

Upon due notice from the Contractor of presumptive completion of the project, the Engineer will arrange a date for inspection of the work. Immediately following the inspection, if all construction provided for and contemplated by the Contract is found completed, the Contractor will be informed in writing of the acceptance date as being the date of the inspection of the project, or should any of the work be found unsatisfactory or incomplete, instructions for corrective action will be issued. As soon as the deficiencies have been corrected to the satisfaction of the Engineer, a second notification will be made in writing to the Contractor establishing the acceptance date.

105.20 CLAIMS FOR ADJUSTMENT AND DISPUTES. In any case where the Contractor deems extra compensation is due for work or materials not clearly covered by the Contract, or for encountering conditions substantially different than represented by the Contract, or for work and materials not ordered by the Engineer as an extra, as defined herein, the Contractor shall notify the Engineer in writing of the specific intention to make a claim for such extra compensation prior to beginning the work on which the claim will be based. If such notification is not given and the Engineer not afforded proper "notice of intent" by the Contractor for documenting an accurate account of the actual work and costs, then the Contractor hereby agrees to waive any claim for such compensation.

Written notification for a claim by the Contractor or the fact that the Engineer has documented an accurate account of said claim shall not in any way be construed as proving the validity of the claim. Claims must be judged by the Director of Project Development. Should the claim be judged in favor of the Contractor, it will be allowed and paid as provided for in the Contract. Should the claim be disapproved by the Director of Project Development, the Contractor may resort to the appeal rights under Subsection 105.02.

All claims by the Contractor shall be submitted in writing within 90 calendar days after the acceptance date of the project or within 90 calendar days of the notification in writing of the specific intention to make a claim, whichever occurs first, and not thereafter. An appeal shall be made within 30 calendar days of disapproval, and not thereafter.

105.21 PAYROLLS. 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.

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 Employment and Training.

105.22 ENVIRONMENTAL PROTECTION. The Contractor shall carry out all project related operations in such a manner as to give adequate protection to the environment, its rivers, streams, impoundments, and State and National Forests.

At the preconstruction conference or prior to the start of applicable construction, the Contractor shall submit, in writing, plans for erosion, siltation, and pollution control work on the project and on associated haul roads and material supply and disposal areas. No work shall be started until these procedures have been approved by the Engineer.

105.23 CONTROL OF EROSION AND SILTATION. The Engineer has the authority to limit the surface area of erodible earth material exposed by excavation, borrow, and fill operations and to direct the Contractor to provide immediate permanent or temporary erosion and siltation control measures to prevent contamination of adjacent wetlands, watercourses, lakes, ponds, or other impoundments. Such work may involve the construction of temporary berms, dikes, dams, sediment basins, slope drains and use of temporary mulches, mats, seeding, or other control devices or methods as necessary to control erosion and siltation. As the earthworks proceed, slopes shall be graded, seeded, and mulched as soon as practical.

The Contractor will be required to incorporate all permanent erosion control features into the project at the earliest reasonable time as outlined in the accepted erosion control schedule. Temporary erosion and siltation control measures will be used to prevent erosion and to correct conditions that develop during construction, prior to installation of permanent erosion and siltation control features and may include work outside the right-of-way where such work is necessary as a result of construction.

Where erosion is likely to be a problem, clearing and grubbing should be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter if the project conditions permit; otherwise temporary erosion and siltation control measures may be required between successive construction stages.

The Engineer may limit the area of clearing and grubbing, excavation, borrow, and embankment operations in progress commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding, and other such permanent erosion control measures current in accordance with the approved environmental protection plans. Without prior approval by the Engineer the amount of surface area of erodible earth material exposed at one time within the right-of-way shall not exceed 2 ha (5 acres).

In the event of conflict between these requirements and pollution control laws, rules, or regulations or other Federal, State, or local agencies, the more restrictive laws, rules, or regulations shall apply.

If conditions develop that will require suspension of construction operations, the excavation and embankment areas shall be shaped in such a manner that the runoff of water will be intercepted and diverted to points where least erosion shall result. Slope drains shall be installed as soon as possible to assist in carrying this runoff. The Contractor shall act immediately to correct any deficiencies that develop with these measures.

Erosion and siltation control measures shall be continued and acceptably maintained until the permanent drainage facilities have been constructed and until grass on seeded slopes is established sufficiently to be an effective deterrent against erosion or until acceptance of the project, whichever occurs first.

Unless otherwise approved in writing, mechanized equipment shall not be operated in flowing streams except as required to construct changes in channel and permanent or temporary structures. Rivers, streams, and impoundments shall, as soon as construction will allow, be cleared of all falsework, piling, and debris caused by the construction operations.

Any construction activity in or adjacent to rivers, streams, brooks, creeks, lakes, ponds, and reservoirs shall not cause the average downstream water quality values to fall outside the classification limits specified in the Vermont Water Quality Standards adopted by the Water Resources Board. Should the Contractor desire a variance from these requirements, the Contractor must obtain a 1272 Permit (Regulation of Activity Causing Discharge - Title 10 VSA § 1272) issued by the Agency of Natural Resources. When the Contract or ANR requirements prohibit working in a river, stream, brook, creek, lake, pond, or reservoir the Contractor will be permitted to do such work only if the Contractor obtains a 1272 Permit for this work.

The Engineer shall approve the location of work roads to ensure that erosion will not result in siltation during or after completion of the work.

105.24 POLLUTION CONTROL. The Contractor shall exercise every reasonable precaution to prevent pollution of the waters of the State. Pollutants such as chemicals, paints, fuels, lubricants, bitumens, raw sewage, and other harmful waste shall not be discharged into or alongside these waters or into natural or constructed channels leading thereto. The Contractor shall comply with applicable statutes and regulations

of the Agency of Natural Resources relating to the prevention and abatement of pollution.

When bridge painting, cleaning, cutting, welding, or grinding operations are in progress the Contractor shall utilize containment devices to retain all materials which might be generated during these operations. All waste materials generated from surface preparation that may contain lead, zinc, or other hazardous materials shall be disposed of as hazardous waste.

The Contractor shall comply with all Federal, State, and local air, ground, and water pollution control regulations, health regulations, and transportation regulations when cleaning, handling, moving, repainting, cutting, welding, sanding, or grinding any coated or treated materials.

The Contractor shall employ standard methods to minimize noise and air pollution occurring in conjunction with and as a result of construction operations such as, but not necessarily limited to, clearing, grubbing, drilling, blasting, excavation, and hauling operations. These methods shall be acceptable to the Engineer and compatible with the location of the work. Any burning of tires or any similar manufactured products is prohibited.

The Contractor shall provide documentation to the Engineer that any generated hazardous waste and any hazardous materials found were disposed of in conformance with all applicable regulations governing the handling, transporting, and disposal of such materials.

105.25 CONTROL OF MATERIAL SUPPLY AND DISPOSAL AREAS. Material supply areas for a project are considered to be all borrow pits, gravel pits, quarries, sand pits, and similar sources of materials to be used in the construction of the project. Material disposal areas are those areas where excess material or materials unsuitable for use as a construction item are to be placed for disposal.

Such material supply and disposal areas are considered to be necessary adjuncts to the Vermont Agency of Transportation construction project. The Contractor and/or the property owner shall be required to obtain a permit in accordance with Title 10 VSA Chapter 151 (Act 250), if applicable, prior to opening or using an area for an Agency project.

In order to establish these areas, the Contractor shall submit to the Engineer, the following package of information:

(a) A cover letter for the particular site which shall indicate the type and approximate quantity of material involved, the location of the area, and the typical cross-sections or maps when requested.

(b) Approval letter with any details of conditions imposed for opening, operating, maintaining, and closing such areas from:

    (1) Town Officials

(2) Property Owners

(3) Any other applicable groups or commissions

(4) The Vermont Agency of Natural Resources for waste areas that will impact wet areas or that will incorporate any hazardous waste or other solid waste such as tree stumps, concrete, guardrail, or bituminous materials.

The Contractor shall not perform any preparatory work or make use of the material supply or disposal area until approval is obtained in writing from the Regional Construction Engineer.

If this is a currently operating area, the owner's letter must state if it has a permit under Title 10 VSA Chapter 151 (Act 250) and include a copy of this permit. If the area does not have a permit as stated above, this letter must state the length of time the area has been operating and the annual rates of use for the last five years.

In addition, the Contractor shall give written notice to the Division of Historic Preservation of all material supply and disposal areas at least three weeks prior to utilization of these areas. It shall be incumbent on the Division of Historic Preservation to give due notice to the Contractor if for any reason these areas cannot be utilized or require special treatment.

(Area to be shown on US Geological Survey Map with a 1 to 24,000 or larger scale.)

105.26 OPENING MATERIAL SUPPLY AND DISPOSAL AREAS. The Engineer, prior to issuing approval, shall be satisfied that the area and its operation shall be consistent with the following requirements:

(a) Will not seriously hurt or impair the rights of any adjacent property owner.

(b) Will not result in undue water or air pollution.

(c) That the final shape, slope and contour of the land in and about the area will not be undesirable from an esthetic and a drainage point of view.

(d) Will not cause unreasonable soil erosion or reduction in the capacity of the surrounding land to hold water so that a dangerous or unhealthy condition may result.

(e) Will not have an undue, adverse effect on the scenic or natural beauty of the areas, esthetics, historic sites or rare and irreplaceable natural areas.

(f) Is consistent with any duly adopted development plan, land use plan or land capability plan whether it be individual, local, or regional.

(g) The entrance shall be at the most desirable angle or perspective from any nearby highways, residences, and the like.

(h) The Contractor shall remove, stockpile, and preserve topsoil, sod, and other suitable material stripped from the surface of the area prior to proceeding with other operations.

105.27 MAINTAINING MATERIAL SUPPLY AND DISPOSAL AREAS. The Contractor shall conduct the area operations in such manner as to maintain a minimum of air pollution. The Contractor shall keep the portions of the area where a pit or pits have been opened reasonably tidy and in a presentable manner and maintain all haul roads with sufficient dust control to not offend adjacent properties and property owners. Area operations will be restricted to normal working hours except by the express written approval of the Engineer.

105.28 CLOSING MATERIAL SUPPLY AND DISPOSAL AREAS. Prior to abandoning any area on which the Contractor has completed operations, with the exception of those which will remain open for commercial use, the Contractor shall landscape the slopes and surface of the entire area and leave the banks in a neat and presentable condition, properly and thoroughly graded and drained. All stones, boulders, stumps, and debris shall be removed or satisfactorily disposed of. Slopes shall not be left steeper than 1:1.5 (vertical:horizontal). The tops of slopes and the toes of slopes shall be neatly rounded. After grading the slopes and surfaces of the area, the stockpiled sod, topsoil, and other stripped material shall be evenly spread over the surface of the area. The complete area shall be seeded with the standard seed formula designated for the project and mulch shall be applied in accordance with the applicable requirements of Section 651. The Contractor shall place screens of vegetation, trees, berms, or embankments where necessary to conceal the undesirable features of a supply or disposal area.

The Contractor shall have the written approval of the Regional Construction Engineer prior to completely abandoning any supply or disposal area.

105.29 PAYMENT FOR EROSION AND SILTATION CONTROL MEASURES. In the event that temporary erosion and siltation control measures are 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, such work shall be performed by the Contractor at the Contractor's expense. Required temporary erosion and siltation control work not attributable to the Contractor's negligence, carelessness, or failure to install permanent controls will be performed and paid for as ordered by the Engineer. When temporary erosion control items are not included in the Contract, such work shall not be paid for directly but will be considered incidental to other items.

In case of repeated failures on the part of the Contractor to control erosion, pollution, or siltation, the Engineer reserves the right to employ outside assistance or to 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 to become due the Contractor.

All environmental protection work in connection with the opening, maintaining and closing of material supply and disposal areas and the like shall be done by the Contractor. This work shall be considered as incidental work pertaining to the project

as a whole and the cost thereof shall be included in the unit prices bid for all the various items involved in the Contract. Any costs for damages to the owners of such areas or to adjacent property owners shall be the responsibility of the Contractor.

105.30 PRESERVATION OF THE BEDS OF STREAMS AND BODIES OF WATER. The Contractor or the Contractor's employees, agents, or subcontractors will be permitted to remove or use existing material from any stream bed or stream bank when such removal or use is covered by a Stream Alteration Permit issued by the Regional Engineer of the Vermont Agency Natural Resources, Division of Protection. It is the Contractor's responsibility to obtain such permit, and the Contractor shall submit a copy of the permit to the Engineer prior to removing the material.

The work required by the Contract to construct the project will be covered by project approvals obtained by the Agency.

105.31 VALUE ENGINEERING. The intent of value engineering is to provide an incentive to the Contractor to initiate, develop, and present to the Engineer for consideration, any 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 value engineering proposal.

The cost reduction proposals contemplated are those that would require a Supplementary Agreement modifying the Contract and would produce a savings to the Agency by providing less costly items or methods than those specified in the Contract, and/or reducing future maintenance costs, without impairing essential functions and characteristics such as service life, reliability, economy of operation, ease of maintenance, and necessary standardized features.

Value engineering proposals will be processed in the same manner as prescribed for any other alterations of the Contract that would require a Supplementary Agreement. As a minimum, the following information shall be submitted by the Contractor with each proposal:

(a) A statement that the proposal is being submitted as a value engineering proposal.

(b) A description of the proposal.

(c) An itemization of the requirements of the Contract that must be changed and a recommendation of how to make each change.

(d) An estimate of the reduction in performance costs that will result from adoption of the proposal.

(e) A prediction of any effects the proposed changes would have on other costs to the Agency, including environmental effects, traffic impacts and preventive measure costs.

(f) A statement of the time by which an agreement for adoption of the proposal must be executed to obtain the maximum costs reduction during the remainder of the Contract and the reasoning for this time schedule.

(g) A statement as to the effect the proposal would have on the time for completion of the Contract.

The Agency shall not be liable for any delay in acting upon any proposal submitted. The Contractor may withdraw, in whole or in part, any value engineering proposal not accepted within the period specified in the proposal. The decision of the Engineer as to the acceptance or rejection of value engineering proposals will be final and will not be subject to the provisions of Subsection 105.02 or 105.20. The Contractor will be notified in writing of the Engineer's decision to accept or reject each value engineering proposal submitted under the provisions of this Subsection.

If a proposal is accepted, the necessary Contract modifications will be effected by execution of a Supplementary Agreement, which will provide for equitable price adjustments giving the Contractor and the Agency equal shares in net savings resulting therefrom. 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.

The Supplementary Agreement 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.

The Agency reserves the right to include in the agreement any conditions it deems appropriate for consideration, approval, and implementation of the cost reduction proposal. The Contractor's 50 percent share of the net savings shall constitute full compensation for effecting all changes pursuant to the agreement.

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 utilization of the proposal on this project or other projects.

Any time savings realized by implementation of value engineering 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 value engineering proposals.

# SECTION 106 - CONTROL OF MATERIAL

106.01 SOURCE OF SUPPLY AND QUALITY REQUIREMENTS. The material used in the work shall meet quality requirements of the Contract. In order to expedite the inspection and testing of materials, the Contractor shall notify the Engineer of the proposed sources of materials at least 96 hours prior to delivery.

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 furnish the appropriate 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 a material meeting the specifications. The Agency's Geologist maintains a list of material sources that have produced materials meeting specifications in the past. Any new material exploration will be the responsibility of the Contractor. The possibility of purchase from the owner(s) of the source and the quality of this material are not guaranteed by the Agency. It shall be understood that it is not feasible to ascertain from samples the limits for an entire deposit and that variations shall be considered as usual and are to be expected. The Engineer may order procurement of material from any portion of a deposit and may reject portions of the deposit 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 plant site, stockpiles, and hauling 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. Any work in which untested and/or unaccepted materials are used without approval or written permission of the Engineer shall be performed at the Contractor's risk. Such work may be considered as unacceptable and unauthorized and will not be paid for. Unless otherwise specified, all testing will conform to the most recent cited standard methods of AASHTO or ASTM, including AASHTO Interim Specifications or the ASTM Tentative Specifications that are current on the date of the advertisement for bids. In the case of conflict between the ASTM and the AASHTO methods of sampling and testing, the AASHTO method shall govern. When modified AASHTO or ASTM test methods or Vermont Agency of Transportation test methods are designated, the test method will be available at the office of the Agency's Materials and Research 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 latest edition of the Agency's 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 possible 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 acceptance by the Engineer. Copies of all test results will be furnished to the Contractor's representative upon request.

In lieu of testing, the Agency may approve the use of certain materials based upon the receipt of a certification from the manufacturer stating that such material is in compliance with these Specification. The requirements for such certifications are specified in Subsection 700.02.

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

(b) 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) 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) 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 the same have been delivered, and to reject all materials that do not meet the requirements of these Specifications or those established for the specific project 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, and they shall meet the requirements of these Specifications at the time of use. Stored materials shall be located so as to facilitate their inspection. Approved 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 therefore must be provided at the Contractor's expense. Private property shall not be used for storage purposes without written permission of the owner 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 under these Specifications.

106.06 HANDLING MATERIALS. All materials shall be handled in such manner as to preserve their quality and fitness for the work.

106.07 UNACCEPTABLE MATERIALS. At the discretion of the Engineer, all materials not in conformance with the requirements of these Specifications shall be considered as unacceptable and all such materials, whether in place or not, shall be rejected and shall be removed immediately from the site of the work, unless otherwise instructed by the Engineer. No rejected materials, the defects of which have been subsequently corrected, shall be used until approval has been given.

106.08 EXPLOSIVE AND FLAMMABLE MATERIALS. The Contractor's attention is directed to the provisions of the Vermont Statutes Annotated as amended, which authorizes the State Fire Marshal to make and publish and enforce and from time to time to alter, amend, or repeal rules and regulations pertaining to fire prevention and public safety concerning the safekeeping, storage, use, manufacture, sale, handling, transportation, or other disposition of blank cartridges, gun powder, dynamite, nitroglycerine, crude petroleum or any of its products including liquefied petroleum gas, explosives, flammable gases and flammable fluids, compounds or tablets, or any other explosive of like nature, or any substance having such properties that it may spontaneously or acting under the influence of any contiguous or of any chemical or physical agent, ignite or inflame, or generate inflammable or explosive vapors or gases to a dangerous extent, and may prescribe the location, materials, and construction of buildings and other facilities to be used for any of the said purposes. Attention is further directed to the regulations applying to explosives while being transported by certified private carriers in motor vehicles, railroad cars, or vessels in conformity with the regulations adopted by the Interstate Commerce Commission, the US Department of Transportation, the US Coast Guard, or the Secretary of Transportation under the provisions of Title 5 VSA § 2001 and Subsection 107.11.

106.09 STOCKPILING OF MATERIALS. The Contractor is urged to place orders for materials with producers and suppliers as early as practical so that delays resulting from material and fuel shortages may be kept to a minimum.

The Engineer may authorize payment for the Contractor's cost of materials, including freight. The materials shall be stockpiled on the project or at locations approved by the engineer; they shall be certified or have passing samples; and a copy of the supplier's paid invoice or a receipt for delivery of materials shall be provided. If a receipt for delivery of materials is provided, the Contractor shall furnish the paid invoice within 28 calendar days after the estimate cutoff date. If the Contractor fails to furnish the paid invoice within the allotted time, the amount of the stockpile payment shall be deducted from one or more subsequent payments.

In the event that unreasonable delays or changes in the work occur as a direct or indirect result of a material or energy shortage, the Contractor shall notify the Agency in writing. If, in the opinion of the Director of Project Development, a valid case exists, alternate methods of construction, substitution of materials, or an extension of time will be authorized. The payment for stockpiled materials will not relieve the Contractor of any responsibility for the condition of these materials as specified elsewhere in these Specifications.

## SECTION 107 - LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.01 LAWS TO BE OBSERVED. 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 such orders or decrees as exist at present and those which may be enacted later by bodies or tribunals having any jurisdiction or authority over the work, and the Contractor shall 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 or by the employees of the Contractor.

If the Contractor should discover 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.

The Contractor's attention is directed to the various regulations promulgated and enforced by the United States and VOSHA and the environmental protection agencies.

The Contractor shall comply with all of the requirements of Title 21 VSA Chapter 5, subchapter 6, relating to fair employment practices to the extent applicable. A similar provision shall be included in any and all subcontracts.

The Contractor's attention is directed to regulations regarding the management of hazardous wastes such as waste crankcase and hydraulic oils, and waste paint generated by construction operations (ref: Agency of Natural Resources' Department of Environmental Conservation and Title 10 VSA Chapter 159).

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, MATERIAL, 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 and a copy of this agreement shall be filed with the Agency. The Contractor and the Contractor's surety shall 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 attention of the bidder is invited to the fact that, pursuant to the provisions of Title 23 USC, 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 each State

shall be done in accordance with its laws and under the direct supervision of the Sate of Vermont, Agency of Transportation, subject to the inspection and approval of the US Department of Transportation or appropriate Federal agency and in accordance with the rules and regulations made pursuant thereto. The construction work, therefore, will be subject to such inspection by the US 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 this 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 any soil moving equipment is 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 State or Federal plant pest control inspectors.

107.07 PUBLIC CONVENIENCE AND SAFETY. The Contractor shall conduct all work so as to ensure the least possible obstruction to traffic. The safety and convenience of the general public and the residents along the highway within the construction area and the protection of persons and property shall be provided for by the Contractor as specified in Subsection 104.04.

The Contractor shall use all necessary dust control on haul road(s) and maintenance yard(s) in the same manner as required for materials sources and disposal areas in Subsection 105.27. Dust control on haul road(s) and maintenance yard(s) shall be performed in accordance with Section 609 and will not be paid for directly, but will be considered incidental to the Contract item Mobilization. When directed by the Engineer, the Contractor shall perform all dust control deemed necessary by the Engineer on the haul road(s) and/or maintenance yard(s) at no expense to the Agency.

The Engineer will direct the use of all necessary dust control within the limits of the construction 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.

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

Fire hydrants located within the construction area shall be kept accessible to fire apparatus at all times and no material or obstruction shall be placed within 4.5 m (15 feet) of any such hydrants.

Footways, gutters, drainage inlets, and portions of highways adjoining the roadway under construction shall be obstructed only when necessary.

On any project where the total useable width of the traveled way will be decreased to 4.3 m (14 feet) or less for a period longer than one working day, the Contractor shall notify the Resident 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 two weeks prior to the beginning of the lane restriction so that the Resident Engineer may provide proper notification to the Oversized/Overweight Section of the Commercial Vehicle Enforcement Unit of the Department of Motor Vehicle and the Agency's Communications Section. When the date of the actual removal of the restriction becomes known, the Contractor shall notify the Resident Engineer so that proper information can be provided to others as necessary.

107.08 TRAFFIC CONTROL DEVICES. All approach signs shown on the Plans 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 in that area. All traffic control devices shall conform to the Contract requirements and the MUTCD. Use of metal drums as traffic control devices is prohibited.

Whenever existing pavement markings conflict with desired traffic patterns within a construction or detour area, or where they otherwise create a potentially misleading, confusing, or hazardous condition for motorists, such markings will be completely removed or obliterated by the Contractor to the satisfaction of the Engineer. Painting over the existing lines will not be considered acceptable. Unless otherwise specified in the Contract, no direct payment will be made for this work, which will be considered incidental to other Contract items.

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.

The Contractor shall erect warning signs in advance of any place on the project where operations may interfere with the use of the road by traffic and at all intermediate points where the new work crosses or coincides with an existing road.

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 route or routes shall be indicated clearly throughout its or their entire length.

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

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

Flashers may be required by the Resident Engineer for use on signs and barricades to call attention to special or hazardous conditions. Any signs or cones authorized for use other than during working hours shall be reflectorized or illuminated or both.

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

If the Contractor neglects 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 USE OF FLAGGERS. The Contractor shall, as conditions warrant, employ one or more flaggers, at any location on the project where equipment or construction operations are such that they will in any manner interfere with the movement or safety of the traveling public. This includes locations of operations where equipment enters, leaves or crosses normal traffic lanes being used or set aside for said traveling public, or locations where heavy equipment such as shovels or bulldozers are operating adjacent to areas where traffic is moving. Flaggers will 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. Attention is directed to the provisions of Section 108 as they may apply to the use of flaggers.

The dress, equipment, and procedures of all flaggers shall conform to the requirements in the MUTCD.

107.10 RAILWAY-HIGHWAY PROVISIONS. If the Contractor is required or elects to haul materials across the tracks of any railway, the Contractor shall make arrangements with that railway for any new private crossings required or for the use of any existing private crossing.

All work to be performed within a railroad right-of-way by the Contractor in the construction of railway-highway separation structures or at grade crossings shall be done in a manner satisfactory to the Chief Engineer of the railway company and shall be performed at such times and in such manner as not to unnecessarily interfere with the movement of trains or traffic upon the track of the railway company. The Contractor shall use all care and precaution in order to avoid accidents, damage or unnecessary delay or interference with the railway company's trains or other property. The Contractor will be required to carry Public Liability and Property Damage Insurance as stipulated elsewhere in these Specifications or in the Special Provisions.

107.11 USE OF EXPLOSIVES. The Contractor shall use the utmost care to protect life or property and, whenever directed by the Engineer, shall reduce the number and size of the charges. Blasting mats shall be used when required by regulation. The Contractor shall notify each person, company, corporation or public utility owning, leasing, or occupying property or structures near the site of the work of any intention to use explosives; such notice shall be given sufficiently in advance to enable the parties of interest to take such steps as they may deem necessary to protect their property or structure from injury. Such notice shall not relieve the Contractor of responsibility for

any damage resulting from the Contractor's blasting operations. All persons within the danger zone of blasting operations shall be warned, a warning whistle shall be sounded and the zone cleared prior to blasting. Sufficient flaggers shall be stationed outside the danger zone to stop all approaching traffic during blasting operations. Explosives shall be used only during daylight hours, shall be handled only by competent workers, and particular care shall be taken to ensure that no unexploded charges remain in the work unattended or when constructions operations cease for the day. All explosives shall be stored in a secure manner and all such storage places shall be marked clearly "DANGEROUS-EXPLOSIVES" and shall be under competent supervision at all times. All explosives and highly flammable materials shall be stored and used in strict conformity with all Federal, State, and local laws, rules, and regulations. Attention is directed to VOSHA *Safety and Health Standards for Construction*, Subpart U, Blasting and the Use of Explosives.

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

The Contractor and not the Agency shall assume full liability for any and all damage or injury to persons or property caused either directly or indirectly by the Contractor's use of explosives. The liability of the Contractor shall apply equally to damages 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 shall not be paid for directly, but all costs therefor shall be included in the bid prices for the pay items under the Contract.

The Contractor and/or the Contractor's agents are hereby advised that there is a potential hazard of a premature explosion due to propagation of radio frequency energy by transmitters of radio and the related radio services such as television and radar and the effect of such energy to electric blasting caps individually or when they are connected into a circuit. Mobile and fixed radio, cellular telephone, radar, television, and related transmitters are in general use in the State of Vermont by, but not limited to, police departments, fire departments, political subdivisions, utility companies, commercial carriers, private and public enterprises, and individuals.

The Contractor and/or the Contractor's agents shall take all precautions necessary to prevent premature explosions of electric blasting caps individually or when they are connected into a circuit.

Prior to blasting operations in any area, the Contractor shall install warning signs in conformance with the MUTCD. Such signs shall be located in prominent positions not less than 370 m (1200 feet) from the point of blasting and visible to any person approaching such point. Payment for furnishing, erecting and maintaining these signs shall be considered incidental to other items in the Contract.

107.12 PROTECTION AND RESTORATION OF PROPERTY. The Contractor shall not enter upon private property for any purpose without obtaining written permission, shall be responsible for the preservation of all public and private property along and adjacent to the work, and shall use every precaution necessary to prevent damage or injury thereto. The Contractor shall protect from disturbance or damage all land

monuments and property markers until an authorized agent has witnessed or otherwise referenced their location and shall not move them until directed. The Contractor shall protect from damage by construction operations all trees, shrubs, or plants, not marked by the Engineer for removal.

It shall be the Contractor's responsibility to see that any portions of the existing roadway and existing structures which are to be retained for public travel are left in as good condition as when the Contractor commenced work. The Contractor shall not move or use any equipment on any pavement or structure in such manner as to cause damage to the pavement or structure when such pavement or structure is to be retained for use.

The Contractor shall be responsible for all claims involving damages or injury to property of any type during the prosecution of the work, resulting from any act, omission, neglect or misconduct of the Contractor's manner or method of executing said work satisfactorily, or due to the Contractor's non-execution of said work, or at any time due to defective work, or materials, and said responsibility shall not be released until the work has been completed and accepted.

When or where 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 by repairing or rebuilding, or otherwise restoring, as directed, or the Contractor shall make good such damage or injury in an acceptable manner.

Any project involving dusty operations, such as cold planing, drilling and blasting, loop saw cutting, or when determined by the Engineer, when done in the vicinity of traffic signals or street lighting that are owned by the State or a municipality shall include cleaning of equipment prior to project completion. Cleaning of traffic signals shall include all vehicle and pedestrian signal face lenses (inside and outside). 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. All costs for cleaning will not be paid for directly, but will be considered incidental to other items in the Contract.

107.13 PROTECTION AND RESTORATION OF UTILITIES AND SERVICES. 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, telegraph, television, and electrical services. They may be located on or adjacent to the project, above, on, or under the ground, and may not be shown on the Plans.

The Contractor shall comply with the requirements of Dig-Safe.

When construction of the project commences or is resumed, 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 seven to 14 calendar days in advance of starting work to enable them to take such steps as they may deem necessary to protect their property or structures from damage. Such notice shall not relieve the Contractor of responsibility for any damages resulting from the Contractor's work.

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 these facilities. There will be no extra compensation paid to the Contractor for any inconvenience caused by working around or with such services or their representatives.

The exact location of any service facility relocated within the project limits shall be as directed by the Engineer.

The Contractor shall cooperate with the owners of any of the aforementioned services in order that their removal and relocation operation may 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.

If interruption occurs to any of the aforementioned services in connection with the work, the Contractor shall promptly notify the owner or the owner's authorized representative and cooperate with the owner in the prompt restoration of service. In no case shall interruption to water or sewer service be allowed to exist outside of normal working hours without the substitution of an alternate service.

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

The Contractor shall be liable for all damages done to the aforementioned services from the beginning of construction to the satisfactory completion of the project.

The Contractor shall be liable for all damages to water supplies and sewage systems, but is 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 hereinafter provided.

The Agency will receive and investigate all complaints relating to damage to springs, wells, and water supply systems. If it is determined that the damage is the responsibility of the State, the Contractor shall be so notified, the Contractor's liability for such damage shall thereupon cease, and the Contractor shall be reimbursed by the State for expenses incurred in providing a temporary water supply and repairing the damage.

If the Contractor fails to restore such property, or to make good such damage or injury, the Engineer may proceed to repair, rebuild or otherwise restore such property as

deemed necessary and the cost thereof will be deducted from any monies due, or which may become due, the Contractor under the Contract.

107.14 PROTECTION OF HISTORICAL AND ARCHAEOLOGICAL SITES. When the Contractor's excavating operations encounter sites or artifacts of historical or archaeological significance, the operations shall be temporarily discontinued. The Engineer will contact archaeological authorities and give them 48 hours to determine the appropriate action to be taken. When directed by the Engineer, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and shall remove them for delivery to the custody of the proper state authorities. Such excavation will be considered and paid for with Contract items or as Extra Work.

107.15 FOREST PROTECTION. In carrying out work within or adjacent to forests or other growth, the Contractor shall satisfactorily burn or otherwise dispose of all valueless trees and logs, stumps, roots, brush, weeds, grass, and other objectionable material. Disposal of such material shall be in conformity with all the laws of the State of Vermont pertaining thereto or other authority having jurisdiction governing the protection of forests in carrying out work within forests. In carrying out work within or adjacent to the National Forest Lands, the Contractor shall comply with the requirements set forth in the Forest Service Special Use Permit included in the Contract for the specific project. Before any fires are kindled on or adjacent to the project, the Contractor shall obtain the necessary permits from the State Agency of Natural Resources and the local fire prevention officials. Copies of permits shall be available on the project

The Contractor shall observe all sanitary laws and regulations with respect to the performance of the work in forest areas. The Contractor shall keep the areas in an orderly condition, obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks, and other structures in accordance with the requirements of the Forest Supervisor.

The Contractor and all subcontractors shall take appropriate action to prevent forest fires. In the event that a fire does get out of control on or near the project, the Contractor and all subcontractors shall do all within their power to suppress the fire, shall notify the Town Fire Warden or other known forest officials of the location and extent of the fire at the earliest possible moment, and shall cooperate with forest officials in suppressing the fire once they have assumed control.

When required, fires must either be thoroughly wet down when construction operations are suspended for the day or the remains shall be attended until work begins again. Night burning will not be allowed.

The Contractor shall reimburse the political subdivisions for all expenses of suppressing any forest fire caused by its operations and shall settle with each landowner for any and all damage caused by the fire.

107.16 RESPONSIBILITY FOR DAMAGE CLAIMS. The Contractor shall indemnify and save harmless the Town, the State, the Agency, and railroad(s) 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 damages received or sustained by any person, persons, or property by or from the Contractor; 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 Workers Compensation Act, or any other law, bylaw, ordinance, order, or decree. So much of the money due 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 damages, as aforesaid, shall have been settled and suitable evidence to that effect furnished to the Agency.

107.17 OPENING SECTIONS OF PROJECT TO TRAFFIC. Opening of sections of the work to traffic prior to completion of the entire Contract may be desirable. Such openings shall be made when so ordered by the Engineer. Under no condition shall such openings constitute acceptance of the work or a part thereof, or a waiver of any provisions of the Contract.

On any section opened by order of the Engineer, the Contractor shall not be required to assume any expense entailed in maintaining the road for traffic. On such portions of the project, compensation for additional expense incurred by having to maintain traffic and allowance of additional time needed, shall be made to the Contractor as determined by the Engineer.

If the Contractor is dilatory in completing shoulders, drainage structures, or other features of the work, the Engineer may so notify the Contractor in writing and establish therein a reasonable period of time in which the work shall be completed. If the Contractor fails to make a reasonable effort toward completion in this period of time, the Engineer may then order all or a portion of the project opened to traffic. On sections that are ordered to be opened, the Contractor shall conduct the remainder of construction operations so as to cause the least obstruction to traffic and shall not receive any added compensation due to the added cost of the work by reason of opening such section to traffic.

107.18 CONTRACTOR'S RESPONSIBILITY FOR WORK. Until acceptance of the project by the Engineer, the Contractor shall have the charge and care thereof 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 damages to any portion of the work occasioned by any of the above causes 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, acts of the public enemy, or governmental authorities. For purposes of this paragraph the term work shall exclude Contractor owned, rented, or leased materials, equipment, and incidentals.

In case of suspension of work from any cause whatsoever, the Contractor shall be responsible for the project and shall take such precautions as necessary to prevent damage to the project, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities solely at the Contractor's expense. During such 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 soddings furnished under the Contract, and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

The performance by the State or by a subdivision thereof or by other authorized agency, of any snowplowing, salting, and sanding in no way relieves the Contractor of any responsibility as outlined herein or elsewhere in the Contract.

107.19 PERSONAL LIABILITY OF PUBLIC OFFICIALS. In carrying out any of the provisions of these Specifications, or in exercising any power or authority granted to them by or within the scope of the Contract, there shall be no liability upon the Secretary, the Engineer, or their authorized representatives, either personally or as officials of the State, it being understood that in all such matters they act solely as agents and representatives of the State.

107.20 NO WAIVER OF LEGAL RIGHTS. Upon completion of the work, the Agency will expeditiously make final inspection and notify the Contractor of acceptance. Such acceptance, however, will not preclude or estop 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 estopped from recovering from the Contractor, the Contractor's surety, or both any overpayment it may sustain 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.

The Contractor, without prejudice to the terms of the Contract, shall be liable to the Agency for latent defects, fraud, and such gross mistakes as may amount to fraud, and as regards the Agency's rights under any warranty or guaranty.

107.21 FURNISHING RIGHT-OF-WAY. It will be the responsibility of the Agency or appropriate political subdivision to not only 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.

All 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 may desire for its own convenience shall be obtained and paid for by the Contractor.

107.22 BUY AMERICA PROVISIONS. All steel products permanently incorporated into Federal-Aid projects shall be products that have been entirely manufactured within the United States. 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 to be considered of domestic origin. This includes processes such as rolling, extending, machining, bending, grinding, and drilling.

This requirement does not prevent a minimal use of foreign materials, provided the cost of foreign materials used does not exceed 0.1 percent 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.

Sections 1041(a) and 1048(a) of the Intermodal Surface Transportation Efficiency Act amended and clarified the Buy America provisions of Section 165(a) of the Surface Transportation Assistance Act of 1982 (STAA) and 23 CFR 635.410. Iron has been added to the materials now 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. Buy America requirements of 23 CFR 635.410 are applicable to all Federal-Aid highway construction projects (NHS and non-NHS).

107.23 DEFENSE OF LAWSUITS - CHALLENGE TO JURISDICTION AND WAIVER OF IMMUNITY. The Contractor in defending any claim that may arise under this Section shall not, without obtaining the express advance permission of the Attorney General's Office, raise or impose any defense involving; the jurisdiction of the tribunal before which said claim is pending, immunity of the State of Vermont, governmental nature of the State, or the provision of any statutes respecting suits against the said State of Vermont.

## SECTION 108 - PROSECUTION AND PROGRESS

108.01 SUBLETTING OR ASSIGNMENT OF CONTRACT. 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 or corporation, without the written consent of the Engineer. In case such consent is given, the Contractor must file with the Agency copies of all executed subcontracts. After approval to sublet a portion of the Contract, the 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. No subcontracts or transfer of Contract shall in any case release the Contractor from liability under the Contract and bonds.

The Contractor shall perform with its own organization Contract work amounting to not less than 50 percent of the total Contract amount minus "Specialty Items." The Contractor's own organization shall be understood to include only workers employed and paid directly by the Contractor and equipment owned, leased or rented by it from a non-debarred person, with or without operators. The term does not include employees or equipment of a subcontractor, assignee, agent, or supplier of the Contractor. To determine whether the Contractor is in compliance with this 50 percent requirement, the following criteria shall apply:

(a) 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 percent requirement is computed.

(b) 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.

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

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 project Special Provisions and may be performed by subcontract.

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

(a) 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:

    (1) Select contracts to be bid.

    (2) Determine prices to be quoted.

    (3) Select material suppliers.

    (4) Hire, fire, supervise, and pay employees.

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

(b) To ensure that any subcontracted work is performed in accordance with the Contract requirements, the Contractor shall be required to furnish:

    (1) A competent and reliable English-speaking representative who is 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 regardless of who performs the work.

    (2) A competent and reliable English-speaking employee designated as the safety officer, authorized to receive orders and to issue binding directions concerning safety to all persons associated with the project, whether

employed by the Contractor, subcontractors, or material suppliers, except Agency representatives.

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

(c) 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.

108.02 NOTICE TO PROCEED. The Contractor shall not commence construction operations until Contract bonds have been filed and the Contract Documents shall have been signed on the part of the State, at which time the Construction Engineer shall give the Contractor written notice to proceed.

The "Notice to Proceed" will stipulate the date on which the Contractor may begin construction and from which date Contract time will be charged.

108.03 PROSECUTION AND PROGRESS. The Contractor shall submit, to and for the approval of the Engineer, a CPM progress schedule within ten calendar days after the award of the Contract. The progress schedule shall show the proposed sequence of work and when the Contractor proposes to complete the various items of work within the time set up in the Contract. During the progress of the work, the Contractor shall confer with the Engineer in regard to the prosecution of the work in accordance with the approved schedule. The approved schedule shall be used as a basis for establishing major construction operations, and for checking the progress of the work.

The work shall be prosecuted from as many different points, in such part or parts, at such times, in such a manner, and with sufficient materials, equipment, and labor as is necessary to ensure its completion within the time as set forth in the proposal.

Should the prosecution of the work for any reason be discontinued by the Contractor, with the consent of the Engineer, 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 such a manner and in such sequence so as to 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 open up work to the prejudice or detriment of work already started. The Engineer may require the Contractor to finish a section on which work is in progress before work is started on any additional sections if the opening of such section is essential to public convenience.

108.05 CHARACTER OF WORKERS, METHODS AND EQUIPMENT. The Contractor shall at all times employ sufficient labor and equipment for prosecuting the several classes of work to full completion in the manner and time required by the Contract Documents.

All workers shall have sufficient skill and experience to perform properly the work assigned to them. Workers engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

All electrical work performed on projects constructed under these Specifications 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 V or more.

"Under the supervision of" shall mean that the licensed electrician shall be employed on the project, must be physically present on the project, and shall be actively supervising the work.

Any person employed by the Contractor or by any 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 request of the Engineer be removed forthwith 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.

Should the Contractor fail to remove such person or persons as required above, or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may withhold all estimates which are or may become due or may suspend the work by written notice until such orders are complied with.

All equipment which is proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the project shall be such that no injury to the roadway, adjacent property, or other highways will result from its use.

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 the Contractor demonstrates to the satisfaction of the Engineer will accomplish the work in conformity with the requirements of the Contract.

When the Contract specifies that the work be performed by the use of certain methods and equipment, such 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 authorization 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 under these provisions.

The Contractor shall not remove from the project any item of machinery or equipment after it has been placed on the project without the prior consent of the Engineer, which consent shall not be unreasonably withheld. Reasonableness shall be tested by the needs of the project and not by the needs of any other project in which the Contractor may be engaged.

108.06 WAGES AND CONDITIONS OF EMPLOYMENT. 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 in contracts containing wage determinations made by the US Department of Labor with the minimum wage established by statutes, the larger of the two amounts shall be the minimum wage for that classification.

(a) Fair Labor Standards Act. Fair Labor Standards Act (FLSA) of 1938, as amended, 29 USC 201: Although there is no law requiring Federal or State agencies to insert in their contracts a clause to ensure compliance by the Contractor with the Act, it may apply to work under a construction Contract with the Federal Government, or financed with the aid of the Federal Government, and in such a case would require payment of a minimum hourly rate as well as overtime pay for work in excess of 40 hours in each workweek. Moreover, it is important to note that the overtime provisions of this Act and of the Eight-Hour Laws are not mutually exclusive. Therefore, where a Contractor's employees are covered by the FLSA, the Contractor is not thereby excused from complying with the overtime provisions of other applicable laws.

This Act, better known as the Wage-and-Hour-Law, applies to individual workers who are engaged in commerce or in the production of goods for commerce as these terms are defined in the Act. Workers on many types of construction jobs are included under these terms. If a worker carries materials or moves equipment across state lines or unloads or guards materials or equipment arriving from other states or performs other functions in commerce in the course of performing work, that worker is covered. Also, if the job is one to repair, reconstruct, enlarge, or improve an existing instrumentality of commerce such as a highway, bridge, or road, the worker is likewise covered while working on the job. Roads would include City streets if they are available to and are regularly used by interstate traffic.

New construction is covered by the FLSA when the projects are part of and directly related to the functioning of an existing instrumentality of commerce. Coverage is therefore extended to construction workers on highways in the "Interstate System" or on other roads built to serve as part of a network carrying

interstate traffic. In this regard, workers engaged in work preparatory to actual construction such as surveying, clearing, or grading are also covered.

Under the FLSA, the minimum age for general employment in the industry is 16 years. The minimum age is 18 years for employment in occupations declared to be hazardous by the US Secretary of Labor. Included in this category are the occupations of motor-vehicle driver and helper. Children 14 and 15 years old may be employed for a limited number of hours and under certain conditions in office work. However, they may not be employed in any manner at covered construction sites.

The above is merely general information concerning the applicability of the FLSA to the highway construction industry, and it is important that the Contractors and subcontractors obtain more detailed information from the Wage and Hour and Public Contracts Divisions, United States Department of Labor, John F. Kennedy Federal Building, Government Center, Boston, Massachusetts 02203-2211.

(b) Contract Work Hours and Safety Standards Act. The Contract Work Hours and Safety Standards Act requires Federal construction contractors and subcontractors to pay time and one-half after 40 hours a week. Work under the Federal-Aid Highway Act (USC Title 23, Section 101, *et. seq.*) and all other construction financially assisted in whole or part by the Federal Government is covered by the Contract Work Hours and Safety Standards Act.

Overtime shall be computed on the basic rate of pay. It is no defense that such laborers and mechanics accepted or agreed to accept less than the required rate of wages or voluntarily made refunds.

The Act applies to all contracts for work financed in whole or in part by loans or grants by the United States or instrumentalities thereof under any "Federal Statute" providing wage standards for such work. See Part IV, Subparts 7, 8, and 9 of the "Required Contract Provisions Federal-Aid Construction Contracts."

In the event a worker works four ten-hour days, that worker would not be entitled to any overtime compensation.

(c) Davis-Bacon Act. Where the Contract includes wage rates, the following also applies.

The wage rate determination of the US Secretary of Labor which has been incorporated in the proposal may not contain all classifications necessary for the work contemplated under this project. The Contractor is responsible, independently, for ascertaining area practice with respect to the necessity, or lack of necessity, for the use of any classifications in the prosecution of the work contemplated by this project, and no inference may be drawn from the omission of these classifications concerning prevailing area practices relative to their use. Further, this omission will not, per se, be construed as establishing any

governmental liability for increased labor cost if it is subsequently determined that such classifications are required.

The Contractor shall submit to the Agency any requests for missing job classifications and proposed wage rates.

The requirements of both the FLSA and Work Hours Standards Act must be met. For example, a laborer or mechanic who, in one workweek, works four eight-hour days and one nine-hour day, a total of 41 hours, is entitled to overtime compensation for one hour only.

The Contractor's attention is directed to the provisions and requirements of the Vermont Workers Compensation Act and to statutes regulating employment of minors.

108.07 LABOR AND RENTAL PREFERENCE. The Contractor shall give preference to Vermont labor and trucks owned in Vermont, in accordance with Vermont Statutes Annotated. This requirement shall not apply to any highway project, or any part thereof, financed in any way with Federal funds.

108.08 MEETING PERSONNEL REQUIREMENTS. Contractors are encouraged to make use of the services of the local offices of the State Department of Employment and Training to meet their personnel requirements. Recruitment of workers in all occupations and skills is conducted by the State Employment and Training Services, 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 US Employment Service.

In addition to providing recruitment assistance to Contractors who need and desire it, cooperation with these local employment offices will further the national program of maintaining continuous assessment of personnel requirements and resources on a national and local basis.

108.09 TEMPORARY SUSPENSION OF THE WORK. The work may be suspended by the Engineer, wholly or in part, for such period or periods as necessary on account of:

(a) Unsuitable weather conditions.

(b) Failure on the part of the Contractor to carry out instruction given, or to do satisfactory work, or to perform any or all provisions of the Contract.

(c) Any other conditions which, in the judgment of the Engineer, make work impractical.

Between December 1 and April 15, no construction work of any kind shall be done except by written permission of the Engineer, and only under such conditions as specified therein.

Construction procedure prior to closing down the project shall be as specified in Subsection 104.04.

The Contractor shall not suspend the work without permission of the Engineer. Such permission will not be unreasonably withheld.

In the event the work is suspended, the provisions of Subsection 108.05 relating to removals shall apply.

108.10 SUSPENSIONS OF WORK ORDERED BY THE ENGINEER.

(a) If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing 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 seven calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

(b) Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the cost and/or time required for the performance of the Contract has increased as a result of such suspension and the suspension 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 Engineer will notify the Contractor whether or not an adjustment of the Contract is warranted.

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

(d) No Contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any other term or condition of this Contract.

108.11 DETERMINATION OF EXTENSION OF CONTRACT TIME FOR COMPLETION. When a definite date for completion or a fixed number of days is specified in the proposal and Contract, and when the Contractor finds it impossible 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 may make a written request within 30 calendar days after final completion of the project for an extension of time setting forth therein the reasons which the Contractor believes will justify the granting of the request. Upon written order by the Engineer establishing a substantial completion date prior to the anticipated completion date, no request for an extension of time by the Contractor will be necessary.

Whenever the work is delayed or suspended through no fault of the Contractor, a completion date extension will be determined upon consideration of the following:

(a) The days from April 15 through December 1, inclusive, on which the weather or condition of the ground caused suspension of the work.

(b) Delay by the Agency in awarding the Contract and/or in issuance of the notice to proceed.

(c) Federal or State laws passed subsequent to the date of the Contract adversely affecting progress.

(d) Acts of God.

(e) In case of suspension of major items of work by order of the Engineer, the time for completion will be extended an amount equal to the elapsed time between effective dates of order to suspend and order to resume.

(f) If satisfactory completion of the Contract with any authorized extension and increases requires the performance of work in greater quantities than those set forth in the proposal, the Contract time allowed for performance of the work will be increased in the same ratio that the total cost of the work actually performed bears to the total cost in the proposal. Additional time may be allowed for unusual circumstances when cost alone is not a determining factor in time required to perform the additional work. Any change in the final Contract time shall be computed to the nearest full day.

(g) An extension of time will be granted for a delay caused by a shortage of materials only when the Contractor furnishes to the Engineer documentary proof that a diligent effort has been made to obtain such materials from all known sources and the inability to obtain such materials when originally planned, did in fact cause a delay in final completion of the entire work which could not be compensated for 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 within 15 calendar days from the beginning of any such delay.

(h) Any other conditions which in the opinion of the Director of Project Development warrants consideration for an extension of time.

Failure to prosecute the work continuously and effectively for the full time allowed, with adequate work force and schedule, will be cause for denial of any such time extension that might otherwise be allowed.

108.12 FAILURE TO COMPLETE WORK ON TIME. Time is an essential element of the Contract and the Contractor shall plan its progress schedule and vigorously press the progress of the work in order to complete the Contract on or before the completion date set forth in the Contract.

Whenever the Special Provisions of the Contract call for any portion or portions of the work to be prosecuted in any particular manner or for any portion or portions of the work to be completed pursuant to a certain sequence or schedule prior to the date of completion of the entire Contract, the Contractor shall punctually comply with the related instructions, dates, and periods of time.

The Contractor in executing the Contract on its part, covenants and agrees that, for each working day on which any work shall remain incomplete after the completion date specified in the Contract for completion of the work involved, there shall be deducted from any monies due the Contractor the amount shown in the following table, unless otherwise specified in the Special Provisions, not as a penalty but as liquidated damages to defray the cost to the Agency of the administration of the Contract including, but not limited to, the cost of engineering, inspection, supervision, inconvenience to the public, obstruction of traffic, and interference with business; provided, however, that due account shall be taken for any adjustment of the Contract time for completion of the work granted under the provisions of Subsection 108.11.

DAILY CHARGE FOR LIQUIDATED DAMAGES
FOR EACH WORKING DAY OF DELAY

| Original Contract Amount | | |
|---|---|---|
| From More Than | To And Including | Daily Charge Per Day of Delay |
| $ 0 | $ 300,000 | $ 390.00 |
| 300,000 | 500,000 | 670.00 |
| 500,000 | 1,000,000 | 1,000.00 |
| 1,000,000 | 1,500,000 | 1,700.00 |
| 1,500,000 | 3,000,000 | 2,500.00 |
| 3,000,000 | 5,000,000 | 3,500.00 |
| 5,000,000 | 10,000,000 | 3,500.00 |
| 10,000,000+ | --- | 3,500.00 |

Should the Contractor elect to work on Saturdays, Sundays, Holidays, or days from December 2 through April 14, inclusive, after the Contract date of completion, the Contractor will be charged liquidated damages for such days worked.

Permitting the Contractor to continue to finish the work or any part of it after the time fixed for its completion, or after the date to which the time for completion may have been extended, will in no way operate as a waiver on the part of the Agency of any of its rights under the Contract.

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 such ascertained liquidated damages, the Contractor and the Contractor's surety shall be liable to the State for such deficiency.

No liquidated damages will be charged after the establishment of a Substantial Completion Date.

108.13 TERMINATION OF CONTRACT. The Secretary, upon written notice from the Engineer or other proof satisfactory to the Secretary, will give notice in writing to the Contractor and the Contractor's surety of such delay, neglect, or default if in the event the Contractor:

(a) fails to begin the work under the Contract within the time specified in the "Notice to Proceed," or

(b) fails to perform the work with sufficient workers and equipment or with sufficient materials to ensure the prompt completion of said work, or

(c) performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as shall be rejected as defective and unsuitable, or

(d) discontinues the prosecution of the work, without authorization of the Engineer, or

(e) fails to resume work that has been discontinued within a reasonable time after notice to do so, or

(f) becomes insolvent or is declared bankrupt, or commits any act of bankruptcy or insolvency, or

(g) allows any final judgment to stand against the Contractor unsatisfied for a period of ten calendar days, or

(h) makes an assignment for the benefit of creditors, or

(i) fails, for any cause whatsoever, to carry on the work in an acceptable manner.

If the Contractor or the Contractor's surety, within a period of ten calendar days after such notice, shall not proceed in accordance therewith, then the Agency will, upon written notification from the Engineer of the fact of such delay, neglect or default, and the Contractor's failure to comply with such notice, have full power and authority without violating the Contract, to take the prosecution 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 opinion of the Engineer, will be required for the completion of the Contract in an acceptable manner.

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. In case the expense so incurred by the Agency shall be less than the sum which would have been payable under the Contract if it had been completed by the Contractor, then the Contractor shall be entitled to receive the difference and, in case such expense shall exceed the sum which would have been payable under the Contract, then the Contractor and the Contractor's surety shall be liable and shall pay to the Agency the amount of said excess.

108.14 EMERGENCY TERMINATION OF CONTRACT. The Agency may, by written order, terminate the Contract or any portion thereof after determining that for reasons beyond the control of either Agency or Contractor, the Contractor is prevented from proceeding with or completing the work as originally contracted for, and that termination would therefore be in the public interest. Such reasons for termination may

include, but need not be necessarily limited to, executive orders of the President relating to prosecution of war or national defense, national emergency which creates a serious shortage of materials, orders from duly constituted authorities relating to energy conservation, and restraining orders or injunctions obtained by third-party citizen action or where the issuance of such order or injunction is primarily caused by acts or omissions of persons or agencies other than the Contractor.

When the Contract, or any portion thereof, is terminated before completion of all items of work in the Contract, payment will be made for the actual number of units or items of work completed at the Contract unit price, or as mutually agreed for items of work partially completed or not started. No claim for loss of anticipated profits will be considered.

Reimbursement for organization of the work (when not otherwise included in the Contract) and moving equipment to and from the job will be considered where the volume of work completed is too small to compensate the Contractor for these expenses under the Contract unit prices, the intent being that an equitable settlement will be made with the Contractor.

Acceptable materials, obtained by the Contractor for the work, that have been inspected, tested, and accepted by the Engineer, and that have not been incorporated in the work will, at the option of the Contractor, be purchased from the Contractor at actual cost as shown by receipted bills and actual cost records at such points of delivery as designated by the Engineer.

Termination of the Contract, or any portion thereof, will not relieve the Contractor of its responsibilities for the completed work, and it will not relieve the Contractor's surety of its obligation for and concerning any just claims arising out of the work performed.

108.15 TERMINATION OF CONTRACTOR'S RESPONSIBILITY. Whenever the improvement provided for by the Contract has completely performed on the part of the Contractor, all parts of the work have been approved and accepted by the Engineer, and all Contract Documents complied with, the Contractor shall then be released from further obligations except as set forth in bonds provided.

Whenever the Contract includes work at more than one location either as separate projects or as separate locations on a single project, the Agency may accept the work at any of these locations when the work at that location is completely finished and all responsible parties agree to the acceptance as for a normal final inspection. If a portion of the Contract is accepted, the Contractor shall remove all construction warning signs and the Contractor's liability for any further work will cease.

## SECTION 109 - MEASUREMENT AND PAYMENT

109.01 MEASUREMENT OF QUANTITIES. All work completed under the Contract will be measured by the Engineer according to the United States standard weights and measures unless otherwise agreed to in writing.

The measurement and determination of the number of units of each pay item will be made in general as specified in this Section, and specifically as described under Method of Measurement and Basis of Payment subsections for each item.

Unless otherwise specified, measurements for area computations will be made horizontally, and no deductions will be made for individual fixtures having an area of 1 $m^2$ (10 square feet) or less. Unless otherwise specified, measurements for area computations will be the neat dimensions shown on the Plans or authorized in writing by the Engineer.

Structures will be measured according to neat lines shown on the Plans or as altered to fit field conditions in accordance with the method of measurement stated in these Specifications.

Volumes of excavation and borrow pits will be calculated from cross-sections and the use of average end area formulae or by other approved methods. Volumes of other work such as Cement Rubble 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.

All items that are measured by the meter (linear foot) will be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the Plans.

The term “metric ton” will be used to indicate a mass of 1000 kg. The term “ton” will mean the English short ton consisting of 2000 pounds. All materials that are measured, or proportioned by mass (weight), shall be done so on accurate, approved scales by competent, qualified personnel.

Bituminous materials will be measured by the liter (gallon) or kilogram [hundredweight (CWT)].

Volumes of bituminous materials will be measured at 15 °C (60° F) or will be corrected to the volume at 15 °C (60° F) using ASTM D 1250 for asphalt or ASTM D 633 for tar.

When liquid bituminous materials are shipped by truck or transport, net certified mass (weight) or volume subject to correction for loss or foaming, may be used for computing quantities.

Cement will be measured by the kilogram [hundredweight (CWT)].

Timber will be measured by the cubic meter [thousand feet board measure (MFBM)] actually incorporated in the work. Measurement will be based on nominal widths and thicknesses and the in place length of each piece.

The term “lump sum” when used as a unit of measurement for an item of payment will mean complete payment for the work described in the Contract.

When a complete structure or structural unit (in effect, “lump sum” work) is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

Rental of equipment will be measured by time in hours of actual working time and the necessary traveling time of the equipment within the limits of the project.

In the interest of saving engineering resources and expediting payments of final estimates, 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 at the time the final survey is to be made. However, if either the Contractor or the State challenges the quantities, then final quantities will be computed in accordance with these Specifications. In those cases where changes of design generate changes in the quantities, final quantities shall be based on final cross-sections or measurements.

109.02 PURCHASES OF MATERIALS BASED UPON AGENCY MEASUREMENTS. The Agency does not undertake to furnish or to guarantee measurements of borrow, gravel, sands, soils, fill, and such other construction materials used on the project for the benefit and convenience of the Contractor in dealings with the sellers thereof.

The Contractor shall not undertake to purchase materials from the owners thereof on terms requiring payment on the basis of the Agency measurements customarily made except by written agreement, with a copy of said agreement furnished to the Agency prior to removal of said materials for the project.

109.03 SCOPE OF PAYMENT. The Contractor shall receive and accept the compensation herein provided, in full payment for furnishing all materials, labor, tools and equipment and performing all work contemplated and embraced under the Contract; also for all loss or damage arising out of the nature of the work, or from the action 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, and for all risks of every description connected with the prosecution of the work; also for all expenses incurred by or in consequence of the temporary suspension or discontinuance of the work as herein specified, and for any infringement of patent, trademark, or copyright, and for completing the work in an acceptable manner according to the Plans and Specifications.

The payment of any current or final estimate, or of any retained percentage, shall in no way and in no degree prejudice or affect the obligation of the Contractor, at its own cost and expense, to repair, correct, renew, or replace any defects or imperfections in the construction project and its appurtenances, or in the strength of or quality of materials used therein or thereabout, or relieve the Contractor from the payment of any and all damages due or attributed to such defects, provided (except for guaranteed work

or material) such defects, imperfections, or damages shall be discovered on or before the final inspection or acceptance of the entire work.

No monies payable under the Contract, or any part thereof, except the estimate for the first period, shall become due and payable, if the Agency so elects, until the Contractor shall satisfy the Agency that the Contractor has fully settled for, or paid for, all damage claims or liabilities incurred in connection with said work; the Agency, if it so elects, may pay any or all such balances wholly or in part and deduct the amount or amounts so paid from any biweekly or final estimate, excepting the first estimate.

If it so elects, the Agency may require and the Contractor shall furnish written evidence of release from all claims and obligations connected with said work.

109.04 SIGNIFICANT CHANGES IN THE CHARACTER OF WORK.

(a) 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 will not invalidate the Contract or release the Contractor's surety, and the Contractor agrees to perform the work as altered.

(b) If the alterations or changes in quantities significantly change the character of the work under the Contract, whether or not changed by any such different quantities or alterations, an adjustment, excluding loss of anticipated profits, 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) 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) 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 elsewhere in the Contract, is increased in excess of 125 percent or decreased below 75 percent of the original Contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125 percent of original Contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed.

(e) A major item of work is defined as any bid item whose total bid value is greater than 20 percent of the total bid amount of the Contract.

109.05 COMPENSATION FOR ALTERED PLANS OR QUANTITIES. 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 percent of the total original Contract amount, or the length of the project is not increased or decreased more than 25 percent 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.

However, when such changes or alterations result in a sum total change of more than 25 percent of the total cost of the Contract, calculated from the original bid quantities and the original Contract unit prices, or the length increased or decreased more than 25 percent, and a demand is made by either party, a negotiated Supplementary 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.

No allowances will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting either directly from such alterations or indirectly from unbalanced allocation among the Contract items of overhead expense on the part of the bidder 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 under a Supplementary Agreement. The agreement will be made before the work is started. When the Engineer deems it impractical to handle any Extra Work ordered on a unit price or lump sum basis, a Supplementary Agreement 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 in writing before beginning the work, and paid while engaged in such work, to which shall be added an amount equal to 15 percent thereof, or 20 percent if the work is being performed by a subcontractor for overhead, profit and any other costs incurred in supplying labor. Twenty percent is the maximum amount that will be allowed regardless of the number or level of subcontractors involved.

Workers Compensation on labor items as paid by the Contractor will be allowed in the final estimate; however, the rates on such compensation will not exceed those paid by the State for similar work. Social Security charges on labor items as paid by the Contractor will be allowed. Actual costs to the Contractor for Unemployment Compensation Insurance and Public Liability and Property Damage Insurance that are required in the Contract will be allowed.

(b) Materials. The Contractor shall receive its actual costs including freight charges (as submitted on original receipted bills) for all materials furnished and used. Fifteen percent shall be added thereto, or 20 percent if the work is performed by a subcontractor for overhead, profit and any other costs incurred in supplying labor. Twenty percent is the maximum amount that will be allowed regardless of the

number or level of subcontractors involved. Vermont sales tax shall not be included.

(c) Equipment Rental. The Contractor will be reimbursed for the number of hours that each piece of equipment is actually used on a specific force account job. Equipment that is used shall be specifically described by manufacturer and model number. In the event the Contractor elects to use equipment of a higher rental value than the equipment suitable for the work, payment will be made at the rate applicable to the suitable equipment.

(1) Contractor Owned Equipment.

a. Ownership Costs. The Contractor shall 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 rates listed in the current Rental Rate Blue Book published by Primedia Information, Inc., divided by 176. The rates will be adjusted for depreciation as computed and published in the Blue Book rate adjustment tables but will not be adjusted as recommended on their regional adjustment maps. These 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.

b. Operating Costs. The rates of operating costs includes fuel, lubricants, other operating expendables, and preventative and field maintenance. Operating costs do not include the operator's wages. The Contractor will be reimbursed an amount equal to the product of the number of hours of actual use multiplied by the Rental Rate Blue Book estimated operating cost per hour.

The rates to be used for comparison shall be those in effect at the time the force account work is done as reflected in the current publication of the Rental Rate Blue Book. When force account procedures are used to establish agreed prices, the rates used for comparison shall be those in effect when the agreed price is developed by the Contractor and submitted to the Engineer.

In the event that a rate is not established in the Rental Rate Blue Book for construction equipment for a particular piece of equipment, truck, or plant, the Engineer shall establish a rate for that piece of equipment, truck, or plant that is 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 $200.

(2) Rented Equipment. In the event that the Contractor does not own a specific type of equipment and must obtain it by rental, the Contractor will be paid the actual rental rate for the equipment for the time that the equipment is used to accomplish the work (not to exceed the rental rate in the Rental Rate

Blue Book). Equipment time will be reimbursed as outlined under part (c)(1)a. above.

The Contractor will be reimbursed for the operating cost of the equipment unless reflected in the rental price. Such operating cost shall be determined in the same manner as specified above for Contractor owned equipment.

(3) Maximum Amount Payable. The maximum amount of reimbursement for the ownership costs of Contractor owned equipment or the rental cost of the rented equipment is limited to the original purchase price of the equipment.

(4) Equipment Downtime. No rental will be paid for downtime for either Contractor owned or rented equipment.

(5) Documented Transportation Costs. The Contractor will be paid for transporting the equipment to the work location and back to its original location (or a new location if the cost is less than that of transportation from the project) for both Contractor owned and rented equipment.

(d) 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 signed by both the Engineer and Contractor's representative. All claims for Extra Work done on a force account basis (including original receipted bills to verify cost and freight charges for all materials) shall be filed by the tenth day of the month that follows the month in which the work was completed.

109.07 ELIMINATED ITEMS. Should any items contained in the proposals be found unnecessary for the proper completion of the work, the Engineer, may, upon written order to the Contractor, eliminate such items from the Contract, and such action shall in no way invalidate the Contract. When a Contractor is notified of the elimination of items, the Contractor will be reimbursed for actual work done and all costs incurred, including mobilization of materials prior to said notification.

109.08 PARTIAL AND FINAL PAYMENTS. Partial payments, computed upon the basis set forth in the specifications, 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 done and will compute a report the value thereof under the Contract. Such estimates may be approximate only and not be based on actual measurements. Ninety-five percent of the estimate value will be paid to the Contractor by the Agency and 5 percent thereof shall be retained. However, on contracts of over $150,000 in amount, the Engineer will review the progress when 50 percent of the Contract has been completed. If at that time the Engineer feels that suitable progress is being made and no claims for unpaid accounts have been received, the remaining partial estimates will be paid in full, holding as retainage the regular 5 percent on the first 50 percent of the Contract. No payments will be made when the total value of the work done since the last estimate amounts to less than $500.

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 the State as required in Title 32 VSA Section 3113, money otherwise owed to the Contractor may be withheld from the biweekly estimate.

A portion of the retainage may be released upon completion of the project as long as no claims for unpaid accounts have been received. This amount released shall be as authorized by the Director of Project Development or officially designated representative but in no case shall the retainage be reduced below 5 percent of the Contract amount or $2,500, whichever is less, until 90 calendar days after the project completion date.

The retained percentage as determined by the final estimate, shall be paid to the Contractor within 90 calendar days after the Contract work has been completed to the satisfaction of the Engineer, except that for the protection of the State and of creditors and other claimants of the Contractor, said final payment shall be held, if the Director of Project Development 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.

Payment of the final estimate will be made when an agreement is reached on the final quantities of all project pay items, when the final acceptance date as defined in Subsection 101.02 is established and when all other project requirements have been met. If the Contractor does not accept the quantities determined by the Agency, the Contractor may appeal to the Director of Project Development, as provided in Subsection 105.20, Claims for Adjustments and Disputes. Notwithstanding Subsections 105.02 and 105.20, failure to appeal or failure to complete required documentation within six months from the time the Contractor is presented with the Agency's final quantities will be deemed a waiver of the Contractor's right to appeal. The Contractor will then be presented with the final estimate for signing. Failure of the Contractor to sign the final estimate within 20 days will result in payment of the amount owed without the Contractor's signature and the Contract will be closed.

109.09 STATEMENT OF MATERIALS AND LABOR, FORM FHWA-47. This form shall be correctly and completely filled out by the Contractor and acceptable to FHWA on all Federal-Aid projects prior to payment of the final estimate.

109.10 RENTAL OF PUBLICLY-OWNED EQUIPMENT. On Federal-Aid projects, the Contractor will be required to file with the Agency upon completion of the project, a statement setting forth such rental charges or depreciation of publicly-owned equipment as the Contractor may have used on the project, whether owned by the State, County, or other political subdivision.

# DIVISION 200

## EARTHWORK

### SECTION 201 - CLEARING

201.01 DESCRIPTION. This work shall consist of the performance of all clearing, grubbing, and thinning and trimming operations within the limits of the project.

201.02 CLEARING. Clearing shall consist of cutting and disposing of all trees, down timber, stubs, brush, bushes, and debris from all areas extending from the centerline to 3 m (10 feet) beyond the top limits of all cut sections or from the centerline to 3 m (10 feet) outside the toes of slopes in all fill sections, but in no case beyond applicable right-of-way limits. Clearing areas shall also include any other areas shown in the Contract Documents.

Where structures are to be constructed, clearing shall include the area within the structure limits. The lateral limits shall provide a clear distance of 6 m (20 feet) beyond the outside of the structure.

Any trees designated for removal under another Contract item are excluded from this work.

Branches of trees extending into and over the roadway shall be carefully trimmed as directed by the Engineer. All branches of trees overhanging the roadbed shall be carefully removed to a minimum height of 6 m (20 feet) above the finished grade.

Clearing operations shall be done in such a manner that the present growth will blend with the limits of construction and a natural appearance will be attained.

The Contractor shall carefully protect and guard all trees, shrubs, and vegetation, within or adjacent to the construction area, that the Engineer directs to be saved. The Contractor shall take every precaution to avoid any damage to public utility lines, buildings, or other property. 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. No machine or appliance shall be used on any part of the work that may in any manner injure, sear, or kill trees and shrubs, within or adjacent to the construction area, that have been designated to be saved, or are outside the area above described for clearing and grubbing. With the preceding exceptions, all trees and shrubs, down timber, stubs, brush, and other objectionable material shall be removed and disposed of from areas to be cleared before grading operations begin in the areas.

Where trees that are to be left standing have become scarred by the Contractor's operations, the cuts or scars shall be repaired by properly cutting, smoothing the wood if necessary, and treating with a product prepared especially for tree surgery. Any repairing or painting required shall be considered incidental to the lump sum price for Clearing and Grubbing.

In areas where embankments are to be constructed more than 1.5 m (5 feet) in depth measured below subgrade, all stumps shall be cut off as close to the ground as is

practical. Stumps shall not exceed 150 mm (6 inches) above the ground surface at the base. Stumps located outside of the construction limits of cut and embankment areas shall be cut flush with or below the surface of the ground or as directed by the Engineer. Stumps that cannot be cut flush shall be removed.

201.03 GRUBBING. Grubbing shall consist of removing and disposing of all stumps, roots, duff, grass, turf, debris, or other objectionable material within excavation limits, and within fill limits where the embankments are to be made to a depth less than 1.5 m (5 feet) below subgrade. Grubbing areas shall also include any other areas shown in the Contract Documents. The grubbing shall progress in such a manner that erosion will be kept to a minimum as required in Subsection 105.23.

The excavated section left below the subgrade by removals shall be backfilled with approved excavated material or borrow and compacted to conform to the surrounding area.

201.04 REMOVING SINGLE TREES AND STUMPS. Removing single trees and stumps shall consist of removing and disposing of single trees and stumps as shown in the Contract Documents or as directed by the Engineer. The work shall be in accordance with Subsections 201.02 and 201.03, and shall include the backfilling of stump holes as directed by the Engineer.

201.05 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.

The methods employed in any of the operations shall conform in all details with approved horticultural practices.

All branches or limbs removed shall be cut flush with the supporting trunk or limb. When directed by the Engineer, all cut surfaces over 25 mm (1 inch) in diameter shall be treated with a standard tree wound dressing.

Trees, stumps, and brush removed shall be cut flush with the ground surface.

201.06 DISPOSAL. In the interest of conservation, the Contractor shall salvage all sound wood 100 mm (4 inches) or more in diameter for marketable timber or firewood, or for other acceptable uses. Unless otherwise specified, all marketable timber and wood that are to be removed within the clearing area shall become the property of the Contractor. In general, marketable timber is understood to mean logs 2.4 to 4.8 m (8 to 16 feet) in length plus appropriate trimming allowance and having a diameter of at least 250 mm (10 inches) measured inside the bark at the small end.

All other trees, stumps, logs, branches, protruding roots, brush, duff, weeds, shrubs, debris, rubbish, and other objectionable material shall be disposed of by the Contractor in compliance with applicable laws of the State of Vermont.

Burying of trees, stumps, and debris will be permitted at locations shown on the Plans. Additional areas within the right-of-way will require the Engineer's written permission.

On National Forest Lands, the Contractor shall comply with the requirements set forth in the Forest Service Special Use Permit included in the Contract for the specific project and in accordance with Subsection 107.15.

Before any fires are kindled on or adjacent to the project, the Contractor shall obtain the necessary permits from the State Agency of Natural Resources and the local fire prevention officials. Copies of permits shall be available on the project.

Whenever elm trees are cut or removed, all portions of the trees shall be disposed of by burning, if allowed, or burying. If disposal is by burying, portions shall be covered by at least 300 mm (12 inches) of earth.

201.07 METHOD OF MEASUREMENT. The quantity of Clearing and Grubbing will not be measured for payment unless the construction limits are changed. When the designed roadway limits are changed, altering the designed areas to be cleared and grubbed, an adjustment for the increased or decreased area will be measured in hectares (acres). No adjustment will be made for changes involving less than 0.04 ha (0.1 acre).

The quantity of single trees and stumps removed to be measured for payment will be on a unit basis for each for the various classes. The class of the trees will be determined by circumferential measurement at a distance of 1.4 m (4.5 feet) above the groundline. Small trees are classified as trees measuring 1000 mm (40 inches) or less [approximately 300 mm (12 inches) in diameter]. Medium trees are classified as trees measuring more than 1000 mm (40 inches) [approximately 300 mm (12 inches) in diameter] and less than 3000 mm (120 inches) [approximately 900 mm (36 inches) in diameter]. Large trees are classified as trees measuring 3000 mm (120 inches) or more. A stump is designated as that portion of the tree remaining after the trunk has been severed having a circumferential measurement of more than 1000 mm (40 inches) measured at the point of cutoff, and is classified for size the same as a single tree.

The quantity of Thinning and Trimming to be measured for payment will be the number of hectares (acres) thinned and trimmed in the complete and accepted work, as determined by using horizontal measurements.

201.08 BASIS OF PAYMENT. The accepted quantity of Clearing and Grubbing will be paid for at the Contract lump sum price. When the designed roadway limits are changed, altering the designed areas to be cleared and grubbed, an adjustment for the increased or decreased area will be made at the Contract unit price of $6,500 per hectare ($2,600 per acre) for the area accepted for adjustment.

The accepted quantity of single trees or stumps removed will be paid for at the Contract unit price for each. Payment for single trees will include removal and disposal of stumps when required. Single small trees and stumps ordered removed, whose circumferential measurement is 1000 mm (40 inches) or less, 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 hectare (acre).

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 |
|---|---|
| 201.10 Clearing and Grubbing | Lump Sum |
| 201.11 Clearing and Grubbing | Hectare (Acre) |
| 201.15 Removing Medium Trees | Each |
| 201.16 Removing Large Trees | Each |
| 201.20 Removing Medium Stumps | Each |
| 201.21 Removing Large Stumps | Each |
| 201.30 Thinning and Trimming | Hectare (Acre) |

## SECTION 202 - DEMOLITION AND DISPOSAL OF BUILDINGS

202.01 DESCRIPTION. This work shall consist of the removal, wholly or in part, and the satisfactory disposal of all buildings, including accessories and appurtenances, 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 600 mm (2 feet) below subgrade or 300 mm (1 foot) below final ground level. Floors below these levels shall be broken or holes approximately 300 by 300 mm (1 × 1 foot) shall be provided at 3 m (10 feet) intervals to provide vertical drainage.

Septic tanks, cesspools, or other underground tanks and appurtenant pipes shall be broken down or removed. Contents shall be disposed of in accordance with applicable regulations.

Basements or cavities left by structure 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 fences and 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 in accordance with all applicable laws, rules, regulations, and protocols.

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 held 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 assumes no responsibility 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 make every reasonable effort to complete the demolition and disposal of each Contract item in a continuous manner to ensure the safety and well being of the public.

The Contractor shall erect suitable fences around unfilled basements and other dangerous locations created by the work.

The Contractor shall be responsible for finding, opening, and maintaining all disposal areas and shall comply with all environmental rules and regulations, zoning ordinances, development plans, land use plans, and land capability plans.

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 and disposing of buildings; for excavating, backfilling, and regrading incidental to their removal; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 202.10 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 (including the removal of slides), borrow pits, waterways, channels, intersections, approaches, and steps in hillside embankments; excavating unsuitable material from the construction area and beneath embankment areas,

surfaces, and pavements; 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; and disposing of all unsuitable or surplus excavated material. The work shall also consist of placing of material in embankments and, in cases where the Contract requires placement of subbase, shall include fine grading of the subgrade when the Contract item Fine Grading - Subgrade is not a part of the Contract.

The work is classified as follows:

(a) Common Excavation. Common Excavation shall consist of the removal of all material, which can be accomplished with normal excavating machinery, encountered in grading the project and 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 1.5 $m^3$ (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 and disposal 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, which can be accomplished with normal excavating machinery, encountered in the excavation, 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 ledge formation that requires blasting or the use of

rippers; and detached rock, boulders, stone masonry, and concrete each having a volume of 1.5 $m^3$ (2 cubic yards) or more encountered in the excavation.

(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 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, Granular Borrow, or Rock Borrow.

(j) Gravel Backfill for Slope Stabilization. Gravel Backfill for Slope Stabilization shall consist of approved gravel placed against slopes and any other places designated for use of this material.

(k) Fine Grading - Subgrade. Fine Grading - Subgrade shall consist of the final grading to construct the subgrade.

203.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Classification of Soils | 703.01 |
| Earth Borrow | 703.02 |
| Sand Borrow | 703.03 |
| Granular Borrow | 703.04 |
| Rock Borrow | 703.05 |
| Gravel Backfill for Slope Stabilization | 704.07 |
| Backfill for Muck Excavation | 704.09 |

203.03 GENERAL CONSTRUCTION REQUIREMENTS. Prior to the beginning of 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 be maintained to ensure proper drainage at all times. 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.

Suitable topsoil on Stage I projects shall be stockpiled for use on Stage II projects. Topsoil shall be excavated to an approximate depth of 150 mm (6 inches), or as directed by the Engineer, and stockpiled at approved locations that will be easily accessible to the Stage II Contractor.

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 of 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 percent of the total surplus will be deducted from the total quantity removed from the borrow source.

When not otherwise shown in the Contract Documents, all bridge approaches in excavation areas, excavation for additional subbase shall be made to a depth of 1.2 m (4 feet) below finish grade for a distance not less than 15 m (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 (vertical:horizontal).

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.

The Contractor shall strip ledge in a professional manner and shall notify the Engineer that the area is ready for cross-sectioning prior to making any rock excavation. Any ledge removed prior to the taking of cross-sections will be paid for as Common Excavation. Instead of stripping, and with the approval of the Engineer, the Contractor may use other means of locating the rock line.

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 1 m (3 feet), center to center of holes. The diameter of the slope holes shall be not greater than 75 mm (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 1.2 m (4 feet) to the proposed finished slope. No portion of any blast hole larger than 75 mm (3 inches) in diameter will be permitted closer than 4 m (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 750 g of explosive per meter (0.5 pounds 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 3.5 kg (8 pounds) of explosive may be used. No explosive charge shall be placed within 750 ± 150 mm (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 8 m (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 Documents, 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 Documents 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 follow immediately behind 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, 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 Clearing and Grubbing is not a Contract item.

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, when directed by the Engineer, shall be wasted and disposed of by the Contractor at no additional compensation in accordance with Subsection 203.09.

Where any part of an existing bridge, substructure, or other structure is outside the limits of the excavation for the new work, such part shall be removed to 300 mm (1 foot) below the proposed limits or to the elevations shown on the Plans or as directed by the Engineer.

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.

The removal of pavement on bridges shall include the complete removal of all bituminous concrete material. Removal methods shall be subject to the approval of the Engineer and shall be such as to prevent any damage to the existing remaining portland cement concrete. Existing sealants, such as tar emulsion, may remain in place if the

material is well bonded to the existing portland cement concrete. Any necessary deck repair will be paid for as shown on the Plans.

203.08 BORROW. The Contractor shall request the Engineer's approval of proposed borrow areas at least seven days in advance of their proposed use. This time is needed for stripping of unsuitable material from borrow areas to allow preliminary measurements and survey cross-sections to be taken, as well as laboratory evaluation of the material.

All test pits and explorations required by the Engineer in order to evaluate the acceptability of borrow shall be done by the Contractor at the Contractor's expense.

Opening, maintaining, and closing borrow pits shall be in accordance with Subsections 105.23 through 105.29.

203.09 DISPOSAL OF SURPLUS MATERIAL. All surplus excavation and waste material shall be used to the fullest extent possible to uniformly flatten slopes, or shall be deposited in such places within the right-of-way as shown on the Plans or as authorized in writing by the Engineer. Excavated material shall not be wasted unless directed 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.

Surplus or waste material shall not be deposited above the adjacent traveled way except when authorized in writing by the Engineer.

Disposal of waste material in an area outside of the limits of right-of-way shall be in accordance with Subsections 105.23 through 105.29.

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 or directed by the Engineer, it shall be the responsibility of the Contractor to locate disposal areas.

203.10 HAUL ROADS. Particular care shall be taken in the locating of haul roads. In wooded areas, haul roads shall be of a minimum width 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, ledge, 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 0 °C (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.

The Engineer may require certain select material from excavation or borrow to be used adjacent to structures to obtain the required compaction or to protect them from damage. All material being placed in embankments at locations where piles are to be driven shall pass a 225 mm (9 inch) square screen opening.

(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 rock or material meeting the requirements for Granular Borrow.

The first layer of the embankment may be constructed in one thickness of rock or material meeting the requirements 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 or Rock 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 cobblestones 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 200 mm (8 inches). When conditions necessitate, the Engineer may authorize layers in excess of 200

mm (8 inches) but not more than 600 mm (24 inches). The Contractor shall make all necessary excavations up to 600 mm (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. Cobblestones 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 day shall be graded, crowned, and rolled to ensure adequate drainage.

When A4, A5, A6, or A7 cohesive soils have excess moisture and cannot effectively be air dried or dried by manipulation, the Contractor may layer or mix the material with dry A1, A2, or A3 granular soils in order 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 400 mm (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 150 mm (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 rockfill, the rock embankment layers shall not exceed 600 mm (24 inches) in loose measurement. The clay or silt layers shall not exceed 200 mm (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 600 mm (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.

If embankment must be deposited on only one side of abutments, wingwalls, piers, or culvert headwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to the extent that it will cause overturning of, or

excessive pressure against, the structure. Unless otherwise specified, the fill adjacent to bridge abutments shall not be placed higher than the bridge seat elevations until the superstructure is in place. When an embankment is to be placed on both sides of a concrete wall or box type structure, operations shall be conducted so that the embankment is always at approximately the same elevation on both sides of the structure.

For structures that can displace longitudinally as a result of unequal horizontal loading against their ends, such as a cantilever designed superstructure supported by piers only, backfill shall be placed on both ends of the structure simultaneously, with the lift differential between opposite ends limited to 150 mm (6 inches). Should the backfilling operation cause any undesired displacement, the Contractor shall remove and replace the fill in a manner that will not adversely affect the structure's position, solely at the Contractor's expense.

(d) Compaction. Each layer between the design embankment limits shown on the Plans shall be uniformly compacted by the use of compaction equipment to not less than 90 percent of the material's maximum dry density as determined by AASHTO T 99, Method C. The material in the top 600 mm (24 inches) of any embankment, immediately below the subgrade, shall be compacted to not less than 95 percent of the maximum dry density. Field density determination will be made in accordance with AASHTO T 191, Sand Cone Method; AASHTO T 238, Nuclear Method; or other approved procedures. Field moisture determination will be made in accordance with AASHTO T 99 or measured in accordance with AASHTO T 239, Nuclear Method. 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 percent 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 disking, 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 percent 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 150 mm (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.

Additionally, the following requirements apply to airport compaction:

(1) Rolling operations shall continue until the embankment is compacted to not less than 90 percent of maximum density for cohesive soils, and 95 percent of maximum density for noncohesive soils.

(2) Under all areas to be paved, the top 225 mm (9 inches) of the embankment shall be compacted to a density of not less than 95 percent of maximum density for cohesive soils, and 100 percent for noncohesive soils, unless otherwise shown in the Contract Documents.

(3) In areas designed for the use of aircraft with a mass (weight) less than 13 600 kg (30,000 pounds), the determination of maximum density and optimum moisture content will be performed according to AASHTO T 99, Method C.

(4) In areas designed for the use of aircraft with a mass (weight) more than 13 600 kg (30,000 pounds), the determination of maximum density and optimum moisture content will be performed according to AASHTO T 180, Method C.

(5) The determination of in-place density and in-place moisture content will be performed according to AASHTO T 191, T 238, T 239, or other methods approved by the Engineer.

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 percent 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 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 300 mm (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 Documents 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 should 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. 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.

If any in-place material becomes contaminated by the Contractor's operations so that it no longer meets the Specifications, the Engineer may order that material to be removed and replaced at the Contractor's expense.

A tolerance of 15 mm (1/2 inch) above or below the finished subgrade will be allowed provided that this tolerance is not maintained for a distance longer than 20 m (50 feet) and that the required cross-section is maintained. Where placement of the subbase is not part of the work, a tolerance of 25 mm (1 inch) above or below the finished subgrade will be allowed provided that this tolerance is not maintained for a distance longer than 20 m (50 feet) and that the required cross-section is maintained.

For airport construction, the field density will be determined in accordance with Subsection 203.11(d). In fill sections, stones or rock fragments larger than 100 mm (4 inches) in their greatest dimension will not be permitted in the top 150 mm (6 inches) below subgrade.

203.13 METHOD OF MEASUREMENT. The quantity of excavation to be measured for payment will be the number of cubic meters (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.

(a) 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.

(b) 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 300 mm (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.

(c) The quantity of Muck Excavation to be measured for payment will be the number of cubic meters (cubic yards) of material excavated as shown on the Plans or as directed by the Engineer.

(d) No differentiation will be made between the channel excavation of dry or wet material. The quantity of Channel Excavation of Earth to be measured for payment will be the number of cubic meters (cubic yards) of material excavated from its original position.

Measurement limits for determining the amount of Channel Excavation of Rock will be as specified in Subsection 203.13(b).

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.

(e) The quantity of Excavation of Surfaces and Pavements to be measured for payment will be the number of cubic meters (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. The quantity of this Contract item which is in the designated limits of excavation will be measured as Common or Solid Rock Excavation.

(f) The quantity of borrow to be measured for payment of the type indicated, except Sand Borrow, will be the number of cubic meters (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 75 mm (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.

With the written permission of the Engineer, the method of measurement for Earth Borrow and Granular Borrow may be changed to the number of cubic meters (cubic yards) in place in the complete and accepted work multiplied by a factor of 1.15.

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 meters (cubic yards) of material used in the complete and the accepted work, as determined by the vehicle loads using three-dimensional measurements. A ticket shall be furnished to the Engineer with 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.

When requested by the Contractor and authorized in writing by the Engineer, material specified to be measured by the cubic meter (cubic yard) may be measured by mass (weighed) and the mass (weight) converted to cubic meters (cubic yards) for payment purposes. Factors for conversion from mass (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.

(g) 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.

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 percent of the amount of such waste or excess will be deducted from the total amount of specified borrow being used.

(h) The quantity of Sand Borrow to be measured for payment will be the number of cubic meters (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 that shown on the Plans unless authorized in writing by the Engineer.

(i) The quantity of Gravel Backfill for Slope Stabilization to be measured for payment will be the number of cubic meters (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.

(j) The quantity of Fine Grading - Subgrade to be measured for payment will be the number of square meters (square yards) of the surface area of the bottom of the subbase course. The slope area under and behind the curb in an urban roadway cut section is excluded.

(k) When obtained from previously blasted or stockpiled sources, the quantity of Rock Borrow to be measured for payment will be the number of cubic meters (cubic yards) of blasted material measured in the pile before removal divided by a factor of 1.35.

(l) The simultaneous extraction of more than one borrow item from a given pit will require the written permission of the Engineer.

203.14 BASIS OF PAYMENT. The accepted quantities as measured will be paid for at the Contract unit price per cubic meter (cubic yard) for the specified Contract items except for Fine Grading - Subgrade, which will be paid for at the Contract unit price per square meter (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.

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 Contract item involved.

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 meter (cubic yard) for the particular Contract item used in making the backfill. If the particular Contract item required for backfill is not included in the Contract, a Supplementary Agreement for this Contract item will be negotiated.

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 Contract items unless the Contract item of Fine Grading - Subgrade is included in the Contract.

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 Common Excavation, Earth Borrow, Granular Borrow, or Rock Borrow, whichever unit price is less, 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 Contract item.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 203.15 Common Excavation | Cubic Meter (Cubic Yard) |
| 203.16 Solid Rock Excavation | Cubic Meter (Cubic Yard) |
| 203.17 Unclassified Excavation | Cubic Meter (Cubic Yard) |
| 203.20 Muck Excavation | Cubic Meter (Cubic Yard) |
| 203.25 Channel Excavation of Earth | Cubic Meter (Cubic Yard) |
| 203.26 Channel Excavation of Rock | Cubic Meter (Cubic Yard) |
| 203.27 Unclassified Channel Excavation | Cubic Meter (Cubic Yard) |
| 203.28 Excavation of Surfaces and Pavements | Cubic Meter (Cubic Yard) |
| 203.30 Earth Borrow | Cubic Meter (Cubic Yard) |
| 203.31 Sand Borrow | Cubic Meter (Cubic Yard) |
| 203.32 Granular Borrow | Cubic Meter (Cubic Yard) |
| 203.33 Rock Borrow | Cubic Meter (Cubic Yard) |
| 203.35 Gravel Backfill for Slope Stabilization | Cubic Meter (Cubic Yard) |
| 203.40 Fine Grading - Subgrade | Square Meter (Square Yard) |

# SECTION 204 - EXCAVATION FOR STRUCTURES

204.01 DESCRIPTION. This work shall consist of the excavation and backfill or disposal of all material removed, and the construction, maintenance, and removal of cofferdams.

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 culverts and pipes of 1.2 m (4 foot) clear span and under, conduits, culvert headwalls, drop inlets, manholes, catch basins, leaching basins, underdrains, concrete steps and other minor structures, and drainage ditches at the inlet and outlet of drainage structures 1.2 m (4 foot) clear span and under; excavation for the removal of existing drainage structures; and any other excavation designated to be removed under this Contract item.

(1) Trench Excavation of Earth. Trench Excavation of Earth shall consist of all material excavated within the limits shown in the Contract Documents, except boulders measuring 0.5 $m^3$ (18 cubic feet) or more, solid rock, mortared stone masonry, and concrete.

(2) Trench Excavation of Rock. Trench Excavation of Rock shall consist of all solid rock in formation, or boulders measuring 0.5 $m^3$ (18 cubic feet) or more, excavated within the limits shown in the Contract Documents. All mortared stone masonry and concrete irrespective of the size of its components, excavated within the above limits, shall likewise be considered as rock and so measured.

(b) Structure Excavation. Structure Excavation shall consist of excavation for the construction of foundations and substructures of all structures over 1.2 m (4 foot) clear span, pipe culverts and storm sewers of over 1.2 m (4 foot) clear span, grade separation structures, retaining walls, cribs, and any other excavation that may be designated to be removed under this Contract item.

(c) Cofferdam. Cofferdam shall consist of the design, construction, maintenance, and removal of a watertight structure built for the purpose of constructing, in the dry, a specific foundation or component of a structure in accordance with the Contract Documents. In the dry means that foundations or structural components being constructed are not in or under water.

(d) 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(a)
Crushed Gravel for Subbase (Fine Graded).....704.05(a)
Granular Backfill for Structures..... 704.08

Concrete shall conform to the requirements of Section 501 for Concrete, Class B.

When approved 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 by the Engineer, material meeting the gradation requirements for Crushed Gravel for Subbase (Fine Graded) 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 normal designated elevation and replacement with an approved material.

All suitable excess excavated material shall be used in the formation of embankments or 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.

204.04 PRESERVATION OF CHANNEL. Unless otherwise shown on the Plans or directed by the Engineer, the Contractor shall confine excavation operations to the site of the proposed structure and within the limits of cofferdams or caissons if used in making excavation for structures. The natural streambed shall not be disturbed without permission of the Engineer. Materials from foundation or other excavation shall not be deposited within a stream area.

204.05 FOOTING MODIFICATIONS. When it is necessary to modify the designed footings as shown on the Plans, the Engineer will issue a written order for such changes in elevations or dimensions required to provide a satisfactory foundation.

204.06 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 be carried to either ledge or a solid foundation, unless otherwise specified. If sloping ledge is encountered, the foundation shall be stepped as directed by the Engineer. All loose material shall be removed, and all seams in the rock shall be cleaned out and filled with concrete, mortar, or grout. 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 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 204.12(a) at the Contractor's expense.

When poor foundation material is encountered at the normal 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 204.12(a).

204.07 COFFERDAMS. The Contractor shall prepare detailed plans and a schedule of its operation for each cofferdam specified in the Contract. The design and structural details of the cofferdam shall be signed, stamped, and dated by a Professional Engineer (Structural or Civil).

The Professional Engineer is responsible for ensuring that the proposed cofferdam meets the following criteria:

(a) the design is structurally stable for all conditions to be encountered (e.g., soils, forces, and loadings);

(b) the design and details conform to the Contract and the applicable requirements of the AASHTO *Standard Specifications for Highway Bridges*;

(c) the applicable safety codes are met;

(d) the size and shape are adequate to construct the foundation and structural components specified;

(e) the cofferdam must be adequately watertight for proper performance of the work; and

(f) a cofferdam may have only two or three sides depending upon the particular location and the Contractor's design. It will be paid as a cofferdam and the costs of excavation within the foundation pit will be included in the lump sum price bid for cofferdam.

Two copies of the plans and schedule of operations shall be submitted to the Engineer for information only.

The submittal shall include plan, elevation, and section details indicating the following:

(a) the waterway;

(b) cofferdam information;

(c) substructure location;

(d) dimensions of any temporary restrictions that are to be placed in the waterway, such as barges, lines, earth dams, causeways, temporary diversion channels, and access bridging;

(e) the location, dimensions, clearances, etc., of any temporary scaffolding or netting;

(f) dewatered heads, taking into consideration fluctuations of water levels;

(g) details for screening, pumping, and filtering discharge;

(h) statement as to whether or not any equipment would be removed at night; and

(i) schedule or sequence of operations.

The Contractor is responsible for performing the work in accordance with the submitted details and schedule of operations. All welding shall be performed in accordance with Subsection 506.10. Cofferdam construction shall conform to Division II of the AASHTO *Standard Specifications for Highway Bridges*.

Cofferdams shall be constructed to protect freshly placed concrete against damage from sudden rising of the stream and to prevent damage to the foundation by erosion. The cofferdam shall be constructed so that no timber, bracing, or forms will extend into the foundation.

It shall be the Contractor's responsibility, at its expense, to protect all stream banks from erosion caused by temporary diversion of a channel or from erection or removal of the cofferdam. Any material eroded from stream banks shall be replaced by the Contractor at no cost to the Agency.

In the event the Contractor elects to place fill material in the stream to facilitate access to, or be part of, the cofferdam operations, it shall be clean rock fill.

204.08 FOUNDATION SEALS. When shown on the Plans, or if conditions are encountered during construction that render dewatering undesirable or impractical, a concrete seal shall be placed below the bottom of the footing.

Placement of underwater concrete shall conform to the requirements of Subsection 501.11.

204.09 PUMPING. Pumping from or dewatering of the interior of any foundation enclosure shall be performed so that disturbance of the subsoil or freshly placed concrete does not occur. Dewatering of a sealed cofferdam will not be permitted until four calendar days after placement of the seal. Pumping during the construction of a foundation 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 Subsections 105.23 and 105.24.

204.10 INSPECTION OF FOUNDATION PIT. Immediately following the completion of each foundation pit, the Contractor shall notify the Engineer who will

approve the depth of the pit and the nature of the foundation before the placement of the concrete.

204.11 BEDDING FOR STRUCTURES. Excavation and preparation of the bed for structures shall conform to the specification for the specific structure being installed.

204.12 BACKFILL.

(a) General. All spaces excavated and not occupied by structures shall be backfilled with material from excavation, unless otherwise specified. The Contractor shall backfill up to the elevation of existing ground or 600 mm (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 150 mm (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 75 mm (3 inches).

Compaction by means of hand tamping will not be permitted.

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. Special precaution shall be taken to prevent wedging action against the structure.

(b) Backfill of Trenches. The backfill shall be carried to the upper-most level of the trench or subgrade. No stones or blasted ledge exceeding 75 mm (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 seven days and until it has obtained 85 percent of the designed compressive strength, and then only with the permission of the Engineer.

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).

204.13 METHOD OF MEASUREMENT.

(a) Trench Excavation. The quantity of Trench Excavation of Earth or Trench Excavation of Rock to be measured for payment will be the actual number of cubic meters (cubic yards) excavated up to the maximum dimensions as follows:

(1) The horizontal dimensions for culverts and pipes shall be the distance between vertical planes 500 mm (1 foot) outside of and parallel to the exterior lines of the culverts, pipes, and end sections when applicable.

(2) The horizontal dimensions for drop inlets, manholes, and other minor structures shall be 500 mm (1 foot) 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.

(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 percent of the volume for the first 1.5 m (5 feet) of vertical depth.

b. 150 percent of the volume below the first 1.5 m (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, all openings having cross-sectional areas of 0.5 $m^2$ (4 square feet) or less will be included as part of the rock. All openings having cross-sectional areas greater than 0.5 $m^2$ (4 square feet) will be deducted and not allowed as either Trench Excavation of Rock or Trench Excavation of Earth.

(b) Structure Excavation. The quantity of Structure Excavation to be measured for payment will be the number of cubic meters (cubic yards) measured and computed by average end area method whenever practical, as follows:

(1) Vertically. Between the original ground surface or the bottom limits of other excavation, whichever is the lower elevation, and the bottom of the structure excavation;

or

Between the original ground surface or the bottom limits of other excavation to 500 mm (1 foot) below the bottom neat lines of any part of a structural component falling outside any horizontal pay limits established for its footings.

Where Excavation (Common, Solid Rock, or Unclassified), Channel Excavation, and Structure Excavation occur at the same location, measurement for Channel Excavation will be made only below the lower limits of 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 the following table:

| Vertical Depth Below Bottom of Excavation Indicated on the Plans | | Volume of Structure Excavation Multiplied by: |
|---|---|---|
| meters | feet | |
| 0 to 0.5 | 0 to 1 | 100% |
| Over 0.5 to 2.0 | Over 1 to 5 | 150% |
| Over 2.0 to 3.0 | Over 5 to 10 | 450% |
| Over 3.0 to 5.0 | Over 10 to 15 | 750% |
| Over 5.0 | Over 15 | (paid as Extra Work) |

Where a foundation or component of a structure is designed or directed to be placed on ledge, an average 150 mm (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 500 mm (1 foot) outside the neat lines of footings or beams, or other structural components, and parallel thereto except for the following:

The horizontal measurements of the Structure Excavation for reinforced concrete boxes shall be the overall width of the box, plus 500 mm (1 foot) on each side, and the length of the structure, plus 500 mm (1 foot) on each end.

The horizontal measurements for corrugated plate arches shall be the width of each abutment, plus 500 mm (1 foot) on each side, and the length of the arch, plus 500 mm (1 foot) on each end.

The horizontal measurements for pipes and pipe arches having a diameter or span over 1200 mm (48 inches) shall be between vertical planes 1 m (3 feet) outside the exteriors of each side, and the length of the pipes or pipe arches plus 500 mm (1 foot) on each end.

When footings are not used, the neat lines shall be the junction line between the new concrete and the old masonry or ledge.

(c) Cofferdam. The quantity of Cofferdam to be measured for payment will be on a unit basis for each cofferdam shown in the Contract Documents. The unit shall include all cofferdam structure or alternate de-watering and stabilizing work required at each pier, abutment, or other site specified.

(d) Granular Backfill for Structures. The quantity of Granular Backfill for Structures to be measured for payment will be the number of cubic meters (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.

204.14 BASIS OF PAYMENT. The accepted quantities for Trench Excavation, Structure Excavation, and Granular Backfill for Structures will be paid for at the Contract unit price per cubic meter (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 of all surplus material, and the cleaning up of the site following completion of construction operations, 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, siltation control, and incidentals necessary for properly constructing, in the dry, a foundation or structural component.

All material removed beneath a vertical depth of 5 m (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 5 m (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.

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; for performing the work specified; and for furnishing all labor, tools, equipment, materials, and incidentals necessary to complete the work. Payment will also include the cost of excavating the material within the foundation pit, seals, sheeting, bracing, siltation control, and all incidentals necessary to properly construct the foundation or structural component and to maintain the cofferdam in a dewatered condition.

When a foundation within a cofferdam (paid as a Contract item) is to be placed on earth, excavation for the first 600 mm (2 feet) of any additional depth below the bottom of excavation elevations shown on the Plans will be included in the Contract lump sum price for the cofferdam involved. Any costs necessary for altering the cofferdam for excavation below the 600 mm (2 foot) limit will be paid for as Extra Work.

When a foundation within a cofferdam (paid as a Contract item) is to be placed on bedrock, the fact that bedrock may be encountered at an elevation different from what is shown on the Plans will not be a basis for Extra Work.

Should the Contractor be required to remove any solid rock within a cofferdam below the designed elevation, the quantity removed will be paid for as Extra Work.

When a seal is not specified in the Contract and is ordered by the Engineer, it will be paid for at the Contract unit price for Concrete, Class B. Payment will include any extra cement or additives in the approved design mix or special equipment required for placing the concrete.

Partial payment for the Contract item Cofferdam will be made as follows:

(a) 75 percent when excavation within cofferdam is completed, any necessary seals are in place, and the interior has been successfully dewatered.

(b) 25 percent when completely removed.

When, by written order, the Engineer requires a cofferdam or a portion to be left in place, the Contractor will be paid for the actual cost of the material left in place.

When the Contract item Cofferdam is not in the Contract and the Contractor elects to construct one to facilitate foundation construction, it will not be paid for directly but will be considered incidental to Structure Excavation. In this instance, when the Engineer requires a cofferdam to be left in place by written order, the Contractor will be paid for the actual cost of the material left in place. However, the labor, tools, equipment, and incidentals required will not be paid for directly but will be considered incidental to Structure Excavation.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 204.20 Trench Excavation of Earth | Cubic Meter (Cubic Yard) |
| 204.21 Trench Excavation of Rock | Cubic Meter (Cubic Yard) |
| 204.25 Structure Excavation | Cubic Meter (Cubic Yard) |
| 204.30 Granular Backfill for Structures | Cubic Meter (Cubic Yard) |
| 204.40 Cofferdam | Lump Sum |

## SECTION 205 - DRILLING AND BLASTING

205.01 DESCRIPTION. This work shall consist of the drilling and blasting of rock.

205.02 DRILLING AND BLASTING OF SOLID ROCK. Holes shall be drilled to the approximate depth and spacing shown on the Plans or as directed by the Engineer.

Following the drilling, explosives shall be placed in each hole and then detonated. The amount of explosive shall be sufficient to shatter and rearrange the rock for the full

depth of the drill holes. Blasting shall be done progressively from the lower level to the top level. The removal of the blasted rock is not required under the work in this Section.

205.03 DRILLING AND BLASTING OF SOLID ROCK SUBGRADE. Subgrade areas shall be shattered 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 1.2 m (4 feet) below subgrade elevation to eliminate water pockets.

After detonation, any rock that protrudes above the subgrade elevation shall be removed. When directed by the Engineer, the Contractor shall excavate a trench across the blasted rock to determine if the rock is broken and rearranged to a depth of 1.2 m (4 feet) below subgrade. Afterwards, the trench shall be backfilled with the rock removed.

205.04 METHOD OF MEASUREMENT. The quantity of Drilling and Blasting of Solid Rock to be measured for payment will be the number of meters (linear feet) of drill holes drilled and detonated in accordance with this Section.

The quantity of Drilling and Blasting of Solid Rock Subgrade to be measured for payment will be the number of square meters (square yards) of subgrade plan area drilled and detonated in accordance with this Section, measured at subgrade level.

The number of cubic meters (cubic yards) of excavation required by the Engineer to inspect the depth of shattered and rearranged rock, computed at a maximum width of 750 mm (30 inches), will be measured for payment as Trench Excavation of Earth.

When Trench Excavation of Rock and Drilling and Blasting of Solid Rock Subgrade occur at the same location, measurement and payment for Trench Excavation of Rock will be made below the subgrade. The area of Trench Excavation of Rock will not be included in the measurement and payment for Drilling and Blasting of Solid Rock Subgrade.

205.05 BASIS OF PAYMENT. The accepted quantities as measured will be paid for at the Contract unit price per meter (linear foot) or square meter (square yard), as applicable, for the specified Contract items. Payment will be full compensation for performing the work specified including any necessary stripping of rock below subgrade, the removal of blasted subgrade rock that may swell above subgrade, and its disposition on the project as directed.

Excavation and backfill required to inspect the depth of broken rock below subgrade will be paid for at the Contract unit price per cubic meter (cubic yard) for Trench Excavation of Earth.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 205.10 Drilling and Blasting of Solid Rock | Meter (Linear Foot) |
| 205.20 Drilling and Blasting of Solid Rock Subgrade | Square Meter (Square Yard) |

## SECTION 210 - COLD PLANING

210.01 DESCRIPTION. This work shall consist of the removal and the satisfactory disposal and clean up of road, airport, or bridge pavements by cold planing.

210.02 EQUIPMENT. The equipment shall consist of a power operated planing machine or grinder capable of accurately establishing profile grades by referencing from both the existing pavement and from an independent grade control. The equipment shall have a positive means for controlling cross slope elevations. The planer shall have sufficient mass (weight) to perform all types of planing without lifting. Sufficient and positive down pressure is to be provided on the drum assembly at all times when planing. The cutting head shall be maintained so that the depth of cut is within a tolerance of 3 mm (1/8 inch) throughout the width of the head. The equipment shall also have an effective means of preventing dust from escaping into the air.

210.03 GENERAL CONSTRUCTION REQUIREMENTS. The bituminous surface shall be removed to the depth, width, grade, and typical cross-section as shown on the Plans or as directed by the Engineer. No variation from the typical cross-section of more than 3 mm (1/8 inch) will be allowed. Any bituminous surfaces adjacent to objects such as scuppers, expansion joints, drop inlets, and curbs that are inaccessible to the cold planer shall be removed by means of other approved equipment.

Unless otherwise specified, the planed material shall become the property of the Contractor and shall be removed from the project. All dust and other remaining material shall be immediately removed with a power vacuum sweeper to the satisfaction of the Engineer. The resulting surface on bridges shall be left in a condition to receive tar emulsion or, if shown on the Plans, a membrane, or as directed by the Engineer. The Contractor shall exercise reasonable care to ensure no damage occurs to the portland cement concrete deck when removing pavement from bridges.

When traffic shall be maintained for any period of time on a cold planed area, the following conditions apply:

(a) All planed and sawed cross roadway butt joints of 19 mm (3/4 inch) depth or greater shall have a temporary wedge of bituminous concrete pavement installed as directed by the Engineer.

(b) The Contractor shall repave any cold planed areas within 14 calendar days of planing or when directed by the Engineer, provided that any cold planed area that is not repaved the same day as it is cold planed has proper and adequate tapers installed before the end of the working day in which the cold planing is performed. Should the area remain unpaved for a period of more than 14

calendar days without the approval of the Engineer, no payment whatsoever will be made for the cold planing. If the Contractor lays down temporary pavement to avoid the above non-payment for cold planing, temporary pavement and subsequent re-cold planing shall be at the Contractor's expense. Traffic cones will be placed along the longitudinal drop-off as directed by the Engineer.

(c) The temporary pavement wedge and taper shall be totally removed prior to placing the permanent final pavement at cold planed locations. All costs involved with installing and removing a temporary pavement wedge and/or taper will not be paid for directly, but will be considered included in Contract item Cold Planing - Bituminous Pavement.

(d) Cold planed areas susceptible to ponding of water shall be drained by cutting slots through the adjoining non-milled shoulder area and filling the slots with materials meeting the requirements of Contract item Open Graded Asphalt Friction Course or Contract item Crushed Stone Bedding as directed by the Engineer. All costs of cutting slots and filling the slots with the designated material will not be paid for directly but will be considered included in the Contract item Cold Planing - Bituminous Pavement.

210.04 METHOD OF MEASUREMENT. The quantity of Cold Planing - Bituminous Pavement to be measured for payment will be the number of square meters (square yards) of surface from which bituminous pavement has been removed to the depth shown on the Plans.

210.05 BASIS OF PAYMENT. The accepted quantity of Cold Planing - Bituminous Pavement will be paid for at the Contract unit price per square meter (square yard). Payment will be full compensation for furnishing all labor, tools, and equipment including the vacuum sweeper necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 210.10 Cold Planing - Bituminous Pavement | Square Meter (Square Yard) |

## SECTION 212 - SCARIFYING PAVEMENTS

212.01 DESCRIPTION. This work shall consist of scarifying or breaking up existing portland cement concrete and/or bituminous concrete pavements that are to be left in place below the subgrade.

212.02 GENERAL CONSTRUCTION REQUIREMENTS. The existing pavement shall be scarified or broken up such that the longest dimension of any piece does not exceed 1 m (3 feet). The broken up pavement shall be left in place, and the work shall be done in such a manner that the resulting surface is relatively flat. Large, jutting, or on edge pieces, or the piling of broken pieces, will not be permitted.

212.03 METHOD OF MEASUREMENT. The quantity of Scarifying Pavement to be measured for payment will be the number of square meters (square yards) scarified, measured in its original position and accepted by the Engineer.

212.04 BASIS OF PAYMENT. The accepted quantity of Scarifying Pavement will be paid for at the Contract unit price per square meter (square yard). Payment will be full compensation for furnishing all labor, tools, and equipment necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 212.20 Scarifying Pavement | Square Meter (Square Yard) |

# 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:

| | |
|---|---|
| Sand Borrow | 703.03 |
| Gravel for Subbase | 704.04 |
| Crushed Gravel for Subbase | 704.05 |
| Dense Graded Crushed Stone | 704.06 |

At the option of the Contractor, unless otherwise specified in the Contract, processed glass aggregate (PGA) may be used to partially replace natural aggregate in materials specified to meet the requirements of Subsections 703.03, 704.04, 704.05, and 704.06.

PGA shall be a crushed and screened material with 95 percent passing a 25.0 mm (1 inch) sieve, and not more than 3 percent of the material passing the 4.75 mm (No. 4) sieve shall pass a 75 μm (No. 200) sieve.

Materials used to produce PGA shall consist of recycled glass food or beverage containers. Small amounts (less than 5 percent 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 a trace of screw tops, plastic cap rings, or other contaminants. Amounts of contaminants greater than 1 percent by mass (weight) shall be grounds for rejection of the entire PGA batch. 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 subbase blends.

PGA subbase blends shall not contain more than 10 percent by mass (weight) of PGA. The final blend shall meet the gradation to ensure that a homogenous mixture conforming to the specified gradation has been obtained. Process control tests shall be performed at a minimum frequency of one test per 2000 $m^3$ (2500 cubic yards) of material produced. A copy of each test result shall be given to the Engineer.

Prior to the use of any PGA subbase blend, the Contractor shall submit in writing, for preliminary approval of the Engineer, information identifying the sources and locations from which PGA material to be used on the project will be obtained. The Contractor shall also submit certified test results verifying that the PGA material will be in compliance with the Contract requirements. Once the sources of PGA are approved, quality assurance samples may be taken by the Engineer.

PGA subbase blends must be approved for use on the project by the Engineer in writing prior to being placed on a project. In-place blending of PGA with other materials will not be permitted.

The supplier of PGA shall provide a Type A Certification that the crushed glass material to be used does not contain, and has never contained, toxic or hazardous substances.

The supplier of the PGA subbase blended material shall provide a Type C Certification that the PGA and the subbase material each meet all specified gradation and cleanliness requirements and that the PGA subbase blend meets all gradation requirements.

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 occur during the placing of the subbase, 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.

The maximum compacted layer thickness for all subbase materials is 300 mm (12 inches). Where the finished depth of the subbase is to be greater than 300 mm (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 300 mm (12 inches).

After each layer of subbase material is placed, it shall be graded to obtain a smooth, even surface using a power grader. Following grading operations the subbase shall be thoroughly compacted by rolling with an approved power roller with a mass (weight) of at least 9 metric tons (10 tons) or by other methods approved by the Engineer. A power grader 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 subbase material, reworked, and compacted as shown on the Plans. If required, water shall be uniformly applied over the subbase materials during compaction in the amount necessary for proper consolidation. Materials containing PGA shall be compacted in the same manner as materials that do not contain PGA.

When it is necessary to maintain traffic over the subbase, 50 percent 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 50 mm (2 inches) of subbase shall be scarified (to restore permeability in the subbase surface), compacted, and regraded as required above, or replaced just prior to the placement of any pavement.

If roadway shoulders are to remain unpaved, subbase or other designated material to be placed in the shoulder area after final roadway paving shall be placed in accordance with Subsection 402.03.

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 25 mm (1 inch). This variation shall not be maintained for a distance longer than 15 m (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.

301.06 METHOD OF MEASUREMENT. The quantity of subbase to be measured for payment will be the number of cubic meters (cubic yards) of the type specified for use in the complete and accepted work, as determined by the plan dimensions of the compacted material.

The quantity of Subbase of Crushed Gravel (Fine Graded), Truck Measurement to be measured for payment will be the number of cubic meters (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.

When specified to be paid by mass (weight), the quantity of Subbase of Crushed Gravel (Fine Graded) to be measured for payment will be the number of metric tons (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 meters (cubic yards) measured in place for this purpose between the lines shown on the Plans.

Materials containing PGA will be measured in the same manner as subbase materials that do not contain PGA.

301.07 BASIS OF PAYMENT. The accepted quantity of subbase will be paid for at the Contract unit price per cubic meter (cubic yard) or metric ton (ton) for the type specified. Payment will be full compensation for furnishing, transporting, placing, grading, and compacting the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Truck measurement, when not specified in the Contract, may be used when ordered by the Engineer. Truck measurement will be converted to in-place measurement by dividing by a factor of 1.15.

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 |
|---|---|
| 301.15 Subbase of Gravel | Cubic Meter (Cubic Yard) |
| 301.25 Subbase of Crushed Gravel (Coarse Graded) | Cubic Meter (Cubic Yard) |
| 301.26 Subbase of Crushed Gravel (Fine Graded) | Cubic Meter (Cubic Yard) |
| 301.27 Subbase of Crushed Gravel (Fine Graded), Truck Measurement | Cubic Meter (Cubic Yard) |
| 301.28 Subbase of Crushed Gravel (Fine Graded) | Metric Ton (Ton) |
| 301.35 Subbase of Dense Graded Crushed Stone | Cubic Meter (Cubic Yard) |

## SECTION 303 - PLANT MIXED BASE COURSE

303.01 DESCRIPTION. This work shall consist of furnishing and placing one or more courses of crushed gravel or crushed stone, plant mixed with bituminous material, on a prepared surface.

303.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Bituminous Material | 702.01 |
| Asphalt Cement | 702.02 |
| Emulsified Asphalt | 702.04 |
| Aggregate for Plant Mixed Base Course | 704.03 |

The grade of asphalt cement shall be as shown on the Plans, unless otherwise specified in the Contract. The grade of asphalt may be changed by the Engineer upon one week's notice.

The materials shall be combined and graded to meet the following composition limits by mass (weight):

| Square Openings Sieve Size | Percent Passing by Mass (Weight) |
|---|---|
| 45 mm (1 3/4 inch) | 100 |
| 37.5 mm (1 1/2 inch) | 95 to 100 |
| 25.0 mm (1 inch) | 60 to 85 |
| 19.0 mm (3/4 inch) | 50 to 70 |
| 12.5 mm (1/2 inch) | 40 to 60 |
| 4.75 mm (No. 4) | 20 to 40 |
| 2.36 mm (No. 8) | 15 to 30 |
| 75 μm (No. 200) | 0 to 4 |

The asphalt content will be determined by the Engineer.

The mixing temperature shall be 143 ± 11 °C (290 ± 20 °F).

No work shall be started until the Contractor has submitted the mix design to the Engineer and received the Engineer's approval. The mix design shall indicate the percentage of each ingredient to be used in the mixture. No change in the approved mix design shall be made without the approval of the Engineer.

303.03 WEATHER LIMITATIONS. Plant mixed base course shall not be placed between November 1 and May 1. When it is in the public interest, the Engineer may extend the dates of the paving season. The material shall not be placed when the ambient air temperature at the paving site in the shade and away from artificial heat is 5 °C (40 °F) or lower. No material shall be placed on any frozen subbase regardless of the temperature.

303.04 BITUMINOUS MIXING PLANT AND TESTING. All plants used by the Contractor for the production of plant mixed base course shall conform to all the requirements of Subsection 406.05. The use of surge bins or a drum-mix plant will not be allowed.

303.05 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated to the temperature specified in Subsection 702.06 in a manner that will

avoid local overheating. A continuous supply of bituminous material shall be furnished to the mixer at a uniform temperature.

303.06 PREPARATION OF AGGREGATES. The aggregate 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 damaging the aggregate and depositing soot and unburned fuel on the aggregate.

303.07 MIXING. The dried aggregate sizes shall be proportioned to meet the composition limit and thoroughly mixed prior to adding the bituminous material.

The dried aggregates shall be combined with the bituminous material in such a manner as to produce a mixture that when discharged from the mixing unit is at the temperature specified in the mix design.

The Engineer will approve the quantity of bituminous material for each batch. The bituminous material shall be measured or gauged and introduced into the mixer in the quantity approved by the Engineer for the particular material being used and at the temperature as specified.

After the required quantity of aggregate and bituminous 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 bituminous material throughout the aggregate is secured. In any event, for a batch plant, the mixing time will be regulated by the Engineer, and a suitable locking means shall be provided for this regulation.

All plants shall have a positive means of eliminating oversized and foreign materials from being incorporated into the mixer.

303.08 HAULING EQUIPMENT. Trucks used for hauling bituminous mixture shall have tight, clean, smooth metal bodies. The Contractor shall apply a thin coat of a non-petroleum based or soap solution to prevent the mixture from adhering to the truck bodies.

Each truck body shall have a cover of canvas or other suitable material of such size sufficient to protect the mixture from the weather. When necessary to ensure delivery of material at the specified temperature, truck bodies shall be insulated, and covers shall be securely fastened.

303.09 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 and finishing the mixture without segregation for the widths and thicknesses specified. The screed shall be adjustable to provide the desired cross-sectional shape. The finished surface shall be of uniform texture and evenness and shall not show any indication of tearing, shoving, or pulling of the mixture. The machine shall, at all times, be in good mechanical condition and shall be operated by competent personnel.

Pavers shall be equipped with the necessary attachments, designed to operate electronically, for controlling the grade of the finished surface.

The adjustments and attachments of the paver will be checked and approved by the Engineer before placement of plant mixed base course.

303.10 ROLLERS. Rollers shall be of the steel-wheel type and shall be in good mechanical condition, operated by competent personnel, capable of reversing without backlash, and operated at speeds slow enough to avoid displacement of the bituminous mixture. The mass (weight) of each roller shall be sufficient to compact the mixture to the required density without excessive crushing of the aggregate. Rollers shall be equipped with water tanks and sprinkling bars for wetting the rolls and shall meet the following requirements:

(a) Two-axle tandem roller shall have a gross mass (weight) of not less than 7 metric tons (8 tons) and not more than 10 metric tons (12 tons) and shall be capable of providing a compactive effort of 44 kN/m (250 pounds per inch) of width of the drive roll. All rolls shall be at least 1 m (42 inches) in diameter.

(b) Three-axle tandem roller shall have a gross mass (weight) of not less than 10 metric tons (12 tons) and not more than 18 metric tons (20 tons) and shall be capable of providing a minimum compaction effort of 44 kN/m (250 pounds per inch) of width of the drive roll. The roller shall be equipped with a locking device to allow the center axle roll to move independently or to be secured in a locked position.

303.11 SPREADING AND FINISHING. Immediately before placing the plant mixed base course, the existing prepared surface shall be cleaned of all loose or deleterious material.

Contact surfaces of cold joints, curbing, gutters, and manholes shall be coated with a thin, uniform coat of Type RS-1 emulsified asphalt immediately prior to placement of the plant mixed base course against them.

The plant mixed base course, at the time of discharge from the haul vehicle, shall be at a temperature of not less than 127 °C (260 °F) and not more than 154 °C (310 °F).

The Contractor shall protect all exposed surfaces that are not to be treated from damage during all phases of the paving operation.

The bituminous mixture shall be spread and finished with the specified equipment. The mixture shall be struck off in a uniform layer to the full width required and of such depth that each course, when compacted, has the required thickness and conforms to the grade and cross-section contour specified. Bituminous concrete pavers shall be used to distribute the mixture over the entire width or over such partial width as may be practical.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture shall be spread and leveled by hand tools.

Bituminous mixture shall not be produced so late in the day as to prohibit the completion of spreading and compaction of the mixture during daylight hours, unless night paving has been approved for the project.

Trucking over material already placed will not be permitted until the material has been thoroughly compacted and has been permitted to cool to 60 °C (140 °F). When the bituminous concrete pavement consists of more than one layer, each layer shall be compacted as specified and allowed to cool to ambient air temperature before the next layer is applied.

303.12 COMPACTION. Immediately after the bituminous mixture has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling until the in-place air voids are between 4.0 and 8.0 percent.

The surface shall be rolled when the mixture is in the proper condition and when the rolling does not cause undue displacement, cracking, or shoving.

The number, mass (weight), and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. Generally, one breakdown roller will be needed for each paver used in the spreading operation.

To prevent adhesion of the mixture to the rolls, they shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls, and other places not accessible to the rollers, the mixture shall be thoroughly compacted with hot or lightly oiled hand tampers, smoothing irons, or with mechanical tampers.

Other combinations of rollers and/or methods of compacting may be used if approved in writing by the Engineer.

Unless otherwise specified, the longitudinal joint shall be rolled first. Next, the Contractor shall begin rolling at the low side of the pavement and shall proceed toward the center or high side with lapped rollings parallel to the centerline. The speed of the roller shall be slow and uniform to avoid displacement of the mixture, and the roller should be kept in as continuous operation as practical. Rolling shall continue until all roller marks and ridges have been eliminated. Rollers will not be permitted to park on any freshly laid mixture and shall set back a sufficient distance behind the paver so that a parked roller will not leave any roller depressions.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with fresh hot mixture, which shall be compacted to conform to the surrounding area. Any area showing an excess or deficiency of bitumen shall be removed and replaced.

303.13 JOINTS. Joints between old and new pavements or between successive day's work shall be made to ensure a thorough and continuous bond between the old and new mixtures. Whenever the spreading process is interrupted long enough for the mixture

to attain its initial stability, the paver shall be removed from the mat and a joint constructed.

Unless otherwise directed by the Engineer, longitudinal joints shall be offset at least 150 mm (6 inches) from any joint in the lower courses of base. Transverse joints shall not be constructed closer than 300 mm (12 inches) to the transverse joint constructed in lower courses.

303.14 SURFACE TOLERANCE. The plant mixed base course shall be finished to within a grade tolerance of 15 mm (1/2 inch) provided that this tolerance is not maintained for a distance longer than 15 m (50 feet) and that the required crown or superelevation is maintained.

The surface will be tested by the Engineer using a straightedge at least 4.9 m (16 feet) in length at selected locations parallel with the centerline. Any variations exceeding 4.5 mm (3/16 inch) between any two contact points shall be satisfactorily eliminated. A straightedge of at least 3 m (10 feet) in length may be used on a vertical curve. The straightedges shall be provided by the Contractor.

If directed by the Engineer, depressions shall be corrected by using a mix conforming to the requirements of bituminous concrete pavement. Payment for this material will be at the Contract unit price for the Contract item Plant Mixed Base Course.

303.15 TRAFFIC CONTROL. Whenever traffic must be maintained during a paving operation, uniformed traffic officers and/or flaggers shall be stationed at each end of the section being paved and at other locations as required by the Engineer. The traffic officers or flaggers shall conform to the requirements of Section 630.

Whenever one-way traffic is maintained by the Contractor, the traveling public shall not be stopped or delayed more than ten minutes, unless otherwise directed by the Engineer. Two-way traffic shall be maintained during non-working hours.

303.16 METHOD OF MEASUREMENT. The quantity of Plant Mixed Base Course to be measured for payment will be the number of metric tons (tons) of mixture used in the complete and accepted work, as determined from the load tickets.

303.17 BASIS OF PAYMENT. The accepted quantity of Plant Mixed Base Course will be paid for at the Contract unit price per metric ton (ton). Payment will be full compensation for furnishing, mixing, hauling, and placing the material specified and for furnishing signs, labor, tools, equipment, and incidentals necessary to complete the work.

The cost of furnishing testing facilities and supplies at the plant will be considered included in the Contract item unit price of Plant Mixed Base Course.

The cost of obtaining, furnishing, transporting, and providing the straightedges required for plant mixed base course will be paid for under the Contract item Testing Equipment - Bituminous.

When not specified as a Contract item, the cost of Uniformed Traffic Officers or Flaggers will not be paid for directly but will be considered incidental to the Contract item of Plant Mixed Base Course.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 303.25 Plant Mixed Base Course | Metric Ton (Ton) |

# 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 Subsection:

Aggregate for Surface Course and Shoulders .....704.12

401.03 PLACING. 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 aggregate shall be thoroughly compacted with an approved power roller with a mass (weight) not less than 7 metric tons (8 tons), or an approved rubber tired roller, or by other approved methods.

The maximum layer thickness for placement of any aggregate surface material shall be 150 ± 50 mm (6 ± 2 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 300 mm (12 inches).

After each layer of surface or shoulder material is placed, it shall be thoroughly compacted to a uniform density of not less than 95 percent of the maximum dry density determined by AASHTO T 99, Method C. 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 as shown on the Plans. If required, water shall be uniformly applied over the aggregate material during compaction in an amount necessary to produce proper consolidation.

401.04 METHOD OF MEASUREMENT. The quantity of Aggregate Surface Course to be measured for payment will be the number of cubic meters (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 will be paid for at the Contract unit price per cubic meter (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.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 401.10 Aggregate Surface Course | Cubic Meter (Cubic Yard) |

## SECTION 402 - AGGREGATE SHOULDERS

402.01 DESCRIPTION. This work shall consist of furnishing and placing shoulders of approved aggregate on a prepared surface.

402.02 MATERIALS. Materials shall meet the requirements of the following Subsection:

Aggregate for Surface Course and Shoulders ..... 704.12

402.03 PLACING. Shoulder material shall be placed with a machine that has been approved by the Engineer. The Contractor shall demonstrate to the Engineer the proposed placement procedure. If necessary, the procedure shall be adjusted to avoid grooving, marking, or other damage to the final pavement course.

Unless otherwise directed by the Engineer or shown on the Plans, the aggregate shall be placed in one course and shall not be placed until the adjacent wearing surface has been completed.

Should segregation occur, the Contractor shall remove and replace the segregated material or manipulate it until uniform gradation is obtained.

402.04 COMPACTION. The shoulder material shall be rolled after shaping with an approved roller, with a mass (weight) not less than 7 metric tons (8 tons), until thoroughly compacted. The Contractor shall wet the material as necessary to obtain proper compaction. Should irregularities in the shoulder material develop during or after rolling, they shall be corrected.

Compaction around mailbox turnouts, driveways, and other obstacles shall be accomplished with equipment designed for that purpose and approved by the Engineer.

The maximum layer thickness for placement of any aggregate shoulder material shall be 150 ± 50 mm (6 ± 2 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 300 mm (12 inches).

After each layer of surface or shoulder material is placed, it shall be thoroughly compacted to a uniform density of not less than 95 percent of the maximum dry density determined by AASHTO T 99, Method C. 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 as shown on the Plans. If required,

water shall be uniformly applied over the aggregate material during compaction in an amount necessary to produce proper consolidation.

402.05 METHOD OF MEASUREMENT. The quantity of Aggregate Shoulders, In Place to be measured for payment will be the number of cubic meters (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.

The quantity of Aggregate Shoulders, Truck Measurement to be measured for payment will be the number of cubic meters (cubic yards) used in the complete and accepted work, as determined by vehicle loads using three dimensional measurements. All vehicles shall be loaded to at least their water level capacity and any 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.

Truck measurement, when not specified in the Contract, may be used when ordered by the Engineer. Truck measurement will be converted to in-place measurement by dividing by 1.15.

When specified to be paid by mass (weight), the quantity of Aggregate Shoulder to be measured for payment will be the number of metric tons (tons) used in the complete and accepted work, as determined from the load tickets.

402.06 BASIS OF PAYMENT. The accepted quantity of Aggregate Shoulders will be paid for at the Contract unit price per cubic meter (cubic yard) or metric ton (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 |
|---|---|
| 402.10 Aggregate Shoulders, In Place | Cubic Meter (Cubic Yard) |
| 402.11 Aggregate Shoulders, Truck | Cubic Meter (Cubic Yard) |
| 402.12 Aggregate Shoulders | Metric Ton (Ton) |

## SECTION 404 - BITUMINOUS SURFACE TREATMENT

404.01 DESCRIPTION. This work shall consist of furnishing and applying one or more courses of bituminous treatment and aggregate cover material when required on an approved surface.

404.02 MATERIALS. Materials shall meet the requirements of the following Subsections:



All additives for asphalt cements and emulsified asphalts must be approved prior to their use.

The type and grade of bituminous material will be determined by the Engineer in accordance with the following table:

TABLE 404.02A - BITUMINOUS MATERIALS

| Bituminous Surface Treatment | First Application | Second and Subsequent Application |
|---|---|---|
| Type I with Cutback Asphalt | MC-250, RC-250, or MC-RC 250 Blend | MC-800, MC-3000, RC-800, RC-3000, MC-RS 800 Blend, or MC-RS 3000 Blend |
| Type II with Cutback Asphalt | MC-3000, RC-3000, or a blend of the two | MC-3000, RC-3000, or a blend of the two |
| Type III with Cutback Asphalt | MC-250, RC-250, MC-800, RC-800, MC-RC 250 Blend, or MC-RC 800 Blend | --- |
| Type IV | MC-800, MC-3000, RC-800, RC-3000, MC-RC 800 Blend, MC-RC 3000 Blend, RS-2, or CRS-2 | --- |

404.03 WEATHER LIMITATIONS. Bituminous material shall be applied only when the following conditions prevail:

(a) The ambient air temperature is at least 10 °C (50 °F) in the shade, and rising.

(b) The road surface and the aggregate are sufficiently dry.

(c) Weather conditions or other conditions are favorable and are expected to remain so for the performance of satisfactory work.

Bituminous material shall not be applied between October 1 and May 15 unless authorized in writing by the Engineer.

404.04 EQUIPMENT. The equipment used by the Contractor shall include scarifying, mixing, spreading, finishing, and compacting equipment; transporting equipment; a bituminous distributor; and equipment for heating bituminous material.

(a) Distributor. The distributor shall be so designed, equipped, maintained, and operated that bituminous material at even heat may be applied uniformly on variable widths of surfaces up to 4.6 m (15 feet) at the specified rate for the item being placed. Distributor equipment shall include suitable hand spray nozzle and hose, a tachometer, pressure gauges, accurate volume measuring devices or a calibrated tank, 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.

Distributors may be required to apply a 7.3 m (24 foot) wide strip at one time.

The mass (weight) of the loaded distributor shall not exceed the legal load limit.

Each pressure distributor shall be equipped with a squeegee and pouring pot, and labor shall be furnished to use the tools.

Each pressure distributor shall be equipped with a measuring stick.

Traveling or stationary plants or other equipment of proven performance may be used by the Contractor instead of the specified equipment if approved.

Operators must be capable and conscientious, and shall cooperate with the Engineer at all times.

(b) Transporting Equipment. Tanks for motor transport trucks shall be made of either steel or aluminum with a minimum capacity of 5.5 $m^3$ (1500 gallons), insulated, equipped with baffle plates to prevent surging, and equipped with the necessary units in order 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.

(c) Rollers. Rollers shall be self-propelled, steel-wheel, tandem or three-wheel with an operating force of not less than 7 metric tons (8 tons) each; and pneumatic-tired with a total compacting width of not less than 1.5 m (60 inches) and an operating force adjustable within the range of 35 to 61 kN/m (200 to 350 pounds per inch) of compaction width. The operating force shall be as directed by the Engineer. Tire pressure or contact pressure may be specified for pneumatic-tired rollers.

404.05 PREPARATION OF SURFACES. All surfaces to be treated shall be patched, cleaned of loose or objectionable material, and free of irregularities to provide a reasonably smooth and uniform surface.

The surface to be primed shall be shaped reasonably close to grade and cross-section; free from ruts, corrugations, or other irregularities; and thoroughly compacted. The use of water may be required to obtain the required compaction.

404.06 APPLICATION OF BITUMINOUS MATERIALS. The application rates of bituminous material shall be as directed by the Engineer.

The application shall not be made on more than 50 percent of the width of the road surface at a time, unless all traffic is detoured, in which case the application may be full width.

An anti-stripping additive shall be added to the asphalt when ordered by the Engineer. The additive will not be paid for separately but will be considered incidental to other Contract items.

Sufficient lap shall be provided between adjoining applications, and care shall be taken that the application at the junctions of spreads does not exceed the specified amount. Excess bituminous material shall be squeegeed from the surface. Skipped areas or deficiencies shall be corrected. Asphalt treated felt shall be placed over the end of the previous applications, and the joining application shall start on the asphalt treated felt. Asphalt treated felt used shall be removed and satisfactorily disposed of.

(a) Tar Emulsion. Prior to treating the surface, it shall be wet with water by truck application or other methods approved by the Engineer. Any surplus water shall be removed so there is no puddling.

The tar emulsion shall be spread in two uniform coats, each coat to be applied at the rate of 0.5 to 0.9 L/m$^2$ (0.1 to 0.2 gallons per square yard) as directed by the Engineer. The time lapse between the first and second application shall be left to the discretion of the Engineer but should not exceed 24 hours. Each coat shall be applied either by the use of soft rubber squeegees or by brushes of approved quality. At least 24 hours shall elapse before any other bituminous material is applied.

(b) Emulsified Asphalt, Cutback Asphalt, or Asphalt Cement. The bituminous material shall be applied by pressure distributors or other methods approved by the Engineer between the temperature ranges shown for the bituminous material specified.

(c) Bituminous Surface Treatment, Type I. (Prime Coat, Tack Coat, and Seal Coat of Bituminous Material with Pea Stone and Sand.)

(1) First Application, Prime Coat. The first application of bituminous material specified shall be applied at the rate of 1.4 to 2.3 L/m$^2$ (0.3 to 0.5 gallons per square yard).

After sufficient time has elapsed for proper penetration, the entire surface shall be covered with sand to absorb excess bituminous material.

(2) Second Application, Tack Coat. Holes that develop between the first and second applications of bituminous material shall be filled with a mixture of pea stone and bituminous material before the second application.

After the prime coat has cured, a second application of bituminous material shall be applied at the rate of 0.9 to 1.1 L/$m^2$ (0.2 to 0.25 gallons per square yard).

Before any traffic is permitted on the newly treated section, pea stone cover material shall be applied immediately over the newly treated section and rolled. This cover material shall be applied by means of an approved mechanical spreading device. Only sufficiently dry pea stone shall be used. The trucks used in spreading shall back over the prime coat and cover material as the cover material is spread.

The Contractor shall limit the amount of the second application applied at any one time to a distance that can be covered with pea stone within ten minutes after the bituminous material is applied.

(3) Third Application, Seal Coat. Immediately following the spreading and rolling of the cover material, the third application of specified bituminous material at a rate of 0.5 to 0.7 L/$m^2$ (0.1 to 0.15 gallons per square yard) shall be applied. The surface shall be sanded lightly and satisfactorily rolled.

(d) Bituminous Surface Treatment, Type II. (Prime Coat and Seal Coat of Bituminous Material with Pea Stone and Stone Grits.) The pea stone and stone grits required for Type II bituminous surface treatment shall be from crushed stone only.

(1) First Application, Prime Coat. Pea stone shall be uniformly spread approximately one stone deep by an approved mechanical spreading device and employing such hand spreading as necessary to completely and uniformly cover the prepared subbase. Sufficient stone shall be spread so that no bare or uncovered spots of subbase will be in evidence. Only sufficiently dry pea stone shall be used.

After the initial application of pea stone has been properly spread, the bituminous material specified shall be applied at the rate of 2.7 to 2.9 L/$m^2$ (0.6 to 0.65 gallons per square yard).

Immediately following this application of bituminous material, cover material of pea stone shall be uniformly spread approximately one stone deep by an approved mechanical spreading device and employing such hand spreading as necessary to completely and uniformly cover the newly treated section without any surplus of pea stone. Only sufficiently dry pea stone shall be used.

Immediately following the second application of pea stone, the surface shall be given a "once over" light broom drag, if directed by the Engineer. Immediately following the broom drag, it shall be satisfactorily rolled.

The Contractor shall limit the placement of the initial application of pea stone to a distance not exceeding 150 m (500 feet) in advance of applying the bituminous material, cover material of pea stone, and the necessary rolling.

The applications of pea stone and bituminous material shall be made the full width of the road surface.

(2) Second Application, Seal Coat. As soon as practical, the second application of bituminous material shall be applied at a rate of 0.7 to 0.9 L/$m^2$ (0.15 to 0.2 gallons per square yard). Immediately after this application of bituminous material, stone grits shall be applied by means of an approved mechanical spreading device.

After the stone grits have been placed, the entire surface shall be completely and thoroughly rolled.

(e) Bituminous Surface Treatment, Type III. (Prime Coat of Bituminous Material with Sand Cover.) The application of bituminous material specified shall be applied at the rate of 1.4 to 2.3 L/$m^2$ (0.3 to 0.5 gallons per square yard).

After sufficient time has elapsed for proper penetration, all sections where the penetration is not complete shall be covered with sand.

(f) Bituminous Surface Treatment, Type IV. (Seal Coat of Bituminous Material with Stone Grits.) An application of bituminous material shall be applied to the existing surface at a rate of 0.9 to 1.6 L/$m^2$ (0.2 to 0.35 gallons per square yard).

Immediately following this application of bituminous material, cover material of stone grits shall be uniformly spread, approximately one stone deep by an approved mechanical spreading device and by employing such hand spreading as necessary to completely and uniformly cover the bituminous material. The aggregate cover shall be sufficient to prevent "picking" or tracking of the bituminous material.

The Contractor shall limit the placement of bituminous material to a distance not exceeding 150 m (500 feet) in advance of applying the stone grits.

After the stone grits have been placed, the entire surface shall be completely and thoroughly rolled with a pneumatic-tired roller.

The Contractor shall lightly cover the surface with sand to absorb any excess bituminous material.

After 24 to 72 hours have elapsed, the surface shall be given a light brooming to remove any excess stone.

404.07 TRAFFIC CONTROL. To control traffic during bituminous surface treatment operations, flaggers shall be used in accordance with Section 630.

Signs informing the traveling public that bituminous surface treatment operations are underway shall be erected at each end of the section under construction during the day. The signs shall be designed, worded, and erected in a manner approved by the Engineer. The signs shall be removed at the end of each day's work unless the condition of the road, as determined by the Engineer, requires otherwise.

All traffic shall be kept off the bituminous material until the penetration is complete and the prime or seal coat will not "pick up" under traffic, or until cover material has been placed and lightly rolled.

On projects where it is necessary to maintain traffic, the traffic shall be controlled by using a pilot car traveling at a low speed.

404.08 ROLLING OPERATIONS. Rolling shall commence at the sides with the roller equipment operating parallel to the centerline of the roadway and progressing toward the center, uniformly lapping each preceding track until the entire surface has been rolled. On banked or superelevated curves, the rolling shall commence on the low side of the curve and progress toward the high side.

404.09 MAINTENANCE. The Contractor shall maintain the treated surfaces until the Contract is completed and the work accepted. Holes or irregularities shall be repaired by filling with material acceptable to the Engineer. When any bleeding develops, the areas affected shall be lightly covered with sand or pea stone and thoroughly rolled with an approved roller. All maintenance work will be considered as part of the item and shall be included in the Contract unit price.

404.10 PROTECTION OF STRUCTURES AND TREES. The Contractor shall use care in applying bituminous material and protecting surfaces of adjacent structures and trees from being spattered with the material.

404.11 METHOD OF MEASUREMENT. The quantity of Bituminous Surface Treatment to be measured for payment will be the number of kilograms [hundredweight (CWT)] of each type used in the complete and accepted work.

The quantity of Tar Emulsion to be measured for payment will be the number of liters (gallons) or kilograms [hundredweight (CWT)] used in the complete and accepted work.

The quantity of Emulsified Asphalt, Cutback Asphalt, or Asphalt Cement to be measured for payment will be the number of kilograms [hundredweight (CWT)] used in the complete and accepted work.

404.12 BASIS OF PAYMENT. The accepted quantities of the specified material will be paid for at the Contract unit price per liter (gallon) or kilogram [hundredweight (CWT)] for the specified material applied or the type of bituminous surface treatment. Payment will be full compensation for furnishing, transporting, and placing the

material and for furnishing all materials, signs, traffic control, labor, tools, equipment, and incidentals necessary to complete the work.

Aggregates, cover material, costs of shaping and compacting of the subbase material preparatory to applying the bituminous material will not be paid for separately but shall be considered incidental to the Contract items involved.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 404.16 Bituminous Surface Treatment, Type I | Kilogram (CWT) |
| 404.21 Bituminous Surface Treatment, Type II | Kilogram (CWT) |
| 404.31 Bituminous Surface Treatment, Type III | Kilogram (CWT) |
| 404.40 Bituminous Surface Treatment, Type IV | Kilogram (CWT) |
| 404.45 Tar Emulsion | Liter (Gallon) |
| 404.46 Tar Emulsion | Kilogram (CWT) |
| 404.55 Cutback Asphalt | Kilogram (CWT) |
| 404.60 Asphalt Cement | Kilogram (CWT) |
| 404.65 Emulsified Asphalt | Kilogram (CWT) |

## SECTION 406 - BITUMINOUS CONCRETE PAVEMENT

406.01 DESCRIPTION. This work shall consist of constructing one or more courses of bituminous mixture on a prepared foundation.

406.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Bituminous Material ..... 702.01
Asphalt Cement ..... 702.02
Emulsified Asphalt, RS-1 ..... 702.04
Aggregate for Bituminous Concrete Pavement ..... 704.10

The grade of asphalt cement shall be as shown on the Plans, unless otherwise specified in the Contract. The grade of asphalt may be changed by the Engineer upon one week's notice.

406.03 COMPOSITION OF MIXTURE.

(a) Gradation. The materials shall be combined and graded to meet the composition limits for each of the pavement types in the following table:

TABLE 406.03A - COMPOSITION OF MIXTURE

| Sieve Designation | | Percentage by Mass (Weight) Passing Square Mesh Sieves | | | | |
|---|---|---|---|---|---|---|
| Metric | English | Type I | Type II | Type III | Type IV | Type V |
| 31.5 mm | 1 1/2 inch | 100 | | | | |
| 25.0 mm | 1 inch | 95 to 100 | 100 | | | |
| 19.0 mm | 3/4 inch | 74 to 86 | 95 to 100 | 100 | | |
| 12.5 mm | 1/2 inch | 60 to 80 | 64 to 88 | 95 to 100 | 100 | |
| 9.5 mm | 3/8 inch | --- | 50 to 82 | 70 to 90 | 95 to 100 | 100 |
| 4.75 mm | No. 4 | 35 to 60 | 32 to 62 | 42 to 75 | 48 to 78 | 85 to 100 |
| 2.36 mm | No. 8 | 25 to 45 | 22 to 45 | 28 to 56 | 28 to 56 | 66 to 88 |
| 1.18 mm | No. 16 | --- | 13 to 35 | 14 to 41 | 14 to 41 | 45 to 67 |
| 600 µm | No. 30 | 10 to 25 | 8 to 27 | 7 to 31 | 7 to 31 | 27 to 53 |
| 300 µm | No. 50 | --- | 3 to 20 | 3 to 22 | 3 to 22 | 13 to 40 |
| 75 µm | No. 200 | 2 to 6 | 2 to 6 | 2 to 6 | 2 to 6 | 2 to 7 |
| Total Aggregate | | 94 to 97 | 93 to 97 | 92 to 97 | 92 to 95 | 91 to 93 |
| Bitumen (% of Total Mix) | | 3 to 6 | 3 to 7 | 3 to 8 | 5 to 8 | 7 to 9 |

(b) Design Criteria. The materials shall be combined and graded to meet the following criteria:

TABLE 406.03B - DESIGN CRITERIA

| Marshall Test Properties | Medium Duty Bit. Concrete Pavement 50 blows/side | Heavy Duty Bit. Concrete Pavement 75 blows/side |
|---|---|---|
| % Air Voids | 3.0 to 5.0 | 3.0 to 5.0 |
| VMA % Type I | 13.0 minimum | 13.0 minimum |
| VMA % Type II | 14.0 minimum | 14.0 minimum |
| VMA % Type III | 15.0 minimum | 15.0 minimum |
| VMA % Type IV | 16.0 minimum. | 16.0 minimum |
| Stability, newtons (pounds) | 5340 minimum (1200 minimum) | 8010 minimum (1800 minimum) |
| Flow, millimeters (0.01 inch) | 2.0 to 4.5 (8.0 to 18.0) | 2.0 to 4.0 (8.0 to 16.0) |
| % Stone Screenings (Fine Aggregate Portion) Passing 2.36 mm (No. 8) sieve | 60.0 minimum | 75.0 minimum |

The percent of air voids of the mixture shall be calculated by the following formula:

$$F = 100\left(\frac{R - P}{R}\right)$$

where:

$F$ = Percent voids in compacted mixture
$R$ = Maximum specific gravity of uncompacted mixture (AASHTO T 209)
$P$ = Bulk specific gravity of compacted mixture (AASHTO T 166, Method B)

Unless specifically shown on the Plans, all bituminous concrete pavement shall be designed in conformance with the design criteria for heavy duty bituminous concrete pavement.

Unless otherwise specified for highways, Type I shall be used for base course; Types I or II shall be used for binder course; and Types II, III, or IV shall be used for wearing course. Unless otherwise specified for bridges, Type IV shall be used for binder course.

Type V mix will be designed to meet the gradation criteria of Subsection 406.03(a) only.

The mix design shall have a filler-asphalt ratio ranging between 0.50 and 1.20.

(c) Mix Design. The Marshall Method of Mix Design will be used to develop a mix that will meet the design criteria. A copy of all test data, including graphs, used in developing the mix may be required with the submittal of the mix design.

The job-mix formula for each mixture shall establish a single percentage of aggregate passing each sieve and a single percentage of bituminous material to be added to the aggregate. No change in the job-mix formula may be made without written approval of the Engineer. The job-mix formula must fall within the master range specified in Table 406.03A.

No work shall be started until the Contractor has submitted and the Engineer has approved a mix design including cold feed and hot bin gradings, mixing times, the percentage of each ingredient including bitumen, the job-mix formula from such a combination, and the optimum mixing and compaction temperatures as required in the Marshall Method of Mix Design.

At the time the above mix design is submitted, the Contractor shall indicate and make available for sampling and testing stockpiles of all aggregates and asphalt proposed for use.

A minimum time of two weeks shall be allowed for testing and evaluation of the submitted mix design. Once a mix design is approved, the job-mix formula is valid until the producer makes a change in aggregate source, asphalt grade, or asphalt source.

The Engineer may order a change in any part of the job-mix formula if placement, finishing, or compaction characteristics are determined by the Engineer to be unsatisfactory.

(d) Control of Mixtures. The plant shall be operated so that no intentional deviations are made from the job-mix formula. The gradation of the actual mixture shall not vary from the job-mix formula by more than the following tolerances:

| Testing Tolerances | |
|---|---|
| Aggregate larger than 2.36 mm (No. 8) sieve | ± 6.0% |
| Aggregate passing 2.36 mm (No. 8) sieve and larger than 75 μm (No. 200) sieve | ± 4.0% |
| Aggregate passing 75 μm (No. 200) sieve | ± 1.0% |
| Temperature of Mixture | ± 11 °C (± 20 °F) |

The quantity of asphalt cement introduced into the mixer shall be that quantity specified in the accepted job-mix formula and will be accepted on the basis of the mass (weight) on the printed load ticket.

If an analyzed sample is outside of the testing tolerances and/or other design criteria, immediate adjustment shall be made by the Contractor. After the adjustment, the resulting mix will be sampled and tested for compliance with these Specifications. With the permission of the Engineer, the plant may continue production pending results of tests, but if the Engineer deems it is in the best interest of the project, the Engineer may at any time order plant production stopped. In this event, additional adjustments shall be made and tested on a trial basis until the deficiency is corrected.

406.04 WEATHER LIMITATIONS. Bituminous material shall not be applied between November 1 and May 1. When it is in the public interest, the Construction Engineer may adjust the ambient air temperature requirements or extend the dates of the paving season. The courses shall not be placed when the ambient air temperature at the paving site in the shade and away from artificial heat is below 5 °C (40 °F) for courses 35 mm (1 1/4 inches) or greater in compacted thickness or below 10 °C (50 °F) for courses less than 35 mm (1 1/4 inches) in compacted thickness.

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.

Bituminous wearing course materials shall not be applied before May 15 or after October 15.

406.05 BITUMINOUS MIXING PLANT AND TESTING. Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall be kept separated until they have been delivered to the cold storage bins. The storage yard shall be maintained neat and orderly, and the separate stockpiles shall be readily accessible for sampling.

An authorized representative of the Agency will inspect existing plants each construction season. The Contractor shall notify the Agency, in writing, of any plant that is to be inspected so that an authorized representative of the Agency may inspect and approve the plant prior to any mixing operation for Agency projects. A minimum

of two weeks should be allowed for the scheduling of the inspections. The plant shall be in operation at the time of inspection.

Plants used for the preparation of bituminous mixtures shall conform to all requirements under part (a) below, except that scale requirements shall apply only where mass (weight) proportioning is used. In addition, batch mixing plants shall conform to the requirements under part (b) below; continuous mixing plants shall conform to the requirements under part (c) below; and drum-mix plants shall conform to the requirements under part (d) below.

Scales used to measure the mass (weight) of materials shall conform to the following requirements, shall meet all specifications, tolerances, and regulations that have been or may be adopted from time to time by the Director of Standards of the Vermont Department of Agriculture, and shall be subject to approval by the Engineer. The scales shall be checked and sealed as deemed necessary to ensure accuracy.

(a) Requirements for All Plants. The plants shall be so designed, coordinated, and operated as to produce a uniform mixture within the mix design fixed by the Contract.

All plants shall have automatic controls that coordinate the proportioning, timing, and discharge of mixture by the single operation of a switch or button. In addition to these controls, all plants shall have approved recordation systems.

The recordation system shall be capable of printing the total net mass (weight) of the load. Each load ticket shall be automatically printed with the date and the time of batching, and shall show project and truck identification.

All originals of recorded data pertaining to the measuring the mass (weight) or proportioning of bituminous concrete, after recordation, will become the property of the Agency.

(1) Truck Scales. Approved truck scales shall be provided at each plant. The scale platform shall be of such length and width that it will conveniently accommodate all trucks or other approved hauling equipment. The entire vehicle load must rest on the scale platform so that the mass (weight) can be measured as one draft.

These scales may be used for spot checking the accuracy of the recordation equipment. Any variance exceeding 0.5 percent of the net mass (weight) shall result in immediate corrective action by the Contractor.

A weatherproof building of sufficient size to house the scale operator and the Inspector shall be provided. The building shall have adequate lighting, both natural and artificial, and it shall be adequately and safely heated.

If the recordation system printer breaks down, the Contractor may continue to operate for the remainder of that day, provided the following conditions are met:

a. The Engineer grants permission to operate, and

b. The Engineer assigns an Inspector to record the total aggregate and asphalt mass (weight) for each batch on the appropriate ticket.

(2) Equipment for Preparation of Bituminous Material. Tanks for storage of bituminous material shall be insulated and capable of heating the material, under effective and positive control at all times, to temperatures specified in these Specifications. The heating system shall provide uniform heating of the entire contents of the tanks. Heating shall be accomplished by steam or oil coils, electricity, or other means so that no flame shall come in contact with the heating tank.

A circulating system for bituminous material shall be of adequate capacity to provide proper and continuous circulation between storage tank and the proportioning units during the entire operating period.

The discharge end of the circulating pipe shall be maintained below the surface of the bituminous material in the storage tank to prevent discharging hot bituminous material into the open air.

All pipelines and fittings shall be steam or oil jacketed or otherwise properly insulated to prevent heat loss.

(3) Feeder for Dryer. The plant shall be provided with an accurate mechanical means for uniformly feeding the mineral aggregate into the dryer so that uniform production and uniform temperatures are obtained.

(4) Dryer. The dryer shall be capable of heating and drying the mineral aggregates in accordance with these Specifications without leaving any visible unburned oil or carbon residue on the aggregate when it is discharged from the dryer. Black smoke from the exhaust stack shall not be permitted. Drying shall continue until all moisture is removed. If unusually wet aggregate is being used, the input to the dryer shall be reduced to that amount which the dryer is capable of drying.

(5) Screens. Plant screens shall have the capacity and size range to separate the aggregates into sizes for proportioning so that they may be recombined within the limits of these Specifications. The screen over the “fines bin” shall have a maximum square opening of 5.0 mm (3/16 inch). Slotted screens may be used when approved by the Engineer. Screens are not applicable to drum-mix plants.

(6) Cold Storage Bins. The plant shall have cold storage bins of sufficient capacity to ensure a uniform and continuous operation.

The bins shall be so constructed as to prevent intermingling of aggregates from one bin to another. The use of loaders or trucks that are larger in width than the bins being charged will not be allowed. The blending of two or more aggregates in the same bin will not be permitted.

For all bituminous concrete supplied for use on Agency projects, uniform feeding of all fine aggregates shall be accomplished by the use of a variable speed continuous belt feeder on each cold storage bin of fine aggregate.

(7) Hot Storage Bins. The plant shall include hot storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. The hot storage bins shall consist of at least four bins arranged to ensure separate and adequate storage of appropriate fractions of the aggregate.

When the material in any bin contains more than 15 percent of material that is under size for that bin, based on the sieve analysis of hot bins used in determining the job-mix formula, the bins shall be emptied, and correction of the cause for such condition shall be made.

Each bin shall be provided with a free flowing overflow pipe that shall be of such size and at such a location as to prevent any backing up of material into other bins or into contact with the screen. This overflow material shall not be fed back into the system or into any accepted stockpiles.

Bins shall be equipped with sensor devices to indicate the position of the aggregate in the bins at the lower quarter point. An automatic plant shutoff device shall be provided to interrupt the batching process when any aggregate bin becomes empty.

Adequate additional dry storage shall be provided when mineral filler is required. The system shall have a device to feed the mineral filler accurately and uniformly at adjustable rates consistent with the percent required. The feeder shall be interlocked in such a manner that production is interrupted if the bin becomes empty or the flow is obstructed.

Adequate and convenient facilities shall be provided to allow aggregate sampling from each bin.

Hot bins are not applicable to drum-mix plants.

(8) Bitumen Control Unit. Satisfactory means, either by measuring the mass (weight) or metering, shall be provided to obtain the proper amount of bitumen. Metering devices for bitumen shall indicate accurately to within ± 2 percent the amount of bitumen delivered when tested for accuracy.

The section of the bitumen flow line between the charging valve and the spray bar shall be provided with a three-way valve and outlet whereby the rate of delivery of the metering device may be checked by actual mass (weight).

Suitable means shall be provided, either by steam or oil-jacketing, or other insulation, for maintaining the specified temperatures of the bitumen in the pipelines, meters, weigh buckets, spray bars, and other containers or flow lines.

(9) Thermometric Equipment. An armored thermometer shall be fixed in the bituminous feed line at a suitable location near the discharge valve at the mixer unit to accurately indicate the temperature of the bitumen.

The plant shall be further equipped with approved recording thermometers, pyrometers, or other approved recording thermometric instruments placed at the discharge chute of the dryer.

The Engineer reserves the right to pass upon the efficiency of the thermometric instruments and, for better regulation of the temperatures of aggregates, may direct replacement of any instrument by an approved temperature recording apparatus. The Engineer may further require that daily temperature charts be filed with the Engineer.

(10) Control of Mixing Time. The plant shall be equipped with positive means to govern the time of mixing and to maintain a constant mixing time unless changed by order of the Engineer.

(11) Dust Collectors. The plant shall be equipped with adequate dust collectors so that objectionable exhaust will not be dissipated into the atmosphere. Provisions shall be made to waste or uniformly reintroduce all or any part of the heavier dust particles from primary collectors into the flow of aggregate.

The introduction of baghouse fines into all bituminous concrete mixes will be allowed when the fines are introduced by an approved metering or mass (weight) measuring system that introduces the fines under positive uniform control.

The Engineer has the authority to withdraw the approval for use of baghouse fines at any time that the bituminous concrete pavement mix provided by the Contractor is unsatisfactory as determined by the Engineer.

(12) Testing Facilities. The Contractor shall provide a weatherproof building with at least 22 $m^2$ (240 square feet) of floor space, in which to house and use the testing equipment. This building shall be maintained for the use of Agency authorized personnel, and shall be located so that details of the Contractor's plant are plainly visible from one window of the building. Adequate lighting, heating, and electrical connections shall be provided for 24 hours a day operation. Proper means for ventilation shall be provided. The method of heating shall be such that a minimum temperature of 21 °C (70 °F) will be maintained at all times. Sanitary toilet facilities with lavatory, with proper sewage disposal, shall be furnished for the use of Agency authorized personnel. Cleaning supplies shall be furnished by the Contractor. A private telephone service shall be provided in the laboratory.

A trailer type mobile laboratory may be used in conjunction with a temporary plant only. Any plant that occupies or has occupied the same location for more than one year will be classified as a permanent plant and will require a permanent building for a laboratory.

The facility shall be equipped with the following standard commercial quality equipment. Substitutes may be provided when approved by the Engineer.

- 1 Air conditioner for the capacity of the building, capable of maintaining a maximum temperature below 25 °C (77 °F).
- 2 2 kg (5 pound) minimum capacity fire extinguishers either ABC Dry Chemical or Carbon Dioxide.
- 1 Standard office desk with drawers, locks, and keys, 1200 by 750 mm (4 × 2 1/2 feet) minimum dimensions.
- 1 Adjustable office chair.
- 2 Adjustable drafting stools.
- 1 Electric calculator, four-function, ten-column, with memory.
- 2 Bench sections and storage compartments. The benches shall be approximately 900 mm (36 inches) high, 600 mm (24 inches) wide, and 3 m (10 feet) long.
- 1 or 2 Approved exhaust fans and hoods shall be provided over the stoves and extractors. The exhaust fans shall be high volume axial flow, at least 300 mm (12 inches) in diameter.
- 1 Water cooler with supply of potable water.
- 1 Sink with faucet inside the office, with a continuous supply of pressurized clean water for the duration of the project. The sink shall drain to the outside of the office.

The facility shall be equipped with the following test equipment and supplies. Substitutes may be provided when approved by the Engineer.

- 1 Marshall Test Set Reference AASHTO T 245 including:
  - 1 Automatic bituminous compactor.
  - 2 Compaction molds with baseplates.
  - 1 Stability mold.
  - 1 Flow meter.
  - 1 Motorized compression and testing machine.
  - 1 Water bath with variable temperature from -18 to 105 °C (0 to 220 °F).
- 1 Motorized 3000 g centrifuge extractor with two small bowls with covers and two large bowls with covers.
- 1 Full set of 203.2 mm (8 inch) diameter sieves full height, pans, and covers necessary for testing all bituminous items required on the project.
- 1 Electronic balance, 6000 g minimum capacity.
- 1 Motorized sieve shaker with either rocking and tapping action, or circular and tapping action capable of holding at least six sieves and one pan.
- 1 Mechanical aggregate shaker with a 0.028 $m^3$ (1 cubic foot) capacity plus necessary screens. This may be placed in a separate enclosure outside of trailer.
- 1 Platform beam scale sensitive to 5.0 g (0.01 pound) with a minimum capacity of 45 kg (100 pounds).

1 Sample splitter, 63.5 mm (2 1/2 inch) chute.
1 Sample splitter, 25 mm (1 inch) chute.
2 Square pointed shovels; one long handled, one short handled.
2 Double burner hot plates, variable temperature.
12 Tin pans, 267 by 267 by 25 mm (10 1/2 × 10 1/2 × 1 inch).
1 Electric oven, 0.028 $m^3$ (1 cubic foot) minimum capacity.
1 Flat triangular trowel.
1 Brass wire bristle brush.
1 Standard floor brush.
1 Standard table brush.
2 40 mm (1 1/2 inch) soft bristle paint brushes.
1 Automatic timer (interval 0 to 30 minutes).
2 Flexible spatulas with 150 mm (6 inch) long blade.
1 10 L (10 quart) pail.
2 Pair lined, heat resistant gloves.
2 Hand scoops (size #1).
2 Metal thermometers, 10 to 260 °C (50 to 500 °F), approximately 200 mm (8 inches) long with a 45 mm (1 3/4 inch) head.
2 Laboratory thermometers, capable of reading at least 60 °C in 1 °C increments (140 °F in 2 °F increments).
1 Cold chisel, approximately 40 mm (1 1/2 inches) wide.
2 Volumetric flasks, having a capacity of at least 2000 mL; for use with the flask, a rubber stopper and a connection, either molded in the flask or attached to the rubber stopper.
2 Volumetric flasks, having a capacity of at least 4000 mL; for use with the flask, a rubber stopper and a connection, either molded in the flask or attached to the rubber stopper.
1 Vacuum pump or water aspirator, for evacuating air from the container. Vacuum system must be capable of removing entrapped air by subjecting the contents to a partial vacuum and maintaining a minimum of 91 kPa (27 inches of Hg) for 15 ± 2 minutes. The vacuum system shall be equipped with an accurate vacuum gauge that reads in kilopascals (inches of Hg) and contains a pressure release valve.
1 Plastic funnel, to introduce mix into volumetric flask.
1 Syringe, to adjust water level in flask.
1 Liter (quart) of Methyl alcohol, available at all times to be used as a drying agent.
Xylol, for use as an asphalt solvent, for the duration of the project.
Filter papers, for duration of project.

For drum-mix plants, the facility shall be equipped with the following additional test equipment and supplies. Substitutes may be provided when approved by the Engineer.

1 Microwave oven, 0.028 $m^3$ (1 cubic foot) minimum capacity, with defrost as well as normal mode of operation.
6 Ovenproof glass dishes, approximately 300 by 300 by 40 mm (12 × 12 × 1 1/2 inches).

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.

The above mentioned equipment is for a one plant operation only. In the event the Contractor chooses to use more than one plant, the Contractor shall provide adequate laboratory facilities as deemed necessary by the Engineer for making tests.

(13) Safety Requirements. Adequate and safe stairways to the mixer platform shall be provided, and guarded ladders to other plant units shall be located where required for accessibility to plant operations.

All heated pipelines adjacent to the work areas, gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected.

Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck-loading space. This space shall be kept free of drippings from the mixing platform. The platform shall be so located at the truck-loading space as to permit easy and safe inspection of the mixture as it is delivered into the trucks. Adequate overhead protection shall be provided where necessary.

(14) Surge Bins. Surge or storage bins will be permitted for use in the production of bituminous items provided they are approved and inspected by the Engineer. Bins shall be capable of storing the mix without any degradation of its properties. Provisions shall be made to cover the bins during inclement weather to protect the stored mix from the elements. Should circumstances preclude paving operations, the Agency will not be obligated to purchase mix remaining in surge or storage bins.

For continuous and drum-mix plants, an approved system for recording mass (weight) shall be used on all surge bins.

When a surge bin is used in conjunction with a batch plant, the determination of pay quantities for this Contract item shall be in accordance with the following procedure:

a. The plant shall produce mix with the printer in operation conforming to the standard requirements for this device. The mix shall be deposited in the surge bin. A sequentially numbered ticket shall be prepared for every normal load produced.

b. As each truck is loaded from the surge bin, the driver shall be given the ticket previously prepared when the mix was produced for that bin. The truck driver shall then deliver the ticket to the Inspector upon reaching the paving site.

c. The mass (weight) shown on the ticket may not be the actual mass (weight) of the mix contained in the truck since the truck was loaded from the surge bin. The bin shall be completely emptied at the end of every day, circumstances permitting, and all tickets shall be delivered to the Inspector.

d. The mass (weight) of the quantity of rejected or held over material, if encountered, shall be recorded while on the platform truck scales, and deducted from the daily totals.

e. When paving ramps or other areas where a definite quantity is desired, the mass (weight) of material required for these areas shall be measured using the platform scales. Appropriate adjustments shall be made in the daily totals obtained from the printer. The mass (weight) shall be entered on the ticket or on a separate ticket provided.

f. The Plant Inspector will sign the first ticket of each day instead of initialing it. If there is a change in Plant Inspectors during the day, this procedure shall be followed for each change of Plant Inspector. At the end of each day, the Plant Inspector will inspect the storage bin to determine that it is empty and so note on the last ticket.

g. The Inspector will acknowledge receipt of the material at the paving sites by initialing the lower right-hand corner of each ticket.

h. All standard checks of the mass (weight) measuring apparatus on the plant will be made at the prescribed intervals.

i. All mix produced for commercial customers and/or other projects must be discharged from other bins or directly from the pugmill into the haul vehicle and not loaded from the bin.

j. All surge bins shall be emptied each day unless written permission is obtained from the Engineer.

(b) Requirements for Batch Plants.

(1) Weigh Box or Hopper. The equipment shall include a means for accurately measuring the mass (weight) of each bin size of aggregate in a weigh box or hopper suspended on scales and shall be of ample size to hold a full batch without hand raking or running over.

The weigh box or hopper shall be supported on fulcrums and knife edges so constructed that they are not easily thrown out of alignment or adjustment.

All edges, ends, and sides of the weigh box or hopper shall be free from contact with any supporting rods or columns or other equipment that may affect proper functioning of the weigh box or hopper. Also, there shall be sufficient clearance between the weigh box or hopper and supporting devices to prevent accumulation of foreign materials.

The discharge gate of the weigh box or hopper shall be hung so that the aggregates will not segregate when dumped into the mixer. The gate shall close tightly when the weigh box or hopper is empty so that no material can leak into a batch in the mixer during the process of measuring the mass (weight) of the next batch.

(2) Aggregate Scales. Scales for any weigh box or hopper shall be either of the springless dial type or the load cell with digital readout type, and shall be of standard make and design sensitive to 0.1 percent of the maximum load that may be required.

Dials shall be free of vibration and so located as to be plainly visible and readable to the operator at all times.

Adequate means for checking the accuracy of the scales shall be provided by the Contractor either by the use of ten 20 kg (50 pound) test masses (weights) or by other methods approved by the Engineer. All test masses (weights) will be certified annually by the Division of Weights and Measures.

(3) Bitumen Bucket. The bucket used for measuring the mass (weight) of bitumen shall be of sufficient capacity to hold the amount required for a single batch while the mass (weight) is being measured.

The filling system and bucket shall be of such design, size, and shape that bitumen does not overflow, splash, or spill outside the confines of the bucket while the bucket is being filled and the mass (weight) is being measured.

The bucket shall be steam or oil-jacketed, or equipped with properly insulated electric heating units. The bucket shall be so arranged as to deliver the bitumen in a thin uniform sheet or in multiple sprays over the full length of the mixer within a period of 15 seconds.

(4) Bitumen Scales. Scales for measuring the mass (weight) of bituminous material shall conform to the requirements for the aggregate scales. The value of the minimum graduation shall be not greater than 1.0 kg (2 pounds).

(5) Mixer Unit for Batch Method. The plant shall include a batch mixer of an approved twin pugmill type, jacketed or insulated, and capable of producing a uniform mixture within the job-mix tolerance fixed by the Contract. The mixer shall be so constructed as to prevent leakage and designed to provide a means of adjusting clearance between the mixer blades and liner plates.

(6) Recordation. The recordation system of the batch plant shall print the mass (weight) of the bitumen, mass (weight) of the aggregate, and the total combined mass (weight) of both, in addition to printing the combined net mass (weight) of each load.

(c) Requirements for Continuous Mixing Plants.

(1) Aggregate Proportioning. The plant shall include means for accurately proportioning aggregate by mass (weight) from each bin. The proportioning unit shall include interlocked feeders mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to control the rate of flow of aggregate from each bin compartment. The opening shall be rectangular, with one dimension adjustable by positive mechanical means. Locks shall be provided on each gate. Calibrated gauges with graduations of not more than 2.5 mm (0.1 inch) shall be provided for each gate to establish gate openings.

(2) Calibration of Aggregate Feed. The plant shall include a method for calibration of gate openings by means of test samples. The materials fed out of the bins through individual openings shall be bypassed to a suitable test box, each compartment material being confined in a separate box section. The plant shall be equipped to handle and accurately measure the mass (weight) of test samples with a mass (weight) of up to 365 kg (800 pounds).

(3) Synchronization of Aggregate Feed and Bituminous Feed. Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bitumen from the meter or other proportioning source. This control shall be accomplished by interlocking mechanical means or by any positive method under the Engineer's control.

(4) Mixer. The plant shall include a continuous mixer of an approved twin pugmill type, insulated or jacketed, and capable of producing a uniform mixture within the job-mix tolerance specified in the Contract. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge and also giving the rate of feed of aggregate per minute, at plant operating speed.

Unless otherwise specified, determination of mixing time shall be by the following formula:

$$\text{Mixing Time in seconds} = \frac{\text{Pugmill Dead Capacity in kilograms (pounds)}}{\text{Pugmill Output in kilograms (pounds) per second}}$$

The mass (weight) shall be determined for the job by tests made under the direction of the Engineer.

(d) Requirements for Drum-Mix Plants.

(1) Aggregate Cold Bin Feeders. The plant shall have a device at each cold bin to feed the aggregate accurately and uniformly. The feeding orifice shall be

adjustable. No gravity type feeders will be permitted. Indicators graduated to not more than 2.5 mm (0.1 inch) shall be provided on each orifice. Each aggregate feeder shall be interlocked in such manner that production is interrupted if one or more cold bins become empty or the flow is obstructed.

(2) Mineral Filler System. When mineral filler is to be added, it shall be fed from a bin and feeder separate from the aggregate cold bins. The system shall have a device to feed the mineral filler at adjustable rates accurately and uniformly.

The feeder shall be interlocked in such a manner that production is interrupted if the cold bin becomes empty or the flow is obstructed. The filler shall be fed in a manner such that no filler is lost in the form of fugitive dust.

(3) Equipment for Measuring the Mass (Weight) of Aggregate. The mass (weight) of all aggregates, including mineral filler, shall be measured by a continuous measuring device either as it is proportioned by the individual feeders or after all materials have been deposited on a common belt. Belt scales shall meet the requirements of the National Institute of Standards and Technology, Handbook No. 44 and they shall be installed according to the scale manufacturer's recommendations by a technician licensed by the Division of Weights and Measures. Any other mass (weight) measuring device shall be submitted for approval by the Engineer.

(4) Bitumen Control Unit. The bitumen shall be proportioned by a meter. A flow switch designed to interrupt production if the bitumen flow is discontinued shall be installed in the delivery line between the meter and the mixer. A temperature compensating device shall be installed in conjunction with the meter to correct the quantity of asphalt to 16 °C (60 °F).

(5) Proportioning Controls. All proportioning controls for aggregates, including mineral filler, and bitumen shall be located at the panel that also controls the mixer and temperature. The panel shall have a master control that increases or decreases the production rate without having to reset the individual controls for each change in production rate.

a. Aggregate Feed Rate Control. The plant shall have an adjustable feed rate control for each aggregate cold bin feeder and mineral filler feeder. The controls shall maintain aggregate flow accurately such that the variation of material per interval of time does not exceed an amount equal to 1.5 percent of the total mass (weight) of bituminous mixture per interval of time. Where the separate addition of mineral filler is required, it shall be added with an accuracy of 0.5 percent on the basis stated above for aggregates. The rate of aggregate flow shall be displayed on a meter and shall be based on mass (weight) or percentage of dry aggregates.

b. Aggregate Mass (Weight) Indicator. The aggregate mass (weight) indicator shall display in the control room the mass (weight) of combined aggregates and mineral filler. The indicator shall continuously accumulate the mass (weight) of material during the production period in the day. The mass (weight) indicated shall be dry aggregate mass (weight). The indicator shall be resettable to zero and lockable.

c. Aggregate Moisture Compensator. The moisture compensation device shall be capable of electronically changing the wet aggregate mass (weight) to dry aggregate mass (weight). The compensator may be set manually based on moisture tests performed on composite aggregate samples. The maximum graduations on the compensator shall be 0.1 percent.

d. Bitumen Control. The bitumen control shall be capable of presetting the actual bitumen content directly as a percentage based on total mass (weight) of mixture. The maximum gradation on the bitumen control shall be 0.1 percent. The asphalt delivery system shall be coupled with the aggregate delivery system to automatically maintain the required proportions as the aggregate flow varies.

e. Bitumen Quantity Indicator. The bitumen quantity indicator shall display in the control room the accumulated quantity of bitumen during the production period in the day. The quantity indicated may be either mass (weight) or volume at 16 °C (60 °F). The indicator shall be resettable to zero and lockable.

(6) Recordation of Proportions. The plant shall be equipped with an automatic digital recording device approved by the Engineer that simultaneously records the accumulated mass (weight) of dry aggregate and bitumen separately during production time and on demand. All recordings shall show the date, including day, month, and year, and time to the nearest minute for each print. The original recordings shall become the property of the Agency.

(7) Calibration of Feed Rates. The feed rates of aggregates from the cold bins, mineral filler when used, and bitumen shall be established for each mix type initially by passing the individual aggregates and mineral filler over the continuous mass (weight) measuring device, and the bitumen through the meter respectively. The feed rates shall be checked periodically or at the direction of the Engineer.

(8) Automatic Aggregate Sampling Device. An automatic aggregate sampling device shall be provided which will divert a representative combined aggregate sample, including mineral filler, into a hopper or container for the purpose of gradation testing. The sampling tray shall cut the full width and depth of the aggregate flow. The sampling point shall be after the aggregate is proportioned and prior to its mixing with bitumen.

(9) Mixer Unit. The plant shall include a drum-mixer of a type approved by the Engineer having an automatic burner control and capable of producing a uniform mixture with the job-mix tolerances. The mixture shall be discharged into a hot bituminous mixture holding bin meeting the requirements for surge bins as described above.

406.06 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated to the temperature specified in Subsection 702.06 in a manner that will avoid local overheating. A continuous supply of bituminous material shall be furnished to the mixer at a uniform temperature.

406.07 PREPARATION OF AGGREGATES. The aggregate 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 damaging the aggregate and depositing soot or unburned fuel on the aggregate.

Immediately after heating, the aggregates shall be screened and conveyed into separate bins ready for batching and mixing with bituminous material.

Mineral filler, if required to meet the grading requirements, shall be added in a manner approved by the Engineer after the aggregates have passed through the dryer.

The above preparation of aggregates does not apply for drum-mix plants.

406.08 MIXING. The dried aggregate shall be combined in the mixer in the amount of each fraction of aggregate required to meet the job-mix formula and thoroughly mixed prior to adding the bituminous material.

The dried aggregates shall be combined with the bituminous material in such a manner as to produce a mixture that when discharged from the mixing unit is at the temperature specified on the approved mix design.

The bituminous material shall be measured or gauged and introduced into the mixer in the quantity determined by the Engineer for the particular material being used and at the temperature specified in Subsection 702.06.

After the required quantity of aggregate and bituminous 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 bituminous material throughout the aggregate is secured. The mixing time will be regulated by the Engineer, and a suitable locking means shall be provided for these regulations.

All plants shall have a positive means of eliminating oversized and foreign material from being incorporated into the mixer.

406.09 HAULING EQUIPMENT. Trucks used for hauling bituminous mixture shall have tight, clean, smooth metal bodies. The Contractor shall apply a thin coat of a non-petroleum based or soap solution to prevent the mixture from adhering to the bodies.

Each truck shall have a cover of canvas or other suitable material of such size sufficient to protect the mixture from the weather. When necessary to ensure delivery of material at the specified temperature, truck bodies shall be insulated, and covers shall be securely fastened.

406.10 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 and finishing the mixture without segregation for the widths and thicknesses required. The screed shall be adjustable to provide the desired cross-sectional shape. The finished surface shall be of uniform texture and evenness and shall not show any indication of tearing, shoving, or pulling of the mixture. The machine shall, at all times, be in good mechanical condition and shall be operated by competent personnel.

Pavers shall be equipped with the necessary attachments, designed to operate electronically, for controlling the grade of the finished surface.

The adjustments and attachments of the paver will 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 edge at longitudinal joints. The sloped plate shall be attached to the paver screed extension

The sloped plate shall produce a tapered edge having a face slope of 1:3 (vertical:horizontal). The plate shall be so constructed as to accommodate compacted mat thickness from 35 to 100 mm (1 1/4 to 4 inches). The bottom of the sloped plate shall be mounted 10 to 15 mm (3/8 to 1/2 inch) above the existing pavement. The plate shall be interchangeable on either side of the screed.

Bituminous concrete pavers shall also be equipped with a joint heater capable of heating the longitudinal edge of the previously placed mat to a surface temperature of 95 °C (200 °F), or higher if necessary, to achieve bonding of the newly placed mat with the previously placed mat. This shall be done without undue breaking or fracturing of aggregate at the interface. The surface temperature shall be measured immediately behind the joint heater. The joint heater shall be equipped with automated controls that shut off the burners when the paving machine stops and reignite them with the forward movement of the paver. The joint heater shall heat the entire area of the previously placed wedge to the required temperature. Heating shall immediately precede placement of the bituminous material.

406.11 ROLLERS. Rollers shall be in good mechanical condition, operated by competent personnel, capable of reversing without backlash, and operated at speeds slow enough to avoid displacement of the bituminous mixture. The mass (weight) of the rollers shall be sufficient to compact the mixture to the required density without crushing of the aggregate. Rollers shall be equipped with tanks and sprinkling bars for wetting the rolls or tires and shall meet the following requirements:

(a) Two-axle tandem rollers shall have a gross mass (weight) of not less than 7 metric tons (8 tons) and not more than 10 metric tons (12 tons) and shall be capable of providing a minimum compactive effort of 44 kN/m (250 pounds per inch) of width of the drive roll. All rolls shall be at least 1 m (42 inches) in diameter.

(b) Three-axle tandem rollers shall have a gross mass (weight) of not less than 10 metric tons (12 tons) and not more than 18 metric tons (20 tons) and shall be capable of providing a minimum compactive effort of 44 kN/m (250 pounds per inch) of width of the drive roll. The roller shall be equipped with a locking device to allow the center axle roll to move independently or be secured in a locked position.

(c) Pneumatic-tired rollers shall be self-propelled and equipped with a minimum of seven wheels situated on the axles in such a way that the rear group of tires does not follow in the tracks of the forward group. The wheels shall be spaced so that a minimum tire path overlap of 13 mm (1/2 inch) is obtained. The wheels on at least one of these axles shall be capable of oscillating in a vertical direction, either individually or in pairs. The tires shall be of equal size. The compressor for inflation of tires shall be capable of inflating the tires so that the air pressure between tires does not vary more than 34 kPa (5 pounds per square inch). The tires shall be smooth and capable of being inflated to a pressure necessary to provide ground contact pressure of at least 550 kPa (80 pounds per square inch) per tire. The Contractor shall provide a gauge at all times to enable the Engineer to check tire pressures. Appropriate charts or tables shall be posted on each roller showing the contact areas and contact pressures for the full range of tire inflation pressures and wheel loadings for the type and size of the roller and tires involved.

(d) Vibratory rollers shall have separate controls for energy and propulsion. Rollers shall be equipped with automatic cutoffs that stop the vibration when the rollers stop or reverse direction of travel.

406.12 CONDITIONING OF EXISTING SURFACE. The existing surface shall be cleaned and sprayed with Type RS-1 emulsified asphalt before placement of the bituminous concrete mixture. However, if the surface to be paved is placed in the same construction season, the asphalt treatment will not be required unless ordered by the Engineer. The emulsion shall be applied under pressure at the rate of 0.05 to 0.14 $L/m^2$ (0.01 to 0.03 gallons per square yard). The application shall be made just prior to the placement of the bituminous concrete mixture and shall progress sufficiently ahead of the paving so that the surface to be paved is tacky. Equipment used to apply the emulsion shall meet the requirements for distributors under Subsection 404.04.

Bridge floors shall be treated as shown on the Plans prior to paving.

When the bottom course of bituminous concrete pavement is left over the winter or paving is to be made over an existing portland cement concrete pavement or bituminous concrete pavement, the existing surface shall be cleaned and the emulsion applied as described above before the next course is applied.

All longitudinal and transverse joints and all cracks shall be sealed by applying an approved joint sealing compound before spreading the mixture on a portland cement concrete surface. All excess bituminous material shall be removed from joints and cracks prior to placing the bituminous concrete mixture.

All large cracks in a bituminous surface shall be thoroughly cleaned and filled with a bituminous material or mixture approved by the Engineer.

Contact surfaces such as curbing, gutters, and manholes shall be painted with a thin, uniform coat of Type RS-1 emulsified asphalt immediately before the bituminous concrete mixture is placed against them.

If there are deficiencies that require corrective action in the base course constructed as part of the Contract, a bituminous concrete mixture that meets the approval of the Engineer shall be used to bring the base course to the designed grade and contour.

If bituminous concrete pavement is used to resurface existing pavements, the Contractor shall correct all irregularities, depressions, or waves in the existing pavement. Extra bituminous material shall be used for leveling to bring the existing base to a uniform section and grade before placing the required courses of bituminous concrete pavement.

406.13 SPREADING AND FINISHING. The bituminous mixture, at the time of discharge from the haul vehicle, shall be within 6 °C (10 °F) of the compaction temperature for the approved mix design.

The Contractor shall protect all exposed surfaces that are not to be treated from damage during all phases of the paving operation.

The bituminous mixture shall be spread and finished with the specified equipment. The mixture shall be struck off in a uniform layer to the full width required and of such depth that each course, when compacted, has the required thickness and conforms to the grade and elevation specified. Bituminous concrete pavers shall be used to distribute the mixture over the entire width or over such partial width as practical.

When operating in tandem on multi-lane paving, the pavers shall be of the same type and characteristics. Material for leveling may be spread by the use of a grader, if approved by the Engineer.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture shall be spread, raked, and luted by hand tools.

No material shall be produced so late in the day as to prohibit the completion of spreading and compaction of the mixture during daylight hours, unless night paving has been approved for the project.

No traffic will be permitted on material placed until the material has been thoroughly compacted and has been permitted to cool to 60 °C (140 °F).

The use of water to cool the pavement will not be permitted.

The Agency reserves the right to require that all work adjacent to the pavement, such as guardrail, cleanup, and turf establishment, is completed prior to placing the wearing course when this work could cause damage to the pavement.

When bituminous concrete is to be placed on a bridge deck that has been waterproofed, a rubber-tired paver shall be used to place the binder course of pavement.

On projects where traffic is to be maintained, the Contractor shall schedule daily paving operations so that at the end of each working day all travel lanes of the roadway on which work is being performed are paved to the same limits.

Suitable aprons to transition approaches where required shall be placed at side road intersections and driveways as directed by the Engineer.

406.14 COMPACTION. Immediately after the bituminous mixture has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling.

The surface shall be rolled when the mixture is in the proper condition and when the rolling does not cause undue displacement, cracking, or shoving.

The number, mass (weight), and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. Generally, one breakdown roller will be needed for each paver used in the spreading operation.

Leveling courses shall be compacted using a self-propelled, pneumatic-tired roller, unless otherwise authorized in writing by the Engineer. On the base, binder, or wearing course, the initial or breakdown rolling shall be done by using a two-axle tandem roller; intermediate rolling by using a two-axle tandem roller or self-propelled, pneumatic-tired roller; and final rolling by using an additional two or three-axle tandem roller. An intermediate roller will not be required for shoulders constructed with one course of bituminous concrete, but the compaction equipment shall be sufficient to obtain the required compaction while the mixture is in a workable condition.

To prevent adhesion of the mixture to the rolls, rolls shall be kept moist with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls, and other places not accessible to the rollers, the mixture shall be thoroughly compacted with hot or lightly oiled hand tampers, smoothing irons or with mechanical tampers. On depressed areas, either a trench roller or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Other combinations of rollers and/or methods of compacting may be used if approved in writing by the Engineer, provided the compaction requirements are met.

Unless otherwise specified, the longitudinal joints shall be rolled first. Next, the Contractor shall begin rolling at the low side of the pavement and shall proceed towards the center or high side with lapped rollings parallel to the centerline. The speed of the roller shall be slow and uniform to avoid displacement of the mixture, and the roller should be kept in as continuous operation as practical. Rolling shall continue until all roller marks and ridges have been eliminated.

Rollers will not be stopped or parked on the freshly placed mat.

The density of compacted pavement shall be at last 92 percent, but not more than 96 percent of the corresponding daily average maximum specific gravity for each type (i.e., I, II, III, or IV) of bituminous mix placed during each day. Values that fall outside of this range will be paid for by adjusting the daily production totals according to the following:

| Average Density | Pay Factor |
|---|---|
| 90.0% to 90.5% | 10% Reduction |
| 90.6% to 90.9% | 7.5% Reduction |
| 91.0% to 91.5% | 5% Reduction |
| 91.6% to 91.9% | 2.5% Reduction |
| 92.0% to 92.9% | Bid Price |
| 93.0% to 95.0% | 1% Bonus |
| 95.1% to 96.0% | Bid Price |
| 96.1% to 96.5% | 2.5% Reduction |
| 96.6% to 97.0% | 5% Reduction |
| 97.1% to 97.5% | 7.5% Reduction |
| 97.6% to 98.0% | 10% Reduction |

Values above 98 percent and below 90 percent will be evaluated by the Engineer to determine whether the pavement shall be removed and replaced by the Contractor at no expense to the Agency or if a greater penalty will be imposed.

It shall be the responsibility of the Contractor to conduct whatever process control the Contractor deems necessary. Acceptance testing will be conducted by Agency authorized personnel using cores provided by the Contractor.

Acceptance testing to verify density of the compacted pavement will be done by averaging the densities of a minimum of three cores for each day's production for each type of bituminous mix placed. The cores will be taken at a rate of one core per lane kilometer (0.6 mile) paved excluding shoulders. Core locations will be randomly selected by the Engineer. These cores shall be taken by the Contractor as soon as possible, but within ten working days after paving. Cores shall be immediately marked with the station and offset of the location taken. Core holes shall be filled by the Contractor the same day the cores are taken. These cores shall be delivered to the Engineer the same day the cores are taken. The Contractor shall replace the pavement with like material where cores are removed during hot mix operations. These replacements shall be at the Contractor's expense.

The cores taken for acceptance testing will be the final cores taken for determination of densities. If the Agency elects not to take cores of any lift, there will be no bonus paid and no reduction taken.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with fresh hot mixture. The mixture shall be compacted to conform to the surrounding area. Any area showing an excess or deficiency of bitumen shall be removed and replaced. These replacements shall be at the Contractor's expense.

Should the Contractor choose to use vibratory rollers, the following additional criteria shall govern their operation. Vibratory rollers may be used when operated at an amplitude, frequency, and speed that produces a mat conforming to specifications and that prevents the creation of transverse ridges in the mat. A vibratory roller may be used as a breakdown roller, an intermediate roller, or a finish roller. A vibratory roller shall not be used as a substitute for a pneumatic-tired roller on leveling courses or to compact lifts of pavement less than 25 mm (1 inch) in depth. The same single vibratory roller shall not be used alone as the breakdown, intermediate, and finish roller, but may be used as any one of the rollers in the roller train.

If the Engineer determines that unsatisfactory compaction or surface distortion is being obtained or damage to highway components and/or adjacent property is occurring using vibratory compaction equipment, the Contractor shall immediately cease using this equipment and proceed with the work in accordance with the fourth paragraph of this Subsection.

The Contractor assumes full responsibility for the cost of repairing all damages that may occur to highway components and adjacent property if vibratory compaction equipment is used.

406.15 JOINTS. Joints between old and new pavements or between successive day's work shall be made to ensure a thorough and continuous bond between the old and new mixtures. Whenever the spreading process is interrupted long enough for the mixture to attain its initial stability, the paver shall be removed from the mat and a joint constructed.

Butt joints shall be formed by cutting the pavement in a vertical plane at right angles to the centerline, at locations approved by the Engineer. The Engineer will determine locations by using a straightedge at least 4.9 m (16 feet) long. The butt joint shall be thoroughly coated with Type RS-1 emulsified asphalt just prior to depositing the paving mixture when paving resumes.

Tapered joints shall be formed by tapering the last 450 to 600 mm (18 to 24 inches) of the course being laid to match the lower surface. 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 Type RS-1 emulsified asphalt just prior to resuming paving. As the paver places new mixture on the taper area, an evenly graduated deposit of mixture shall complement the previously made taper. Shovels

may be used to add additional mixture if necessary. The joint shall be smoothed with a rake, coarse material discarded, and properly rolled.

Longitudinal joints that have become cold shall be coated with Type RS-1 emulsified asphalt before the adjacent mat is placed. If directed by the Engineer, joints shall be cut back to a clean vertical edge prior to applying the emulsion.

Longitudinal joints shall be offset at least 150 mm (6 inches) from each joint in the lower courses of pavement. Transverse joints shall not be constructed nearer than 300 mm (12 inches) from any transverse joint constructed in lower courses.

406.16 SURFACE TOLERANCES. The surface will be tested by the Engineer using a straightedge at least 4.9 m (16 feet) in length at selected locations parallel with the centerline. Any variations exceeding 3 mm (1/8 inch) between any two contact points shall be satisfactorily eliminated. A straightedge at least 3 m (10 feet) in length may be used on a vertical curve. The straightedges shall be provided by the Contractor.

406.17 TRAFFIC CONTROL. Whenever traffic must be maintained during a paving operation, uniformed traffic officers and/or flaggers shall be stationed at each end of the section being paved and at other locations as required by the Engineer. The traffic officers or flaggers shall conform to the requirements of Section 630.

Whenever one-way traffic is maintained by the Contractor, the traveling public shall not be stopped or delayed more than ten minutes. Two-way traffic shall be maintained during non-working hours.

406.18 METHOD OF MEASUREMENT. The quantity of Bituminous Concrete Pavement or Medium Duty Bituminous Concrete Pavement to be measured for payment will be the number of metric tons (tons) used in the complete and accepted work, as determined from the load tickets.

When any pay factor for a lot (a day's run of each type) of bituminous concrete pavement is less than, or more than, 100 percent due to the density of the compacted pavement, the total quantity of bituminous concrete pavement placed that day will be multiplied by the pay factor to determine an adjusted tonnage for the day.

406.19 BASIS OF PAYMENT. The accepted quantity of Bituminous Concrete Pavement or Medium Duty Bituminous Concrete Pavement will be paid for at the Contract unit price per metric ton (ton), as appropriate. Payment will be full compensation for furnishing, mixing, hauling, and placing of the material specified and for furnishing signs, labor, tools, equipment, and incidentals necessary to complete the work.

When any pay factor for a lot of bituminous concrete pavement is less than, or more than, 100 percent as determined in accordance with Subsection 406.14, payment will be made by using the adjusted tonnage as the accepted quantity to be paid at the Contract unit price per metric ton (ton).

The cost of taking cores for acceptance testing and filling the core holes will be considered included in the item being cored. The cost of traffic control while taking

cores for acceptance testing and filling the core holes will be paid under the appropriate item in Section 630.

The costs of furnishing testing facilities and supplies at the plant will be considered included in the Contract item Bituminous Concrete Pavement or Medium Duty Bituminous Concrete Pavement, as appropriate.

The costs of obtaining, furnishing, transporting, and providing the straightedges required by Subsection 406.16 will be included in the appropriate Section 631 Contract item included in the Contract.

When not specified as a Contract item in the Contract, the cost of providing uniformed traffic officers or flaggers will not be paid for directly but will be considered included in the Contract item Bituminous Concrete Pavement or Medium Duty Bituminous Concrete Pavement, as appropriate.

When not specified as Contract items in the Contract, the costs of cleaning and filling of joints and cracks; sweeping and cleaning of existing paved surfaces; applying emulsified asphalt to tack these surfaces; and painting manholes, curbs, gutters, and other contact surfaces will not be paid for directly but will be considered included in the Contract item Bituminous Concrete Pavement or Medium Duty Bituminous Concrete Pavement, as appropriate.

The bituminous concrete mixture approved by the Engineer for use in correcting deficiencies in the base course constructed as part of the Contract will not be paid for as Bituminous Concrete Pavement or Medium Duty Bituminous Concrete Pavement but will be considered incidental to the Contract item for the specified type of base course.

The bituminous concrete mixture used to correct deficiencies in an existing pavement or to adjust the grade of a surface completed as part of the Contract will be paid for at the Contract unit price for Bituminous Concrete Pavement or Medium Duty Bituminous Concrete Pavement, as appropriate.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 406.25 Bituminous Concrete Pavement | Metric Ton (Ton) |
| 406.27 Medium Duty Bituminous Concrete Pavement | Metric Ton (Ton) |

## SECTION 409 - OPEN GRADED ASPHALT FRICTION COURSE

409.01 DESCRIPTION. This work shall consist of constructing one course of bituminous concrete mixture on a prepared foundation.

409.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Bituminous Material | 702.01 |
| Asphalt Cement | 702.02 |
| Emulsified Asphalt, RS-1 | 702.04 |
| Anti-Strip Additives | 702.07 |
| Silicone Additive | 702.08 |
| Coarse Aggregate | 704.10(a) |
| Fine Aggregate | 704.10(a) |
| Mineral Filler | 704.10(e) |

The grade of asphalt cement shall be as shown on the Plans, unless otherwise specified in the Contract.

When crushed gravel is used as coarse aggregate for open graded asphalt friction course, at least 75 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve shall have at least two fractured faces, and 90 percent shall have one or more fractured faces.

Coarse aggregate particles for open graded asphalt friction course shall have an acid insoluble content of not less than 80 percent when tested in accordance with the requirements of VAOT, Test Procedure MRD-6.

A heat stable additive shall be furnished to improve the anti-stripping properties of the asphalt cement. The amount of additive to be used will be determined by the Engineer based on the manufacturer's recommendations and the mix design test results.

Silicone shall be added to the asphalt cement in the rate of 1.5 $mL/m^3$ (1 ounce to 5000 gallons).

All additives shall be added to the asphalt cement and thoroughly mixed while still in the asphalt storage tanks.

409.03 GENERAL. The mixing plant, hauling and placing equipment, and construction methods shall be in conformance with the applicable requirements of Section 406, except as modified by this Section.

The use of surge bins shall not be permitted.

409.04 COMPOSITION OF MIXTURE.

(a) Gradation. The materials shall be combined and graded to meet the following composition limits by mass (weight):

TABLE 409.04A - COMPOSITION OF MIXTURE

| Sieve Designation | | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|---|
| Metric | English | |
| 12.5 mm | 1/2 inch | 100 |
| 9.5 mm | 3/8 inch | 95 to 100 |
| 4.75 mm | No. 4 | 30 to 50 |
| 2.36 mm | No. 8 | 5 to 15 |
| 75 μm | No. 200 | 2 to 5 |
| Total Aggregate | | 92 to 94.5 |
| Bitumen (% of Total Mix) | | 5.5 to 8.0 |

(b) Mix Design. No work shall be started until the Contractor has submitted and the Engineer has approved a mix design including cold feed and hot bin gradings, mixing times, the percentage of each aggregate, and the job-mix formula from such a combination. The bitumen content and mixing temperature will be determined by the Agency's Materials and Research Section in accordance with the method described in the FHWA TA T-5040.31.

The job-mix formula shall establish a single percentage of aggregate passing each sieve and a single percentage of bituminous material to be added to the aggregate. No change in the job-mix formula may be made without written approval of the Engineer. The job-mix formula must fall within the master range specified in Table 409.04A.

At the time the above mix design is submitted, the Contractor shall indicate and make available for sampling and testing stockpiles of all aggregates, additives, and asphalt cement proposed for use.

A minimum time of three weeks shall be allowed for testing and evaluation of the submitted mix design. Once a mix design is approved, the job-mix formula is valid until the producer makes a change in aggregate source or asphalt source.

(c) Tolerances. Samples of the actual mixture in use will be taken as many times daily as necessary in the opinion of the Engineer. The gradations of the aggregate and bitumen content shall not vary from the job-mix formula by more than the following tolerances:

| Testing Tolerances | |
|---|---|
| Aggregate larger than 2.36 mm (No. 8) sieve | ± 6.0% |
| Aggregate passing 2.36 mm (No. 8) sieve and larger than 75 μm (No. 200) sieve | ± 4.0% |
| Temperature of Mixture | ± 11 °C (± 20 °F) |

409.05 WEATHER AND SEASONAL LIMITATIONS. Open graded asphalt friction course shall not be placed between September 1 and May 1. When it is in the public interest, the Construction Engineer may adjust the air temperature requirement or extend the dates of the paving season. The material shall not be placed when the

ambient air temperature at the paving site in the shade away from artificial heat is below 16 °C (60 °F) or when the actual pavement temperature is below 10 °C (50 °F).

The Contractor shall not pave on days when rain is forecast for the day, unless a change in the weather results in favorable paving conditions as determined by the Engineer.

409.06 ROLLERS. Rollers shall be in good mechanical condition, operated by competent personnel, capable of reversing without backlash, and operated at speeds slow enough to avoid displacement of the bituminous mixture. The mass (weight) of the rollers shall be sufficient to compact the mixture to the required density without crushing of the aggregate. Rollers shall be equipped with tanks and sprinkling bars for wetting the rolls.

Rollers shall be two-axle tandem rollers with a gross mass (weight) of not less than 7 metric tons (8 tons) and not more than 10 metric tons (12 tons) and shall be capable of providing a minimum compactive effort of 44 kN/m (250 pounds per inch) of width of the drive roll. All rolls shall be at least 1 m (42 inches) in diameter.

A rubber tired roller will not be required on the open graded asphalt friction course surface.

409.07 CONDITIONING OF EXISTING SURFACE. The existing surface shall be cleaned and sprayed with Type RS-1 emulsified asphalt before placement of the bituminous mixture. The emulsion shall be applied under pressure at the rate of 0.05 to 0.14 L/m$^2$ (0.01 to 0.03 gallons per square yard). The application shall be made just prior to the placement of the bituminous concrete mixture and shall progress sufficiently ahead of the paving so that the surface to be paved is tacky.

Bridge floors shall be treated as shown on the Plans prior to paving.

All large cracks in a bituminous surface shall be thoroughly cleaned and filled with a bituminous material or mixture approved by the Engineer.

If open graded asphalt friction course is used to resurface existing pavements, the Contractor shall correct all irregularities, depressions, or waves in the existing pavement. Extra bituminous material shall be used for leveling to bring the existing base to a uniform section and grade before placing of the required course of open graded asphalt friction course.

409.08 MIXING. The mixture shall be prepared in conformance with Subsection 406.08, except that the dried aggregates shall be combined in such a manner as to produce a mixture that when discharged from the pugmill is at a target temperature in the range that corresponds to an asphalt cement viscosity of 700 to 900 centistokes and within a tolerance of ± 11 °C (± 20 °F).

409.09 METHOD OF MEASUREMENT. The quantity of Open Graded Asphalt Friction Course to be measured for payment will be the number of metric tons (tons) used in the complete and accepted work, as determined from the load tickets.

409.10 BASIS OF PAYMENT. The accepted quantities of Open Graded Asphalt Friction Course will be paid for at the Contract unit price per metric ton (ton). Payment will be full compensation for furnishing, mixing, hauling, and placing of the material specified and for furnishing signs, labor, tools, equipment, and incidentals necessary to complete the work.

The cost of furnishing testing facilities and supplies at the plant will be considered included in the Contract item Open Graded Asphalt Friction Course.

When not specified as a Contract item in the Contract, the cost of providing uniformed traffic officers or flaggers will not be paid for directly but will be considered included in the Contract item Open Graded Asphalt Friction Course.

When not specified as Contract items in the Contract, the cost of cleaning and filling of joints and cracks; sweeping and cleaning of existing paved surfaces; and applying emulsified asphalt to tack these surfaces will not be paid for directly but will be considered included in the Contract item Open Graded Asphalt Friction Course.

The bituminous concrete mixture used to correct deficiencies in an existing pavement will be paid for at the Contract unit price for Bituminous Concrete Pavement or Medium Duty Bituminous Concrete Pavement, as appropriate.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 409.25 Open Graded Asphalt Friction Course | Metric Ton (Ton) |

## SECTION 417 - BITUMINOUS CRACK FILLING

417.01 DESCRIPTION. This work shall consist of furnishing and placing sealing compound in cracks of existing bituminous concrete pavement.

417.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Joint Sealer, Hot Poured ..... 707.04(a) & (d)
Aggregate for Bituminous Surface Treatment ..... 704.11

417.03 EQUIPMENT. The equipment shall meet the approval of the Engineer and shall be maintained in working condition at all times.

(a) Air Compressor. Air compressors shall be portable and capable of furnishing not less than 2.8 $m^3$ (100 cubic feet) of air per minute at a pressure of not less than 620 kPa (90 pounds per square inch) at the nozzle. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water.

(b) Hand Tools. Hand tools shall consist of brooms, shovels, metal bars with chisel-shaped ends, and any other tools that 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 277 °C (530 °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 kettle shall be equipped with thermostatic control calibrated between 93 and 288 °C (200 and 550 °F). The kettle shall be mounted on rubber tires and shall be equipped with a metal shield beneath the firebox to protect the pavement.

(d) Hand Pouring Pots. The hand pouring pots shall be equipped with a mobile carriage and a rubber shoe and shall have a flow control valve that allows all cracks to be filled to refusal.

(e) Router. Equipment for reshaping cracks shall be a vertical spindle or rotary type cutter.

(f) Flame Cleaner. Equipment for blowing clean and drying cracks and joints shall be a propane gas and compressed air burner (ATAFA unit or approved equivalent) operating at 1650 °C (3000 °F) at a velocity of 915 m/s (3000 feet per second).

417.04 PREPARATION. All cracks 6 mm (1/4 inch) and wider shall be shaped with a power router and flame cleaned of all dirt, foreign material, and loose edges to a minimum depth of 19 mm (3/4 inch). All cracks may be cleaned with a hot compressed air lance instead of routing, if approved by the Engineer. The material removed from the cracks shall be removed from the pavement surface immediately by means of sweepers or hand brooms. No crack sealing material shall be applied in wet cracks or where frost, snow, or ice is present; when the ambient air temperature is below 5 °C (40 °F); or when the temperature of the existing pavement is below 5 °C (40 °F).

417.05 PLACING OF SEALER. The joint sealing material shall be heated and applied at the temperature specified by the manufacturer and approved by the Engineer.

All cracks shall be filled, and the sealer well bonded to the pavement. Cracks shall be completely filled flush with the pavement, and not less than 3 mm (1/8 inch) below surface. Care shall be taken so that voids or entrapped air do not result. More than one application may be necessary to fill the cracks.

If traffic is being maintained in the lane being sealed, the joint sealer shall be lightly sanded at all intersections and driveways to prevent “picking” of the sealer.

417.06 METHOD OF MEASUREMENT. The quantity of Bituminous Crack Filling to be measured for payment will be the number of kilograms (pounds) used in the complete and accepted work.

417.07 BASIS OF PAYMENT. The accepted quantity of Bituminous Crack Filling will be paid for at the Contract unit price per kilogram (pound). Payment will be full compensation for furnishing, transporting, handling, and installing the material

specified including cleaning and preparation of cracks and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete this work including any necessary sand cover.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 417.10 Bituminous Crack Filling | Kilogram (Pound) |

# DIVISION 500

## STRUCTURES

### SECTION 501 - STRUCTURAL CONCRETE

501.01 DESCRIPTION. This work shall consist of furnishing and placing portland cement concrete for structures and incidental construction.

The portland cement concrete shall consist of a homogeneous mixture of cement, fine aggregate, coarse aggregate, water, admixtures, and pozzolan (when used), proportioned and mixed according to these Specifications.

501.02 MATERIALS. Materials shall meet the requirements of the following Subsections:



501.03 CLASSIFICATION AND PROPORTIONING. The following classes of concrete are included in these Specifications and shall be used as shown on the Plans:

TABLE 501.03A (METRIC)

| Class | Minimum Cement ($kg/m^3$) | Maximum Water-Cement Ratio | Range in Slump (mm) | Air Content (%) | Coarse Aggregate Gradation Table | 28-Day** Comp. Strength (MPa) | 28-Day** Modulus of Rupture (MPa) |
|---|---|---|---|---|---|---|---|
| AA | 418 | 0.40 | 25 to 65 | 7.0 ± 1 | 704.02A | 30 | 4.48 |
| A* | 392 | 0.44 | 50 to 100* | 6.0 ± 1 | 704.02B | 30 | 4.48 |
| B | 363 | 0.49 | 50 to 100 | 5.0 ± 1 | 704.02B, C | 25 | 4.14 |
| C | 335 | 0.49 | 50 to 100 | 4.5 ± 1 | 704.02B, C | 20 | 3.79 |
| D | 279 | 0.58 | 50 to 100 | 4.5 ± 1 | 704.02B, C | 20 | 3.10 |
| LW | 392 | 0.44 | 25 to 75 | 6.0 ± 1 | 704.02B | 30 | --- |

* When this class of concrete is used for bridge decks, the range in slump shall be 25 to 75 mm.

** The listed 28-day compressive strength or modulus of rupture will serve as the basis of designing or approving the concrete mix.

TABLE 501.03A (ENGLISH)

| Class | Minimum Cement ($lbs./ft^3$) | Maximum Water-Cement Ratio | Range in Slump (in.) | Air Content (%) | Coarse Aggregate Gradation Table | 28-Day** Comp. Strength (psi) | 28-Day** Modulus of Rupture (psi) |
|---|---|---|---|---|---|---|---|
| AA | 705 | 0.40 | 1 to 2 1/2 | 7.0 ± 1 | 704.02A | 4000 | 650 |
| A* | 660 | 0.44 | 2 to 4* | 6.0 ± 1 | 704.02B | 4000 | 650 |
| B | 611 | 0.49 | 2 to 4 | 5.0 ± 1 | 704.02B, C | 3500 | 600 |
| C | 564 | 0.49 | 2 to 4 | 4.5 ± 1 | 704.02B, C | 3000 | 550 |
| D | 470 | 0.58 | 2 to 4 | 4.5 ± 1 | 704.02B, C | 2500 | 450 |
| LW | 660 | 0.44 | 1 to 3 | 6.0 ± 1 | 704.02B | 4000 | --- |

* When this class of concrete is used for bridge decks, the range in slump shall be 1 to 3 inches.

** The listed 28-day compressive strength or modulus of rupture will serve as the basis of designing or approving the concrete mix.

The maximum unit density of Class LW concrete shall be:

(a) Plastic: 1922 $kg/m^3$ (120 pounds per cubic foot).

(b) Dry: 1842 $kg/m^3$ (115 pounds per cubic foot).

Unless otherwise specified in the Contract, Class B concrete shall be used.

Silica fume concrete shall conform to the requirements of Class A concrete with the following modifications:

(a) Water/(Cement + Silica Fume) ratio: maximum 0.40.

(b) Slump: 125 ± 50 mm (5 ± 2 inches) (after addition of water-reducing, high range admixture).

(c) Air content: 7.0 ± 2.0 percent.

(d) Seven-day compressive strength: no less than 31 MPa (4500 pounds per square inch).

(e) Twenty-eight-day compressive strength: no less than 35 MPa (5000 pounds per square inch).

The silica fume concrete mixture shall be proportioned to contain silica fume at the rate of 7.5 percent by mass (weight) of portland cement or 30 kg of silica fume per cubic meter of concrete (50 pounds per cubic yard). Silica fume may be supplied as an admixture, in slurry or in dry powdered form, or as a constituent of blended silica fume cement. Use of a water-reducing, high range admixture will be required to produce a workable mix.

If the blended silica fume cement contains silica fume at a rate other than that required for the approved design mix, the Contractor shall provide additional silica fume or cement, as required, to provide concrete meeting the mix design requirements. The additional cement or silica fume provided shall be of the same brand and type as contained in the silica fume cement blend.

If test results indicate a failure to obtain the 28-day compressive strength as specified in Table 501.03A as tested in accordance with AASHTO T 22 or AASHTO T 97, changes shall be made with no extra payment. Changes may include, but are not limited to, using additional cement, changing the source of cement or aggregate, using a water reducer or other additives, or, if necessary, obtaining concrete from another supplier. If deemed to be in the best interest of the project, the Engineer may, at any time, order plant production stopped.

A water-reducing, retarding, or water-reducing-retarding admixture shall be used for all Class AA, Class A, Class B, and Class LW concrete, unless otherwise authorized in writing by the Engineer. These admixtures may be used in Class C and Class D concretes when required or approved by the Engineer. The use of an accelerating or water-reducing-accelerating admixture to alter the setting characteristics of concrete mixtures shall be employed 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 501.03A. The volumetric proportioning method such as that outlined in ACI Standard 211.1, *Recommended Practice for Selecting Proportions for Normal Weight Concrete*, or other approved volumetric proportioning methods shall be employed in the mix design. The mix shall be designed or approved by the Engineer.

The Engineer will supply written notice to the Contractor 72 hours prior to any major change in cement content.

After the materials to be furnished by the Contractor have been approved, no change in the source or character of the materials shall be made without notice to the Engineer. No new materials shall be used until the Engineer has accepted such materials, and has designated or approved new proportions. In no case shall concrete from more than one batch plant be permitted on the same structure without prior written approval of the Engineer. The Engineer may require a period of up to 60 calendar days from the date the aggregate is available for testing to test the material(s) and redesign the mix.

The various classes of concrete shall have an air content by volume as specified. The entrained air may be obtained by the use of air-entraining portland cement, an approved admixture, or a combination of admixtures and cements.

The Contractor may substitute fly ash up to a maximum of 20 percent of the required portland cement. The fly ash shall be substituted at a minimum ratio of 1 kg (1 pound) of fly ash for 1 kg (1 pound) of portland cement. Fly ash shall not be substituted for Type IP cement.

The use of fly ash in high early strength concrete will not be permitted. When any pozzolan is incorporated into a standard class of concrete, necessary adjustments to the mix design shall be made by the Contractor and approved by the Engineer. Proportioning of the concrete mixtures containing pozzolan shall be by the absolute volumes method in accordance with the requirements for each class as specified in Table 501.03A except that the listed water-cement ratio shall be based on total cementitious material (portland cement and fly ash).

The Contractor shall submit test data and a materials report generated by a CCRL inspected laboratory for the proposed mix design. The report shall include all sources and properties of materials used in trial batches; test results showing conformance to these Specifications for aggregate, cement, pozzolan, and admixture; plastic concrete test results; compressive strength data for seven, 14, and 28 days; and all mix proportions for both a non-pozzolan comparison mix and the proposed concrete mixture. Mixing shall be performed in accordance with AASHTO T 126.

The Contractor shall make available for sampling and testing all material used in the design, and shall provide four 75 by 75 by 400 mm ($3 \times 3 \times 15.7$ inches) concrete specimens made and cured in accordance with AASHTO T 126 for freeze-thaw testing of each mix. Freeze-thaw testing will be performed in accordance with AASHTO T 161, Procedure A, as modified by the Agency (3 percent salt solution). The relative durability factor of the pozzolan mix shall be not less than 80. The Engineer may require up to 60 calendar days to review the mix design and test materials proposed for use in any design containing pozzolans.

The Contractor, at its option, may substitute ground granulated blast-furnace slag (GGBFS), Grade 100 or 120 for portland cement. The substitution rate will be limited to a maximum of 25.0 percent of the required portland cement for concrete. The GGBFS shall be substituted at a minimum ratio of one unit of GGBFS for one unit of portland cement. Fly ash and GGBFS will not be permitted in the same concrete mixture.

The Contractor shall submit a mix design at least 60 calendar days in advance of the anticipated placement. The proportioning of the concrete mixture shall be mixed using the absolute volumes method and in accordance with the requirements for each class of concrete as specified in Table 501.03A. The water-cement ratio shall be based on the total cementitious material (portland cement plus GGBFS). Upon receipt of the mix design, the Agency's Structural Concrete Engineer will schedule a trial batch at the supplier's facilities. The Engineer will test aggregates, sample cement and GGBFS, witness batching, and perform tests for slump, air content, unit mass (weight), and temperature. The Engineer will also fabricate test specimens for compressive strength and freeze-thaw.

Strict adherence to the requirements of Subsection 501.02 is required when using concrete with GGBFS. The setting time may be retarded in cool weather, or accelerated in hot weather. The Resident Engineer, after consultation with the Agency's Structural Concrete Engineer, may require that the curing period, as designated in Table 501.17A, be extended.

501.04 BATCHING. Measuring and batching of materials shall be done at an approved batch plant. The batch plant shall meet the requirements of AASHTO M 157, except as modified and shall be maintained in good repair at all times and shall be subject to a periodic inspection by an authorized representative of the Agency.

All new or relocated concrete batch plants offered for Agency approval shall be equipped for semi-automatic batching and proportioning of all cement, aggregates, water, and fly ash (when used) and for automatic insertion of admixtures. The plants shall be equipped to automatically and accurately record the quantity of all aggregates, cement, fly ash, and the water incorporated into each batch and shall identify and record the addition of the required admixtures.

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.

The Contractor shall give the Engineer 24-hour notice of intent to place concrete so that arrangements can be made for laboratory inspection and control.

(a) Semiautomatic Batch Plants. When actuated by a starting mechanism, the semiautomatic batch controller shall start the mass measuring (weighing) operation of the materials and stop the flow automatically when the designated mass (weight) has been reached. It shall be interlocked to ensure that the discharge mechanism cannot be opened until the mass (weight) is within the tolerance specified in Subsection 501.04(d).

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.

(b) Testing Laboratory. The Contractor shall provide at the plant site a weatherproof building or room for the use of Agency personnel as a testing laboratory. The laboratory shall have a minimum gross internal area of 14 $m^2$ (150 square feet) with a layout providing a minimum internal width of 2.1 m (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. An adequate method of ventilation, lighting, heating, and necessary electrical or gas connections shall be provided. Sanitary toilet facilities with lavatory shall be available for use by Agency personnel at the plant site.

The laboratory shall be equipped with the following:

1 Standard office desk, with lockable drawers or a separate lockable two-drawer file cabinet.
1 Side chair.
1 Bench section(s) at least 600 mm (2 feet) wide providing a minimum of 2.6 $m^2$ (28 square feet) of working area with undercounter shelving.
1 Standard laboratory stool.
1 Fully automatic 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 203 mm (8 inch) sieve shaker with sieving operation conducted by means of lateral and vertical motion of the sieve accompanied by jarring action with the following 203 mm (8 inch) diameter sieves: 9.5 mm (3/8 inch), 4.75 mm (No. 4), 2.36 mm (No. 8), 1.18 mm (No. 16), 600 μm (No. 32), 300 μm (No. 50), 150 μm (No. 100), plus pan and cover.
1 Mechanical aggregate shaker with a 0.0283 $m^3$ (1 cubic foot) capacity with the following screens: 45 mm (1 3/4 inch), 37.5 mm (1 1/2 inch), 25 mm (1 inch), 19 mm (3/4 inch), 12.5 mm (1/2 inch), 9.5 mm (3/8 inch), 6.3 mm (1/4 inch), 4.75 mm (No. 4), 2.36 mm (No. 8), 1.18 mm (No. 16), and pan. The aggregate shaker may be placed in a separate enclosed area. When the mechanical aggregate shaker is placed in a separate enclosed area, the enclosed area shall contain one bench section approximately 900 mm (36 inches) high, 600 mm (24 inches) deep and 1250 mm (50 inches) long. The bench shall be located adjacent to the mechanical aggregate shaker.
1 Platform beam scale accurate to 5.0 g (0.01 pound) with a minimum capacity of 45 kg (100 pounds) or an electronic balance with a minimum capacity of 45 kg (100 pounds) accurate to 1.0 g (0.002 pound).

1 Torsion balance, 4.5 kg (10 pound) minimum capacity, with arrest and dash pot and standard masses (weights) for full capacity of balance.
1 Double burner hot plate, variable temperature.
5 Metal pans, nominal size, 230 by 230 by 50 mm (9 × 9 × 2 inches).
1 Sample splitter, 63.5 mm (2 1/2 inch) chute.
1 250 mm (10 inch) blunted trowel.
1 1.25 by 1.25 m (4 × 4 feet) minimum heavy canvas for quartering samples.
1 Brass wire bristle brush.
1 Pair, heat resistant gloves.
2 38 mm (1 1/2 inch) soft bristle paint brushes.
3 355 mL (12 ounce) clear graduated glass bottles.
1 Reference color comparison chart with five organic plate number colors. Reagent sodium hydroxide solution (3 percent) in sufficient quantity for the duration of the project.

Acceptable substitutes for the aforementioned equipment may be provided when approved by the Materials and Research Engineer.

Prior to constructing a new testing laboratory or modifying an existing laboratory, the Contractor shall submit to the Agency for approval, two sets of drawings and specifications detailing the proposed location, dimensions, and materials to be used. The details shall include the location of all testing equipment, benches, desk/file cabinet, sink, doors, windows, electrical or gas connections, lighting, ventilating, and heating equipment. The laboratory and all testing equipment shall be maintained in operating condition. Equipment which, during concrete operations, becomes worn or damaged to the point of being unsuitable for testing purposes, shall be replaced or repaired by the Contractor. A testing laboratory shall be required at each plant site at least one week prior to the start of batching operations, and shall remain at the site either until concreting operations on the project are completed and the concrete has been accepted, or as otherwise directed by the Chief Engineer.

Batching operations shall not begin until the testing laboratory has been installed and approved as being in compliance with these Specifications. Removal of any equipment, except at the direction of the Engineer, will revoke any prior approval 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 user and kept free of all articles not necessary for the testing of materials. Cleaning supplies shall be furnished by the Contractor.

(c) 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. Means of removing the overload

of any one of the several materials shall be provided. Hoppers shall be constructed so as to eliminate accumulations of tare materials and to discharge fully without jarring the scales. Partitions between compartments shall be ample 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 mass measuring (weighing) mechanism.

The scales for determining the mass (weight) of aggregate, cement, and fly ash shall be comprised of a suitable system of levers or load cells. The levers or load cells will determine the mass (weigh) consistently within 0.5 percent 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 by the use of 22.68 kg masses (50 pound weights) or by other methods approved by the Engineer. 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 mass measuring (weighing) and 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 Division of Weights and Measures of the Vermont Department of Agriculture. For Vermont plants, an inspector representing the Division of Weights and Measures 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 Division of Weights and Measures. Standard test masses (weights) used to determine the accuracy of hopper scales shall be certified yearly by the Division of Weights and Measures 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 Division of Weights and Measures between February 15 and April 30 of each year. After April 30, 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 mass measurement (weighing) and seal requirements of their respective states of location.

(d) Accuracy of Plant Batching. For weighed ingredients, accuracy of batching is determined by comparison between the desired mass (weight) and the actual scale reading; for volumetric measurement of water and admixtures, accuracy is

determined by checking the quantity either by mass (weight) on a scale or by volume in a calibrated container.

Batching shall be conducted to accurately measure the desired quantities within the following tolerances:

| | | | |
|---|---|---|---|
| Cement: | ± 1 percent | Aggregates: | ± 2 percent |
| Water: | ± 1 percent | Admixtures: | ± 3 percent |
| Fly Ash: | ± 1 percent | | |

(e) 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 mass measuring (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. This device shall be a permanent installation located so as to allow safe and easy access. It shall provide a sample that represents the true nature of the material being used.

(2) Water. Water may be measured either by volume or by mass (weight). When measurement is by meter, the water meter shall be so located that the measurements will not be affected by variable pressure and temperature 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.

(3) Aggregates. In stockpiling aggregates, the location and preparation of the sites shall be subject to the approval of the Engineer. 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 1.2 m (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 that the aggregate be 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, such as when lightweight concrete is being produced.

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 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 contain high or non-uniform moisture content, storage or stockpile period in excess of 12 hours may be required by the Engineer.

d. Lightweight aggregate stockpiles shall be presoaked for a minimum period of 48 hours immediately prior to use. Soaking shall be accomplished by continuous sprinkling or other suitable means that will provide a uniform moisture content throughout the stockpile.

(4) Admixtures. The Contractor shall follow an approved procedure for adding the necessary amount(s) of admixture(s) to each batch. Admixture(s) shall be dispensed in such a manner that will ensure uniform distribution of the material throughout the batch within the required mixing period. All admixtures shall be added to the batch at the plant, unless otherwise directed by the Engineer.

All dispensers shall include visual inspection aids such as graduated transparent cylinders. A separate dispenser shall be provided for each liquid admixture. Storage and dispensing systems for liquid admixtures shall be equipped so as to allow thorough circulation and/or 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 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 Engineer.

Storage and dispensing systems for liquid admixtures shall be sufficiently protected to prevent freezing of admixtures at all times.

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 additions of admixtures will be approved by the Engineer prior to incorporation into the mix.

The use of calcium chloride as an admixture or an admixture ingredient will not be permitted.

a. Air-Entraining Admixture. Air-entraining admixture shall be used as required to obtain the specified air content.

b. Water-Reducing, Retarding, and Water-Reducing and Retarding Admixtures. Dosages shall be those recommended by the Manufacturer, unless otherwise directed by the Engineer.

(5) Fly Ash. Pozzolan (fly ash) shall be stored at the batch plant in a separate storage or holding bin and shall be protected from rain and moisture.

When the mass (weight) of any pozzolan is determined cumulatively with the cement, the pozzolan shall be the last component in the sequence to determine mass (weight) and the batching delivery tolerance for each material draw mass (weight) shall be based upon the total mass (weight) of cement plus pozzolan.

501.05 MIXING AND DELIVERY.

(a) General. 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 within 1.5 hours after the cement has been added to the aggregates. When retarded concrete or concrete with a water reducer is being used, time in excess of the 1.5-hour limit may be allowed. The Engineer will determine this additional time. When the ambient air temperature is 16 °C (60 °F) or above, the elapsed time may be reduced by as much as 45 minutes, as directed by the Engineer or in accordance with Subsection 501.07(a).

(2) If the elapsed time is expected to exceed the specified limits, the Engineer may authorize the addition of cement and water at or near the site, or the use of retarding admixture at the Contractor's expense.

(3) The addition of water in excess of the design water cement ratio for purposes of meeting the slump limits will not be permitted. Concrete that is not within the specified slump limits at time of placement shall not be used.

(4) Each load of concrete delivered at the job site shall be accompanied by a State of Vermont Batch Slip signed by the authorized Agency representative at the plant. Batch Slips shall contain such information as is deemed necessary by the Engineer.

(5) 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.

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 having a capacity of 7.5 $m^3$ (10 cubic yards) or less shall be not less than 60 seconds. For mixers of more than 7.5 $m^3$ (10 cubic yards) capacity, the mixing time shall be determined by the Engineer. The time is valid provided 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 a periodic inspection 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.

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.

No transit mixer or agitator shall be charged with the ingredients of the concrete unless an authorized Agency representative is present.

Electrically actuated revolution counters shall be required on all transit mixers except on mixers charged at central mix plants and utilized as agitator trucks only.

The transit mixer, when loaded with concrete, shall not contain more than 63 percent of the gross drum volume. The mixer shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

The agitator, when loaded, shall not exceed 80 percent of gross drum volume and shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

The Engineer may make tests for consistency (slump) of individual samples at approximately the beginning, the midpoint and end of the load. If the range of results exceeds 50 mm (2 inches), the mixer or agitator shall not be continued in use unless the condition is corrected.

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 19 mm (3/4 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.

When a transit mixer is used for complete mixing, each batch of concrete shall be mixed for at least 70 or more than 100 revolutions of the drum at the rate of rotation designated as mixing speed by the mixer manufacturer. Additional mixing, if any, shall be at the speed designated by the manufacturer as agitating speed. The mixing and agitating speeds shall be found on the metal plate on the mixer.

When a transit mixer or agitator is used for transporting concrete that has been completely mixed in a stationary mixer, mixing during transport shall be at the speed designated by the manufacturer of the equipment as agitating speed.

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 in order 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 a transit mixer that has been operating at agitating speed, the drum or blades shall be rotated approximately one minute at mixing speed.

If additional mixing water is required to maintain the specified slump and is added with the permission of the Engineer, a minimum of 20 revolutions of the transit mixer drum at mixing speed shall be required before discharge of any concrete. At no time shall the total water introduced into any mix exceed the maximum water cement ratio shown in Table 501.03A.

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. Retempering of concrete or mortar that has partially hardened, by remixing with or without additional materials, shall not be permitted.

(d) Silica Fume Concrete. When silica fume concrete is specified, the following provisions will apply:

(1) When a transit mixer is used for complete mixing, each batch of concrete shall be mixed for not less than 150 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as the mixing speed.

(2) Maximum load size shall be limited to 80 percent of rated mixing capacity; however, legal vehicle load restrictions shall not be exceeded.

(3) When a stationary mixer is used for complete mixing of the concrete, mixing times shall be increased a minimum of 50 percent.

When a slurry silica fume admixture is used, the above requirements may be waived at the discretion of the Engineer.

501.06 FIELD TESTS. 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 sampling and testing.

(a) Sampling. Sampling for tests shall be taken in accordance with AASHTO T 141 or other procedures approved by the Agency.

(b) Slump Tests. Slump tests shall be made in accordance with AASHTO T 119.

(c) Air Content Tests. Air content tests shall be made in accordance with the pressure method in AASHTO T 152, for acceptance or rejection. The Chace meter may be used in conjunction with the pressure method of AASHTO T 152 for monitoring other air content tests. A volumetric air meter shall be used for determining the air content of Class LW concrete in accordance with AASHTO T 196.

(d) Strength Tests.

(1) General. Strength tests shall be by test cylinder, except that when specified in the Contract or when authorized in writing by the Engineer, test beams may be used.

A test shall be the average of the strengths of at least two specimens from the same sample of concrete.

The number of strength tests shall be as follows:

a. A minimum of one test shall be required for each project.

b. One test shall be required for each placement of 75 $m^3$ (100 cubic yards) or fraction thereof except that a test will not be required on placements of less than 7.5 $m^3$ (10 cubic yards).

c. The Engineer may order additional tests as deemed necessary.

Test Cylinders. Test cylinders shall be made in accordance with AASHTO T 23, and tested for compressive strength in accordance with AASHTO T 22.

Test Beams. Test beams of dimensions 152 by 152 by 508 mm (6 × 6 × 20 inches) shall be made in accordance with AASHTO T 23, and tested for flexural strength in accordance with AASHTO T 97. Beam molds for constructing test beams shall be reusable steel molds conforming to the requirements of AASHTO T 23.

(2) Categories of Testing.

a. Quality acceptance testing utilizes specimens to determine the compliance with strength 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 central laboratory.

When the Engineer gives written permission to use test beams for quality acceptance testing, the beams will be cured in accordance with a method approved by the Engineer.

Quality acceptance testing shall be performed at 28 days except as follows:

1. When 90 percent of the 28-day design compressive strength requirement is obtained at 14 days, the 28-day testing may be omitted when approved by the Engineer.

2. When high early strength concrete is used, specimens will be tested at seven days at which time 100 percent of 28-day design strength must be obtained.

b. Job control testing utilizes 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.

c. Specimen curing requirements shall be as follows:

| Number of Specimens | Category | Location of Curing |
|---|---|---|
| 2 | Quality Acceptance - 28 days | Curing Box |
| 2 | Quality Acceptance - 14 days | Curing Box |
| 4 | Quality Acceptance - 7 days (Type III only) | Curing Box |
| 2 | Job Control - Applicable Curing Period | On Structure |

501.07 WEATHER AND TEMPERATURE LIMITATIONS - PROTECTION OF CONCRETE. The temperature of the concrete just prior to placement in the forms shall be between 10 and 27 °C (50 and 80 °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 29 °C (85 °F) during placement except with written permission of the Engineer.

(b) Cold Weather Concrete.

(1) General. When it is necessary to place concrete or mortar at or below an ambient air temperature of 5 °C (40 °F), or whenever in the opinion of the Engineer, ambient air temperatures may fall below this limit within the curing period, the mixing water, aggregates, or both, shall be heated and the work protected by adequate housing, covering and heating, or insulated forms.

When it is necessary to place concrete with GGBFS at or below an ambient temperature of 10 °C (50 °F), or whenever in the opinion of the Engineer ambient air temperature may fall below this temperature within the curing period, the mixing water, aggregates or both, shall be heated and the work protected by adequate housing, covering and heating, or insulated forms.

The Contractor shall have on the job, ready to install prior to starting any placing operation adequate equipment meeting the approval of the Engineer for heating and protecting the materials and freshly placed concrete.

No concrete shall be placed when the temperature of the surrounding atmosphere is lower than -12 °C (10 °F) except by written permission of the Engineer.

No concrete shall be placed in any superstructure or thin section under cold weather conditions without written permission of the Engineer.

(2) Heating of Materials. The heating equipment shall be capable of heating the materials uniformly. Aggregates shall not be heated over 66 °C (150 °F). If

water is heated in excess of 66 °C (150 °F), the water shall be mixed with the aggregate before the cement 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 placing. Materials containing frost or frozen lumps shall not be used. Stockpiled aggregates may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over 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; ice, snow, and frost shall be completely removed from the forms.

Concrete shall not be placed on a subgrade that is frozen or on one that contains frozen materials. The frozen subgrade shall be completely thawed the day previous to the placing of the concrete and shall be kept continuously thawed until the concrete is poured.

(5) Housing. The Contractor shall furnish sufficient canvas and framework or other suitable type of housing to enclose and protect the structure. The sidewalls of the housing for protecting abutments and piers shall be completely built before the placing of any concrete. They shall be constructed independent of the forms and bracing and with space large enough to provide for form removal and initial finishing of concrete as required during the heating period. Joists adequately spaced to prevent sagging shall support the top of the housing. The housing shall be completely built and the heat applied before placing any concrete.

Bridge decks, floor slabs, and roof slabs placed when the ambient air temperature is below 5 °C (40° F) shall be protected by a housing which also encloses the space beneath and which extends approximately 300 mm (12 inches) outside the edge of the floor. Alternatively, the deck may be insulated in accordance with part (b)(8)b. below.

When the temperature readings taken on or in the concrete indicate the temperature of the concrete may fall below 10 °C (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 501.17. 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 10 °C (50 °F) for the designated curing period. During this time, the concrete shall be kept continuously wet to provide proper curing. 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 0.5 °C (1 °F) change per hour.

When dry heat is used, a means of maintaining atmospheric moisture shall be supplied. The Contractor shall maintain adequate fire protection and shall provide personnel to keep the heating units in continuous operation. When 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.

(7) Temperature Records. The Contractor shall provide an automatic temperature recorder to continuously record concrete curing temperatures for the entire curing period. Recording thermometers shall be capable of measuring and recording temperatures within the range of -20 to 100 °C (-4 to 212 °F) with maximum graduations of 5 °C (10 °F).

Temperature sensors shall be carefully placed within the curing enclosure or the concrete to ensure that temperatures are measured at typical locations. Recorder accuracy shall be certified once every 12 months, and the certificate displayed with each recorder. The Engineer may make random checks of each recorder. On each recorder chart, the Engineer shall indicate the location of the representative concrete, date of placement, and time of start and finish of the record. At the completion of the curing period, the recorder charts shall be given to the Engineer.

When the Contractor places concrete at more than one location within the specified curing period, additional recorders shall be furnished to provide temperature records at each location.

In addition to concrete curing temperatures, a permanent daily record of ambient air temperatures shall be maintained. Thermometer readings shall be taken twice daily and data recorded showing the date, hour, location of each reading, and any conditions that might have an effect on the temperature.

(8) Insulated Forms.

a. General. When authorized by the Engineer, the concrete forms shall be completely covered with an approved insulating material.

To prevent loss of heat, immediately upon completion of concrete placement, all exposed surfaces shall be covered with a double thickness of burlap or cotton mats. This covering will be designed to prevent loss of moisture from the concrete and then covered with sufficient hay, straw, or insulated mats to prevent loss of heat from the concrete during the curing period. Tarpaulins shall be used as additional cover when directed.

To prevent excessive heat build up, provisions shall be made for loosening of insulation to provide ventilation and the subsequent cooling of the concrete if the surface temperature of the concrete approaches 38 °C (100 °F). In no case shall this temperature drop below 10 °C (50 °F) during the curing period.

The following table shall be used as a guide in determining the outside temperature at which concrete walls, piers, abutments, or floor slabs above ground shall be protected with blanket insulation.

TABLE 501.07A
MINIMUM AIR TEMPERATURE ALLOWABLE
FOR ALL CLASSES OF CONCRETE

| Concrete Thickness | | Insulation Rating of R-4 | | Insulation Rating of R-8 | |
|---|---|---|---|---|---|
| mm | in. | °C | °F | °C | °F |
| 150 | 6 | 5 | 40 | -2 | 29 |
| 300 | 12 | -2 | 28 | -18 | 0 |
| 450 | 18 | -11 | 13 | -34 | -29 |
| 600 | 24 | -18 | 0 | -48 | -55 |
| 900 | 36 | -33 | -27 | --- | --- |
| 1200 | 48 | -40 | -40 | --- | --- |
| 1500 | 60 | -40 | -40 | --- | --- |

b. Bridge Decks, Floor Slabs, and Roof Slabs. Immediately upon completion of the finishing, the surface shall be protected as specified under part (b)(5) above. When approved in writing by the Engineer, the Contractor may insulate the top and bottom of the slab as specified in Table 501.07A instead of constructing a heated housing. This insulating material shall be installed immediately upon the completion of finishing in such a way that the fresh concrete surface is not marred.

501.08 THIS SUBSECTION RESERVED

501.09 FORMS. If required by the Engineer, falsework and form work plans shall be submitted by the Contractor for approval before being used. In all cases, the Contractor shall be responsible for, and shall make good, any injury arising from inadequate forms. The Engineer shall inspect and approve all forms prior to concrete placement. Unless the Plans specifically call 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 in the construction of substructure elements in locations where the Engineer agrees that removable formwork is impossible to use.

(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 take up any slight settlement 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 incident to the construction operations including vibration. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. Sealer/caulking as approved by the Engineer shall be used where forms abut structural steel members, such as top flanges of beams and girders, etc.

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 to ensure easy removal.

Falsework and forms for slabs, beams, and girders shall be constructed to provide camber shown on the Plans or ordered by the Engineer.

(c) Form Lumber. All face form lumber for exposed surfaces shall be concrete form exterior grade plywood, not less than five ply and not less than 19 mm (3/4 inch) in thickness. In computing stud spacing, plywood shall be considered 25 mm (1 inch) lumber provided that the grain of three of the plys runs perpendicular to the studs.

Form lumber for unexposed surfaces may be dressed tongue and groove, dressed shiplap, or square edge sized four sides of uniform width and thickness. It shall have a minimum thickness, after finishing, of 19 mm (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 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 material may be used with permission of the Engineer.

(d) Studs. Studs shall have a minimum nominal size of 50 by 150 mm (2 × 6 inches), except that 50 by 100 mm (2 × 4 inch) nominal size studs may be used for pours not exceeding 1.1 m (3 1/2 feet) in height. Studs shall be spaced center to center not more than 16 times the actual thickness of the form lumber.

Studs shall be capped at the top with a plate of not less than 50 by 150 mm (2 × 6 inches) nominal size, carefully selected as to straightness. All joints in plates shall be scabbed 1.2 m (4 feet) each way to provide continuity.

(e) Wales. All wales shall be at least 100 by 150 mm nominal size (4 × 6 inches, minimum section) or equivalent and shall be scabbed at least 1.2 m (4 feet) each side of joints to provide continuity. A row of wales shall be placed within 150 mm (6 inches) of the bottom of each pour unless studding can be extended below the bottom of the pour and secured by wales fastened to ties in the previous pour. Wales shall have a maximum spacing of 900 mm (36 inches).

(f) Form Ties. Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 25 mm (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.

The cavities shall be filled with cement mortar in accordance with Subsection 501.16.

(g) Walls. Where the bottom of the form is inaccessible, the lower form boards shall be left loose or other provisions made so that extraneous material may be removed from the form immediately before placing the concrete.

(h) 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.

(i) Metal Forms. The specifications for forms regarding design, mortar tightness, filleted 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. 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.

(j) Removal of Forms. The forms, or their supports, for any portion of a structure shall not be removed without the approval of the Engineer. Forms under arches, beams, floor slabs, pier caps, or special designs may be removed upon approval of the Engineer after the concrete attains 85 percent of the minimum compressive strength as specified in Table 501.03A.

If field operations are not controlled by beam or cylinder tests, the following periods for removal of forms and supports, exclusive of days when the ambient air temperature is below 5 °C (40 °F), may be used as a guide:

| | |
|---|---|
| Arch Center | 14 Days |
| Centering under Beams | 14 Days |
| Supports under Flat Slabs | 14 Days |
| Floor Slabs | 14 Days |
| Vertical Wall Surfaces | 24 Hours |
| Columns | 24 Hours |
| Sides of Beams | 12 Hours |
| Top Slabs R.C. Box Culverts | 14 Days |

If high early strength is obtained with Type III cement or by the use of additional cement, these periods may be reduced as directed by the Engineer.

When field operations are controlled by strength tests, the removal of forms and supports may begin when the concrete is found to have the required strength. In no case shall the number of curing days be less than specified in Table 501.17A.

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. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own dead load.

501.10 PLACING CONCRETE.

(a) Workforce. The Contractor shall have sufficient skilled personnel at all times 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 such time as the Contractor has remedied this condition.

(b) 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 concreting operation.

Concrete shall not be placed under adverse environmental conditions that the Engineer determines will interfere with acceptable placement and/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.

When transit mix is used, 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.

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 must 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.

For simple spans, concrete should be deposited by beginning at the lower end of the span and working toward the upper end. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers. For continuous spans, where required by design considerations,

the concrete placing sequence shall be shown on the Plans or in the Special Provisions.

Concrete shall not be deposited in the forms more than 2 m (6 feet) from its final position.

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 slabs, decks, girders, or ribs of arches 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 450 mm (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 compacted in a manner that will eliminate any line of separation between the layers. When it is necessary, by reason of 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 placing any strain on the ends of projecting reinforcing bars.

(c) Placement of Overlays. Unless otherwise shown on the Plans, existing expansion joints and dams shall be maintained through the overlay. A bulkhead equal in width to that of the joint shall be installed to the required grade and profile prior to placing the overlay material. Expansion dam treatment shall be as shown on the Plans.

Screed rails shall be placed and fastened in position to ensure finishing the new surface to the required profile. Supporting rails shall be anchored in such a manner as to provide horizontal and vertical stability. Screed rails shall not be placed so as to create a recess in the overlay surface and shall not be treated with form oil.

A construction dam or bulkhead shall be installed in case of major delay in placement. During minor delays of one hour or less, the end of the placement shall be protected from drying with several layers of wet burlap.

For a period of at least one hour 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 so as to coat the horizontal and vertical surfaces to be covered. The rate of progress shall be controlled so as to prevent the drying of previously deposited material.

(d) Use of Chutes. Chutes, troughs, and pipes used in placing concrete shall be arranged so as 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 of metal or 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 1.5 m (5 feet) or depositing a large quantity at any point and running or working it along the forms will not be permitted.

(e) 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 as a means to cause concrete to flow or run into position instead 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 be used in concrete with reasonable care and shall not come in contact with structural steel, reinforcing steel, ties, forms, or partially set or hardened concrete at any time. Vibrators used in concrete with epoxy coated reinforcing steel 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 by reason of 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 600 mm (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 20 $m^3$ (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 4500 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 50 mm (2 inch) slump over a radius of at least 450 mm (18 inches).

(f) Blasting Operation. All blasting operations within 60 m (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.

501.11 DEPOSITING CONCRETE UNDER WATER.

(a) General. Concrete shall not be deposited under water except upon approval of the Engineer and shall be subject to the following modifications:

(1) After the standard concrete mix has been designed, the cement shall be increased by 56 kg/$m^3$ (94 pounds per cubic yard) in all classes of concrete and no additional compensation will be allowed for the extra cement used.

(2) The slump shall be within the range of 125 to 180 mm (5 to 7 inches) as determined by the Engineer.

(b) Use of Seal. When shown on the Plans or when conditions are encountered that render dewatering of the foundation impractical prior to the placing of the concrete, a concrete seal shall be placed entirely below the bottom of the footing. Unless otherwise shown on the Plans, a seal shall not be used without written permission of the Engineer and then shall be used at the Contractor's expense.

(c) Placement. Concrete deposited under water shall be carefully placed in still water by use of a tremie hopper and tube, and shall not be disturbed after being deposited.

In no case shall vibrators be used for underwater concrete where their use will incorporate free water into the mix.

The placement shall be continuous to the elevations shown on the Plans and the resulting concrete seal shall be monolithic and homogeneous.

Concrete shall not be deposited in water having a temperature of 2 °C (35 °F) or below. When the water temperature is between 2 and 5 °C (35 and 40 °F), the mixing water, the aggregates, or both shall be heated and placed as specified in Subsection 501.07(b).

A tremie shall consist of a watertight tube with a diameter of not less than 250 mm (10 inches). The tremie hopper shall have a capacity of at least 0.4 $m^3$ (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.

The discharge tubes for tremies shall be equipped with a device that will prevent water from entering the tube while charging the tube with concrete. Such tubes shall be supported to permit free movement of the tubes over the entire work surface and to permit rapid lowering, when necessary to retard or stop the flow of concrete from the tube.

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 will 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.

(d) Dewatering of Cofferdam. Dewatering of the cofferdam shall not be done until at least four full calendar days after placement of the seal and not before the concrete has attained sufficient strength to withstand the hydrostatic pressure.

501.12 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.

501.13 CONSTRUCTION JOINTS.

(a) Location of Construction Joints. 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 and joints shall be so formed with inset form work that each layer of concrete will have a thickness of not less than 150 mm (6 inches).

(b) Joining Fresh Concrete to Previously Set Concrete. In joining fresh concrete to concrete that has hardened, the surface shall be roughened in such a manner that will not leave loosened particles or damaged concrete at the surface and 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 or neat cement grout and all forms drawn tight against the face of the concrete. The neat cement mortar or bonding agent shall not be allowed to dry out before being covered with fresh concrete.

(c) Keys. Suitable keys shall be formed at construction joints. Unless otherwise directed by the Engineer, these keys shall be of the type and detail shown on the Plans.

(d) Filled Construction Joints. Filled construction joints shall contain a preformed cork joint filler or other preformed joint filler that may be shown in the Contract Documents. 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 preformed joint filler) that can easily be removed prior to placement of the above indicated filler.

(e) Water Stops. Approved water stops shall be placed at locations shown on the Plans. They shall form continuous watertight joints.

(f) Bond Breakers. Bond breakers shall be one of the following materials as shown on the Plans: asphalt-treated felt, pipe insulation, or tar emulsion.

501.14 EXPANSION JOINTS. All 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 preformed self-expanding cork joint filler or other preformed joint filler that may be shown in the Contract Documents. 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 so shown on the Plans or ordered by the Engineer.

501.15 PATCHING. Patching of existing concrete shall be accomplished with the type of material shown on the Plans. Type IV mortar shall be used where a non-shrink or expansive mortar is shown on the Plans. Patching of new concrete shall be as specified in Subsection 501.16(a)(1).

501.16 CONCRETE FINISHING.

(a) General. Unless otherwise specified, the surface of the concrete shall be finished immediately after form removal.

All concrete surfaces shall be given a dressed finish. If further finishing is required, exposed surfaces shall be given a rubbed finish. Other finish classes may be shown on the Plans for designated surfaces.

(1) Dressed Finish. The dressed finish work shall begin within 12 hours after removal of forms and shall continue until completed. 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 defects shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a mortar composed of the same type of cement and fine aggregate and mixed in the same proportions used in the grade of the concrete being finished. Mortar used in pointing shall be not more than one hour old. The mortar patches shall be cured a minimum of 72 hours in accordance with Subsection 501.17. 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.

All surfaces that cannot be repaired to the satisfaction of the Engineer shall be "rubbed" as specified for a Rubbed Finish.

(2) Rubbed Finish. After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of the same type of cement and fine sand mixed in proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place.

After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color.

After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder, and objectionable marks.

(3) 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 made uniform by longitudinal or transverse floating.

When the concrete has hardened sufficiently, the surface shall be given a broom finish, burlap drag finish, or left smooth as determined by the Engineer.

(4) Finishing Silica Fume Concrete. The finishing characteristics of silica fume concrete are different from portland cement concrete. The rate of addition of silica fume when specified will essentially eliminate bleeding.

Plastic shrinkage cracking may be a problem and should be guarded against by fogging the newly placed concrete both before and during finishing as directed by the Engineer.

Minor fogging or mist spraying of water into the atmosphere (high above the concrete surface) shall be used to keep the concrete moist between finishing operations. Accumulation of water droplets or standing water on the concrete surface will not be permitted during finishing operations. Fogging shall be continued until curing in accordance with Subsection 501.17 has begun.

The Contractor shall submit for approval the proposed method of fogging or mist spray at the same time the proposed silica fume concrete mix design is submitted.

(b) Finishing Bridge Deck.

(1) General. At least one week prior to placing any bridge deck concrete, the Contractor shall review the proposed procedure and details for placing deck concrete with the Engineer. The procedure shall provide for adequate labor, equipment, and material supply to complete placement of concrete on the entire deck or specified portion thereof within an eight-hour period. If, during the placement, unforeseen circumstances make placement within the eight-hour period impossible, the Contractor shall be prepared to place a bulkhead, as directed by the Engineer, to limit the placement to eight hours.

A finishing machine shall be provided on all decks constructed with Class LW concrete regardless of length.

Approval of the method and equipment will not relieve the Contractor of full responsibility for obtaining the required surface finish.

Finishing shall continue until such time as there remains no deviation greater than 3 mm (1/8 inch) when tested for trueness with a metal straightedge at least 3 m (10 feet) in length. The Contractor shall furnish the straightedge. When a bituminous concrete surface is to be placed on a bridge deck, the deviation shall be not greater than 6 mm (1/4 inch). When a sheet membrane is being applied, sharp ridges shall not be allowed. All costs of providing a straightedge to test the trueness of the concrete finishing shall be included in the Contract unit prices under Section 631.

After finishing has been completed and as soon as all excess moisture has disappeared, the bridge deck shall be textured to a uniform gritty surface using a burlap, felt, or other drag satisfactory to the Engineer. Sidewalks and safety curbs shall receive their final finish with a fine bristled broom.

If the bridge deck concrete does not meet the above smoothness requirements, the Contractor shall remove high spots up to 13 mm (1/2 inch) high by means of grinding. Any other corrections shall be made only with the written approval of the Chief 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 Chief Engineer shall be removed and replaced at the Contractor's expense.

(2) Overall Length of Bridge Over 18 m (60 feet). Bridge floors over 18 m (60 feet) in length shall be struck off and finished by an approved self-propelled finishing machine. This machine will be supported on suitable rails and equipped with adjustable strike-off or finishing screeds capable of producing the required finish surface for the full width of the bridge from face to face

of curbs. Machines shall be kept in true adjustment. Machines shall not be used until 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 measured, and the controlling dimensions of slab reinforcement and forms checked.

After the concrete has been placed, it shall be struck off by a self-propelled finishing machine and the operation 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.

The Contractor shall furnish a work bridge or bridges of an approved type, capable of spanning the entire width of the deck, supported on the finishing machine rails, and supporting at least a 2.2 kN (500 pound) load without deflection to the concrete slab surface.

(3) Overall Length of Bridge 18 m (60 feet) and Less. Screed rails shall be rigidly set to grade and supported sufficiently on adjustable chairs so as to allow no deflection in the rails under operating conditions. Screed guides or chairs shall be supported on structural members where possible. 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.

The Contractor shall furnish a minimum of one work bridge of an approved type, capable of spanning the entire width of the deck and supporting at least a 2.2 kN (500 pound) load without deflection to the concrete slab surface.

After the concrete is placed, it shall be struck off by one of the following methods:

a. A self-propelled concrete finishing machine used as specified in part (b)(2) above for concrete finishing on bridges longer than 18 m (60 feet);

b. A straight steel roller with a minimum diameter of 100 mm (4 inches), at least 300 mm (12 inches) longer than the distance between screed strips, and equipped with handles at each end, which shall be rolled back and forth until the surface is smooth and even with all holes filled;

c. An approved mechanical vibrating screed exerting a force of not less than 175 N/m (12 pounds per foot), the vibrations of which shall be of not less than 6500 vibrations per minute when checked by a vibration reed-type tester, uniform throughout its entire length and adjusted so as not to drive the aggregate more than 6 mm (1/4 inch) below the surface; or

d. An approved wood, metal shod template fitted with handles. If satisfactory results are not obtained with the type of screed selected, the Engineer may direct the use of another type of screed.

After the preliminary screeding, floats shall be operated with a combined longitudinal and transverse motion, planing off the high areas and floating the material removed into the low areas. Each pass shall lap the previous pass by 50 percent of the length of the float.

501.17 CURING CONCRETE.

(a) General. Water for use in curing concrete shall conform to the provisions of Subsection 745.01.

Effective cure time shall be only the time that the concrete has been maintained in a wet condition with the concrete surface temperature above 10 °C (50 °F).

Regardless of the curing medium specified and before any premature drying has set in, 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 atomized flow shall be applied continuously until the exposed surface is sufficiently hard so that it can be covered by the specified curing mediums. 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.

TABLE 501.17A
CURING OF CONCRETE COMPONENTS

| Type of Construction | Curing Methods | Curing Period Days |
|---|---|---|
| Substructure | 501.17(b)(1), (2), (3), (5), & (7) | 7 |
| Superstructure | 501.17(b)(1), (2), (5), & (7) | 10 |
| Retaining Walls | 501.17(b)(1), (2), (5), & (6) | 7 |
| Headwalls | 501.17(b)(1), (2), (5), & (6) | 7 |
| Sidewalks, Curbs, and Gutters | 501.17(b)(1), (2), (3), (5), (6), & (7) | 7 |

If high early strength (Type III) portland cement is permitted and used, the curing period may be reduced as directed by the Engineer.

(b) Methods of Curing. 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 by continuously sprinkling or flooding of all exposed surfaces 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. The burlap shall be soaked with water and kept wet for the entire curing period.

(3) Sand Cover. The entire exposed surface of the concrete shall be covered with at least 75 mm (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 concrete cure, then white polyethlyene 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 450 mm (18 inches).

(6) Membrane Forming Curing Compound. White pigmented or fugitive dye membrane curing solution may be used for curing concrete in minor drainage structures. All other use of curing compound shall be approved in writing by the Engineer. 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 on the concrete surface so as to result in a uniform coverage of the surface area at the rate of 275 $mL/m^2$ (1 gallon for each 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 result in a streaked or blotchy appearance, the method shall be stopped and water curing applied.

Only curing compounds approved by the Agency's Materials and Research Section may be used.

(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 part (b)(4) above. The airtight condition shall be obtained by the addition of a uniform sand cover at a minimum depth of 50 mm (2 inches).

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 costs to the Agency.

501.18 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 until the concrete has been cured in accordance with Table 501.17A, and until the field cured test cylinders have attained 85 percent 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 12.4 MPa (1800 pounds per square inch) 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 percent of the compressive strength specified by Table 501.03A, and provided curing of the supporting section is maintained in accordance with Table 501.17A.

(b) Superstructure. Static loads, such as forms, granite curbing, cast-in-place concrete curb, and other materials necessary for deck construction, may be placed on deck concrete as long as the field cured test cylinders for this concrete have attained 85 percent of the compressive strength specified in Table 501.03A, the proper curing is maintained, and the materials are spread out uniformly to avoid point loading.

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 have attained 85 percent of the compressive strength specified in Table 501.03A.

(c) Vertical Joint. Concrete shall not be placed against a vertical construction joint until the previously placed concrete has been in place a minimum of 72 hours.

The Contractor must not allow loads that are in excess of the legal loads permitted by the laws of the State to travel over the completed structure, except with written permission of the Engineer.

501.19 METHOD OF MEASUREMENT. The quantity of Concrete, Class AA, A, B, C, D, or LW, or Concrete, Silica Fume to be measured for payment will be the number of cubic meters (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. 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 38 mm (1 1/2 inches) or less in depth, or any pipe less than 200 mm (8 inches) in diameter.

The quantity of Mortar, Type I or Type IV to be measured for payment will be the number of cubic meters (cubic yards) of the type of mortar specified in the complete and accepted work. The number of cubic meters (cubic yards) will be based on sack count of cement used. One cubic meter (1 cubic yard) of Type I or Type IV mortar is considered equivalent to 950 kg (1600 pounds) of portland cement.

501.20 BASIS OF PAYMENT. The accepted quantities of the Contract items specified will be paid for at the Contract unit prices. Payment will be full compensation for performing the work specified, including satisfactory finishing and curing, and for furnishing all forms, materials including joint filler and bond breaker, labor, tools, admixtures, equipment, 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 Section 501.

The costs of providing automatic temperature recording units to monitor concrete curing temperatures as required under Subsection 501.07(b)(7) will be paid for under the Contract item Testing Equipment - Concrete.

When, in accordance with Subsection 501.11(b), the Engineer orders the construction of a concrete foundation seal not shown on the Plans, the volume of concrete in the complete and accepted seal will be paid for at the Contract unit price per cubic meter (cubic yard) for Concrete, Class B. Payment will include any additives in the approved design mix and any special equipment required for placing the concrete.

The cost of furnishing testing facilities and supplies at the batch plant and the setting of inserts, bench marks, and bridge plaques furnished by the Agency will not be paid for separately but will be considered incidental to the Contract unit price of structural concrete.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 501.21 Concrete, Class AA | Cubic Meter (Cubic Yard) |
| 501.22 Concrete, Class A | Cubic Meter (Cubic Yard) |
| 501.25 Concrete, Class B | Cubic Meter (Cubic Yard) |
| 501.30 Concrete, Class C | Cubic Meter (Cubic Yard) |
| 501.31 Concrete, Class D | Cubic Meter (Cubic Yard) |
| 501.40 Concrete, Class LW | Cubic Meter (Cubic Yard) |
| 501.55 Mortar, Type I | Cubic Meter (Cubic Yard) |
| 501.58 Mortar, Type IV | Cubic Meter (Cubic Yard) |
| 501.60 Concrete, Silica Fume | Cubic Meter (Cubic Yard) |

## SECTION 502 - SHORING SUPERSTRUCTURES

502.01 DESCRIPTION. This work shall consist of furnishing the necessary shoring, vertically jacking any structure to a position immediately above its present location, holding it in position during any construction process, lowering it to it's supports, removing all shoring or falsework, and cleaning up of the site.

502.02 CONSTRUCTION DRAWINGS. Details and calculations for shoring and jacking shall be prepared by a Professional Engineer (Structural or Civil). The Contractor shall submit the calculations and details to the Resident Engineer, for information only, at least two weeks prior to performing the work. The design and details shall be signed, stamped, and dated by the Professional Engineer.

502.03 CONSTRUCTION DETAILS. The structure shall be raised by jacking to the specified elevation, blocked, and jacks released. After the new foundation or supports have been constructed, the structure shall be jacked free, the blocking removed and the structure lowered onto it's newly constructed supports. The shoring bents or falsework shall then be removed and the site cleaned up.

The Contractor shall be responsible for the strength, capacity, and performance of the construction method(s) employed.

502.04 METHOD OF MEASUREMENT. The quantity of Shoring Superstructure to be measured for payment will be on a lump sum basis for each site in the complete and accepted work specified in the Contract or ordered by the Engineer.

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 in accordance with the Contract or ordered by the Engineer.

502.05 BASIS OF PAYMENT. The accepted quantity of Shoring Superstructure will be paid for at the Contract lump sum price. Payment will be full compensation for 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.

When the structure has been jacked and blocked onto it's temporary position, a payment of 75 percent of the Contract unit price will be allowed. The remaining 25 percent will be paid when all shoring or falsework has been removed and the site cleaned up.

The accepted quantity of Shoring Superstructure Bearings will be paid for at the Contract unit price for each. Payment will be full compensation for 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.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 502.10 Shoring Superstructure | Lump Sum |
| 502.11 Shoring Superstructure Bearings | Each |

## SECTION 503 - PREPARING SUBSURFACE FOR DRIVING PILING

503.01 DESCRIPTION. This work shall consist of loosening the foundation materials that may be encountered in designated areas to permit the driving of piles.

503.02 CONSTRUCTION REQUIREMENTS. The areas designated in the Contract or ordered by the Engineer shall be prepared for the driving of piles by shattering and breaking up subsurface material within the specified limits. This will be done by drilling and blasting or other approved means, in a manner that will permit piles to be driven to the limits specified.

503.03 METHOD OF MEASUREMENT. The quantity of Preparing Subsurface for Driving Piling to be measured for payment will be on a lump sum basis for each substructure location in the complete and accepted work specified in the Contract or directed by the Engineer.

503.04 BASIS OF PAYMENT. The accepted quantity of Preparing Subsurface for Driving Piling will be paid for at the Contract lump sum price. Payment will be full compensation for performing the work specified and for furnishing of all labor, tools, equipment, materials, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 503.10 Preparing Subsurface for Driving Piling | 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. Prior to beginning test pile or production pile driving, the Contractor shall obtain approval for the pile driving equipment. During the pile driving operations, no changes to the approved equipment will be permitted without the Engineer's permission. The Contractor shall obtain from the Engineer a copy of the PILE AND DRIVING EQUIPMENT DATA FORM. The Contractor shall complete this form in every detail and shall submit copies to the geotechnical consultant employed by the Contractor, (when load tests are required) and 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 approval, specifications, and applicable information to verify the capacity and capability of the proposed hammer.

(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 ultimate capacity 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; 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 percent 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 and 15 blows per 25 mm (1 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 must 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 when beginning pile driving at each substructure unit or after each 100 hours of pile driving, whichever is less. Hammer cushions shall be replaced when worn to 75 percent of their original thickness.

(e) 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. The type and size of the equipment for driving piling shall be approved 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, and demobilizing equipment from the project including the erecting, dismantling, and all incidentals necessary to complete the work.

When the equipment for driving piles has been set up and driving operations have started, a payment of 50 percent of the Contract unit price will be allowed. The remaining 50 percent will be paid when pile-driving operations are complete and the equipment has been removed from the site.

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, with the exception of the costs specified in this Subsection, will be considered as being included in the Contract unit price(s) for the type(s) of piles being driven.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 504.10 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 loading tests.

505.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Bar Reinforcement | 713.01 |
| Steel Piling | 730.01 |
| Steel Sheet Piling | 730.02 |

Receipt of approved mill test reports and verification that they correspond to the heat or lot numbers marked on the piles is required before the piles are driven.

505.03 FURNISHING OF PILING.

(a) General. 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 6 m (20 feet) in length shall be furnished in one unwelded piece.

Steel piling over 6 m (20 feet) in length shall be furnished with not more than the number of splices allowed by 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.

(d) Temporary Sheet Piling. When temporary sheet piling is shown on the Plans, the project quantities shall include an estimated quantity of temporary sheet piling. The temporary piling is estimated for specific locations. With the approval of the Engineer it may be used, and paid for, at other appropriate locations.

The length, type, classification, and necessary quantity of Temporary Sheet Piling at each location shall be calculated and detailed by a Professional Engineer (Structural or Civil). The Contractor shall submit the calculations and details to the Resident Engineer, for information only, at least two weeks prior to performing the work. The design and details shall be signed, stamped, and dated by the Professional Engineer.

505.04 DRIVING OF PILING.

(a) General. Piling other than sheet piling shall not be driven until the excavation has been made to the elevation shown for the bottom of the entire 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 induce upsetting of the metal in steel piles.

All piling shall be driven to the bearing value or the penetration shown on the Plans. Under no condition shall the bearing capacity be less than that shown on the Plans except upon written approval of the Engineer. Piling shall be driven with a hammer, or a combination of hammer with water jets or predrilled holes. The depth and size of predrilled holes shall be as shown on the Plans or as approved by the Engineer

When water jets are used, the number of jets and the volume and pressure of the water at the jet nozzle shall be sufficient to freely erode the material adjacent to the piling. A minimum of two 19 mm (3/4 inch) jets shall be used. The water pumping equipment shall have sufficient capacity to deliver at least 690 kPa (100 pounds per square inch) pressure to each jet nozzle. At least 1 m (3 feet) before the desired penetration is reached, the jetting shall be discontinued, and the piling shall be driven to final penetration in a manner satisfactory to the Engineer.

When the Contractor proposes to use a vibratory or sonic method for driving of 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 bearing capacity of one or more piles with an air, or diesel hammer. Verification of bearing capacity of sonic or vibratory driven piles shall be at the Contractor's expense.

The driving operation shall be continuous in the sequence determined by the Engineer and shall, in general, either start at the center of the foundation and proceed each way or start at the outside row and work progressively across the footing. Piling shall be driven in conformity with the requirements shown on the Plans or as ordered by the Engineer and shall be either vertical or battered as shown. Piling after driving shall not vary more than 20 mm/m (1/4 inch per foot) from the specified batter. Piles for trestle bents shall be so driven that the cap may be placed in its proper location without inducing excessive stresses in the piling. The tops of foundation piling after driving shall not vary from the position shown on the Plans by more than 150 mm (6 inches) and shall have a minimum of 150 mm (6 inches) of concrete encasement.

Piling shall not be driven within 35 m (115 feet) of any concrete footings or structures that have not cured for at least seven days or attained 85 percent of their designed compressive strength.

Piling that penetrates a very soft stratum overlying a hard stratum shall penetrate the hard material sufficiently to rigidly fix the ends. Piles pushed up by driving adjacent piles or by any other cause shall be redriven to the required bearing or penetration.

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 with a new and, if necessary, longer pile.

(2) Driving a second pile adjacent to the defective pile.

(3) Splicing the pile or extending the footing to properly enclose the pile.

(b) Pile Loading Tests. Pile loading tests, when required, shall be performed prior to driving any production piles. The test pile shall be driven in the vicinity of 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 the purpose of dynamic and/or static testing of the test pile(s). A list of approved geotechnical consultants may be obtained from the Agency's Materials and Research Section, telephone: (802) 828-2561.

The test pile may be used 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 (that is, location, batter, length, has not failed under test loading, is not damaged, etc.); and

(2) The test pile is driven within the footprint of the footings; and

(3) The test pile is used as a permanent pile at no additional cost to the Agency; and

(4) The use of the test pile as a permanent production pile is approved by the Engineer.

(c) Determination of Bearing Values. Bearing values shall be determined by dynamic loading tests, static loading tests, wave equation analysis, or a combination thereof as follows:

(1) Bearing Capacity by Static Load Test. Static pile load tests shall be performed by the procedures set forth in ASTM D 1143, using the quick load test method, except that the test shall be taken to plunging failure or the capacity of the loading system. Testing equipment and measuring systems shall conform to ASTM D 1143 with the following exceptions:

a. The loading system shall be capable of applying 200 percent of the ultimate pile capacity.

b. The jack, load cell, and reaction system shall be capable of withstanding 200 percent of the ultimate pile capacity shown on the Plans. The load cell shall have been calibrated within the previous six months.

The load shall be applied to the pile through a hydraulic jack acting against a weighed platform or reaction pile system. The Contractor shall submit to the Engineer, for approval, detailed plans of the proposed loading apparatus prepared by a Professional Engineer. The apparatus shall be constructed to allow the various increments of the load to be placed gradually without causing vibration to the test pile.

The failure load for the pile shall be defined as follows:

For piles 610 mm (24 inches) or less in diameter or width, the failure load of a pile test under axial compressive load is that load which produces a settlement at failure of the pile head equal to:

$$SF = S + (3.81 + 0.008D) \quad \text{[Metric]}$$
$$SF = S + (0.15 + 0.008D) \quad \text{[English]}$$

where:

$SF$ = Settlement at failure in millimeters (inches)
$D$ = Pile diameter or width in millimeters (inches)
$S$ = Elastic deformation of total pile length in millimeters (inches)

The top elevation of the test pile shall be determined immediately after driving and again just before load testing to check for heave. Any pile that heaves more than 6 mm (0.25 inch) shall be redriven or jacked to the original elevation prior to testing. Unless otherwise specified in the Contract, a minimum three-day waiting period shall be observed between the driving of any anchor piles or the load test pile and commencement of the load test.

(2) Bearing Capacity by 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 determine the pile bearing capacity.

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 ASTM D 4945. The preliminary report shall be presented to the Engineer prior to the completion of static load tests, 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 the following factors:

| 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 25 mm (15 blows per inch). This refusal value may be adjusted by the Engineer according to the results of pile dynamic monitoring of the test piles.

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 restriking of the test piles. Both dynamic and static 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 ASTM D 4945 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 1 m (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.

Test piles shall be driven to an acceptable penetration resistance as determined by the Engineer. 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 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 1.2 by 1.2 m (4 × 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, 10 A, 115 V AC with 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 restriking of the test piles. The stresses in the piles shall be monitored to ensure that the driving stresses do not exceed 90 percent 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 in order 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 the appropriate size 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. Time required to ascend, complete the attachments, and 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.

Restriking of all test piles is required. The minimum time between the end of initial driving and restriking shall be 48 hours. Prior to restriking 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. Restrike shall consist of either 50 mm (2 inches) of penetration or 30 hammer blows, whichever occurs first.

(3) Bearing Capacity by Wave Equation Analysis. When load tests are not specified, the Engineer will determine the ultimate capacity based on the Agency's wave equation analysis.

(d) Steel Sheet Piling. Permanent sheet piling shall be left in place as part of the finished structure. Temporary sheet piling shall not become a part of the finished structure but shall be removed after it has served its purpose in the construction.

(e) Steel Piling. Unless otherwise specified, the driving point of all 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 ledge. Point reinforcement details shall conform to the Contract requirements and shall be approved by the Engineer. Requirements for commercially fabricated weldments are:

(1) Fabrication drawings and welding procedures shall be submitted to the Structures Engineer for approval in accordance with the requirements in Subsection 105.03.

(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.

(3) One extra pile point of each type and size supplied shall be furnished by the Contractor for destructive testing.

(4) The Engineer reserves the right to order cast steel points if any fabricated weldment fails by test or performance.

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 percent of the pile flange thickness but in no case less than 8 mm (5/16 inch).

The minimum thickness of the cutting edge of the point, shall be 25 mm (1 inch) or 150 percent of the flange thickness of the pile, whichever is greater.

When the Contract requires the piles to be driven to point bearing on ledge, the ledge 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.

Splices will be allowed as shown in the following table:

TABLE 505.05A
ALLOWABLE SPLICES

| Length of Steel Piling | | Maximum Number of Splices Allowed |
|---|---|---|
| meters | feet | |
| Over 6 to and including 18 | Over 20 to and including 60 | 1 |
| Over 18 to and including 37 | Over 60 to and including 120 | 3 |
| Over 37 to and including 55 | Over 120 to and including 180 | 5 |

All piles to be spliced shall be cut square and even, and the flanges shall be beveled in accordance with an approved welding procedure. 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.

(b) Splices for Steel Sheet Piling. Splicing 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 elevation 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 will be the total number of meters (linear feet) for each pile driven, accepted, and left in place, measured to the nearest meter (linear foot). Preboring, jetting, or other methods used to facilitate pile driving will not be measured.

(2) Steel sheet piling will be the total number of square meters (square feet) of Permanent Steel Sheet Piling driven, accepted, and left in place after cut-off;

or the total number of square meters (square feet) of Temporary Steel Sheet Piling driven, as shown on the Plans or directed by the Engineer, and retracted after use. Preboring, jetting, or other methods used to facilitate driving will not be measured.

(b) Pile Loading Tests. 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 of the size specified will be paid for at the Contract unit price per meter (linear foot).

(b) Steel Sheet Piling of the type specified will be paid for at the Contract unit price per square meter (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 be full compensation for furnishing, transporting, handling, and driving the test pile, complete with tip, end plate, or stinger plate as required; for providing, cooperating with, and assisting the geotechnical consultant in the performance of dynamic testing; for providing dynamic testing equipment; for restriking the test pile; for cutting off the test pile at the elevation directed by the Engineer when a static load test is not also to be performed on the test pile; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Static Pile Load Test will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, transporting, handling, and driving the test pile and test equipment, including hydraulic jacks and loading apparatus; for providing, cooperating with, and assisting the geotechnical consultant during testing; for providing the settlement measuring devices, load cells, etc., required to perform the static pile load test as detailed in Subsection 505.04(b); for cutting off the test pile at the elevation directed by the Engineer; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The length of pile driven as a test pile will not be paid for as any Steel Piling item, and is specifically included in the materials and cost included in the price bid for the Pile Loading Test item(s) in the Contract.

Preboring, jetting, or other methods used to facilitate the driving of piling will not be paid for separately but will be considered incidental to the Contract item for the piling being driven.

When the Contract does not contain a quantity for the furnishing of pile driving equipment, this work will not be paid for directly but will be considered to be incidental to other Contract items.

Payment will be made under

| Pay Item | Pay Unit |
|---|---|
| 505.15 Steel Piling (HP 310 × 79) [Steel Piling (HP 12 × 53)] | Meter (Linear Foot) |
| 505.16 Steel Piling (HP 310 × 110) [Steel Piling (HP 12 × 74)] | Meter (Linear Foot) |
| 505.17 Steel Piling (HP 360 × 108) [Steel Piling (HP 14 × 73)] | Meter (Linear Foot) |
| 505.18 Steel Piling (HP 360 × 132) [Steel Piling (HP 14 × 89)] | Meter (Linear Foot) |
| 505.19 Steel Piling (HP 360 × 152) [Steel Piling (HP 14 × 102)] | Meter (Linear Foot) |
| 505.20 Steel Piling (HP 360 × 174) [Steel Piling (HP 14 × 117)] | Meter (Linear Foot) |
| 505.35 Permanent Steel Sheet Piling | Square Meter (Square Foot) |
| 505.36 Temporary Steel Sheet Piling | Square Meter (Square Foot) |
| 505.40 Static Pile Loading Test | Each |
| 505.45 Dynamic Pile Loading Test | Each |

## SECTION 506 - STRUCTURAL STEEL

506.01 DESCRIPTION. This work shall consist of furnishing, erecting, and when specified, painting fabricated metal structures and structural components.

506.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Mortar, Type IV | 707.03 |
| Paint | 708.01 - 708.12 |
| General Requirements for Structural Steel | 714.01 |
| Structural Steel | 714.02 |
| High-Strength Low-Alloy Structural Steel | 714.03 |
| Carbon Steel Bolts and Nuts | 714.04 |
| High-Strength Bolts, Nuts, and Washers | 714.05 |
| Heat-Treated Structural Bolts | 714.06 |
| Anchor Bolts, Bearing Devices | 714.08 |
| Welded Stud Shear Connectors | 714.10 |
| Steel Tubing | 714.11 |
| Iron Castings | 715.01 |

Bronze Castings ..... 715.02
Preformed Fabric Bearing Pads ..... 731.01
Bearing Pads ..... 731.02

Unless otherwise specified in the Contract, all steel shall be unpainted high-strength low-alloy structural steel conforming to AASHTO M 270M/M 270, Grade 345W (Grade 50W). Galvanizing or metalizing shall be applied in accordance with Subsection 506.15.

All materials shall conform to the prescribed AASHTO or ASTM specifications, and no substitution will be allowed.

506.03 GENERAL FABRICATION REQUIREMENTS. Material furnished under Section 506 shall be fabricated and coated in the United States.

Except as modified below, fabrication shall be performed in accordance with AASHTO *Standard Specifications for Highway Bridges*, ANSI/AASHTO/AWS D1.5, hereinafter designated as AWS D1.5, and interim specifications in effect on the date of the Contract.

Prior to performing any work under this item, the fabricator must have received approval for all shop drawings, welding procedures and any special Contract requirements and notified the Structures Engineer at least seven days in advance of fabrication. The fabricator shall bear full responsibility and costs for all materials ordered or work performed, prior to approval of the shop drawings or written authorization from the Structures Engineer.

Structural steel furnished under this Section shall be fabricated in a plant having an AISC Category III Certification, or in a plant approved by the Agency prior to award of the Contract. Plants without certification shall have an organization, operation, and equipment capable of producing a product equal to a certified plant.

All plants, including those having AISC Category III Certification, must satisfy the following minimum requirements:

(a) Capability. The fabricator shall demonstrate full capability for fabricating material(s) meeting the requirements of the Contract.

(b) Reference Materials. The plant shall have a library containing current editions of the following publications:

(1) AWS A5.0, A5.5, A5.17, A5.20, A5.23, C2.18, D1.1, D1.2, D1.3, D1.4, and D1.5.

(2) AASHTO *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, Parts I and II.

(3) AISC Quality Criteria and Inspection Standards, A Guide to the Shop Painting of Structural Steel, Manual of Steel Construction, and Structural Steel Detailing.

(4) Vermont *Standard Specifications for Construction*.

(5) AASHTO *Standard Specifications for Highway Bridges*.

(6) AASHTO *Standard Specifications for Welding of Structural Steel Highway Bridges*.

(7) AREA specifications, when applicable.

(8) American Society for Nondestructive Testing (ASNT) SNT-TC-1A.

(9) SSPC *Steel Structures Painting Manual*, Volumes 1 and 2.

In addition to the above, access to applicable ASTM standards is required.

(c) Files. The fabricator shall maintain an organized file containing:

(1) Records of material purchased.

(2) Inventory of material in stock.

(3) Certification records of all material and welding supplies.

(d) Personnel. Fabrication personnel shall meet the following minimum requirements:

The fabricator's representative responsible for inspection, testing and quality matters shall be qualified and certified in accordance with the provisions of AWS QC 1, entitled *Standard for Qualification and Certification of Welding Inspectors*.

Welders shall be certified for each process and position of prequalified joints in the approved welding procedures, including tacking, in accordance with AWS D1.5 for all structural bridge items and ANSI/AWS D1.1, hereinafter designated as AWS D1.1, for items not covered in AWS D1.5.

(e) Material Fabrication and Storage.

(1) All fabrication shall be performed in an enclosed permanent structure, unless otherwise approved by the Agency.

To meet minimum requirements, a plant shall have the following:

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.

e. DC and AC manual shielded metal arc welding equipment capable of at least 500 A output.

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 and the requirements of Section 513.

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 600 mm (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 22 mm (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 include the following:

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:

Weld gauges, micrometer, dry and wet film paint gauge, 3 m (10 foot) steel tape, 30 m (100 foot) steel tape, 2 m (6 foot) straightedge, temperature and marking crayons, ambient air thermometer, a level at least 600 mm (2 feet) long, and a 600 mm (2 foot) carpenter's square.

The Agency reserves the right to reject inadequate facilities and require suitable alternatives.

(f) 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 the Contract.

506.04 DRAWINGS AND PROCEDURES.

(a) General. As soon as practical after award of the Contract, the fabricator shall prepare fabrication drawings in accordance with Subsection 105.03. Drawings, details, and welding procedures must be submitted as a complete package for each structure sufficiently in advance of fabrication to allow for review, resubmittals, and approval.

The Agency will review fabrication drawings, details, and procedures for their compliance with the Contract. 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 to make 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 shop drawings shall provide a material list on each sheet for tabulating the number of pieces, piece marks, description, dimensions, type of material, and mass (weight) of each piece. When the item pay unit is on a per kilogram (pound) basis, the mass (weight) of each piece shall be extended and summarized for each sheet as specified in the Method of Measurement subsections. Mass (weight) extensions shall be submitted to the Agency upon completion of fabrication.

All welds shown on the shop drawings shall identify, by symbol, the applicable procedure(s) and appropriate nondestructive testing requirements. A separate symbol must be used to identify each approved welding procedure. When more than one procedure is available, the fabricator may identify several procedures for any given weld.

(c) Welding Procedures. Detailed welding procedures shall be prepared in accordance with the provisions of the applicable AWS/ANSI/AASHTO code revisions and submitted in accordance with the following:

(1) Welding procedures for each structure shall be a separate package of consecutively numbered sheets. Each sheet of the set shall identify the project name, number, structure, and procedure qualification record.

(2) 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. The minimum heat input shall be 1.4 kJ/mm for material 10 to 19 mm (35 kilojoules per inch for material 3/8 to 3/4 inch) in thickness and 2.0 kJ/mm for material over 19 mm (50 kilojoules per inch for material over 3/4 inch) in thickness.

$$\text{Kilojoules per Millimeter} = \left( \frac{\text{Volts} \times \text{Amps} \times 0.06}{\text{Travel Speed in Millimeters per Minute}} \right) \quad \text{[Metric]}$$

$$\text{Kilojoules per Inch} = \left( \frac{\text{Volts} \times \text{Amps} \times 0.06}{\text{Travel Speed in Inches per Minute}} \right) \quad \text{[English]}$$

(3) Procedure specifications shall be presented in a format similar to Form E-1 of AWS D1.1, Appendix E, or Form E-2 of AWS D1.5, Appendix IV. Procedure qualification test records shall be presented in a format similar to Form E-2 of AWS D1.1, Appendix E, or Form E-1 of AWS D1.5, Appendix IV.

(4) Details of welded joints not prequalified under AWS D1.5, Section 2.6 shall be qualified.

(d) Revisions. Adjacent to or incorporated with the title box of each sheet shall be a revision record box including provision for: 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.

506.05 QUALITY ASSURANCE. Quality Assurance is inspection of fabrication by the Agency or the Agency's representative to verify compliance with these Specifications.

(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 Inspector is a representative of the Engineer and will perform all the duties assigned and delegated to the Engineer by Subsections 105.01, 105.10, and 105.12 as they pertain to the Contract with the exception of quantities of materials and payment thereof. The Inspector will witness, interpret, and accept or reject all testing.

The Inspector will have the authority to reject any material or work that does not conform to the Contract requirements. Inspection of the work will conform to the requirements of the applicable AWS/ANSI/AASHTO codes and specifications referenced in the Contract.

(c) Tools and Equipment. 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. 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 also responsible for 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. The fabricator's representative responsible for Quality Control shall be an AWS Certified Welding Inspector (CWI), qualified and certified in accordance with the provisions of AWS QC 1.

(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 inspector. Nondestructive tests shall be performed in accordance with AWS D1.5, Section 6.7.

Personnel performing and interpreting nondestructive tests (radiographic, magnetic particle, ultrasonic, and dye penetrant) shall be NDT certified for Level II qualification in accordance with the American Society for Nondestructive Testing, Recommended Practice Number 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.

506.07 MATERIAL IDENTIFICATION.

(a) Material Certifications. Certifications shall be prepared in accordance with Subsection 700.02. Prior to any fabrication, of material to be used in the work, the Contractor shall furnish the Agency's Inspector one copy of all Type C Certification material test reports. Any material not properly identified or lacking acceptable test information shall not be incorporated in the work. If no Quality Assurance Inspector is assigned or available when fabrication begins, it is the Contractor's responsibility to ensure that Contract requirements are complied with.

Prior to shipment of any material, a copy of all Type C Certification material test reports and all applicable Type A Certifications, both pertaining to the items to be shipped, shall be sent to the Vermont Agency of Transportation, Materials and Research Section, National Life Building, Montpelier, Vermont 05633-5001. Acceptable certifications received by the Agency are a pre-requisite to payment for any fabricated material.

(b) 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 3 mm (1/8 inch) and a maximum of 6 mm (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.

Primary stress carrying material (e.g., flanges, webs, splice plates, and lateral connection plates) shall be ordered and prepared so that the direction of rolling is parallel to the stress in the member. Pieces that are to be bent during fabrication shall in so far as practical, be prepared so the direction of rolling is normal to the axis of bending.

Members identified as “fracture critical” shall be subject to additional base metal requirements as set forth in Subsection 506.11.

Members or components of members designated in the Contract as requiring Charpy V-Notch (CVN) testing, or members subject to tensile or compressive stress as specified in Subsection 714.01 shall be identified as a main member and shall therefore be subject to the requirements of AWS D1.5, Section 6.7.

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 [e.g., AASHTO M 270M/M 270, Grade 345W (Grade 50W) or Grade 345 (Grade 50)] 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.

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 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. All design details, quality of work, procedures, and inspection of welding shall conform to the requirements of AWS D1.5 Bridge Welding Code. For welding items other than those covered in AWS D1.5, one of the following publications shall be adhered to:

ANSI/AWS D1.1 Structural Welding Code - Steel
ANSI/AWS D1.2 Structural Welding Code - Aluminum
ANSI/AWS D1.3 Structural Welding Code - Sheet Steel
ANSI/AWS D1.4 Structural Welding Code - Reinforcing Steel

Welding will not be permitted without approved welding procedures and shop 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, the fabricator shall:

(1) Submit the proposed repair procedure to the Inspector 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 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.

Fillet welds connecting cross frame member components, lateral bracing connection plates, cross frame connection plates, and bearing stiffeners shall be terminated a minimum of 6 mm (1/4 inch) or a maximum of 13 mm (1/2 inch) from the edge of a gusset plate, web, flange connecting member of connection plate. Fillet welds shall also be terminated within 25 mm (1 inch) of a beam or flange edge.

(b) Welding Processes. Shielded metal arc welding (SMAW) conforming to 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, Section 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 shall be used for all principal welds:

(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 process shall be limited to attaching connection plates to rolled beams, welding bearing assemblies, repairs, tack welding, joints under 600 mm (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 gas metal arc welding (GMAW) and flux cored arc welding (FCAW) processes will be limited to indoor shop welding of 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 8.0 km/h (5 miles per hour) shall be protected by the use of a draft barrier(s).

(c) Shop Welding. The fabricator shall maintain a file of the qualifications of all welders, welding operators, and tackers qualified in accordance with AWS D1.5, Section 5. Requalification may be required in accordance with AWS D1.5, Section 6. 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 have an AWS Certification designating them as qualified in the appropriate category for Structural Welding for the Agency.

Information regarding the Agency's qualification requirements for field welding is contained in the *Manual for Field Welding* that may be obtained from the Agency's Construction Section.

The axis of any weld used to attach miscellaneous construction fixtures to main members as defined in Subsection 714.01 shall be in the same direction as the primary stress in the member and shall be approved by the Engineer.

Welding performed in the field is subject to all applicable provisions within this specification. The shielded metal arc welding (SMAW) process is the only process approved for field welding.

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 must be obtained before the affected structural steel is fabricated.

(e) Process and Procedure Qualification.

(1) General. Welding processes and procedures requiring qualification shall be qualified in accordance with AWS D 1.5, Section 5.

Welding and testing of samples shall be witnessed by an Agency Inspector or an authorized representative of a testing agency that is AWS certified in accordance with the provisions of AWS QC 1.

Process and procedure qualification record tests shall be reported in a format similar to Form E-2 of AWS D1.1, Appendix E, or Form E-1 of AWS D1.5, Appendix IV.

Procedure specifications shall be reported in a format similar to Form E-1 of AWS D1.1, Appendix E, or Form E-2 of AWS D1.5, Appendix IV.

(2) Acceptance Requirements. The basis for acceptance shall conform to the requirements of AWS D1.5, Section 5. AWS D1.1, Section 5, as modified by AASHTO, shall be used only for those 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, Section 12.

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, Section 12.

506.12 ASSEMBLY.

(a) General. Steel structures shall be fabricated in accordance with Division II, Section 11 of the AASHTO *Standard Specifications for Highway Bridges*.

(b) Camber. Beams and girders shall be fabricated to the camber indicated on the approved shop drawings.

(c) Curved Girders. Welded girders with radii less than 230 m (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 be not less than 6 m (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.

(d) 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 610 °C (1125 °F). Artificial cooling will not be permitted until a member has cooled to 315 °C (600 °F). Under no conditions will water be permitted for cooling. Air may be used subject to the approval of the Inspector. Any member heated in excess of 650 °C (1200 °F) shall be rejected.

(e) Finish. All sharp corners and edges that are marred, cut, or roughened in handling shall be rounded to a 1.6 mm (1/16 inch) radius by grinding.

(f) Connections and Bolting. Where applicable the materials and fabrication procedure shall comply with the provisions of Subsection 506.19.

(g) Bearing Connections. Connections in bearings may require different tolerances of fit. Terms used to define the fit of connections are:

(1) Tight Fit (Welded Ends Only). Fifty percent of the projected bearing area shall be in contact within 0.5 mm (0.02 inch) with a permissible variation of 1.6 mm (1/16 inch) for the remaining 50 percent of projected area.

(2) Grind to Bear. Seventy-five percent of the projected area shall be in contact within 0.25 mm (0.01 inch) with a permissible variation of 0.8 mm (1/32 inch) for the remaining projected area.

(3) Mill to Bear. One hundred percent of the projected bearing area shall be in full contact.

(h) Intermediate Stiffeners. Where tight fit of intermediate stiffeners is specified, 50 percent of the projected bearing area shall be in contact within 0.5 mm (0.02 inch) with a permissible variation of 1.6 mm (1/16 inch) for the remaining 50 percent of the projected bearing area.

(i) 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 AASHTO M 160M/M 160.

The camber and sweep of fabricated rolled members shall be subject to the same dimensional tolerances specified for welded members in AWS D1.5, Section 3.5.

The metal bearing surface of any masonry bearing plate shall be flat, with a maximum permissible variation of 1 mm (0.04 inch) from a plane determined by any three of its corners.

There will be no permissible tolerance for overgrinding. Welded butt joints of flanges and other plates subject to tension stresses shall be finished so that the final thickness of the joint is not less than the thickness of the thinner adjacent plate. Welded butt joints subjected to only compressive stresses shall be finished so the final thickness of the joint is not less than the ordered thickness of the thinner plate.

506.14 SURFACE PREPARATION. All materials shall be blast cleaned to the grade specified as defined by the pictorial surface preparation standard SSPC-VIS 1.

Further preparation shall conform to the following:

(a) Surfaces to Remain Unpainted. Surfaces may be blast cleaned either before or after fabrication. The final surface appearance after fabrication shall be at least equivalent to preparation grade SSPC-SP10.

(b) Surfaces to be Galvanized or Metalized. Prior to galvanizing or metalizing, all corners and edges of steel plates, shapes, etc., shall be ground to a 1.6 mm (1/16 inch) radius.

(1) Galvanized. All material to be galvanized shall be cleaned to be at least equivalent to surface preparation grade SSPC-SP8.

(2) Metalized. All material to be metalized shall be cleaned in accordance with Subsection 506.15(b).

(c) Surfaces to be Painted. All material to be painted shall be cleaned in accordance with the applicable requirements in Section 513.

506.15 GALVANIZING OR METALIZING. Galvanizing or metalizing shall be performed in accordance with the following:

(a) Galvanizing. Surfaces to be galvanized shall be zinc coated in conformance with AASHTO M 111M/M 111 or, when applicable, AASHTO M 232M/M 232.

The fabricator is responsible for straightening to specification tolerances any weldments that may have been distorted through stress relieving during the hot dipping process.

(b) Metalizing. Surfaces to be metalized shall be prepared and coated in accordance with AWS C 2.18, entitled Guide for the Protection of Steel with Thermal Sprayed Coating of Aluminum and Zinc and Their Alloys and Composites, and the following:

(1) The coating shall be pure zinc (99.9 percent purity minimum).

(2) A minimum thickness of 150 μm (6 mils) shall be applied to all exterior surfaces. Internal surfaces (e.g., pot bearings) shall have a minimum coating of 50 μm (2 mils).

(3) All surfaces to be thermal sprayed shall be blast cleaned to white metal immediately prior to receiving surface protections. The final surface appearances shall be equivalent to preparation grade SSPC-SP5 as defined by SSPC-VIS 1. The first coating shall be applied within one hour of blast cleaning and the surface must be completely coated to the specified thickness within two hours of blasting.

(4) Exterior surfaces shall be sealed with an approved sealant conforming to the recommendations of the thermal spray supplier and approved by the Engineer. The minimum dry film thickness of the sealant shall be 50 μm (2 mils).

(5) Adherence of the metalized coating to the base metal shall be tested in accordance with AASHTO M 111M/M 111, Section 7.

506.16 MARKING, STORING, AND SHIPPING.

(a) Marking. Each member shall be identified with an erection mark corresponding with the member identification mark on the approved shop 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 has the opportunity to weather uniformly.

(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, without the Agency's approval. The Agency's Inspector will place a seal of approval on all material that has been accepted and will approve the loading, positioning, and anchorage of all material being shipped.

506.17 FIELD HANDLING AND STORING. The Contractor is responsible for providing equipment that is adequate for safely lifting and placing, 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 2 mm (1/16 inch) radius.

The storage requirements in Subsection 506.16 shall be applicable for all material stored in the field.

506.18 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,

position, and align all members and their components without damage. The Contractor shall submit details of the proposed method of erection and the equipment to be used for this erection when:

(1) The length of the segment being erected exceeds 38 m (125 feet) for straight girders or 30 m (100 feet) for curved girders;

(2) When two or more segments are field bolted prior to erection regardless of individual or total length; or

(3) Whenever requested by the Engineer.

The Contractor's submittal shall include the necessary computations to indicate the magnitude of stress caused during erection. This submittal is for the Agency's information only and shall in no way be construed as approval of the proposed method of erection.

The Contractor is responsible for lifting and erecting curved girders so that the web of the girder is maintained vertical within a 10 degree vertical tolerance.

(b) Bearings and Anchorages.

(1) Bearings shall be set level and in the exact position specified with full and uniform bearing. Pedestals detailed to be on a slope shall be set at the elevation and position specified.

(2) Metal bearing plates shall be placed on a 3 mm (1/8 inch) thick bearing pad conforming to Subsection 731.01 or 731.02. The bearing pad shall be the same size as the bearing plate with holes to accommodate the anchor bolts.

(3) Anchor bolts shall be positioned to the alignment and dimensions specified or approved in the shop drawings. When preset or cast-in anchorages are not specified, the Contractor may drill holes and set the anchor bolts in a Type IV mortar.

(4) Bearings shall initially be positioned to account for a mean temperature of 7 °C (45 °F) and for any bottom chord or flange elongation due to dead load deflection. As erection progresses, fixed bearings may be fully welded and expansion bearings tack welded to their respective members to prevent displacement. When full dead load has been applied to the structural system, any adjustments necessary shall be made to correct bearing position and inclination for a mean temperature of 7 °C (45 °F). Anchor bolts for sliding bearings shall be in the center of their slots and rockers or rollers set vertical.

Bearings shall be reset if they are out of position by more than the following tolerances:

| | |
|---|---|
| Sliding Bearings: | 6 mm (1/4 inch) from the correct position. |
| Rockers and Rollers: | Inclination of more than 3 degrees from the correct position. |

(c) Assembly.

(1) Parts shall be accurately assembled as shown on the Plans 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. Members shall be erected to the position specified and externally supported until all connections have been completed.

(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 have been match marked and shop reamed to fit a specified profile and should fit together easily.

Main and secondary members with oversized holes shall not be reamed without Agency approval.

Secondary members may be subjected to limited field reaming. Reaming or drilling to connect misaligned holes will not be permitted without approval of the Engineer. Reaming or drilling shall not cause elongation of any hole more than 1.6 mm (1/16 inch) for 75 percent of the holes in any subassembly and 3.2 mm (1/8 inch) for the remaining 25 percent of the subassembly (diaphragm, lateral bracing, etc.). Reaming that produces results in excess of these limits will be cause for rejection. Assembled parts requiring drilling or reaming shall be disassembled to remove any burrs or shavings.

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) The correction of minor misfits involving reaming (within specified limits) and cutting will be considered a legitimate part of the erection. However, errors in shop fabrication that prevent proper assembly shall be reported immediately to the Engineer. The Agency will determine what corrective action will be made.

506.19 BOLTING AND CONNECTIONS.

(a) General. Field connections shall be made with high-strength bolts conforming to AASHTO M 164M (AASHTO M 164). Type 3 bolts shall be used for unpainted applications. 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. Galvanized bolts, nuts, and washers shall be shipped and stored in plastic bags in wood or metal containers. All bolts and nuts shall be adequately and uniformly lubricated. Black bolts shall be oily to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and relubricated prior to installation in accordance with applicable specification.

Bolt holes are generally specified as 2 mm (1/16 inch) larger in diameter than the bolt.

Field connection bolts for structural components that have been painted prior to being erected shall be high-strength bolts meeting the requirements of AASHTO M 164M (AASHTO M 164) and shall be coated in accordance with AASHTO M 298, Class 50, Type I.

(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.

Prior to assembly, contact surfaces of galvanized stress-carrying members shall be lightly brushed or blasted to a dull gray appearance.

Surfaces of metal to be in contact when assembled shall not be painted. Temporary protective coatings shall be removed prior to final assembly.

Splices and field connections of main members shall have all holes filled with high-strength bolts or cylindrical drift pins, with bolts fully tightened before external support systems are removed.

(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 Contract).

(2) Replacing existing bolts or rivets.

(3) Oversized and irregular hole conditions caused from field drilling or reaming.

(4) Connections between new steel and existing steel.

Where an outer face of the bolted parts has a slope of more than 1:20 (vertical:horizontal) 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 vertical shall have the heads up. Bolts installed with the stem horizontal shall have the head towards the weather unless clearance restrictions dictate otherwise.

Normally the nut will be the tightened element; however, if the position of bolt entering or wrench operation clearances prohibit this procedure the bolt may be the turned element.

Impact wrenches shall be capable of tightening bolts to their minimum required tension within ten seconds.

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 a wrench may be required any time there appears to be a significant change in the condition of bolt tightening.

All bolts in a connection shall first be brought to a "snug tight" condition. "Snug tight" is defined as the tightness that exists when the plies of the joint are in firm contact. "Snug tight" shall be considered as the tightness attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary spud wrench.

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 five days after installation unless specific instructions to do so are shown on the Plans or directed by the Engineer.

Bolts shall be tightened to develop a tension not less than 5 percent in excess of the minimum bolt tension specified in Table 506.19A by either the calibrated wrench, turn of the nut, or torque methods. Bolts shall not be tightened to more than the maximum tension specified in Table 506.19A. The Contractor shall be responsible for providing a tension measuring device that has been calibrated within the last year and is accompanied by a certificate verifying its date of calibration. The working torque of each wrench shall be determined by the Contractor in the presence of the Engineer using one of the following methods:

(1) Calibrated Wrench Method. At the beginning of each working day, the working torque of each wrench shall be checked by tightening at least three bolt and nut assemblies of each diameter, length, and grade to be used in the work, in a device capable of indicating actual bolt tension. Additional checking of wrenches shall be performed as directed by the Engineer. Separate checks will be required for each diameter fastener with hardened

washers placed under the nut and/or bolt head as they will be used in the structure. Variations in the number or location of washers will require separate checks. All powered wrenches shall be adjusted to stall or cut-out at the specified tension. Power wrenches without cut-outs will not be permitted.

(2) Turn of the Nut Method. All bolts shall be tightened by the applicable amount of nut or head rotation specified in Table 506.19B. During the tightening operation, there shall be no rotation of the part not turned by the wrench.

A representative sample of not less than three bolt and nut assemblies of each diameter, length, grade, and type to be used in the work shall be checked each working day in a device capable of indicating bolt tension. The test shall demonstrate that the method of estimating the "snug tight" condition and controlling turns from "snug tight" to be used by the bolting crews develops a tension of at least 5 percent in excess of the minimum bolt tension specified in Table 506.19A, or more than the maximum tension specified in Table 506.19A. Separate checks will be required for each diameter fastener with hardened washers placed under the nut and/or bolt head as they will be used in the structure. Variations in the number or location of washers will require separate checks.

(3) Torque Method. Manual torque wrenches for installation shall be supplied by the Contractor, calibrated yearly, and each accompanied by a certificate indicating its date of calibration. At the beginning of each working day, the working torque of each wrench shall be checked by tightening at least three bolt and nut assemblies of each diameter, length, and grade to be used in the work, in a device capable of indicating actual bolt tension. Additional checking of wrenches shall be performed as directed by the Engineer. Separate checks will be required for each diameter fastener with hardened washers placed under the nut and/or bolt head as they will be used in the structure. Variations in the number or location of washers will require separate checks.

This method may be used to "touch up" bolts previously tightened and that may have been loosened by the tightening process or as a means of bringing all bolts in any given connection to the specified tension.

TABLE 506.19A (METRIC)
BOLT TENSION
AASHTO M 164M (ASTM A 325M) BOLTS

| Nominal Bolt Diameter (mm) | Minimum Bolt Tension (kN)* | Maximum Bolt Tension (kN)** |
|---|---|---|
| M16 | 91.0 | 117.0 |
| M20 | 142.1 | 182.7 |
| M22 | 175.7 | 225.9 |
| M24 | 205.1 | 263.7 |
| M27 | 266.7 | 342.9 |
| M30 | 326.2 | 419.4 |
| M36 | 474.6 | 610.2 |

* Equal to 70 percent of specified maximum tensile strength of bolts.
** Equal to 90 percent of specified maximum tensile strength of bolts.

TABLE 506.19A (ENGLISH)
BOLT TENSION
AASHTO M 164 (ASTM A 325) BOLTS

| Nominal Bolt Diameter (inches) | Minimum Bolt Tension (pounds)* | Maximum Bolt Tension (pounds)** |
|---|---|---|
| 1/2 | 12,050 | 15,500 |
| 5/8 | 19,200 | 24,700 |
| 3/4 | 28,400 | 36,500 |
| 7/8 | 39,250 | 50,500 |
| 1 | 51,500 | 66,200 |
| 1 1/8 | 56,450 | 72,600 |
| 1 1/4 | 71,700 | 92,200 |
| 1 3/8 | 85,450 | 109,800 |
| 1 1/2 | 104,000 | 133,700 |

* Equal to 70 percent of specified maximum tensile strength of bolts.
** Equal to 90 percent of specified maximum tensile strength of bolts.

TABLE 506.19B
NUT ROTATION FROM SNUG TIGHT CONDITION
AASHTO M 164M (ASTM A 325M) [AASHTO M 164 (ASTM A 325)] BOLTS

| Bolt Length (as measured from underside of head to extreme end of point) | Disposition of Outer Faces of Bolted Parts | | |
|---|---|---|---|
| | Both faces normal to bolt axis | One face normal to bolt axis and other face sloped not more than 1:20 (v:h) (bevel washer not used) | Both faces sloped not more than 1:20 (v:h) from normal to bolt axis (bevel washers not used) |
| Up to and including 4 diameters | (120 °) 1/3 turn | (180 °) 1/2 turn | (240 °) 2/3 turn |
| Over 4 diameters but not exceeding 8 diameters | (180 °) 1/2 turn | (240 °) 2/3 turn | (300 °) 5/6 turn |
| Over 8 diameters but not exceeding 12 diameters | (240 °) 2/3 turn | (300 °) 5/6 turn | (360 °) 1 turn |

Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn (180 degrees) and less, the tolerance shall be ± 30 degrees; for bolts installed by 2/3 turn (240 degrees) and more, the tolerance shall be ± 45 degrees.
For bolt lengths exceeding 12 diameters, the required rotation must be determined by actual test in a suitable tension device simulating the actual conditions.

(d) Inspection. The Engineer shall observe the installation and tightening of bolted connections to determine if the tightening procedure selected is working properly and the correct tension has been achieved. The Engineer will observe and verify the checking of impact wrenches used for the calibrated wrench method. The Engineer will also observe and verify the checking of manual torque wrenches used for the torque method.

The Engineer will inspect fasteners after installation by applying the inspecting wrench to a minimum of 10 percent of the bolts, but not less than two bolts, selected at random in each connection. The actual torque value of each inspected bolt will be determined as the head or nut is rotated 5 degrees in the tightening direction. This value shall be within the minimum and maximum job inspecting torque values as determined during the calibration of the inspection torque wrench using the bolt tension values in Table 506.19A. If any bolt in a connection is found to have a torque value below the minimum or above the maximum job inspecting torque, all bolts in that connection shall be inspected. All under-tightened bolts shall be tightened and reinspected. All over-tightened bolts shall be loosened and the bolt and nut removed for visual inspection of the bolt and nut threads. If there is visible thread damage or the nut does not spin freely on the bolt when turned by hand without the aid of a wrench, a new bolt and nut shall be installed. Undamaged fasteners may be reinstalled.

All new fasteners shall be tightened and inspected as described above. AASHTO M 253M (AASHTO M 253) bolts and galvanized AASHTO M 164M (AASHTO M 164) bolts shall not be reused.

The Engineer will determine the inspection torque at least once each day by tightening five bolts of the diameter, length, and grade being used in the work in a device capable of indicating actual bolt tension. The job inspecting torque shall be taken as the average of three values thus determined after rejecting the high and low values. The inspecting wrench shall then be applied to the tightened bolts in the work and the torque necessary to turn the nut or head 5 degrees [approximately 25 mm at a 300 mm radius (1 inch at a 12 inch radius)] in the tightening direction shall be determined. Either the Engineer, or the Contractor in the presence of the Engineer, at the Engineer's option, shall use the inspection wrench.

506.20 FIELD WELDING. Welding performed in the field shall conform to the requirements of Subsection 506.10.

Shear connectors applied in the field shall be installed in accordance with Section 508.

506.21 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 for approval in accordance with Subsection 105.03. 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 must 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 III personnel at the Contractor's expense.

506.22 FIELD CLEANING AND PAINTING. 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.

If the components are new steel, which is metalized or galvanized, or which is to remain unpainted, the cost of such necessary cleaning will not be paid for directly but will be considered incidental to the Section 506 Contract items in the Contract.

If the components are reconditioned or rehabilitated components, the costs of such necessary cleaning will not be paid for directly but will be considered incidental to the appropriate Section 513 Contract item.

Connection surfaces from which a primer or other coat was omitted and other areas from which protective coatings have worn off or are found defective shall be cleaned and coated in accordance with the requirements set forth in Section 513 for the designated coating system. The costs of such cleaning and coating will not be paid for directly but will be considered incidental to the Section 513 Contract items, as appropriate to the work being performed and the project conditions.

506.23 UNPAINTED STEEL. Care must be taken to keep chemicals and oils from contact with the exposed surfaces of unpainted steel during storage, erection, and construction of the deck.

(a) Staining of Masonry. The Contractor shall protect all concrete and masonry from staining due to oxide formation on the steel.

(b) Cleaning of Steel. After all concrete has been placed and protected with water repellent, 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 preparation grade SSPC-SP10 defined by SSPC-VIS 1. The use of acids for cleaning is prohibited.

506.24 METHOD OF MEASUREMENT.

(a) Bids on a Kilogram (Pound) Basis. The quantity of Structural Steel, or other material being paid under this item, to be measured for payment will be the number of kilograms (pounds) used in the complete and accepted work. The mass (weight) of the material to be measured for payment under this item will be computed based on the approved shop drawings, as follows:

(1) Masses (weights) determined by the volume of material will be computed on the basis of the following densities:

| Material | $kg/m^3$ | $lbs./ft^3$ |
|---|---|---|
| Aluminum, alloy | 2800 | 173 |
| Bronze, cast | 8600 | 536 |
| Copper, alloy | 8600 | 536 |
| Copper, sheet | 8900 | 558 |
| Iron, cast | 7100 | 445 |
| Iron, wrought | 7800 | 487 |
| Lead, sheet | 11 300 | 707 |
| Steel; rolled, cast, copper bearing, silicon, nickel, and stainless | 7850 | 490 |
| Preformed fabric pads | 1400 | 88 |

For any material not listed above, the material will be paid for by actual mass (weight) as measured on a certified scale.

(2) The masses (weights) of rolled structural shapes will be computed on the basis of their nominal mass per meter (weight per foot) as shown on the Plans or, if not shown on the Plans, by the masses (weights) shown in the current edition of the AISC Manual.

The masses (weights) of rolled shapes will be based on the overall net length shown on the approved shop drawings, with no allowance for milling, finishing, or overrun, and with no deduction for cuts, clips, copes, or open holes.

(3) The masses (weights) of plates will be based on the net finished dimensions shown on the approved shop drawings, with no allowance for milling, finishing, tolerance, or overrun, and with no deductions for copes, clips, and open holes. The masses (weights) of beveled plates or curved surface plates will be based on the finished maximum thickness shown on the approved shop 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 mass (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 shop drawings.

(4) The masses (weights) of fabricated metal items such as U-bolts, welding studs, and lugs will be based on the overall net dimensions of the finished product as shown on the approved shop drawings.

(5) All welding will be considered as incidental work to the fabrication, and no payment will be made for the mass (weight) of weld metal used.

(6) Payment for castings will be by mass (weight) measured on scales.

(7) When it is specified that any part of the material is to be paid for by actual mass (weight), finished work shall be weighed in the presence of the Inspector. In such case, the scales shall have been certified for accuracy within a one-year period.

(8) When the Contract includes bearings or bearing connections as part of this work, the mass (weight) of anchor bolts to be embedded in concrete will be based on the nominal dimensions shown on the approved shop drawings with no deduction for deformations but including the mass (weight) of nuts and washers. The mass (weight) of pins, pintels, and rollers will be based on the overall finished dimensions shown on the approved shop drawings with no deductions for threads, open holes, pockets, or allowance for excess diameter required for finishing.

(9) The mass (weight) of shop and field bolts, nuts, and washers incorporated into the structure; driving nuts, pilot nuts, temporary erection bolts, shop and field paint, galvanizing, boxes, crates, and other containers used for shipping, and materials used for supporting members during transportation and erection, will be incidental to the work.

(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 the number of units for each structure complete and accepted as specified in the Contract.

506.25 BASIS OF PAYMENT. The accepted quantity of Structural Steel will be paid for at the Contract unit 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 galvanized, metalized, or to remain unpainted; for necessary field cleaning; for primer coating of metalized surfaces; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The costs of surface preparation of new steel to remain unpainted or to be galvanized or metalized will not be paid for directly but will be considered incidental to the Section 506 Contract items in the Contract.

Surface preparation of rehabilitated or reconditioned steel, whether it is to receive protective coating(s) or it is to remain uncoated; surface preparation of galvanized steel that is to receive additional protective coating(s); and surface preparation of new steel that is to receive protective coating(s), except for primer coating of metalized surfaces are not included in any Contract item in Section 506, the costs of this work will be incidental to the Section 513 Contract items.

The Engineer may authorize progress payments in the following manner:

(a) A maximum of 75 percent of the estimated quantity may be paid when the steel has been delivered to the site.

(b) A maximum of 95 percent 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.

(c) After completion and acceptance of all work under this Section, 100 percent of the quantity will be paid.

All nondestructive testing and required quality control activities will be considered incidental work to the fabrication, and no separate payment will be made.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 506.50 Structural Steel (Rolled Beam) | Kilogram (Pound) |
| 506.55 Structural Steel (Plate Girder) | Kilogram (Pound) |
| 506.60 Structural Steel | Kilogram (Pound) |

## SECTION 507 - REINFORCING STEEL

507.01 DESCRIPTION. This work shall consist of furnishing and placing bar reinforcement, dowels, wire, and wire fabric.

507.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Mortar, Type IV | 707.03 |
| Bar Reinforcement | 713.01 |
| Mechanical or Welded Splices for Bar Reinforcement | 713.02 |
| Cold-Drawn Steel Wire | 713.04 |
| Welded Steel Wire Fabric | 713.05 |
| Coated Bar Reinforcement | 713.07 |

Spiral reinforcement for columns may be bar reinforcement or cold-drawn steel wire.

507.03 FABRICATION AND SHIPMENT. Bar reinforcement shall be cold bent to the shapes shown on the Plans. Bends shall be made in accordance with Division I of the AASHTO *Standard Specifications for Highway Bridges*.

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 on blocking, racks, or platforms. When placed in the work, the reinforcing steel shall be free from dirt, detrimental scale, paint, oil, or other foreign substances.

All systems for handling and storing coated reinforcement shall have padded contact areas. Epoxy coated reinforcement stored on a project shall be covered with canvas or other suitable material that will effectively protect it against damage from ultraviolet light.

All damaged areas of reinforcement coating shall be repaired with materials and procedures approved by the coating manufacturer prior to installation. This repair prior to installation does not relieve the Contractor from repairing areas damaged during placement. All bars with total damage, including previously repaired areas, greater than 2 percent of the bar surface area shall 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 as required for damaged areas.

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

placing of concrete. 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. Support material within 40 mm (1 1/2 inches) of a finished concrete surface shall be stainless steel, epoxy, plastic coated galvanized steel, or plastic.

If the Contractor elects to post drill holes for installation of anchor bolts, care must be taken to position reinforcement to minimize possible interference during the drilling operation.

When the Engineer or Contract permits the option of field bending material, it will be limited to Nos. 13 and 16, Grade 300 (Nos. 4 and 5, Grade 40) bars bent to a minimum inside diameter of 3.5 times the bar diameter.

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. Grade 420 (Grade 60) bar reinforcement shall not be field bent or straightened.

Bars spaced 300 mm (12 inches) apart or greater shall be tied at every intersection. Bars spaced less than 300 mm (12 inches) apart shall be tied at every other intersection. If reinforcement shows signs of distress during construction, the Engineer may direct additional tying.

Welding of reinforcement steel will not be permitted unless shown on the Plans or allowed by approved welding procedures. 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.

Tie wires and supports used for installation of coated reinforcement shall be coated with or be constructed of plastic, epoxy, or other approved materials that will prevent damage to the bar surface.

Horizontal mats of reinforcing steel shall have lines of support not exceeding 1 m (4 foot) spacing in either direction. Additional individual chairs may be required in the area of the fascia.

Reinforcement placed in any member shall be inspected and approved before any concrete is placed.

507.06 PLACING DOWELS. Dowels shall be placed in existing concrete or ledge at locations shown on the Plans. Holes shall be drilled to the depth shown on the Plans and shall be at least 25 mm (1 inch) greater in diameter than the dowel. Dowels shall be grouted with Type IV mortar.

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.

507.08 LAPPING. Sheets of welded steel wire fabric reinforcement shall overlap 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 BAR LISTS. Bar lists and bending schedules shown on the Plans are prepared for the purpose of arriving at an estimated quantity and any errors shall not be considered cause for an adjustment of the Contract unit price. It is the Contractor's responsibility to verify the vendor's bar lists and schedules for quantity, size, and shape of bar reinforcement for constructing the structural components shown in the Contract Documents or made a part thereof. Prior to fabrication, two file copies of the vendor's bar lists shall be sent to the Construction Engineer, Vermont Agency of Transportation, National Life Building, Montpelier, Vermont 05633-5001; and two copies shall be furnished to the Engineer for information. Upon delivery of the fabricated material, one copy of the shipping schedule and tabulation of masses (weights) shall be furnished to the Engineer.

507.10 METHOD OF MEASUREMENT. The quantity of Reinforcing Steel to be measured for payment will be the total number of kilograms (pounds) of reinforcing bars, dowels, wire, and wire fabric used in the complete and accepted work except as otherwise provided, computed on the following basis:

(a) The mass (weight) of bars, dowels, and wire will be the product of the length as shown on the approved shop bar lists and the standard mass per meter (weight per foot) of length as adopted by the CRSI. Vendor's bar list lengths will be adjusted for any material accepted with an overall dimensional length less than or greater than the 25 mm (1 inch) CRSI tolerance.

(b) The mass (weight) of wire fabric will be the computed mass (weight) in accordance with the details shown on the Plans based on the standard mass (weight) accepted by the trade for the unit of material specified.

(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) When the substitution of bars of greater diameter than specified is permitted by written authorization of the Engineer, payment will be made for only the mass (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, the mass (weight) to be measured will be only the equivalent of the mass (weight) of full length bars as if they had been used, with no allowance for laps.

The quantity of Drilling and Grouting Dowels to be measured for payment will be for the length of hole in meters (linear feet) to be drilled as shown on the Plans. If not shown on the Plans, the depth of drilled holes shall be 600 mm (2 feet). The dowel will be measured as Reinforcing Steel.

507.11 BASIS OF PAYMENT. The accepted quantities of Reinforcing Steel will be paid for at the Contract unit price per kilogram (pound). Payment will be full compensation for furnishing, handling, and placing the material including grouting of dowels and for furnishing all labor, fastening devices, 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 as incidental to other Contract items.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 507.15 Reinforcing Steel | Kilogram (Pound) |
| 507.16 Drilling and Grouting Dowels | Meter (Linear Foot) |
| 507.17 Epoxy Coated Reinforcing Steel | Kilogram (Pound) |
| 507.18 Galvanized Reinforcing Steel | Kilogram (Pound) |

## SECTION 508 - SHEAR CONNECTORS

508.01 DESCRIPTION. This work shall consist of furnishing and welding shear connectors for either structural steel shapes or studs to structural members.

508.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Structural Steel ..... 714.02
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 -18 °C (0 °F) or when the surface is wet or exposed to falling rain or snow.

508.04 PLACING, INSPECTING, AND TESTING.

(a) General. Shear connectors shall be placed, inspected, and tested in accordance with AWS D 1.5. When the base metal temperature of a member to which automatically welded shear connectors are to be attached is less than 2.0 °C (35 °F), the following requirements shall apply:

(1) Base Metal in Compression Only. The Contractor has the option of obtaining an approved welding procedure for application of the studs or preheating the base metal to a minimum of 10 °C (50 °F).

(2) Base Metal in Tension or Stress Reversal Zones. The base metal shall be preheated to a minimum of 20 °C (70 °F).

When the Contractor elects to apply the shear connectors in the field, the Contractor shall submit working drawings in conformance with Subsection 105.03. Details shall include the size, shape, spacing, and preheat requirements for shear connectors shown on the Plans. Note: The Contractor may elect to have the structural steel fabricator provide shear connector information on the fabricator-provided shop drawings. If the shear connectors are to be shop applied, connection details must be included on structural steel drawings.

The base metal of all portions of a member in tension to which shear connectors are to be welded shall be preheated to 20 °C for thicknesses up to 40 mm (70 °F for thicknesses up to 1 1/2 inches); preheated to 65 °C for thicknesses over 40 to 65 mm (150 °F for thicknesses over 1 1/2 to 2 1/2 inches); and preheated to 110 °C for thicknesses over 65 mm (225 °F for thicknesses over 2 1/2 inches). Preheating applies to either shop or field applied shear connectors.

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.

All tested shear connectors that show no sign of failure shall be left in the bent position.

(b) Studs. Installation and acceptance of stud shear connectors shall be in accordance with AWS D1.5, Section 7.

After being allowed to cool, the first two studs welded on each beam or girder shall be bent 45 degrees 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 degrees from the correct axis of installation. In the case of a repaired weld, the stud shall be bent 15 degrees 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.

The Engineer may select additional studs to be subjected to the bend test specified above.

(c) Structural Steel Shapes. Structural steel shaped shear connectors shall be attached or repaired by the shielded metal arc welding (SMAW) process using low hydrogen electrodes in accordance with Subsection 506.10.

After being allowed to cool, the first structural steel shape welded on each beam or girder shall be bent 15 degrees by striking it with a hammer. If failure occurs in the weld zone, another shear connector shall be successfully welded and tested before any more shear connectors are welded to the beam or girder.

The Engineer will check approximately 1 percent of the structural steel shape shear connectors selected at random by striking them and bending them to an angle of 15 degrees from the vertical to establish the overall quality of the welding.

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 |
|---|---|
| 508.15 Shear Connectors | Lump Sum |

## SECTION 510 - PRECAST CONCRETE

510.01 DESCRIPTION. This work shall consist of manufacturing, transporting, and erecting precast concrete members.

510.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Portland Cement | 701.02 |
| Air-Entraining Portland Cement | 701.03 |
| High Early Strength Portland Cement | 701.04 |
| Fine Aggregate for Concrete | 704.01 |
| Coarse Aggregate for Concrete | 704.02 |
| Mortar, Type IV | 707.03 |
| Bar Reinforcement | 713.01 |
| Prestressing Reinforcement | 713.06 |
| Structural Steel | 714.01 - 714.05 |
| Air-Entraining Admixtures | 725.02(b) |
| Retarding Admixtures | 725.02(c) |
| Water-Reducing Admixtures | 725.02(f) |
| Water-Reducing and Retarding Admixtures | 725.02(g) |
| Water-Reducing, High Range Admixtures | 725.02(h) |
| Water-Reducing, High Range, and Retarding Admixtures | 725.02(i) |

Bearing Pads for Structures ..... 731.01 - 731.05
Water ..... 745.01

Unless otherwise specified in the Contract, all bar reinforcement shall conform to AASHTO M 31M/M 31, Grade 420 (Grade 60).

510.03 GENERAL FABRICATION REQUIREMENTS.

(a) General. The manufacture of the prestressed units shall be in accordance with PCI MNL-116 *Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products*, except as modified in this Section.

(b) Qualification. The prestressed members shall be manufactured in a plant that has either been:

(1) Certified by the Prestressed Concrete Institute under its Plant Certification Program, or

(2) Approved by the Agency for the production of prestressed concrete members prior to opening of bids.

The Agency reserves the right to disqualify a certified or previously approved plant.

(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 and actively used to maintain the quality of the concrete within the specified requirements.

510.04 DESIGN AND DRAWINGS. The fabricator shall submit working drawings in accordance with Subsection 105.03. In addition to the requirements in Subsection 105.03, the following shall be included:

(a) The dimensions of the sections to be prestressed.

(b) The concrete mix design.

(c) The sources and properties of the materials proposed for use.

(d) The methods of prestressing, including certified calibration charts for all jack and gauge combinations.

(e) Design calculations for gauge pressure, camber, dead load deflection, live load deflection, and elongation. Friction losses, elastic shortening, and anchorage set shall be included in the computations for the required elongation of post-tensioned tendons. Stress losses due to slippage of strand anchorages and

movement of anchorage abutments shall be included in the computations for elongation of pretensioned strands.

(f) The method and sequence of tensioning and detensioning.

(g) The placement of normal reinforcing steel and prestressing steel.

(h) The type of surface finish, defining how the finish will be obtained.

(i) The curing method, detailing sequence, and duration.

(j) The grouting procedure (for post-tensioned systems only).

(k) The design of the lifting attachments.

(l) Transportation, handling, and storage details.

(m) Installation procedure.

(n) Description of Quality Control procedures.

(o) The complete sequence of operations.

All design details shall be in accordance with the AASHTO *Standard Specifications for Highway Bridges*.

As soon as practical after award of the Contract, the fabricator shall submit drawings and details as a complete package, allowing at least 45 calendar days for review and response.

510.05 CONCRETE.

(a) Batch plant equipment, materials, and batching procedures shall conform to the following provisions of Section 501:

| | |
|---|---|
| 501.04 | Batching, paragraphs 1 and 3 only |
| 501.04(c) | Bins and Scales, in its entirety |
| 501.04(d) | Accuracy of Plant Batching, in its entirety |
| 501.04(e) | Storage and Proportioning of Materials, in its entirety |
| 501.05 | Mixing and Delivery, in its entirety; except that for plants not located in the State, the Agency will have the option of waiving the requirements of part (a)(4), in its entirety; and part (c), paragraphs 1 and 3 only. |

(b) Concrete for prestressed members shall have a compressive strength at 28 days, as determined in accordance with AASHTO T 22, of not less than 35 MPa (5000 pounds per square inch). When a 28-day test result, as defined in this Section or in the Contract, is below the specified 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 made from this concrete. The

cement factor in the mix design shall be between 363 and 475 kg/m$^3$ (611 and 800 pounds per cubic yard) of concrete. The percent of air entrainment shall be 6 percent with a tolerance of ± 1 percent, and the slump shall be between 25 and 75 mm (1 and 3 inches).

The maximum water-cement ratio shall be 0.44. When a water-reducing, high range admixture (AASHTO M 194, Type F or Type G) has been included in the approved mix design, the concrete slump prior to the addition of the admixture shall not exceed 65 mm (2 1/2 inches) and the slump following mixing shall not exceed 180 mm (7 inches).

(c) 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 as part of Subsection 510.04. Six weeks may be required for testing and approval of the mix design.

To check the fabricator's mix design, test specimens of concrete may be required to be made from the aggregate, cement, and admixtures that are proposed to be used. All quantities of these materials, as required for the tests, shall be furnished at the fabricator's expense.

(d) Any admixture containing calcium chloride shall not be used. Type II or Type III portland cement may be used. Only one type of cement and only one source of that type shall be used for the prestressed units required for any one structure.

510.06 INSPECTION. Materials furnished and the work performed under 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. Advance notification of at least three working days must be provided by the fabricator to the Agency concerning the proposed intention to commence work.

Prior to shipment of any members, the Materials and Research Engineer must have approved all applicable material certifications required in accordance with Subsection 700.02.

510.07 PRESTRESSING. Prestressing shall be accomplished by pre-tensioning, post-tensioning or by a combination of the two methods. The procedure used will be optional to the fabricator with approval of the Agency.

The fabricator shall provide all equipment necessary for the manufacture and installation of the prestressed members. Prestressing shall be done with approved jacking equipment. Hydraulic jacks shall be equipped with accurate reading pressure gauges or other indicating devices. The combination of jack and gauge, or other indicating device, shall be accompanied by a certified calibration chart showing the relationship between the gauge reading and 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 percent, 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 for the purpose of checking possible strand relaxation.

510.08 FABRICATION.

(a) Forming Members. Side forms shall be supported without the use of ties or spreaders within the body of the member. Any defects or damage of more than a minor nature due to form work, stripping, or handling shall 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 mass (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 drainhole. Holes or cut outs 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.

(b) Placing Post-Tensioning Conduits and Tendons. Each tendon to be post-tensioned shall be encased in an approved conduit. The ratio of the cross-sectional area of the tendon to be encased to the interior cross-sectional area of the conduit shall not exceed 0.4, except that, when a steel bar is used as a tendon, the inside diameter of the conduit shall be at least 10 mm (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 6 mm (1/4 inch) from the position shown on the Plans. Bundling of conduits will not be permitted.

(c) Placing Pre-Tensioning 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. Prestressing strands shall be protected against corrosion and be free of nicks, kinks, dirt, rust, oil, grease, and other deleterious substances.

(d) Bar Reinforcement. Bar reinforcement shall be furnished and installed in conformance with Subsections 507.03, 507.04, 507.05, and 507.07.

(e) Pre-Tensioning. The prestressing strands shall be stressed by jacking in accordance with 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. No stress shall be transferred to the concrete until a compressive strength of 28 MPa (4000 pounds per square inch) has been attained. The compressive strength shall be determined by cylinders tested in accordance with Subsection 510.09. The prestressing strands shall be released in the de-tensioning pattern detailed on the shop drawing.

(f) Placing Concrete. Concrete shall not be deposited in the forms until the Agency representative has approved placement of the reinforcement, ducts, anchorages, and prestressing steel. 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, conduit, voids, and prestressing steel is avoided.

(3) Acceptable finish surfaces are produced.

Concrete shall be placed only in the presence of an Agency representative. The temperature of the concrete at the time of placing shall be between 10 and 27 °C (50 and 80 °F).

(g) Welding. All welding shall conform to the requirements of Subsection 506.10.

510.09 CONCRETE TESTING.

(a) General. Prestressed members shall be manufactured in a plant, which maintains a quality control laboratory complete with equipment for measuring the properties of fresh and hardened concrete. As a minimum, the laboratory shall be equipped with a compression testing machine, curing room or chamber, apparatus for measuring slump 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.

(b) Testing of Compressive Strength. Specimens shall be 150 by 300 mm (6 × 12 inch) standard cylinders made by the fabricator in accordance with AASHTO T 23. Fabrication of test specimens shall be witnessed by an Agency representative. Molds for forming test specimens shall conform to AASHTO M 205 and shall be supplied by the fabricator. For each post-tensioned member or for each bed of pre-tensioned members, the fabricator shall make for the Agency the following minimum number of specimens:

(1) Six specimens to determine strength prior to de-tensioning or post-tensioning. These specimens shall be cured from the time of casting, under the same conditions as the concrete in the work.

(2) Four specimens to determine compliance with the 28-day strength requirement. The specimens shall be cured under the same conditions as the member from the time of casting until the member is removed from the form. At that time, the specimens shall be moved to storage where curing shall continue under standard conditions in accordance with AASHTO T 23. These specimens shall be retained by the fabricator for testing by the Agency.

The average of the compressive strength of each of two specimens shall constitute a test result. Specimens shall be tested either at the Agency's Materials and Research Section, or at the manufacturer's plant laboratory. An Agency representative will witness all tests. Unless otherwise specified, de-tensioning or post-tensioning shall only be permitted after two successive specimens have been tested, and when the average strength of these specimens is equal to or greater than the strength required in the Contract for de-tensioning or post-tensioning.

510.10 CURING.

(a) General. All curing methods shall be subject to the Engineer's approval. Where the fabricator elects to cure by method(s) other than low pressure steam or radiant heat as described below, the fabricator shall submit with the shop drawings complete details of the proposed method(s) for approval.

The fabricator shall provide one automatic temperature recorder for every 30 m (100 feet) of casting bed. The recorder shall continuously record curing temperature for the entire curing period. Temperature sensors shall be carefully placed within the curing enclosure to ensure that ambient temperatures are measured at typical locations. Recorder accuracy shall be certified once every 12 months, and the certificate displayed with each 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. Each recorder chart shall indicate the casting bed, date of casting, time of start and finish of record, and the mark number of prestressed units being cured. At the completion of the curing period, the recorder charts shall be given to the Agency representative. Temperatures recorded on the charts shall be used to determine whether the prestressed units

have been cured in accordance with the specifications or the approved shop drawings.

Curing by the approved method shall continue uninterrupted until the start of de-tensioning operations. De-tensioning shall be accomplished immediately after the steam curing or heat curing has been discontinued.

If any member does not reach the 28-day design strength within 28 days, it shall be rejected.

(b) Curing with Low-Pressure Steam or Radiant Heat.

(1) Immediately upon completing placement of the concrete of each unit, an enclosure shall be placed over the casting bed. This enclosure shall be suitable for containing the live steam or heat. The fabricator shall make these covers available for inspection prior to casting.

(2) When low pressure steam methods are used for curing, precautions shall be taken to prevent live steam from being directed on the concrete or forms in such a way as to cause localized high temperatures.

(3) 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 a circulation pipe containing steam, hot oil or hot water, or by electric heating elements.

(4) The concrete shall be allowed to attain its initial set before commencing accelerated curing. This waiting period shall not exceed four hours from time of placement for concrete with no retarder added, or eight hours from the time of placement for concrete with retarder. During this initial curing period, while waiting for the initial set to take place, the temperature within the enclosure shall be maintained between 10 and 27 °C (50 and 80 °F).

(5) During the initial application of heat or steam, the ambient air temperature within the enclosure shall increase at a rate not exceeding 20 °C (40 °F) per hour until the maximum curing temperature is reached. The maximum curing temperature shall not exceed 71 °C (160 °F). The selected curing range shall be as approved on the working plans. The maximum temperature shall be held until the concrete has reached a minimum compressive strength of 28 MPa (4000 pounds per square inch), unless otherwise specified in the Contract.

510.11 POST-TENSIONING. Post-tensioned steel shall be bonded to the concrete, unless otherwise shown on the Plans. All prestressed reinforcement to be bonded to the concrete shall be free of dust, rust, grease, or other deleterious substances. Reinforcement that is not to be bonded to the concrete shall be galvanized or otherwise protected against corrosion as specified in the Contract.

Post-tensioning shall not commence until a compressive strength of 28 MPa (4000 pounds per square inch) has been attained.

Post-tensioning reinforcement shall be stressed by hydraulic jacking in accordance with Subsection 510.08(e). The tensioning process shall be conducted so that the applied tension and elongation of the elements may be measured at any time.

Tendons shall be stressed in the approved sequence shown on the shop drawings. Post-tensioning elements shall be placed in approved enclosures and after stressing shall be bonded by pressure grouting the space between the enclosure and the tendon. The enclosures shall be thoroughly cleaned of all foreign materials prior to grouting. The discharge ports shall be closed after all air has been forced out of the enclosure, as evidenced by the steady discharge of grout at its proper consistency. A pump pressure of at least 690 kPa (100 pounds per square inch) shall be maintained on the grout for 15 seconds to ensure the complete filling of all voids in the enclosure.

510.12 HANDLING. Handling and installation of prestressed members shall be performed with members in an up-right position and with points of support and direction of reactions in approximately the same position as designated for the final position of the member in the structures. The Contractor must receive authorization from the Agency prior to shipment or erection of any members.

Care shall be taken during storage, hoisting, and handling of the precast units to prevent cracking or damage. Units damaged by improper storing or handling shall be replaced at the Contractor's expense.

510.13 INSTALLATION.

(a) Placing Precast Concrete Members. Prestressed concrete members shall be placed on the substructure in conformance with the Contract and approved placement procedures.

(b) Mortar. Mortar used to fill keyways and dowel holes, and for fairing joints shall be Type IV. The surfaces to be mortared shall be thoroughly cleaned, wetted, and free of all standing water.

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.

(c) Fairing Surface. This work shall consist of placing mortar between precast members as required for fairing out any unevenness between adjacent units. Type IV mortar shall be used. Placement shall be at the same time mortar is placed to fill shear keys between members.

The mortar shall be placed to the thickness necessary 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.

510.14 METHOD OF MEASUREMENT. The quantity of Prestressed Concrete Members to be measured for payment will be the number of each type and size specified and used in the complete and accepted work.

510.15 BASIS OF PAYMENT. The accepted quantity of Prestressed Concrete Members will be paid for at the Contract unit price each for the type and size specified. Payment will be full compensation for detailing, fabricating, quality control testing, transporting, handling, and installing the material specified, including the concrete, reinforcement, prestressing steel, transverse ties, enclosures for prestressing steel, anchorages, mortar, anchor rods, and any other material contained within or attached to the unit(s), and for furnishing all labor, tools, equipment, and incidentals necessary to complete the installation of the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 510.20 Prestressed Concrete Member (type and size) | Each |

## SECTION 511 - STRUCTURAL PLATE PIPES, PIPE ARCHES, AND ARCHES

511.01 DESCRIPTION. This work shall consist of detailing, fabricating, furnishing, and erecting short and long span corrugated structural plate pipes, pipe arches, or arches at locations shown on the Plans.

"Long Span Structures" are structural plate structures as defined in Division I of the AASHTO *Standard Specifications for Highway Bridges*.

511.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Sand Borrow and Cushion | 703.03 |
| Granular Borrow | 703.04 |
| Stone Bedding | 704.02 |
| Granular Backfill for Structures | 704.08 |
| Joint Sealer, Hot Poured | 707.04 |
| Joint Sealer, Polyurethane | 707.05 |
| Structural Plate, Bolts and Nuts | 711.06 |
| Metal Bin-Type Retaining Wall | 712.01 |
| Timber Cribbing | 712.03 |
| Bar Reinforcement | 713.01 |
| Structural Steel | 714.02 |

Concrete shall be of the class specified in the Contract and shall conform to the requirements of Section 501.

Any welding required during fabrication or assembly shall be performed in accordance with Subsection 506.10.

The sizes, dimensions, and thicknesses of structural plate pipes, pipe arches, and arches shall be as shown on the Plans. Stone bedding shall conform to the size requirements of Table 704.02B.

511.03 PLANS AND WORKING DRAWINGS (LONG SPAN STRUCTURES ONLY). The Contractor shall submit both detailed fabrication drawings and construction drawings in accordance with Subsection 105.03 for any composite pipe, pipe arch, or arch, including, when applicable, headwalls, wingwalls, and other incidental items.

511.04 INSTALLATION SUPERVISION (LONG SPAN STRUCTURES ONLY). The Contractor shall arrange to have a qualified representative of the manufacturer continuously on the project during the installation and backfill of any composite structures. The representative will be responsible for approving the preparation of the foundation, the bedding, assembly of the structure, and all backfilling within the limits specified for Granular Borrow. The qualifications and performance of the representative shall be acceptable to the Engineer.

511.05 FOUNDATION. Foundation material on which bedding is to be placed shall be compacted to a uniform density, graded, and carefully shaped to fit the curvature of pipes, pipe arches, or footings of arches. Unless otherwise specified, the foundation for pipes and pipe arches shall be shaped for a depth of not less than 10 percent of their total height.

Where ledge or boulders are encountered at the invert grade of pipes and pipe arches, the formation shall be removed a minimum of 300 mm (12 inches) below the invert grade and replaced with granular backfill for structures, sand borrow, or stone bedding as directed by the Engineer.

Where soft, spongy, or other unstable material is encountered at the foundation level it shall be removed to the width and depth specified in the Contract or ordered by the Engineer. Backfill shall be granular backfill for structures, sand borrow, or stone bedding and shall be compacted to the satisfaction of the Engineer.

511.06 BEDDING. Pipes and pipe arches shall be bedded on a 75 mm (3 inch) blanket of loose sand borrow that has been graded and carefully shaped with a template to fit their bottom curvature.

511.07 CAMBER. The invert grade of the structure shall be cambered as shown on the Plans or as ordered by the Engineer.

511.08 ASSEMBLY. The plates shall be unloaded and handled with reasonable care. Galvanizing or other coatings shall be intact, and all plates damaged by dragging over the ground, or struck against rock or other objects during placement shall be repaired or rejected as directed by the Engineer.

Steel bolts for structural steel plate sections shall be initially torqued during installation to 270 ± 70 N•m (200 ± 50 pounds-force foot). Final tightening shall be to 340 ± 70 N•m (250 ± 50 pounds-force foot). Steel bolts for aluminum plate sections shall be initially torqued during installation to 200 ± 35 N•m (150 ± 25 pounds-force foot) and retorqued as required to obtain a final torque of 200 ± 35 N•m (150 ± 25 pounds-force foot). Bolts shall be of sufficient length to provide for a full nut engagement of the threads.

Structural plate pipes, pipe arches, and arches shall be assembled in accordance with the Plans and detailed erection instructions. They may be assembled in their final location or adjacent to it and then placed on the prepared bed. Elongated circular pipe shall be installed with the longer axis vertical.

Any bin-type retaining walls or headwalls included as part of a Section 511 item shall be assembled and constructed in accordance with Section 526.

Structural aluminum alloy plate that is to be in contact with concrete, stone, or masonry shall have the contact surface thoroughly coated with an approved coating, which shall be allowed to dry before installation.

For plate arches, the galvanized steel bearing shapes shall be completely filled with either a hot-poured joint sealer or a polyurethane joint sealer.

The concrete footings for plate arches shall be constructed in accordance with the details shown on the Plans and the excavated areas shall be backfilled to the flow line before assembly of the structural plate arch is begun.

511.09 BACKFILLING. Granular material for backfilling of structural plate structures shall be placed within the limits shown on the Plans. Structures up to 4.6 m (15 feet) span shall have 1 m (3 feet) of cover and structures with over 4.6 m (15 feet) of span shall have 1.5 m (5 feet) of cover before permitting heavy construction equipment to pass over them during construction.

Backfill material shall not be placed against any structure anchored to concrete until the concrete has reached a minimum compressive strength of 17 MPa (2500 pounds per square inch).

Backfill materials shall be placed uniformly on both sides of any structure. The layers shall not exceed 150 mm (6 inches) in depth and the differential level from one side to the other shall not exceed 300 mm (1 foot). Special care shall be taken to thoroughly compact each layer by means of mechanical tampers for the full width of trench and above any trench for a distance each side as specified in the Contract, but not less than a full diameter or span each side of the structure. Compaction equipment used and its method of operation shall be approved by the Engineer. Equipment or procedures that cause distortion or damage will not be allowed.

Each layer of backfill shall be compacted for its full width, to not less than 90 percent of the maximum dry density as determined by AASHTO T 180, Method C. The field density determination will be made on at least every third layer in accordance with AASHTO T 191, by the Agency's nuclear method, or by other approved procedures. Moisture content requirements shall conform to Subsection 203.11(d).

Restricted fill placement shall continue uniformly on both sides until a specified minimum cover of compacted material is obtained above the top of the structure or until subgrade is reached.

Backfilling shall conform to the following:

(a) Backfilling Arches with Half Height (or Less) Headwall. The fill material shall first be placed midway between the ends of the arch by covering both sides and the crown with a narrow ramp (place fill material against and over the arch in uniform layers). The backfill material shall be thoroughly compacted by means of mechanical tampers, as it is placed. After the ramp has been built over the crown, continue placing backfill by widening the ramp uniformly toward both ends, as evenly as possible, each layer conforming to the shape of the arch and thoroughly compacted by means of mechanical tampers as the work progresses.

Headwalls above the flow line shall not be constructed until the ramp described above has been constructed.

(b) Backfilling Arches with Full Height Headwalls. The fill material shall first be placed against each headwall, covering the sides and crown of the arch with a narrow ramp as described above. After both ends have been backfilled and compacted, placement of the fill shall continue equally towards the center.

(c) Backfilling Composite Structures (Long Span Structural Plate Structures). The fill shall be brought up to the base of the thrust beams (continuous longitudinal structural stiffeners) and suspended until the thrust beams have been constructed and the concrete attains a compressive strength of 17 MPa (2500 pounds per square inch). Backfill placed above the thrust beams shall follow the procedures specified above for arches.

511.10 MOVEMENT CONTROL (LONG SPAN STRUCTURES ONLY). Monitoring the movement of long span structures during the backfilling operation is a critical part of the installation.

Prior to placing any backfill material against a structure, basic dimensions for its rise, span, and alignment shall be measured and recorded. The tools and methods used to check movement shall be recommended by the fabricator and approved by the Engineer. The proposed details shall be submitted for review and approval with the construction drawing. The method of measurement used shall be accurate to the nearest 5 mm (1/4 inch).

Heavy compaction adjacent to any structure can cause distortion or rotation of the unit. Frequent measurements of the structure's geometry will be necessary to observe any undesirable movement during backfilling.

The frequency of measurement should vary with the rate of the backfilling operation and type of compaction equipment used. Heavy continuous compaction could move a structure quickly, thus requiring measurements for every lift. Large vibratory compaction equipment will not be permitted within the limits of Granular Borrow.

Upon constructing the backfill to subgrade level, the monitoring process shall continue at least on a monthly frequency until the project is accepted.

During backfilling, the structure shall not deviate from its designed sectional configuration by more than 2 percent or out of alignment by more than 75 mm (3 inches). At any time during the backfilling operation (up to and including the level of

the subgrade), should the rise, the span, the radii, or the alignment deviate outside the above tolerance limitation, the Contractor shall remove sufficient backfill material to allow the structure to return to its specified shape. The Contractor shall not resume placement of any backfill material until the Engineer is satisfied that the placement procedures will permit the structure to stay within the tolerances specified.

511.11 LONGITUDINAL STRUCTURAL STIFFENERS (LONG SPAN STRUCTURES ONLY). Longitudinal structural stiffeners (thrust beams) may be either reinforced concrete or structural metal plate filled with concrete. Concrete shall be Class B and shall meet the requirements of Section 501. Reinforcing steel shall meet the requirements of Subsection 713.01 and shall be placed in accordance with Section 507. The metal plate shall meet the requirements of Subsection 711.06.

511.12 DAMAGES. Any place where the galvanizing has been damaged by cutting, burning, welding, placing, or any other means shall be repaired by thoroughly cleaning the damaged areas, preparing the surface, and applying an approved coating in accordance with AASHTO M 167M.

511.13 METHOD OF MEASUREMENT. The quantity for each plate structure to be measured for payment will be on a unit basis as shown on the Plans and specified in the Contract.

511.14 BASIS OF PAYMENT. The accepted quantity for each plate structure will be paid for at the Contract unit price for each structure. Payment will be full compensation for detailing, fabricating, furnishing, transporting, handling, and assembling the structure and for furnishing all supervision, labor, tools, equipment, field painting, joint sealer, and incidentals necessary to complete the work. For long span structures, the unit price will also include the furnishing and installation of all materials required for structural longitudinal stiffeners. When the designated Contract item includes headers and wings, the lump sum price will include furnishing and installation of these components.

Excavation will be measured and paid for as provided in Section 204. Granular borrow will be measured and paid for as provided in Section 203.

Backfill material required to replace poor foundation material, to fill bin-type retaining walls, or to backfill concrete retaining structures will be measured and paid for as Granular Backfill for Structures. Any material authorized by the Engineer to be used for bedding will be measured and paid for as Granular Backfill for Structures.

The headwalls, substructures, slope protection material, and specified backfill will be measured and paid for as provided under the appropriate Contract item for the type of material used, unless otherwise specified in the Contract.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 511.15 Corrugated Galvanized Metal Plate Pipe | Each |

| | | |
|---|---|---|
| 511.16 | Corrugated Galvanized Metal Plate Pipe Arch | Each |
| 511.20 | Corrugated Galvanized Metal Plate | Each |
| 511.25 | Corrugated Aluminum Alloy Plate Pipe | Each |
| 511.30 | Corrugated Aluminum Alloy Plate Pipe Arch | Each |
| 511.35 | Corrugated Aluminum Alloy Plate Arch | Each |
| 511.40 | Corrugated Galvanized Long Span Metal Plate Structure | Each |
| 511.45 | Corrugated Galvanized Long Span Metal Plate Structure with Headers and Wings | Lump Sum |

## SECTION 513 - PAINTING

THIS SECTION RESERVED

## SECTION 514 - WATER REPELLENT

514.01 DESCRIPTION. This work shall consist of furnishing and applying water repellent on exterior concrete surfaces.

514.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Boiled Linseed Oil .....726.02
Mineral Spirits.....726.03

The water-repellent solution shall be a 50-50 (by volume) mixture of boiled linseed oil and mineral spirits.

514.03 PREPARATION OF SURFACE. All surfaces on which the water repellent is to be applied shall be clean and thoroughly dry. Dirt, grease, asphalt, tar, stains, or resinous materials shall be removed from the surfaces, by approved methods, prior to application of the water repellent.

New concrete shall have been in place a minimum of 40 days and shall be free from precipitation for 48 hours prior to application of repellent.

514.04 APPLICATION. The water repellent shall be applied by brush, spray or roller. If a spray technique is used, the material shall be forced from the nozzle in an easy stream and not atomized. The nozzle shall be held close to the surface being treated.

Normal coverage shall be made in two applications. However, a third application may be ordered when, in the Engineer's opinion, it becomes necessary to ensure that the surface is adequately sealed. The solution shall be applied at the following rates per liter (gallon):

| | |
|---|---|
| 1st application: | 6 to 7 $m^2$ (28 to 33 square yards) |
| 2nd application: | 11 to 12 $m^2$ (50 to 60 square yards) |
| 3rd application: | 11 to 12 $m^2$ (50 to 60 square yards) |

The second and third applications shall be made only after the previous coat is thoroughly dry.

No application shall be made when either the temperature of the surface to be treated or the ambient temperature is below 10 °C (50 °F) except as modified below, and then only with the approval of the Engineer.

If it is necessary to apply water repellent at temperatures below 10 °C (50 °F), three applications shall be made. The application rate for each liter (gallon) of solution shall be 11 to 12 $m^2$ (50 to 60 square yards). In no case shall this material be applied when either the temperature of the surface to be treated or the ambient air temperature is below 2 °C (35 °F).

Unless otherwise specified, water repellent shall be applied to all exposed concrete surfaces of bridges, except the bottom surfaces of decks between drip beads.

514.05 PROTECTION. After application of the water repellent, the surface shall be protected against precipitation for at least six hours. If an unprotected surface treated with water repellent is subjected to precipitation within a period of six hours after application, the surface shall be retreated to the satisfaction of the Engineer at the Contractor's expense.

514.06 METHOD OF MEASUREMENT. The quantity of Water Repellent to be measured for payment will be the number of liters (gallons) of solution applied in the complete and accepted work, measured to the nearest liter (gallon).

514.07 BASIS OF PAYMENT. The accepted quantity of Water Repellent will be paid for at the Contract unit price per liter (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 |
|---|---|
| 514.10 Water Repellent | Liter (Gallon) |

## SECTION 516 - EXPANSION DEVICES

516.01 DESCRIPTION. This work shall consist of furnishing and installing expansion devices.

516.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Joint Sealer, Preformed Neoprene | 707.06 |
| Preformed Fabric Material | 707.07 |
| Joint Sealer, Butyl Rubber Tape | 707.12 |
| Structural Steel | 714.02 |
| High-Strength Low-Alloy Structural Steel | 714.03 |
| Carbon Steel Bolts and Nuts | 714.04 |
| High-Strength Bolts, Nuts and Washers | 714.05 |
| Welded Stud Shear Connectors | 714.10 |
| Epoxy Bonding Compound | 719.02 |

Galvanizing shall conform to AASHTO M 111M/M 111 or AASHTO M 232M/M 232, and metalizing shall conform to Subsection 506.15(b).

516.03 FABRICATION DRAWINGS. The fabricator of the expansion devices furnished under this Section shall submit detailed shop drawings in accordance with Subsections 105.03 and 506.04.

516.04 FABRICATION. Material furnished under this Section shall conform to all applicable provisions of Subsections 506.03 through 506.18.

Assemblies shall be fabricated to the designed roadway cross-section within 3 mm (1/8 inch) tolerance of the theoretical dimensions at any point.

Unless otherwise specified, all expansion devices shall be galvanized or metalized in accordance with Subsection 506.15.

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 whole unit except that curb 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 all applicable provisions of Subsections 506.19 through 506.25.

Final gap adjustments of an expansion joint assembly shall be made during installation in accordance with the movement chart shown on the Plans, shop drawings, or as directed by the Engineer.

Joint assemblies shall be properly positioned within 3 mm (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 epoxy bonding compound. Application of the epoxy bonding compound shall be done in accordance with Section 530.

516.06 METHOD OF MEASUREMENT. The quantity of Bridge Expansion Joint to be measured for payment will be the number of meters (linear feet) used in the complete and accepted work, measured along its centerline.

516.07 BASIS OF PAYMENT. The accepted quantity of Bridge Expansion Joint will be paid for at the Contract unit price for the Contract items specified. Payment will be full compensation for detailing, furnishing, handling, transporting, and placing the material specified, including nondestructive testing of welds, surface preparation, protective coating, and epoxy bonding compound, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 516.10 Bridge Expansion Joint | Meter (Linear Foot) |

## SECTION 519 - SHEET MEMBRANE WATERPROOFING

519.01 DESCRIPTION. This work shall consist of the application of a reinforced asphalt, synthetic resin, or coal-tar based preformed sheet membrane to bridge decks to serve as a waterproof barrier between the concrete deck and the bituminous concrete surface pavement. The system shall include 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.

519.02 MATERIALS. The membrane materials used shall be one of the sheet membranes and the necessary associated materials on the Approved Products Listing on file and maintained by the Agency's Materials and Research Section, telephone: (802) 828-2561.

519.03 WEATHER LIMITATIONS. Waterproofing shall not be done in wet weather or when the temperature is below 5 °C (40 °F) , without the authorization of the Engineer.

519.04 SURFACE PREPARATION. 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. The area of the bridge decks 1 m (3 feet) from the face of the curbs and for the full length of the curbs shall be blast cleaned. The blast cleaning shall include the vertical face of the curbs and expansion dams to the height of the specified finish pavement surface elevation. Any other areas of the deck with severe laitance shall also

be blast cleaned. The Engineer or Inspector shall check all drain tubes to ensure they are free of obstructions. The location and offset of each tube shall be marked on the face of the curb so that each tube can be relocated following installation of the membrane.

519.05 CONSTRUCTION DETAILS.

(a) Primer Application. The primer shall be mixed thoroughly before use. It shall be applied by roller over the horizontal deck surface to a point approximately 100 mm (4 inches) from each curb face. The primer shall be applied at the manufacturer's recommended application rate. Heavy applications shall be avoided with any build up eliminated by brushing out the excess material. The primer shall be allowed to dry to a tack free condition prior to applying the membrane. The surface shall be reprimed if it has become contaminated with dust or dirt or if the membrane has not been applied within 24 hours.

(b) Treatment Adjacent to Curb Face and Expansion Dams. The treatment adjacent to the curbs and dams shall be as follows:

(1) The two-component polyurethane, which is acceptable for use with the membrane system selected, shall be mixed and applied on the unprimed 100 mm (4 inch) wide area adjacent to each curb face. The application shall be made at the rate of 2.5 to 3 m/L (30 to 40 linear feet per gallon). A narrow squeegee or paintbrush shall be used to apply a coating of the material approximately 75 mm (3 inches) up the curb face, or a minimum of 15 mm (1/2 inch) above the top of the mortar fillet. To ensure a build up of material on the vertical face, the squeegee or paint brush shall be used to rework material up the curb face immediately prior to the installation of the first strip of preformed sheet membrane. The pot life of the mixed material may vary from 15 to 60 minutes depending on ambient air temperature. Mixed material that has started to thicken in the container must be discarded.

(2) The first strip of membrane material shall be placed into the polyurethane membrane while it is still liquid (five to 20 minutes after application). The sheet membrane shall overlay the polyurethane membrane by approximately 50 mm (2 inches), which will place the edge of the sheet on the horizontal portion of the deck at the base of the mortar fillet. Pressure shall be applied along the edge of the sheet membrane in order to force any excess liquid sealant from beneath the membrane.

(3) Before the polyurethane membrane has cured to a tack free condition, a second coat of the material shall be applied over the edge of the sheet membrane and on the curb face at the rate of 4 to 5 m/L (50 to 60 linear feet per gallon). The application shall be made in a manner that will ensure a minimum 25 mm (1 inch) overlap onto the membrane sheet.

(c) Sheet Membrane Installation. Additional rolls of the 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. A chalk line shall be used to ensure

proper alignment of each roll. The ends of strips shall be staggered to prevent excessive overlapping of the membrane. The membrane shall be pressed or rolled into place as the installation progresses to ensure a bond with the primed surface and to avoid entrapment of air between the membrane and the deck. Rolling shall be accomplished with a light duty vehicle such as a pickup truck or with a heavy-duty segmented linoleum roller.

The membrane sheet shall be overlapped a minimum of 50 mm (2 inches) laterally and 150 mm (6 inches) on end laps. If the installation cannot be completed in a single day, the perimeter of the membrane shall be sealed with mastic to prevent the intrusion of moisture. An X-shaped slit shall be cut in the membrane directly over the drain tubes to allow the dissipation of moisture that collects between the membrane and the bituminous overlay.

If any large air bubbles develop, they shall be eliminated prior to paving by slitting the membrane at a nearly horizontal angle and forcing the air out. These punctures and any damaged areas found shall be repaired by applying a bead of mastic completely around the area and applying a patch of the membrane over the mastic.

If blisters develop during paving, they shall be eliminated by puncturing the pavement and membrane with an ice pick or other sharp instrument at a nearly horizontal angle.

519.06 PROTECTION OF MEMBRANE. No traffic shall be permitted on an exposed membrane surface. 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.

The specified bituminous overlay shall be placed on the membrane within three days after application. Failure to adhere to this requirement may result in the development of an excessive amount of blisters prior to, during, and following the pavement application.

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 sheet membrane waterproofing shall be as recommended by the membrane manufacturer and approved by the Engineer.

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.

519.07 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.

519.08 METHOD OF MEASUREMENT. The quantity of Sheet Membrane Waterproofing to be measured for payment will be the number of square meters (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.

519.09 BASIS OF PAYMENT. The accepted quantity of Sheet Membrane Waterproofing will be paid for at the Contract unit price per square meter (square yard). Payment will be full compensation for furnishing, transporting, handling, and placing the waterproofing system specified, including primer, 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 |
|---|---|
| 519.20 Sheet Membrane Waterproofing | Square Meter (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 | 707.04(a) |
| Coatings for Wood | 708.05 |
| Structural Lumber and Timber | 709.01 |
| Miscellaneous Hardware | 709.01(g) |
| Nonstructural Lumber | 709.02 |
| Structural Glued Laminated Timber | 709.03 |
| Timber Preservative | 726.01 |
| Waterproofing Pitch | 726.05 |

Material furnished under this Section shall conform to the requirements of AASHTO M 168.

Unless otherwise specified, all metal parts and hardware shall be galvanized in accordance with AASHTO M 111M/M 111 or AASHTO M 232M/M 232.

522.03 GENERAL FABRICATION REQUIREMENTS. Glued laminated timber furnished under this Section shall be fabricated by an AITC licensed laminator and shall comply with AITC A190.1. In addition to being a licensed laminator, the fabricator must 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 2 mm (1/16 inch) of the details specified.

522.04 DRAWINGS. Unless otherwise specified, as soon as practical after award of the Contract, the Contractor shall prepare fabrication or construction drawings necessary for performance of the work in accordance with Subsection 105.03 and applicable requirements of Subsection 506.04.

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 300 mm (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, courses, and the ground.

Untreated timber and lumber shall be stored under cover. The covering shall adequately protect it from direct and blowing rain or snow and yet provide full circulation of air. When authorized by the Engineer, treated material may be left uncovered.

Fabricated material shall be stored in a manner that will prevent dimensional changes in the members prior to assembly.

522.06 QUALITY OF WORK. Quality of work shall be first-class throughout. All framing shall be true and exact. Nails and spikes shall be driven with the heads set flush with the surface of the wood. Wood surfaces shall be free from deep or frequent hammer marks.

522.07 HANDLING. Material shall be carefully handled to avoid damaging the edges or surface and to keep it 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.

522.08 FRAMING. Lumber and 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. No shimming will be permitted in making joints, and open joints will not be accepted.

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 522.14.

522.09 CONNECTIONS.

(a) Holes for Bolts, Dowels, Rods, and Lag Screws. Holes for round drift-bolts and dowels shall be bored with a bit 2 mm (1/16 inch) less in diameter than the bolt or dowel to be used. The diameter of holes for square drift-bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit the same diameter as the bolt, except as required for timber connectors.

Holes for rods shall be bored with a bit 2 mm (1/16 inch) greater in diameter than the rod.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

(b) Countersinking. Countersinking shall be done wherever smooth faces are required. All recesses in treated timber formed for countersinking shall be painted with hot creosote oil. Recesses likely to collect injurious materials shall be filled with hot pitch or a hot-poured joint sealer 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, which would otherwise come in contact with wood.

All nuts shall be effectively locked after they have been finally tightened.

(d) Timber Connectors. Timber connectors may be either the split ring, shear plate, or spike grid type. The split ring and the shear plate shall be installed in precut grooves of dimensions as recommended by the manufacturer. The spike grid shall be forced into the contact surfaces of the timbers 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 2 mm (1/16 inch) larger in diameter than the bolt.

(e) Framed Bents. Framed bents shall be constructed in accordance with Division II, Section 16 of the AASHTO *Standard Specifications for Highway Bridges* and interim specifications in effect on the date of the Contract.

522.10 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.

522.11 TRUSS HOUSING. The carpentry on truss housings shall be equal in all respects to the best house carpentry. The finished appearance of the housing is considered of primary importance and 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 built after the removal of the falsework and the adjustment of the trusses to correct alignment and camber.

522.12 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 joists. The planks shall be laid heart side down, with 6 mm (1/4 inch) openings between them. Each plank shall be securely spiked to each joist. The planks shall be carefully graded as to thickness and so laid that no two adjacent planks shall vary in thickness by more than 2 mm (1/16 inch). Unless otherwise specified, the lengths of planks shall be full width of the designed cross-section.

Two-ply timber floors shall consist of two layers of planking supported on stringers or joists. The top course may be laid either diagonal or parallel to the centerline of roadway, and each plank shall be securely fastened to the lower course. Joints in the top layer shall be staggered at least 1 m (3 feet) apart. Care shall be taken to securely fasten the ends of each plank. At ends of the bridge, the decking shall be beveled to match the approach surface.

(b) In-Place Laminated Decking. Deck material shall be of the grade specified. The lumber (plank) shall be placed on edge, at right angles to the centerline of roadway. Unless otherwise specified, the lengths of planks shall be full width of the designed cross-section. Each plank shall be spiked to the preceding board at each end and at intervals of approximately 450 mm (18 inches) with the spikes driven alternately near the top and bottom edges. The spikes shall be of sufficient length to pass through two planks and at least halfway through the third plank.

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 the use of approved galvanized metal clips. Care shall be taken to have each strip vertical and tight against the preceding one and bearing evenly on all the supports.

(c) Glued Laminated Decking. Glued laminated deck material shall be furnished and installed in accordance with the Contract, approved shop drawings, or as directed by the Engineer.

522.13 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 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 15 mm (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.

522.14 PRESERVATIVE TREATMENT.

(a) Pressure Treatment. Lumber and timber shall be pressure treated with the type of preservative specified in the Contract. When a specific type or options are not specified, Type II preservative shall be used.

(1) Treatment of Cuts, Abrasions, and Bolt Holes. Cuts, abrasions, and holes bored after treatment shall be treated with the same preservative as the type used to treat the product. Cuts and abrasions shall be carefully trimmed prior to treatment. Holes left unfilled shall be filled with plugs treated with the same preservative as the product. Application of the preservatives shall be as follows:

a. Creosote Preservative. Apply two coats of a hot mixture of 60 percent creosote and 40 percent coal-tar pitch. Creosote shall meet the requirements of ASTM D 43, and the coal-tar pitch shall meet the requirements of ASTM D 450, Type II. The temperature of the mixture shall be between 66 and 93 °C (150 and 200 °F).

b. Oil-Borne Penta Preservative. Apply two coats of the same oil-borne preservative mixture used for pressure treating the product with a toxicant concentration of pentachlorophenol of not less than 5 percent of the solution by mass (weight).

c. CCA Water-Borne Preservative. Apply two coats of the same water-borne preservative mixture used for pressure treating the product with a minimum of 5 percent concentration of CCA in solution.

(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 plugs treated with the same preservative as the material.

(b) Field Treatment. When field applications of preservatives are specified, the materials shall be furnished, prepared, and applied in accordance with AWPA Standard M4.

522.15 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.

Paint or stain shall be applied in accordance with Section 513.

522.16 METHOD OF MEASUREMENT. The quantity of Structural Lumber and Timber and of Nonstructural Lumber to be measured for payment will be the number of cubic meters [thousand feet board measure (MFBM)] incorporated into the complete and accepted work, as computed from the nominal sizes of the actual in-place lengths. [If round timbers are specified, the number of board feet will be computed by the Vermont Log Rule: Board Feet = $(D \times R \times L)/12$; where D=diameter in inches, measured under the bark at the small end; R=D/2; and L=length in feet.]

The quantity of Structural Glued Laminated Timber to be measured for payment will be on a lump sum basis for each structure or each structural unit in the complete and accepted work.

522.17 BASIS OF PAYMENT. The accepted quantity of Structural Lumber and of Timber and of Nonstructural Lumber will be paid for at the Contract unit price per cubic meter [thousand feet board measure (MFBM)]. The accepted quantities of Structural Glued Laminated Timber will be paid for at the Contract lump sum price. Payment for each quantity will be full compensation for detailing, furnishing, transporting, handling, placing or erecting, and painting or treating the material specified, including all hardware; for providing all falsework, forms, bracing, sheeting, or other timber used for erection purposes; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 522.20 Structural Lumber and Timber - Untreated | Cubic Meter (MFBM) |
| 522.25 Structural Lumber and Timber - Treated | Cubic Meter (MFBM) |
| 522.30 Nonstructural Lumber - Untreated | Cubic Meter (MFBM) |
| 522.35 Nonstructural Lumber - Treated | Cubic Meter (MFBM) |
| 522.40 Structural Glued Laminated Timber | Lump Sum |

## SECTION 523 - BLAST CLEANING OF CONCRETE SURFACES

523.01 DESCRIPTION. This work shall consist of surface preparation of portland cement concrete surfaces.

523.02 MATERIALS. Abrasives used for blast cleaning shall be either clean dry sand, mineral grit, steel shot, or steel grit, at the option of the Contractor, and shall be of a grading suitable to produce satisfactory results.

523.03 CONSTRUCTION DETAIL. Portland cement concrete surfaces shall be blast cleaned to sound durable material. Residues from this operation shall be removed by vacuuming or high pressure air blast.

Equipment used for blast cleaning shall be provided with suitable traps to prevent water or oil from being deposited on the surface.

The prepared portland cement concrete surface shall be approved by the Engineer prior to the placing of any surface treatment.

523.04 METHOD OF MEASUREMENT. The quantity of Blast Cleaning of Concrete Surfaces to be measured for payment will be the number of square meters (square yards) of cleaned concrete surface in the complete and accepted work, measured in place between the limits shown on the Plans or ordered by the Engineer.

523.05 BASIS OF PAYMENT. The accepted quantity of Blast Cleaning of Concrete Surfaces will be paid for at the Contract unit price per square meter (square yard). Payment will be full compensation for performing the work specified and for furnishing all labor, tools, material, equipment, and incidentals necessary to complete the work acceptably to the Engineer.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 523.10 Blast Cleaning of Concrete Surfaces | Square Meter (Square Yard) |

## SECTION 524 - JOINT SEALER

524.01 DESCRIPTION. 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:

| | |
|---|---|
| Joint Sealer, Hot Poured | 707.04(a) |
| Joint Sealer, Cold Poured | 707.04(b) |
| Backer Rod | 707.04(c) |
| Joint Sealer, Polyurethane | 707.05 |
| Bond Breaker | 707.05(c) |
| Joint Sealer, Preformed Neoprene | 707.06 |

Joints sawn in bituminous concrete pavement shall be filled and sealed with either hot poured or cold poured joint sealer, appropriate backer rod, and an approved bond breaker.

The Contractor may contact the Vermont Agency of Transportation, Materials and Research Section, National Life Building, Montpelier, Vermont 05633-5001, to obtain the names of products approved for use to seal these joints.

524.03 TEMPERATURE LIMITATIONS. The joint sealers shall be applied, preferably, when both the ambient air and pavement temperatures are above 10 °C (50 °F). In no event shall either the ambient air or pavement temperature be less than 5 °C (40 °F) at the time of application.

524.04 SAWED JOINTS. Where shown on the Plans, the 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."

When placing new bituminous concrete pavement, each lift of pavement shall be scored with a single blade cut to a depth of 75 percent of the lift thickness, at the location of the center of the proposed joint. This will be completed prior to exposing the location to traffic or, where traffic is not maintained the same working day as 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. The Engineer may allow the Contractor an additional 48 hours to cut and seal the joint, if the joint location will not be exposed to traffic.

The width of the sawed joint shall be as shown on the Plans or may be adjusted for seasonal temperature variations by the Engineer. In general, the depth of the sealant will be approximately 50 percent 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 approved and on the project 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 of sealers.

(a) Prior to placing poured or preformed joint sealers, the vertical faces of the sawed joint and the horizontal pavement surfaces within 25 mm (1 inch) of the joint edge shall be thoroughly sandblasted to improve joint sealant adhesion. The resulting dust, sandblast 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 use all necessary precautions to avoid contaminating the other project construction work with the removed dust and debris.

(b) Prior to placing polyurethane joint sealer, the concrete surface shall be sandblasted to remove surface mortar and expose underlying aggregate. Sand blasting equipment shall be 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 sandblasted.

Steel surfaces shall be sandblasted to the bare metal. Primer shall be applied immediately after the sand blasting is completed.

Epoxy mortar surfaces shall be cleaned by use of suitable solvents or by sand blasting 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 200 to 210 °C (390 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 pot before heating more material. New material shall not be added to a partially filled pot 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 3 mm (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 also 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 sandblasted, horizontal, pavement surfaces next 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 percent of both components. Mixing shall be accomplished with a variable speed drill and mixing paddle operated at speeds that are 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 must be placed within the 30 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 3 mm (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 also 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 sandblasted, horizontal, pavement surfaces next to the joint.

(c) Joint Sealer, Preformed Neoprene. Procedures for placing of preformed neoprene joint sealer shall be in accordance with the manufacturer's recommendations. Neoprene joint sealer shall be of the size and cross-section shown on the Plans and shall be furnished and installed in one continuous length for each joint.

Prior to placing the preformed material, the sides of the joint shall be treated with an approved lubricant-adhesive.

The joint material shall be thoroughly cleaned, compressed, and carefully placed in the joint so that the top is slightly below the adjacent surface and free from an objectionable amount of curling or twisting. Stretching of materials to facilitate installation will not be allowed.

The ends of the joint filler shall be plugged with styrofoam or neoprene sponge inserts to prevent the admission of foreign matter.

(d) 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 as approved by the Engineer, shall be applied to those surfaces where bond is not desired.

Primer material(s) 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 prescribed 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.

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 impervious material to prevent contact with 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 meters (linear feet) or the number of liters (gallons) 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 set forth in the Contract. Payment will be full compensation for furnishing, handling, placing, and installing the specified materials, including any required backer rod or bond breaker, lubricants, primers, or bonding agents; for preparing and 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 |
|---|---|
| 524.10 Joint Sealer, Hot Poured | Liter (Gallon) |
| 524.11 Joint Sealer, Hot Poured | Meter (Linear Foot) |
| 524.12 Joint Sealer, Cold Poured | Liter (Gallon) |
| 524.13 Joint Sealer, Cold Poured | Meter (Linear Foot) |
| 524.15 Joint Sealer, Preformed Neoprene | Meter (Linear Foot) |
| 524.20 Joint Sealer, Polyurethane | Liter (Gallon) |
| 524.21 Joint Sealer, Polyurethane | Meter (Linear Foot) |

## SECTION 525 - RAILINGS

525.01 DESCRIPTION. This work shall consist of furnishing and erecting hand railing or bridge railing.

525.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Mortar, Type IV ..... 707.03
Grease Rustproof Compound ..... 708.04

Delineation Devices ..... 728.04
Bearing Pads ..... 731.02
Metal Hand Railing ..... 732.01
Aluminum Bridge Railing ..... 732.02
Galvanized Box Beam Bridge Railing ..... 732.03
Steel Beam Bridge Railing ..... 732.04

Galvanizing shall be applied in accordance with AASHTO M 111M/M 111 or AASHTO M 232M/M 232.

525.03 FABRICATION DRAWINGS. The fabricator of railing furnished under this Section shall submit detailed shop drawings in accordance with Subsections 105.03 and 506.04.

525.04 FABRICATION. Material furnished under this Section shall conform to all applicable provisions of Subsections 506.03 through 506.18. Railing shall be fabricated in a plant having, as a minimum, an AISC Category I Certification, or in a plant approved by the Agency. Non-certified plants must satisfy the requirements of Subsection 506.03.

Unless otherwise specified, all ferrous metal railing components shall be galvanized.

525.05 INSTALLATION.

(a) General. Railings shall be installed in conformance with all applicable provisions of Subsections 506.19 through 506.23. 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 511.12 or as directed by the Engineer.

(b) Aluminum. Aluminum alloys in contact with other materials shall be cleaned and protected as follows:

(1) Cleaning. Contact surfaces shall be thoroughly cleaned with solvent such as naphtha or turpentine so that they are free from oil, grease, and dirt.

(2) Contact with Other Metals. Aluminum in contact with copper, copper base alloys, lead, or nickel shall be thoroughly coated with an aluminum-impregnated caulking compound.

(3) Contact with Concrete, Stone, or Masonry. Posts shall be placed on 3 mm (1/8 inch) thick bearing pads. Where bond between concrete and aluminum is desired, the aluminum shall be coated with an approved sealer. The sealer shall be allowed to dry thoroughly prior to placement of any concrete.

(4) Contact with Wood. Contact surfaces with wood shall be coated with an aluminum-impregnated caulking compound.

(c) Painting. Railing required to be painted shall be coated in accordance with the applicable provisions of Section 513.

Wherever bridge railing panels are nested or overlapped full length, the surfaces on both panels that will be in contact with each other shall be coated with a grease rustproof compound.

(d) 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.

525.06 METHOD OF MEASUREMENT. The quantity of Metal Hand Railing and of Bridge Railing, of the kind specified, to be measured for payment will be the number of meters (linear feet) of the type of 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 Removal of Existing Railing, or Resetting Railing, to be measured for payment will be the number of meters (linear feet) of railing dismantled and disposed of, or reset, between the limits specified or as ordered by the Engineer.

525.07 BASIS OF PAYMENT. The accepted quantity of Metal Hand Railing and of Bridge Railing, of the kind specified, will be paid for at the Contract unit price per meter (linear foot). Payment will be full compensation for detailing, furnishing, handling, placing, delineating, galvanizing, applying grease rustproof compound, or painting the railing and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 525.10 Removal of Existing Railing | Meter (Linear Foot) |
| 525.11 Resetting Railing | Meter (Linear Foot) |
| 525.15 Metal Hand Railing | Meter (Linear Foot) |
| 525.21 Bridge Railing - 2 Rail Aluminum | Meter (Linear Foot) |
| 525.22 Bridge Railing - 3 Rail Aluminum | Meter (Linear Foot) |
| 525.23 Bridge Railing - Aluminum/Pedestrian | Meter (Linear Foot) |
| 525.30 Bridge Railing - 1 Rail Galv. Box Beam | Meter (Linear Foot) |
| 525.31 Bridge Railing - 2 Rail Galv. Box Beam | Meter (Linear Foot) |
| 525.32 Bridge Railing - Galv. Box Beam/ Pedestrian | Meter (Linear Foot) |

| | | |
|---|---|---|
| 525.40 | Bridge Railing - HD Steel Beam/ Curb Mounted | Meter (Linear Foot) |
| 525.41 | Bridge Railing - HD Steel Beam/ Fascia Mounted | Meter (Linear Foot) |
| 525.42 | Bridge Railing - HDSB/Curb Mounted/ Hand Rail | Meter (Linear Foot) |
| 525.43 | Bridge Railing - HDSB/Fascia Mounted/ Rail | Meter (Linear Foot) |

## SECTION 526 - BIN-TYPE RETAINING WALL

526.01 DESCRIPTION. This work shall consist of the furnishing and erecting of bin-type retaining wall at locations designated.

526.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Granular Backfill for Structures | 704.08 |
| Metal Bin-Type Retaining Wall | 712.01 |
| Concrete Bin-Type Retaining Wall | 712.02 |
| Timber Cribbing | 712.03 |
| Bar Reinforcement | 713.01 |
| Structural Steel | 714.02 |

The Contractor shall submit fabrication drawings and erection details for approval in accordance with Subsection 105.03 prior to fabrication of any material.

The Contractor shall assume all risks for material ordered or fabricated prior to approval of the drawings.

Concrete used for bin-type retaining walls shall conform to the requirements of Section 501 for Concrete, Class A.

526.03 GENERAL CONSTRUCTION REQUIREMENTS.

(a) Excavation. Excavation and grading for the foundation shall be made to the lines and grades specified. The entire foundation area shall be uniformly compacted to 95 percent maximum dry density in accordance with Subsection 203.11(d).

A layer of granular backfill for structures, at least 300 mm (1 foot) thick, shall be placed to cushion metal or timber bins from ledge, boulders, or concrete.

(b) Installing. The units shall be erected as shown on the Plans or approved shop drawings. Members or units shall be handled carefully and if damaged as a result of handling, storing, or erecting shall be removed and replaced at the Contractor's expense. Drilling, punching, drifting, or shimming to correct manufacturing defects will not be permitted.

All components shall conform to the detailed plans or approved shop drawings and when erected shall be in conformity with the lines, grades, and dimensions shown on the Plans.

(c) Backfilling. Granular backfill for structures shall be used for filling the interior of the wall and backfilling behind the wall. The interior and exterior fill shall progress simultaneously; shall be placed in 150 mm (6 inch) layers; and shall be thoroughly compacted to 95 percent maximum dry density in accordance with Subsection 203.11(d). The puddling method of compaction shall not be used.

526.04 METHOD OF MEASUREMENT. The quantity of Bin-Type Retaining Wall, of the kind specified, to be measured for payment will be the number of square meters (square feet) of area of the total of all front panels in the complete and accepted work. The area of each front panel will be determined by multiplying the width of each panel (center to center of the columns for metal bin-type) by the total height of each panel.

526.05 BASIS OF PAYMENT. The accepted quantity of Bin-Type Retaining Wall, of the kind specified, will be paid for at the Contract unit price per square meter (square foot). Payment will be full compensation for detailing, fabricating, transporting, handling, and installing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Excavation will be paid for at the Contract unit price per cubic meter (cubic yard) for Structure Excavation under Section 204.

Backfill will be paid for at the Contract unit price per cubic meter (cubic yard) for Granular Backfill for Structures under Section 204.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 526.10 Metal Bin-Type Retaining Wall | Square Meter (Square Foot) |
| 526.15 Treated Timber Bin-Type Retaining Wall | Square Meter (Square Foot) |
| 526.20 Concrete Bin-Type Retaining Wall | Square Meter (Square Foot) |

## SECTION 527 - MAINTENANCE OF TRAFFIC FOR BRIDGE PROJECTS

527.01 DESCRIPTION. This work shall consist of the maintenance of all traffic over the full length of the project.

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. The Contractor shall also maintain detours in accordance with Subsection 104.04 when ordered by 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.

The Contractor shall construct and maintain guardrail, lights, signs, and barricades as shown on the Plans or as directed by the Engineer. The Contractor shall provide one or more flaggers on any part of the structure or its approaches to safeguard the traveling public at such times as the Engineer may require.

If the existing structure or temporary bridge over which traffic is being maintained becomes unsafe for public travel, and if, on 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 Traffic for Bridge Projects to be measured for payment will be on a lump sum basis.

527.05 BASIS OF PAYMENT. The accepted quantity of Maintenance of Traffic for Bridge Projects 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, flaggers, material, tools, equipment, and incidentals necessary to properly maintain traffic, roadway, substructure, superstructure, and approaches. Unless the Contract includes the Contract item Flaggers, the use of flaggers will be considered incidental to other items in the Contract.

When the Contract specifically provides for Roadway Patrol Maintenance or Temporary Bridge, the Contract item Maintenance of Traffic for Bridge Projects shall only cover maintenance of traffic over the existing structure.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 527.10 Maintenance of Traffic for Bridge Projects | 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, approaches, and the barricades and lights required for the safety and convenience of the public.

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:

(a) A fully bolted connection, with high-strength bolts, designed for its location in accordance with the AASHTO *Standard Specifications for Highway Bridges*.

(b) A fully welded connection designed, welded, inspected, and tested in accordance with AASHTO 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 must be detailed on the working drawings and performed in conformance with Subsection 506.10.

528.03 DRAWINGS. Working drawings shall be prepared by the Contractor for the proposed work under this item in compliance with the provisions in Subsection 105.03. Drawings for the bridge approaches shall include plan, profile, typical section, and specific cross-sections for the temporary roadway and channel (when applicable) with complete details and identification of materials to be used. Geometrics of the temporary bridge and its approaches shall be adequate for the volume of traffic served and individual conditions encountered.

Plan, elevation, and section views of the structure shall include size and spacing of all members or components for:

Abutments
Piers
Main supporting members or stringers
Floor system
Diaphragms and lateral bracing
Railing (bridge and approach)
Curbs
Bearings
Other applicable information

528.04 DESIGN AND CONSTRUCTION DETAILS. In designing and constructing a temporary bridge, 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 percent of the waterway provided for the 100-year event (Q 100) for the new structure, with a clear height equal to a ten-year event (Q 10) headwater; this waterway to be adequate for safely conveying a mean annual flood (Q 2.33) at a headwater no greater than what would be created by the existing structure during a ten-year event.

Fill placed in or adjacent to the stream shall be clean granular or rock material meeting the requirements of Subsection 703.04 or 703.05 and protected with sufficient stone to prevent erosion to a Q 10 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. The sizing of any temporary bridges to be left in place between January 1 and May 1, or for any period greater than seven months shall be approved by the Engineer. Questions regarding hydraulic information not furnished shall be addressed to the Engineer.

(a) Roadway. Approach embankments shall be constructed of acceptable fill material, compacted to adequately support design loading requirements. A minimum of 380 mm (15 inches) of approved gravel or other acceptable surfacing material shall be provided for the full width of the typical section.

Turnouts with adequate space for two-way traffic shall be provided at each end of a one-way structure or coordinated with traffic signalization, if used.

(b) Bridge.

(1) Loading. Unless otherwise specified, all temporary bridge structures shall be designed for an MS-18 (HS-20) live load, and for all other applicable forces, in accordance with the AASHTO *Standard Specifications for Highway Bridges*. Sidewalks and pedestrian structures shall be designed for a minimum live load of 2.9 kPa (60 pounds per square foot). Materials used shall be selected and sized to provide an acceptable factor of safety within an appropriate allowable stress. The design and structural details of the temporary bridge shall be signed, stamped, and dated by a Professional Engineer (Structural or Civil).

(2) Clearances. A one-way temporary bridge shall have a minimum clear width between faces of railing of 4.4 m (14 feet, 6 inches). A two-way temporary bridge shall have a minimum clear width between faces of railing of 7.3 m (24 feet). Sidewalks and pedestrian bridges shall have a minimum clear width of 1.2 m (4 feet) between faces of railing or edge of curb and face of railing. A minimum vertical clearance of 4.3 m (14 feet) shall be provided for vehicular traffic and 2.4 m (8 feet) for pedestrian traffic.

(c) Railing. Approach railing, temporary barrier rail, and bridge railing on a structure shall conform to Subsection 621.06.

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 7.65 m (25 feet) off the ends of any structure and shall be provided for all approach fill slopes steeper than 1:3 (vertical:horizontal).

The free end of any steel beam rail shall be protected with a W-beam end section RE-6 (rounded) as defined in the *Guide to Standardized Highway Barrier Rail Hardware*, flared to a 1.25 m (4 foot) offset. The free end of any concrete barrier rail shall be flared horizontally to a 1.25 m (4 foot) offset for a minimum panel length 3 m (10 feet) and project a maximum of 150 mm (6 inches) above the adjacent roadway surface.

The top of the steel beam railing shall be 760 ± 25 mm (30 ± 1 inch) above the adjacent surface and the concrete barrier railing shall be 790 ± 25 mm (31 ± 1 inch) above the adjacent surface.

Vehicular bridge rail posts and anchorage shall be designed to withstand a horizontal loading of 8.76 kN/m (600 pounds per foot) applied 530 mm (1 foot, 9 inches) above the deck surface.

Pedestrian railing and posts shall provide protection for a height of 1070 mm (42 inches) above the walkway surface and be designed to withstand a horizontal loading of 730 N/m (50 pounds per foot) applied 1070 mm (42 inches) above the walkway surface.

When a pedestrian walkway is specified or used in conjunction with vehicular traffic, a 300 by 300 mm (12 × 12 inch) curb separation shall be provided. Curbs shall be anchored to withstand a horizontal loading of 3.65 kN/m (250 pounds per foot). The outside pedestrian railing shall be a combination of vehicular and pedestrian railing. The pedestrian railing shall be constructed to limit clearance between horizontal rail components to 150 mm (6 inches).

When temporary barrier rail is specified or used as a movable rail system (e.g., adjusting traffic flow patterns), the "concrete median barrier" specified herein shall be used. An adequate connection shall be provided when concrete median barrier is used in combination with standard steel beam rail.

(d) 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 for the in the current ADA 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. This item shall include erection, construction, and maintenance of signs, barricades, and lights specified. Flaggers shall be provided for the safety of the traveling public when directed by 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 107.18.

528.06 METHOD OF MEASUREMENT. The quantity of One-Way Temporary Bridge, Two-Way Temporary Bridge, or Temporary Pedestrian Bridge 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-Way Temporary Bridge, Two-Way 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, signs, barricades, and lights.

When a temporary bridge is accepted and open to public use, a payment of 75 percent of the lump sum will be allowed. The remaining 25 percent will be paid when the temporary bridge and its approaches have been removed and the site cleaned up 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 to be included in the Contract lump sum price for Temporary Bridge.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 528.10 One-Way Temporary Bridge | Lump Sum |
| 528.11 Two-Way Temporary Bridge | Lump Sum |
| 528.12 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. 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. If removal is by

cold planing, work shall be done in accordance with 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. Sealants or membranes shall remain in place as shown on the Plans or directed by the Engineer. 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. When the superstructure steel is to be retained for future use, a drop ball for deck removal will not be allowed. 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 shall be carefully preserved and cleaned for use in the new construction. Any bars bent or broken beyond possible use shall be replaced by welding a bar of equal diameter to the broken or bent bars 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 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.

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 damages to the portions remaining in service shall be satisfactorily repaired by the Contractor at no additional compensation. 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 meters (square yards) of bridge deck from which bituminous pavements have been removed as shown on the Plans or ordered by the Engineer.

The quantity of Removal of Structure 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 meters (cubic yards) or square meters (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 meter (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 meter (cubic yard) or square meter (square yard). Payment will be full compensation for removal and disposal of such items; for excavating, backfilling, and re-grading incidental to their removal; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 529.10 Removal of Bridge Pavement | Square Meter (Square Yard) |
| 529.15 Removal of Structure | Each |
| 529.20 Partial Removal of Structure | Each |
| 529.25 Removal of Concrete or Masonry | Cubic Meter (Cubic Yard) |
| 529.26 Removal of Concrete or Masonry | Square Meter (Square Yard) |

## SECTION 530 - EPOXY COMPOUNDS

530.01 DESCRIPTION. This work shall consist of furnishing and applying or placing epoxy compounds of the types specified in the Contract or as ordered by the Engineer.

530.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Epoxy Mortar Compound and Epoxy Mortar ..... 719.01
Epoxy Bonding Compound ..... 719.02

530.03 GENERAL CONSTRUCTION REQUIREMENTS. These compounds shall be prepared and used in accordance with manufacturer's specific instructions in addition to the requirements of this Section.

530.04 WEATHER LIMITATIONS. Epoxy compounds shall not be applied or placed between October 1 and May 15 unless authorized in writing by the Engineer.

Epoxy compounds shall be applied or placed only when all of the following conditions prevail:

(a) When the surfaces are dry.

(b) When the ambient air temperature is 5 °C (40 °F) and rising, unless otherwise specified or authorized in writing by the Engineer.

(c) When the temperature of surfaces to which epoxy compound is to be applied is greater than 5 °C (40 °F). External heat that does not leave any deleterious residue may be applied to warm and dry the surface when authorized by the Engineer.

(d) When weather and other conditions are favorable to the performance of satisfactory work as determined by the Engineer.

530.05 CURING AND PROTECTION. Epoxy compounds covered in this Section are self-curing thermosetting materials. Curing periods will vary with each compound and are affected by temperatures, sunlight, and wind. During the curing period, the Contractor shall provide protection from the elements, traffic, personnel, and equipment. Any damage to the compound due to the Contractor's negligence shall be repaired to the satisfaction of the Engineer at the Contractor's expense.

530.06 STORAGE AND MATERIALS. All materials required for the preparation and application of the compounds specified under this Section shall be stored in a dry enclosed area. The containers of the compound components shall be kept tightly sealed, elevated from concrete floors, and maintained at a temperature not less than 10 °C (50 °F) or greater than 29 °C (85 °F) for at least 24 hours prior to their use. It is recommended that the compound components be preconditioned between 21 and 27°C (70 and 80 °F) prior to use.

530.07 PREPARATION.

(a) General. Epoxy compounds shall not be applied to portland cement concrete surfaces until a minimum of 14 calendar days have elapsed after placement, except that epoxy bonding compound may be applied after three days have elapsed. Surfaces to which epoxy compounds are to be applied shall be free of moisture, grease, oil, paint, dust, rust, mill scale, loose aggregate, laitance, curing compound residues, rubber residues, wax treatments, tar, or other contaminants. Surface preparation shall be coordinated closely so that the compound can be applied promptly. Voids and cracks shall be filled and sealed with the epoxy compound prior to the overall application.

(b) Cleaning. Equipment used for sand blasting and air blasting shall be equipped with suitable traps to prevent water or oil from being deposited on the surface being cleaned.

(1) Metal surfaces shall be sandblasted until free of paint, scale and rust and then cleaned of dust and residue. The entire surface shall be sandblasted a second time using only clean unused sand and then recleaned of residue.

The epoxy compound shall be applied to the steel surface on the same day in which the second sand blasting is completed.

(2) Portland cement concrete surfaces shall be sandblasted to sound durable material. Residues from this operation shall be removed by vacuuming or high pressure air blast. The prepared portland cement concrete surface shall be approved by the Engineer prior to placing any epoxy compound.

(3) Other surfaces shall be sandblasted and cleaned as directed by the Engineer.

(c) Mixing and Working Life. Mixing shall be done in the component containers supplied or in clean, uncontaminated containers using slow speed (300 to 500 rpm) mechanical mixing equipment. With approval of the Engineer, manual mixing may be permitted for small quantities of 4 L (1 gallon) or less. Irrespective of equipment or method of mixing used, it is essential that the mixture be thoroughly blended to obtain a complete dispersion and homogeneous mass of the components and aggregate.

When aggregate is added to epoxy mortar compound, mechanical mixing equipment shall be used regardless of the batch size. Before aggregate is added, the liquid components shall first be thoroughly mixed, then aggregate slowly added while continuing to blend the mixture until a smooth uniform consistency is obtained. Aggregate shall be added in proportions by mass (weight) as recommended by the manufacturer.

Automatic equipment for metering, mixing, and dispensing epoxy compounds covered under this Section shall be approved by the Engineer prior to use.

The mixed compound shall be formulated such that its minimum working life will conform to the requirements in this Subsection and will permit placement of the material consistent with the batch size to be mixed and with the temperature and weather conditions.

530.08 APPLICATION.

(a) Epoxy Mortar. Epoxy mortar shall be placed on the prepared surfaces in accordance with the details shown on the Plans or as directed by the Engineer. If the epoxy mortar does not adhere to the existing surfaces against which it is applied, these surfaces shall be primed by applying epoxy mortar compound to which no aggregate has been added.

The material shall be thoroughly compacted after placing by tamping or troweling to completely fill the void or form and shall be struck off and finished with either a steel trowel or a wood or plastic float to the neat lines and texture shown on the Plans or ordered by the Engineer. No soaps, water, or solvents shall be used on the steel trowels or wood floats during finishing.

Should the depth of application exceed 50 mm (2 inches) in vertical and overhead applications, the epoxy mortar shall be applied in two or more layers not to

exceed 50 mm (2 inches) in thickness, allowing adequate time for curing between placement of successive layers.

(b) Bonding Compound. Bonding compound shall be applied by either brush or squeegee to the surfaces shown on the Plans or ordered by the Engineer.

The approximate application rates shall be as indicated in the following table:

TABLE 530.08A - APPLICATION RATES

| Type of Surface | Coverage | |
|---|---|---|
| | $m^2/L$ | $ft^2/gal$ |
| Smooth concrete | 1.2 | 50 |
| Rough concrete (Jack hammered) | 0.6 | 25 |

New concrete must be placed while the bonding compound is still "tacky." The film open or tack time may be expected to approximate the following:

| Ambient Air Temperature | Minimum Time |
|---|---|
| 32 °C (90 °F) | 2 hours |
| 24 °C (75 °F) | 3 hours |
| 16 °C (60 °F) | 4 hours |

If the bonding compound is not "tacky," the concrete shall not be placed until the surface has been recoated.

530.09 METHOD OF MEASUREMENT. The quantity of Epoxy Bonding Compound and of Epoxy Mortar to be measured for payment will be the authorized number of liters (gallons) of the specified epoxy that makes up the total volume of the two components, including solvent where applicable but not the aggregate filler added to the epoxy mortar, used in the complete and accepted work.

530.10 BASIS OF PAYMENT. The accepted quantity of Epoxy Bonding Compound and of Epoxy Mortar will be paid for at the Contract unit price per liter (gallon) for the type specified. Payment will be full compensation for preparing the surface, including sand blasting; for furnishing, transporting, handling, and placing the materials specified, including aggregates and additives; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 530.25 Epoxy Bonding Compound | Liter (Gallon) |
| 530.30 Epoxy Mortar | Liter (Gallon) |

# SECTION 531 - BEARING DEVICES

531.01 DESCRIPTION. This work shall consist of furnishing and installing bearing devices.

531.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Mortar, Type IV | 707.03 |
| Structural Steel | 714.02 |
| High-Strength Low-Alloy Structural Steel | 714.03 |
| Carbon Steel Bolts and Nuts | 714.04 |
| High-Strength Bolts, Nuts, and Washers | 714.05 |
| Anchor Bolts, Bearing Devices | 714.08 |
| Bronze Castings | 715.02 |
| Preformed Fabric Bearing Pads | 731.01 |
| Bearing Pads | 731.02 |
| Elastomeric Material | 731.03 |
| TFE Material | 731.04 |
| Stainless Steel | 731.05 |
| Socket-Head Cap Screws | 731.06 |
| Brass Rings | 731.07 |

Unless otherwise specified, all materials shall conform to the AASHTO or ASTM specifications specified in this Section, and alternate substitutions will not be allowed unless approved on the fabrication drawings.

531.03 FABRICATION DRAWINGS. The fabricator of bearings furnished under this Section shall submit detailed shop drawings, bonding procedures, welding procedure specifications, and welder qualification test records in accordance with Subsections 105.03 and 506.04. 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.

Bonding procedures shall include details of surface preparation and adhesive applications for bonding tetrafluoroethylene (TFE) to fabric, fabric to fabric, or, if applicable, fabric to steel.

531.04 FABRICATION.

(a) General. Material furnished under this Section shall conform to all applicable provisions of Subsections 506.03 through 506.16. Bearings shall be fabricated in a plant having as a minimum an AISC Category I Certification or in a plant approved by the Agency prior to the award of the Contract. Plants that are not certified must satisfy the requirements of Subsection 506.03.

All corners and edges of steel plates shall be ground to a 1.6 mm (1/16 inch) radius.

Bearing devices shall be fabricated, assembled, and certified by one supplier. Anchor bolt assemblies may be fabricated and supplied by an alternate supplier. Under certain conditions, the Agency may waive the "one supplier" requirement for expansion fabric bearings.

Unless otherwise specified, bearing device components shall be constructed of either structural steel or high-strength low-alloy structural steel.

Expansion fabric pad bearings and fixed and expansion pot bearings shall be designed and fabricated in accordance with Division I, Sections 14, 15, 19, and 20 and Division II, Section 18 of the AASHTO *Standard Specifications for Highway Bridges*.

(b) Surface Protection. All bearing devices shall be galvanized or metalized. Galvanizing shall be applied in conformance with AASHTO M 111M/M 111 or AASHTO M 232M/M 232. Metalizing shall be applied in conformance with Subsection 506.15(b).

When bearings are to be metalized, they shall receive a coat of an approved sealant conforming to the recommendations of the thermal spray supplier and approved by the Engineer. The minimum dry film thickness of the sealant shall be 50 μm (2 mils).

Weldments may be stress relieved during galvanizing; therefore, the fabricator is responsible for straightening the unit to conform to specified tolerances.

The interior surfaces of pot bearings shall be machined equal to ANSI 125 and coated with a silicon grease.

(c) Finish. The surface finish of bearing device components after fabrication and application of surface protection shall conform to Division II of the AASHTO *Standard Specifications for Highway Bridges.*

(d) Tolerances. After fabrication and application of surface protection, bearing devices or components shall be within the following tolerances:

(1) Dimensions (Length, Width, Thickness, Hole Locations, and Position of Welded Components). The tolerance shall be ± 1.6 mm (1/16 inch).

(2) Flatness.

a. Top Sole Plate. Bearing surfaces shall be flat with maximum permissible variation of 0.25 mm (0.01 inch) from a plane determined by any three corners of the plate.

b. Bottom Sole Plate (Masonry Plate). Bearing surfaces shall be flat with a maximum permissible variation of 1.00 mm (0.04 inch) from a plane determined by any three corners of the plate.

c. Sliding Surfaces. For stainless steel mating with TFE bonded to steel, the tolerance shall be the "nominal dimension" in millimeters (inches) times 0.0005. The "nominal dimension" shall be the distance between any diagonal corners or opposite edges of the bearing surface. The tolerance is applicable to both surfaces.

For stainless steel mating with TFE bonded to fabric bearing pad material, the tolerance shall be 0.25 mm (0.01 inch) from a plane determined by any three corners of the plate.

d. Curved Surfaces (Curved Plates, Rockers, and Rollers). The tolerance shall be the contact length along the axis of rotation times 0.0001.

(e) Sliding Surfaces.

(1) The minimum thickness of TFE material shall be as follows:

| | |
|---|---|
| Pot Bearings: | 3.0 mm (1/8 inch) [recessed 1.6 mm (1/16 inch)] |
| | 2.4 mm (3/32 inch) (not recessed) |
| Other Applications: | 1.6 mm (1/16 inch) for TFE bonded to steel |
| | 0.8 mm (1/32 inch) for TFE bonded to fabric bearing pad material |

TFE material shall be bonded to its substrate in accordance with the written instructions of the manufacturer of the adhesive system.

(2) Stainless steel used as a mating surface with TFE shall conform to the following:

a. Stainless steel sheets shall be 1.00 mm (20 gauge) minimum thickness for bonded applications and 2.00 mm (14 gauge) minimum thickness for circumferentially welded application.

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 must 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 Subsections 506.04 and 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 in part (d)(2)c. above and shall be blast cleaned to an appearance equivalent to SSPC-SP10. The contact surface of stainless steel sheets to be bonded with epoxy shall be mechanically abraded or etched prior to application of adhesive.

(f) Steel Bearings. The surface upon which a curved plate, a rocker or a roller makes contact shall be machined in the direction of movement. The contact surface of a curved plate, rocker, or roller shall be machined normal to the direction of movement.

Unless otherwise shown on the Plans, a 3.0 mm (1/8 inch) bearing pad, preformed fabric pad, or elastomeric bearing pad meeting the requirements of Subsection 731.01, 731.02, or 731.03, as appropriate, shall be used between steel baseplates and masonry.

(g) Fabric Bearings.

(1) Fabric bearings shall be constructed of material conforming to Subsection 731.01.

(2) Expansion bearings shall have sliding contact surfaces of TFE and stainless steel. The TFE shall normally be bonded to the preformed fabric bearing pad material and the stainless steel shall normally be welded or bonded to the structural steel.

The design coefficient of friction between the TFE and the stainless steel shall not exceed 0.06 at 5.5 MPa (800 pounds per square inch) compressive loading.

(h) Confined Elastomer (Pot) Bearings. In addition to the requirements of the AASHTO *Standard Specifications for Highway Bridges*, the following shall apply to the design and fabrication of pot bearings:

(1) Bearings shall be designed for the vertical and horizontal forces shown on the Plans; however, the minimum horizontal design force shall be not less than 10 percent of the maximum vertical bearing load.

(2) The shape characteristics, clearances, and sealing mechanism of the piston and cylinder must be designed to prevent extrusion of the elastomer under load and rotational movement. The following design and fabrication conditions will be required, unless otherwise approved on the shop drawings:

a. The difference between the inside diameter of the cylinder and the outside diameter of the piston shall be not less than 0.50 mm (0.02 inch) or greater than 1.50 mm (0.06 inch), including tolerances.

b. A brass sealing ring (or rings) shall be provided at the outer edge and on top of the elastomer. Where more than one flat sealing ring is used, ring gaps shall be staggered equally around the ring circumferences.

c. Either TFE sheets or other approved material shall be provided to lubricate compressive surfaces of the elastomer.

(3) The internal floating portion of the bearing must be sealed to prevent the intrusion of foreign material.

(4) Exposed TFE material on a guide bar or other component shall be pigmented to prevent penetration of ultraviolet light.

(5) The pot cavity shall be machined from a solid plate.

(6) The fabricator may alter the design of each device from that shown on the Contract drawings to conform to the particular method of fabrication used at that fabricator's plant. The general intent of the Plans shall be followed with modifications approved on the shop drawings, including minor changes to the overall height of the bearing.

(7) Pot bearings shall be tested in accordance with Division II of the AASHTO *Standard Specifications for Highway Bridges*, modified as follows:

a. General.

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 for bearings designed for less than 13 345 kN (3000 kips) capacity.

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. Measured static coefficient of friction shall be less than 4 percent.

4. Measured dynamic coefficient of friction shall be less than 4 percent

5. Measurement of first movement static and dynamic coefficients of friction shall be determined at a sliding speed of less than 25 mm (1 inch) per minute.

   If additional sliding surfaces are required for measuring the coefficient of friction, the fabricator may incorporate the stacking of two similar test specimens or provide an extra sliding surface in conjunction with the test apparatus. Any extra sliding surface must have the same contact area and materials as the unit being tested.

6. Design Load equals Dead Load + Live Load + Impact.

7. Basis of acceptance:

    a) Coefficients of friction are less than 4 percent.

    b) Acceptable material certifications.

    c) Assembled bearings meet requirements and tolerances of Contract.

    d) Inspection of tested bearings show no sign of bond failure, material failure, or other defects.

8. Test results and material certifications shall be sent to the Agency's Materials and Research Section with a copy of the test results sent to the Structures Engineer.

b. Procedure for Testing Expansion Bearings.

1. Load the bearing with its design loading for a minimum duration of 12 hours.

    Measure force required for the first movement and calculate coefficient of friction.

    Measure force required for movement under dynamic loading and calculate coefficient of friction.

2. Load at 70 percent of the design load, but not less than 13.8 MPa (2000 pounds per square inch).

    Measure static coefficient of friction.

    Measure dynamic coefficient of friction.

3. Load at 150 percent of the design load for 30 minutes, at a 2 percent rotation, and subject the bearing to 100 cycles of movement.

    Measure static coefficient of friction.

    Measure dynamic coefficient of friction.

4. Disassemble bearing and inspect for:

    a) Any sign of bond failure.

    b) Any sign of material failure.

    c) Any other defects.

c. Procedure for Testing Fixed Bearings.

1. Load bearing at 150 percent of its design loading for 30 minutes, at a 2 percent rotation.

2. Disassemble bearing and inspect for:

a) Any sign of sealing failure.

b) Any sign of material failure.

c) Any other defects.

(8) Acceptable test results are a prerequisite for certification acceptance. Expenses for performing any testing shall be incidental to the work.

531.05 INSTALLATION. Bearing devices shall be installed in conformance with all applicable provisions of Subsections 506.17 through 506.23.

Pot 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. Pot bearings that have been disassembled shall not be accepted unless recertified by the manufacturer.

Whenever a bridge seat is off by 6 mm (1/4 inch) or more from its designed or adjusted elevation, corrective measures may be required as directed by the Engineer.

If shims are required, they shall be a single thickness plate of AASHTO M 270M/M 270, Grade 250 or 345 (Grade 36 or 50) steel, galvanized or metalized according to Subsection 506.15. Details of shims shall be furnished and approved in accordance with Subsection 105.03. The cost of any necessary corrective measures, including any costs due to a delay, shall be borne by the Contractor.

531.06 METHOD OF MEASUREMENT. The quantity of Bearing Device Assembly to be measured for payment will be the number of units used in the complete and accepted work. All bearing device materials including bearing pads 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.

531.07 BASIS OF PAYMENT. The accepted quantity of Bearing Device Assembly will be paid for at the Contract unit price. Payment will be full compensation for detailing, furnishing, handling, transporting, and placing the material specified, including surface preparation, protective coating, testing, anchor bolt assemblies, mortar, bearing pads, welding, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 531.10 Bearing Device Assembly | Each |

# DIVISION 600

## INCIDENTAL 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:

| | |
|---|---|
| Granular Backfill for Structures | 704.08 |
| Mortar, Type II | 707.02 |
| Rubber Gaskets | 707.11 |
| Reinforced Concrete Pipe | 710.01 |
| Reinforced Concrete Pipe End Sections | 710.02 |
| Corrugated Polyethylene Pipe | 710.03 |
| Corrugated Steel Pipe, Pipe Arches, and Underdrains | 711.01 |
| Corrugated Aluminum Alloy Pipe, Pipe Arches, and Underdrains | 711.02 |
| Polymeric Coated Corrugated Steel Pipe and Pipe Arches | 711.03 |
| Bituminous Paving for Pipe Inverts | 711.04 |
| Coal-Tar Based Coating | 711.05 |

Manufacturing plants may be inspected periodically for compliance with specified manufacturing methods.

All units in a given 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.

All materials will be subject to inspection for acceptance prior to or during incorporation of materials in the work.

When either corrugated steel pipe or pipe arches with 75 by 25 mm (3 × 1 inch) corrugations are shown on the Plans, the Contractor may substitute pipe or pipe arches of the same thickness with 125 by 25 mm (5 × 1 inch) corrugations at no additional compensation.

601.03 GENERAL. Care shall be exercised when unloading pipe from delivery trucks and moving pipe to its 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 installation shall be approved by the Engineer.

Where existing pipe is to be retained or relaid 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 and Research Section, which shall be allowed to 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 as follows:

(a) in accordance with AASHTO M 36M.

(b) for damaged polymeric coating, application of a coal-tar based coating.

601.04 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, 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. The invert grade shall be cambered by an amount to be determined by the Engineer.

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.

Ledge rock, 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 having a width measurement of the inside width of the pipe plus 600 mm (24 inches) and to a minimum depth of 300 mm (12 inches) below the pipe grade, unless otherwise shown on the Plans or directed by the Engineer.

601.05 BEDDING. Unless otherwise specified, the bed shall be shaped and compacted to fit the pipe for a depth of not less than 10 percent of its total height. Recesses to receive the bell shall be formed when applicable.

601.06 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 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 outside circumferential laps of flexible pipe shall be placed facing upstream. The longitudinal laps or seams of riveted pipe shall be at the sides.

Pipe with paved inverts shall be laid so that the paved segment is centered at the bottom of the pipe.

The handling holes in concrete pipes shall be filled with a precast plug, sealed, and covered with mastic or mortar.

601.07 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, oakum and mortar, oakum and joint compound, a combination of these types, or any one type as specified and approved by the Engineer. Joints in concrete pipe should 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. Where oakum is used, the joint shall be caulked with this material and then sealed with the specified materials.

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 together 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 together.

The connecting devices shall be at least 3.7 m (12 feet) in length when used with 2.3 m (7.5 foot) minimum length sections and at least 3 m (10 feet) in length when used with 1.8 m (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 450 mm (18 inches) from the end of the pipe sections and the flared end sections. Each end of the device shall be anchored with an M24 (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 150 $mm^2$ (0.23 square inch) for all pipe 1200 mm (48 inches) in diameter or smaller. For pipe larger than 1200 mm (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 as long as they provide equivalent restraining properties and durability.

Restraining devices may be placed on either the inside or outside of the pipe. If placed on the inside, the device shall not protrude from the wall to the degree that flow would be obstructed. 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 900 mm (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 percent) will be joined either by 600 mm (24 inches) 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.

601.08 BACKFILLING. The 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 selected fine compactable soil from excavation when available, or granular backfill for structures. This material shall be placed to a height of 600 mm (24 inches) over the pipe. No stones in excess of 75 mm (3 inches) in diameter shall be placed in contact with the pipe. Rock fill or boulders shall not be placed within 600 mm (24 inches) of the outside of the pipe.

The backfill material shall be placed in 150 mm (6 inch) thick layers and compacted in accordance with Subsection 203.11(d) using air or mechanical tampers. 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 4 m (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 pipe shall be protected by a 1.2 m (4 foot) cover of fill before heavy equipment or traffic is permitted to cross during construction of the roadway. 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 1.2 m (4 foot) protective cover requirement shall not relieve the Contractor of any responsibility concerning damage to the pipe.

601.09 CLEANING OF CULVERTS. The pipe culverts at the locations shown on the Plans, or as directed by the Engineer, that contain silt, debris, and other material within the barrel and appurtenances 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 relaid in accordance with the applicable Subsections. 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 the Contract item Cleaning Culvert Pipe In Place.

If however, the Engineer determines that the pipe must be replaced, replacement will be paid for under the appropriate Contract items.

601.10 METHOD OF MEASUREMENT. The quantities of culverts and storm drains to be measured for payment will be the number of meters (linear feet) used in the complete and accepted work, as shown on the Plans or 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 to the next whole meter (2 foot) increment.

The quantity of Re-laying Pipe Culverts to be measured for payment will be the number of meters (linear feet) of re-laid pipe in the complete and accepted work.

The quantities of pipe elbows, end sections, and concentric reducer units 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 number of meters (linear feet) for the size of pipe acceptably cleaned, as determined along the flow line of the pipe. The measurement will only be for pipes cleaned as the result of existing conditions. The cost to clean material from pipes as the result of on-project construction activities shall be at the Contractor's expense.

601.11 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 meter (linear foot).

The accepted quantity of Re-laying Pipe Culverts will be paid for at the Contract unit price per meter (linear foot).

The accepted quantities of pipe elbows, end sections, and concentric reducer units of the type and size specified will be paid for at the respective Contract unit price each.

The cost of vertical risers, when shown on the Plans, shall be included in the Contract unit price per meter (linear foot) for each culvert to which a riser is attached. Each vertical riser pipe shall be bid as a separate unit.

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 as follows:

(a) For all pipes, pipe arches, elbows, end sections, or concentric reducers of 1200 mm (48 inches) in diameter and under, at the Contract unit price per cubic meter (cubic yard) for Trench Excavation.

(b) For all pipes, pipe arches, elbows, end sections, or concentric reducers of over 1200 mm (48 inches) in diameter, at the Contract unit price per cubic meter (cubic yard) for Structure Excavation.

(c) When material is required to replace poor foundation material below the normal grade of the culvert, it will be paid for at the Contract unit price per cubic meter (cubic yard) for the type of backfill specified.

(d) When granular backfill for structures is required for backfill material, it will be paid for at the Contract unit price per cubic meter (cubic yard).

Anchor bolts, required in 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 meter (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 |
|---|---|
| 601.0000 to 601.0199 CSP | Meter (Linear Foot) |
| 601.0200 to 601.0399 CAAP | Meter (Linear Foot) |
| 601.0400 to 601.0599 PCCSP | Meter (Linear Foot) |
| 601.0600 to 601.0799 PCCSP(PI) | Meter (Linear Foot) |
| 601.0800 to 601.0899 RCP | Meter (Linear Foot) |
| 601.0900 to 601.0999 CPEP | Meter (Linear Foot) |
| 601.2000 to 601.2199 CSP(SL) | Meter (Linear Foot) |
| 601.2200 to 601.2399 CAAP(SL) | Meter (Linear Foot) |
| 601.2400 to 601.2599 PCCSP(SL) | Meter (Linear Foot) |
| 601.2600 to 601.2799 CPEP(SL) | Meter (Linear Foot) |
| 601.3000 to 601.3199 CSPA | Meter (Linear Foot) |
| 601.3200 to 601.3399 CAAPA | Meter (Linear Foot) |
| 601.3400 to 601.3599 PCCSPA | Meter (Linear Foot) |
| 601.3600 to 601.3799 PCCSPA(PI) | Meter (Linear Foot) |
| 601.4000 to 601.4199 CSPA(SL) | Meter (Linear Foot) |
| 601.4200 to 601.4399 CAAPA(SL) | Meter (Linear Foot) |
| 601.4400 to 601.4599 PCCSPA(SL) | Meter (Linear Foot) |
| 601.5000 to 601.5199 CSP Elbow | Each |

| | | |
|---|---|---|
| 601.5200 to 601.5399 | CAAP Elbow | Each |
| 601.5400 to 601.5599 | PCCSP Elbow | Each |
| 601.5600 to 601.5799 | PCCSP Elbow (PI) | Each |
| 601.5800 to 601.5999 | CPEP Elbow | Each |
| 601.6000 to 601.6199 | CSPES | Each |
| 601.6200 to 601.6399 | CAAPES | Each |
| 601.6800 to 601.6899 | RCPES | Each |
| 601.7000 to 601.7099 | CPEPES | Each |
| 601.8000 to 601.8199 | CSPAES | Each |
| 601.8200 to 601.8399 | CAAPAES | Each |
| 601.98 | Concentric Reducer Section | Each |
| 601.99 | Re-laying Pipe Culverts | Meter (Linear Foot) |
| 601.995 | Cleaning Culvert Pipe, In-Place [0 to 600 mm (0 to 24 inches), inclusive] | Meter (Linear Foot) |
| 601.996 | Cleaning Culvert Pipe, In-Place [Greater than 600 mm (24 inches)] | Meter (Linear Foot) |

Key to ABBREVIATIONS:

| | |
|---|---|
| CSP | Corrugated Steel Pipe |
| CAAP | Corrugated Aluminum Alloy Pipe |
| PCCSP | Polymeric Coated Corrugated Steel Pipe |
| RCP | Reinforced Concrete Pipe |
| CPEP | Corrugated Polyethylene Pipe |
| (PI) | Paved Invert |
| (SL) | Smooth Lined |
| ...A | ...Arch |
| ...ES | ...End Section |

## SECTION 602 - RUBBLE MASONRY

602.01 DESCRIPTION. This work shall consist of furnishing materials and constructing pipe headwalls, pipe cradles, and other masonry of the types and sizes specified, or repointing of existing masonry.

602.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Stone for Rubble Masonry | 706.01 |
| Stone for Masonry Facing | 706.02 |
| Mortar, Type II | 707.02 |
| Dowels and Ties | 713.01 |
| Bar Reinforcement | 713.01 |

The Contractor, with the approval of the Engineer, may use Class B concrete instead of cement rubble masonry in the construction of headwalls and cradles. The concrete shall conform to the requirements of Section 501 for Concrete, Class B.

602.03 MIXING OF MORTAR. The fine aggregate and cement shall be mixed in a clean, tight box 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 retempering of mortar will not be permitted.

602.04 PLACING OF STONE. The placing and shaping of stone shall be the same for dry or mortar joint masonry.

The bed shall be clean and well moistened just prior to the placement of the stone. The stone shall be thoroughly saturated with water and 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 25 mm (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 1.2 m (4 feet), the stones used as headers for the purpose of holding in the heart of the wall shall extend not less than 1.2 m (4 feet) into the core and shall occupy not less than 20 percent of the front and back surface area of the wall.

In walls where the thickness is 1.2 m (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 150 mm (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 COPINGS, BRIDGE SEATS, AND BACKWALLS. Copings, bridge seats, and backwalls, unless otherwise specified, shall be of Concrete, Class B.

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 15 mm (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 DOWELS AND TIES. Where required, bonding of various portions of the work shall be accomplished with dowels and ties of the shapes and dimensions as 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.

602.09 BACKFILLING. Spaces excavated for masonry structures, but not occupied by these structures, shall be backfilled with material meeting the requirements for granular backfill for structures. The backfill shall be placed in horizontal layers of not more than 150 mm (6 inches) in depth and each layer shall be thoroughly compacted by means of air or mechanical tampers in a manner approved by the Engineer.

602.10 METHOD OF MEASUREMENT. The quantities of Cement Rubble Masonry and Dry Rubble Masonry to be measured for payment will be the number of cubic meters (cubic yards) used in the complete and accepted work, measured in accordance with the dimensions shown on the Plans or ordered by the Engineer. Deductions for pipes in headwalls will be made as shown on the Plans.

The quantities of Repointing Masonry and Stone Masonry Facing to be measured for payment will be the number of square meters (square yards) performed in the complete and accepted work, measured as follows:

(a) The quantity of Repointing Masonry will be the total surface area of the masonry repointed.

(b) The quantity of Stone Masonry Facing will be 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 of less than 0.2 $m^2$ (2 square feet).

602.11 BASIS OF PAYMENT. The accepted quantities will be paid for at the Contract unit price per cubic meter (cubic yard) or square meter (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 meter (square yard) for Stone Masonry Facing.

Excavation will be paid for as Trench Excavation, unless otherwise shown on the Plans.

When the Contractor elects to use Concrete, Class B in the construction of headwalls or cradles, the Contractor will be paid for this work at the Contract unit price for Cement Rubble Masonry. Payment will include the required reinforcing steel.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 602.15 Cement Rubble Masonry | Cubic Meter (Cubic Yard) |
| 602.20 Dry Rubble Masonry | Cubic Meter (Cubic Yard) |
| 602.25 Stone Masonry Facing | Square Meter (Square Yard) |
| 602.30 Repointing Masonry | Square Meter (Square Yard) |

## SECTION 604 - DROP INLETS, CATCH BASINS, AND MANHOLES

604.01 DESCRIPTION. This work shall consist of the construction, reconstruction, or adjustment to grade of drop inlets, catch basins, and manholes; and the furnishing and placing of cast iron or steel grates and cast iron or precast concrete covers.

604.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Clay or Shale Sewer Brick | 705.01 |
| Concrete Masonry Blocks | 705.02 |
| Precast Drop Inlets, Catch Basins, and Manholes | 705.04 |
| Mortar, Type II | 707.02 |
| Reinforced Concrete Pipe | 710.01 |
| Vitrified Clay Pipe | 710.04 |
| Bar Reinforcement | 713.01 |
| Welded Steel Wire Fabric | 713.05 |
| Steel Grates | 714.01 & 714.02 |
| Cast Iron Frame, Grate, and Cover | 715.01(b) |
| Ductile Iron Frame and Cover | 715.01(c) |

Concrete shall conform to the requirements of Section 501 for Concrete, Class B.

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 various Contract items, when used in conjunction with covers and frames, shall be understood to mean "cast iron or ductile iron." The Contractor may use ductile iron covers and frames meeting the requirements of Subsection 715.01(c) instead of cast iron covers and frames. 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. The notes in the D-Series of Standard Drawings concerning steps and the materials from which they are fabricated shall not apply to any construction performed under this Section.

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 footings for drop inlets, catch basins, and manholes may be either precast or cast-in-place concrete.

The concrete for footings, walls, and tops shall be Class B, unless otherwise specified.

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(c).

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(c) as part of the work and costs included in the Contract item Changing Elevation of Drop Inlets, Catch Basins or Manholes or the Contract item Changing Elevation of Sewer Manholes.

Channels, inverts, and floor areas for sewer manholes shall be constructed of brick and mortar or Class C concrete. 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 628.08.

In the construction of baffled drop inlets, the angle attaching bolts may be inserted into anchors cast into the fresh concrete, or expansion anchors drilled and set into the concrete after the form work has been removed. Expansion anchors shall not be drilled and placed until a minimum of eight days after the day of the pour has passed.

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 300 mm (12 inches) but not more than 600 mm (24 inches) into any

openings in the walls for inspection to determine the extent of the work that will be required.

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 footing 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. Brick shall be laid in a professional manner by a competent mason. After the bricks are laid, the joints on the inside of the brick masonry shall be neatly pointed. The outside surface of the brick shall be covered with mortar of the same quality as used for laying the bricks so that a reasonably smooth surface is obtained.

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) Concrete Block Catch Basin or Manhole. The concrete block wall shall be constructed reasonably close to line and grade in circular, horizontal courses with full mortar joints. Vertical joints shall be broken or staggered. Blocks shall be laid in mortar. As each course is laid, the outside mortar joints shall be struck flush, and projecting mortar on the inside shall be rubbed down with burlap.

The construction of the top section for a concrete block catch basin or manhole, and work pertinent thereto, shall conform to the requirements for Concrete Drop Inlet, Catch Basin, or Manhole.

(c) Precast Reinforced Concrete Catch Basin or Manhole. The precast reinforced concrete risers shall be set reasonably close to line and grade on the previously placed concrete footing. 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.

(d) 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.

(e) 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).

(f) 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, and/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 729.06. Bituminous fillet shall conform to the applicable requirements of Section 406, for the type of mix specified by the Engineer and, after installation, shall be sealed in accordance with Subsection 616.08(d). Concrete curb and granite curb shall conform to the applicable requirements of Section 616. The cost of this curb replacement will not be paid for directly, but will be considered incidental to the Contract item Changing Elevation of Drop Inlets, Catch Basins or Manholes.

Where the unit is to be raised and the change in elevation is less than 50 mm (2 inches), concentric structural steel rings of nominally 13 mm (1/2 inch) thick material properly welded to the frame may be used.

The Contract unit price bid for the Contract item Changing Elevation of Drop Inlets, Catch Basins or Manholes shall include all the work and costs involved in cutting pavements and excavating around the top of the unit and the bricks, to provide room to accomplish the work, and shall also include all costs of backfilling around the elevation reset unit up to the bottom of pavement or the upper surface of the unit top, as appropriate to the individual location.

If excavating through paved surfaces is required, the edges of the excavated area shall be saw cut to a minimum depth of 40 mm (1 1/2 inches).

(g) 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 sewer manholes shall have the word "SEWER" cast into the top surface.

(h) Grates. The grates shall be properly installed at the locations shown on the Plans or directed by the Engineer.

Steel grates shall be painted with two coats of an approved Black Paint system from Section 513.

(i) 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 705.04 except that all barrel joints shall contain an o-ring seal. Steps, if required, 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.

(j) Changing Elevations of Sewer Manholes. Existing sewer manholes, that are to be altered or adjusted, shall be reconstructed in accordance with Subsection 604.04(f) 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, and necessary steps, pipe joints, and barrel joints shall conform to the requirements of Subsection 604.04(i).

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 Contract item.

(k) 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 reconstructed to the required grade using existing grates, frames, covers, or tops, if useable, as specified. If necessary, this work shall include removal of the existing structure and the complete replacement of the drop inlet, catch basin, or manhole with a unit meeting current standards.

This work shall belong to one of three classes. Class I shall include all work down to a depth of 1 m (3 feet). Class II shall include all work greater than 1 m (3 feet) in depth down to a depth of 2 m (6 feet). Class III shall include all work greater than 2 m (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 utilizing 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 reconstruction 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 and/or exiting the unit are within the area of rehabilitation and/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. If the Contract includes a Contract item for the pipe, the pipe stubs will be paid for under the appropriate Section 601 or Section 605 Contract item in the Contract. If the Contract does not include a Contract item for the pipe, the pipe stubs and collar will not be paid for directly, but will be considered incidental to the Contract item Rehabilitating Drop Inlets, Catch Basins or Manholes, Class I, II, or III, as appropriate.

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 729.06 Bituminous fillet shall conform to the applicable requirements of Section 406 for the type of mix specified by the Engineer and, after installation, shall be sealed in accordance with Subsection 616.08(d). Concrete curb and granite curb shall conform to the applicable requirements of Section 616. The costs of this curb replacement will not be paid for directly, but will be considered incidental to Contract items Rehabilitating Drop Inlets, Catch Basins or Manholes, Class I; Rehabilitating Drop Inlets, Catch Basins or Manholes, Class II; Rehabilitating Drop Inlets, Catch Basins or Manholes, Class III; as appropriate.

Where the unit is to be raised and the change in elevation is less than 50 mm (2 inches), concentric structural steel rings of nominally 13 mm (1/2 inch) thick material properly welded to the frame may be used.

The Contract unit price bid for the Contract items Rehabilitating Drop Inlets, Catch Basins or Manholes, Class I, II, or III shall include all the work and costs involved in cutting pavements and excavating around the top of the unit and the bricks, to provide room to accomplish the work, and shall also include all costs of backfilling around the reconstructed unit up to the bottom of pavement or the upper surface of the unit top, as appropriate to the individual location.

Unless otherwise directed by the Engineer, the Contractor shall saw all pavements to a minimum depth of 40 mm (1 1/2 inches).

(l) Rehabilitation of Sewer Manhole. Rehabilitation of sewer manholes shall consist of removing the existing top with cover, with or without frame, and reconstruction of the existing unit to a safe and useful structure, satisfactory to the Engineer. If necessary, this Contract 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 705.04 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 501.17.

604.06 BACKFILLING. Backfilling shall not begin until the end of the curing period. The backfill shall be made with material approved by the Engineer placed in layers not exceeding 150 mm (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 METHOD OF MEASUREMENT. The quantities of new structures to be measured for payment will be the number of units of the respective types used in the complete and accepted work. Cast Iron Grates or Cast Iron Cover with Frames and Cast Iron Grates and Steel Grates when used and not included in a specific unit will be measured as the number of each type specified.

The quantity of Rehabilitating or Changing Elevation of Drop Inlets, Catch Basins or Manholes to be measured for payment will be the number of units modified in the complete and accepted work.

604.08 BASIS OF PAYMENT. The accepted quantities of new Drop Inlets, Catch Basins or Manholes will be paid at the Contract unit price per unit each for 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, vitrified clay tile pipe, concrete block, mortar, brick, frames, grates, covers, coatings, pipestubs, weep holes, underdrain ends, curb board, and bituminous fillets, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Changing Elevation of Drop Inlets, Catch Basins or Manholes and Rehabilitating Drop Inlets, Catch Basins or Manholes will be paid for at the Contract unit price 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, pipe stubs, weep holes, 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.

Frames, grates, and/or covers for new or rehabilitated drop inlets, catch basins, and manholes are part of the unit and will not be paid for separately.

Excavation for new drop inlets, catch basins, and manholes will be paid for as Trench Excavation of Earth or Trench Excavation of Rock, as appropriate.

Excavation associated with the rehabilitation or changing elevation of existing drop inlets, catch basins, and manholes will not be paid for separately, but will be considered incidental to the appropriate Contract items.

Backfill material for backfilling around elevation adjusted and rehabilitated drop inlets, catch basins, and manholes shall meet the requirements of Subsection 704.08, unless otherwise directed by the Engineer.

The Contract items Changing Elevation of Drop Inlets, Catch Basins or Manholes and Rehabilitating Drop Inlets, Catch Basins or Manholes, Class I, Class II, and Class III and Sewer Manholes are mutually exclusive. Only one of these Contract items will be paid at any designated location.

The Contract items Changing Elevation of Drop Inlets, Catch Basins or Manholes will include adjusting the elevation of an existing top, including replacement of deteriorated bricks and mortar, only. The Contract item Rehabilitating Drop Inlets, 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 1 m (3 feet) below the elevation of the upper surface of the unit top. The Contract item Rehabilitating Drop Inlets, 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 1 m (3 feet) to a maximum depth of 2 m (6 feet) below the elevation of the upper surface of the unit top. The Contract item Rehabilitating Drop Inlets, 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 2 m (6 feet) below the elevation of the upper surface of the unit top.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 604.10 | Concrete Catch Basin with Cast Iron Grate | Each |
| 604.11 | Concrete Manhole with Cast Iron Cover | Each |
| 604.15 | Concrete Block Catch Basin with Cast Iron Grate | Each |
| 604.16 | Concrete Block Manhole with Cast Iron Cover | Each |
| 604.20 | Precast Reinforced Concrete Catch Basin with Cast Iron Grate | Each |
| 604.21 | Precast Reinforced Concrete Manhole with Cast Iron Cover | Each |

| | | |
|---|---|---|
| 604.22 | Sanitary Sewer Manhole | Each |
| 604.25 | Precast Reinforced Concrete Pipe Drop Inlet with Cast Iron Grate | Each |
| 604.26 | Precast Reinforced Concrete Pipe Drop Inlet with Concrete Cover | Each |
| 604.30 | Precast Reinforced Concrete Drop Inlet with Cast Iron Grate | Each |
| 604.40 | Changing Elevation of Drop Inlets, Catch Basins or Manholes | Each |
| 604.42 | Changing Elevation of Sewer Manholes | Each |
| 604.45 | Cast Iron Grate with Frame, Type A | Each |
| 604.46 | Cast Iron Grate with Frame, Type B | Each |
| 604.47 | Cast Iron Grate with Frame, Type D | Each |
| 604.48 | Cast Iron Grate with Frame, Type E | Each |
| 604.49 | Cast Iron Grate, Type C | Each |
| 604.50 | Steel Grate | Each |
| 604.55 | Cast Iron Cover with Frame | Each |
| 604.56 | Cast Iron Cover with Frame, Sewer | Each |
| 604.412 | Rehabilitating Drop Inlets, Catch Basins or Manholes, Class I | Each |
| 604.415 | Rehabilitating Drop Inlets, Catch Basins or Manholes, Class II | Each |
| 604.418 | Rehabilitating Drop Inlets, Catch Basins or Manholes, Class III | Each |

## SECTION 605 - UNDERDRAINS

605.01 DESCRIPTION. This work shall consist of constructing underdrains using pipe and granular filter material, underdrain outlets, flushing basins and risers.

605.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Sand Borrow | 703.03 |
| Granular Backfill for Structures | 704.08 |
| Corrugated Polyethylene Underdrain | 710.03 |
| PVC Plastic Underdrain | 710.06 |
| Corrugated Steel Pipe and Underdrain | 711.01 |
| Corrugated Aluminum Alloy Pipe and Underdrain | 711.02 |
| Cast Iron Cover | 715.01(b) |

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) Perforated Corrugated Steel

(b) Perforated Corrugated Aluminum Alloy

(c) Perforated Corrugated Polyethylene

(d) Perforated 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. A cushion of material, of either Sand Borrow or Granular Backfill for Structures, shall be placed to the depth shown on the Plans and thoroughly compacted.

Trenches for carrier pipe shall be excavated in the same manner as for culvert pipe, to a width 600 mm (24 inches) greater than the inside diameter. The cushion shall be omitted except that proper bedding material shall be provided where excavation is in solid rock or other unyielding material.

(b) Placing Underdrain. The underdrain shall be placed in the center of the trench and firmly embedded in the cushion material. Placing shall be started at the outlet end and proceed toward the upper 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.

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 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.

(c) Placing Carrier Pipes. Carrier pipes used in an underdrain system placed at road crossings, outlets, or as directed by the Engineer shall be placed on a firm bed and joined in the same manner as underdrain. Unless otherwise directed, non-perforated pipe shall be used.

(d) Backfill. After an underdrain installation has been inspected and approved, material meeting the requirements of granular backfill for structures or sand borrow shall be placed to a height of 300 mm (12 inches) above the top of the underdrain and the layer compacted. Care shall be taken not to displace the underdrain. The remainder of the backfill material shall be placed in uniform layers of not more than 150 mm (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 150 mm (6 inches) in thickness and thoroughly compacted. Unless otherwise specified, this material shall be from trench or roadway 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.

(e) 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 carrier pipe to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work.

The quantity of Underdrain Flushing Basins 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.

The quantity of Underdrain Risers to be measured for payment will be the number of units installed in the complete and accepted work.

605.06 BASIS OF PAYMENT. The accepted quantities of each type and size of underdrain or carrier pipe will be paid at the respective Contract unit price per meter (linear foot).

Underdrain Flushing Basins and Underdrain Risers will be paid at the respective Contract unit price for each. Underdrain used for vertical stand pipes at flushing basin locations 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, sand borrow for cushion when specified, and the necessary backfill material to an elevation 2 m (7 feet) above the flowline, and for furnishing of all labor, tools, equipment, and incidentals necessary to complete the work.

Excavation for underdrain, carrier pipe, flushing basins, and risers will be paid for as Trench Excavation.

Backfill placed above an elevation of 2 m (7 feet) over the flowline will be paid for as Granular Backfill for Structures or Sand Borrow as ordered by the Engineer.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| (a) Underdrain. | |
| 605.10 150 mm (6 inches) | Meter (Linear Foot) |
| 605.11 200 mm (8 inches) | Meter (Linear Foot) |
| 605.12 250 mm (10 inches) | Meter (Linear Foot) |
| 605.13 300 mm (12 inches) | Meter (Linear Foot) |
| (b) Underdrain Carrier Pipe. | |
| 605.20 150 mm (6 inches) | Meter (Linear Foot) |
| 605.21 200 mm (8 inches) | Meter (Linear Foot) |
| 605.22 250 mm (10 inches) | Meter (Linear Foot) |
| 605.23 300 mm (12 inches) | Meter (Linear Foot) |
| 605.90 Underdrain Riser | Each |
| 605.95 Underdrain Flushing Basin | Each |

## SECTION 607 - ROADWAY PATROL MAINTENANCE

607.01 DESCRIPTION. This work shall consist of the maintenance of any section of roadway that is open to public travel and the maintenance of detours in a reasonably smooth and passable condition. The work shall be limited to those roadways within the construction area and any detours shown on the Plans or as directed by the Engineer.

607.02 SCOPE OF WORK. Roadway patrol maintenance shall include only the leveling and smoothing of sections of the roadway or detours within the construction areas that are not subject to the influence of the Contractor's operations.

This work shall be performed by means of a road grader or other approved equipment. Snow shall be removed by use of an approved grader or other approved plowing equipment. The material and equipment required to maintain the roadway and the furnishing and spreading of sand necessary for winter maintenance shall be included in the Contract unit price for roadway patrol maintenance, unless otherwise directed by the Engineer.

607.03 METHOD OF MEASUREMENT. The quantity to be measured for payment will be the number of hours actually worked in doing roadway patrol maintenance.

607.04 BASIS OF PAYMENT. The accepted quantity will be paid for at the Contract unit price per hour for roadway patrol maintenance. Payment will be full compensation for performing the work specified and for furnishing all labor, sand and other materials, tools, equipment, and incidentals necessary to complete the work.

Granular borrow, sand borrow, gravel, and calcium chloride, if directed by the Engineer to be used in connection with roadway patrol maintenance, will be paid for at the Contract unit price for the particular item being used.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 607.10 Roadway Patrol Maintenance | Hour |

## 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 or Type II in parts (a), (c), (d), or (g) below, the make and model number shall be referenced against an equipment guide book.

Whenever certain size equipment is requested by the Engineer and the Contractor supplies a larger size, payment will be for the size requested.

(a) Bulldozer. The tractor shall be a 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 112 kW (150 horsepower).

(2) Type II. Type II bulldozers shall have a net engine or flywheel power rating of not less than 112 kW (150 horsepower).

(b) Grader. The power grader shall be self propelled with pneumatic tire wheels, power operated controls, and a wheel base of at least 5.50 m (18 feet).

(c) Dragline. The dragline shall be the full revolving type equipped with a dragline bucket, clamshell bucket, or approved drop ball as required by the Engineer. One

set of mats shall be included with each dragline when necessary. The machine shall be classified by size as follows:

(1) Type I. Type I draglines shall have a rated bucket capacity of less than 1.50 $m^3$ (2 cubic yards).

(2) Type II. Type II draglines shall have a rated bucket capacity of not less than 1.50 $m^3$ (2 cubic yards).

(d) All Purpose Excavator. The machine shall be a hydraulic excavator and may be self propelled, truck mounted, or crawler mounted. It shall include all attachments required by the Engineer to efficiently perform the work for which it is rented. The machine shall be classified by size as follows:

(1) Type I. Type I all purpose excavators shall have a rated bucket capacity of at least 0.40 $m^3$ (1/2 cubic yard) but less than 0.75 $m^3$ (1 cubic yard).

(2) Type II. Type II all purpose excavators shall have a rated bucket capacity of not less than 0.75 $m^3$ (1 cubic yard).

(e) Power Broom. The power broom shall be self-propelled or a towed type including the tow vehicle, or an approved design having a sweeping path of not less than 2 m (80 inches). It shall be capable of maintaining a speed of 6.50 km/h (4 miles per hour) when sweeping. All hand labor required in connection with a sweeping operation shall be included.

(f) Truck. The truck may be the highway type or off-highway type with a minimum capacity of 5 $m^3$ (6 1/2 cubic yards). The capacity of the truck shall be determined by three-dimensional measurement of the body.

(g) Loader. The loader may be the wheel 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 0.75 $m^3$ (1 cubic yard) but less than 3.0 $m^3$ (4 cubic yards).

(2) Type II. Type II loaders shall have a rated bucket capacity of not less than 3.0 $m^3$ (4 cubic yards).

608.03 METHOD OF MEASUREMENT. 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.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 608.10 Bulldozer Rental, Type I | Hour |
| 608.11 Bulldozer Rental, Type II | Hour |
| 608.15 Power Grader Rental | Hour |
| 608.20 Dragline Rental, Type I | Hour |
| 608.21 Dragline Rental, Type II | Hour |
| 608.25 All Purpose Excavator Rental, Type I | Hour |
| 608.26 All Purpose Excavator Rental, Type II | Hour |
| 608.30 Power Broom Rental | Hour |
| 608.37 Truck Rental | Hour |
| 608.40 Loader Rental, Type I | Hour |
| 608.41 Loader Rental, Type II | Hour |

## SECTION 609 - DUST AND ICE CONTROL

609.01 DESCRIPTION. This work shall consist of treating traveled areas to control dust or reduce ice hazard on the project.

609.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Water ..... 745.01
Calcium Chloride ..... 746.01
Sodium Chloride ..... 747.01

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 AND ICE 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 in writing by the Engineer.

Unless otherwise authorized in writing by the Engineer, calcium chloride shall be applied at the rate of 270 $g/m^2$ (1/2 pound per square yard) for dust and ice control. In

general, calcium chloride shall be used on roadways under construction. It shall not be used on surfaces on which bituminous material will be applied, unless directed by the Engineer.

Sodium chloride may be substituted for calcium chloride in ice control when approved in writing 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 cubic meters (1000 gallons) 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 and Ice Control with Calcium Chloride to be measured for payment will be the number of metric tons (tons) of calcium chloride actually used in the complete and accepted work. When calcium or sodium chloride is delivered in bulk, the quantity will be determined from load tickets.

When sodium chloride is used instead of calcium chloride for ice control, the quantity measured for payment will be the total quantity used multiplied by 0.50.

609.06 BASIS OF PAYMENT. The accepted quantity of Dust Control with Water will be paid for at the Contract unit price per cubic meter (1000 gallons). The accepted quantity of Dust and Ice Control with Calcium Chloride will be paid for at the Contract unit price per metric ton (ton). Payment will be full compensation for furnishing, measuring the load, transporting, handling, and placing the material 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 |
|---|---|
| 609.10 Dust Control with Water | Cubic Meter (Thousand Gallons) |
| 609.15 Dust and Ice Control with Calcium Chloride | Metric Ton (Ton) |

## SECTION 613 - STONE FILL, RIPRAP, AND SLOPE PAVING

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:

| | |
|---|---|
| Sand Borrow and Cushion | 703.03 |
| Gravel Backfill for Slope Stabilization | 704.07 |
| Concrete Units for Slope Paving | 705.03 |
| Stone for Riprap, Heavy Type | 706.03(a) |

Stone for Riprap, Light Type ..... 706.03(b)
Stone for Stone Fill, Type I ..... 706.04(a)
Stone for Stone Fill, Type II ..... 706.04(b)
Stone for Stone Fill, Type III ..... 706.04(c)
Stone for Stone Fill, Type IV ..... 706.04(d)
Stone for Slope Paving ..... 706.05

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, riprap, or slope paving.

Sand borrow shall be placed and graded as bedding material for slope paving.

613.04 PLACING.

(a) Stone Fill. The specified stone fill shall be placed in one course thickness 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.

The stones shall be so placed and distributed that there will be no accumulations 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 filter blanket 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 and filter blanket are 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.

(b) Riprap. The stones shall be placed on the prepared slope or filter blanket 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.

(c) Slope Paving. The slope paving shall be placed on a minimum 50 mm (2 inch) thick bed of sand borrow in such a manner that the finished paving will present a smooth appearance.

When concrete units are used, the courses shall be laid from the bottom or toe of slope upward, with close joints and with consecutive courses breaking joints. The minimum dimension side of block shall be perpendicular to the slope and the long dimension approximately horizontal. Half blocks shall be used at the edge of the paved area when required.

When field or quarry stone is used, the stones shall be placed from the bottom or toe of slope upward, with close joints approximately perpendicular to the slope. Open joints shall be filled with spalls or gravel so that the entire paved surface will be firmly locked and keyed. Consecutive courses of quarry stone shall break joints and shall be so joined and butted that no part of the joints shall exceed 50 mm (2 inches) in width.

613.05 METHOD OF MEASUREMENT. The quantities of Stone Fill and Riprap to be measured for payment will be the number of cubic meters (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.

The quantity of Slope Paving to be measured for payment will be the number of square meters (square yards) installed in the complete and accepted work, measured using slope measurements.

613.06 BASIS OF PAYMENT. The accepted quantities of Stone Fill and Riprap of the type specified will be paid for at the Contract unit price per cubic meter (cubic yard). The accepted quantities of Slope Paving of the type specified will be paid for at the Contract unit price per square meter (square yard). Payment will be full compensation for furnishing, transporting, 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, slope paving, and the filter blanket or bedding material will be paid for at the Contract unit price per cubic meter (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 Contract item.

Unless otherwise shown on the Plans, the filter blanket will be paid for under the Contract item Gravel Backfill for Slope Stabilization.

Bedding material of sand borrow will not be paid separately, but will be considered incidental to the Contract unit price for Slope Paving, unless otherwise specified.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 613.10 Stone Fill, Type I | Cubic Meter (Cubic Yard) |
| 613.11 Stone Fill, Type II | Cubic Meter (Cubic Yard) |
| 613.12 Stone Fill, Type III | Cubic Meter (Cubic Yard) |
| 613.13 Stone Fill, Type IV | Cubic Meter (Cubic Yard) |
| 613.15 Riprap, Heavy Type | Cubic Meter (Cubic Yard) |

| | |
|---|---|
| 613.16 Riprap, Light Type | Cubic Meter (Cubic Yard) |
| 613.20 Slope Paving | Square Meter (Square Yard) |

## 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:

| | |
|---|---|
| Asphalt Cement (Prepared from Petroleum) | 702.02 |
| Cutback Asphalt | 702.03 |
| Emulsified Asphalt | 702.04 |
| Tar Emulsion | 702.05 |
| Sand Borrow and Cushion | 703.03 |
| Gravel for Subbase | 704.04 |
| Mortar, Type I | 707.01 |
| Mortar, Type IV | 707.03 |
| Joint Sealer, Hot Poured | 707.04(a) |
| Preformed Joint Filler, Cork | 707.08 |
| Preformed Joint Filler, Bituminous Type | 707.14 |
| Epoxy Mortar Compound and Epoxy Mortar | 719.01 |
| Epoxy Bonding Compound | 719.02 |
| Water-Reducing, High Range Admixture | 725.02(h) |
| Water-Reducing, High Range, and Retarding Admixture | 725.02(i) |
| Liquid Membrane-Forming Compound | 725.01(d) |
| Timber Preservative | 726.01 |
| Vertical Granite Curb | 729.01 |
| Granite Bridge Curb | 729.02 |
| Granite Slope Edging | 729.03 |
| Precast Reinforced Concrete Curb | 729.04 |
| Bituminous Concrete Curb | 729.05 |
| Treated Timber Curb | 729.06 |

All cast-in-place concrete for curbing and gutters shall conform to the requirements of Section 501 for Concrete, Class B.

Bituminous material for curbs, gutters, and traffic islands of the type specified by the Engineer shall meet the requirements of Section 406.

Concrete, bituminous mixes, and precast concrete curbing materials will be subject to inspection and tests at the plants for compliance with quality requirements.

Cast-in-place concrete for concrete bridge barrier curb shall conform to the requirements of Section 501 for Concrete, Class LW or Concrete, Class A as shown on the Plans.

Reinforcing steel for concrete bridge barrier curb shall meet the requirements of Section 507.

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. The curb and slope edging shall be set so that the front top arris line is in close conformity to the line and grade required. 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 25 mm (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 150 mm (6 inches) in depth.

616.04 GRANITE BRIDGE CURB. Prior to beginning work, the Contractor shall receive the Engineer's approval of the proposed fabrication plan. Working drawings shall be submitted in accordance with Subsection 105.03.

Curbstones shall be carefully set and shimmed to the line and grade shown on the Plans. The space under the curb shall be completely filled with concrete or mortar. When shown on the Plans, the mortar shall be removed from the front 50 mm (2 inches) under the curbstone. The curb stones shall be anchored as shown on the Plans with anchors grouted with Type IV mortar or an appropriate epoxy bonding compound into the curb. The curb shall be firmly held in position to prevent sliding or tipping until the concrete has been placed and is sufficiently set.

Long and short lengths of curb stone shall be alternated, unless otherwise directed by the Engineer. The curb shall be set so that joints between curb stones coincide with joints in the concrete deck.

The anchorage and the alignment of the curb shall be approved by the Engineer prior to placing the adjacent concrete.

The joints between the stones shall be raked out to a 50 mm (2 inch) depth and then carefully filled with epoxy mortar. The joints shall be neatly pointed on the top and

exposed front surfaces with a 5 mm (1/4 inch) recess. The space beneath the stones shall be raked out and filled with epoxy mortar as shown on the Plans.

Joints in curb at concrete deck joints shall be treated as shown on the Plans.

The Contractor shall protect curb stones against damage or discoloration of exposed surfaces until completion of the Contract.

616.05 CONCRETE BRIDGE BARRIER CURB. The barrier curb shall be accurately constructed to the line and grade shown on the Plans.

Joints and expansion devices shall be formed as shown on the Plans.

(a) Forms. Forms shall be metal of sufficient thickness and design to maintain a true shape and alignment as shown on the Plans. They shall be braced and secured sufficiently so that no deflection from alignment or grade will occur during the placement of the concrete. Forms shall be left in place a minimum of six hours.

(b) Finish. The Contractor shall be responsible for producing a high density surface free from cavities, honeycombing, and other defects.

For determination of an acceptable finish, the Contractor shall prepare a test panel, using the proposed process, for the approval of the Engineer. The test panel shall represent the in-place section to be constructed and shall be formed using one of the metal forms erected in its designed position. The test panel shall have a minimum thickness of 230 mm (9 inches), a minimum length of 1.2 m (4 feet), and shall be the full height of the designed section.

An acceptable process may require, but is not limited to, the following:

(1) The use of superplasticizers (water-reducing, high range admixture or water-reducing, high range, and retarding admixture) as an additive to the concrete mix.

(2) The use of external form vibration.

(3) The use of form liner.

(4) Control of the mixing time prior to placement in the forms.

(5) Cooling of the forms when their temperature is above 21 °C (70 °F).

As many test panels as necessary shall be cast until an acceptable finish is obtained.

(c) Curing. Immediately upon removal of the forms, the barrier curb shall be cured in accordance with the procedure specified for superstructures in Table 501.17A.

616.06 CAST-IN-PLACE CEMENT CONCRETE CURB.

(a) Excavation. Excavation and bedding shall conform to the requirements of Subsection 616.03(a).

(b) Forms. Forms shall be of wood or metal, straight or curved as required, free from warp and shall be in accordance with Subsection 501.09. 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 501.16(a).

(d) Sections. Curbing shall be constructed in sections having a uniform length of 3 m (10 feet), unless otherwise specified. Sections shall be separated by open joints 3 mm (1/8 inch) wide except at expansion joints.

(e) Expansion Joints. Expansion joints shall be formed at the intervals shown on the Plans using a preformed expansion joint filler having a thickness of 6 mm (1/4 inch). They shall be constructed at 6 m (20 feet) intervals or as directed by the Engineer. When the curb is constructed adjacent to or on concrete pavement, expansion joints shall be located opposite or at expansion joints in the pavement.

(f) Curing. Curbs shall be cured in accordance with Subsection 501.17.

(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 150 mm (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.

616.07 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. Unless otherwise shown on the Plans or directed by the Engineer, expansion joints shall be placed every 6 m (20 feet). The curb sections shall be placed and fitted so that there will be no open joints between them exceeding 3 mm (1/8 inch) in width.

Expansion joints shall be filled with preformed expansion joint filler having a thickness of 6 mm (1/4 inch).

Joints in 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 150 mm (6 inches) with the same material as the bedding, unless otherwise specified.

616.08 BITUMINOUS CONCRETE CURB.

(a) General. The plant and equipment necessary for this work shall be in conformance with the requirements of Section 406.

(b) Preparation of Bed. The bituminous concrete curb shall be placed on bituminous concrete pavement or other hard surface. The surface shall be thoroughly cleaned of all dirt, dust, sand, or other loose material and treated with a tack coat of Type RS-1 emulsified asphalt applied at a rate of from 225 to 450 mL/$m^2$ (6 to 13 ounces 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 seem to be warranted. The resulting curbing shall conform in all respects to the curbing produced by the use of the machine.

(d) Sealing. After the curb has been in place seven days, the exposed surface shall be treated with two coats of emulsified asphalt or tar emulsion.

616.09 TREATED TIMBER CURB. The treated timber, bituminous fillet, and granular material behind the curb shall be installed as shown on the Plans. The fillet will be sealed as specified in Subsection 616.08(d).

616.10 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 in order 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 25 mm (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 completely filled 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 150 mm (6 inches) in depth.

616.11 REMOVAL OF EXISTING CURB. The Contractor shall remove existing curb at locations shown on the Plans or as directed by the Engineer. When shown in the Contract Documents that the curb will remain the property of the State or municipality, the Contractor shall exercise reasonable 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.

616.12 PORTLAND CEMENT CONCRETE GUTTER.

(a) Requirements for Forms. Forms shall be of wood or metal, straight or curved as required, free from warp, and shall be in accordance with Subsection 501.09.

(b) Preparation of Bed. The bed shall be prepared and shaped at the proper depth in accordance with the dimensions shown on the Plans. All soft, yielding, or unsuitable material below the subgrade shall be removed and replaced with approved material. The foundation course, when required, shall be placed, compacted thoroughly, and finished to a firm, smooth surface.

(c) Construction of Gutters. The foundation shall be moistened prior to the placing and consolidation of the concrete. The surface shall be smoothly and evenly finished with a wooden float and shaped to conform to the required dimensions of the gutter.

The gutter shall be constructed in alternate sections, each having a uniform length of 4 m (13 feet). The abutting face and adjacent edges of the gutter sections shall be painted with a bituminous material approved by the Engineer. The length of sections may be shortened where necessary for closures but no section less than 1 m (3 feet) in length will be permitted.

During construction, the first alternate sections shall be allowed to set at least 24 hours before the intermediate sections are placed. Forms shall not be removed until 24 hours after the concrete has been placed.

The edges of the gutter shall be finished with an approved edging tool having a radius of not more than 6 mm (1/4 inch).

Immediately upon completion of the finishing of the concrete, it shall be cured in accordance with Subsection 501.17. The method and details of curing shall be subject to the approval of the Engineer.

Expansion joints shall be formed at intervals of 8 m (26 feet) or as shown on the Plans using a preformed expansion joint filler having a thickness of 19 mm (3/4 inch). When the curb is constructed adjacent to or on concrete pavement, expansion joints shall be subject to the approval of the Engineer.

The expansion joints shall be properly sealed with approved joint sealer following completion of the gutter and pavement.

After the forms have been removed, the sides of the gutter shall be backfilled to the required elevation as shown on the Plans or as directed by the Engineer.

616.13 BITUMINOUS CONCRETE GUTTERS AND TRAFFIC ISLANDS.

(a) General. The plant and equipment necessary for this work shall conform to the requirements of 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 of Gutter. The bituminous concrete shall be laid in two courses. Each course shall be rolled with a roller with a mass of (weighing) at least 68 kg (150 pounds). The finished gutter shall be uniform in appearance, free from irregularities, and present a smooth surface.

All joints adjacent to pavements, curbs and structures shall be painted with Type RS-1 emulsified asphalt.

Headwalls or intermediate cutoff walls when shown on the Plans or directed by the Engineer shall be constructed of Concrete, Class B, cement rubble masonry, or bituminous concrete gutters and traffic islands.

616.14 METHOD OF MEASUREMENT. The quantities of Granite Slope Edging, Vertical Granite Curb, Granite Bridge Curb, Precast Reinforced Concrete Curb, Cast-in-Place Concrete Curb, Treated Timber Curb, Concrete Bridge Barrier Curb, and Removing and Resetting Curb to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work, as determined along the face of the finished curb.

The quantity of Removal of Existing Curb to be measured for payment will be the number of meters (linear feet) removed in the complete and accepted work, measured along the face of the curb in its original position.

The quantities of Bituminous Concrete Curb and Bituminous Concrete Gutters and Traffic Islands to be measured for payment will be the number of metric tons (tons) installed in the complete and accepted work, as determined from the load tickets.

The quantity of Portland Cement Concrete Gutter to be measured for payment will be the number of cubic meters (cubic yards) of Class B concrete installed in the complete and accepted work.

616.15 BASIS OF PAYMENT. The accepted quantities of Granite Slope Edging, Vertical Granite Curb, Granite Bridge Curb, Precast Reinforced Concrete Curb, Cast-in-Place Concrete Curb, Treated Timber Curb, Removing and Resetting Curb, and Removal of Existing Curb will be paid for at the Contract unit price per meter (linear foot) of curb placed, removed, or removed and reset.

The accepted quantities of Bituminous Concrete Curb or Bituminous Concrete Gutters and Traffic Islands will be paid for at the Contract unit price per metric ton (ton).

The accepted quantity of Portland Cement Concrete Gutter will be paid for at the Contract unit price per cubic meter (cubic yard).

Payment will be full compensation for furnishing, transporting, handling, and placing the specified material, including all excavation, 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 by the construction of Bituminous Concrete Curb 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 the Contract item 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 Portland Cement Concrete Gutter and Bituminous Concrete Gutters and Traffic Islands will be paid for separately.

The accepted quantity of Concrete Bridge Barrier Curb will be paid for at the Contract unit price per meter (linear foot), except that reinforcing steel will be paid for under Section 507.

The costs necessary to produce an acceptable finish, including preparation and casting of test panels, will be considered incidental to the Contract unit price for Concrete Bridge Barrier Curb.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 616.20 Granite Slope Edging | Meter (Linear Foot) |
| 616.21 Vertical Granite Curb | Meter (Linear Foot) |
| 616.22 Granite Bridge Curb | Meter (Linear Foot) |
| 616.23 Granite Bridge Curb (Median Slope Edge) | Meter (Linear Foot) |
| 616.24 Concrete Bridge Barrier Curb | Meter (Linear Foot) |
| 616.25 Precast Reinforced Concrete Curb, Type A | Meter (Linear Foot) |
| 616.26 Precast Reinforced Concrete Curb, Type B | Meter (Linear Foot) |
| 616.27 Cast-in-Place Concrete Curb, Type A | Meter (Linear Foot) |
| 616.28 Cast-in-Place Concrete Curb, Type B | Meter (Linear Foot) |
| 616.30 Bituminous Concrete Curb, Type A | Metric Ton (Ton) |
| 616.31 Bituminous Concrete Curb, Type B | Metric Ton (Ton) |
| 616.35 Treated Timber Curb | Meter (Linear Foot) |
| 616.40 Removing and Resetting Curb | Meter (Linear Foot) |
| 616.41 Removal of Existing Curb | Meter (Linear Foot) |
| 616.45 Portland Cement Concrete Gutter | Cubic Meter (Cubic Yard) |
| 616.47 Bituminous Concrete Gutters and Traffic Islands | Metric Ton (Ton) |

## SECTION 617 - MAILBOXES

617.01 DESCRIPTION. This work shall consist of the removal and relocation of existing mailboxes to permanent locations. The work shall include the replacement of any non-conforming boxes, supports, or attachment hardware.

As used in this Section, the term “mailbox” shall include the actual box, post or other support, and attachment hardware.

617.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Timber Preservative, Type IV | 726.01 |
| Metal Hand Railing | 732.01 |
| Aluminum Posts | 750.01(b) |
| Wood Posts | 750.01(c) |

Steel tubing produced to ASTM A 500, Grade B specifications will be considered acceptable for steel posts.

Brackets and platforms shall be made of pre-galvanized steel sheets. Holes shall be neatly punched or drilled.

Fasteners shall be of good commercial quality, shall be galvanized, and shall have the approval of the Engineer prior to use.

New boxes must meet the approval of the US Postal Service.

Certifications will not be required for materials supplied under this Section.

617.03 GENERAL. Mailboxes designated to be relocated shall be carefully removed and reinstalled as shown on the Plans. Any materials in the existing mailbox installation which do not conform to the Plans or Subsection 617.02 shall be replaced with new, conforming materials. Materials not reused shall remain the owner's property.

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 as long as 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 150 mm (6 inch) layers. The backfill material shall be thoroughly tamped.

Mailboxes shall be attached to the posts using the mountings and hardware shown on the Plans. All fasteners shall be drawn sufficiently tight so 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 relocated mailboxes to be measured for payment will be the number of each type (single or multiple support) relocated in the complete and accepted work, as determined by the Engineer.

617.06 BASIS OF PAYMENT. The accepted quantity of each type of mailbox relocation will be paid for at the Contract unit price each. Payment will be full compensation for removing the existing mailbox, installing the mailbox in its permanent location, excavating as necessary, backfill, and furnishing all new materials including mailbox, supports, support hardware, and lettering, 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.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 617.10 Relocate Mailbox, Single Support | Each |
| 617.12 Relocate Mailbox, Multiple Support | Each |

## SECTION 618 - SIDEWALKS

618.01 DESCRIPTION. This work shall consist of the construction of bituminous or portland cement concrete sidewalks.

618.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Emulsified Asphalt | 702.04 |
| Asphalt Treated Felt | 707.08 |
| Preformed Joint Filler, Cork | 707.08 |
| Preformed Joint Filler, Bituminous Type | 707.14 |

Concrete for sidewalks shall conform to the requirements of Section 501 for Concrete, Class B.

The type of bituminous materials for sidewalks shall be specified by the Engineer. The material shall meet the requirements of Section 406.

Portland cement and bituminous mixes will be subject to inspection and tests at the mixing plants for compliance with quality requirements.

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 to the depth and section shown on the Plans. When the layer required exceeds 150 mm (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 required to obtain the compaction.

(b) Forms. Forms shall be of wood or metal and shall extend for the full depth of the concrete. All forms shall be straight or curved as required, free from warp and in accordance with the requirements of Subsection 501.09.

(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 depth that, after being consolidated and finished, it shall be to 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. No plastering will be permitted. The edges shall be rounded with an edger having a radius of 6 mm (1/4 inch). Before the concrete has taken its initial set, it shall be tested for waves or irregularities with a straightedge at least 3 m (10 feet) long. Deviations of 6 mm (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. Special texturing on sidewalk ramps shall be installed in accordance with construction Plan details.

(e) Joints. Unless otherwise shown on the Plans or directed by the Engineer, expansion joints shall be placed every 6 m (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 6 mm (1/4 inch) thick 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 walk.

Between the expansion joints, the sidewalk shall be divided at intervals of 1.5 m (5 feet) by dummy joints formed by a jointing tool or other acceptable means to provide grooves approximately 3 mm (1/8 inch) wide and at least 33 percent of the depth.

When the sidewalk is constructed next to a concrete or granite curb, asphalt treated felt shall be placed between sidewalk and curb for the depth of the sidewalk.

(f) Curing. Concrete shall be cured in accordance with Subsection 501.17. During the curing period, all traffic, both pedestrian and vehicular, shall be excluded. Vehicular traffic shall be excluded for such additional time as the Engineer may direct.

(g) Backfilling. After the sidewalk has been opened to traffic, the space on each side shall be backfilled to the required elevation with suitable material, firmly compacted, and neatly graded.

618.04 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 immediately prior to the placing of any material against them. Forms shall be cleaned thoroughly each

time they are used. String or wire lines staked to grade will not be accepted as equivalent to grade control forms. When a suitable abutting curb or header is available and is approved by the Engineer as 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.

(e) Texturing. Special texturing on sidewalk ramps shall be installed in accordance with the details shown on the Plans.

618.05 METHOD OF MEASUREMENT. The quantities of Portland Cement Concrete Sidewalk to be measured for payment will be the number of square meters (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 metric tons (tons) of material installed in the complete and accepted work, as determined from load tickets.

618.06 BASIS OF PAYMENT. The accepted quantities of Portland Cement Concrete Sidewalk will be paid for at the Contract unit price per square meter (square yard) for the specified depth. The accepted quantity of Bituminous Concrete Sidewalk will be paid for at the Contract unit price per metric ton (ton). Payment will be full compensation for furnishing, transporting, handling, and placing the materials specified, including expansion joint material and texturing 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 the Contract item Bituminous Concrete Sidewalk.

Bed course material will be paid for under the type of subbase placed.

Excavation, unless otherwise specified, will be paid for under the Contract item Excavation and Embankments in Section 203.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 618.10 Portland Cement Concrete Sidewalk, 125 mm (5 inch) | Square Meter (Square Yard) |
| 618.11 Portland Cement Concrete Sidewalk, 200 mm (8 inch) | Square Meter (Square Yard) |
| 618.15 Bituminous Concrete Sidewalk | Metric Ton (Ton) |

## SECTION 619 - MARKERS

619.01 DESCRIPTION. This work shall consist of furnishing and placing boundary markers and marker posts, and the removing and resetting existing property markers.

619.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Mortar, Type I | 707.01 |
| Bar Reinforcement | 713.01 |
| Wood Posts | 728.01(a) |
| Steel Posts and Post Accessories | 728.01(c) |
| Yielding Marker Posts | 751.01(a) |

Concrete for boundary markers shall conform to the requirements of Section 501 for Concrete, Class A.

Yielding marker posts shall be 2 m (6.5 feet) long and shall be embedded to a depth of 1 m (3 feet) in the ground.

619.03 PLACING.

(a) General. Boundary markers and marker posts of the dimensions shown on the Plans 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 150 mm (6 inches) in depth.

Marker posts may be driven if suitable caps and driving equipment are used to prevent damage to the post.

(b) Boundary Markers. When the marker point falls on ledge, a steel rod marker shall be placed in a hole of the diameter and depth as shown on the Plans or directed by the Engineer. The rod shall be solidly wedged into the hole and cut off to the required elevation. The space around the rod shall be filled with Type I mortar.

(c) 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 commencement of 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 150 mm (6 inches) above the ground, sidewalk, or other surface unless otherwise directed by the Engineer.

When the marker point falls on ledge 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 to be measured for payment will be the number of markers of each type set and the number of property markers removed and reset in the complete and accepted work.

619.05 BASIS OF PAYMENT. The accepted quantities of each type of marker set and property markers removed and reset 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 excavation, backfill, and mortar and for furnishing all labor, tools, materials, equipment, and incidentals necessary to complete the work.

The Contract unit prices for the items of Wood Marker Posts, Steel 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 of an existing marker post.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 619.10 Boundary Markers | Each |
| 619.15 Wood Marker Posts | Each |
| 619.16 Steel Marker Posts | Each |
| 619.17 Yielding Marker Posts | Each |
| 619.20 Removing and Resetting Property Markers | Each |

## SECTION 620 - FENCES

620.01 DESCRIPTION. This work shall consist of the construction of fences and gates.

620.02 MATERIALS. Materials shall meet the requirements of the following Subsections.

| | |
|---|---|
| Mortar, Type I | 707.01 |
| Creosote Oil | 726.01 |
| Woven Wire Fence | 727.01 |
| Barbed Wire | 727.01 |

Chain-Link Fence.....727.02
Grounding Electrodes.....753.05

When chain-link fence is specified, the Contractor may elect to use galvanized, vinyl coated, or aluminum coated steel fabric for the fence as long as it conforms to the design shown on the Plans.

The materials for galvanized snow barrier shall conform to the requirements of this Subsection and the details shown on the Plans.

The wire fabric for the galvanized snow barrier shown on the Plans shall be a 25 mm (1 inch) mesh, galvanized, steel chain-link fabric conforming to the requirements of Subsection 727.02.

Hardware for the galvanized snow barrier shall be hot-dip galvanized or mechanically galvanized using a mechanically deposited process conforming to the requirements of AASHTO M 298, Class 110.

The fabric shall be installed on the traffic side of the support system.

The Contractor may use preformed 1.6 by 9.5 mm (1/16 × 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 205 MPa (30 kips per square inch), and an approved closure, as an alternate to the stainless steel clips shown on the Plans.

620.03 GENERAL. All trees, brush, and other obstructions which interfere with proper grade, alignment, and construction of fences shall be removed and disposed of in accordance with the requirements of 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 150 mm (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 cross fences shall be connected to the new fences. 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.

At bridges, cattle passes, and large culverts, the fence shall be installed as shown on the Plans or as directed by the Engineer. In no case shall the fence be connected to a structure.

620.04 ERECTION OF 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 with two coats of creosote oil.

Steel posts shall be set with anchor plates down, except when set in rock the anchor plates shall be omitted. When driving posts, the tops shall be protected by driving caps.

When ledge rock 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 redrilled 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 degrees. The maximum distance between braces shall be 180 m (600 feet).

The 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 and shall conform to the requirements of Section 501 for Concrete, Class B.

The woven wire fence shall be stretched taut and attached to the posts so that the bottom wire is approximately 75 mm (3 inches) above the ground.

When wood posts are used, each horizontal wire shall be fastened to the posts with 3.76 mm (No. 9 gage) galvanized or aluminum coated staples 38 mm (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 3.05 mm (No. 11 gage) rust resistant spring wire clips. Instead of the fasteners, posts equipped with fastening studs approximately 13 mm (1/2 inch) high and 57 mm (2 1/4 inches) apart may be used.

Barbed wire shall be installed at river crossings only, as shown on the Plans or as directed by the Engineer. The installation of barbed wire at river crossings will be considered installation of woven wire fence.

620.05 ERECTION OF 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 redrilled 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 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 location as shown on the Plans for the type of fence being installed.

620.07 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 reasonable 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 either be removed from the project area or disposed of on site in a manner acceptable to the Engineer.

620.08 GATES. The gates shall be of the design shown on the Plans and shall be completed in a neat and professional manner. The gate hold backs 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.

620.09 METHOD OF MEASUREMENT. The quantity of fence and snow barrier of the type and size specified to be measured for payment will be the number of meters (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 length of barbed wire fence installed at a river crossing will be measured for payment as an equal length of woven wire fence.

The quantity of Removing and Resetting Fence and Removal of Existing Fence will be measured for payment as the number of meters (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 braces 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 Bracing Assemblies 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 gates of the type and size specified to be measured for payment will be the number of meters (linear feet) of clear distance between gate posts in the complete and accepted work.

620.10 BASIS OF PAYMENT. The accepted quantities of fence, gates, and snow barrier, installed or removed and reset, will be paid for at the Contract unit price per meter (linear foot) of the type and size specified.

Barbed wire fence installed at a river crossing will be paid for as Woven Wire Fence.

Removal of Existing Fence will be paid for at the Contract unit price per meter (linear foot). Payment will include compensation for stockpiling or disposal, as appropriate.

Braces and bracing assemblies will be paid for at the Contract unit price for each type specified.

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, 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 |
|---|---|
| 620.11 Chain-Link Fence, 1.2 m (4 feet) | Meter (Linear Foot) |
| 620.12 Chain-Link Fence, 1.8 m (6 feet) | Meter (Linear Foot) |
| 620.13 Chain-Link Fence, 2.4 m (8 feet) | Meter (Linear Foot) |
| 620.15 Gate for Chain-Link Fence, 1.2 m (4 feet) | Meter (Linear Foot) |
| 620.16 Gate for Chain-Link Fence, 1.8 m (6 feet) | Meter (Linear Foot) |
| 620.17 Gate for Chain-Link Fence, 2.4 m (8 feet) | Meter (Linear Foot) |
| 620.20 Bracing Assembly for Chain-Link Fence, 1.2 m (4 feet) | Each |
| 620.21 Bracing Assembly for Chain-Link Fence, 1.8 m (6 feet) | Each |

| | | |
|---|---|---|
| 620.22 | Bracing Assembly for Chain-Link Fence, 2.4 m (8 feet) | Each |
| 620.25 | Woven Wire Fence with Steel Posts | Meter (Linear Foot) |
| 620.26 | Woven Wire Fence with Wood Posts | Meter (Linear Foot) |
| 620.30 | Drive Gate for Woven Wire Fence | Each |
| 620.40 | Steel Brace for Woven Wire Fence | Each |
| 620.41 | Wood Brace for Woven Wire Fence | Each |
| 620.50 | Removing and Resetting Fence | Meter (Linear Foot) |
| 620.55 | Removal of Existing Fence | Meter (Linear Foot) |
| 620.75 | Snow Barrier (Galvanized) | Meter (Linear Foot) |

## SECTION 621 - TRAFFIC BARRIERS

621.01 DESCRIPTION. This work shall consist of the furnishing, assembling, removing, and/or resetting of guardrail, median barriers, and guide posts.

621.02 MATERIALS. Materials shall meet the requirements of the following Subsections.

| | |
|---|---|
| Asphalt Emulsion | 702.04 |
| Tar Emulsion | 702.05 |
| Grease Rustproof Compound | 708.04 |
| Coatings for Wood | 708.05 |
| Boiled Linseed Oil | 726.02 |
| Mineral Spirits | 726.03 |
| Posts and Post Accessories | 728.01 |
| Rail Elements | 728.02 |
| Hardware | 728.03 |
| Delineation Devices | 728.04 |
| Concrete Anchors | 728.05 |

The materials for Terminal Connector for Steel Beam Guardrail shall conform to the requirements shown on the Plans.

Materials for constructing, curing, and protecting concrete median barrier shall meet the requirements of Sections 501, 507, and 514, as appropriate.

Materials for removing and resetting guardrail, replacing guardrail post assembly, replacing guardrail beam unit, replacing guardrail cable, and adjusting height of guardrail shall consist of the acceptable posts, cables, rails, bolts, offset blocks, and other hardware of the existing guardrail together with the necessary new replacement parts. The new replacement parts shall match as close as possible the existing components they replace.

Materials for aluminum approach railing shall meet the requirements of Subsection 732.02. The installation of aluminum approach railing shall meet the requirements of Subsections 525.05 and 621.03.

All welding shall conform to the requirements of Subsection 506.10.

621.03 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. Round posts shall be set or driven with the larger post cross-section facing downward. The space around the posts shall be backfilled with suitable material in 150 mm (6 inch) layers and tamped thoroughly with air or mechanical tampers.

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 without compensation. The new materials shall be equal to or better than the material of the existing guardrail.

Guardrail posts and anchors shall be installed prior to placing the adjacent top course of pavement unless otherwise directed by the Engineer.

Unless otherwise shown on the Plans, S75×8.5 (S3×5.7) steel posts shall be used with cable guardrail; W150×13.5 (W6×9) steel posts and offset blocks shall be used with steel beam, heavy duty steel beam, and thrie beam guardrail and median barrier; and S75×8.5 (S3×5.7) steel posts shall be used with box beam guardrail.

When wood posts are shown on the Plans, full-sawn wood posts and offset blocks with a 152 by 203 mm (6 × 8 inch) cross-section shall be used with steel beam, heavy duty steel beam, and thrie beam guardrail and median barrier, unless a different cross-section is shown on the Plans. All posts shall be full-sawn to the designated nominal size.

Unless otherwise shown on the Plans, guide posts shall be 100 to 140 mm (4 to 5 1/2 inch) diameter wood posts.

621.04 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) Cable Rail. Cable guardrail shall be installed as shown on the Plans.

Splicing of cable will be permitted when necessary, but no single piece of cable shall be less than 15 m (50 feet) in length.

(c) Cedar Log Rail. Cedar log guardrail shall be constructed as shown on the Plans. All cuts and notches on rails and posts shall be made in a manner to provide uniform bearing and close joints. The rails shall be attached to posts by steel straps and lag screws.

621.05 CONCRETE MEDIAN BARRIERS (CMB).

(a) General. The Contractor shall notify the Resident Engineer at least three working days prior to the date that casting of the units is to begin, in order that arrangements for plant inspection may be made by Agency personnel.

Once casting has begun, it shall be done on a relatively continuous basis. Casting on a piecemeal basis will not be acceptable.

(b) Fabrication. The CMB shall be precast to conform to the shape and size shown on the Plans. The Contractor shall produce units that are uniform in appearance.

Reinforcement shall be the type, size, and configuration shown on the Plans. The ends of chairs or spacers used to support or locate reinforcing steel, that bear on the faces of forms, shall be made of or coated with non-corrosive material so that no discoloration will show on the face of the units.

Forms shall be metal of sufficient thickness, externally braced to maintain a true shape and alignment, as shown on the Plans. Form oil shall be a non-staining type.

The concrete shall be thoroughly consolidated by external or internal vibration, or a combination of both. Vibrating shall be done with care and in such a manner as to prevent displacement of reinforcement.

The length of individual precast sections shall not exceed 6 m (20 feet), unless otherwise specified. The Contractor may need to cast sections of odd lengths to meet field conditions. However, in no case will sections less than 3 m (10 feet) in length be permitted.

(c) Curing and Handling. All median barrier sections shall be cured in accordance with Subsection 501.17 or 510.10. If the accelerated curing methods specified in Subsection 510.10 are used, curing shall be continued until the concrete has attained a compressive strength of at least 20.7 MPa (3000 pounds per square inch).

Median barrier sections shall not be moved until the concrete has attained a compressive strength of at least 20.7 MPa (3000 pounds per square inch).

Any median barrier sections damaged by the Contractor's operations shall be replaced by the Contractor at the Contractor's expense.

(d) Repair. Median barrier sections 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 that are 150 mm (6 inches) or less in diameter and that do not penetrate deeper than 50 mm (2 inches) into the concrete. Surface voids or "bugholes" that are less than 16 mm (5/8 inch) in diameter and less than 6 mm (1/4 inch) deep need not be repaired. Repairs shall be made using mortar composed of the exact ingredients of the concrete with the

coarse aggregate omitted. The repairs shall be made to the satisfaction of the Engineer.

Barrier sections having map or craze cracking or large spalls are not acceptable and shall not be repaired. Barrier sections having any cracks that go through the section are not acceptable and shall not be repaired.

(e) Concrete Testing. The Contractor shall provide all labor, materials and equipment for field tests and sampling, in accordance with Subsection 501.06. Testing shall be performed by the Contractor, subject to approval and inspection by the Engineer.

Specimens for compressive strength testing shall be 150 by 300 mm (6 × 12 inch) standard cylinders. A complete test result shall be the average of the strengths of at least two specimens from the same sample of concrete.

A minimum of four cylinders per day or per 40 $m^3$ (50 cubic yards) of concrete shall be made by the Contractor to determine compliance with the 28-day strength requirements. Additional cylinders shall be made by the Contractor to monitor the required curing or handling strength.

Test cylinders shall be cured for the required curing period with and by the same methods as the sections they represent. At the end of the required curing period, the cylinders shall be removed from their molds and placed in storage in a moist condition at 23 ± 1.7 °C (73.5 ± 3 °F).

(f) Shipping. Precast units shall meet the 28-day strength requirements before shipping. The Inspector will inspect all units prior to shipping. No units will be considered for shipment unless the units are free from defects, as defined in Subsection 621.05(d), and all requirements are met.

(g) Installation. The precast sections shall be installed at the location and in accordance with the details shown on the Plans. The sections shall be firmly butted against each other; any subbase or other material between units shall be removed. Units shall be joined with suitable connectors, where necessary, to prevent differential lateral movements of individual units as a result of vehicle impact.

(h) Sealing. Prior to backfilling and paving, the lower vertical faces of the CMB shall be treated by the Contractor with a uniform protective coat of asphalt or tar emulsion. Care shall be taken to ensure that the bituminous material used is not applied, smeared, or spattered on portions of the barrier other than the vertical faces. The bituminous material and application method shall both be approved in advance by the Engineer. The cost of the bituminous protective treatment shall be included in the Contract unit price for the CMB.

At some time prior to final project completion, the Contractor shall apply a mixture of 50 percent boiled linseed oil and 50 percent mineral spirits in accordance with Subsection 514.04 to all exposed surfaces of the CMB for its

entire length. Delaying this treatment as long as possible is desired to reduce the amount of curing compound remaining on the concrete surfaces that would prevent adherence of the linseed oil/mineral spirits treatment to the CMB. The cost of this protective treatment shall be included in the Contract unit price for the CMB.

(i) Alternate Designs. Instead of the design shown on the Plans, the Contractor may submit an alternate design, including reinforcing details, to the Engineer for approval prior to construction. Ultimate acceptance of a design utilizing less concrete and/or steel may be contingent upon a reduction in the unit bid price, at the discretion of the Engineer.

It is the responsibility of the Contractor to ensure that the time required for submittal, review, and approval of alternate CMB designs does not jeopardize the timely completion of the project. A request for a Contract time extension on this basis will be denied.

621.06 TEMPORARY TRAFFIC BARRIER. Temporary traffic barrier shall be either steel beam guardrail or CMB, at the Contractor's discretion, unless otherwise specified.

If steel beam guardrail is used, the maximum post spacing will be 1.9 m (75 inches). Guardrail components shall be in good condition to the satisfaction of the Engineer, and materials and installation shall otherwise be in accordance with the requirements for steel beam guardrail.

If CMB is used, precast units in good condition, satisfactory to the Engineer, and of a design as shown on the Plans or otherwise approved in advance of construction shall be used. Installation shall be in accordance with Subsection 621.05(g).

Temporary traffic barrier shall be erected in accordance with details shown on the Plans or as directed by the Engineer. Unless otherwise specified, temporary traffic barrier shall be removed when no longer needed on the project as determined by the Engineer, and shall remain the property of the Contractor. The area from which the barrier was removed shall be restored to a satisfactory condition where and when no other construction activities are indicated.

621.07 TERMINALS. Guardrail and median barrier terminals shall be constructed and installed as shown on the Plans. Concrete anchors associated with terminals shall be constructed in accordance with Subsection 621.08.

621.08 ANCHORS. Anchors for guardrail shall be placed at the locations and depths shown on the Plans. The backfill material shall be placed in layers of not more than 150 mm (6 inches) and shall be thoroughly compacted by use of air or mechanical tampers.

Cable, when required, shall be drawn taut and fastened securely to the anchor assemblies as shown on the Plans and adjusted to equalize the stresses.

621.09 DELINEATION. Delineation devices shall be of the design and materials shown on the Plans and shall be securely fastened to traffic barriers or guide posts as shown on the Plans or as directed by the Engineer.

Delineation devices for use on CMB shall be one of the devices on the approved list on file at the Agency's Materials and Research Section, telephone: (802) 828-2561.

621.10 FIELD PAINTING. Galvanized components that have been cut, abraded, or damaged such that base metal is exposed shall be cleaned and painted with two coats of an approved coating.

Wherever guardrail panels are nested, the surfaces on both panels that will be in contact with each other shall be coated with grease rustproof compound.

621.11 REMOVAL AND DISPOSAL OF GUARDRAIL OR GUIDE POSTS. Unless otherwise shown on the Plans, material to be removed shall become the property of the Contractor. The material shall be dismantled in a manner to best meet the requirements of the Contractor and shall be removed from the project limits and disposed of to the satisfaction of the Engineer.

Unless otherwise specified, anchor blocks may be abandoned in place, and the anchor rod or anchor cable may be cut off a minimum of 150 mm (6 inches) below ground level.

If posts or anchors are removed from an area where there is no additional excavation and embankment work, then the resultant holes shall be backfilled with suitable material in layers not more than 150 mm (6 inches) in depth and thoroughly compacted using air or mechanical tampers.

621.12 METHOD OF MEASUREMENT. The quantity of Plank Rail to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work measured from end to end of plank rail.

The quantity of Cedar Log Rail to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work, measured from end to end of log rail.

The quantity of Cable Guardrail to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work, measured from center to center of end posts. The distance from end posts to the anchors will not be included for payment. The measured quantity of Cable Guardrail will be multiplied by factors as follows:

| Post Spacing | Factor |
|---|---|
| 4.9 m (16 ft.) | 1.0 |
| 3.7 m (12 ft.) | 1.1 |
| 1.8 m (6 ft.) | 1.5 |
| 1.2 m (4 ft.) | 1.8 |

The quantities of Steel Beam Guardrail, Heavy Duty Steel Beam Guardrail, and Thrie Beam Guardrail to be measured for payment will be the number of meters (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 Breakaway Cable Terminals or Twisted End Terminals. Where terminal end sections are installed, an additional 600 mm (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 quantities of Steel Beam Guardrail, Heavy Duty Steel Beam Guardrail, and Thrie Beam Guardrail will be multiplied by factors as follows:

| Post Spacing | Factor |
|---|---|
| 3.8 m (12 ft., 6 in.) | 0.7 |
| 1.9 m (6 ft., 3 in.) | 1.0 |
| 1.3 m (4 ft., 2 in.) | 1.2 |
| 1.0 m (3 ft., 1 1/2 in.) | 1.4 |

The quantity of Box Beam Guardrail to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work, measured from center to center of end posts. An additional 300 mm (1 foot) of guardrail will be allowed for each overhang.

The quantities of Steel Beam Median Barrier and Thrie Beam Median Barrier to be measured for payment will be the number of meters (linear feet) of each kind specified installed in the complete and accepted work, measured from center to center of end posts to which rail is attached, excluding terminals.

The quantity of Concrete Median Barrier to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work, measured from end to end along the top of the barrier, including depressed or ramped end sections.

The quantity of Aluminum Approach Railing to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work, measured as shown on the Plans.

The quantity of terminals, anchors, approach sections, and guide posts to be measured for payment will be the number of units of each kind specified, installed in the complete and accepted work.

The quantity of Removing and Resetting Guardrail to be measured for payment will be the number of meters (linear feet) reset in the complete and accepted work, measured in accordance with the type of guardrail specified.

The quantity of Removal and Disposal of Guardrail to be measured for payment will be the number of meters (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 and Disposal of Guide Posts to be measured for payment will be the number of posts removed in the complete and accepted work.

The quantity of Temporary Traffic Barrier to be measured for payment will be the number of meters (linear feet) installed and removed in the complete and accepted work, measured from end to end of each installation, including terminals.

621.13 BASIS OF PAYMENT. The accepted quantities of rail, guardrail, or median barrier, new or reset, permanent or temporary, will be paid for at the Contract unit price per meter (linear foot) for the Contract item specified.

The accepted quantities of terminals, anchors, approach sections, and guide posts will be paid for at the Contract unit price each for the Contract item specified.

The accepted quantity of Aluminum Approach Railing will be paid for at the Contract unit price per meter (linear foot).

The accepted quantity of Removal and Disposal of Guardrail will be paid for at the Contract unit price per meter (linear foot). Removed and not reset guardrail will be paid for as Removal and Disposal of Guardrail.

The accepted quantity of Removal and Disposal of Guide Posts will be paid for at the Contract unit price each.

Payment will be full compensation for furnishing, transporting, handling, and placing the material specified, including excavation, backfill, delineation devices, steel strapping, stain, paint, and preservative material and for furnishing labor, tools, equipment, and incidentals necessary to complete the work.

Payment for CMB will be full compensation for furnishing, transporting, handling, and placing the material specified, including the protective coat of asphalt or tar emulsion and the linseed oil and mineral spirits mixture. Excavation and backfill required for installation of CMB will be paid for separately under the appropriate Sections.

Payment for removing and resetting guardrail will be full compensation for removing, transporting, storing, reassembling all parts necessary, cutting, furnishing of new parts when necessary, reinstalling at the new locations, and furnishing and applying stain, paint, and preservative material and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will include removing and replacing of anchors and terminal ends when required.

Payment for removing and disposing of guardrail or guide posts will be full compensation for removing and disposing of materials, and for restoration of the old installation site when required.

Payment for temporary traffic barriers 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. Temporary traffic barrier on a temporary bridge

will not be paid for under the Contract item Temporary Traffic Barrier, but will be considered incidental to the work under Section 528.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 621.15 Plank Rail | Meter (Linear Foot) |
| 621.16 Cedar Log Rail | Meter (Linear Foot) |
| 621.17 Cable Guardrail | Meter (Linear Foot) |
| 621.20 Steel Beam Guardrail | Meter (Linear Foot) |
| 621.21 Heavy Duty Steel Beam Guardrail | Meter (Linear Foot) |
| 621.25 Thrie Beam Guardrail | Meter (Linear Foot) |
| 621.30 Box Beam Guardrail | Meter (Linear Foot) |
| 621.35 Steel Beam Median Barrier | Meter (Linear Foot) |
| 621.40 Thrie Beam Median Barrier | Meter (Linear Foot) |
| 621.45 Concrete Median Barrier | Meter (Linear Foot) |
| 621.50 Breakaway Cable Terminal | Each |
| 621.51 Twisted End Terminal | Each |
| 621.55 Median Barrier Terminal | Each |
| 621.60 Anchor for Steel Beam Rail | Each |
| 621.61 Anchor for Steel to Box Beam Transition | Each |
| 621.65 Anchor for Cable Rail | Each |
| 621.66 Anchor for Cable Rail at Openings | Each |
| 621.70 Guardrail Approach Section, Type I | Each |
| 621.71 Guardrail Approach Section, Type II | Each |
| 621.74 Aluminum Approach Railing | Meter (Linear Foot) |
| 621.75 Removing and Resetting Guardrail | Meter (Linear Foot) |
| 621.80 Removal and Disposal of Guardrail | Meter (Linear Foot) |
| 621.81 Removal and Disposal of Guide Posts | Each |
| 621.85 Guide Posts | Each |
| 621.90 Temporary Traffic Barrier | Meter (Linear Foot) |

## SECTION 622 - INSULATION BOARD

622.01 DESCRIPTION. This work shall consist of furnishing and installing extruded expanded polystyrene insulation board on a prepared surface.

622.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Sand Borrow ..... 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 percent of the maximum dry density and the in-place moisture content shall be not more than 2 percent 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 75 mm (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 degrees 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 200 mm (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 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 cubic meters [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 cubic meter [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 at the Contract unit price per cubic meter (cubic yard) for sand borrow under Contract item Sand Borrow.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 622.10 Insulation Board | Cubic Meter (MFBM) |

## SECTION 625 - SLEEVES FOR UTILITIES

625.01 DESCRIPTION. This work shall consist of the furnishing and installation of sleeves for public or private utilities. Sleeves are hereby defined as encasements for utility lines and are also known as ducts, casings, and conduits.

625.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Reinforced Concrete Pipe | 710.01 |
| ABS Plastic Pipe | 710.05 |
| PVC Plastic Pipe | 710.06 |
| Corrugated Steel Pipe, Pipe Arches, and Underdrains | 711.01 |
| Corrugated Aluminum Alloy Pipe, Pipe Arches, and Underdrains | 711.02 |

The inside diameter of the sleeve shall be at least 50 mm (2 inches) larger than the largest diameter of the conduit or conductor being installed, except the minimum inside diameter of sleeves shall be as follows:

| | |
|---|---|
| Power Lines: | 100 mm (4 inches) |
| Telephone Lines: | 100 mm (4 inches) |
| Cable TV Lines: | 100 mm (4 inches) |
| Water Pipe: | 150 mm (6 inches) |
| Sewer Pipe: | 150 mm (6 inches) |
| Gas Pipe: | 150 mm (6 inches) |

Sleeves for power, telephone, cable TV, and metal pipes shall be nonmetallic.

625.03 INSTALLATION. Sleeves are to be installed using the same methods as for culverts as specified in Section 601, unless otherwise specified in the Contract. Nonmetallic pipe shall be positively joined in accordance with standard procedures.

Unless otherwise specified, any sleeve installed for future use is to be fitted with plugs or caps at both ends and will contain a suitable pull wire or pull cord accessible from both ends.

625.04 METHOD OF MEASUREMENT. The quantity of Sleeves for Utilities to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work.

625.05 BASIS OF PAYMENT. The accepted quantities of Sleeves for Utilities will be paid for at the Contract unit price per meter (linear foot). Payment will be full compensation for fabricating, furnishing, transporting, handling, and placing the material, including pull wire and end caps, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Sand, pea stone, spacer blocks, brick end walls, and other materials required in conjunction with sleeves will be considered incidental to the Contract item Sleeves for Utilities.

Excavation of trenches and boring or jacking pits for the placement of sleeves for utilities will be paid for under the Contract item Trench Excavation of Earth or Trench Excavation of Rock. Pay limits will be as indicated for culverts in Section 601.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 625.10 Sleeves for Utilities | Meter (Linear Foot) |

## SECTION 626 - WELLS AND CASINGS

626.01 DESCRIPTION. This work shall consist of constructing a well, to the depth required, by driving or drilling using either cable or rotary type machines. This work also includes furnishing and installing a well casing and all fittings; sealing of the casing, capping of the casing; and performing pumping or bailing tests, or other approved methods of water measurement.

626.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Well Casing ..... 741.01
Chlorine Solution ..... 742.01
Water ..... 745.01

626.03 GENERAL. The Contractor shall notify the Engineer at least two days in advance of the time that work is expected to begin on a specific well drilling site. Drilling beyond the Contract estimated depth shall not be performed unless ordered in writing by the Engineer. The written order will specify the additional depth to be drilled. Unless otherwise specified, the well shall be driven or drilled to a depth

necessary to obtain the required rate of flow of water and shall be cased with a well casing of at least 150 mm (6 inches) in diameter.

The Contractor shall drive or drill the well with a minimum of disturbance to the property owners concerned and surrounding areas. Waste water and cuttings shall be disposed of in a manner approved by the Engineer.

The Contractor shall furnish all necessary water for driving or drilling purposes at the site of the well.

If at any time the Engineer should decide that it is essential to discontinue drilling a particular well for any reason such as excessive depth, insufficient flow of water, or contamination, the Engineer will notify the Contractor in writing.

The well casing shall extend at least 600 mm (24 inches) above the highest ground surface immediately adjacent to the casing. The Contractor shall take every possible precaution to prevent any foreign material, ground or surface water from entering the well casing.

Upon completion of the well, the top of casing shall be securely capped to prevent the introduction of any foreign material into the well.

All cuttings, waste, and surplus material shall be removed and disposed of; all ruts and damage to lawns, landscaping, or drives shall be repaired, and the site shall be left in a clean and presentable condition.

626.04 DRILLING WELL. The driving or drilling of the well shall be started with a 200 mm (8 inch) diameter hole and extended at least 3 m (10 feet) into bedrock, or more when directed by the Engineer, to ensure a proper seal with the 150 mm (6 inch) diameter casing. The 150 mm (6 inch) diameter casing shall be placed and drilling continued with a 150 mm (6 inch) drilling head for approximately 300 mm (12 inches) before seating the casing to provide a proper seal against outside contamination. Unless otherwise directed by the Engineer, a standard drive shoe shall be used on the well casings.

When a rotary drill type machine is used, the water ejection mechanism shall be turned on and shall deliver water through the drill stem at all times when drilling in solid rock.

After the casing has been sealed, the drilling shall continue until a sufficient flow of water has been secured, as specified in Special Provisions for each well. If it is determined by the Engineer that the well will not be productive, drilling shall be discontinued.

After the required rate of flow of water has been obtained, drilling shall be continued for approximately 5 m (15 feet) in additional depth, or to the depth directed by the Engineer, to provide a sump for collection of sediment whereupon the well may be considered drilled to its full depth. The well hole shall be cleaned by continuous blowing with the drill head held just off the bottom if a rotary type drill machine is used, or by bailing if a cable type machine is used, until all fines are removed from the well hole and the water obtained is reasonably clean and clear.

When drilling is proceeding through a water bearing strata of porous material of sufficient depth for development of a well in gravel formation, the Engineer may order in writing the cessation of further drilling to make preparations for development of the well in the gravel formation

626.05 DEVELOPMENT OF WELL IN GRAVEL FORMATION. The development of a well in a gravel formation shall be in accordance with the standard specifications of the American Water Works Association, and as directed by the Engineer.

The casing shall extend at least 3 m (10 feet) below the anticipated maximum drawdown elevation.

626.06 MEASUREMENT OF FLOW. The Contractor shall determine the flow of water at all water bearing strata encountered while driving or drilling the well and perform any additional measuring tests that may be ordered by the Engineer. This work shall not be construed as part of the pump test for yield, but shall be included in the item for a driven or drilled well.

During the time of driving or drilling of the well, the Contractor shall furnish the Engineer with every reasonable facility for ascertaining the amount of flow and quality of water.

When the flow test or tests show that the required output of the well has not been obtained, drilling shall resume and continue until sufficient flow has been obtained or the Engineer determines that the well should be abandoned.

626.07 DISINFECTING. The Contractor shall disinfect the well with a chlorine solution after the drilling is completed and at least 12 hours prior to making the pump test for yield.

626.08 PUMP TEST FOR YIELD. Unless otherwise specified, all wells shall be given a pump test for yield whether drilled by a rotary type or a cable type drilling machine. The test shall be performed with the pump placed within 3 m (10 feet) of the bottom of the well. The Contractor shall install a pump with necessary power and connections capable of pumping the required rate of flow of water for each well.

The tests shall be conducted continuously for at least four hours, and up to a maximum of 72 hours, as specified by the Engineer, to determine that the well is capable of continuously producing the required rate of flow of water.

Suitable means, such as a hydrostatic air pressure tube with the bottom end taped to the top of the pump and an accurate pressure gauge at the top end of the tube with a provision for applying air pressure, shall be provided for determining the water level during the pumping operations.

Readings of the well water level and the well output shall be taken and recorded at 30-minute intervals . The Contractor shall furnish a copy of the test records in tabular form to the Engineer.

When the ordered length of pump test for yield is eight hours or less, the pumping shall be started at an hour that will allow completion of the test not later than 5:00 p.m. of the same day, unless otherwise directed by the Engineer prior to beginning the test.

626.09 SAMPLING. In order to determine that the quality of the water is suitable for domestic use or the intended consumption, the Engineer will submit water samples for analysis to the Vermont Department of Health Laboratory, Division of Environmental Health, 195 Colchester Avenue, Burlington, Vermont 05402, or other testing laboratory approved by the Vermont Department of Health. Sample bottles shall be obtained from the same laboratory.

626.10 METHOD OF MEASUREMENT. The quantity of Driven or Drilled Well to be measured for payment will be the number of meters (linear feet) driven or drilled in the complete and accepted work, measured as the difference in elevation between the bottom of the hole and the ground level. However, a minimum depth of 12 m (40 feet) will be measured for each well.

The quantity of Well Casing Pipe to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work, measured from end to end of casing.

The quantity of Development of Well in Gravel Formation to be measured for payment will be the number of hours actually worked.

The quantity of Pump Test for Yield to be measured for payment will be the number of hours actually consumed, while pumping continuously, measured from the time pumping is started, to the completion of the pump test for yield. No allowance will be made for time lost due to breakdown.

626.11 BASIS OF PAYMENT. The accepted quantity of Driven or Drilled Well will be paid for at the Contract unit price per meter (linear foot). Payment will be full compensation for furnishing, transporting, and handling the equipment; driving or drilling the well; sealing the well casing when required; measurement of flow; disinfecting and chlorinating the well; sampling the water; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work, including disposal of surplus materials and the cleaning of the site following completion of the construction operations.

The accepted quantity of Well Casing Pipe will be paid for at the Contract unit price per meter (linear foot). Payment will be full compensation for furnishing, transporting, and installing the casing; for capping the well; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Development of Well in Gravel Formation will be paid for at the Contract unit price per hour. Payment will be full compensation for performing the work specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Pump Test for Yield will be paid for at the Contract unit price per hour. Payment will be full compensation for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 626.15 Driven or Drilled Well | Meter (Linear Foot) |
| 626.20 Well Casing Pipe | Meter (Linear Foot) |
| 626.25 Development of Well in Gravel Formation | Hour |
| 626.30 Pump Test for Yield | Hour |

## SECTION 627 - PUMP AND TANK INSTALLATION

627.01 DESCRIPTION. This work shall consist of the furnishing of a water pump and pressure tank of capacity, size, and type specified, including complete installation as a system, and connection to existing plumbing with copper tubing or galvanized steel pipe of proper size.

627.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Flexible Plastic Water Pipe | 740.01 |
| Rigid PVC Plastic Water Pipe | 740.02 |
| Rigid ABS Plastic Water Pipe | 740.03 |
| Seamless Copper Water Tube | 740.04 |
| Galvanized Steel Water Pipe | 740.05 |
| Water Pumps | 741.02 |
| Water Storage Tanks | 741.03 |
| Chlorine Solution | 742.01 |
| Topsoil | 755.01 |
| Seed | 755.03 |

The Contractor shall furnish to the owner the manufacturer's warranties for the installed pump, tank, pipe, and necessary fittings and connections.

627.03 INSTALLATION.

(a) Pumps, General. The diameter of the pipe shall be that recommended by the manufacturer for the size pump being installed.

All pipes installed between the well and building entrance shall be located below the frost line and in no case shall the depth be less than 1.5 m (5 feet) below the ground, unless otherwise directed by the Engineer.

If the rated capacity of the pump is equal to or greater than the yield of the well, a low pressure cutoff or low-flow switch shall be installed as directed by the Engineer. In the case of a jet pump installation, a flow control valve may be used.

If an overflowing well is encountered, the well will be drained with a pitless adapter and check valve or well pit as approved by the Engineer and connected with a pipe of a size that will properly contain the overflow. The pipe shall be a plastic pipe as approved by the Engineer. Pitless adapter and connections shall be either bronze or brass.

(b) Jet Pump System. Jet pumps shall be installed using a flexible plastic pipe of at least 1.1 MPa (160 pounds per square inch) working pressure, with Schedule 80 rigid plastic or galvanized steel pipe between the well cap or pitless adapter and the ejector, and with the same type of pipe between the well and the storage tank, unless otherwise specified in the Contract.

A tailpiece of rigid pipe, 9 m (30 feet) in length, shall be installed with a foot valve of non-corrosive metal.

No splices will be allowed when flexible plastic pipe is installed between the well cap and the injector assembly.

(c) Submersible Pump System. Submersible pumps shall be installed using galvanized steel pipe, rigid plastic pipe, or flexible plastic pipe as specified. The installation will be in accordance with the manufacturer's recommendations.

If rigid plastic pipe is specified, the hanger pipe, between the pump and the certified pitless adapter, shall have threaded couplings. Schedule 40 plastic pipe may be used to a depth of 60 m (200 feet). For pump setting between 60 and 120 m (200 and 400 feet) of depth, Schedule 80 plastic pipe shall be used. For pump setting between 120 and 245 m (400 and 800 feet) of depth, galvanized pipe shall be used. When Schedule 40 or 80 plastic pipe is used, it will have threaded male and female adapters that shall be securely cemented to opposite ends of each length of pipe. An adjustable rubber or synthetic spider shall be attached to the first length of riser pipe at the top of the pump to protect the unit from damage by vibration. The spider shall be expanded to a tight fit of the well diameter and locked in place using stainless steel clamps of size to fit the top end of the pump and the riser pipe. The motor leads shall run through the spider so that they will be protected from disturbance. The pump cable shall be firmly taped to the riser pipe at intervals of approximately every 3 m (10 feet).

Pipe used between the well head and the pressure tank, shall have a pressure rating of at least 1.1 MPa (160 pounds per square inch). This pipe shall be either galvanized steel, Schedule 40 rigid plastic or flexible plastic.

A 4.5 kN (1000 pound) safety cable shall be furnished and installed when plastic hanger pipe is used.

A pump lightning arrestor shall be furnished and installed.

(d) Shallow Well Pump System. Shallow well pumps shall be installed using galvanized steel pipe, rigid plastic pipe, Schedule 40, or flexible plastic pipe of at least 700 kPa (100 pounds per square inch) working pressure on the suction line and shall extend a minimum of 9 m (30 feet) below pump intake and shall have

attached a foot valve of non-corrosive metal. The same type of pipe shall be installed between the pump and storage tank.

627.04 WELL CAP. The well cap will be a sealing type made of cast iron or steel.

627.05 VENT PIPE. The casing left projecting above ground shall have the casing cap vented with a screened 15 mm (1/2 inch) DN vent if necessary.

627.06 CONNECTION TO EXISTING SYSTEM. The connection between the storage tank and water system shall be made with seamless copper water tube of adequate size required for the installation except that galvanized steel pipe shall be used if the existing plumbing system is of galvanized steel pipe.

627.07 STORAGE TANK. The capacity, material, construction requirements, and the installation (vertically or horizontally) shall be as specified in the Contract or as ordered by the Engineer.

A pipe union shall be installed between the pump and storage tank, and a gate valve shall be installed between the storage tank and the existing system. A hose threaded drain cock shall be so located that the tank may be drained without breaking the line.

All air pressure tanks shall have a pressure relief valve of adequate size.

The storage tank shall be supported on stone, brick, concrete blocks, or by use of a tank frame to allow air to circulate freely under the tank. In no case shall the storage tank rest directly in contact with the existing floor or ground.

A non-air containing pressure type unit, or a group of such units equal in usable water capacity to that required, may be specified by the Contract for installation instead of standard air pressure tank. The units may be supported on the pressure line or suspended from the ceiling joists.

627.08 ELECTRICAL WORK. The electrical work shall include furnishing and installation of all electrical work, cables, switch and fuse box, pump control box, pressure gauge, and control switch to connect the pump with power supply entrance. All work shall be completed in a competent and professional manner.

Both 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. Electrical materials approved by the Underwriters' Laboratories, Inc. shall be used wherever standards have been established by that agency.

The electrical feeder circuit shall be sufficient in size to limit the voltage drop to 3 percent or less. A manually operable disconnect switch shall be inserted in the circuit.

Automatic controlling switches and devices as recommended by the manufacturer of the pump unit shall be installed in accordance with the National Electrical Code.

Overcurrent protection for the motor shall be provided to effectively protect the motor against overload or short circuit conditions. The type of fuse or breaker shall be a time lag device which shall allow the passage of momentary starting current but which will open the circuit when exposed to other than normal operating current. The overcurrent protection device shall be located as near the master switch control as possible.

627.09 GROUNDING. Grounding shall be installed remote from the system to prevent possibility of current feedback.

All water piping, pressure tank and associated metal frames, electrical switches and control devices shall be effectively grounded by means of a grounding conductor attached thereto and connected to the "ground wire" or "ground buss" at the service entrance switch.

627.10 CELLAR INSTALLATIONS. Unless otherwise required to meet field conditions, storage tanks, jet pumps, shallow well pumps, and electrical control boxes shall be located in the cellar.

627.11 CHLORINATION OF SYSTEM. The Contractor shall disinfect the complete water system by adding an approved chlorine solution at the well head prior to making the water system operative. After the system is operative, the Contractor shall run water through the system for a sufficient time to ensure that all taste, odor, and coloring has been removed and that the water is clear and suitable for use. The owner may assume responsibility of this clearing operation in order to allow the chlorine solution to remain for a longer period in the existing plumbing system for more complete decontamination.

627.12 ALTERATIONS TO PROVIDE ACCEPTABLE WATER. If the water as available from the installation provided under this Section is not potable according to the Vermont Department of Health test results, or is not acceptable because of hardness, iron content, or other unusual conditions as determined from the representative samples taken from this system, the Contractor agrees to furnish adequate conditioning equipment to provide potable and acceptable water. This work shall be done as Extra and Force Account Work, as provided under Subsection 109.06. All equipment for water conditioning shall be approved by the Engineer prior to placing any purchase order.

627.13 LANDSCAPING. Contingent upon the backfilling operation, the site shall be properly graded to blend with the undisturbed present ground. Topsoil, to a depth of 75 mm (3 inches), shall be placed in area(s) formerly covered with grass and the area seeded in accordance with Section 651. Upon completion of the work, the Contractor shall properly clean up the worksite and leave the area in a neat, presentable condition.

627.14 METHOD OF MEASUREMENT. The quantity to be measured for payment will be on a unit basis for the specified type of pump system installed in the complete and accepted work.

Acceptance date for completion will be the date of the satisfactory report or reports of the Vermont Department of Health Laboratory, Division of Environmental Health, 195

Colchester Avenue, Burlington, Vermont 05402, or other testing laboratory approved by the Vermont Department of Health, indicating potable and acceptable water samples collected after the installation is completed.

627.15 BASIS OF PAYMENT. The accepted quantity will be paid for at the Contract lump sum price for the type of pump system specified, including storage tank. Payment will be full compensation for furnishing; transporting; handling; and placing the material specified including excavation, backfill, gravel, topsoil, or similar materials as needed for grading and seeding; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Any alterations of the pump installation required to provide acceptable water will be paid for as Extra Work and Force Account Work as provided under Subsection 109.06.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 627.20 Double Pipe Jet Pump System | Lump Sum |
| 627.25 Submersible Pump System | Lump Sum |
| 627.30 Shallow Well Pump System | Lump Sum |

## 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 |
| Rubber Gaskets | 707.11 |
| Reinforced Concrete Sewer Pipe | 710.01 |
| Clay Pipe, Vitrified, Extra Strength | 710.04 |
| ABS Pipe | 710.05 |
| PVC Pipe | 710.06 |
| Ductile Iron Pipe, Cement-Lined | 740.07 |

Concrete shall be Class B, unless otherwise specified, and shall conform to the requirements of Section 501.

Sleeves shall conform to the requirements of Section 625.

628.03 GENERAL. Care shall be exercised by the Contractor to avoid disrupting the operation of existing sanitary sewer facilities 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 107.13 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 pipe, pipe fittings, and accessories shall be handled so as 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 stored in a safe manner 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 location of all pipes shall be approved by the Engineer.

628.04 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. 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 600 mm (24 inches), and to a depth of 300 mm (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 reasonable limits, and unless otherwise permitted or directed by the Engineer, shall be not longer than three structure-to-structure runs, or 300 m (1000 feet), whichever is less.

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 so as to prevent at all times the accumulation of water, ice, and snow in excavations or in the vicinity of 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 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 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.

628.05 BEDDING FOR PIPE. Unless otherwise specified, the bed shall be shaped to fit the pipe for a depth of not less than 10 percent of its total height and shall have recesses to receive the bell.

Concrete cradle bedding shall be installed on approved subgrades when shown on the Plans or directed by the Engineer.

628.06 LAYING PIPE. No pipe shall be placed until the trench and the prepared foundation 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 pipe 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 indicated on the drawings 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" without approval of the Engineer.

Before any joint is made, the pipe shall be checked to ensure that a close 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.

Concrete reaction blocking shall be provided as detailed at all bends deflecting 22.5 degrees 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 each side of the bends.

628.07 JOINING PIPE. Sewer pipe shall be joined in accordance with the detailed instructions of the manufacturer.

Sewer pipe with premolded gaskets shall be shoved 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 oakum and 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 gages 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 an incipient 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.

628.08 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 made in the presence of the Engineer. Preliminary tests made by the Contractor without being observed by the Engineer will not be accepted. The Engineer will 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 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. The Contractor shall have the option of using the air test or water test for testing sewers. Manholes must be tested by a water test.

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 to 70 kPa (0 to 10 pounds per square inch) relief. The monitoring pressure gauge shall have a range of 0 to 100 kPa (0 to 14.5 pounds per square inch) with divisions of 1 kPa (0.10 pound per square inch), and an accuracy of 0.25 kPa (0.05 pound per square inch).

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 24 kPa (3.5 pounds per square inch) is maintained.

d. A pressure above 21 kPa (3 pounds per square inch) 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 24 kPa (3.5 pounds per square inch) and the air supply disconnected.

f. Measure and record the time interval for the test line pressure to drop from 21 to 17 kPa (3 to 2.5 pounds per square inch).

g. If the groundwater table is above the pipe, increase above test pressures 4 kPa (0.6 pound per square inch) for each 300 mm (1 foot) the groundwater is above the invert of the pipe.

h. The minimum time required for a pressure drop of 4 kPa (0.6 pound per square inch) using the air test shall be 15 seconds per 5 mm (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 time specified will be considered to have failed the pressure test and shall be repaired and retested. The Contractor may have the option of conducting a water test in accordance with these Specifications if the air test has failed.

(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 plumbers plug should be inserted in the downstream manhole inlet sewer. The water supply connection is 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 shall be 600 mm (24 inches) higher than any point in the sewer or 600 mm (24 inches) higher than the highest known groundwater table, whichever is higher, and shall be not higher than 7.5 m (25 feet) above the lowest point in the section being tested.

c. Water shall be added at the downstream connection in order 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 four hours in order that air may escape and absorption may 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, adding any volume of

water required and including that volume in the leakage measurements. The test shall be repeated as directed.

f. The reading shall be recorded, and the leakage shall be converted to liters per millimeter of pipe diameter per kilometer of sewer per 24-hour day (gallons per inch of pipe diameter per mile of sewer per 24-hour day).

g. Allowable leakage shall be 9.3 L/mm/km/day (100 gallons/inch/mile/day).

(4) Infiltration Test. If the groundwater table is at least 600 mm (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 must be installed so as to maintain a watertight seal between the weir and the interior surface of the pipe. The weir 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, and the leakage shall be converted to liters per millimeter of pipe diameter per kilometer of sewer per 24-hour day (gallons per inch of pipe diameter per mile of sewer per 24-hour day).

e. Allowable leakage shall be 9.3 L/mm/km/day (100 gallons/inch/mile/day).

(b) Manhole Leakage Test. Each manhole shall be tested by means of a 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 not require an independent manhole test. 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. A period of time may be permitted, if the Contractor so wishes, 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 converted to liters

per vertical meter of depth per 24-hour day (gallons per vertical foot of depth per 24-hour day). The leakage for each manhole shall not exceed 12.4 L/m/day (1 gallon/foot/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, absorption, etc. 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 watertightness 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.

(c) Pressure Pipe Testing.

(1) General. All force mains shall pass the hydrostatic pressure test and 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 seven 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 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 percent of the designed operating pressure and adjusted to the lowest point of the section being tested.

c. The pressure shall be maintained for ten 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 should 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 will 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 percent for the test duration of two hours minimum.

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 converted to liters per hour (gallons per hour).

c. The allowable leakage is as follows:

1. No leakage will be allowed for exposed piping; buried piping with flanged, threaded, or welded joints; or buried pipe in conflict with potable water lines.

2. Leakage for buried pipe with slip-type or mechanical joints shall not exceed the rate as determined by the following formula:

$$L = 0.00102 \times N \times D \times \sqrt{P}$$

where:

$L$ = Maximum allowable leakage in liters per hour (gallons per hour).
$N$ = Number of gasketed joints in the line under test.
$D$ = Nominal internal diameter of the pipe in millimeters (inches).
$P$ = The average test pressure on the line being tested in kilopascals gauge (pounds per square inch gauge).

628.09 BACKFILLING.

(a) General. Immediately prior to backfilling, all debris, forms, and similar materials shall be removed from the excavation. Backfilling shall not be done in freezing weather, with frozen materials, or when materials already placed are frozen.

(b) Pipe Bedding Area. Prior to laying 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 and stones over 25 mm (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 is to 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 300 mm (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 450 mm (18 inches) long or 15 mm (1/2 inch) thick, or stones greater than 20 kg (50 pounds) or larger than 150 mm (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 300 mm (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.

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 the following percentages of maximum dry density and the in place moisture content shall be not more than 2 percent above the optimum moisture content, as determined by AASHTO T 99, Method C:

| | |
|---|---|
| Around all structures, under roadway paving, shoulders, and embankments | 95 percent |
| All other areas | 90 percent |

628.10 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 600 mm (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.

628.11 MANHOLES. Manholes shall conform to the requirements of Section 604.

628.12 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. The Contractor shall submit and receive approval of a detailed construction schedule and procedure for transferring service from the existing system to the new system prior to beginning work on the system.

Prior to making the connection, the Contractor shall notify the owner and the Engineer three days in advance in writing 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 600 mm (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.

628.13 WATER MAIN - 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 set forth in "Ten States Standards" for Water and Sewer Works and as specified below.

In addition, all reconstruction or relocation of existing water or sewer facilities shall be as approved by the utility. 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 3 m (10 feet) horizontally from sewers, storm drains, or manholes whenever possible; the distance shall be measured edge-to-edge.

When local conditions prevent a horizontal separation of 3 m (10 feet), a water main and sewer may be laid closer to each other provided that:

(1) Special written approval is obtained from the Department of Health.

(2) The bottom of the water main is at least 460 mm (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 watertightness prior to backfilling.

(b) Crossings. 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 460 mm (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) In addition, water mains passing under sewers shall be protected by providing the following:

a. A vertical separation of at least 460 mm (18 inches) between the bottom of the sewer and the top of the water main;

b. Adequate structural support for the sewers to prevent excessive deflection of joints and settling on and breaking of the water mains;

c. The length of water pipe shall be centered at the point of crossing so that the joints will be equivalent and as far as possible from the sewer.

The Contractor shall assume the responsibility of 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.

628.14 METHOD OF MEASUREMENT. The quantities of sewer pipes of the type and size specified to be measured for payment will be the number of meters (linear feet) of sewer line installed in the complete and accepted work, as measured along the flow line of the pipe.

The quantity of Transfer to New System - Sanitary Sewer to be measured for payment will be on a unit basis for each transfer completed in the complete and accepted work.

628.15 BASIS OF PAYMENT. The accepted quantities of sewer pipes of the type and size specified will be paid for at their Contract unit price per meter (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 tools, labor, equipment, and incidentals necessary to complete the work.

Excavation, including backfill, and disposal of excavated material not suitable for backfill will be paid for at the Contract unit price per cubic meter (cubic yard) for Trench Excavation of Earth or Trench Excavation of Rock, as specified 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. 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 Transfer to New System - Sanitary Sewer will be paid for on a lump sum basis. Payment will be full compensation for furnishing all materials, tools, labor, and equipment suitable for effecting the transfer of systems as specified. Items for payment under this lump sum amount include, but are not limited to, maintenance of existing sewage flows, excavation and location of the new connection point, diversion of sewage flow from the connection point, associated pumping/dewatering of connection area, making the physical connection including all fittings and appurtenances, transfer of sewage flow to the new system, abandonment of existing system, and furnishing all tools, labor, equipment, and incidentals necessary to complete the work.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 628.20 ABS Sewer Pipe Solid Wall | Meter (Linear Foot) |
| 628.21 ABS Sewer Pipe Composite | Meter (Linear Foot) |
| 628.22 Reinforced Concrete Sewer Pipe | Meter (Linear Foot) |
| 628.25 Cast Iron Soil Pipe, Extra Heavy | Meter (Linear Foot) |
| 628.26 Cast Iron Pipe, Cement-Lined | Meter (Linear Foot) |
| 628.27 Vitrified Clay Pipe, Extra Strength | Meter (Linear Foot) |
| 628.28 Ductile Iron Pipe, Cement-Lined | Meter (Linear Foot) |
| 628.30 Relaying Sewer Pipe | Meter (Linear Foot) |
| 628.35 PVC Sewer Pipe | Meter (Linear Foot) |
| 628.42 Transfer to New System - Sanitary Sewer | 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:

| | |
|---|---|
| Crushed Stone Bedding | 704.02 |
| Granular Backfill for Structures | 704.08 |
| Plastic Water Pipe, Flexible | 740.01 |
| Plastic Water Pipe, Rigid (PVC) | 740.02 |
| Plastic Water Pipe, Rigid (ABS) | 740.03 |

Concrete shall be Class B, unless otherwise specified, and shall conform to the requirements of Section 501.

Sleeves shall conform to the requirements of Section 625.

Crushed stone used for pipe bedding shall meet the gradation requirements of Table 704.02B.

Ductile iron fittings shall be so-called compact or short-bodied fittings.

The Engineer will approve corporation stops for use on a project after consultation with the utility owner but prior to the stops being ordered by the Contractor.

629.03 GENERAL. Care shall be exercised by the Contractor to avoid disrupting 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 107.13 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 shall be performed as an incidental item of construction.

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 pipe, pipe fittings and accessories shall be handled so as 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 will approve the location of all pipes.

629.04 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 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.

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 600 mm (24 inches). The minimum depth shall be 300 mm (12 inches) below the pipe grade, unless otherwise shown on the Plans 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.

The Contractor, at all times, shall conduct operations so as to prevent the accumulation of water, ice, and snow in excavations or in the vicinity of 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 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 1 m (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.

629.05 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, gravel, or suitable material excavated from the trench free from rocks, foreign materials, and frozen earth.

Concrete cradle bedding shall be installed on approved subgrades when shown on the Plans or directed by the Engineer. Concrete shall conform to the requirements of Section 501.

629.06 LAYING PIPE. Installation of all water lines shall be in accordance with ANSI/AWWA C 600, "Ten States Standards," and as specified.

The 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 pipe 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 drawings 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."

Before any joint is made, the pipe shall be checked to ensure that a close 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 degrees 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 degrees 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.

As shown on the Plans and where sewer lines shall be encased in concrete at water line crossings, concrete shall conform to the requirements of Section 501.

Separation of water mains and sewers shall conform to the requirements of Subsection 628.13.

629.07 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 an incipient fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work.

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.

629.08 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 or masonry pit shall be provided for every valve.

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 so as 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 blowoffs to dry wells from which the water can be pumped. Drainage branches, blowoffs, air vents, and appurtenances shall be provided with valves and shall be located and installed as shown on the Plans.

Drainage branches or blowoffs 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; such dead ends shall be equipped with suitable blowoff 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 1.5 m (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 the Engineer. The stops may be installed at a later date, 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.

629.09 SETTING OF HYDRANTS. Hydrants shall be located as shown 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 150 mm (6 inches) or more than 300 mm (12 inches) from the gutter face of the curb.

When set in the lawn space 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 150 mm (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 that hydrants having two hose nozzles 90 degrees apart shall be set with each nozzle facing the curb at an angle of 45 degrees. Hydrants shall be set to the established grade, with nozzles at least 300 mm (12 inches) above the ground, as shown or as directed by the Engineer.

Each hydrant shall be connected to the main with a 150 mm (6 inches) 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 150 mm (6 inches) above the waste opening in the hydrant, and to a distance of 300 mm (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 600 by 600 mm by 1 m deep (24 × 24 inches by 3 feet 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 150 mm (6 inches) above the waste opening. No drainage pit shall be connected to a sewer.

629.10 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 or clamps 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 or clamps 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 rustproofed, or shall be painted as shown or directed by the Engineer.

629.11 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 300 m (1000 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 blowoffs 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 percent of the working pressure measured in kilopascals (pounds per square inch). Failure to hold the designated pressure for the two-hour period constitutes 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 Table 6B of ANSI/AWWA C 600 latest revision. All testing shall be conducted in accordance with ANSI/AWWA C 600 latest revision.

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.

629.12 DISINFECTING. Before being placed in service, the pipeline, valves, hydrants, etc., shall be chlorinated in accordance with ANSI/AWWA C 651, latest revision. The entire procedure of chlorinating the pipes shall be discussed with the Engineer well in advance of the time the work is to be done and the methods to be employed shall be fully satisfactory to the Engineer before they are applied. The location of chlorination and sampling points is to 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 must be flushed, pressure tested, disinfected and flushed again. Following this procedure, at least two water samples must be collected from representative sample points and sent to the Vermont Department of Health Laboratory, Division of Environmental Health, 195 Colchester Avenue, Burlington, Vermont 05402, or other 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 must be obtained from the same laboratory.

629.13 HOUSE CONNECTIONS. Service lines disrupted within the construction limits shall be 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; and 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 150 mm (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 hacksaw, preferably used with a miter box, shall be used to cut the tubing. A cutter or tool designed for tube cutting may be used also. 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.

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 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 and/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.

629.14 BACKFILLING.

(a) General. Immediately prior to backfilling, all debris, forms, and similar materials shall be removed from the excavation. Backfilling shall not be done in freezing weather, with frozen materials, or when materials already placed are frozen.

(b) Pipe Bedding Area. Prior to laying 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 over 25 mm (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 is to 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 300 mm (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 150 mm (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 300 mm (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.

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 the following percentages of maximum dry density and the in-place moisture content shall be not more than 2 percent above the optimum moisture content as determined in accordance with AASHTO T 99, Method C:

| | |
|---|---|
| Around all structures, under roadway paving, shoulders, and embankments | 95 percent |
| All other areas | 90 percent |

629.15 PIPE INSULATION. Pipe insulation shall be installed on water lines where insufficient cover, less than 1.5 m (5 feet), may exist as a result of vertical alignment conflicts with sanitary sewers, storm sewers, etc., as shown on the Plans or as directed by the Engineer. Insulation shall be at least 50 mm (2 inches) thick and shall conform to Subsection 740.08.

Pipe insulation shall be installed only by a factory approved insulation Contractor. Certification from the insulation manufacturer as to the ability of the Contractor to properly install the insulation in accordance with the manufacturer's specifications shall be required before insulation work begins. In addition, the insulation contractor shall submit detailed shop drawings as to the methods and materials to be used in the installation of the insulation along pipe barrels, couplings, fittings, expansion joints and sleeves for approval. Variance from the approved methods and materials shall not be

allowed without written permission of the Engineer. Insulation shall not be installed until the section of water line to be insulated has passed both pressure and leakage tests, unless otherwise directed by the Engineer.

629.16 WATER SYSTEM TRANSFER. The Contractor shall maintain 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 Department of Health, a detailed construction schedule and procedure for transferring service from the existing system to the new system and shall receive approval(s) of the submittal prior to beginning work on the system.

Prior to making the transfer, the Contractor shall notify the owner and the Engineer three 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 directed by the Engineer.

629.17 METHOD OF MEASUREMENT. The quantity of water pipe to be measured for payment will be the number of meters (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 Corporation Stop 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 Crushed Stone Bedding to be measured for payment will be the number of metric tons (tons) of material installed in the complete and accepted work, as determined by load tickets.

The quantity of Extension Service Box and Curb Stop measured for payment will be the number of units of each installed in the complete and accepted work.

The quantity of valve pits, valves, hydrants, and tapping sleeves 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 Meter Pit measured for payment will be the number of units of each installed in the complete and accepted work including all interior piping and appurtenances.

The quantity of Pipe Insulation to be measured for payment will be the number of meters (linear feet) of the size and type installed in the complete and accepted work, as measured along the flow line of the pipe.

The quantity of Transfer to New System - Water System to be measured for payment will be on a lump sum basis for each transfer in the complete and accepted work.

The quantity of 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.

629.18 BASIS OF PAYMENT. The accepted quantities of water pipe will be paid for at their Contract unit price per meter (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 tools, labor, equipment, and incidentals necessary to complete the work.

The accepted quantity of Pipe Insulation will be paid for at the Contract unit price per meter (linear foot). Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified, including all work at couplings, joints, valves, expansion assemblies, an insulation jacket if shown on the Plans, for providing weatherproof seals at required points, and for furnishing all tool, labor, equipment, and incidentals necessary to complete the work.

The accepted quantities of Extension Service Box and Curb Stop units, valves, valve pits, hydrants, tapping sleeves, and Expansion Assembly will be paid for at their respective Contract unit price 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; and 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.

The accepted quantity of Meter Pit will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing all materials, tools, labor, and equipment suitable for installing the meter pit. The unit price includes, but is not limited to, reinforced concrete, concrete fill, wall sleeves and caulking, insulation, control system, hatch and ladder, interior piping and fittings, pipe supports, gate valves, flow meter or other measuring device, and all other costs incidental to the work including any manufacturer's supervision in conjunction with the special work of installing valves and meters.

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 stops and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Crushed Stone Bedding will be paid for at the Contract unit price per metric ton (ton). 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 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 Water Supply Division of the Department of Environmental Conservation, Agency of Natural Resources. The Professional Engineer shall advise the Engineer, and the Engineer will provide direction to the Contractor.

The accepted quantity of Adjust Elevation of Valve Box, Remove Hydrant, or Relocate Hydrant will be paid for at the Contract unit price per each. Payment will be full compensation for the furnishing of all labor, tools, equipment, and incidentals necessary to complete the work.

Excavation, including backfill and disposal of excavated material not suitable for backfill, will be paid for at the Contract unit price per cubic meter (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.

The accepted quantity of Transfer to New System - Water System 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 including, but not limited to, cutting and capping existing mains and laterals, closing existing valves and curb stops, 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; for providing specialized labor, materials, 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 will be made under:

| Pay Item | Pay Unit |
|---|---|
| 629.20 Adjust Elevation of Valve Box | Each |
| 629.23 Seamless Copper Water Tube | Meter (Linear Foot) |
| 629.24 Ductile Iron Pipe, Cement-Lined | Meter (Linear Foot) |
| 629.25 Extension Service Box and Curb Stop | Each |
| 629.26 Gate Valve | Each |
| 629.27 Gate Valve with Valve Box | Each |
| 629.28 Hydrant | Each |
| 629.29 Relocate Hydrant | Each |
| 629.30 Remove Hydrant | Each |
| 629.31 Meter Pit | Each |
| 629.32 Plastic Water Pipe, Flexible | Meter (Linear Foot) |
| 629.33 Plastic Water Pipe, Rigid | Meter (Linear Foot) |
| 629.34 Steel Water Pipe, Galvanized | Meter (Linear Foot) |
| 629.35 Tapping Sleeve and Valve with Valve Box | Each |
| 629.36 Valve Pit | Each |
| 629.39 Corporation Stop | Each |
| 629.40 Expansion Assembly | Each |
| 629.42 Transfer to New System - Water System | Lump Sum |

| | |
|---|---|
| 629.44 Pipe Insulation | Meter (Linear Foot) |
| 629.54 Crushed Stone Bedding | Metric Ton (Ton) |

## SECTION 630 - UNIFORMED TRAFFIC OFFICERS AND FLAGGERS

630.01 DESCRIPTION.This work shall consist of furnishing qualified uniformed traffic officers and flaggers for the handling of traffic around and through the site of any work. Uniformed traffic officers and flaggers are also referred to as traffic control personnel.

(a) Uniformed traffic officers and flaggers shall be used, primarily, for control and protection of traffic and workers during construction operations where required, but only when and at such locations as directed by the Engineer.

(b) Uniformed traffic officers shall have police powers granted by statutory authority.

(c) Uniformed traffic officers and flaggers shall have completed a training course given by their employer. The employer shall certify to the Engineer the names of all trained traffic control personnel on the project. The certification shall be updated when necessary.

(d) Uniformed traffic officers and flaggers shall be used within the limits of the project or where the entrance or exit of construction equipment or other construction activity constitutes a hazard to the traveling public, but only when and at such locations as directed by the Engineer.

Directing the use of uniformed traffic officers and flaggers, by the Engineer, does not in any way release the Contractor from responsibility to protect the traveling public in any area of the project.

630.02 QUALIFICATIONS. Uniformed traffic officers and flaggers shall be trained in traffic control by their employer. All Contractors and subcontractors providing traffic control personnel to a project shall have an employee certified to train traffic control personnel. All traffic control personnel on a project shall have satisfactorily completed the course in traffic control given by the certified employee representing the specific Contractor or subcontractor providing traffic control personnel for that project.

Certification to train traffic control personnel may be obtained by completing one of the following courses:

(a) Associated General Contractors of Vermont, Work Zone Traffic Control Course; or

(b) Associated General Contractors of New Hampshire, Flagger Certification Course; or

(c) American Traffic Safety Services Association, Worksite Traffic Supervisor Certification Course.

630.03 CLOTHING AND EQUIPMENT.

(a) Uniformed traffic officers shall wear uniforms, headgear, and exposed police badges that will clearly identify them as a law enforcement officer and shall present a neat appearance commensurate with their assignment. They shall wear reflectorized vests in one of the colors designated for high visibility clothing in the latest version of the MUTCD.

Uniformed traffic officers shall be equipped with a signaling device as detailed in part 6E-4 of the MUTCD when directed by the Engineer. When employed between the hours of sunset and sunrise, they shall be equipped with hand-held lighted signals that display a red light suitable for directing traffic and with reflectorized vests as specified above.

(b) Uniformed traffic officers shall be accompanied by a vehicle with operating law enforcement signal lamp(s). The signal lamp(s) shall be blue or blue and white law enforcement signal lamp(s) conforming in all respects to those signal lamps permitted under 23 VSA § 1252.

The lamp shall be in operation during the times and at the locations required by project-specific traffic control plans, or as directed by the Engineer when, in the Engineer's opinion, the safety of the public and/or project personnel will be enhanced by the operation of the lamp.

(c) Flaggers shall be properly dressed in conformance with part 6E-3 of the MUTCD, shall wear approved headgear and reflectorized vests as specified in part (a) above, and shall be equipped with a signaling device conforming to part 6E-4 of the MUTCD.

Approved headgear shall consist of a protective headgear, commonly referred to as a hard hat; a brimmed cap of the type commonly referred to as a baseball cap, or headgear required by law, regulation, or governmental policy. The first two types of headgear shall only be provided in one of the colors designated for high visibility clothing in the latest version of the MUTCD. Approved headgear shall have no additions, adornments, or ornamentation, except that on the front of the headgear above the brim, there may be displayed a small company or governmental logo or name which does not significantly reduce the visibility of the headgear.

Flaggers shall present a neat appearance and shall have all reflectorized gear clean and visible to the public. The Engineer shall make final determination as to the suitability of the appearance of any flagger. An unsuitable appearance will be considered to constitute ineffectiveness in controlling traffic and the flagger will be removed.

(d) The Contractor shall equip all traffic control personnel on the project with two-way radios capable of maintaining all necessary contact within the project limits. The traffic control personnel shall use these radios to maintain contact and coordination whenever distance, noise, intervening operations, dust, and other

existing conditions make it difficult or impossible to work together on a line-of-sight basis and/or whenever the use of two-way radios is ordered by the Engineer. The Contractor shall maintain at all times on the project sufficient spare batteries, spare parts and spare complete units so that no individual performing traffic control is without a working two-way radio for a period longer than 30 minutes. When two-way radios are required and an individual performing traffic control is without a working two-way radio for more than 30 minutes, without exception the individual will be considered ineffective and will be removed in the manner set forth in Subsection 630.04.

(e) The reflectorized vests worn by traffic control personnel shall have the words "TRAFFIC CONTROL" in 50 mm (2 inches) high black letters on front and back reflective panels. Unless the words, and the reflective panels on which they are mounted, were placed on the vest by the original vest manufacturer, the layout, dimensions, proportions, and spacing of the letters in the words shall proportionally conform to the requirements for Series B Upper Case Letters in the Standard Sign Alphabets for Highway Signs.

Personnel not actually engaged in traffic control shall not wear vests with the traffic control legend.

630.04 STANDARD PROCEDURES. The Contractor or subcontractor supplying uniformed traffic officers and/or flaggers on a project shall designate a person as the responsible party to coordinate the traffic control procedures with the prime Contractor and the Engineer.

Any uniformed traffic officer, or flagger determined by the Engineer to be ineffective in controlling traffic 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 such operations as are necessary until a qualified replacement can be provided. Such a suspension of operations will not be considered as a basis for a claim or an extension of time.

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 in writing by the Engineer. No allowance will be made for premium time.

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 equipment, materials, and incidentals necessary to perform this work.

When the Contract item(s) Uniformed Traffic Officers and/or Flaggers is not included in the Contract or when Uniformed Traffic Officers and/or Flaggers are employed by the Contractor without a written order of authorization by the Engineer, the cost will be

considered as included in the Contract unit price for the various items involved in the Contract.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 630.10 Uniformed Traffic Officers | Hour |
| 630.15 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 office(s), furniture, accessories, and equipment provided shall remain the property of the Contractor.

The testing equipment and supplies are 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.

631.02 FIELD OFFICE, ENGINEERS.

(a) Design and Appendages.

(1) General. The field office shall be available to the representatives of the State and the Federal Government throughout the duration of the work on the project, shall be independent of other buildings or office space used by the Contractor, and shall be removed when released by the Engineer. The field office, equipment, and supplies shall be maintained in good condition and adequate quantities at all times.

The field office shall be provided with adequate light, heat, potable water, ventilation, and electrical or gas connections as required. The method of heating shall be such that a minimum temperature of 20 °C (68 °F) can be maintained at all times.

The Contractor shall furnish all labor and materials for winterizing field offices.

Sanitary facilities consisting of a flush toilet, chemical, 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.

Entrances shall be provided with a 1.2 by 1.2 m (4 × 4 foot) minimum size deck with appropriate steps and railings meeting the requirements of VOSHA *Safety and Health Standards for Construction*.

Each field office shall be equipped with an exterior security light of 400 W minimum.

(2) Field Office. The field office 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 of 22 $m^2$ (240 square feet) of floor space. The fully equipped field office shall be available for use from the day that work is commenced by the Contractor until 30 days after acceptance of the project, unless otherwise directed by the Engineer.

(3) Foundation. The field office shall be constructed on a firm foundation, vibration free and shall not be adversely affected by frost action or water runoff.

(4) Outside Doors. The field office shall have a minimum of two outside doors equipped with dead bolt locks. All keys shall be in the possession of the Engineer or the Engineer's representatives.

(5) Windows. The field office shall have a minimum of four side windows, one front window, and one rear window, all glassed and screened with provisions for opening and locking. All windows shall be equipped with adjustable louvered blinds.

(6) Electrical System. The field office shall be equipped with a 110 V AC, 60 Hz, single-phase electrical system with service entrance equipment suitable for power company attachment and with at least twelve properly positioned interior electrical outlets. The materials and installation methods of all electrical wiring, connections, switches, and grounds shall conform to the provisions of the National Electrical Safety Code and shall be in accordance with all State and local electrical ordinances.

(7) Interior Lights. The field office shall be provided with a minimum of five 1200 mm (48 inch) long fluorescent lighting fixtures, or equivalent, on the ceiling.

(8) Air Conditioner. The field office shall be equipped with an air conditioner of adequate capacity, unless otherwise specified in the Contract.

(9) Fire Extinguishers. The field office shall be equipped with at least two fire extinguishers. Each shall have a minimum capacity of 2 kg (5 pounds) and shall be either ABC Dry Chemical or Carbon Dioxide fire extinguishers of standard commercial quality.

(b) Office Equipment. Office equipment shall be standard commercial quality office equipment. Substitutes may be provided when approved by the Engineer. This office shall be provided with at least the following office equipment:

1 Standard office desk with drawers, locks, and keys, 1500 by 750 mm (60 × 30 inches) (minimum dimensions).
2 Adjustable office chairs.
1 Standard drafting table, 1 by 2 m (37 1/2 × 72 inches) (minimum dimensions).
2 Adjustable drafting stools.
1 Fire resistant, four-drawer, legal-size file cabinet, rated to withstand a one-hour fire, with lock and two keys.
1 Storage cabinet, 600 by 600 by 900 mm (2 × 2 × 3 feet) (minimum dimensions).
1 Plan file, 500 by 600 by 750 mm (20 × 24 × 30 inches) (minimum dimensions).
1 Plan rack, 600 by 600 by 600 mm (2 × 2 × 2 feet) (minimum dimensions).
1 Locker or closet of sufficient size for storage of surveying equipment.
1 Electronic printing calculator, four-function, ten-column with memory.
1 Telephone, rotary or touch tone dial, compatible with the local telephone service available.

The Contractor shall arrange for the connection to the system and pay the installation charge as part of the Contract item Field Office. The Contractor shall also pay the monthly service bill. Upon presentation of the paid monthly service bill to the Engineer, the Engineer will pay the Contractor the cost of the service bill under the Contract item Field Office Telephone. Connected to the telephone shall be a good quality telephone answering device capable of receiving and storing messages.

1 Electric calculator, four-function, eight-column with memory.
1 Electric clock having a dial face of at least 200 mm (8 inches) in diameter.
1 Outdoor thermometer with an easy to read weatherproof thermometer having a minimum scale range of -40 to 40 °C (-40 to 100°F) in graduations of 1 or 2 degrees.
1 110 L (30 gallon) trash can.
1 Sink with faucet within the office, with a continuous supply of pressurized, clean, potable water for the duration of the project.

631.03 FIELD OFFICE, SOILS AND MATERIALS.

(a) Design and Appendages.

(1) General. The field office shall be available to the representatives of the State and the Federal Government throughout the duration of the work on the project, shall be independent of other buildings or office space used by

the Contractor, and shall be removed when released by the Engineer. The field office, equipment, and supplies shall be maintained in good condition and adequate quantities at all times.

The field office shall be provided with adequate light, heat, potable water, ventilation, and electrical or gas connections as required. The method of heating shall be such that a minimum temperature of 20 °C (68 °F) can be maintained at all times.

The Contractor shall furnish all labor and materials for winterizing field offices.

Sanitary facilities consisting of flush toilet, chemical, 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.

Entrances shall be provided with a 1.2 by 1.2 m (4 × 4 foot) minimum size deck with appropriate steps and railings meeting the requirements of VOSHA *Safety and Health Standards for Construction*.

Each field office shall be equipped with an exterior security light of 400 W minimum.

(2) Field Office. The field office shall be a commercial type mobile laboratory trailer of standard commercial quality, or a building, in good condition as determined by the Engineer with a minimum of 22 $m^2$ (240 square feet) of floor space. The fully equipped field office shall be available for use from the day that work is commenced by the Contractor until 30 days after acceptance of the project, unless otherwise directed by the Engineer.

(3) Foundation. The field office shall be constructed on a firm foundation, vibration free and shall not be adversely affected by frost action or water runoff.

(4) Outside Doors. The field office shall have a minimum of two outside doors equipped with dead bolt locks. All keys shall be in the possession of the Engineer or the Engineer's representatives.

(5) Windows. The field office shall have a minimum of four side windows, one front window, and one rear window, all glassed and screened with provisions for opening and locking. All windows shall be equipped with adjustable louvered blinds.

(6) Electrical System. The field office shall be equipped with a 110 V AC, 60 Hz, single-phase electrical system with service entrance equipment suitable for power company attachment and with at least twelve properly positioned interior electrical outlets. The materials and installation methods of all electrical wiring, connections, switches, and grounds shall conform to the

provisions of the National Electrical Safety Code and shall be in accordance with all State and local electrical ordinances.

(7) Interior Lights. The field office shall be provided with a minimum of five 1200 mm (48 inch) long fluorescent lighting fixtures, or equivalent, on the ceiling.

(8) Air Conditioner. The field office shall be equipped with an air conditioner of adequate capacity, unless otherwise specified in the Contract.

(9) Fire Extinguishers. The field office shall be equipped with at least two fire extinguishers. Each shall have a minimum capacity of 2 kg (5 pounds) and shall be either ABC Dry Chemical or Carbon Dioxide fire extinguishers of standard commercial quality.

(b) Office Equipment. Office equipment shall be standard commercial quality office equipment. Substitutes may be provided when approved by the Engineer. This office shall be provided with at least the following equipment:

| | |
|---|---|
| 1 | Standard office desk with drawers, locks, and keys, 1500 by 750 mm (60 × 30 inches) (minimum dimensions). |
| 2 | Adjustable office chairs. |
| 2 | Adjustable drafting stools. |
| 1 | Electric printing calculator, four-function, ten-column with memory. |
| 1 | Four-drawer legal-size file cabinet with lock and two keys. |
| 1 | Bench top cabinet, approximately 900 mm (36 inches) high and 600 mm (24 inches) wide with minimum bench area of 3 $m^2$ (32 square feet) and a minimum storage area of 3 $m^2$ (32 square feet) using a suitable combination of fully enclosed shelf space and drawers. |
| 1 | Sink with gooseneck faucet within the office, with a continuous supply of pressurized, clean, potable water for the duration of the project. |
| 2 | 110 L (30 gallon) trash cans. |

(c) Test Equipment and Supplies. This office shall be equipped with the following testing equipment and supplies or substitutes approved by the Engineer:

| | |
|---|---|
| 1 | AASHTO *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, Parts I and II. |
| 1 | Balance of 10 kg minimum capacity accurate to 5.0 g. |
| 1 | Scale of 1 kg minimum capacity accurate to 100 mg. |
| 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 pan of 203 mm (8 inch) diameter, enclosed in a dust retaining enclosure. |
| 1 | Set of US Standard, brass 203 mm (8 inch) diameter, full height, woven wire sieves conforming to the requirements of AASHTO M 92. The sieves required shall be: |

| | | | |
|---|---|---|---|
| 1 | 100 mm (4 inch) sieve | 1 | 90 mm (3 1/2 inch) sieve |
| 1 | 75 mm (3 inch) sieve | 1 | 63 mm (2 1/2 inch) sieve |
| 1 | 50 mm (2 inch) sieve | 1 | 45 mm (1 3/4 inch) sieve |
| 1 | 37.5 mm (1 1/2 inch) sieve | 1 | 25.0 mm (1.00 inch) sieve |
| 1 | 19.0 mm (3/4 inch) sieve | 1 | 16.0 mm (5/8 inch) sieve |
| 1 | 12.5 mm (1/2 inch) sieve | 1 | 9.5 mm (3/8 inch) sieve |
| 2 | 4.75 mm (No. 4) sieves | 2 | 2.36 mm (No. 8) sieves |
| 2 | 2.00 mm (No. 10) sieves | 2 | 1.18 mm (No. 16) sieves |
| 2 | 600 μm (No. 30) sieves | 2 | 425 μm (No. 40) sieves |
| 2 | 300 μm (No. 50) sieves | 2 | 150 μm (No. 100) sieves |
| 4 | 75 μm (No. 200) sieves | 3 | 203 mm (8 inch) sieve pans |
| 3 | 203 mm (8 inch) sieve covers | | |

2 360 mm (14 inch) safety gloves to withstand 600 °C (1110 °F).
1 Brass (wire bristle) brush.
1 Standard floor broom.
1 Round pointed, “D” handle shovel.
1 Square pointed, “D” handle shovel.
2 1 by 1.2 m (2 1/2 × 4 foot) heavy canvas for quartering samples.
10 Aluminum moisture cans 90 mm (3 1/2 inches) in diameter and 50 mm (2 inches) deep.
2 50 mm (2 inch) soft bristle paint brushes.
4 50 by 200 mm (2 × 8 inch) table brushes.
1 200 mm (8 inch) pointed mason’s trowel.
4 300 by 360 by 130 mm (12 × 14 × 5 inch) plastic dish pans.
8 230 by 230 by 50 mm (9 × 9 × 2 inch) cake pans.
1 150 mm (6 inch) grain scoop.
1 Spatula with a 250 by 30 mm (10 × 1 1/8 inch) blade.
2 300 mm (12 inch) long solid heavy duty plated steel mixing spoons.
1 Microwave oven meeting the following requirements:

(1) A minimum rating of 500 W.

(2) A minimum volume of approximately 0.02 $m^3$ (0.7 cubic foot). The interior dimensions shall be approximately 280 by 280 mm (11 × 11 inches) by an acceptable height. The interior dimensions shall be of adequate size to accept the microwaveable pans listed below.

(3) A minimum of ten adjustable power levels.

(4) A digital display of power level and time.

4 Microwaveable pans with minimum interior dimensions of approximately 200 by 200 by 50 mm (8 × 8 × 2 inches).
1 101.60 mm (4 inch) diameter compaction mold, conforming to the requirements of AASHTO T 99.

1 2.5 kg (5.5 pound) rammer, conforming to the requirements of AASHTO T 99.
1 Steel straightedge conforming to the requirements of AASHTO T 99.
1 Density apparatus consisting of a sand cone and a baseplate, conforming to the requirements of AASHTO T 191.
2 4 L (1 gallon) jugs with standard G mason jar top threading with covers.
1 Cushioned carrying box for the two 4 L (1 gallon) mason jugs.
2 4 L (1 gallon) metal cans with moisture proof friction covers and handles, similar to paint cans.
1 Supply of standard Ottawa sand conforming to the requirements of ASTM C 778, Section 3.1 (approximately 50 kg (100 pounds) of sand will be used for each 40 000 $m^3$ (50,000 cubic yards) of embankment).
1 Number 2 rubber mallet with 255 mm (10 inch) handle.
1 Box to contain the compaction testing equipment.

When compaction testing in accordance with AASHTO T 180 is required, the following additional equipment shall be supplied by the Contractor:

1 4.54 kg (10 pound) rammer, conforming to the requirements of AASHTO T 180.

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 beginning any construction for which testing is required.

The equipment to be provided for portland cement concrete testing or bituminous concrete testing, when such equipment is also in the Contract, will not be considered common to the equipment for gradation testing or compaction testing and is not to be used as part of them.

631.04 COMBINED ENGINEERS AND SOILS OFFICE.

(a) Design and Appendages. The Contractor shall provide weatherproofed space in which to store and use testing equipment. This space shall have a floor area equal to or greater than 11 $m^2$ (120 square feet). The space shall have a window and a lockable door. Access to the space shall be made available to the Engineer at all times during the construction of the project. If electricity is available at the site, the Contractor shall provide electricity and outlets to run the equipment to be furnished and electric lights for the space. If electricity is not available, the Contractor shall provide a generator having a minimum rating of at least 10 kW and electrical outlets to run the equipment to be furnished and electric lights. The generator shall be maintained ready to go and available to the Engineer at all times. The space shall be provided with a shelf or table approximately 0.6 by 2.0 m (2 × 7 feet) on which the Engineer can write while performing the necessary tests and other tasks the Engineer is required to perform on the project. Other

shelves or bases will be required to support the equipment during use. An ABC Dry Chemical or Carbon Dioxide fire extinguisher having a minimum fire fighting capacity of 2 kg (5 pounds) shall be supplied.

(b) Office Equipment. This office shall be provided with at least the following equipment:

1 Chair or drafting stool suitable for use with the shelf or table supplied.
1 Telephone, rotary or touch tone dial, compatible with the local telephone service available. The Contractor shall arrange for the connection to the system and pay the installation charge as part of the Contract item Combined Engineers and Soils Office. The Contractor shall also pay the monthly service bill. Upon presentation of the paid monthly service bill to the Engineer, the Engineer will pay the Contractor the cost of the service bill under the Contract item Field Office Telephone. Connected to the telephone shall be a good quality telephone answering device capable of receiving and storing messages.
1 Elevated clean water tank having a minimum capacity of 400 L (100 gallons) with a hose or pipe leading to a convenient location near the testing and storage space provided. The Contractor shall provide two 20 L (5 gallon) pails to enable the Engineer to use this water source and shall fill the tank on a daily basis. The outlet end of the hose or pipe shall be fitted with a faucet. The faucet shall be fixed at least 600 mm (24 inches) above the ground.
1 110 L (30 gallon) trash can.

(c) Test Equipment and Supplies. This office shall be equipped with the following testing equipment and supplies or substitutes approved by the Engineer:

1 AASHTO *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*, Parts I and II.
1 Balance of 10 kg minimum capacity accurate to 5.0 g.
1 Scale of 1 kg minimum capacity accurate to 100 mg.
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 pan of 203 mm (8 inch) diameter, enclosed in a dust retaining enclosure.
1 Set of US Standard, brass, 203 mm (8 inch) diameter, full height, woven wire sieves conforming to the requirements of AASHTO M 92. The sieves required shall be:

| | | | |
|---|---|---|---|
| 1 | 100 mm (4 inch) sieve | 1 | 90 mm (3 1/2 inch) sieve |
| 1 | 75 mm (3 inch) sieve | 1 | 63 mm (2 1/2 inch) sieve |
| 1 | 50 mm (2 inch) sieve | 1 | 45.0 mm (1 3/4 inch) sieve |
| 1 | 37.5 mm (1 1/2 inch) sieve | 1 | 25.0 mm (1.00 inch) sieve |
| 1 | 19.0 mm (3/4 inch) sieve | 1 | 16.0 mm (5/8 inch) sieve |
| 1 | 12.5 mm (1/2 inch) sieve | 1 | 9.5 mm (3/8 inch) sieve |
| 2 | 4.75 mm (No. 4) sieves | 2 | 2.36 mm (No. 8) sieves |

| | | | |
|---|---|---|---|
| 2 | 2.00 mm (No. 10) sieves | 2 | 1.18 mm (No. 16) sieves |
| 2 | 600 μm (No. 30) sieves | 2 | 425 μm (No. 40) sieves |
| 2 | 300 μm (No. 50) sieves | 2 | 150 μm (No. 100) sieves |
| 4 | 75 μm (No. 200) sieves | 3 | 203 mm (8 inch) sieve pans |
| 3 | 203 mm (8 inch) sieve covers | | |

2 360 mm (14 inch) safety gloves to withstand 600 °C (1110 °F).
1 Brass (wire bristle) brush.
1 Standard floor broom.
1 Round pointed, "D" handle shovel.
1 Square pointed, "D" handle shovel.
2 1 by 1.2 m (2 1/2 × 4 foot) heavy canvas for quartering samples.
10 Aluminum moisture cans 90 mm (3 1/2 inches) in diameter and 50 mm (2 inches) deep.
2 50 mm (2 inch) soft bristle print brushes.
4 50 by 200 mm (2 × 8 inch) table brushes.
1 200 mm (8 inch) pointed mason's trowel.
4 300 by 360 by 130 mm (12 × 14 × 5 inch) plastic dish pans.
8 230 by 230 by 50 mm (9 × 9 × 2 inch) cake pans.
1 150 mm (6 inch) grain scoop.
1 Spatula with a 250 by 30 mm (10 × 1 1/8 inch) blade.
2 300 mm (12 inch) long solid heavy duty plated steel mixing spoons.
1 Microwave oven meeting the following requirements:

(1) A minimum rating of 500 W.

(2) A minimum volume of approximately 0.02 $m^3$ (0.7 cubic foot). The interior dimensions shall be approximately 280 by 280 mm (11 × 11 inches) by an acceptable height. The interior dimensions shall be of adequate size to accept the microwaveable pans listed below.

(3) A minimum of ten adjustable power levels.

(4) A digital display of power level and time.

4 Microwaveable pans with minimum interior dimensions of approximately 200 by 200 by 50 mm (8 × 8 × 2 inches).
1 101.60 mm (4 inch) diameter compaction mold, conforming to the requirements of AASHTO T 99.
1 2.5 kg (5.5 pound) rammer, conforming to the requirements of AASHTO T 99.
1 Steel straightedge conforming to the requirements of AASHTO T 99.
1 Density apparatus consisting of a sand cone and a baseplate conforming to the requirements of AASHTO T 191.
2 4 L (1 gallon) jugs with standard G mason jar top threading with covers.
1 Cushioned carrying box for the two 4 L (1 gallon) mason jugs.

2 4 L (1 gallon) metal cans with moisture proof friction covers and handles, similar to paint cans.
1 Supply of standard Ottawa sand conforming to the requirements of ASTM C 778, Section 3.1 (approximately 50 kg (100 pounds) of sand will be used for each 40 000 $m^3$ (50,000 cubic yards) of embankment).
1 Number 2 rubber mallet with 255 mm (10 inch) handle.
1 Box to contain the compaction testing equipment.

When compaction testing in accordance with AASHTO T 180 is required, the following additional equipment shall be supplied by the Contractor:

1 4.54 kg (10 pound) rammer conforming to the requirements of AASHTO T 180.

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 beginning any construction for which testing is required.

The equipment to be provided for portland cement concrete testing or bituminous concrete testing, when such equipment is also in the Contract, will not be considered common to the equipment for gradation testing or compaction testing and is not to be used as part of them.

631.05 TESTING EQUIPMENT, CONCRETE. The Contractor shall provide the following testing equipment to perform the field tests required under Subsection 501.06:

1 Slump test set conforming to the requirements of AASHTO T 119.
1 Platform beam scale sensitive to 5 g (0.01 pound) with a minimum capacity of 50 kg (100 pounds).
1 Steel “Contractors” wheelbarrow.
1 Square pointed, “D” handle shovel.
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 6 mm (1/4 inch) thick, a glass or acrylic plate at least 13 mm (1/2 inch) thick, or a wire reinforced glass plate a least 6 mm (1/4 inch) thick with a length and width at least 50 mm (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. The concrete curing box shall be of standard commercial quality. One or more boxes shall be supplied to meet specimen requirements for the project. The curing box shall maintain an internal water temperature of 21 ± 5 °C (70 ± 10 °F) and 100 percent humidity.
1 Straightedge at least 3 m (10 feet) in length.

For the testing of Class LW concrete, the following additional testing equipment will be required:

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 mass (weight) measure meeting the requirements of AASHTO T 121, supplied with a flat, rectangular, metal plate at least 6 mm (1/4 inch) thick, a glass or acrylic plate at least 13 mm (1/2 inch) thick, or a wire reinforced glass plate at least 6 mm (1/4 inch) thick with a length and width at least 50 mm (2 inches) greater than the diameter of the measure 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 the placing of any concrete.

When the Contractor places concrete at more than one location simultaneously, necessary testing equipment shall be furnished at each location.

When the equipment to be provided for concrete testing is required by the Contract, it will not be considered common to the equipment for gradation testing, compaction testing, or bituminous concrete testing and is not to be used as part of them.

631.06 TESTING EQUIPMENT, BITUMINOUS. The following items shall be provided:

1 Straightedge at least 4.5 m (16 feet) in length.
1 3 m (10 foot) straightedge.
1 Round pointed, "D" handle shovel.
1 Electronic hand-held thermometer having a digital display visible under all lighting conditions.

The thermometer shall be at least capable of measuring temperatures between -50 and 650 °C with a resolution of 1 °C and an accuracy of at least ± 1 °C (-60 and 1200 ºF with a resolution of 2 ºF and an accuracy of at least ± 2 ºF) and shall provide accurate measurements of 1) the ambient air temperature measured at least 1.2 m (4 feet) above the ground and 8 m (26 feet) from any vehicle or other heat source, and 2) the surface temperature of such materials as bituminous pavement and thermoplastic pavement markings in place, or for placement thereof, on the roadway. The final accurate measurement shall be indicated within one second or less.

The unit shall have internal protection against meter overload, automatic zero adjustment, and low battery indication if battery powered and shall be provided with an instruction manual.

The unit shall be completely self-contained and shall not require external probes or other attachments to perform the required functions.

1 Micrometer having a capacity of 0 to 25 mm (0 to 1 inch) and calibrated in micrometers (0.1 mil).

Black duct tape and tar paper or asphalt treated felt in adequate amounts for the Engineer to perform necessary thickness and moisture testing.

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 the placing 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 is not to be used as part of them.

631.07 METHOD OF MEASUREMENT. The quantity of each type of field office and/or testing equipment to be measured for payment will be on a unit basis for each type specified and used on the project.

The quantity of Field Office Telephone to be measured for payment will be on a lump sum basis for all telephone service supplied.

The Agency will, as specified in the sixth paragraph of Subsection 102.07, include in the proposal a quantity of one with a unit price and a total price set for all telephone service required. However, the Contractor will be reimbursed the actual costs of providing the telephone service as evidenced by the paid bills submitted to the Engineer. Upon entering the cost of the submitted bill into the next biweekly estimate, the Engineer will forward the original paid bill to the Construction Office to be retained with the project records and will place a copy of the paid bill into the field office records.

631.08 BASIS OF PAYMENT. The accepted quantity of each type of field office and/or testing equipment will be paid for at the Contract lump sum prices for the specified type. 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 office and/or testing equipment specified.

Supplies that become exhausted and equipment that becomes unsuitable for use due to normal wear and tear shall be replaced as necessary by the Contractor as part of the Contract item under which these items are furnished.

Payment for this work will be made periodically as follows:

(a) 25 percent will be paid after each specified office and/or equipment unit has been installed on the project in full working order.

(b) The second payment of 25 percent will be paid when 33 percent of the anticipated construction time has expired.

(c) The third payment of 25 percent will be paid when 67 percent of the anticipated construction time has expired.

(d) The fourth and final payment of the remaining 25 percent will be paid upon final acceptance of the project.

The quantity of Field Office Telephone to be paid will be the total of all paid telephone bills for providing service to all telephones, modems, and fax machines supplied in the project field offices by the Contractor, which total will be limited to the total of the paid telephone bills submitted to the Engineer.

The costs of installing and removing the telephone lines in the field office are part of the costs included in the field office Contract items and are not part of the Contract item Field Office Telephone.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 631.10 Field Office - Engineers | Lump Sum |
| 631.11 Field Office - Soils and Materials | Lump Sum |
| 631.12 Combined Engineers and Soils Office | Lump Sum |
| 631.16 Testing Equipment - Concrete | Lump Sum |
| 631.17 Testing Equipment - Bituminous | Lump Sum |
| 631.25 Field Office Telephone | Lump Sum |

## 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. The Contractor shall provide on-the-job training aimed at developing full journeyman qualifications in the type of trade, craft, or skill involved.

The training program shall be carried out in accordance with a training schedule and curriculum devised to give the employee 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 US Department of Transportation.

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 such manner acceptable to the Engineer as to provide all the information necessary to properly and adequately support progress and final payment for the item, as well as to show the status of training accomplishment.

634.04 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.

634.05 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.

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 |
|---|---|
| 634.10 Employee Traineeship | Hour |

## SECTION 635 - MOBILIZATION

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 the project site; for the establishment 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 on the various items.

635.02 METHOD OF MEASUREMENT. The quantity of Mobilization to be measured for payment will be on a lump sum basis.

635.03 BASIS OF PAYMENT. The accepted quantity of Mobilization 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, the adjusted Contract price will include all items bid excluding the amount bid for mobilization.

Partial payments will be made as follows:

(a) The first payment of 50 percent of the lump sum price for mobilization or 3.5 percent of the adjusted Contract price, whichever is less, will be made with the first biweekly estimate as determined by work on other items.

(b) The second payment of 50 percent of the lump sum price for mobilization or 3.5 percent of the adjusted Contract price, whichever is less, will be made on the first estimate following the completion of 10 percent of the Contract, excluding Mobilization.

(c) Upon substantial completion of all the work on the project, payment of any amount bid for mobilization in excess of 7 percent of the adjusted Contract price will be paid.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 635.10 Mobilization | 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 and construction operations.

The requirements for uniformed traffic officers and flaggers used in conjunction with traffic control are specified in Section 630.

641.02 GENERAL CONSTRUCTION REQUIREMENTS. 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. The Contractor shall refer to Subsection 104.04 for the limits of working hours. Should the Contractor desire to divert traffic after sunset or before sunrise, a written request shall be submitted to the Engineer. In the request, the Contractor shall justify the request and detail the enhanced safety procedures the Contractor proposes to provide and pay for to protect the safety of the traveling public and project personnel. The request shall be submitted at least three weeks prior to the date the Contractor plans to divert traffic outside the normal working hours.

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 authorized by the Engineer.

During other than working hours, all highway facilities 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 relative 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 a minimum of 10 m (30 feet) from the edge of pavement.

When the Plans contain an Agency-designed traffic control plan that includes, but is not limited to, references to standard sheets, the Contractor may submit an alternate traffic control plan for this project. This alternate plan may be for the entire traffic control plan of this project or for revisions to various phases of the Agency's design in the Plans, including the specific location of the lanes where the traffic will be maintained.

The submitted alternative must include complete construction details, including all facets of traffic control, to the same extent as provided in the Agency design.

The Contractor shall allow the Agency 30 calendar days to review the proposed alternative before it is to be implemented.

641.03 TRAFFIC CONTROL DEVICES. All traffic control devices shall conform to the requirements of the Contract and with the MUTCD. Traffic control devices required in the performance of this work may include barricades, signs with yielding posts or portable supports, reflectorized drums, traffic cones, delineators, portable flashing arrow boards, 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 for maximum visibility and usefulness. Traffic control devices shall be kept clean so they are clearly visible at all times.

Unless protected by guardrail or other positive barrier, mounted traffic control devices shall be erected on yielding or breakaway supports.

When protected by guardrail, these devices shall be placed outside the deflection distance of the particular guardrail in use.

Traffic cones shall be orange, at least 700 mm (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 percent of their original thickness.

Portable flashing arrow boards shall be located as specified in the Contract or as directed by the Engineer. The arrow board(s) shall conform to type C part 6E-9 of the MUTCD. The second light from any arrow point shall not be operating. Arrow board circuitry shall be solid-state photocell control and each flashing light shall use #4412

sealed beam par 48 000 cd. The power for the flashing arrow board shall be from a self-contained generator unit, 2500 W, 60 Hz, AC with a DC convertor and regulator to charge an 85 ampere-hour battery. It shall also have a fuel supply to run power for 24 hours without refilling. The flashing arrow board with independent power drive and battery shall be mounted on a trailer or other vehicle suitable for moving to the required locations. The trailer or vehicle shall not be rigidly anchored but be capable of rolling a short distance if struck by an errant vehicle. The generator and its fuel supply shall be located at least 10 m (30 feet) from the traveled edge of the roadway unless it is powered by a diesel unit in which case they may be mounted on the vehicle or trailer. The flashing arrow board shall be equipped with an automatic dimming device for nighttime operation. The control box for the flashing arrow board shall be locked at all times to prevent unauthorized adjustments of the board.

The Engineer may order the Contractor to cease operations if traffic control devices found to be deficient in any respect are not immediately replaced or repaired. Time lost due to failure to correct deficient traffic control devices will not be considered justifiable cause for granting an extension of time.

641.04 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.

641.05 SPEED ZONE ENACTMENT. If the traffic control plan shown on 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.

641.06 METHOD OF MEASUREMENT. The quantity of Traffic Control to be measured for payment will be on a lump sum basis for providing traffic control in the complete and accepted work.

641.07 BASIS OF PAYMENT. The accepted quantity of Traffic Control 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 including traffic patrol vehicle operators, if used by the Contractor, tools, materials, equipment, and incidentals necessary to complete the work.

Uniformed traffic officers and flaggers will be paid for under Section 630.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 641.10 Traffic Control | Lump Sum |

# SECTION 646 - REFLECTORIZED PAVEMENT MARKINGS

646.01 DESCRIPTION. This work shall consist of furnishing and placing reflectorized markings including temporary markings and necessary signing on roadway pavement and other surfaces.

Details not shown on the Plans shall be in conformity with the MUTCD.

646.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Regular Dry Traffic Paint | 708.08(a) |
| Fast Dry Traffic Paint | 708.08(b) |
| Epoxy Paint | 708.08(c) |
| Glass Beads | 708.09 |
| Thermoplastic | 708.10 |
| Raised Pavement Markers | 708.11 |
| Pavement Marking Tape | 708.12 |
| Preformed Traffic Markings and Symbols | 708.13 |
| Line Striping Target | 708.14 |
| Reflective Sheeting | 750.08 |

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 646.11.

646.03 CLASSIFICATION. Reflectorized Pavement Markings are hereby classified as: Paint Pavement Markings; Durable Pavement Markings; Temporary Pavement Markings and Other Related Markings.

646.04 APPLICATION OF MARKINGS, GENERAL.

(a) Placement of Markings. The final pavement markings shall be placed the same day as the wearing course of pavement.

Roadway surfaces shall be clean and dry at the time of application of pavement markings. 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 so as to provide for an acceptable bond between the marking and the pavement or surface.

Pavement markings shall be applied only during daylight hours, and in accordance with the manufacturer's recommendations.

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. 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. Markings shall be protected from the moment of application until they are sufficiently dry to bear traffic without tracking or adhering to vehicle tires.

Any pavement marking materials spilled or tracked on roadway surfaces shall be removed by the Contractor to the satisfaction of the Engineer without additional compensation. The method of removal shall be such that it is not injurious to the roadway or other surface and is acceptable to the Engineer.

Any pavement marking that is applied on hot pavement and discolors shall be reapplied, at the Engineer's discretion. Payment for each reapplication will be at the Contract unit price for the reapplied item.

The Engineer shall order the placement of necessary temporary/interim pavement markings and will pay for the application under the appropriate Contract bid items.

All interim pavement markings, including line striping targets when used, shall be applied so that at the end of each working day all centerlines, island markings, gore markings, lane lines, special markings, etc. are in place on all paved surfaces where traffic will be maintained. During paving and cold planing, work shall be scheduled so that the pavement markings are complete immediately after the paving and cold planing operations cease for the day. All required markings shall be completely placed before dusk.

Edgelines, for both interim and final applications shall be applied within seven calendar days of the placement of the pavement. The Engineer may require edgelines to be applied within a shorter time frame if traffic volume and the safety of the traveling public appear to require a quicker application. Those surfaces that are overlaid with another course of pavement within the seven calendar day period will not require edgeline placement unless such markings are ordered by the Engineer.

When line striping targets 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 LST's are substituted. However, if it becomes necessary to replace those temporary LST's with either more LST's or the actual temporary pavement markings designated for that particular location, no further payment for the temporary pavement markings at that particular location will be made.

The Engineer has the authority to delete from the Contract those pavement marking items which the Engineer determines are not required.

(b) Equipment, General. The pavement marking equipment shall meet the approval of the Engineer and shall be maintained in working condition at all times. It shall be of standard commercial manufacture of the type capable of satisfactorily applying the designated material at required application temperatures. For long line markings, each machine shall be capable of applying two separate stripes, either solid or dash, 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. Each applicator shall also be equipped with suitable line guides.

Applicating equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.

The pavement marking equipment shall be operated in accordance with recommendations of the manufacturer, unless otherwise directed by the Engineer. Operating speeds shall be such as to provide uniformity and the specified wet or dry film thicknesses.

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.

The application equipment shall be so constructed as to ensure continuous uniformity in the dimensions of stripes. The applicator shall provide a means for cleanly cutting off stripe ends squarely and shall provide a method of applying dashed and dotted lines. The equipment shall be capable of applying varying widths of traffic markings.

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 631.06.

(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 5 °C (41 °F) and the ambient air temperature shall be 5 °C (41 °F) and rising.

(2) At the time of application of durable pavement markings, the pavement surface temperature shall be a minimum of 10 °C (50 °F) and the ambient air temperature shall be a minimum of 10 °C (50 °F) and rising.

(3) If weather does not permit the application of durable markings prior to October 15, paint will be applied in accordance with this Section and Section 708.

(4) When it is in the public interest, the Engineer may authorize the application of pavement markings under other than suitable conditions.

(d) Layout and Control. The Contractor is responsible for the layout of all markings. The pattern of painted, durable or temporary markings shall be as follows, unless otherwise shown in the Contract Documents or directed by the Engineer:

(1) Centerline Markings. Centerline markings shall be positioned at the geometric center of the roads. Solid (barrier) lines and dash lines shall start and end at points shown on the Plans or as directed by the Engineer. A dash line shall consist of 3 m ± 300 mm (10 foot ± 12 inch) line segments, and 9 m ± 300 mm (30 foot ± 12 inch) spaces. The spacing between a double barrier line and between a barrier line and a dash line shall be 100 ± 5 mm (4 ± 1/4 inch). The width of the lines shall be as shown on the Plans, ± 5 mm (± 1/4 inch).

Raised pavement markers will not be permitted for solid (barrier) lines. For dashed lines, four raised pavement markers on 1 m (3 foot) centers shall be used for the 3 m (10 foot) line segment. The 9 m (30 foot) space shall remain a space.

(2) Edgeline Markings. Edgeline markings shall be applied along both edges of the road, as shown on the Plans or as directed by the Engineer. Edgelines shall be discontinued through intersections of paved public side roads, unless otherwise shown on the Plans. The width of edgelines shall be as shown on the Plans, ± 5 mm (1/4 inch).

On four-lane roadways, raised pavement markers shall not be used on the drivers' right side. Raised pavement markers on the drivers' left side shall be placed on 1.5 m (5 foot) centers.

(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 600 ± 50 mm (24 ± 2 inch) line segments, and 1200 ± 50 mm (48 ± 2 inch) spaces. The width of the lines shall be as shown on the Plans, ± 5 mm (± 1/4 inch).

Raised pavement markers shall not be used for dotted lines.

(4) Control. The Contractor shall provide the necessary horizontal and longitudinal control to keep all longitudinal lines within 50 mm (2 inches) of their designated locations.

In addition, on tangent, the Contractor shall not allow longitudinal lines to vary from either side of a straight line by more than 25 mm (1 inch) in a distance of 30 m (100 feet).

646.05 ACCOMMODATION AND PROTECTION OF TRAFFIC. The Contractor shall provide adequate warning signs and traffic control measures for the accommodation and protection of traffic, as shown on the Plans or as directed by the

Engineer. Placement of pavement markings may be suspended at the discretion of the Engineer during peak traffic hours, or at any time, when in the Engineer's judgement, traffic is being unduly hampered, delayed by the work, or when traffic interferes with the quality of work.

All equipment and devices necessary for the application of pavement markings and protection thereof, and for the protection of the traveling public shall be as usually required for work of this type, as shown on the Plans or as directed by the Engineer, and shall be furnished by the Contractor.

646.06 PAINT PAVEMENT MARKINGS. At the Contractor's option, regular dry or fast dry traffic paint may be used.

Liquid tanks on paint application equipment shall be equipped with mechanical agitators.

Paint shall be applied at a rate of 2.5 to 2.8 $m^2/L$ (100 to 115 square feet per gallon) with glass beads applied at a rate of 720 g/L (6 pounds per gallon) of paint for painted pavement markings.

Fast-drying paint shall be applied at a temperature of 50 to 65 °C (125 to 150 °F) at the spray gun.

Reflectorized paint pavement markings shall be applied by a method in which the liquid paint is applied to the road surface and the glass beads are immediately applied on the paint 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 380 ± 25 μm (15 ± 1 mil) for paint, unless otherwise specified, and shall be applied in a smooth uniform coat, free from thin places or films of excessive thickness.

Only painted pavement markings shall be used on portland cement concrete pavement surfaces.

646.07 DURABLE PAVEMENT MARKINGS. Durable pavement markings shall be used at those locations shown on the Plans or directed by the Engineer. Durable pavement markings are classified as pavement marking tape; epoxy paint, and thermoplastic markings. Unless otherwise specified, the Contractor may choose any of the following as being acceptable for durable pavement markings:

(a) Pavement Marking Tape, Type I. Type I tape for pavement markings is classified as non-removable. Type I tape shall conform to the requirements of Subsection 708.12.

Type I tapes when used as a final durable marking shall be applied only by being inlaid in the bituminous pavement during the rolling operation in accordance with the manufacturer's requirements.

(b) Epoxy Paint. Epoxy Paint for pavement markings shall conform to the requirements of Subsection 708.08(c). Application shall be in accordance with the manufacturer's requirements.

(c) Thermoplastic. Thermoplastic pavement markings shall conform to the following requirements and shall meet the requirements of Subsection 708.10.

The thermoplastic pavement marking compound shall be extruded onto the pavement surface in a molten state. 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 reflectorized stripe of the specified thickness and width that is capable of resisting deformation by traffic.

(1) Thermoplastic Application Equipment. Thermoplastic applicating 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 heating the thermoplastic composition, the application equipment shall include a melting kettle(s) of such capacity as to allow for continuous marking operations. The melting kettle(s) may be mounted on a separate supply vehicle or included as part of the mobile applicating equipment. The kettle(s) shall be capable of heating the thermoplastic composition to temperatures of from 205 to 225 °C (400 to 435 °F). For applications of small quantities with portable applicating equipment, a "melting stack" integral to the equipment may be substituted for the kettle as long as the required temperatures and continuous application can be maintained. The heating mechanism shall be by means of a thermostatically controlled heat transfer medium. Heating of the composition by direct flame shall not be allowed. Material temperature gauges shall be visible at both ends of the kettle(s).

Application equipment shall be constructed to provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the extrusion shoe(s) shall be so constructed as to prevent accumulation and clogging. All parts of the equipment which come into contact with the material shall be so constructed as to be easily accessible and exposable for cleaning and maintenance. The equipment shall be constructed so that all mixing and conveying parts, including the extrusion shoe(s), maintain the material at the required plastic temperature.

The bead dispenser shall be automatically operated in such a manner that it will only dispense beads while the composition is being applied.

The equipment used for the placement of thermoplastic pavement markings shall be of two general types:

a. 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 205 °C (400 °F), and at the widths and thicknesses specified below. The mobile unit shall be capable of operating continuously and/or installing a minimum of 6.1 km (3.8 miles) of longitudinal markings in an eight-hour day.

   The mobile unit shall be equipped with extrusion shoes, and shall be capable of simultaneously marking edgeline and/or two centerline stripes. The extrusion shoes shall be closed, heat jacketed, or suitably insulated units; shall hold the molten thermoplastic at a temperature from 205 to 225 °C (400 to 435 °F); and shall be capable of extruding a line from 100 to 200 mm (4 to 8 inches) wide, between 2 and 2.5 mm (80 and 100 mils) thick, and of generally uniform cross-section. 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, so as to be capable of applying dashed, dotted or solid lines in any sequence and through any extrusion shoe in any cycle length.

b. 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, edge, 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 kettle(s) 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, so as to be capable of holding the molten thermoplastic at a temperature of from 205 to 225 °C (400 to 435 °F), and of extruding a line of from 100 to 200 mm (4 to 8 inches) wide in 50 mm (2 inch) increments, between 2 and 2.5 mm (80 and 100 mils) thick, and of generally uniform cross-section. 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.

(2) Application Requirements.

a. Primer. Primer shall be used under such conditions, at such rates and thicknesses, and of a type as is recommended by the manufacturer of the thermoplastic material being applied. Bituminous concrete primer shall be applied to pavements older than two years at the application rates and procedures recommended by the manufacturer of the thermoplastic material.

b. Thermoplastic Composition.

1. Application Temperature. Thermoplastic composition shall be applied at a temperature range between 205 and 225 °C (400 and 435 °F).

2. Extruded Markings. All extruded markings shall be applied at the specified width and at a thickness between 2 and 2.5 mm (80 and 100 mils).

c. Beads.

1. Glass beads meeting the requirements of Subsection 708.09(a) through (i) shall be incorporated into the thermoplastic composition at a rate between 28 and 30 percent by mass (weight) of the combined material.

2. Reflective glass spheres (for "drop on") shall be placed concurrently with application of the thermoplastic. The reflective glass spheres shall be dropped onto the molten thermoplastic marking at the rate of 245 g/m$^2$ [7 ounces (avoir) per square yard] of composition. The glass spheres shall conform to the requirements of Subsection 708.09(a) through (j).

d. 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.

646.08 TEMPORARY PAVEMENT MARKINGS. Temporary pavement markings are used during construction. These markings are classified as Type I tape (non-removable construction grade), Type II tape (removable), Type II raised pavement markers, traffic paint with glass beads, and line striping targets. Unless specifically detailed otherwise, the Contractor may choose any of the above as being acceptable for temporary pavement markings.

(a) Tape, Type I. Type I tape for temporary pavement markings is classified as non-removable construction grade. Type I tape shall conform to the requirements as specified in Subsection 708.12, and shall be installed in accordance with the manufacturer's requirements.

(b) Tape, Type II. Type II tape for pavement markings is classified as removable. Type II tape shall conform to the requirements as specified in Subsection 708.12, and shall be installed in accordance with the manufacturer's requirements.

(c) Raised Pavement Markers, Type II. Type II raised pavement markers are intended to be temporary markers, usually placed and removed during the period of construction activity.

Type II raised pavement markers, of the color shown on the Plans or directed by the Engineer, shall be installed at the locations shown on the Plans or directed by the Engineer. Unless otherwise shown on the Plans or directed by the Engineer, Type II raised pavement markers shall be installed in accordance with the requirements of the MUTCD.

(d) Line Striping Targets. Line striping targets are intended to be substitutes for planned pavement markings on the wearing course of pavement, and shall be used only in conjunction with "Do Not Pass" signs for not longer than 14 calendar days.

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.

Line Striping Targets in conjunction with "Do Not Pass" signs shall be used on wearing courses of pavement prior to applying durable markings. Durable markings shall be placed within two weeks of the date the segment of wearing course pavement is placed. Line striping targets shall be placed at 12 m (40 foot) intervals on tangents and curves with a radius of 235 m (771 feet) or greater and at 6 m (20 foot) intervals on curves with a radius less than 235 m (771 feet) or as determined by the Engineer.

"Do Not Pass" signs shall be erected prior to traffic traveling on the wearing course of pavement. "Do Not Pass" signs shall be erected on each side of the road 300 m (985 feet) into the project limits and subsequent signs placed at 800 m (2625 foot) intervals. Additional signs shall be utilized 300 m (985 feet) from significant side roads.

"Do Not Pass" signs shall be 610 by 760 mm (24 × 30 inch) black text on orange Type III reflective sheeting as shown on the Plans and shall be mounted as shown on the Plans. The signs shall be turned away from traffic immediately upon placement of the durable markings.

(e) Paint. Temporary paint applied on the base or intermediate courses of pavement shall have a thickness of 200 ± 25 μm (8 ± 1 mil). Beads shall be applied at a rate of 360 g/L (3 pounds per gallon) of paint.

All paint used for temporary markings shall be held to the same alignment and horizontal control standards as specified in Subsection 646.04.

Temporary markings that remain in place for fewer than seven calendar days shall be Type II tape (removable) or Type II raised pavement markers. Paint will not be permitted for use as a temporary marking which remains in place for fewer than seven calendar days on the wearing course of pavement.

646.09 OTHER RELATED MARKINGS.

(a) Raised Pavement Markers, Type I. Type I raised pavement markers are intended to be permanently installed in the pavement surface and are manufactured of a material which will resist destruction by snow plowing equipment.

Type I raised pavement markers shall meet the requirements as specified in Subsection 708.11, and shall be permanently installed in the wearing course of pavement in accordance with the manufacturer's recommendations.

Type I raised pavement markers of the color shown on the Plans or directed by the Engineer, shall be installed at the locations shown the Plans or directed by the Engineer. Unless otherwise shown on the Plans or directed by the Engineer, Type I raised pavement markers shall be installed in accordance with the requirements of the MUTCD.

(b) Painted Curbs and Islands. Where painted curb or painted island is called for, the existing curb or island shall be sandblasted 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 Contract item Painted Curb or Painted Island.

Paint shall be applied at a rate of 2.5 to 2.8 $m^2/L$ (100 to 115 square feet per gallon) with glass beads applied at a rate of 720 g/L (6 pounds per gallon).

Fast-drying paint shall be applied at a temperature of 50 to 65 °C (125 to 150 °F) at the spray gun.

Reflectorized 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 380 ± 25 μm (15 ± 1 mil), unless otherwise specified, and shall be applied in a smooth uniform coat, free from thin places or films of excessive thickness.

Beads shall be applied uniformly over the entire painted surface area at the specified rate.

646.10 SUBSTITUTION OF MARKING MATERIALS. If the durable markings are not placed by October 15, paint shall be applied at the current standards as specified in Subsection 646.06 at no cost to the Agency. Where it can be determined that through

no fault of the Contractor, the durable markings cannot be applied until after October 15, paint may be paid for as Contract items 100 mm (4 inch) White Lines, 100 mm (4 inch) Yellow Lines, 200 mm (8 inch) White Lines, 200 mm (8 inch) Yellow Lines, 300 mm (12 inch) White Lines, 300 mm (12 inch) Yellow Lines, 600 mm (24 inch) Stop Bars, Letter or Symbol, Crosswalk Marking w/ Diagonal Line, and Railroad Crossing Symbol, where appropriate and as directed by the Engineer.

646.11 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 and Research Engineer, 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.

646.12 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 of the existing marking is removed; i.e., 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.

646.13 METHOD OF MEASUREMENT. The quantity of pavement marking edgelines and centerlines of the type and size specified to be measured for payment will be the number of meters (linear feet) applied in the complete and accepted work, as measured along the centerline of the pavement stripe. The number of meters (linear feet) of open spaces in a dashed or dotted line will not be measured for payment.

The quantity of Stop Bar of the type specified to be measured for payment will be the number of meters (linear feet) applied in the complete and accepted work, as measured along the centerline of the pavement stripe.

The quantity of Painted Curb to be measured for payment will be the number of meters (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 meters (square feet) of the top of an island painted in the complete and accepted work.

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. Example: “SCHOOL” would be measured as six units.

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 "R's," and one "X" for one traffic lane in one direction of travel.

The quantity of Removal of Existing Pavement Markings to be measured for payment will be the number of square meters (square feet) of markings removed or total area in square meters (square feet) of symbol or letter removed in the complete and accepted work, as determined by the Engineer.

The quantity of Crosswalk Marking with Diagonal Line of the type specified to be measured for payment will be the number of meters (linear feet) applied from curb to curb in the complete and accepted work, as measured along the center of the crosswalk.

The quantity of handicapped marking symbols to be measured for payment will be the number of symbols applied in the complete and accepted work.

The quantity of Raised Pavement Markers, Type I to be measured for payment will be the number of individual markers installed on/in the pavement in the complete and accepted work.

The quantity of Raised Pavement Markers, Type II to be measured for payment will be the number of individual markers installed in each phase of the traffic control plan and removed when no longer needed.

The quantity of Line Striping Targets to be measured for payment will be the number of individual targets installed on the pavement and removed when no longer needed.

646.14 BASIS OF PAYMENT. The accepted quantity of pavement marking edgelines and centerlines of the type and size specified will be paid for at the Contract unit price per meter (linear foot).

The accepted quantity of Stop Bar of the type specified will be paid for at the Contract unit price per meter (linear foot).

The accepted quantity of Painted Curb will be paid for at the Contract unit price per meter (linear foot).

The accepted quantity of Painted Island will be paid for at the Contract unit price per square meter (square foot).

The accepted quantity of Letter of Symbol of the type specified will be paid for at the Contract unit price per each unit.

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 Crosswalk Marking with Diagonal Line of the type specified will be paid for at the Contract unit price per meter (linear foot).

The accepted quantity of Raised Pavement Markers, Type I will be paid for at the Contract unit price per each unit.

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 pavement marking items that are used as temporary pavement markings (tape, raised pavement markers, paint, and line striping targets) as specified in Subsection 646.08 will also include all costs of removal of those temporary markings, if removal is required by construction procedures, shown on the Plans, or directed by the Engineer.

The accepted quantity of Removal of Existing Pavement Markings will be paid for at the Contract unit price per square meter (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. No payment will be made for removal of temporary paint markings installed and removed under the Contract.

The accepted quantity of Raised Pavement Markers, Type II will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, transporting, handling, and installing the markers as required for each phase of the traffic control plan; for maintaining the installed units during the phase and removing the markers, if necessary, when the phase has been completed; and for furnishing all necessary labor, tools, equipment, and incidentals to complete the work. Adjusting the markers as required by the Engineer during each phase of the traffic control plan, including replacing or resetting improperly placed or poorly oriented markers, will be considered incidental to the Contract item Raised Pavement Markers, Type II.

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, removing, and disposing of the targets and the "Do Not Pass" signs, posts, and sleeves (if used); and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. If line striping targets remain in place on the roadway for longer than 14 calendar days, no payment will be made for the Contract item Line Striping Targets.

"Do Not Pass" signs will not be paid for directly, but will be considered incidental to the Contract item Line Striping Targets.

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 are paid for under the appropriate Contract item specified in Section 631.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| (a) Paint Pavement Markings. | | |
| 646.20 | 100 mm (4 inch) White Lines | Meter (Linear Foot) |
| 646.21 | 100 mm (4 inch) Yellow Lines | Meter (Linear Foot) |
| 646.22 | 200 mm (8 inch) White Lines | Meter (Linear Foot) |
| 646.23 | 200 mm (8 inch) Yellow Lines | Meter (Linear Foot) |
| 646.24 | 300 mm (12 inch) White Lines | Meter (Linear Foot) |
| 646.25 | 300 mm (12 inch) Yellow Lines | Meter (Linear Foot) |
| 646.26 | 600 mm (24 inch) Stop Bars | Meter (Linear Foot) |
| 646.30 | Letter or Symbol | Each |
| 646.31 | Crosswalk Marking w/ Diagonal Line | Meter (Linear Foot) |
| 646.32 | Railroad Crossing Symbol | Each |
| (b) Durable Pavement Markings. | | |
| 646.40 | Durable 100 mm (4 inch) White Line | Meter (Linear Foot) |
| 646.41 | Durable 100 mm (4 inch) Yellow Line | Meter (Linear Foot) |
| 646.42 | Durable 200 mm (8 inch) White Line | Meter (Linear Foot) |
| 646.43 | Durable 200 mm (8 inch) Yellow Line | Meter (Linear Foot) |
| 646.44 | Durable 300 mm (12 inch) White Line | Meter (Linear Foot) |
| 646.45 | Durable 300 mm (12 inch) Yellow Line | Meter (Linear Foot) |
| 646.46 | Durable 600 mm (24 inch) Stop Bar | Meter (Linear Foot) |
| 646.50 | Durable Letter or Symbol | Each |
| 646.51 | Durable Crosswalk w/ Diagonal Lines | Meter (Linear Foot) |
| 646.52 | Durable Railroad Crossing Symbol | Each |
| (c) Temporary Pavement Markings. | | |
| 646.60 | Temporary 100 mm (4 inch ) White Line | Meter (Linear Foot) |
| 646.61 | Temporary 100 mm (4 inch ) Yellow Line | Meter (Linear Foot) |
| 646.62 | Temporary 200 mm (8 inch) White Line | Meter (Linear Foot) |
| 646.63 | Temporary 200 mm (8 inch) Yellow Line | Meter (Linear Foot) |
| 646.64 | Temporary 300 mm (12 inch) White Line | Meter (Linear Foot) |
| 646.65 | Temporary 300 mm (12 inch) Yellow Line | Meter (Linear Foot) |
| 646.66 | Temporary 600 mm (24 inch) Stop Bar | Meter (Linear Foot) |
| 646.70 | Temporary Letter or Symbol | Each |
| 646.71 | Temporary Crosswalk w/ Diagonal Lines | Meter (Linear Foot) |
| 646.72 | Temporary Railroad Crossing Symbol | Each |
| 646.75 | Raised Pavement Markers, Type II | Each |
| 646.76 | Line Striping Targets | Each |
| (d) Other Related Marking Items. | | |
| 646.80 | Raised Pavement Markers, Type I | Each |
| 646.81 | Painted Curb | Meter (Linear Foot) |

646.82 Painted Island — Square Meter (Square Foot)

(e) Marking Removal.

646.85 Removal of Existing Pavement Markings — Square Meter (Square Foot)

## SECTION 649 - GEOTEXTILE FABRIC

649.01 DESCRIPTION. This work shall consist of furnishing and placing geotextiles in underdrains, under embankments, for embankment reinforcement, under riprap and stone fill, behind retaining structures, over roadbed subgrades, and beneath pavement overlays.

649.02 MATERIALS. Geotextile terms are defined in Section 720. Materials shall conform to the applicable requirements of Section 720 and the following:

(a) Where sewn seams are used, the Contractor shall furnish the manufacturer's certified wide strip tensile test results attesting 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) Where field seams are made, the Contractor shall provide the Engineer with a field-stitched seam test sample in accordance with ASTM D 1683. The Engineer's approval will be required prior to the Contractor beginning production field stitching/seaming.

649.03 GENERAL. 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 shall be rejected if, at the time of installation, it has defects, deterioration, or damage, as determined by the Engineer.

649.04 INSTALLATION.

(a) General. The surface receiving the geotextile shall be prepared to a smooth condition free of obstructions, depressions and debris, unless otherwise directed by the Engineer. Where angular aggregate or sharp objects will be in contact with the geotextile, increased geotextile strength properties will be required, as specified in Section 720. 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 or sewn 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 (vertical:horizontal), 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 upwards.

(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 15 m (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) Geotextiles 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 rockfill 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 150 mm (6 inches) thick, unless otherwise directed by the Engineer. In addition, the following limits apply:

| | Maximum Drop Height | |
|---|---|---|
| Type of Stone Fill | Onto Geotextile | Onto a Sand Cushion Blanket |
| Type I | 900 mm (36 inches) | 900 mm (36 inches) |
| Type II, III, IV and Riprap | 0 | 300 mm (12 inches) |

After placement of the riprap or stone fill, all voids in the stone face that allow the geotextile to be visible 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 mass (weight) such that rutting of the initial lift placed above the geotextile is no greater than 75 mm (3 inches) deep. Ruts shall not be graded off but shall be filled with material specified by the Engineer such that a minimum of a 200 mm (8 inches) 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.

(6) Silt Fence. The geotextile shall be attached on the up-slope side of posts in accordance with the manufacturer's recommendation or as directed by the Engineer. The geotextile at the bottom of the fence shall be buried in a trench a minimum of 150 mm (6 inches) below the ground surface. Where the geotextile elongation is 50 percent as measured in accordance with ASTM D 4632, the post spacing shall not exceed 1.2 m (4 feet); and where the elongation is less than 50 percent, the post spacing shall not exceed 2 m (6 feet).

Either wood or steel posts shall be used. The posts shall have a minimum length of 1.5 m (5 feet) and shall be embedded a minimum of 460 mm (18 inches) below the ground surface. The spacing of the posts shall be determined by the silt fence manufacturer or by the Engineer.

Wood posts shall have minimum dimensions of 25 by 25 mm (1 × 1 inch) and shall be free of defects such as knots, splits or gouges. Steel posts shall consist of either No. 22 (No. 7) size reinforcing steel or larger, or shall consist of ASTM A 120 steel pipe with a minimum diameter of 20 mm (3/4 inch).

Sediment deposits that accumulate behind the fence shall be removed when the deposit reaches 50 percent of the height of the silt fence above the ground surface.

The Contractor shall repair or replace damaged silt fence as ordered by the Engineer. The silt fence shall be completely removed prior to acceptance of the project, unless otherwise directed by the Engineer.

(7) Filter Curtain. When used to contain sediments or pollutants from a work area that is adjacent to or under water, the fabric shall be installed to completely enclose the portion of the work area that will be under water. The Contractor shall design and construct the curtain to deflect and withstand any existing current or wave action, to be anchored continuously along the bottom, to be effective at any anticipated water level, and to prevent the escape of all sediments or pollutants into the main stream or body of water.

The Contractor shall repair or replace damaged or otherwise ineffective filter curtains as ordered by the Engineer. The Contractor shall remove material accumulated behind the filter curtain as directed by the Engineer.

The Contractor shall remove the filter curtain and all supporting and anchoring material prior to acceptance of the project, unless otherwise directed by the Engineer.

The design, construction, and maintenance plan for the filter curtain installation shall be acceptable to the Engineer before installation of the curtain begins.

(b) Protection of Geotextile. The Contractor shall not permit traffic or construction equipment to travel directly on the geotextile. The geotextile shall be protected at all times during construction 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 seven 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 200 mm (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 900 mm (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 by sewing, unless otherwise shown in the Contract Documents or as directed by the Engineer.

(d) Overlaps. The minimum overlap requirements for geotextiles are as follows:

| Minimum Overlap Requirements | |
|---|---|
| Underdrain | 300 mm (12 inches) |
| Geotextiles under Type I and II Stone Fill | 600 mm (24 inches) |
| Geotextiles Under Riprap and Type III and IV Stone Fill | 900 mm (36 inches) |
| Roadbed Subgrade Stabilization | 900 mm (36 inches) |
| Geotextile Under Railroad Ballast | 900 mm (36 inches) |

In the event that 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 part (e) below 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 13 mm (1/2 inch) apart with a tolerance of ± 6 mm (± 1/4 inch) and shall not cross, except for restitching.

(3) Minimum Seam Allowance. The minimum required seam allowance, i.e., the minimum distance from the geotextile edge to the stitchline nearest to that edge, are as follows:

| Seam Type (See Plans) | Minimum Seam Allowance |
|---|---|
| Flat or Prayer Seam, Type SSa-1 | 40 mm (1 1/2 inches) |
| "J" Seam, Type SSa-1 | 25 mm (1 inch) |
| Butterfly-Folded Seam, Type SSd-1 | 25 mm (1 inch) |

(4) Seam Type. The Contractor shall obtain the geotextile manufacturer's recommendation for the type of seam and stitch to be used. If the Contractor 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 25 mm (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 fabric of the type specified to be measured for payment will be the number of square meters (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 fabric of the type specified will be paid for at the Contract unit price per square meter (square yard). Payment will be full compensation for furnishing, transporting, storing, handling, maintaining, placing, and removing the material specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

The cost of removal of material accumulated behind the fabric will not be paid for directly, but will be considered incidental to the appropriate geotextile Contract item.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 649.11 Geotextile For Roadbed Separator | Square Meter (Square Yard) |
| 649.21 Geotextile Under Railroad Ballast | Square Meter (Square Yard) |
| 649.31 Geotextile Under Stone Fill | Square Meter (Square Yard) |
| 649.41 Geotextile For Underdrain Trench Lining | Square Meter (Square Yard) |
| 649.51 Geotextile For Silt Fence | Square Meter (Square Yard) |
| 649.61 Geotextile For Filter Curtains | Square Meter (Square Yard) |

## SECTION 651 - TURF ESTABLISHMENT

651.01 DESCRIPTION. This work shall consist of the preparation of the area and the application of topsoil, grubbing material, sod, seed, fertilizer, limestone, and mulch.

651.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Topsoil | 755.01 |
| Sod | 755.02 |
| Seed | 755.03 |
| Fertilizer | 755.04 |
| Agricultural Limestone | 755.05 |
| Hay Mulch | 755.06(a) |
| Mulch Binder | 755.06 |

Pegs for holding sod shall be rounded or square wooden stakes at least 200 mm (8 inches) long, having a cross-sectional area of approximately 650 $mm^2$ (1 square inch). Pegs 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. Material for use on rock fill 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.

651.03 SEASONAL LIMITATIONS. Turf establishment may be carried on from the time the ground becomes workable in the spring until October 15, unless otherwise directed by the Engineer.

Regardless of the time of seeding or sodding, the Contractor shall be responsible for a full growth of grass.

651.04 GENERAL. The Contractor shall establish turf on all cut and fill slopes as soon as practical, unless otherwise directed by the Engineer.

651.05 PREPARATION OF AREA. The ground surface shall be shaped to the lines and grades shown on the Plans. In areas to be topsoiled and/or sodded, allowance shall be made for the depth of topsoil and/or thickness of sod. All breaks in grade shall be well rounded. The surface shall be thoroughly raked, dragged, or otherwise mechanically smoothed. All stones, lumps, roots, or other objectionable materials shall be removed. When necessary, the soil shall be loosened to a depth of approximately 50 mm (2 inches).

If shown on the Plans or if in the opinion of the Engineer, the area to be seeded or sodded is of such a composition that it is unsuitable for vegetation, it shall be covered with 50 mm (2 inches) of compacted topsoil.

Fertilizer and Agricultural Limestone, when required, shall be spread over the area to be sodded.

Stone and rock fill slopes to be covered with grubbing material shall be shaped in reasonably close conformity with the grades and typical cross-sections shown on the Plans or directed by the Engineer.

651.06 TOPSOIL. Approved topsoil shall be obtained from a source outside the project, unless otherwise shown on the Plans or directed by the Engineer. Spreading shall not be done when ground or topsoil is frozen, excessively wet, or otherwise in a condition detrimental to the work.

The topsoil shall be spread evenly to a depth after compaction of approximately 50 mm (2 inches) or to the depth as shown on the Plans or directed by the Engineer.

All large stones and other unsuitable material shall be removed from the area.

Topsoil stockpile areas shall be graded, seeded, and left in a neat and presentable condition. Areas shall be properly drained and all excess or unsuitable materials disposed of to the satisfaction of the Engineer.

651.07 GRUBBING MATERIAL. Approved grubbing material shall be placed as shown on the Plans or as directed by the Engineer. Spreading shall not be done when grubbing material is frozen, excessively wet, or otherwise in a condition detrimental to the work.

The grubbing material shall be spread evenly to a depth of approximately 300 mm (12 inches) or to the depth shown on the Plans or directed by the Engineer. All large stones and other unsuitable material shall be removed from the area, as directed by the Engineer.

Grubbing material stockpile areas shall be graded, seeded, and left in a neat and presentable condition. Areas shall be properly drained and all excess or unsuitable materials disposed of to the satisfaction of the Engineer.

651.08 SEEDING. Limestone, fertilizer, and seed shall be spread uniformly by hydraulic or dry methods at the rate specified and at the locations shown on the Plans.

Fertilizer and seed may be mixed with water and the mixture sprayed over the area to be seeded. Any mechanical operation may be used which will place the limestone, fertilizer, seed, or any combination of these in direct contact with the soil and which meets the approval of the Engineer.

After the seed has been applied, lawn areas shall be lightly raked to mix seed with the soil and rolled with a lightweight roller to the satisfaction of the Engineer.

Mulching shall follow the seeding operation by not more than 24 hours.

Mulch shall be spread uniformly over the area at a rate of approximately 4.5 metric tons per hectare (2 tons per acre) or as ordered by the Engineer. Spreading by mechanical spreading devices may be used if approved by the Engineer. The application of mulch shall be made in such a manner that lumps and thick spots are avoided.

An emulsified asphalt may be used to anchor the mulch. When used, it shall be applied at the rate of 1.4 to 1.9 $m^3$/ha (150 to 200 gallons per acre) or as directed by the Engineer. When the mulch is spread by a blower or other similar device, emulsified asphalt shall be injected into the mulch at the above rate as it leaves the blower.

When other types of mulch binders are used they shall be applied using the methods and rates recommended by the manufacturer.

When necessary, mulch without a binder shall be anchored by a light coating of brush or tree branches, use of stakes and twine; or any other method approved by the Engineer.

651.09 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 50 mm (2 inches) and cleared of excess grass clippings and other foreign material.

The sod shall be cut with an approved sod cutter into strips of uniform width having a minimum dimension of 300 mm (12 inches) in width and 450 mm (18 inches) in length and uniform thickness of approximately 50 mm (2 inches), unless otherwise directed by the Engineer. The sod shall contain the majority 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, grass to grass and roots to roots for not more than five 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.

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. The exposed edges of the sod shall be watered and thoroughly rolled or tamped with approved equipment to give a smooth surface. Slopes subject to wash and slopes steeper than 1:2 (vertical:horizontal) shall have the sod secured with wooden pegs, unless otherwise directed by the Engineer.

The pegs shall be driven approximately 600 mm (24 inches) center to center in each direction and driven through the sod perpendicular to the surface so that the tops of pegs are flush with the top of the sod.

651.10 HAY BALES FOR EROSION CONTROL. Bales of hay shall be used in the construction of settling basins, to control erosion, to contain soil runoff, and for other applications as determined by the Engineer. The Contractor shall install and anchor the bales as specified in the Contract or as directed by the Engineer. Hay bales used for erosion control shall be at least 900 mm (3 feet) in length.

651.11 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 107.18.

651.12 METHOD OF MEASUREMENT. The quantity of Topsoil to be measured for payment will be the number of cubic meters (cubic yards) used in the complete and accepted work, as measured in its final position using slope measurements for determining area.

The quantities of Seed, of the type specified, and Fertilizer to be measured for payment will be the number of kilograms (pounds) for the specified item used in the complete and accepted work, as determined from load tickets furnished to the Engineer.

The quantities of Agricultural Limestone and Hay Mulch to be measured for payment will be the number of metric tons (tons) for the specified item used in the complete and accepted work, as determined from load tickets furnished to the Engineer. With written permission of the Engineer, the mass (weight) of small quantities of mulch may be determined by alternate methods. The Engineer will verify and document such mass (weight) determination.

The quantity of Sodding to be measured for payment will be the number of square meters (square yards) of sod used in the complete and accepted work, as determined by using slope measurements.

The quantity of Hay Bales for Erosion Control to be measured for payment will be the number of bales of hay used in the complete and accepted work, as determined by the Engineer.

The quantity of Grubbing Material to be measured for payment will be the number of square meters (square yards) of grubbing material used in the complete and accepted work, as measured in its final position using slope measurements for determining area.

651.13 BASIS OF PAYMENT. The accepted quantity of Topsoil will be paid for at the Contract unit price per square meter (square yard).

The accepted quantities of Seed, of the type specified, and Fertilizer will be paid for at the Contract unit price per kilogram (pound) for the item specified.

The accepted quantities of Agricultural Limestone and Hay Mulch will be paid for at the Contract unit price per metric ton (ton) for the item specified.

The accepted quantity of Hay Bales for Erosion Control will be paid for at the Contract unit price for each.

The accepted quantity of Sodding will be paid for at the Contract unit price per square meter (square yard).

The accepted quantity of Grubbing Material will be paid for at the Contract unit price per square meter (square yard).

Payment will be full compensation for furnishing, transporting, handling, and placing the material specified, including mulch binder when used, and for furnishing all labor, tools, equipment, maintenance, and incidentals necessary to complete the work.

Water used in the watering of seeded or sodded areas shall be applied upon written order of the Engineer and will be paid for under the Contract item Dust Control with Water.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 651.15 Seed | Kilogram (Pound) |
| 651.16 Wildflower Seed | Kilogram (Pound) |
| 651.17 Seed - Winter Rye | Kilogram (Pound) |
| 651.18 Fertilizer | Kilogram (Pound) |
| 651.20 Agricultural Limestone | Metric Ton (Ton) |
| 651.25 Hay Mulch | Metric Ton (Ton) |
| 651.26 Hay Bales for Erosion Control | Each |
| 651.30 Sodding | Square Meter (Square Yard) |
| 651.35 Topsoil | Cubic Meter (Cubic Yard) |

| | |
|---|---|
| 651.40 Grubbing Material | Square Meter (Square Yard) |

## SECTION 654 - EROSION CONTROL WITH MATTING

654.01 DESCRIPTION. This work shall consist of furnishing and placing erosion control matting.

654.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Topsoil | 755.01 |
| Seed | 755.03 |
| Fertilizer | 755.04 |
| Hay Mulch | 755.06(a) |
| Erosion Matting | 755.07 |

Staples shall be made from 300 mm (12 inch) lengths of No. 11 gage steel wire bent to form a "U" of 25 to 50 mm (1 to 2 inches) in width. Longer staples may be required for loose soils as directed by the Engineer.

654.03 PREPARATION OF AREA. The ground surface shall be shaped to the lines and grades shown on the Plans and shall have a smooth surface free of depressions and eroded areas that would allow water to collect or flow under the matting. The surface shall be cleared of stones, sticks, and other objectionable material that would prevent the matting from close contact with the ground. Placement of the topsoil, fertilizer, seed, and mulch, when required, shall be completed prior to placing of the matting.

654.04 INSTALLATION. After the soil has been properly shaped, fertilized, seeded, and mulched the matting shall be laid out parallel to the flow of water or vertically on slopes.

No traffic of any kind will be permitted over the matting during or after placement. Any torn or damaged material shall be replaced at the Contractor's expense.

Mulch should be under the complete coverage of the net so that the net is not in direct contact with the ground. The net shall be spread over the hay mulch so that there is space for a worker to walk between adjacent widths of the net. The edges of adjacent widths of the net shall be pulled together and held in place with wire staples spaced not more than 900 mm (36 inches) apart along the edge of the net. The staples shall be pushed into the ground so that the top of the staple is about 15 mm (1/2 inch) above the ground. The ends of each strip of net shall be held in place by staples at each corner and at the center of the net. Additional staples shall be installed as directed by the Engineer.

654.05 MAINTENANCE. The Contractor shall maintain the matted areas until all work has been completed and accepted. Maintenance shall consist of repairing areas damaged by erosion, wind, fire, or other causes at the Contractor's expense except for conditions covered in Subsection 107.18. Such areas shall be repaired to re-establish

the condition and grade of the soil prior to application of the matting and shall be refertilized and reseeded as specified under Section 651.

654.06 METHOD OF MEASUREMENT. The quantity of Erosion Matting to be measured for payment will be the number of square meters (square yards) used in the complete and accepted work, as measured in its final position using slope measurements for determining area.

654.07 BASIS OF PAYMENT. The accepted quantity of Erosion Matting will be paid for at the Contract unit price per square meter (square yard). Payment will be full compensation for furnishing, transporting, handling, and placing the material specified and for furnishing all labor, tools, equipment, maintenance, and incidentals necessary to complete the work.

Any topsoil, fertilizer, seed, and hay mulch used will be paid for under Section 651.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 654.10 Erosion Matting | Square Meter (Square Yard) |

## SECTION 656 - PLANTING TREES, SHRUBS, AND VINES

656.01 DESCRIPTION. This work shall consist of furnishing, transporting, planting, and transplanting trees, shrubs, vines, and ground cover plants.

656.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Water | 745.01 |
| Topsoil | 755.01 |
| Fertilizer | 755.04 |
| Mulch | 755.06 |
| Plant Materials | 755.08 |
| Antidesiccant Spray | 755.09 |
| Wire Rodent Guards | 755.10 |
| Plant Wrapping | 755.11 |

When weed separator fabrics are required, the separator fabric used shall be one of the separator fabrics and the necessary associated materials on the Approved Products Listing on file and maintained by the Agency's Materials and Research Section, telephone: (802) 828-2561.

656.03 PLANTING SEASON. For best results the initial planting should be accomplished between April 1 and June 1, or between August 15 and November 1, unless otherwise shown on the Plans or directed by the Engineer.

No planting shall be done in frozen ground, when snow covers the ground, or when the soil or weather is unsatisfactory for planting.

656.04 INSPECTION AND DELIVERY. 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.

A more thorough inspection will be made just prior to planting. Only those plants that have received this inspection and have been approved for planting shall be planted.

656.05 PROTECTION AND TEMPORARY STORAGE. The Contractor shall keep all plant material moist and protected from drying out. Plants shall be protected when in transit, in temporary storage, or 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 delivered but not scheduled for immediate planting shall be protected as follows:

(a) Bare root materials that are not planted immediately upon receipt shall have the bundles opened, the plants separated and heeled-in in moist soil so as to leave no air spaces and shall be properly maintained until planted.

(b) Balled and burlapped plants which are not scheduled for planting within 48 hours shall be kept in a moist condition and protected adequately by covering the earth balls with topsoil, wood chips, or other suitable material until removed for planting.

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 excavating 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.

The size of plant pits shall bear the following relation to the root spread (or diameter of balls) of the plants to be planted in them. The pit diameters shall be three times the root spread diameter.

The pits shall be no deeper than the root ball. Plants shall be set straight and at the same depth at which they were previously growing. Soil shall be firmly compacted around the roots, leaving no air pockets.

Pits for vines shall be approximately 500 mm in diameter by 500 mm deep (18 inches in diameter by 18 inches deep).

The soil at the bottom of a plant pit shall be loosened to a depth of at least 150 mm (6 inches) by spading or other approved methods before backfilling begins.

Bare root evergreens such as seedlings or transplants may be planted in the existing soil. Plant holes must be deep enough to allow room for the full depth of the root without doubling or folding and wide enough to allow room for its normal spread. Plants must be set straight and at the same depth at which they were previously growing. Soil must be firmly compacted around the roots, leaving no air pockets.

All excavations for trees and shrubs shall be filled with water, and the water shall be allowed to percolate out prior to planting the tree or shrub.

If material excavated for plant pits is found to be suitable for backfill, it shall be approved by the Engineer for that use, prior to being used.

656.08 BACKFILL MATERIAL. The backfill material shall be topsoil approved by the Engineer or obtained from an approved source.

656.09 SETTING PLANTS. Plants shall be set plumb and shall stand, after settlement of the backfill, at the same level in relation to the ground in which they are planted as they stood in the ground from which they were dug.

(a) Bare Root Plants (BR). After the material at the bottom of the pit has been loosened, topsoil shall be placed to the required minimum depth. Bare root plants shall be placed in the center of the plant pit and the roots properly spread out in a natural position. All broken or damaged roots shall be cleanly cut back to sound root growth.

Topsoil shall be carefully worked around and over the roots and be thoroughly and properly tamped. Thorough watering shall accompany backfill around bare root plants. Water basins, at least 100 mm (4 inches) in depth for trees and 75 mm (3 inches) in depth for shrubs, shall be formed about individual plants with a diameter equal to that of the plant pit.

(b) Balled and Burlapped Plants (B & B). Balled and burlapped plants shall be carefully placed in prepared pits on the required depth of tamped topsoil so as to rest in a firm, upright position. Plants shall be handled and moved only by the ball. They shall be planted as follows:

(1) Plants Balled in Synthetic Material. Once positioned in the pit, the synthetic covering shall be sliced open vertically every 100 mm (4 inches) for 75 percent of the height of the ball. All synthetic material shall be cut from around the stem of plant.

(2) Plants Balled in Hemp Burlap. Once positioned in the pit, all ropes shall be cut from around the stem of the plant.

Backfill soil shall be filled in around the plant ball to 50 percent of the depth of the ball and then tamped. The remainder of the soil shall then be placed and tamped. Water basins, at least 100 mm (4 inches) in depth for trees and

75 mm (3 inches) in depth for shrubs, shall be formed about individual plants with a diameter equal to that of the plant pit.

All plants shall be moved with the root ball intact. If the wrapping material is held in place by wire, the wire shall be removed prior to planting. If the root ball has been badly cracked or broken, the plant shall be rejected for use.

(c) Transplanted Plants. Transplanted plants shall be set in accordance with the requirements of part (a) or (b) above, as appropriate.

(d) Fertilizing. Fertilizer shall be applied and cultivated into the top 50 mm (2 inches) of the plant pit area or shrub bed within five days after planting. No fertilizer shall be applied to seedlings.

The rates of application shall be approximately as follows:

| | |
|---|---|
| Trees: | 40 g/mm (32 ounces per inch) of caliper |
| Shrubs and Evergreens: | 400 g/m (4 ounces per foot) of height or spread |
| Vines: | 50 g/vine (2 ounces per vine) |

A second application of fertilizer, at the same rates, shall be applied to all plant items over the mulch at the end of the establishment period.

(e) Watering. All plant material shall be watered thoroughly at planting. Unless otherwise specified, the minimum interval for watering 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 40 L (10 gallons) at each watering, shrubs a minimum of 20 L (5 gallons) and vines and plants a minimum of 10 L (3 gallons).

(f) Guys and Stakes. All trees shall be guyed and staked in accordance with details shown on the Plans as soon as planting is completed.

Support posts may be required instead of guys and stakes when ordered by the Engineer.

Stakes, support posts, and deadmen shall be sound new hardwood, treated softwood, or redwood that is free of knots, knot holes, and other defects.

Guys shall prevent lateral deflection of the supported plant. The type of guy shall be approved by the Engineer prior to installation. Guys and stakes shall be removed within 30 days of final acceptance.

The Contractor shall provide rubber or soft plastic hose of a green color to provide protection for guyed trees from the wire. This hose shall be a minimum of 13 mm (1/2 inch) in diameter and long enough to provide full protection. The hose shall be of the same material and the same color for all guyed trees. Guyed

trees shall have a minimum of three guys per tree, unless otherwise shown on the Plans or directed by the Engineer.

(g) Wrapping. Wrapping shall be placed around all trunks of deciduous trees 40 mm (1 1/2 inches) or larger in caliper or as directed by the Engineer. The wrapping shall begin at the base of the tree and extend up to the first branches. Wrapping shall be secured at the top, bottom, and at intervals of not more than 600 mm (24 inches). Wrapping shall be done as soon as planting is completed but not before inspection of the plant. The wrapping shall be removed after the first winter season.

(h) Antidesiccant Spray. Antidesiccant spray shall be applied immediately after planting. A second spraying shall be applied prior to winter or as directed by the Engineer.

(i) Pruning. Pruning shall be accomplished before or immediately after planting in such a manner as to preserve the natural character of each plant. All pruning shall be performed by experienced personnel with proper equipment and in keeping with accepted horticultural practice.

(j) Mulching. Unless otherwise specified, the mulch material used for landscape plantings shall be approved Cedar, Pine, Hemlock, or Spruce bark material reasonably free from insect pests, eggs, or larvae. The same type of material shall be used in all areas to provide visual uniformity.

The mulch used in restoring seeded or originally grassed areas outside landscape planting areas shall be hay mulch.

(k) Wire Rodent Guards. Wire rodent guards may be used at the Contractor's option. If used, wire rodent guards shall be removed within 30 days of final acceptance.

(l) Weed Separator Fabric. The weed separator fabric shall be installed on the prepared top surface of the planting bed during the planting procedure as shown on the Plans. The fabric shall extend to the edges of the plant pit and shall be closely fitted around the trunks or stems of the plants, unless otherwise shown on the Plans or directed by the Engineer. Small plants may be inserted through the fabric by making cuts of sufficient size in the fabric to allow planting. Fabric patches may be required over the cuts to ensure coverage.

The fabric shall be covered with a minimum of 100 mm (4 inches) of bark mulch, unless otherwise shown on the Plans or directed by the Engineer.

(m) Restoration and Maintenance. The Contractor shall restore all seeded and grassed areas outside the planting areas that were disturbed by the planting operations at no cost to the State.

All debris, excess excavation, and other objectionable material shall be removed and disposed of as directed by the Engineer.

The Contractor shall actively maintain the plants immediately after planting. Plants shall be pruned and/or cultivated, as appropriate. All mulched areas shall be kept weeded, neat, and maintained to the original layout lines. Stakes, support posts, and deadmen shall be restored or replaced as necessary and guys adjusted as necessary. Weed separator fabric and tree wrappings shall be restored or replaced as necessary and basins and saucers shall be repaired to hold water.

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 Department of Agriculture approving the spraying.

(n) Establishment Period. The Contractor shall properly maintain all planted trees, shrubs, vines, plants, and ground cover until final planting by necessary watering, weeding, fertilizing, spraying with approved insecticides or fungicides, providing protection from rodents and other work necessary to keep plants in living healthy condition. Any plants damaged, dried out, or otherwise in poor condition shall be replaced in kind with healthy stock at the Contractor's expense.

The initial planting season shall be in accordance with Subsection 656.03.

Approximately six months following the first planting, the Engineer and Contractor shall inspect the planted material and any dead, dying, or damaged material shall be replaced by the Contractor. This is the second planting and shall be completed within 30 days after inspection or as directed by the Engineer.

The planted material shall be inspected again by the Engineer and Contractor approximately six months following the second planting and any dead, dying, or damaged material found at the time shall be replaced by the Contractor. This final planting shall be completed within 30 days of the inspection.

The acceptability of the plant material furnished and planted shall be determined at the end of the establishment period. The end of the establishment period shall be upon completion of final planting.

656.10 TRANSPLANTING. Transplanting shall be done in accordance with Subsection 656.09(b) through (n) or as ordered by the Engineer.

Transplanted plant materials shall be maintained during establishment in accordance with Subsection 656.09(n) except that on projects where only transplanting of existing plant materials is performed, the establishment period shall end on the project acceptance date.

656.11 METHOD OF MEASUREMENT. The quantity of plants to be measured for payment will be the number of each of the specified sizes and kinds furnished and planted or transplanted in the complete and accepted work. Only living plants in healthy condition at the time of final inspection will be accepted.

656.12 BASIS OF PAYMENT. The accepted quantity of plants will be paid for at the Contract unit price each of the specified sizes and kinds for planting or transplanting. Payment will be full compensation for furnishing and transporting of plants; for furnishing and transporting of topsoil for plant backfill, fertilizer, mulch, and all incidental materials; for digging holes for plants; for planting, pruning, guying and staking, mulching, wrapping, wire rodent guards, water basin formation, cleanup, and plant maintenance establishment work and care including replacement; and for all labor, equipment, tools, and incidentals necessary to complete the work.

All seedlings trees, shrubs, ground covers, and vines 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 material at the Contractor's expense.

Water applied during the plant establishment period will not be paid for directly, but will be considered incidental to the Contract items in the Contract under which the planting or transplanting was performed.

Payment will be made as follows:

(a) 80 percent of the Contract unit price after the first planting;

(b) 10 percent of the Contract unit price after the second planting;

(c) 5 percent of the Contract unit price after the final planting; and

(d) The remaining percentage of the Contract unit price after the Acceptance Date.

The project will not be accepted until the replacement of all dead, dying, or poorly growing material found at the time of the second or final inspection has been completed to the satisfaction of the Engineer.

The cost of weed separator fabric will not be paid for separately, but will, like bark mulch, be included in the Contract unit price for each plant installed under the Contract.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 656.15 Evergreen Seedlings | Each |
| 656.20 Evergreen Trees | Each |
| 656.25 Evergreen Shrubs | Each |
| 656.30 Deciduous Trees | Each |
| 656.35 Deciduous Shrubs | Each |
| 656.40 Ground Covers and Vines | Each |
| 656.45 Transplanting Trees | Each |
| 656.50 Transplanting Shrubs | Each |

# SECTION 675 - TRAFFIC SIGNS

675.01 DESCRIPTION. This work shall consist of furnishing and installing traffic signs, removing existing signs, installing salvaged signs, and overlaying existing signs.

675.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Paint for Traffic Signs | 708.06 |
| Bar Reinforcement | 713.01 |
| Sign Posts | 750.01 |
| Extruded Aluminum Panels | 750.02 |
| Flat Sheet Aluminum | 750.03 |
| Galvanized Flat Sheet Steel | 750.04 |
| Formed Galvanized Steel Panels | 750.05 |
| High Density Overlaid Plywood | 750.06 |
| Acrylic Plastic Reflectors | 750.07 |
| Reflective Sheeting | 750.08 |
| Demountable Characters | 750.09 |
| Plastic Lettering Film | 750.10 |
| Extruded Aluminum Molding | 750.11 |
| Assembly Hardware | 750.12 |

If the Contract does not specify a particular type of sign material, the Contractor may furnish any one of the following materials:

(a) For a sign with an area 2 $m^2$ (20 square feet) or less:

(1) Flat sheet aluminum.

(2) Galvanized flat sheet steel.

(3) High density overlaid plywood.

(b) For a sign with an area greater than 2 $m^2$ (20 square feet):

(1) Extruded aluminum panels.

(2) Formed galvanized steel panels.

(3) High density overlaid plywood.

Type A signs are signs having an area of 2 $m^2$ (20 square feet) or less. Type B signs are signs with an area greater than 2 $m^2$ (20 square feet).

Concrete shall conform to the requirements of Section 501 for Concrete, Class B.

All new signs installed shall be marked on the back with the following information:

| | Examples | |
|---|---|---|
| (State) or (Town) | VAOT | Swanton |
| Month and Year of Sign Fabrication | 01/00 | 09/85 |
| Route Where Sign Installed | US 5 | TH 13 |

The letters and numbers of the text shall be 25 mm (1 inch) high.

Either stick-on letters and numbers or silk-screened letters or numbers will be allowed as long as they are applied in such a way that they remain intact during the life of the sign. If stick-on letters and numbers are used, all the letters and numbers to be placed on a sign shall come from the same stick-on sheet. Individual stick-on letters or numbers will not be allowed.

Type II, Type III, Type IV, or Type V reflective sheeting shall be used wherever "Encapsulated Lens" or "High Intensity" sheeting is shown on the Plans. Type VI reflective sheeting may be used on traffic cones or barrels. Type I or Type II reflective sheeting shall be used for all other applications.

The use of Type II shall be restricted to the colors orange, white, and yellow and, when used on signs, shall be restricted to use on ground mounted signs only.

675.03 EXTRUDED ALUMINUM PANELS. Extruded aluminum panels shall be of the butting type, 300 mm (12 inches) wide and of the lengths shown on the Plans. The moment of inertia of a panel shall be not less than 318 500 $mm^4$ (0.765 $inch^4$), and shall be designed to carry a wind load of 1.44 kPa (30 pounds per square foot).

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. Cut edges shall be true and smooth and free from burrs. Flame cutting will not be permitted. Bolt holes may be drilled to finished size or punched to finished size provided the diameter of the punched hole is at least twice the thickness of the metal being punched. The surface of all panels shall be flat and free of defects. 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 600 mm (24 inches) to each adjacent panel.

675.04 FLAT SHEET ALUMINUM. Fabrication of the flat aluminum sheets, including cutting to size, bending and punching or drilling holes and the welding of reinforcing or stiffening members, if any are required, shall be completed prior to degreasing, etching or treating and application of the background material. Material may be sheared, blanked, sawed, or milled. Cut edges shall be true and smooth and free from burrs. No flame cutting will be permitted. The surface of all sign faces shall be flat and free of buckles, warp, dents, burrs, or other defects.

675.05 HIGH DENSITY OVERLAID PLYWOOD. Fabrication of plywood sign blanks, including drilling holes and cutting to size, shall be completed prior to the application of reflective sheeting. Plywood sign blanks shall be cut to shape and size

using a saw blade that does not tear the plywood grain. Holes shall be 11 mm (7/16 inch) in diameter, clean cut, and uniform. When cut to size and shape, the sign blanks shall be free of warping, open checks, open splits, open joints, open cracks, loose knots, and other defects. The surfaces of all sign blanks shall be flat.

All edges and holes shall be thoroughly sealed with exterior aluminum paint meeting the approval of the Engineer. The paint shall contain at least 30 percent solids (aluminum powder) by volume. After sealing, the edges and interior of the holes shall be painted with one coat of enamel primer followed by one coat of exterior black sign enamel. After a sign has been installed, the edges shall be resealed and repainted if ordered by the Engineer.

The color of the plywood used for the sign base material may be either natural or black. When of natural color, the edges and back of the sign blank shall be painted with one coat of enamel primer followed by one coat of exterior black sign enamel. Before applying the first coat, the surface shall be cleaned with an approved solvent, abraded lightly with fine sandpaper or steel wool and wiped clean.

675.06 GALVANIZED FLAT SHEET STEEL. Fabrication of the flat steel sheets including cutting to size, bending and punching or drilling holes and the welding of reinforcing or stiffening members, if required, shall be completed prior to galvanizing. Cut edges shall be true and smooth and free from burrs. Flame cutting will not be permitted. The surface of all sign blanks shall be flat and free of buckles, warp, dents, burrs, or other defects.

Care should be taken in the choice and use of reinforcing or stiffening members, when required, to avoid creating pockets that will collect and retain moisture.

675.07 FORMED GALVANIZED STEEL PANELS. Formed galvanized steel panels shall be of a butting type, 300 mm (12 inches) wide and of the lengths shown on the Plans. The thickness of the steel shall be not less than 20 gage and the panel shall be designed to carry a wind load of 1.44 kPa (30 pounds per square foot). Fabrication of the formed galvanized steel panels, including cutting to size, bending to shape, and the punching or drilling of all holes, shall be completed prior to galvanizing. Cut edges shall be true and smooth and free from burrs. Flame cutting will not be permitted. An exterior bend shall have a minimum radius equal to the thickness of the material, up to and including 16 gage. The surface of all panels shall be flat and free of defects. The panels shall be fabricated for horizontal mounting and each panel shall extend the full width of a sign.

Flange holes shall be spaced approximately every 300 mm (12 inches), with the end holes and every other hole used for bolting the panels together and the intermediate holes to facilitate drainage.

675.08 SHEET ALUMINUM FOR OVERLAY. The Contractor shall remove copy, install sheet aluminum on the face of a sign, and replace the copy as shown on the Plans.

675.09 APPLICATION OF REFLECTIVE SHEETING. Reflective sheeting shall be of the color shown on the Plans. The face of a sign shall be completely covered by the reflective sheeting when used as a background. All panels of a multi-panel sign shall be of uniform background color and brilliance both day and night.

Before application of the reflective sheeting, the sign face shall be cleaned, degreased, coated, treated, and etched or abraded in accordance with standard commercial processes for the sign base material involved. The faces shall be dried by use of a forced hot-air drier and shall not be handled except by device or clean canvas gloves between all cleaning operations and application of the reflective sheeting. There shall be no opportunity for the sign faces to come in contact with greases, oils, or other contaminants prior to the application of the reflective sheeting.

Reflective sheeting shall be applied to the face of an extruded aluminum panel or a formed galvanized steel panel by a squeeze roller applicator. Reflective sheeting shall be applied to flat sheet aluminum, embossed letter frames, high density overlaid plywood, and galvanized flat sheet steel by vacuum heat applicator at 95 °C (200 °F), or by squeeze roller applicator. After aging 48 hours at 20 °C (68 °F), adhesion of the reflective sheeting to the sign surface shall be strong enough to resist stripping when tested with a stiff putty knife.

Reflective sheeting having a solvent or heat-activated adhesive shall be completely covered with a clear coating. Reflective sheeting with a pressure sensitive adhesive shall be edge sealed with a clear coating. When plastic lettering film, or reflective sheeting or lettering paint is used for the sign text, the clear coating shall be applied only after the entire text is in place on the reflective sheeting.

675.10 TRANSPORTATION AND HANDLING. Sign materials and finished signs shall be handled at all times so as to prevent damage or disfigurement. Damaged signs shall be rejected.

675.11 ERECTION OF SIGN POSTS AND FOUNDATIONS. Signs shall be installed at the locations shown on the Plans or directed by the Engineer. In erecting the sign posts, the materials, methods, and installation procedures shown on the Plans shall be followed, unless otherwise directed by the Engineer.

When a post is set in a concrete footing, the post shall be placed in position and plumbed and braced before the footing is constructed. The type of footing, materials used, and method of construction shall be as shown on the Plans. Care shall be taken during construction of the footing to preserve the setting of the post. When aluminum posts are used, the area to be in contact with concrete shall be treated with one coat of an approved sealer paint. The sealer shall be allowed to dry thoroughly before installing the post.

When a breakaway-type galvanized steel post on a concrete footing is to be used, the post stub section, with or without the upper post section attached, shall be set carefully in the foundation hole and held in place by an approved form or template before the concrete for the footing is placed. The stub post sections shall be so positioned that the projection above finished grade is as shown on the Plans. The shear plates shall be so

positioned that when the upper post section is attached, using shims as required, the upper post section shall be vertical and properly oriented with the roadway. The upper post section shall be attached to the stub post section by bolts using procedures as shown on the Plans. With all supporting form work removed from the posts, the bolts shall be tightened as shown on the Plans. Springing or raking of posts to secure proper alignment will not be permitted.

The forms and templates supporting the posts shall not be removed, and a sign shall not be mounted on the posts, until the concrete has cured.

Sign posts shall be installed so that the sign face is oriented as shown on the Plans.

When two or more posts are used to support a single sign, the flanges to which the sign will be fastened shall be in the same plane and the tops of the posts shall be at the same elevation.

When a post does not require a concrete footing, it may either be driven or placed in a hole carefully dug to the depth shown on the Plans. The post shall be plumbed and set so that the sign will face in the proper direction. The hole shall be backfilled with suitable material approved by the Engineer. The backfill shall be placed in layers of not more than 150 mm (6 inches) and thoroughly compacted by the use of an air or mechanical tamper. Care shall be taken in placing and tamping the backfill to preserve the setting of the post.

675.12 MOUNTING OF SIGNS. After the post or posts required for a sign have been erected, the sign shall be mounted as shown on the Plans. A sign shall be mounted tightly to the post or posts, or to the horizontal supporting members if shown on the Plans.

Horizontal and vertical supporting members required to hold together the separate 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 and shall conform to the designs shown on 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.

675.13 REMOVING SIGNS. The Contractor shall remove and salvage signs, posts, and overhead supports and remove foundations and posts, if any, as shown on the Plans or indicated in the Contract. All salvaged signs shall be carefully separated from the posts and/or frames on which they are mounted.

Unless otherwise specified, the signs, supports, mounting frames, and posts shall remain the property of the Agency and shall be carefully removed, separated, transported, and stockpiled at locations specified or as ordered by the Engineer. All salvaged mounting hardware shall be placed in separate covered pails and labeled as to contents with a permanent label.

Foundations shall be removed to a depth of at least 300 mm (12 inches) below the ground surface and the unsuitable material disposed of as directed by the Engineer. The resulting holes and post holes from which posts are removed shall be backfilled

with suitable material and the area restored to a condition similar to that of the adjacent area.

675.14 ERECTING SALVAGED SIGNS. The specified salvaged signs shall be transported from their stockpiled location and erected on posts at the locations shown on the Plans. The same care in handling, transporting, and erecting new signs shall be exercised for salvaged signs. Attaching devices shall be repositioned or new ones furnished as necessary. Any new material required shall be furnished by the Contractor. Material and erection requirements shall be in accordance with the applicable requirements of this Section.

After erection, the signs shall be washed to remove dirt, grease, and other foreign material to the satisfaction of the Engineer.

675.15 SETTING SALVAGED POSTS. When specified, salvaged sign posts of the type required shall be transported from the stockpiled location and erected on new foundations or placed in holes at the locations shown on the Plans.

The same care in transporting and erecting the new posts shall be exercised for salvaged posts.

The fastening devices, including bolts, nuts, and washers, shall be furnished as necessary for the erection of the posts.

Material and erection requirements shall be in accordance with the applicable requirements of this Section.

675.16 MODIFYING SIGN POSTS. The Contractor shall modify the existing sign posts as shown on the Plans. Posts shall be removed and re-erected where applicable.

675.17 METHOD OF MEASUREMENT. The quantity of traffic signs and sheet aluminum for overlay to be measured for payment will be the number of square meters (square yards) of the types specified, installed in the complete and accepted work.

The quantity of traffic sign posts to be measured for payment will be the number of kilograms (pounds) of each type of post installed in the complete and accepted work, as determined by the lengths and the standard mass per meter (weight per linear foot) of the specified material.

The quantity of foundations, setting salvaged posts, erecting salvaged signs, and modifying sign posts to be measured for payment will be the number of each installed in the complete and accepted work.

The quantity for removing signs to be measured for payment will be the number of signs removed in the complete and accepted work.

675.18 BASIS OF PAYMENT. The accepted quantities of the specified Contract items will be paid for at their respective Contract unit prices.

When shown on the Plans, the use of tee-bar auxiliary sign mounting will be considered incidental to the Contract item Traffic Signs.

The concrete, galvanized steel post stub section required for breakaway posts, reinforcing steel, or anchor bolts required for the various types of foundations will not be paid for separately but be considered incidental to the Contract unit price of the specified type of foundation.

Removal of sign posts and foundations will be considered incidental to the Contract item Removing Signs.

The cost of attachment hardware, including vandal proof hardware when required, will be considered included in the Contract 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.

Signs having an area of 2 $m^2$ (20 square feet) or less will be paid for as Type A signs without regard for any limitations placed on the choice of the basic panel material by the existence of a parent sign.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 675.20 Traffic Signs (Type A) | Square Meter (Square Foot) |
| 675.21 Traffic Signs (Type B) | Square Meter (Square Foot) |
| 675.25 Sheet Aluminum for Overlay | Square Meter (Square Foot) |
| 675.30 Flanged Channel Sign Posts | Kilogram (Pound) |
| 675.31 W-Shape Steel Sign Posts | Kilogram (Pound) |
| 675.32 Tubular Aluminum Sign Posts | Kilogram (Pound) |
| 675.33 Tubular Steel Sign Posts | Kilogram (Pound) |
| 675.40 Foundation for W-Shape Steel Posts, 450 mm (18 inch) Diameter | Each |
| 675.41 Foundation for W-Shape Steel Posts, 600 mm (24 inch) Diameter | Each |
| 675.42 Foundation for W-Shape Steel Posts, 750 mm (30 inch) Diameter | Each |
| 675.43 Foundation for Tubular Steel Posts | Each |
| 675.50 Removing Signs | Each |
| 675.60 Erecting Salvaged Signs | Each |
| 675.61 Setting Salvaged Posts | Each |
| 675.70 Modifying Sign 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:

| | |
|---|---|
| Delineator Posts | 751.01 |
| Acrylic Plastic Reflectors | 751.02 |
| Reflective Sheeting | 751.03 |
| Back Plates and Housings | 751.04 |
| Plaques | 751.05 |
| Assembly Hardware | 751.06 |

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 satisfactorily firm in the ground. 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. When salvaged delineator posts are required, the Engineer shall determine which posts may be reused.

Delineator assemblies and plaques, when required, shall be attached after the posts are set.

The replacement of reflector units on existing posts or guardrail 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 or reflector units to be measured for payment will be the number removed or installed in the complete and accepted work.

676.05 BASIS OF PAYMENT. The accepted quantity of delineators or reflector units will be paid for at the Contract unit price 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 |
|---|---|
| 676.10 Delineators with Steel Posts | Each |

| | | |
|---|---|---|
| 676.11 | Delineators with Salvaged Posts | Each |
| 676.12 | Removal of Existing Delineators | Each |
| 676.15 | Remove and Replace Reflector Units | Each |
| 676.20 | Delineators with Flexible Posts | Each |

## SECTION 677 - OVERHEAD TRAFFIC SIGN SUPPORTS

677.01 DESCRIPTION. The work shall consist of furnishing and installing overhead traffic sign supports, including the concrete footings.

677.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Mortar, Type IV | 707.03 |
| Caulking Compound | 707.13 |
| Bar Reinforcement | 713.01 |
| Anchor Bolts | 714.09 |
| Preformed Fabric Bearing Pad | 731.01 |
| Grounding Electrodes | 753.05 |

The sign support shall be 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).

Overhead traffic sign support structures, components, and hardware furnished under this Section shall be covered by a Type D Certification. All design details, quality of work, procedure, materials, etc., shall be in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

The concrete shall conform to the requirements of Section 501 for Concrete, Class B.

All welding shall be performed in accordance with the provisions of Subsection 506.10.

677.03 GENERAL. The overhead traffic sign supports shall be constructed in accordance with details shown on the Plans.

Prior to installation, the Contractor shall submit and receive approval of shop drawings in accordance with Subsection 105.03. A complete list of materials will accompany the shop drawings.

Concrete footings shall be backfilled by placing and compacting uniform layers of approved material not exceeding 150 mm (6 inches) in depth.

Where aluminum alloys come in contact with other materials, the contacting surfaces shall be separated with a fabric pad 3.2 mm (1/8 inch) in thickness or cleaned and thoroughly coated with an aluminum impregnated caulking compound.

The space between the top of the concrete footing and metal base of the support shall be filled with Type IV mortar.

677.04 GROUNDING. All posts used in overhead sign supports shall be grounded. The grounding shall be accomplished by means of a soft drawn, bare, copper wire with a cross-sectional area of 13.30 $mm^2$ (No. 6 AWG) run between the post or pole base and the grounding electrode(s). The grounding electrode conductor shall be attached to the grounding electrode by an exothermic welding process.

After erection of the structure, the Contractor shall demonstrate, by tests, that the resistance of the entire specified grounding system is not more than 25 Ω.

If lights are to be installed on the overhead sign supports, the lighting work shall be performed in accordance with the applicable requirements of Section 679.

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.

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 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 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 this 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.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 677.12 | Overhead Traffic Sign Support, Cantilever | Each |
| 677.13 | Overhead Traffic Sign Support, Multi-Support | Each |
| 677.22 | Overhead Traffic Sign Support, Cantilever with Lighting | Each |
| 677.23 | Overhead Traffic Sign Support, Multi-Support with Lighting | Each |

| | | |
|---|---|---|
| 677.25 | Remove and Reset Overhead Traffic Sign Support | Each |

## SECTION 678 - TRAFFIC CONTROL SIGNALS

678.01 DESCRIPTION. This work shall consist of furnishing and installing a traffic control system.

All electrical work performed under the Contract and all materials installed shall be subject to inspection and approval of the State or Municipal Electrical Inspector, whichever position is applicable. As a minimum, all work must meet the requirements of the National Electrical Code.

678.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

| | |
|---|---|
| Mortar, Type IV | 707.03 |
| Paint for Traffic Control Signals | 708.07 |
| Electrical Conduit Sleeve | 710.06 |
| Bar Reinforcement | 713.01 |
| Anchor Bolts | 714.09 |
| Preformed Fabric Bearing Pads | 731.01 |
| Pedestal Posts | 752.01 |
| Strain Poles | 752.02 |
| Traffic Signal Poles with Cantilever Arms or Bracket Arms | 752.03 |
| Span Wire | 752.04 |
| Traffic Signal Heads | 752.05 |
| Traffic Signal Controllers | 752.06 |
| Flashing Beacons | 752.07 |
| Electrical Conduit | 752.08 |
| Traffic Signal Conductor Cable | 752.09 |
| Detectors | 752.10 |
| Vehicle Detector Slot Sealant | 752.11 |
| Junction Box | 752.12 |
| Pedestrian Audio Signals | 752.13 |
| Grounding Electrodes | 753.05 |

All welding shall be performed in accordance with the provisions of Subsection 506.10.

Prior to ordering any traffic control components of the signal system, the Contractor shall submit and receive approval of shop drawings in accordance with Subsection 105.03. The submittal shall contain, as a minimum, the following information:

(a) Traffic Signal Controller. Type of controller, manufacturer, model, number of phases and functions, and assurance of conformance to NEMA standards. Bench testing (minimum of seven calendar days) will be required. Copies of the test results shall be submitted as discussed in Subsection 752.06. The test results shall

contain the begin and end time and date of the test, all controller and time-based coordinator settings used, equipment serial numbers, signature of the person performing the test, and signature of a witness who shall be either a registered electrical engineer or a licensed master electrician. The bench test report shall be approved by the Agency prior to the shipping of the controller(s).

(b) Traffic Signal and Pedestrian Heads. Size, manufacturer, model, lamp wattage, wiring, housing (material and color), visors, and back plates, if required. The signal heads shall conform to the requirements of ITE standards.

(c) Controller Cabinet. Size, manufacturer, model, accessories, materials, and finish.

(d) Auxiliary Equipment. Flasher(s), vehicle detector(s), conflict monitor, clock(s), pedestrian audio unit(s), manufacturer, model, functions, and assurance of conformance to NEMA standards, where applicable.

(e) Strain Poles, Cantilevers, and Pedestal Posts.

(1) Dimensions for pole/post height, span wire attachment height, pole/post diameter (top and bottom), pole gauge, handhole (size and location), baseplate, bolt circle, and anchor bolt size.

(2) Material specifications for each component.

(3) Welding information for all welded connections.

(4) Special features as shown on the Plans, such as finish or color.

(5) Pole/baseplate stamping detail.

In the above, all information supplied shall match or be equivalent to the details shown on the Plans. If equivalent, the Contractor may be asked to supply proof of equivalency. Copies of catalogue sheets are acceptable if all the appropriate information is included.

Submitted shop drawings shall indicate by either text in the transmittal letter or by text and signature on the shop drawings, that the Contractor has reviewed the shop drawings and that the shop drawings are in conformance with the Contractor's proposed installation procedures.

Strain pole styles other than that shown on the Plans will be permitted. The poles must be able to carry the design loads with a maximum dead load (span wire and signal head) deflection of 150 mm (6 inches). Bending stress ($f_b$) is limited to 66 percent of the minimum yield stress ($f_y$). All design details, quality of work, procedures, materials, etc., shall be in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Schedule 40 conduit shall be used underground, and Schedule 80 shall be used above ground.

Schedule 80 conduit shall be used under roadways or as a service riser.

Concrete shall conform to the requirements of Section 501 for Concrete, Class B.

Pull box frames and covers shall be steel plate and conform to the requirements of Subsection 714.02. Where the cover is exposed to vehicle or pedestrian traffic, it shall have an approved nonskid surface such as diamond plate. Frames and covers shall be galvanized in accordance with AASHTO M 111M/M 111. Pull boxes shall be designed and constructed to support at least an M-18 (H 20) loading.

678.03 EXCAVATION AND BACKFILL.

(a) General. Unless otherwise shown in the Contract Documents, the Contractor shall perform all excavation, 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 Documents or as directed by the Engineer.

In making excavations in paved surfaces, cuts shall be made with a concrete saw to a minimum depth of 50 mm (2 inches) along the neat lines of the area to be removed.

All landscaping and underground utility systems that have been disturbed by the construction shall be restored to their original condition at the Contractor's expense upon completion of the work.

(b) Excavation. Excavation shall be at the locations and to the dimensions shown on the Plans.

(c) Backfill. Backfill of suitable material shall be placed and compacted in layers not exceeding 150 mm (6 inches). The bottom of pull boxes shall be filled with granular materials approved by the Engineer to within 150 mm (6 inches) of the bottom of conduit.

678.04 ERECTION OF POSTS AND POLES. All posts and poles shall be erected on concrete bases at the locations shown on the Plans.

In the erection of posts and poles, leveling nuts shall be provided for installation between the bases and the concrete foundation to aid in plumbing.

The space between the top of the concrete footing and metal base of the support shall be filled with Type IV mortar.

Where aluminum alloys come in contact with other materials, the contacting surfaces shall be separated with a fabric pad 3.2 mm (1/8 inch) in thickness or cleaned and thoroughly coated with an aluminum impregnated caulking compound.

678.05 PLACING OF CONDUIT, PULL BOXES, AND JUNCTION BOXES. Unless otherwise specified, the conduit for the cable shall be placed not less than 600 mm (24 inches) below the top of curb in the sidewalk areas and not less than 1 m (36

inches) below the finished grade of pavement when passing under roadways. Conduit shall be pitched or graded at not less than 1:400 (vertical:horizontal) and provision shall be made for draining moisture away from pull boxes as directed by the Engineer.

Red plastic marking tape 150 mm (6 inches) wide shall be placed in the excavated trench 150 to 300 mm (6 to 12 inches) below the finished grade for all conduit and sleeve runs except those jacked under the roadway.

High density polyethylene (HDPE) plastic pipe conduit shall be used only for underground installations.

A minimum of 600 mm (24 inches) of cover shall be required over conduit at all times during construction.

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 or a concrete base.

All joints for PVC or HDPE conduit shall be made with a tapering tool and not an edging tool.

For metal conduit, all couplings shall be tightened until the ends of the conduit are together and provide a good electrical connection. 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.

Where factory conduit 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 and in a manner that will not crimp or flatten the conduit.

No more than three 90-degree bends or equivalent (270 degrees total) shall be used on a continuous conduit line. If more than 270 degrees in total bends are necessary, then a pull box or junction box shall be installed. 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.

One approved expansion fitting shall be used for each conduit run on a bridge structure at every expansion joint of the bridge. Expansion couplings shall also be used on the power service pole and all conduits entering or leaving the meter or disconnects on a power drop stanchion.

After the conduit lines are completed, the Contractor shall, in the presence of the Engineer, check the installation by pushing a one diameter long mandrel having a diameter of 5 mm (1/4 inch) less than the diameter of the conduit through the length of conduit. Any obstructions, including stone and dirt, shall be removed. Damaged conduit shall be removed and replaced at the Contractor’s expense. When conductor cable is not being placed in conduit under the Contract, a pull cord with a 2.2 kN (5 kip) minimum pull strength shall be installed in all conduits. 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.

Pull Boxes and Junction Boxes shall be placed at locations shown on the Plans or as directed by the Engineer.

678.06 INSTALLATION OF ELECTRICAL CONDUIT SLEEVES. Electrical Conduit Sleeves shall be installed at the locations shown on the Plans or as directed by the Engineer.

Unless otherwise specified, electrical conduit sleeves placed under roadways or drives shall have a minimum cover depth of 1 m (3 feet) measured from the finished roadway surface. Sleeves shall be pitched or graded at not less than 1:400 (vertical:horizontal) and provision shall be made for draining moisture away from the sleeve location or as directed by the Engineer.

Unless otherwise specified, the Contractor shall install electrical conduit sleeves in a straight line with no bends. The installed sleeve shall terminate a minimum of 1.2 m (4 feet) outside the face of curb or edge of shoulder of the roadway or drive that the sleeve crosses.

When conduit is not being placed in a sleeve, prior to backfilling around the sleeve, the Contractor shall install a suitable pull cord with a 2.2 kN (5 kip) minimum pull strength in the sleeve and seal the ends prior to backfilling the sleeve.

678.07 DETECTORS AND CONTROLLERS. Detectors and controllers shall be installed at the locations shown on the Plans and in accordance with directions furnished by the manufacturer. The type of mounting of the controller cabinet shall be as shown on the Plans. Controller cabinets shall be provided with locks as shown on the Plans. Two keys shall be furnished with each lock. All pedestrian activated push buttons shall have an advisory sign attached as shown on the Plans.

When time switches for the control of dial transfer, offset and/or flashing operation are to be installed, they shall be protected against jarring and heavy vibrations, and shall not be mounted on the cabinet door.

When applying vehicle detector slot sealant to the slot, it shall be by a pressurized system such as a manual or mechanical caulking gun. The loop wires shall be held in place during sealing by nonmetallic strips or tabs approximately 50 mm (2 inches) long located about every 600 mm (24 inches) along the slot.

678.08 ELECTRIC POWER SERVICE. Prior to submitting a proposal, the Contractor shall obtain from the utility company, the location of the power source; the amount of power to be supplied; an understanding of the termination of the power companies' services; and the requirements of the power company for connection of the electrical facilities to be constructed under the Contract.

The Contractor shall furnish and install a service riser at the power control center, a fully enclosed and watertight cabinet with a meter socket, appropriate sized and

number of disconnect equipment, and circuit breakers to meet load and/or equipment manufacturer's requirements. All State and local codes shall be adhered to.

Luminaires installed on strain poles shall utilize the same power source as the traffic signal but with a separate disconnect breaker near the meter.

678.09 WIRING. All wiring shall be done in accordance with the National Electrical Code. Splices shall be made only at pull boxes, junction boxes, or pole bases. All splices shall be electrically and mechanically secure and shall be insulated for 600 V. 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 by the application of dual wall heat-shrinkable tubing.

Unless otherwise shown on the Plans, a minimum of 1 m (3 feet) of slack shall be left in each cable 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 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 an installed conduit shall be 50 mm (2 inch) DN inside diameter conduit or shall match the size of the existing conduit to which it attaches, provided that 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 circuit(s) will not exceed 3 percent; shall be of sufficient inside diameter that the combined cross-sectional area of the wiring shall not exceed the percentage of conduit fill specified in the National Electrical Code; and shall, in accordance with the other requirements of this Subsection, contain the wires necessary to make the completed system or subsystem function.

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 circuit(s) will not exceed 3 percent and the wiring will contain only the number of conductors necessary to make the completed system or subsystem function.

The minimum wire sizes for circuits shall conform to the following requirements:

| Service | Area in $mm^2$ | AWG |
|---|---|---|
| From supply to Main Switch | 13.30 | No. 6 |
| Ground | 13.30 | No. 6 |
| Main Switch to Controller or Flasher | 8.37 | No. 8 |
| Controller to Signals or Beacons | 3.31 | No. 12 |
| Controller to Pavement Units | 2.08 | No. 14 |
| Controller to Push Buttons | 2.08 | No. 14 |
| Interconnect Figure "8" | | |
| [1 km (1/2 mile) or less] | 2.08 (solid) | No. 14 (solid) |
| [1 to 2 km (1/2 to 1 mile)] | 3.31 (solid) | No. 12 (solid) |

Not more than one power cable will be permitted in a conduit, unless otherwise shown on the Plans. Other signal cable may have more than one cable in a conduit.

There shall be a neutral wire for every eight or fewer ungrounded conductors.

Plastic cable rings shall not be permitted for supporting electrical cable from a span wire.

Stranded wire shall be used for all unsupported and span wire supported wiring.

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 fire and railroad preemption cables.

The Contractor shall wire the system in accordance with the following color-coding system:

| Wire Color | Application |
|---|---|
| Red | Red, Main Street |
| Orange | Yellow, Main Street |
| Green* | Green, Main Street |
| Red with tracer | Red, Side Street |
| Orange with tracer | Yellow, Side Street |
| Green with tracer* | Green, Side Street |
| White | Common ground for all signals and exposed metal parts |
| Blue | All Steady Burning Arrows |
| Blue with tracer | Intermittent Arrows |
| Remaining | Pavement units, push buttons, and spare |

* Green wires shall be tagged "NOT GROUNDED WIRES"

678.10 GROUNDING AND TESTING. Each metal pedestal post, strain pole and signal pole, and the common grounding electrode connector of the signal system shall be grounded to the power source and shall also be effectively grounded by connection to a grounding electrode driven at each post or pole location. The grounding shall be accomplished by means of a soft drawn, bare, copper wire with a cross-sectional area of 13.30 $mm^2$ (No. 6 AWG) run between the post or pole base and the grounding

electrode or electrodes. The grounding electrode conductor shall be attached to the grounding electrode by an exothermic welding process.

The "white wire" shall be used for the neutral ground connections and it shall be continuously connected to ground.

All exposed metal parts, including service pipe and control box housing shall be connected to ground. On all controllers employing the solid common ground, there shall be installed a visible jumper between the service neutral and the signal common ground.

Upon completion of each signal or beacon system, the Contractor shall demonstrate by tests that all circuits are continuous and free from short circuits; that all circuits are free from unspecified grounds; that the resistance to ground of non-grounded conductors is at least 100 MΩ for new construction or 5 MΩ for existing wiring at 16 °C (60 °F) when the test is conducted using 500 V DC. The resistances in the entire specified grounding systems shall be not more than 25 Ω

If luminaires are to be installed on strain poles, the lighting work shall be performed in accordance with the applicable requirements of Section 679.

All new traffic and pedestrian signal heads that have been installed but not placed in either flashing or full operation shall be covered. Existing signal heads which are placed out of service in order to perform work on the signal system shall also be covered, except when such work can be completed in a relatively short period of time (several hours) and traffic control has been provided for.

The signal covers shall consist of a one-piece plastic bag having a minimum thickness of 100 μm (4 mils). The bag shall be black or dark brown in color and shall be opaque. The cover shall slip over the entire signal head and shall be securely tied at the opening to secure the cover. An intermediate tie of the same material shall be drawn around the center of the cover to prevent excess flapping in the wind.

A drain hole shall be made at the bottom of the bag to allow the escape of moisture. No tape or adhesive will be allowed to be attached to any surface of the signal housing or lenses. All covers shall be placed in a neat professional manner. Any cover that is torn or missing shall be immediately replaced. Payment for the covers, their placement and removal, and all incidentals for completion of the work will be considered incidental to the installation of the traffic signal.

678.11 INSTALLATION AND COMPLETION. The signals and equipment shall be properly installed, and operating sequences set as shown on the Plans by a competent factory-trained representative of the manufacturer or by workers under the manufacturer's supervision.

All span wire mounted signals shall have disconnect hangers. All fixed mounted signals shall have terminal components.

Traffic signals installed at locations that were previously unsignalized shall be operated in the flash mode for a minimum of 48 hours prior to being put into full operation. Full operation for new installations or switch over for replacement signals shall not be initiated except in the presence of the Traffic Design Engineer or a designated representative.

The traffic signals shall not operate without the pavement markings and signal related signing in place.

All work shall conform to the requirements of the National Electrical Code.

After the signal or beacon system has been completely installed, any fixtures with damaged factory applied paint shall be corrected by applying one coat of enamel meeting the requirements of VT 6.01 (Flat Black Enamel) or VT 6.02 (Yellow Enamel) applied to the complete sectional area that is damaged after being lightly sanded to remove gloss. The visors (hoods) and the entire surface of louvers, fins, and the front surface of back plates shall have a dull black finish.

The Contractor shall submit in duplicate to the Engineer the wiring diagrams, cam chart (if applicable), signal sequence chart, signal terminal connection diagram, service manual, programming manual (if applicable), and parts list for each signal controller. The foregoing and manufacturer's warranties and guarantees furnished for materials used in the work shall be delivered to the Engineer prior to acceptance of the project. The warranties shall be the manufacturer's customary trade warranties.

There will be a minimum 30-day test control period to adjust and establish timing sequences for the installation. If, during the last 14 days of the control period, the system does not operate correctly, the test period will be extended until the system operates correctly for 14 calendar days.

The Contractor shall correct all deficiencies found in the traffic control signal system as a result of the test control period, and shall repair or replace defective equipment at no additional cost to the Agency. The traffic control system shall not be accepted until successful completion of the test control period.

The Contractor shall make every reasonable effort to have the installation complete and operating, including the test control period, prior to the date specified in the Contract. However, if all other work for the project has been completed, any portion of the test control period which extends beyond the completion date will not be considered time charged for liquidated damages.

For new traffic signals or flashing beacons, the Contractor shall be responsible for all utility costs until acceptance of the signal or beacon system. For upgrading of existing signals or beacons, the State or Municipality, whichever is applicable, shall continue to pay for normal monthly power usage while the Contractor shall be responsible for all other utility costs.

When shown on the Plans to install a telephone line (Centrex) in a traffic signal controller cabinet as a part of the project, the Contractor shall initiate the installation by the telephone company by contacting the Agency's Business Manager for

Administration at (802) 828-3589. The billing for the telephone service will be set up in the name of the Agency's Maintenance District within which the traffic signal controller is located. The Contractor shall reimburse the District for all costs incurred for the installation and for the monthly fees until acceptance of the traffic signal installation. The Contractor shall reimburse the District within 14 days of receiving a copy of the bill. The Final Estimate will not be paid until the District Transportation Administrator certifies that all reimbursements have been received.

The required 30-day test control period for the signal installation shall not begin until all construction of the signal installation is complete and the Engineer has received notice from the responsible Agency parties that all paperwork, including shop drawings, materials certifications, bench test reports, etc., related to the signal equipment and installation have been completed to the satisfaction of the responsible parties. Upon completion of the test period and acceptance of the project by the Engineer, the traffic signal installation shall become the property and responsibility of either the State of Vermont or the local municipality, and the Engineer shall notify the responsible party immediately.

For projects where several signal systems are coordinated, all the individual signal systems must have successfully completed the 30-day test control period before the signal systems can be accepted.

The Contractor shall notify the Engineer and/or the town or city engineer at least 48 hours prior to turning off existing traffic control signals at any location, or when the Contractor is ready to install the traffic control signal system. Notice is required so that a representative may be provided to observe the installation of the equipment in preparation for maintenance and repair of the system and to have a uniformed traffic officer present to maintain traffic.

Removal of existing or reuse of salvaged equipment:

(a) Unwanted equipment must be disposed of by the Contractor. Removal of equipment shall include removal of concrete bases and backfill of the holes, where applicable. Any equipment that is damaged or lost by the Contractor during removal shall be repaired or replaced to the satisfaction of the Agency, at the Contractor's expense.

(b) All salvaged and reused equipment shall be thoroughly cleaned and painted as required, before reuse.

(c) All reused traffic signal, flashing beacon, or street lighting lenses and reflectors shall be cleaned and all lamps shall be replaced using lamps conforming to the applicable requirements in Subsection 752.05.

678.12 TEMPORARY TRAFFIC CONTROL SIGNALS AND FLASHING BEACONS.

(a) General. Temporary traffic control signals and temporary flashing beacons shall be installed by the Contractor at the locations shown on the Plans or directed by

the Engineer. The provisions of Subsection 678.03 shall apply to temporary signal and temporary beacon installations.

The temporary traffic control signal system or temporary flashing beacon 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, controllers, flashers, wiring, conduit, strain poles, associated signs, sign posts, pavement markings, electrical service, vehicle detectors, span wires, interconnect cables, signal heads, warning beacons, and lights. In the case of temporary signals at a temporary bridge location, the signal system shall include all the signals and associated signage to be installed at all approaches to the temporary bridge.

(b) Materials. The traffic signal, flashing beacon, and lighting equipment provided shall conform to the requirements of the MUTCD and NEMA, but are not required to be new. Shop drawings and certification will not be required for the temporary signal, flashing beacon, and lighting materials and equipment.

Materials shall conform to the applicable requirements of Sections 678 and 679.

All associated signing shall conform to the MUTCD and Section 675 except that the materials are not required to be new.

Pavement marking shall conform to the MUTCD and Section 646.

(c) Installation. The components of the temporary traffic signal and flashing beacon systems shall be installed in accordance with the applicable requirements of Sections 646, 675, 677, 678, and 679, with the following changes:

Concrete bases will not be required for temporary traffic signal installations.

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 State.

During installation of the temporary traffic signal system or flashing beacons for advanced warning signs, no conduit shall be placed under the existing roadway.

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 be considered completion of the item.

The Contractor shall be responsible for all permits and costs associated with providing electrical power for the traffic signal and warning beacon operation.

The Contractor shall notify the Engineer and/or the town or city officials at least 48 hours prior to turning off the existing traffic control signals, and/or installing temporary signals.

Pavement marking shall meet the requirements for temporary pavement markings, unless otherwise shown on the Plans.

(d) Detectors. Unless 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. In the event that the furnished detector either does not function properly or does not perform the required actuation in the Engineer's opinion, the Contractor shall replace the detector within 24 hours of receiving notice to do so from the Engineer. The costs of replacement shall be solely at the Contractor's expense.

Unless otherwise shown on the Plans, detectors designed to be installed in the roadway shall be cut and sealed in the pavement in the same manner as permanently installed detectors.

If temporary loop detectors are installed in a gravel roadway, they shall be placed in Schedule 80 PVC or HDPE conduit and buried at least 100 mm (4 inches) below the travel surface. Other detectors installed in gravel roadways shall be installed in accordance with the manufacturer's recommendations.

678.13 METHOD OF MEASUREMENT. The quantity of Traffic Control Signal System - Intersection to be measured for payment will be the number of each signals installed in the complete and accepted work.

The quantity of Vehicle Loop Detector to be measured for payment will be the number of meters (linear feet) of pavement cut and sealed, measured from the curb, containing the loop and lead-in wires, in the complete and accepted work.

The quantity of Pull Box, of the type specified, and Junction Box to be measured for payment will be the number of each box installed in the complete and accepted work.

The quantity of Flashing Beacon - Ground Mounted or Flashing Beacon - Aerial Mounted to be measured for payment will be the number of each beacon system installed in the complete and accepted work.

The quantity of Interconnecting Cable to be measured for payment will be the number of meters (linear feet) of the interconnected system installed in the complete and accepted work, as measured between controller units along the alignment shown on the Plans. No allowance will be made for sag between poles or for loops created in making connections.

The quantity of Electrical Conduit and Wired Conduit to be measured for payment will be the number of meters (linear feet) of the specified conduit installed as required by the system being constructed in the complete and accepted work. The measurement will include sweeps into, and out of, bases, pull boxes, and junction boxes.

The quantity of Electrical Conduit Sleeve to be measured for payment will be the number of meters (linear feet) of the specified sleeve installed in the complete and accepted work.

The quantity of Electrical Wiring to be measured for payment will be the number of meters (linear feet) of specified wiring installed in the complete and accepted work, as measured between connection points along the installed alignment. No allowance will be made for sags or loops for making connections, but including the wiring installed in sweeps into, and out of, bases, pull boxes, and junction boxes.

The quantity of Temporary Traffic Signal System, Temporary Detector, or Temporary Flashing Beacon to be measured for payment will be the number of each complete system installed in the complete and accepted work, maintained during construction, and then removed from the project when the Engineer determined it was no longer required.

678.14 BASIS OF PAYMENT. The accepted quantity of Traffic Control Signal System - Intersection will be paid for at the Contract unit price per each at each designated intersection. Payment will include strain poles, signal heads, controller and cabinet, wiring, except for the wiring included in the Contract items Wired Conduit and Electrical Wiring, and all other materials necessary for a fully operational traffic control signal system not otherwise paid for under other Contract items in this Section. The Contractor shall be responsible for all maintenance costs for new or existing signal(s) and beacons until project acceptance. This period shall include any winter shut downs during the Contract period. Replacement of poles and cabinet/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 cabinet/controllers that are lost or damaged due to an accident. 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.

The accepted quantity of Flashing Beacon - Ground Mounted will be paid for at the Contract unit price per each at each designated location. Payment will include beacon head(s), flasher and cabinet, wiring, except for wiring included in the Contract items Wired Conduit and Electrical Wiring, power source, and all other materials necessary for a fully operational flashing beacon not otherwise paid for under other Contract items in this Section. Sign post(s) and panel(s) will be paid under their own items.

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 not otherwise paid for under other Contract items in this Section. Sign post(s) and panel(s) will be paid under their own items.

The accepted quantities of Interconnect Cable, Electrical Conduit, and Vehicle Loop Detectors will be paid for at the Contract unit price per meter (linear foot). Payment for Electrical Conduit will include installed electrical conduit only.

The accepted quantities of Pull Box, of the type specified, and Junction Box will be paid for at the Contract unit price per each.

The accepted quantity of Wired Conduit will be paid for at the Contract unit price per meter (linear foot). Payment will include of both the installed conduit and the wiring inside the conduit.

The accepted quantity of Electrical Wiring will be paid for at the Contract unit price per meter (linear foot). Payment will include removing any existing wiring in an existing conduit, strain pole, streetlight pole, or bracket arm; installing new updated wiring including necessary connections; fusing in that existing enclosed location, and providing all the required number of conductors (including grounds, neutrals, and the designated number of spares). No adjustment of the Contract price will be made if a lesser or greater number of conductors becomes necessary to complete the work.

Unless specifically shown on the Plans, wired conduit and electrical wiring will not occur in the same location as electrical conduit. Furthermore, electrical wiring will only occur inside existing, previously installed, conduits, strain poles, streetlight poles, or bracket arms.

The accepted quantity of Electrical Conduit Sleeve will be paid for at the Contract unit price per meter (linear foot). The cost of excavation and backfill will not be included in the costs of the sleeve. When the sleeve is installed for use with one or more conduits, the costs of excavation and backfill will be considered included in the Contract unit price for the conduit(s) installed within the sleeve. When the sleeve is installed without conduit, the pay limits and the excavation and backfill will be paid in the same manner as detailed for culverts in Subsection 601.10.

Payment for the above Contract unit prices will be full compensation for furnishing, transporting, handling, and installing the materials and equipment specified, including excavation, backfill, concrete, hanger hardware for pole mounting of cable, pole identification, cutting and resealing the pavement, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Disconnecting existing loop or other detectors will be considered incidental to other Contract items.

Payment for Traffic Control Signal Systems - Intersection, Flashing Beacon - Ground Mounted, and Flashing Beacon - Aerial Mounted will be made as follows:

(a) When applicable, 10 percent of the Contract unit price will be paid for the installation of strain poles.

(b) Upon installation of a functioning system as indicated by a successful continuous 24-hour operation test period, an additional 10 percent of the Contract unit price will be paid. When the installation does not include strain poles, 20 percent of the Contract unit price will be paid upon successful completion of a continuous 24-hour operation test.

(c) Thirty percent of the Contract unit price will be paid upon receipt by the Engineer of notice from all responsible Agency parties that all paperwork related to the signal or beacon installation has been completed to the satisfaction of the Agency.

(d) The remainder, less 20 percent of the Contract unit price, will be paid after successful completion of the 30-day test control period.

(e) The final 20 percent of the Contract unit price will be paid upon acceptance of the project.

(f) The Contractor will not be paid more than 50 percent of the Contract unit price for the traffic signal or flashing beacon installation, whether directly or through stock pile or any other means until the Engineer has been notified that all signal related paperwork has been completed to the satisfaction of the Agency.

The accepted quantity of Temporary Traffic Signal System will be paid for at the Contract unit price per each. Payment will include the installation and removal of strain poles, signal heads, controller and cabinet, luminaires, signs, sign posts, flashing beacons, pavement markings, wiring, conduit, and all other materials necessary for a fully operational temporary traffic control system complete in place.

When a temporary flashing beacon system is installed on a project that also requires the installation of a temporary traffic signal, the temporary flashing beacon will not be paid for directly, but will be considered incidental to the Contract item Temporary Traffic Signal System.

The accepted quantity of Temporary Flashing Beacon will be paid for at the Contract unit price per each. Payment will include the installation and removal of poles, span wires, signs, sign posts, beacon heads, flasher units and cabinets, conduit, wiring, attachment hardware and all other materials necessary for a fully operational flashing beacon system complete in place.

The accepted quantity of Temporary Detector will be paid for at the Contract unit price per each. Payment will include the detector and all necessary installation hardware and materials. A detector consists of the "black box" container or the loop and leads within the paved area of the roadway (on unpaved highways, the graveled surface). Wiring from the controller to the detector, including connection to the detector is included in the Contract item Temporary Traffic Signal System.

Payment of the above Contract unit prices will be full compensation for furnishing, transporting, handling, and installing the materials and equipment specified, including excavation, backfill, hanger hardware for cable and signals, span wires, poles, cutting and resealing pavement, providing electrical service and power, and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work, to maintain the system while it is required, and then to completely remove it from the project and properly dispose of it when so directed by the Engineer.

All components, materials, and equipment furnished by the Contractor shall remain the property of the Contractor and shall be properly removed from the project and disposed of by the Contractor when the temporary system is removed. Existing components and materials that were utilized for the temporary system shall be disposed of as shown in the Contract Documents.

Payment for Temporary Traffic Signal System and Temporary Flashing Beacon will be made as follows:

(a) When the entire system has been installed at a site (including signing and pavement markings) and working for 24 hours to the satisfaction of the Engineer, 50 percent of the Contract unit price for each will be paid.

(b) When 60 percent of the working days between the date of installation and the original completion date have elapsed, an additional 30 percent of the Contract unit price for each will be paid.

(c) Upon complete removal of the system from the site and restoration of disturbed areas, the remaining 20 percent of the Contract unit price will be paid.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 678.15 Traffic Control Signal System - Intersection | Each |
| 678.16 Flashing Beacon - Ground Mounted | Each |
| 678.17 Flashing Beacon - Aerial Mounted | Each |
| 678.20 Interconnecting Cable | Meter (Linear Foot) |
| 678.21 Electrical Conduit | Meter (Linear Foot) |
| 678.22 Vehicle Loop Detector | Meter (Linear Foot) |
| 678.23 Wired Conduit | Meter (Linear Foot) |
| 678.24 Electrical Wiring | Meter (Linear Foot) |
| 678.25 Pull Box - Standard | Each |
| 678.26 Junction Box | Each |
| 678.27 Pull Box - Double | Each |
| 678.30 Electrical Conduit Sleeve | Meter (Linear Foot) |
| 678.40 Temporary Traffic Signal System | Each |
| 678.41 Temporary Flashing Beacon | Each |
| 678.42 Temporary Detector | Each |

## SECTION 679 - STREET LIGHTING

679.01 DESCRIPTION. This work shall consist of furnishing and installing a street lighting system.

All electrical work performed under the Contract and all materials installed shall be subject to inspection and approval of the State or Municipal Electrical Inspector, whichever is applicable. All work must meet the requirements of the National Electrical Code.

679.02 MATERIALS. Materials shall meet the requirements of the following Subsections:

Mortar, Type IV ..... 707.03
Bar Reinforcement ..... 713.01

All welding shall be performed in accordance with provisions of Subsection 506.10. Unless otherwise specified, AWS ER 4043 electrode wire shall be used with Alloy 6063-T6, and AWS ER 5356 electrode wire shall be used with Alloys 6005-T5 and 6061-T6 when welding aluminum.

Concrete shall conform to the requirements of Section 501 for Concrete, Class B.

Prior to ordering the items, the Contractor shall submit to the Engineer for approval shop drawings for street lighting poles and luminaires. The submittal shall contain at a minimum the following information:

(a) Luminaires.

(1) Fixture.

a. Voltage rating.

b. Wattage and lamp type.

c. Ballast type.

d. Photo cell.

e. Any other features shown on the Plans, such as finish, special wire access, etc.

(2) Photometric Data.

a. IES Distribution type.

b. Utilization curve.

c. Iso-lux curves.

d. Mounting height factor.

e. Maintenance factor.

(b) Poles.

(1) Dimensions for pole height, mounting height, pole diameter (top and bottom), arm length and diameter(s), handhole (size and location), baseplate, bolt circle, and anchor bolt size.

(2) Material specifications for each component.

(3) Anchor bolts, nuts, and washers. (See Subsection 714.09.)

(4) If frangible bases are shown on Plans, the submittal shall include type (transformer base, breakaway coupling, or other approved type) and literature to indicate that the base meets the AASHTO standards.

(5) Types of connections and welding information for pole to baseplate, pole to arm and arm components if a truss arm is used. (See Subsection 506.10.)

(6) The welding process and procedures and the materials used to make the two continuous circumferential welds, one attaching the top of the shoe base (anchor base) to the pole shaft and the other attaching the bottom of the pole shaft to the inside of the shoe base.

(7) Special features as shown on the Plans, such as finish or color.

(c) Wiring. Conductor material, insulation type, voltage rating and temperature rating, shall conform to the National Electrical Code for use and size and shall be color-coded.

(d) Welding Information. For all welded connections in all of the above, the information supplied shall match or be equivalent to the details shown on the Plans. If equivalent, the Contractor may be asked to supply proof of equivalency. Copies of catalogue sheets are acceptable if all the appropriate information is included.

All design details, quality of work, procedure, material, etc. shall conform to AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, Section 5-Aluminum Design.

Pull box frames and covers shall be of steel plate and conform to the requirements of Subsection 714.02. Where the cover is exposed to vehicle or pedestrian traffic, it shall have an approved nonskid surface such as diamond plate. Frames and covers shall be galvanized in accordance with AASHTO M 111M/M 111. Pull boxes shall be constructed to support an M-18 (H 20) loading.

679.03 EXCAVATION AND BACKFILL.

(a) General. Unless otherwise shown in the Contract Documents, the Contractor shall perform all excavation, 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 Documents or as directed by the Engineer.

In making excavations in paved surfaces, cuts shall be made with a concrete saw to a minimum depth of 50 mm (2 inches) along the neat lines of the area to be removed.

All landscaping and underground utility systems that have been disturbed by the construction shall be restored to their original condition upon completion of the work, at the Contractor's expense.

(b) Excavation. Excavation shall be at the locations and to the dimensions shown on the Plans.

(c) Backfill. Backfill of suitable material shall be placed and compacted in layers not exceeding 150 mm (6 inches). The bottom of pull boxes shall be filled with granular materials approved by the Engineer, to within 150 mm (6 inches) of the bottom of conduit.

679.04 PLACING OF CONDUIT, PULL BOXES, AND JUNCTION BOXES. Unless otherwise specified, the conduit for the cable shall be placed not less than 600 mm (24 inches) below the top of curb in the sidewalk areas and not less than 1 m (3 feet) below the finished grade of pavement when passing under roadways. Conduit shall be pitched or graded at not less than 1:400 (vertical:horizontal) and provision shall be made for draining moisture away from pull boxes as directed by the Engineer.

Red plastic marking tape of 150 mm (6 inch) width shall be placed in the excavated trench 150 to 300 mm (6 to 12 inches) below the finished grade for all conduit and sleeve runs except those jacked under the roadway.

HDPE conduit shall be used for underground installations only.

A minimum of 600 mm (24 inches) of cover shall be required over conduit at all times during construction.

Unless otherwise specified, the conduit shall be laid in a straight line with no bends except preformed bends or bends at the entrance to a pull box or a concrete base.

All joints for PVC or HDPE conduit shall be made with a tapering tool and not an edging tool.

For metal conduit, all couplings shall be tightened until the ends of the conduit are together and provide a good electrical connection. 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.

Where factory conduit 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 and in a manner that will not crimp or flatten the conduit.

No more than three 90-degree bends or equivalent (270 degrees total) shall be used on a continuous conduit line. If more than 270 degrees in total bends are necessary, then a pull box or junction box shall be installed. 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.

One approved expansion fitting shall be used for each conduit run on a bridge structure at every expansion joint of the bridge. Expansion couplings shall also be used on the power service pole and all conduits entering or leaving the meter or disconnects on a power drop stanchion.

After the conduit lines are completed, the Contractor shall, in the presence of the Engineer, check the installation by pushing a one-diameter long mandrel having a diameter of 5 mm (1/4 inch) less than the diameter of the conduit through the length of conduit. Any obstructions, including stone and dirt, shall be removed. Damaged conduit shall be removed and replaced at the Contractor's expense. When conductor cable is not being placed in conduit under the Contract, a pull cord with a 2.2 kN (5 kip) minimum pull strength shall be installed in all conduits. 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.

Pull boxes and junction boxes shall be placed at locations shown on the Plans or as directed by the Engineer.

679.05 ERECTION OF LIGHT STANDARDS. The light standards shall be erected on concrete bases at locations shown on the Plans.

If a pole that does not have a breakaway feature needs leveling or plumbing when being erected, metal shims shall not be used. Leveling or plumbing shall be accomplished by the use of leveling nuts installed on the anchor bolts between the pole base and the concrete foundation.

If a pole that has a transformer base needs leveling or plumbing when being erected, metal shims shall be used between the transformer base and the concrete foundation. Leveling nuts shall not be installed on the anchor bolts.

The space between the top of the concrete footing and metal base of the support shall be filled with Type IV mortar.

The length of bracket arms and mounting height shall be as shown on the Plans. The bracket arm shall be mounted perpendicular to the centerline of roadway, unless otherwise specified.

Where aluminum alloys come in contact with other materials, the contacting surfaces shall be separated with a fabric pad 3.2 mm (1/8 inch) in thickness or cleaned and thoroughly coated with an aluminum impregnated caulking compound.

Luminaires shall be installed simultaneously with the erection of light standards when aluminum or steel poles are used. Failure to do so may result in damage to the pole due to vibrations that can occur.

Where street lighting is to be installed on existing wood poles, the bracket arms shall be equipped with devices suitable for attachment to wood poles.

679.06 ELECTRIC POWER SERVICE. It shall be the responsibility of the Contractor, prior to submitting a proposal, to have obtained from the utility company, the location of the power source; the amount of power to be supplied; an understanding of the termination of the power companies' services; and the requirements of the company for connection of the electrical facilities to be constructed under the Contract.

The Contractor shall furnish and install a service riser at the power control center; a totally enclosed and watertight cabinet with a meter socket; appropriate sized and number of disconnect equipment and circuit breakers to meet load and/or equipment manufacturers requirements. All State and local codes shall be adhered to.

679.07 WIRING. All wiring shall be done in accordance with the National Electrical Code. Splices shall be made only at pull boxes, junction boxes or pole bases. All splices shall be electrically and mechanically secure and shall be insulated for 600 V. The completed splice shall be watertight and shall test electrically equal to or greater than the cable.

Unless otherwise shown on the Plans, a multiple system of distribution shall be used and the wire sizes shall be such that the voltage drop in the secondary circuit(s) does not exceed 3 percent. Fuses in each light pole base shall be rated three times the maximum current for high intensity discharge ballasts.

Wire connections in the base of each light pole shall be made with a watertight wye or in-line plug-in type connector of a type that will disconnect upon impact to eliminate the shock hazard in a "knock-down" situation and eliminate damage to the rest of the underground wiring. There shall also be enough slack cable to permit working on the wye-connector outside the pole hand hole.

679.08 GROUNDING AND TESTING. Each metal light standard and the continuous grounded conductor of the distribution circuit shall be effectively grounded at the power source and at each metal light standard with a soft drawn, bare, copper wire with a cross-sectional area of 13.30 $mm^2$ (No. 6 AWG) run between light standard, power source and grounding electrode(s) at each concrete base location. The grounding electrode conductor shall be attached to the grounding electrode by an exothermic welding process. The neutral wire shall be grounded at the power source. On bridges, the light standards and conduits, if metallic, shall be electrically connected in an approved manner. For bridges that are less than 150 m (500 feet) in length, one end of the conduit, if metallic, shall be connected to a ground electrode and for bridges that are greater than 150 m (500 feet) in length, the conduit shall be grounded in the same manner at both ends.

Upon completion of the system, the Contractor shall demonstrate by tests that all circuits are continuous and free from short circuits; that all circuits are free from unspecified grounds; that the resistance to ground of non-grounded conductors is at least 100 MΩ for new construction or 5 MΩ for existing wiring at 16 °C (60 °F) when the test is conducted using 500 V DC. The resistances in the entire specified grounding systems shall be not more than 25 Ω.

Voltage readings shall be made at each circuit breaker and distribution transformer with load and without load, and on each side of each circuit breaker and at the end of each circuit with load. Except for no load readings, nighttime and daytime readings shall be taken with the lighting system in normal operation.

Current readings shall be made on the load side of each circuit breaker phase and neutral. Readings shall be made at nighttime and daytime with the lighting system in normal operation.

The lamps shall not be removed or inserted when the power is on.

679.09 ACCEPTANCE. The lighting system shall be completely operable and energized at least 30 days prior to the acceptance of the project and shall be operated each night at the Contractor's expense. The Contractor shall replace all defective parts of the system prior to acceptance of the project. The Contractor shall adjust the luminaire photoelectric switch, if required, so that operation is satisfactory to the Engineer prior to acceptance.

The Contractor shall be responsible for all power costs through project acceptance or the end of the test period, whichever is later.

679.10 METHOD OF MEASUREMENT. The quantity of Direct Burial Cable for Street Lighting to be measured for payment will be the number of meters (linear feet) of cable installed in the complete and accepted work, as measured from pole base to pole base.

The quantity of Light Pole Base to be measured for payment will be the number of each base installed in the complete and accepted work.

The quantity of Removing and Resetting Light Pole to be measured for payment will be the number of each light pole completely reset on a new or existing concrete base in the complete and accepted work.

The quantity of Extend Light Pole Base to be measured for payment will be the number of each light pole base extended in the complete and accepted work.

The quantity of Breakaway Feature for Light Pole to be measured for payment will be the number of each breakaway feature (approved transformer base, breakaway coupling, etc.) installed in the complete and accepted work.

The quantity of Light Pole to be measured for payment will be the number of each light pole, with pole tag and internal wiring, installed on existing concrete base in the complete and accepted work.

The quantity of Bracket Arm to be measured for payment will be the number of each, with internal wiring, installed in the complete and accepted work.

The quantity of Luminaire to be measured for payment will be the number of each, with photocell, connected both mechanically and electrically in the complete and accepted work.

679.11 BASIS OF PAYMENT. Street Lighting item prices shall be full compensation for furnishing, transporting, handling and placing the materials specified. Connections to power source, circuit testing, and the furnishing of all labor, tools, equipment and incidentals necessary to complete the work will be incidental to other items.

The accepted quantity of Direct Burial Cable for Street Lighting will be paid for at the Contract unit price per meter (linear foot).

The accepted quantities of Light Pole Base, Removing and Resetting Light Pole, Extend Light Pole Base, Light Pole, Breakaway Feature for Light Pole, Luminaire, and Bracket Arm will be paid for at the Contract unit price for each.

Payment will be full compensation for furnishing, transporting, handling, and installing the materials and equipment specified. This includes, but is not limited to, excavation, backfill, concrete, cover plate and frame, anchor bolts, mast, bracket or mast arms, poles, bases, luminaires, ballasts, lamps, transformer enclosures, breakaway devices, wiring, pole identification, necessary fusing, connections to power sources, circuit testing, circuit breakers, photoelectric cells, grounding, hardware and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

For new construction, fusing in the light pole base, wiring within the pole and base, including within breakaway features, and pole identification are part of the costs included in the Contract item Light Pole. Wiring and fusing within bracket arms are part of the costs included in the Contract item Bracket Arm. Ballasts, lamps, and photoelectric devices are part of the costs included in the Contract item Luminaire.

For rehabilitation work, wiring and fusing within poles, bases, and bracket arms will paid for under the Contract item Electrical Wiring.

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 will be paid for under the applicable Contract items of Section 678.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| 679.16 Direct Burial Cable for Street Lighting | Meter (Linear Foot) |
| 679.21 Light Pole Base | Each |
| 679.22 Extend Light Pole Base | Each |

| | | |
|---|---|---|
| 679.23 | Breakaway Feature for Light Pole | Each |
| 679.25 | Removing and Resetting Light Pole | Each |
| 679.45 | Light Pole | Each |
| 679.47 | Bracket Arm | Each |
| 679.50 | Luminaire | 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:

| | |
|---|---|
| Paint for Traffic Signs | 708.11 |
| Structural Timber and Lumber | 709.01 |
| Lumber | 709.02 |
| Timber Preservative | 726.01 |
| Signs Posts | 750.01 |
| Acrylic Overlaid Plywood | 750.07 |
| Reflective Sheeting | 750.09 |
| Plastic Lettering Film | 750.11 |
| Assembly Hardware for Signs | 750.13 |

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 FED-STD-595B.

| Color | Chip Number |
|---|---|
| Black | Chip No. 17038 |
| White | Chip No. 17875 |
| Magenta | Chip No. 11158 |
| Brown | Chip No. 10100 |
| Orange | Chip No. 12501 |
| Gray | Chip No. 16373 |

The color of reflective material shall be Silver-White #2.

Concrete shall conform to the requirements of Section 501 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. Unless otherwise shown on the Plans, aluminum posts shall be used. Posts shall be set to the depth shown on the Plans.

When wooden posts are specified, travel information signs shall be mounted on two 100 by 100 mm (4 × 4 inch) nominal wooden posts, S4S. The posts shall be set plumb and true in holes excavated to a minimum depth of 1 m (3 feet). That portion of the post to be in contact with or within 225 mm (9 inches) of the ground shall be treated with an approved preservative.

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. The base material for all signs shall be 16 mm (2/3 inch) nominal thickness acrylic overlaid plywood.

All lettering, mileage numerals, and directional arrows shall be formed from reflective 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 reflective sheeting or by applying reflective symbols on acrylic material of the appropriate color. All other travel information symbols and background 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, will be applied to certain signs as shown on the Plans.

680.06 INFORMATION PLAZAS. Type A (Wooden Mansard Style) 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 and shall be erected as shown on the Plans.

The area in which the information plaza is erected shall be reasonably level and unobstructed in order to provide for easy circulation by pedestrians. In areas subject to vehicular traffic, a 2.5 m (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 300 mm (12 inches) of pea stone.

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 considered to be included in the relocation item.

An information plaza that is damaged during its removal and resetting shall be repaired or components replaced by the Contractor.

Information plaza lighting and electrical circuitry shall be as shown on the Plans. The plazas shall be lighted during the hours of darkness under the control of a suitably designed photoelectric device. All electrical materials and installation methods shall conform to the provisions of the National Electrical Safety Code and all electrical work shall be in accordance with State and local regulations.

680.07 SIGN MAINTENANCE. Sign maintenance shall consist of regular inspection of, and minor maintenance work on those travel information signs in place at the locations specified. The work shall include plugging holes, patching plugs and scratches with acrylic material of the appropriate color, repairing or replacing damaged or peeling letters and symbols, and tightening loose hardware. The condition of each sign shall be checked at least three times annually, during the months of April, June, and September.

680.08 WINTER MAINTENANCE FOR INFORMATION PLAZAS. Winter maintenance shall include both scheduled and unscheduled removal of snow and ice from the area of the plaza or plazas specified in the Contract. The area of the plaza may vary depending on the site, but will generally include a strip 2.5 m (8 feet) wide on each side of the structure and a path 2.0 m (6.5 feet) wide from the nearest publicly maintained road, street, or parking area. When applicable, the area to be maintained will also include parking space for four automobiles.

The areas specified shall be visited and cleaned of accumulated snow and ice at least every two weeks. In addition, the area shall be cleaned of accumulated snow and ice within four hours of the cessation of any storm in which 50 mm (2 inches) or more of snow accumulates.

680.09 MAGNETIC PLAZA INFORMATION PLAQUES. When indicated in the Contract, the Contractor shall furnish magnetic plaques of the sizes and types indicated on the order form, complete with the legend provided on the order form.

Type A plaques will have space reserved for the application of a commercial logo to be furnished by others. The plaques shall be installed by others.

The graphics will be white on a square panel of magnetic vinyl in the color specified. Graphics will be of the nominal sizes indicated below:

| Plaque Size | Heading | Text | Type A Logo |
|---|---|---|---|
| 150 mm square (6 inches square) | 48 point | 18 point | 38 mm square (1 1/2 inches square) |

680.10 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 will be installed by others.

680.11 METHOD OF MEASUREMENT. The quantity of Travel Information Signs and Business Information Signs to be measured for payment will be the number of square meters (square feet) of signs installed in the complete and accepted work.

The quantity of Travel Information Plaza, Type A or Relocate Information Plaza, Type A to be measured for payment will be the number of each plaza installed or relocated in the complete and accepted work.

The quantity of Travel Information Sign Maintenance or Winter Maintenance for Information Plazas to be measured for payment will be on a lump sum basis for the specified maintenance provided in the complete and accepted work.

The quantity of Magnetic Information Plaque, of the type specified, Travel Information Symbol, or 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.

680.12 BASIS OF PAYMENT. The accepted quantity of Travel Information Signs will be paid for at the Contract unit price per square meter (square foot). Payment will include furnishing the sign complete with letter and symbol text and installing the sign as part of a unit at the location specified.

Metal sign posts for travel information signs will be paid for at the Contract unit price for the appropriate Contract item for sign posts under Section 675. Wooden sign posts will not be paid for directly but will be considered incidental to the Contract item Travel Information Signs.

The accepted quantity of Travel Information Plaza, Type A will be paid for at the Contract unit price per each. Payment will include preparation and grading of the area, furnishing and installing protective curb where required, and furnishing and installing of the information plaza complete with electrical service.

The accepted quantity of Relocate Information Plaza, Type A will be paid for at the Contract unit price per each. Payment will include disassembly of the plaza, disposal of the original posts, cleanup of the original area, and reinstallation of the plaza on new posts or base at the location specified, complete with prepared, graded, and curbed area and electrical service.

The accepted quantity of Travel Information Sign Maintenance will be paid for at the Contract lump sum price. Payment will include inspection of the sites specified and furnishing of materials required to repair damaged or deteriorated signs.

The accepted quantity of Winter Maintenance for Information Plazas will be paid for at the Contract lump sum price.

The accepted quantity of Overlay for Travel Information Signs will be paid for at the Contract unit price per each. Payment will include furnishing the acrylic background of the color specified, placing the required text on the background, and installation of the overlay on the sign panel at the location specified.

Payment for the above Contract unit prices will be full compensation for performing the work specified and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work.

The accepted quantities of Magnetic Plaza Information Plaque, of the type specified, 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.

Payment will be made under:

| Pay Item | | Pay Unit |
|---|---|---|
| 680.20 | Travel Information Signs | Square Meter (Square Foot) |
| 680.25 | Business Information Signs | Square Meter (Square Foot) |
| 680.30 | Travel Information Plaza, Type A | Each |
| 680.40 | Relocate Information Plaza, Type A | Each |
| 680.50 | Travel Information Sign Maintenance | Lump Sum |
| 680.55 | Winter Maintenance for Information Plazas | Lump Sum |
| 680.65 | 150 mm (6 inch) Magnetic Information Plaque, Type A | Each<br>Each |
| 680.66 | 150 mm (6 inch) Magnetic Information Plaque, Type B | Each |
| 680.70 | Travel Information Symbol | Each |
| 680.72 | Overlay for Travel Information Signs | Each |

# DIVISION 700

## MATERIALS

### SECTION 700 - GENERAL

700.01 GENERAL STATEMENT. Where the Contract requires that materials conform to AASHTO or ASTM specifications, the latest publications and all modifications thereto in effect on the date of the invitation for bids shall apply.

At the Engineer's discretion, testing of any material may be required either at the point of manufacture or after delivery to the site of the work. In such cases, the results of the tests shall govern the acceptance or rejection of the material tested.

In the case of small quantities of material having a cost of less than $2,000 and that are not directly involved with the safety of the structure or the roadway, the Agency may waive the requirement for certification.

Whenever there is a subsection entitled "General Requirements" within any 700 series section, that subsection is applicable to all other subsections in that 700 series section.

700.02 MATERIALS CERTIFICATIONS.

(a) General. When these Specifications require a certification, the certification will be approved prior to use of the material, unless otherwise directed by the Engineer. In all cases, certifications must be approved prior to payment.

All material used on the basis of a materials certification may be sampled and tested at any time. The fact that a material is used on the basis of a certification shall not relieve the Contractor of responsibility for incorporating material in the work which conforms to the requirements of the Contract and any such material not conforming to such requirements will be subject to rejection whether in place or not.

New materials, purchased by the Contractor for use on an Agency contracted project, may be used on another Agency project. To do this, the Contractor must submit a sworn statement certifying such materials were part of the quantity purchased for use on another project. The sworn statement must identify the project and certify that the certifications were furnished to the Agency covering such materials for that project.

When Agency approval is given for working drawings covered under the requirements of Subsection 105.03 and the referenced drawings have identified a component of an item by a specific product name and/or number, the Engineer may waive all or part of any certification requirements for that particular product.

The right is reserved, by the Agency, to refuse the use of materials where acceptance is based only on certification.

Within each subsection, materials designated to conform to another subsection shall require the certification type of the referenced subsection.

For steel materials, the following requirements shall apply:

(1) To comply with Buy America provisions, a manufacturer must certify that all manufacturing processes have occurred in the United States.

(2) To identify a chain of custody documentation trail that the product meets the Buy America provisions, each supplier or fabricator involved in a product will be required to include in its certification a statement that each process performed by them was entirely done in the United States.

All certifications shall be forwarded to the Vermont Agency of Transportation, Materials and Research Section, National Life Building, Montpelier, Vermont 05633-5001.

(b) Required Information. Certifications shall contain the following information, except as waived by the Agency:

(1) Project to which the material is consigned.

(2) Name of the contractor or supplier to which the material is supplied.

(3) Kind of material supplied.

(4) Means of identifying the consignment, such as label, marking, seal number, lot number, etc.

(5) Statement to the effect that the material has been tested and found in conformity with these Specifications.

(6) Results of all tests including the chemical and physical analyses when required by a Type C Certification.

(7) Signature of a person having legal authority to bind the manufacturer. Signatures must be legally notarized or be signed by a person whose name has been submitted on a notarized, prefiled, signature list to the Agency's Materials and Research Section.

(c) Types of Certifications. Unless otherwise specified, certifications shall be prepared by the manufacturer and shall be one of the following types:

(1) Type A. A Type A Certification shall certify that the component materials, manufacturing operations, and finished products conform to all requirements of the Agency, the State, pertinent Plans, Special Provisions, and Specifications for the Contract item or items indicated.

(2) Type B. A Type B Certification shall certify that the material conforms to the requirements of the Agency, the State, current specifications, and is of the same formulation as that previously approved by the Agency.

(3) Type C. A Type C Certification shall consist of certified test results showing actual chemical and physical analysis of material used in the manufacture of products delivered to the project.

(4) Type D. A Type D Certification shall consist of both a Type A Certification and a Type C Certification.

(5) Type E. A Type E Certification shall consist of a yearly Type A Certification plus a certification prepared by the manufacturer indicating test results of the required chemical and physical properties of discrete, identifiable quantities of material. The manufacturer's measured test values will be compared against independent assurance test results.

(d) List of Materials with Advanced Certification. Manufacturers of materials requiring either a Type A or a Type B Certification may submit their certifications annually at the beginning of each calendar year and, if approved, their products will be included on a list of materials with advanced certification. Materials that are included on the List of Materials with Advanced Certification will not require separate certification for each project.

The Agency reserves the right to remove any manufactured product from the List of Materials with Advanced Certification at any time for just cause.

700.03 DEFINITION OF TERMS.

ADVANCED DECAY - In the case of wood, the older stage of decay in which the disintegration is readily recognized because the wood has become punky, soft, and spongy.

BEDROCK (LEDGE) - Rock of relatively great thickness and extent in its native location; any solid rock exposed at the surface of the earth or overlain by unconsolidated material.

BITUMINOUS MATERIAL - A substance which is characterized by the presence of bitumen, or one from which bitumen can be derived.

BOULDER - A rock fragment, usually rounded by weathering or abrasion, with an average dimension of 300 mm (12 inches) or more.

CAPILLARY ACTION (CAPILLARITY) - The rise or movement of water in the interstices of a soil due to capillary forces.

CHECK - In the case of wood, a separation of the wood grain due to internal stresses caused by severe moisture cycling.

CLAY (CLAY SOIL) - 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-dry.

COBBLE (COBBLESTONE) - A rock fragment, usually rounded or semirounded, with an average dimension between 75 and 300 mm (3 and 12 inches).

COHESIONLESS SOIL - A soil that when unconfined has little or no strength when air-dried and that has little or no cohesion when submerged.

COHESIVE SOIL - A soil that when unconfined has considerable strength when air-dried and that has significant cohesion when submerged.

COMPACTION - Densification by means of mechanical manipulation.

COMPACTION CURVE (PROCTOR CURVE) (MOISTURE-DENSITY CURVE) - The curve on a graph that shows the relationship between the dry density and the water content of a soil for a given compactive effort.

COMPACTION TEST (MOISTURE-DENSITY TEST) - A laboratory procedure whereby a soil at a known water content is placed in a specified manner into a mold of given dimensions, subjected to a compactive effort of controlled magnitude, and the resulting unit mass (weight) determined.

COMPRESSIVE STRENGTH - The maximum compressive stress that a material is capable of sustaining.

CONSOLIDATION - Gradual reduction in volume of a soil mass.

CRUSHED GRAVEL - The product resulting from the mechanical crushing of gravel and cobblestones.

CRUSHED STONE - The product resulting from the mechanical crushing of blasted ledge, rocks, boulders, or cobblestones.

DENSITY - The density of a soil is measured in terms of the ratio of its mass (weight) per unit volume and usually expressed as kilograms of wet soil or dry soil per cubic meter (pounds per cubic foot). These ratios are designated as wet density and dry density respectively.

DRYING TIME -

> Set to Touch - Film is “set to touch” when it still exhibits a tacky condition, but none of it adheres to the finger.
>
> Dry to Recoat - Film is “dry to recoat” when the topcoat can be applied without the development of film irregularities, such as lifting or loss of adhesion of the undercoat.

Dry Through (Dry to Handle) - Film is “dry through” when there is no loosening, detachment wrinkling or other distortion of film under condition of test. Test conditions require full thumb pressure with twisting action.

ELONGATED PIECE - One in which the ratio of the length to width of its circumscribing rectangular prism is greater than five.

ELONGATION - The increase in gage length of a tension test specimen, usually expressed as percentage of the original gage length.

FAMILY OF CURVES - A group of similar moisture-density curves assuming a characteristic shape.

FILTER (PROTECTIVE FILTER) - A layer or combination of layers of pervious materials designed and installed in such a manner as to provide drainage, yet prevent the movement of soil particles due to flowing water.

FINENESS MODULUS - An empirical factor obtained by adding the total percentages of a sample of the aggregate retained on each of a specified series of sieves, and dividing the sum by 100.

FINES - Portion of a material finer than a 75 μm (No. 200) sieve.

FLY ASH - Finely divided residue that results from the combustion of ground or powdered coal.

FRACTURED FACES - Fractured faces are faces on aggregate pieces with sharp and well defined edges.

FREEZING DEGREE-DAYS - The difference between the average temperature each day and 0 °C (32 °F). Freezing degree-days are positive for daily average temperatures above 0 °C (32 °F) and negative for those below.

FREEZING INDEX - The number of freezing degree-days between the highest and lowest points on the cumulative freezing degree-days/time curve for one freezing season.

GAGE LENGTH - The original length of that portion of the specimen over which strain or change of length is determined.

GLACIAL TILL (TILL) - Material deposited by glaciation, usually composed of a wide range of particle sizes, which has not been subjected to the sorting action of water.

GRADATION (GRAIN-SIZE DISTRIBUTION), (SOIL TEXTURE) - Proportion of material of each grain size present in a given material.

GRAIN-SIZE ANALYSIS (MECHANICAL ANALYSIS) - The process of determining gradation.

GRAVEL (AASHTO) - Rounded or semirounded particles of rock that will pass a 75 mm (3 inch) sieve and be retained on a 2.00 mm (No. 10) sieve.

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

HARDPAN - Extremely dense, cemented soil, which does not soften when wet.

HEAVE - Upward movement of soil caused by expansion or displacement resulting from phenomena such as moisture absorption, removal of overburden, driving of piles, and frost action.

INCIPIENT DECAY - The early stage of decay that has not proceeded far enough to soften or otherwise perceptibly impair the hardness of wood.

LIQUID LIMIT - The water content corresponding to the arbitrary limit between the liquid and plastic states of soil.

LOAM - A mixture of sand, silt, or clay, or a combination of any of these, with organic matter. It is sometimes called topsoil in contrast to the subsoils that contain little or no organic matter.

MANUFACTURED SAND - The product resulting from the mechanical processing and crushing of gravel or cobbles in which at least 50 percent of the material passing the 2.36 mm (No. 8) sieve has two fractured faces as determined by ASTM C 295, as modified by the Agency's Materials and Testing Section.

MODULUS OF RUPTURE IN BENDING - The value of maximum tensile or compressive stress (whichever causes failure) in the extreme fiber of a beam loaded to failure in bending.

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.

MSDS - Material Safety Data Sheet as required by OSHA.

MUCK - A soil of very soft consistency containing greater than 10 percent organic matter.

MUD - A mixture of soil and water in a fluid or weakly solid state.

NATURAL SAND - Any sand that is found to exist in a natural deposit.

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.

PEAT - A fibrous mass of organic matter in various stages of decomposition, generally dark brown to black in color and of spongy consistency.

PERCENT COMPACTION - The ratio, expressed as a percentage, of dry density of a soil to maximum density obtained in a laboratory compaction test.

PERMEABILITY - The property of a soil allowing it to transmit water; largely dependent upon the size and number of continuous soil pores.

pH - An index of the acidity or alkalinity of a soil where seven is neutral, below seven is acidic and above seven is alkaline.

PLASTICITY INDEX - Numerical difference between the liquid limit and the plastic limit.

PLASTIC LIMIT - The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of soil.

POZZOLANS - Siliceous or siliceous and aluminous materials which in themselves possess little or no cementitious value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

PVC - Polyvinyl chloride, a plastic polymer.

SAMPLING - The process of selecting a fraction of a total material that is similar in all respects to the total material.

SACK - A standard unit of dry powder cement with a mass (weight) of 42.64 kg (94 pounds).

SAND (AASHTO) - Particles of rock that will pass the 2.00 mm (No. 10) sieve and be retained on the 75 μm (No. 200) sieve.

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

SILICA FUME - An extremely fine product of high amorphous silica content resulting from the condensation of rising vapor given off in the manufacture of ferrosilicon and metallic silicon in high temperature electric arc furnaces. This material is also referred to as Microsilica.

SILT - Material passing the 75 μm (No. 200) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dry.

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

TENSILE STRENGTH - The maximum tensile stress that a material is capable of sustaining.

THIN PIECE - One for which the ratio of the width to thickness of its circumscribing rectangular prism is greater than five.

WANE - Bark or lack of wood on the surface or edges of lumber.

YIELD STRENGTH - The stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain.

## SECTION 701 - HYDRAULIC CEMENT

701.01 GENERAL REQUIREMENTS.

(a) General. 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.

The mixing of different brands or types of portland cement, and the mixing of portland cement of the same brand or types from different mills, will not be permitted except by written permission of the Engineer.

(b) Certification. A Type E Certification shall be furnished as specified in Subsection 700.02. A delivery slip or bill of lading shall accompany each transport identifying the manufacturer, whom the material was shipped to, date of delivery, and an identification number traceable to a discrete quantity of material with certified test results.

701.02 PORTLAND CEMENT. Portland cement shall conform to the requirements of AASHTO M 85, Type II, unless otherwise shown on the Plans or directed by the Engineer.

701.03 AIR-ENTRAINING PORTLAND CEMENT. Air-entraining portland cement shall conform to the requirements of AASHTO M 85, Type I-A, unless otherwise shown on the Plans or directed by the Engineer.

701.04 HIGH EARLY STRENGTH PORTLAND CEMENT. High early strength portland cement shall conform to the requirements of AASHTO M 85, Type III or Type III-A.

701.05 PORTLAND-POZZOLAN CEMENT. Portland-pozzolan cement shall conform to the requirements of AASHTO M 240, Type IP except that the pozzolan constituent shall be not more that 20 percent of the total mass (weight) of the portland-pozzolan cement.

701.06 BLENDED SILICA FUME CEMENT. Blended silica fume cement shall conform to the requirements of ASTM C 1157.

A Type D Certification shall accompany each shipment of blended silica fume cement identifying the percent, by mass (weight), of silica fume contained in the blend.

# SECTION 702 - BITUMINOUS MATERIALS

## 702.01 GENERAL REQUIREMENTS.

(a) Sampling. Bituminous materials shall be sampled at the delivery point from vehicle tanks, above ground stationary tanks, or asphalt plant feed lines in a manner that the samples will show the true nature and condition of the materials. Certification under part (e) below shall cover the material until test results are obtained for the material.

(b) Sampling Valves. Sampling valves shall be installed in strategic locations, readily accessible so that representative samples of the required size can be obtained easily and quickly. The sampling valve shall be constructed of materials compatible with the product at the temperatures handled. The valve seat shall be either inside the tank or compartment or inside the insulating jacket. The flow shall be over a route that is as short and direct as practical. Pockets that will retain product will not be allowed. The outlet shall be a 20 mm (3/4 inch) DN pipe size. The outlet shall be provided with a chained cap or plug. The sampling valves shall conform to the requirements of AASHTO T 40.

(c) Location of Sampling Valves. The recommended location and number of sampling valves needed is as follows:

(1) Vehicle Tanks. The sampling valve shall be located below the horizontal mid line of the end head (rear preferred) at least 300 mm (12 inches) from the shell. The inlet to the sampling valve shall be at least 150 mm (6 inches) from walls or other internal surfaces, except that it shall be at least 300 mm (12 inches) from any heating surface.

(2) Horizontal Tanks. The location on horizontal tanks shall be below the horizontal mid line of an end bulkhead. The inlet of the sampling device shall be at least 1 m (3 feet) from the bottom and 300 mm (12 inches) from the shell.

(3) Vertical Tanks. On vertical tanks, where the contents can be agitated, one sampling device shall be required. It shall be located on the side, at least 1060 mm (42 inches) from the bottom.

On vertical tanks, not capable of being agitated, two sampling devices shall be required. They shall be located, with easy and safe access provided, on the side of the tank, as follows: One no closer than 900 mm (36 inches) from the top, and one no closer than 1060 mm (42 inches) from the bottom.

(d) Defective Sampling Valves. When there is an apparent defect in the sampling valve and a sample cannot be obtained as indicated, the following procedure shall be used:

(1) The sample shall be taken directly from the tank, through the inspection access port or an alternate valve.

(2) A defective equipment tag shall be made out and attached to the valve and the plant manager or carrier shall be notified.

(3) A notation shall be made in the plant log or Engineer's daily report giving location of valve, date, storage tank, vehicle tank, or the asphalt plant number.

(4) The plant manager or carrier shall make the necessary repairs within 48 hours from the time notification is given.

(5) If, at the end of the repair period, the plant or tank valve is still found to be defective, the plant shall be shut down and not started again until repairs are made and inspected to the satisfaction of the plant engineer.

(6) Should the tanker return on a second trip and the defective tanker valve not be repaired, the load shall not be used but shall be returned to the sender.

(e) Certification. No bituminous material will be used on any project until the required certifications covering the entire shipment have been received.

702.02 ASPHALT CEMENT (PREPARED FROM PETROLEUM).

(a) Properties. The asphalt cement shall be homogenous, free from water and shall not foam when heated to 175 °C (350 ºF).

The various grades of asphalt cement shall be performance grade (PG) as specified in AASHTO MP1. Specific requirements for the specified grade of asphalt cement shall be as designated in Table 702.02A.

The producer shall furnish to the Agency viscosity temperature charts for each grade of asphalt cement supplied.

TABLE 702.02A - PERFORMANCE GRADED ASPHALT BINDER SPECIFICATION

| Performance Grade | PG 46 | | | PG 52 | | | | | | | PG 58 | | | | | PG 64 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -34 | -40 | -46 | -10 | -16 | -22 | -28 | -34 | -40 | -46 | -16 | -22 | -28 | -34 | -40 | -10 | -16 | -22 | -28 | -34 | -40 |
| Average 7-day Maximum Pavement Design Temperature, °C (Note 1) | <46 | | | <52 | | | | | | | < 58 | | | | | <64 | | | | | |
| Minimum Pavement Design Temperature, °C (Note 1) | >-34 | >-40 | >-46 | >-10 | >-16 | >-22 | >-28 | >-34 | >-40 | >-46 | >-16 | >-22 | >-28 | >-34 | >-40 | >-10 | >-16 | >-22 | >-28 | >-34 | >-40 |
| | Original Binder | | | | | | | | | | | | | | | | | | | | |
| Flash Point Temp, T48: Minimum, °C | 230 | | | | | | | | | | | | | | | | | | | | |
| Viscosity, ASTM D 4402: (Note 2) Maximum, 3 Pa•s (3000 cP), Test Temperature, °C | 135 | | | | | | | | | | | | | | | | | | | | |
| Dynamic Shear, TP5: (Note 3) G*/sin δ, Minimum, 1.00 kPa Test Temperature @ 10 rad/s, °C | 46 | | | 52 | | | | | | | 58 | | | | | 64 | | | | | |
| | Rolling Thin Film Oven (T 240) or Thin Film Oven (T 179) Residue | | | | | | | | | | | | | | | | | | | | |
| Mass Loss, Maximum, % | 1.00 | | | | | | | | | | | | | | | | | | | | |
| Dynamic Shear, TP5: G*/sin δ, Minimum, 2.20 kPa Test Temperature @ 10 rad/s, °C | 46 | | | 52 | | | | | | | 58 | | | | | 64 | | | | | |
| | Pressure Aging Vessel Residue (PP1) | | | | | | | | | | | | | | | | | | | | |
| PAV Aging Temperature, °C (Note 4) | 90 | | | 90 | | | | | | | 100 | | | | | 100 | | | | | |
| Dynamic Shear, TP5: G*/sin δ, Maximum, 5000 kPa Test Temperature @ 10 rad/s, °C | 10 | 7 | 4 | 25 | 22 | 19 | 16 | 13 | 10 | 7 | 25 | 22 | 19 | 16 | 13 | 31 | 28 | 25 | 22 | 19 | 16 |
| Physical Hardening (Note 5) | Report | | | | | | | | | | | | | | | | | | | | |
| Creep Stiffness, TP1: (Note 6) S, Maximum, 300 MPa m-valve, Minimum, 0.300 Test Temperature @ 60 s, °C | -24 | -30 | -36 | 0 | -6 | -12 | -18 | -24 | -30 | -36 | -6 | -12 | -18 | -24 | -30 | 0 | -6 | -12 | -18 | -24 | -30 |
| Direct Tension, TP3: (Note 6) Failure Strain, Minimum, 1.0% Test Temperature @ 1.0 mm/min, °C | -24 | -30 | -36 | 0 | -6 | -12 | -18 | -24 | -30 | -36 | -6 | -12 | -18 | -24 | -30 | 0 | -6 | -12 | -18 | -24 | -30 |

1. Pavement temperatures are estimated from air temperatures using an algorithm contained in the SUPERPAVE software program. The temperatures may be provided by the specifying agency, or by following the procedures as outlined in AASHTO MP2 and AASHTO PP28.
2. This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.
3. For quality control of unmodified asphalt cement production, measurement of the viscosity of the original asphalt cement may be substituted for dynamic shear measurements of G*/sin δ at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary or rotational viscometry (AASHTO T 201 or T 202).
4. The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures: 90 ºC, 100 ºC, or 110 ºC. The PAV aging temperature is 100 ºC for PG 58 and above, except in desert climates, where it is 110 ºC.
5. Physical Hardening - TP1 is performed on a set of asphalt beams according to Section 13.1, except the conditioning time is extended to 24 hours ± 10 minutes at 10 ºC above the minimum performance temperature. The 24-hour stiffness and m-value are reported for information purposes only.
6. If the creep stiffness is below 300 MPa, the direct tension test is not required. If the creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used instead of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.

TABLE 702.02A - PERFORMANCE GRADED ASPHALT BINDER SPECIFICATION (CONTINUED)

| Performance Grade | PG 70 | | | | | | PG 76 | | | | | PG 82 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -10 | -16 | -22 | -28 | -34 | -40 | -10 | -16 | -22 | -28 | -34 | -10 | -16 | -22 | -28 | -34 |
| Average 7-day Maximum Pavement Design Temperature, °C (Note 1) | <70 | | | | | | <76 | | | | | <82 | | | | |
| Minimum Pavement Design Temperature, °C (Note 1) | >-10 | >-16 | >-22 | >-28 | >-34 | >-40 | >-10 | >-16 | >-22 | >-28 | >-34 | >-10 | >-16 | >-22 | >-28 | >-34 |
| | Original Binder | | | | | | | | | | | | | | | |
| Flash Point Temp, T48: Minimum, °C | 230 | | | | | | | | | | | | | | | |
| Viscosity, ASTM D 4402: (Note 2) Maximum, 3 Pa•s (3000 cP), Test Temperature, °C | 135 | | | | | | | | | | | | | | | |
| Dynamic Shear, TP5: (Note 3) G*/sin δ, Minimum, 1.00 kPa Test Temperature @ 10 rad/s, °C | 70 | | | | | | 76 | | | | | 82 | | | | |
| | Rolling Thin Film Oven (T 240) or Thin Film Oven (T 179) Residue | | | | | | | | | | | | | | | |
| Mass Loss, Maximum, % | 1.00 | | | | | | | | | | | | | | | |
| Dynamic Shear, TP5: G*/sin δ, Minimum, 2.20 kPa Test Temperature @ 10 rad/s, °C | 70 | | | | | | 76 | | | | | 82 | | | | |
| | Pressure Aging Vessel Residue (PP1) | | | | | | | | | | | | | | | |
| PAV Aging Temperature, °C (Note 4) | 100(110) | | | | | | 100(110) | | | | | 100(110) | | | | |
| Dynamic Shear, TP5: G*/sin δ, Maximum, 5000 kPa Test Temperature @ 10 rad/s, °C | 34 | 31 | 28 | 25 | 22 | 19 | 37 | 34 | 31 | 28 | 22 | 40 | 37 | 34 | 31 | 28 |
| Physical Hardening (Note 5) | Report | | | | | | | | | | | | | | | |
| Creep Stiffness, TP1: (Note 6) S, Maximum, 300 MPa m-valve, Minimum, 0.300 Test Temperature @ 60 s, °C | 0 | -6 | -12 | -18 | -24 | -30 | 0 | -6 | -12 | -18 | -24 | 0 | -6 | 12 | -18 | -24 |
| Direct Tension, TP3: (Note 6) Failure Strain, Minimum, 1.0% Test Temperature @ 1.0 mm/min, °C | 0 | -6 | -12 | -18 | -24 | -30 | 0 | -6 | -12 | -18 | -24 | 0 | -6 | 12 | -18 | -24 |

1. Pavement temperatures are estimated from air temperatures using an algorithm contained in the SUPERPAVE software program. The temperatures may be provided by the specifying agency, or by following the procedures as outlined in AASHTO MP2 and AASHTO PP28.
2. This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.
3. For quality control of unmodified asphalt cement production, measurement of the viscosity of the original asphalt cement may be substituted for dynamic shear measurements of G*/sin δ at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary or rotational viscometry (AASHTO T 201 or T 202).
4. The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures: 90 ºC, 100 ºC, or 110 ºC. The PAV aging temperature is 100 ºC for PG 58 and above, except in desert climates, where it is 110 ºC.
5. Physical Hardening - TP1 is performed on a set of asphalt beams according to Section 13.1, except the conditioning time is extended to 24 hours ± 10 minutes at 10 ºC above the minimum performance temperature. The 24-hour stiffness and m-value are reported for information purposes only.
6. If the creep stiffness is below 300 MPa, the direct tension test is not required. If the creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used instead of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.

(b) Pretest. Failure of asphalt cement from any one source to meet the Specifications may require placing this source on Pretest Status. This will require that samples from the source be tested in the Agency's Materials and Research Laboratory and accepted prior to being used on a project.

The Pretest Status will remain in effect until the Engineer is satisfied there is no longer any reason to continue on a Pretest Status.

(c) Certification. A Type E Certification shall be furnished in accordance with Subsection 700.02.

702.03 CUTBACK ASPHALT. Cutback asphalt shall be produced by fluxing an asphaltic base with suitable petroleum distillates.

The cutback asphalt shall show no separation or curdling prior to use and shall not foam when heated to the application temperature.

(a) Properties. Cutback asphalt of the grade designated shall conform to the requirements of AASHTO M 81 for rapid-curing cutback asphalt and AASHTO M 82 for medium-curing cutback asphalt.

When blends of rapid-curing type and medium-curing type cutback asphalt are specified, the separate components shall conform to the above requirements, and in addition, the blend shall conform to interpolated values between the types and grades blended.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

702.04 EMULSIFIED ASPHALT. Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt at the time of use and shall be used within 30 calendar days after delivery.

Emulsified asphalt shall not be allowed to freeze.

(a) Properties. Emulsified asphalt shall conform to the requirements of AASHTO M 140 or AASHTO M 208, as appropriate.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

702.05 TAR EMULSION.

(a) Properties. This material shall conform to the requirements of ASTM D 3320 except that paragraph 4.3 shall not apply.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

702.06 APPLICATION TEMPERATURES. Bituminous materials for the applications specified in the Specifications shall be applied within the temperature ranges designated the following table:

TABLE 702.06A - APPLICATION TEMPERATURES

| | °C | | | | °F | | | |
|---|---|---|---|---|---|---|---|---|
| | Spray | | Mix | | Spray | | Mix | |
| Asphalt Cement | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. |
| Plant Mixed Base Course, Section 303 | --- | --- | 116 | 138 | --- | --- | 240 | 280 |
| Penetration Base Course, Section 305 | 149 | 177 | --- | --- | 300 | 350 | --- | --- |
| Bituminous Surface Treatment, Section 404 | 135 | 177 | --- | --- | 275 | 350 | --- | --- |
| Bituminous Concrete Pavement, Section 406 | --- | --- | --- | * | --- | --- | --- | * |
| Cutback Asphalt | | | | | | | | |
| RC 70 | 27 | 66 | 27 | 66 | 80 | 150 | 80 | 150 |
| RC 250 | 38 | 79 | 27 | 66 | 100 | 175 | 80 | 150 |
| RC 800 | 71 | 107 | 57 | 85 | 160 | 225 | 135 | 185 |
| RC 3000 | 93 | 135 | 79 | 107 | 200 | 275 | 175 | 225 |
| MC 30 | 10 | 49 | 10 | 49 | 50 | 120 | 50 | 120 |
| MC 70 | 27 | 66 | 27 | 66 | 80 | 150 | 80 | 150 |
| MC 250 | 38 | 93 | 38 | 93 | 100 | 200 | 100 | 200 |
| MC 800 | 85 | 127 | 71 | 99 | 185 | 260 | 160 | 210 |
| MC 3000 | 107 | 135 | 93 | 121 | 225 | 175 | 200 | 250 |
| Emulsified Asphalt | | | | | | | | |
| RS-1 | 21 | 60 | --- | --- | 70 | 140 | --- | --- |
| RS-2, CRS-1 | 49 | 71 | --- | --- | 120 | 160 | --- | --- |
| CRS-2 | 60 | 79 | --- | --- | 140 | 175 | --- | --- |
| SS-1h, CSS-1h | 24 | 54 | 10 | 54 | 75 | 130 | 50 | 130 |
| MS-2h, CMS-2h | --- | --- | 24 | 60 | --- | --- | 75 | 140 |

* As required to achieve a kinematic viscosity of 170 ± 20 centistokes.

702.07 ANTI-STRIP ADDITIVES. Anti-strip additives shall be capable of improving the bonding properties of the cutback asphalt or the asphalt cement to the aggregates in the presence of moisture and shall also be capable of reducing film stripping.

(a) Cutback Asphalt. The additive used in cutback asphalt shall remain stable at the maximum temperature permitted for the cutback asphalt, and during the period of time the cutback asphalt is subjected to elevated temperatures.

The amount of additive used shall be determined by the Engineer, but in no case shall it exceed 2 percent of the cutback asphalt by volume.

(b) Asphalt Cement. The additive used in asphalt cement shall be heat stable for all temperature ranges prescribed for such asphalt cement. The additive shall not appreciably alter the characteristics of the asphalt cement when added in the

recommended proportions. The additive shall be capable of thorough dispersion in the asphalt cement and capable of remaining in the asphalt cement, in storage, and at temperatures specified for the mix without losing its effectiveness.

(c) Testing Procedures. Testing of anti-strip additives shall be in accordance with, and meet the requirements of Vermont Agency of Transportation, Test Procedures, MRD-1 and MRD-10.

The percentage of anti-strip additive shall be a minimum of 0.5 percent of the asphalt content and shall be adjusted, as required, above this amount to meet testing requirements. Prior to the use of any anti-strip additive, the Contractor shall submit for testing and approval samples of the specific aggregates, the specific asphalt and the specific anti-strip additive proposed for the mix design.

To identify any change in effectiveness, the asphalt and the anti-strip additive being used shall acceptably pass the requirements of the MRD-10 test procedure on a daily basis.

702.08 SILICONE ADDITIVE. Silicone additive shall be a silicone material of the dimethyl polisiloxane type with a viscosity grading of 1000 ± 200 centistokes at 25 °C (77 °F). It shall be added to the liquid asphalt cement at hot mix plants in amounts not to exceed five parts per million. After addition of the silicone additive, the asphalt cement shall be thoroughly mixed by mechanical means to ensure complete dispersal.

Other types of silicone material, or the addition of amounts in excess of five parts per million, must be approved by the Engineer before being used in the work.

## SECTION 703 - SOILS AND BORROW MATERIALS

703.01 CLASSIFICATION OF SOILS. Based upon their field performance, soils shall be classified into seven groups that shall be 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 designated in the following table:

TABLE 703.01A - CLASSIFICATION OF SOILS

| General Classification | Granular Materials | | | Silt-Clay Materials | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A-1 | | | A-2 | | | | | | | A-7 | |
| 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 | A-7-6 |
| Sieve Analysis, percent passing: | | | | | | | | | | | | |
| 2.00 mm (No. 10) | 50- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 425 µm (No. 40) | 30- | 50- | 50+ | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 75 µm (No. 200) | 15- | 25- | 10- | 35- | 35- | 35- | 35- | 36+ | 36+ | 36+ | 36+ | 36+ |
| Characteristics of fraction passing 425 µm (No. 40) sieve: | | | | | | | | | | | | |
| Liquid Limit | --- | | --- | 40- | 41+ | 40- | 41+ | 40- | 41+ | 40- | 41+ | |
| Plasticity Index | 6- | | NP | 10- | 10- | 11+ | 11+ | 10- | 10- | 11+ | 11+ | |
| Usual Types of Soils | Gravel and Sand | | Fine Sand | Silty or Clayey Gravel and Sand | | | | Silty Soils | | Clay Soils | | |

\+ indicates that value shown is the minimum allowable.

\- indicates that value shown is the maximum allowable.

NP indicates non-plastic.

Plasticity Index of A-7-5 subgroup is equal to or less than Liquid Limit minus 30.

Plasticity Index of A-7-6 subgroup is greater than Liquid Limit minus 30.

Classification Procedure. With the required data, proceed from left to right on above chart, and the correct group will be found by the process of elimination. The first group from left into which the test data will fit is the correct classification.

Where the unified classification of soils is referenced in the Contract, it shall be based on the Unified Soil Classification Chart in Appendix B of the AASHTO *Manual on Foundation Investigations*.

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 sand cushion shall consist of material reasonably free from silt, loam, clay, or organic matter. It shall be obtained from approved sources and shall meet the requirements of the following table:

TABLE 703.03A - SAND BORROW AND CUSHION

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 50 mm (2 inch) | 100 |
| 37.5 mm (1 1/2 inch) | 90 to 100 |
| 12.5 mm (1/2 inch) | 70 to 100 |
| 4.75 mm (No. 4) | 60 to 100 |
| 150 μm (No. 100) | 0 to 20 |
| 75 μm (No. 200) | 0 to 8 |

703.04 GRANULAR BORROW. Granular borrow shall be obtained from approved sources, consisting of stone and sand reasonably free from loam, silt, clay, and organic material and shall meet the requirements of the following table:

TABLE 703.04A - GRANULAR BORROW

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 4.75 mm (No. 4) | 20 to 100 |
| 75 μm (No. 200) | 0 to 12 |

The maximum size of stone particles in the granular borrow shall not exceed 67 percent of the thickness of the layer being spread.

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 900 mm (36 inches) in its widest dimension and that size which may be incorporated in a 600 mm (24 inch) layer of rock embankment.

## SECTION 704 - AGGREGATES

704.01 FINE AGGREGATE FOR CONCRETE. Fine aggregate for concrete shall consist of natural sand washed in an approved manner or a combination of washed natural sand and stone screenings. The stone screenings shall not exceed 50 percent, by mass (weight), of the combination.

Fine aggregate shall consist of clean, hard durable grains, uniformly graded from coarse to fine, and shall be free from injurious amounts of organic matter or other harmful substances.

(a) Grading. The fine aggregate shall meet the requirements of the following table:

TABLE 704.01A - FINE AGGREGATE FOR CONCRETE

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 9.5 mm (3/8 inch) | 100 |
| 4.75 mm (No. 4) | 95 to 100 |
| 1.18 mm (No. 16) | 50 to 80 |
| 600 μm (No. 30) | 25 to 60 |
| 300 μm (No. 50) | 10 to 30 |
| 150 μm (No. 100) | 2 to 10 |

The fineness modulus on that portion of material passing the 9.5 mm (3/8 inch) sieve shall be determined by laboratory sieve test. This fineness modulus is the summation of the percentages of sand retained on the following sieve sizes: 150 μm (No. 100), 300 μm (No. 50), 600 μm (No. 30), 1.18 mm (No. 16), 2.36 mm (No. 8), and 75 mm (No. 4) divided by 100. The minimum fineness modulus shall be 2.60 and the maximum shall be 3.10. 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. The fine aggregate shall show a color of not greater than two when 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 50 mm (2 inch) cubes, the resulting mortar at the age of three and seven days shall have a compressive strength of at least 100 percent 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 the requirements of AASHTO T 106. Only one series of mortar cube compressive strength tests will be required for each fine aggregate source in any one calendar year unless the Engineer deems additional testing necessary.

(d) Soundness. When there is any question of either soft or laminated pieces being detrimental to any aggregate, 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 percent, 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, uniformly graded. The blending of crushed stone and crushed gravel in the stockpile shall not be permitted. It shall be free from deleterious material, pieces that are structurally weak, and when proportioned in concrete shall not adversely affect the structural integrity or durability of the concrete when subjected to freezing and thawing. It shall also meet the following requirements:

(a) Grading. The coarse aggregate shall be furnished in the required separate size(s) for the specified class of concrete and shall meet the requirements of the following tables:

TABLE 704.02A - GRADATION REQUIREMENTS
FOR 9.5 MM (3/8 INCH) STONE

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 12.5 mm (1/2 inch) | 100 |
| 9.5 mm (3/8 inch) | 85 to 100 |
| 4.75 mm (No. 4) | 10 to 30 |
| 2.36 mm (No. 8) | 0 to 10 |
| 1.18 mm (No. 16) | 0 to 5 |

TABLE 704.02B - GRADATION REQUIREMENTS
FOR 19.0 MM (3/4 INCH) STONE

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 25.0 mm (1 inch) | 100 |
| 19.0 mm (3/4 inch) | 90 to 100 |
| 9.5 mm (3/8 inch) | 0 to 55 |
| 4.75 mm (No. 4) | 0 to 10 |
| 2.36 mm (No. 8) | 0 to 5 |

TABLE 704.02C - GRADATION REQUIREMENTS
FOR 37.5 MM (1 1/2 INCH) STONE

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 45 mm (1 3/4 inch) | 100 |
| 37.5 mm (1 1/2 inch) | 90 to 100 |
| 25.0 mm (1 inch) | 20 to 55 |
| 19.0 mm (3/4 inch) | 0 to 15 |
| 9.5 mm (3/8 inch) | 0 to 5 |

(b) Percent of Wear. When the coarse aggregate is composed of crushed stone or crushed gravel, the percent of wear of the aggregate shall be not more than 35 percent when tested in accordance with AASHTO T 96. When the aggregate is composed of crushed igneous rock, the percent of wear of the aggregate shall be not more than 50 percent when tested in accordance with AASHTO T 96.

(c) Fractured Faces. When crushed gravel is used as coarse aggregate, at least 50 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall have at least one fractured face.

(d) Thin and/or Elongated Pieces. Not more than 10 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall consist of thin and/or elongated pieces.

(e) Soundness. The soundness of this material shall conform to the requirements specified in Subsection 704.01(d).

(f) Aggregate Failure. Coarse aggregate that fractures when used in a test cylinder, at a strength less than the minimum compressive strength of the class of concrete tested, may be cause for rejection of the coarse aggregate.

704.03 AGGREGATE FOR PLANT MIXED BASE COURSE. Aggregate for plant mixed base course shall consist of clean, hard, crushed stone or crushed gravel. The blending of crushed stone and crushed gravel may be permitted if, in the opinion of the Engineer, the materials to be blended are equal in quality and are compatible. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that the resulting gradation conforms to the requirements specified in Subsection 303.02(b). The aggregate shall be reasonably free from dirt, deleterious material, and pieces that are structurally weak and shall meet the following requirements:

(a) Percent of Wear. When the coarse aggregate is composed of crushed stone or crushed gravel, the percent of wear of the aggregate shall be not more than 35 percent when tested in accordance with AASHTO T 96. When the aggregate is composed of crushed igneous rock, the percent of wear of the aggregate shall be not more than 50 percent when tested in accordance with AASHTO T 96.

(b) Fractured Faces. When crushed gravel is used, at least 75 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall have at least two fractured faces.

(c) Thin and/or Elongated Pieces. Not more than 10 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall consist of thin and/or elongated pieces.

(d) Soundness. The soundness of this material shall conform to the requirements specified in Subsection 704.01(d).

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. The gravel shall meet the requirements of the following table:

TABLE 704.04A - GRAVEL FOR SUBBASE

| Sieve Designation | Percentage By Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 4.75 mm (No. 4) | 20 to 60 |
| 150 μm (No. 100) | 0 to 12 |
| 75 μm (No. 200) | 0 to 6 |

The gravel shall be uniformly graded from coarse to fine, and the maximum size stone particles shall not exceed 67 percent of the thickness of the layer being placed.

(b) Percent of Wear. The percent of wear of the gravel shall be not more than 50 percent when tested in accordance with AASHTO T 96.

704.05 CRUSHED GRAVEL FOR SUBBASE. Crushed gravel for subbase shall be produced from natural gravels or crushed quarried rock and shall be a material reasonably free from silt, loam, clay, or organic matter. It shall be obtained from approved sources and shall meet the following requirements:

(a) Grading. The crushed gravel shall be uniformly graded from coarse to fine and shall meet the requirements of the following table:

TABLE 704.05A - CRUSHED GRAVEL FOR SUBBASE

| Grading | Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|---|
| Coarse | 100 mm (4 inch) | 95 to 100 |
| | 4.75 mm (No. 4) | 25 to 50 |
| | 150 μm (No. 100) | 0 to 12 |
| | 75 μm (No. 200) | 0 to 6 |
| Fine | 50 mm (2 inch) | 100 |
| | 37.5 mm (1 1/2 inch) | 90 to 100 |
| | 4.75 mm (No. 4) | 30 to 60 |
| | 150 μm (No. 100) | 0 to 12 |
| | 75 μm (No. 200) | 0 to 6 |

(b) Percent of Wear. The percent of wear of the crushed gravel shall be not more than 40 percent when tested in accordance with AASHTO T 96.

(c) Fractured Faces. At least 50 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve shall have at least one fractured face.

704.06 DENSE GRADED CRUSHED STONE FOR SUBBASE. Dense graded crushed stone for subbase shall consist of clean, hard, uniformly graded, crushed stone. It shall be sufficiently free from dirt, deleterious material, and pieces that are structurally weak and shall meet the following requirements:

(a) Source. This material shall be obtained from approved sources and the area from which this material is obtained shall be stripped and cleaned before blasting.

(b) Grading. This material shall meet the requirements specified in the following table:

TABLE 704.06A - DENSE GRADED CRUSHED STONE FOR SUBBASE

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 90 mm (3 1/2 inch) | 100 |
| 75 mm (3 inch) | 90 to 100 |
| 50 mm (2 inch) | 75 to 100 |
| 25.0 mm (1 inch) | 50 to 80 |
| 12.5 mm (1/2 inch) | 30 to 60 |
| 4.75 mm (No. 4) | 15 to 40 |
| 75 μm (No. 200) | 0 to 6 |

(c) Percent of Wear. The percent of wear of the crushed stone shall be not more than 40 percent when tested in accordance with AASHTO T 96. When the aggregate is composed of crushed igneous rock, the percent of wear of the crushed stone shall be not more than 50 percent when tested in accordance with AASHTO T 96.

(d) Thin and/or Elongated Pieces. Not more than 30 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve shall consist of thin and/or elongated pieces.

(e) Filler. The approved filler shall be obtained from approved sources and shall consist of clean, hard, uniform graded, crushed stone and/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 parts (a), (c), and (d) above.

Approved filler material shall meet the requirements specified in the following table:

TABLE 704.06B - APPROVED FILLER

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 19.0 mm (1/4 inch) | 100 |
| 12.5 mm (1/2 inch) | 70 to 100 |
| 4.75 mm (No. 4) | 50 to 90 |
| 150 μm (No. 100) | 0 to 12 |
| 75 μm (No. 200) | 0 to 6 |

704.07 GRAVEL BACKFILL FOR SLOPE STABILIZATION. Gravel backfill for slope stabilization shall conform to the requirements specified in Subsection 704.04(a).

704.08 GRANULAR BACKFILL FOR STRUCTURES. Granular backfill for structures shall be obtained from approved sources. It shall consist of satisfactorily graded, free draining granular material reasonably free from loam, silt, clay, and organic material.

The granular backfill shall meet the requirements specified in the following table:

TABLE 704.08A - GRANULAR BACKFILL FOR STRUCTURES

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 75 mm (3 inch) | 100 |
| 4.75 mm (No. 4) | 45 to 75 |
| 150 μm (No. 100) | 0 to 12 |
| 75 μm (No. 200) | 0 to 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 specified in Subsection 703.04.

704.10 AGGREGATE FOR BITUMINOUS CONCRETE PAVEMENT. Coarse aggregate for bituminous concrete pavement shall consist of clean, hard, crushed stone or crushed gravel, and be uniformly graded. The blending of crushed stone and crushed gravel may be permitted in the binder course only, if in the opinion of the Engineer the materials to be blended are equal in quality and are compatible. It shall be sufficiently free from dirt, deleterious material, and pieces that are structurally weak. The coarse aggregate shall be considered that portion of material coarser than the 2.36 mm (No. 8) sieve.

Fine aggregate for bituminous concrete pavement shall consist of stone screenings or a combination of stone screenings, screened natural and/or manufactured sands, and other fine aggregates, such that at least 95 percent of any individual stockpile of the fine aggregate shall pass a 9.5 mm (3/8 inch) sieve. The minimum percentage, by mass (weight), of the blended material passing the 2.36 mm (No. 8) sieve that must be stone

screenings shall be as shown in Table 406.03B, unless otherwise authorized in writing by the Engineer.

(a) Grading.

(1) Coarse Aggregate. Coarse aggregate shall be furnished in at least three nominal sizes for Type I mix and in at least two nominal sizes for Types II and III mix.

The cold feed coarse aggregate shall meet the requirements specified in the following table:

TABLE 704.10A - COARSE AGGREGATE

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves | | | |
|---|---|---|---|---|
| | 25.00 mm (1 inch) Size | 19.0 mm (3/4 inch) Size | 12.5 mm (1/2 inch) Size | 9.5 mm (3/8 inch) Size |
| 37.5 mm (1 1/2 inch) | 100 | | | |
| 25.0 mm (1 inch) | 90 to 100 | 100 | | |
| 19.0 mm (3/4 inch) | | 90 to 100 | 100 | |
| 12.5 mm (1/2 inch) | 0 to 10 | | 90 to 100 | 100 |
| 9.5 mm (3/8 inch) | | 0 to 10 | | 90 to 100 |
| 4.75 mm (3/8 inch) | | | 0 to 10 | |
| 2.36 mm (No. 8) | | | | 0 to 10 |

(2) Fine Aggregate. The gradation of the fine aggregate shall be such that, when combined with a coarse aggregate, the composite aggregate shall meet the specified gradation requirements for bituminous concrete as specified in Subsection 406.02(a). The process of blending the fine and coarse aggregates shall be accomplished through the use of separate bins. Blending in the stockpile will not be permitted.

The percentage of fine aggregate passing the 2.36 mm (No. 8) sieve shall remain uniform within a tolerance of ± 15 percent for any one mix design. Material produced that does not meet this tolerance may be stockpiled separately and used after an appropriate change is made in the mix design.

(3) Recycled Asphalt Pavement. When recycled asphalt pavement (RAP), is used to produce bituminous concrete pavement, the resulting mixture will meet all specification requirements for the type(s) of mix specified. The

grade(s) of asphalt for use with the recycled mix will be determined by the Engineer based on the characteristics of the reclaimed asphaltic concrete.

The bitumen component of the RAP shall be free of significant contents of solvents, tars, or other contaminating substances that will make the RAP unacceptable for recycling as determined by the Engineer.

Should the characteristics of any proposed material for recycling be such that an acceptable mixture cannot be produced and/or maintained, the recycled mix will not be allowed for use on the project.

When a mix design is submitted using RAP, the Contractor shall submit an analysis of the RAP material to include aggregate gradation, asphalt content and recovered asphalt cement values. The recovered values will be obtained by using AASHTO T 170. The information required will include the penetration at 25 °C (77 °F), 100 g five seconds; absolute viscosity at 60 °C (140 °F), poises; and kinematic viscosity at 135 °C (275 °F), centistokes. A minimum of four samples is required to produce design data.

The RAP from different projects shall be separated in individual stockpiles according to specific pavement source and type of mix by the Contractor, unless otherwise directed by the Engineer. A separate mix design will be required for each specific pavement source, unless otherwise directed by the Engineer.

(b) Percent of Wear. When the coarse aggregate is composed of crushed stone or crushed gravel, the percent of wear of the aggregate shall be not more than 35 percent when tested in accordance with AASHTO T 96. When the aggregate is composed of crushed igneous rock, the percent of wear of the aggregate shall be not more than 50 percent when tested in accordance with AASHTO T 96.

(c) Fractured Faces. When crushed gravel is used as coarse aggregate, at least 75 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve shall have at least two fractured faces.

(d) Thin and/or Elongated Pieces. Not more than 10 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall consist of thin and/or elongated pieces.

(e) Mineral Filler. The mineral filler shall consist of approved limestone dust, talc dust, or other approved materials and shall be added to the aggregate if required.

(f) Soundness. The soundness shall conform to the requirements of Subsection 704.01(d), except the percentage of loss shall be not more than 12 percent, by mass (weight), and shall apply to wearing course aggregates only.

(g) Control of Aggregate Stockpiles. Before the start of bituminous concrete paving operations and throughout the duration of the paving operation, the cold feed aggregate stockpiles shall each contain at least 1000 metric tons (1000 tons) of

accepted aggregate, or the job requirements when less than 1000 metric tons (1000 tons).

The addition of unacceptable material to an accepted stockpile shall result in the rejection of the entire stockpile.

The stockpiles shall be separated by partitions or separated to the satisfaction of the Engineer to prevent intermixing of the stockpiles.

All stockpiles shall be maintained at the mixing plant site, unless otherwise authorized in writing by the Engineer.

The respective sources of all aggregates to be used in the wearing course shall remain the same for the entire project, unless otherwise authorized in writing by the Engineer.

704.11 AGGREGATE FOR BITUMINOUS SURFACE TREATMENT. The peastone and stone grits shall consist of washed, crushed gravel or crushed stone. It shall be reasonably free from dirt, deleterious material, and pieces that are structurally weak.

The sand shall be washed, natural sand and shall consist of clean, hard, durable grains, reasonably free from dirt and deleterious material.

(a) Grading. The peastone, stone grits, and sand shall meet the requirements of the following table:

TABLE 704.11A - AGGREGATE FOR BITUMINOUS SURFACE TREATMENT

| | Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|---|
| Peastone | 19.0 mm (3/4 inch) | 100 |
| | 16.0 mm (5/8 inch) | 90 to 100 |
| | 4.75 mm (No. 4) | 0 to 5 |
| Stone Grits | 12.5 mm (1/2 inch) | 100 |
| | 9.5 mm (3/8 inch) | 90 to 100 |
| | 2.36 mm (No. 8) | 0 to 10 |
| | 75 µm (No. 200) | 0 to 3 |
| Sand | 16.0 mm (5/8 inch) | 100 |
| | 4.75 mm (No. 4) | 90 to 100 |
| | 150 µm (No. 100) | 0 to 8 |

(b) Percent of Wear.

(1) Crushed Gravel. When the aggregate is composed of crushed gravel, the percent of wear shall be not more than 35 percent when tested in accordance with AASHTO T 96. No wear requirements shall apply when grits are used as a shoulder treatment.

(2) Crushed Stone. When the aggregate is composed of crushed stone, the percent of wear of the aggregate shall be not more than 35 percent when tested in accordance with AASHTO T 96. No wear requirements shall apply when grits are used as a shoulder treatment.

(c) Fractured Faces. When crushed gravel is used, at least 50 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall have at least one fractured face.

(d) Thin and/or Elongated Pieces. Not more than 15 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve shall consist of thin and/or elongated pieces.

704.12 AGGREGATE FOR SURFACE COURSE AND SHOULDERS. Aggregate for surface course and shoulders shall consist of clean, hard, gravel, crushed gravel or crushed stone. It shall be reasonably free from silt, loam, clay or organic matter. It shall be obtained from approved sources and shall meet the following requirements:

(a) Grading. This material shall be uniformly graded from coarse to fine and shall meet the requirements of the following table:

TABLE 704.12A - AGGREGATE FOR SURFACE COURSE AND SHOULDERS

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 37.5 mm (1 1/2 inch) | 100 |
| 25.0 mm (1 inch) | 90 to 100 |
| 4.75 mm (No. 4) | 45 to 65 |
| 150 μm (No. 100) | 0 to 15 |
| 75 μm (No. 200) | 0 to 12 |

(b) Percent of Wear. The percent of wear when tested in accordance with AASHTO T 96 shall be not more than 40 percent for material used as aggregate surface course or not more than 50 percent for material used as aggregate shoulders.

704.13 SAND FOR CEMENT MORTAR. Sand for cement mortar shall be a washed natural sand and shall consist of clean, hard, durable grains. It shall be uniformly graded from coarse to fine, and shall be free from injurious amounts of organic matter or other harmful substances.

(a) Grading. This material shall meet the requirements of the following table:

TABLE 704.13A - SAND FOR CEMENT MORTAR

| Sieve Designation | Percentage by Mass (Weight) Passing Square Mesh Sieves |
|---|---|
| 2.36 mm (No. 8) | 100 |
| 300 μm (No. 50) | 15 to 40 |
| 150 μm (No. 100) | 0 to 10 |
| 75 μm (No. 200) | 0 to 5 |

(b) Organic Impurities. The sand shall show a color of not greater than two when determined in accordance with AASHTO T 21.

704.14 LIGHTWEIGHT COARSE AGGREGATE FOR STRUCTURAL CONCRETE. Lightweight coarse aggregate for structural concrete shall be clean, hard, and uniformly graded. It shall be reasonably free from dirt, deleterious material, and pieces that are structurally weak. It shall meet the following requirements:

(a) General Characteristics. Two general types of lightweight aggregates may be used:

(1) Aggregates prepared by expanding, calcining, or sintering products such as blast furnace slag, clay, shale, or slate. Other raw materials may be used if the resulting prepared aggregates meet the requirements of these Specifications.

(2) Aggregates prepared by crushing, screening, and cleaning natural lightweight materials such as pumice, scoria, or tuff.

(b) Grading. The grading shall conform to the requirements designated in Table 704.02B.

(c) Percent of Wear. The percent of wear shall be not more than 50 percent when tested in accordance with AASHTO T 96.

(d) Thin and/or Elongated Pieces. The thin and/or elongated pieces shall conform to the requirements specified in Subsection 704.02(d).

(e) Soundness. The soundness shall conform to the requirements specified in Subsection 704.01(d).

(f) Density. The maximum dry loose density of the lightweight coarse aggregate shall not exceed 880 kg/$m^3$ (55 pounds per cubic foot) when tested in accordance with AASHTO T 19/T 19M. The density of lightweight aggregate shall not differ by more than 10 percent from samples submitted for acceptance tests.

## SECTION 705 - MASONRY UNITS

705.01 BRICK.

(a) Clay or Shale Manhole Brick. Brick used for sewer manhole inverts shall conform to AASHTO M 91, Grade MS.

(b) Clay or Shale Building Brick. Building brick shall be used in masonry construction where a high degree of resistance to frost action is desired and the exposure is such that water permeating the brick may be frozen. It shall conform to the requirements of AASHTO M 114, Grade SW.

(c) Clay or Shale Sewer Brick. Brick used for construction where resistance to the action of sewage is needed shall conform to the requirements of AASHTO M 91, Grade SM.

(d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

705.02 CONCRETE MASONRY BLOCKS.

(a) Properties. Concrete masonry blocks intended for use in the construction of catch basins or manholes shall conform to the requirements of ASTM C 139 (solid, precast units) or ASTM C 90, Grade N, Type I or Type II (hollow, precast units).

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

705.03 CONCRETE UNITS FOR SLOPE PAVING. Concrete units for slope paving shall be solid precast units, of uniform quality and appearance, with all faces smooth and flush, reasonably free from surface defects and shall conform to the following requirements:

(a) Size. The concrete units shall conform to the details shown on the Plans as to size, shape, and, if required, placement of bar reinforcement.

(b) Materials. The concrete shall have a minimum compressive strength of 20.7 MPa (3000 pounds per square inch). Bar reinforcement, when required, shall conform to the requirements specified in Subsection 713.01.

(c) Curing. The concrete units shall be cured in accordance with the requirements of ASTM C 478M, Section 8, and for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less.

(d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

705.04 PRECAST DROP INLETS, CATCH BASINS, AND MANHOLES. Precast drop inlets, catch basins, and manholes shall conform to the requirements of AASHTO M 199M with the following notes or exceptions:

(a) Reinforced Concrete Pipe. Reinforced concrete pipe for drop inlets shall conform to the requirements specified in Subsection 710.01. It shall be of the tongue and groove type with positive connection between sections.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 706 - STONE FOR MASONRY, RIPRAP, AND OTHER PURPOSES

706.01 STONE FOR RUBBLE MASONRY. Stone for rubble 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 destroy its resistance to the weather.

At least 80 percent of the individual stones in a unit shall have a thickness of not less than 200 mm (8 inches) and a width of not less than 150 percent of the thickness. The minimum size of the other stones in the unit shall have a thickness of not less than 100 mm (4 inches) and a width of not less than 150 percent of the thickness.

706.02 STONE FOR MASONRY FACING. Stone for masonry facing shall be irregularly shaped or roughly rectangular quarried granite, marble, or other approved quarried stone.

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 shall be rejected.

The stone shall be kept free from dirt, oil, and any other injurious 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 25 mm (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) Heavy Type. The individual stones shall have a depth equal to the thickness of the course of riprap. At least 75 percent of the volume of the riprap, complete in

place, shall consist of stones that have a minimum volume of 0.5 $m^3$ (16 cubic feet).

(b) Light Type. The individual stones shall have a depth equal to the thickness of the course of riprap. The riprap, complete in place, shall consist of stones that have a minimum volume of 0.015 $m^3$ (1/2 cubic foot)

706.04 STONE FOR 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 percent of the longest dimension. The stone fill shall be reasonably well graded from the smallest to the maximum size stone specified so as to form a compact mass when in place.

(a) Type I. The longest dimension of the stone shall vary from 25 to 300 mm (1 to 12 inches), and at least 50 percent of the volume of the stone in place shall have a least dimension of 100 mm (4 inches).

(b) Type II. The longest dimension of the stone shall vary from 50 to 900 mm (2 to 36 inches), and at least 50 percent of the volume of the stone in place shall have a least dimension of 300 mm (12 inches).

(c) Type III. The longest dimension of the stone shall vary from 75 to 1200 mm (3 to 48 inches), and at least 50 percent of the volume of the stone in place shall have a least dimension of 400 mm (16 inches).

(d) Type IV. The longest dimension of the stone shall vary from 75 to 1500 mm (3 to 60 inches), and at least 50 percent of the volume of the stone in place shall have a least dimension of 500 mm (20 inches).

706.05 STONE FOR SLOPE PAVING. Stone for slope paving shall be approved, rough, unhewn quarry stone or field stone, approximately rectangular in shape and shall be free from structural defects or imperfections.

The individual stones shall have one reasonably flat face for the exposed portion and shall be not less than 130 mm (5 inches) in thickness perpendicular to the exposed face, which thickness shall be the least dimension of the stone.

Seventy-five percent of the stones shall have a minimum volume of 0.055 $m^3$ (2 cubic feet). The minimum volume of other stones shall be 0.015 $m^3$ (1/2 cubic foot).

## SECTION 707 - JOINT MATERIALS

707.01 MORTAR, TYPE I. Type I mortar is generally used as a joint filler between curb stones, for stone slope edging, and for the grouting of dowels. It shall be used in small quantities as needed and shall not be retempered or used after it has begun to set.

The mortar shall be composed of one part cement and one part sand and mixed with sufficient water to form a plastic composition. For grouting, sufficient water shall be added to provide the required consistency.

The cement, sand, and water shall meet the following requirements:

(a) Cement. Cement shall conform to the requirements of Subsection 701.03.

(b) Sand. Sand shall conform to the requirements of Subsection 704.13 or 704.01, as appropriate.

(c) Water. Water shall conform to the requirements of Subsection 745.01.

707.02 MORTAR, TYPE II. Type II mortar is generally used as a joint filler for concrete and clay pipes, stone and brick masonry, and for repointing. It shall be used in small quantities as needed and shall not be retempered or used after it has begun to set.

The mortar shall be composed of one part cement and two parts sand, and shall be mixed with sufficient water to form a plastic composition.

The cement, sand, and water shall meet the requirements specified in Subsection 707.01.

707.03 MORTAR, TYPE IV. Type IV mortar is used when a non-shrinking cement mortar is required.

(a) Packaging. The manufacturer's name, product designation, and recommendations for surface preparation, mixing, placing, finishing, and curing shall be clearly outlined on the product packaging. Handling precautions and toxicity warnings shall be printed on all containers. The expiration date and lot number shall appear on each package of material delivered to the project site.

(b) Sampling and Testing. Upon request, the Agency's Materials and Research Section will furnish a list of products that have been tested and are considered satisfactory. Should the Contractor wish to use a product not included on the approved list, an alternate product may be submitted for consideration. Application for alternate material approval shall be submitted to the Agency's Materials and Research Section accompanied by a 45 kg (100 pound) sample of the product and complete MSDS information. Upon approval, the product name and manufacturer will be placed on the Agency's approved list. A minimum period of two months shall be allowed for testing purposes.

(c) Performance Requirements.

(1) Compressive Strength. The neat material shall exhibit a minimum three-day compressive strength of 17.2 MPa (2500 pounds per square inch), a minimum seven-day compressive strength of 24.1 MPa (3500 pounds per square inch) and a minimum 28-day compressive strength of 34.5 MPa

(5000 pounds per square inch) when tested in accordance with AASHTO T 106.

(2) Freeze-Thaw Durability. Resistance to rapid freezing and thawing shall be determined in accordance with AASHTO T 161, Procedure A, as modified by the Agency's Materials and Research Section for use of a 3 percent sodium chloride solution. The material shall exhibit no more than an 8 percent loss in mass (weight) after 300 cycles.

(3) Volume Stability. The material shall exhibit a maximum height change of +0.3 percent and a minimum height change of 0.0 percent when tested in accordance with ASTM C 1090.

(d) Other. Instead of a commercially prepared product, the Contractor may produce a non-shrinking cement mortar composed of one part cement, one part sand, and aluminum powder mixed with sufficient water to form a plastic composition as follows:

From 2 to 4 g of the superfine unpolished variety of aluminum powder shall be added for each sack of cement used in the mortar. The exact amount of aluminum powder shall be as directed by the Engineer. The dosage per batch of mortar shall be carefully measured. The aluminum powder shall be blended with pozzolan or pumicite in the proportion of one part aluminum powder to 50 parts pozzolan or pumicite by mass (weight). The blend shall be thoroughly mixed with the cement and sand before water is added to the batch, as it has a tendency to float on water. The amount of the blend used shall vary from 128 g (4.5 ounces) per sack of cement for a placing temperature of 21 °C (70 °F) to 198 g (7 ounces) per sack of cement for a placing temperature of 5 °C (40 °F). After all ingredients are added, the batch shall be mixed for three minutes. Batches of mortar shall be placed within 45 minutes after mixing as the action of the aluminum powder becomes very weak after this time and it shall not be retempered or used after it has begun to set.

The cement, sand, and water shall meet the requirements specified in Subsection 707.01.

707.04 JOINT SEALER, POURABLE.

(a) Joint Sealer, Hot Poured. This material shall consist of a hot applied, single-component, low-modulus, elastic sealant meeting the requirements of AASHTO M 301. The sealant shall allow up to 200 percent elongation at temperatures down to -29 °C (-20 °F) when placed in a typical joint configuration.

(b) Joint Sealer, Cold Poured. This material shall consist of a cold applied, two-component, low-modulus, elastic sealant capable of 200 percent elongation at temperatures down to -29 °C (-20 °F) when placed in a typical joint configuration.

(c) Backer Rod. Backer rod shall be 100 percent 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 210 °C (410 °F), shall remain stable down to -29 °C (-20 °F), and shall not cause bubbling of the sealant bead. The backer rod shall be approximately 3 mm (1/8 inch) larger in diameter than the width of the joint in which it is used.

(d) Certification. Either a Type B or a Type C Certification shall be furnished in accordance with Subsection 700.02.

707.05 JOINT SEALER, POLYURETHANE. Polyurethane joint sealer shall consist of a single or a two-component, cold-applied, polyurethane, elastomeric compound for use in expansion joints in widths up to 150 mm (6 inches). The sealer shall be suitable for installation at temperatures above 7 °C (45 °F) and below 27 °C (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:

Name and Address of Manufacturer
Name of Product or Component Identification
Batch Number
Date of Manufacture

The manufacturer shall furnish with each shipment complete instructions for its storage, proportioning, mixing, handling, joint preparation, and joint installation procedures and complete MSDS information. A copy of these instructions shall be furnished to the Engineer.

(f) Performance Requirements for Two-Component Materials. The joint sealer system, consisting of sealer and primer, shall meet the requirements of the following:

Sealer system shall meet the performance requirement of Federal Specification TT-S-00227E, Sealing Compound, Elastomeric Type, Class A.

(g) Performance Requirements for Single-Component Materials. The joint sealer system shall meet the requirements of following:

Sealer system shall meet the performance requirement of Federal Specification TT-S-00230C, Sealing Compound, Type II, Class B.

(h) Certification. Either a Type B or a Type C Certification shall be furnished in accordance with Subsection 700.02.

707.06 JOINT SEALER, PREFORMED NEOPRENE.

(a) Properties. Preformed neoprene joint sealer shall conform to the requirements of AASHTO M 220. 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 Section at the time of the 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 and reclosed.

(b) Certification. Either a Type B or a Type C Certification shall be furnished in accordance with Subsection 700.02.

707.07 PREFORMED FABRIC MATERIAL.

(a) Properties. Preformed fabric material shall be a multi-layered sheet composed of multi-plies of 510 $g/m^2$ ± 5 percent (15 ounces per square yard ± 5 percent) polyester fabric laminated with butadiene acrylonitrile, vulcanized to form an integral laminate.

Physical properties of the laminate shall meet the following requirements:

| | Number of Plies | | |
|---|---|---|---|
| | 2 | 3 | 5 to 8 |
| Minimum Mass (Weight) per Unit Area of laminate, kg/m$^2$ (lbs./ft$^2$) | 3.65 (0.75) | 4.15 (0.85) | 19.50 (4.0) |
| Minimum Thickness, mm (in.) | 3.2 (1/8) | 4.0 (5/32) | 19.0 (3/4) |
| Minimum Ultimate Tensile Strength of laminate, kN/m (lbs./in.) of width | 140 (800) | 210 (1200) | 350 (2000) |
| Maximum Elongation at Ultimate Tensile | 30% | 30% | 30% |
| Maximum Elongation at 10% of Ultimate Tensile | 3% | 3% | 3% |

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.08 PREFORMED JOINT FILLER, CORK AND ASPHALT-TREATED FELT.

(a) Properties. Preformed cork joint filler shall conform to the requirements of AASHTO M 153, Type II, unless otherwise specified. Asphalt-treated felt shall conform to the requirements of ASTM D 226, unless otherwise specified.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.09 PREFORMED JOINT FILLER, CLOSED-CELL FOAM.

(a) Properties. Preformed joint filler shall be a closed-cell polyethylene or PVC foam, premolded to a semi-rigid consistency.

When tested in accordance with ASTM D 3575, the premolded foam shall have the following physical properties:

| Property | Test Procedure | Minimum | Maximum |
|---|---|---|---|
| Density, kg/m$^3$ (lbs./ft$^3$) | Test C | 48 (3) | 80 (5) |
| Buoyancy, kg/m$^3$ (lbs./ft$^3$) | Test AA | 830 (52) | 930 (58) |
| Tensile Strength, kPa (psi) | Test E | 240 (35) | --- |
| Water Absorption, % by volume | Test G | --- | 0.5 |
| Tensile Elongation, % | Test E | 65 | 75 |
| Compressive Strength, kPa (psi) | Test B @ 25% | 70 (10) | 100 (15) |
| Compressive Strength, kPa (psi) | Test B @ 50% | 140 (20) | 170 (25) |
| Compressive Set Not Recovered, % original thickness | Test A | 10 | 15 |

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.10 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 given in this Section. No reclaimed, scrap, or reprocessed PVC shall be used.

(a) Physical Properties. The finished waterstop shall conform to the requirements of the following table:

TABLE 707.10A - PVC WATERSTOP

| Property | ASTM Procedure | Minimum | Maximum |
|---|---|---|---|
| Tensile Strength, kPa (psi) | D 412 | 9650 (1400) | --- |
| Ultimate Elongation, % | D 412 | 250 | --- |
| Low Temperature Brittleness | D 746 | * | --- |
| Durometer Hardness - Shore Type A | D 2240 | 60 | 80 |
| Stiffness in Flexure, kPa (psi) | D 747 | 2750 (400) | --- |
| Alkali Resistance (10% NaOH) Mass (Weight) Change, % | D 543 | -0.10 | +0.25 |
| Durometer Hardness Change | --- | -5 | +5 |

* No cracking or chipping permitted on three specimens at -29 °C (-20 °F).

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.11 RUBBER GASKETS.

(a) Properties. Rubber gaskets for culvert pipe joints shall conform to the requirements of AASHTO M 198, Type A.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.12 JOINT SEALER, BUTYL RUBBER TAPE.

(a) Properties. Butyl rubber joint sealer tape shall be a flexible plastic gasket conforming to AASHTO M 198, Type B. The sealant shall be in roll form with release paper backing dimensioned to the width and thickness specified.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02

707.13 ALUMINUM IMPREGNATED CAULKING COMPOUND. Aluminum impregnated caulking compound is generally used to protect the surfaces of aluminum alloy in contact with other metals, wood, or portland cement concrete. The compound shall be impregnated with aluminum flake or powder and shall be of such consistency and properties that it can be readily applied with a trowel, putty knife, or caulking gun without pulling or drawing. The material shall meet the approval of the Engineer.

707.14 PREFORMED JOINT FILLER, BITUMINOUS TYPE.

(a) Properties. Bituminous type preformed joint filler shall conform to the requirements of AASHTO M 33 or AASHTO M 213.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 708 - PAINT MATERIALS AND MIXED PAINTS

708.01 GENERAL REQUIREMENTS.

(a) General. 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 and 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.

The paint, when applied by brush or spray to a smooth vertical metal surface at a wet film thickness of 75 μm (3 mils), shall dry without running, streaking, or sagging.

(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:

Name and Address of Manufacturer
Manufacturer's Batch Number
Date of Manufacture
Vermont Paint Number, Name, and Color
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) Sampling, Testing, and Certification. No paint or stain shall be used until it has been tested and approved by the Agency's Materials and Research Section.

(1) Sampling. At least one sample, not less than 1 L (1 quart), shall be taken for each batch of paint or stain to be used regardless of whether or not the quality of the paint is certified by the manufacturer.

(2) Testing. Testing of paints shall be done in accordance with FED-STD-141C or ASTM test methods, at the discretion of the Agency's Materials and Research Section.

(3) Certification.

a. Shop and Field Primers Used on Aluminum and Galvanized Surfaces. Paints used under this Section shall be covered by a Type A Certification in accordance with Subsection 700.02.

b. Paint for Pavement Markings. Pigment and vehicle constituents used in the paints shall be covered by a Type A Certification in accordance with Subsection 700.02.

(d) Identification. To provide a means of identification for all paint, the applicable identification number and name taken from the following list shall be printed on all Test Reports and container labels.

(1) Primer Coatings for Structural Steel and Other Metals. RESERVED

(2) Intermediate Coatings for Structural Steel and Other Metals. RESERVED

(3) Finish Coatings for Structural Steel and Other Metals. RESERVED

(4) Coatings for Wood.

VT 4.01 Dark Brown Oil Base Stain

(5) Paint For Traffic Signs.

VT 5.01 Black Enamel
VT 5.02 Blue Enamel
VT 5.03 Green Enamel
VT 5.04 Red Enamel
VT 5.05 White Enamel
VT 5.06 Yellow Enamel
VT 5.07 Brown Enamel
VT 5.08 Orange Enamel

(6) Paint For Traffic Control Signals.

VT 6.01 Flat Black Enamel
VT 6.02 Yellow Enamel

(7) Paint For Pavement Marking.

| | |
|---|---|
| VT 7.01 | White Traffic Paint |
| VT 7.02 | Yellow Traffic Paint |
| VT 7.05 | White Traffic Paint, Fast Dry |
| VT 7.06 | Yellow Traffic Paint, Fast Dry |

(e) Pigment Constituents. RESERVED

(f) Vehicle Constituents. RESERVED

708.02 THIS SUBSECTION RESERVED

708.03 THIS SUBSECTION RESERVED

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. It shall contain effective rust inhibitors and conform to the following:

| | |
|---|---|
| Appearance (Color): | Brown Green |
| Flash, COC, Min.: | 66 ºC (150 ºF) |
| Undist. (D-127): | 280 (∀ 30 units) |
| Melting Point, Min.: | 63 ºC (145 ºF) |
| Thinner, % by mass (weight), Max.: | 20 |
| Density, gm/ml at 16 ºC, Min.: | 0.839 |
| (lbs./gal at 60 ºF, Min.): | (7.00) |
| Approximate NLGI Grease Grade: | No. 2 before solvent evaporation and No. 5 after solvent evaporation. |

708.05 COATINGS FOR WOOD.

(a) VT 4.01 Dark Brown Oil Base Stain. The stain is used as a protective coating for wood surfaces.

The stain shall conform to the requirements of Table 708.05A.

TABLE 708.05A - DARK BROWN OIL BASE STAIN

| | Minimum | Maximum |
|---|---|---|
| Pigment: | | |
| The pigment shall consist of pure mineral pigments combined in proportions necessary to match the specified color. | | |
| Vehicle: | | |
| Heavy Bodied Linseed Oil, % | 15 | --- |
| Mineral Spirits, % | --- | 85 |
| Stain: | | |
| Pigment, % | 15 | --- |
| Vehicle, % | --- | 85 |
| Density, g/L (lbs./gal) | 910 (7.5) | --- |
| Drying Time, hrs., dry to recoat | --- | 24 |
| Fineness of Grind (Hegman Scale) | 4 | --- |
| Color: | | |
| Dark Brown to match color standard supplied by the Agency's Materials and Research Section. | | |

708.06 PAINT FOR TRAFFIC SIGNS. Paint for traffic signs shall consist of ready-mixed enamels suitable for exterior use on primed wood and metal surfaces. They shall conform to the requirements of CID A-A-2962. The type of cure shall be as shown on the Plans. Porcelain enamels shall conform to the requirements of Porcelain Enamel Institute, Inc. Specification ALS-105.

The Color Tolerance Charts prepared by FHWA shall be used to determine acceptable color match for blue, brown, green, orange, red, and yellow traffic sign paints.

(a) VT 5.01 Black Enamel. The color shall be an acceptable match to Chip No. 17038 in FED-STD-595B.

(b) VT 5.02 Blue Enamel. The color shall be an acceptable match to Chip No. 15090 in FED-STD-595B.

(c) VT 5.03 Green Enamel. The color shall be an acceptable match to Chip No. 14109 in FED-STD-595B.

(d) VT 5.04 Red Enamel. The color shall be an acceptable match to Chip No. 11105 in FED-STD-595B.

(e) VT 5.05 White Enamel. The color shall be an acceptable match to Chip No. 17875 in FED-STD-595B.

(f) VT 5.06 Yellow Enamel. The color shall be an acceptable match to Chip No. 13538 in FED-STD-595B.

(g) VT 5.07 Brown Enamel. The color shall be an acceptable match to a chip provided by the Agency's Materials and Research Section.

(h) VT 5.08 Orange Enamel. The color shall be an acceptable match to a chip provided by the Agency's Materials and Research Section.

708.07 PAINT FOR TRAFFIC CONTROL SIGNALS. Paint for traffic control signals shall consist of ready-mixed enamels suitable for exterior use on primed metal surfaces.

(a) VT 6.01 Flat Black Enamel. The color shall conform to the requirements of Federal Specification TT-E-527. The color shall be an acceptable match to Chip No. 37038 in FED-STD-595B.

(b) VT 6.02 Yellow Enamel. The color shall conform to the requirements of CID A-A-2962. The color shall be an acceptable match to Chip No. 13538 in FED-STD-595B.

708.08 PAINT FOR PAVEMENT MARKINGS. Ready-mixed white and yellow traffic paint suitable for marking on either bituminous or portland cement concrete pavements shall conform to the following requirements:

(a) Regular Dry White and Yellow Traffic Paint. This traffic paint shall consist of properly formulated pigment and vehicle to give the desired results. When used with reflecting glass beads, the paint shall bind the beads in such a fashion that it will produce maximum adhesion, refraction, and reflection. 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 600 g/L (5 pounds per gallon) of paint.

(1) Materials.

a. Pigments. The pigments used shall be those described below and shall conform to the following requirements:

1. Titanium Dioxide. Titanium dioxide shall be of the rutile type and shall meet the requirements specified in ASTM D 476, Type II, Class II.

2. Medium Chrome Yellow. Medium chrome yellow shall conform to ASTM D 211, Type III.

3. Calcium Carbonate. Calcium carbonate shall be a natural, non-reactive, low oil absorption product with a minimum $CaCO_3$ content of 97 percent.

b. Vehicle. The vehicle shall consist of pure oil modified alkyd resin, petroleum distillate thinner, driers, and wetting and anti-skinning agents, complying with the following requirements:

| | |
|---|---|
| Solid Content by Mass (Weight): | 50% Minimum |
| Solvent*: | V.M. & P. Naphtha |
| Color (Gardnes - 1933): | 9 Maximum |
| Acid Number of Non-Volatiles: | 7 Maximum |
| Viscosity: | J-N |
| Density, g/L (lbs./gal) (Gardner): | 900 (7.5) Minimum |

* The V.M. & P. Naphtha shall be a petroleum distillate, free from insoluble matter, lubricating oil, wax, and water; shall have no acid or corrosive action; and shall conform to the following requirements when tested in accordance with ASTM D 86.

| | |
|---|---|
| Initial Boiling Point: | 88 to 107 °C (190 to 225 °F) |
| End Point: | 177 °C (350 ºF) Maximum |
| 50% Distillate over at: | 132 °C (270 ºF) Maximum |
| Dry Point: | 132 to 177 °C (270 to 350 ºF) |
| Residue: | 1.0% Maximum |
| Specific Gravity at 60/16 °C (60/60 °F): | 0.735 to 0.775 |

The resin solids by analysis shall conform to the following requirements:

| | |
|---|---|
| Phthalic Anhydride: (ASTM D 563) | 32.0% Minimum |
| Fatty Acids: (FED-STD-141C) | 48.0 to 53.0% |
| Iodine Number of Fatty Acids: | 115 to 130 |
| Resin and Resin Derivatives: | None |
| Natural Resins: | None |
| Other Synthetic Resins: | None |

(2) Composition. The specified materials shall be mixed in proportion by mass (weight) according to the following formulae, and the paint shall be furnished ready-mixed.

| | Percent by Mass (Weight) | |
|---|---|---|
| | Minimum | Maximum |
| Pigment | 55.0 | 60.0 |
| Vehicle | 40.0 | 45.0 |

VT 7.01 REGULAR DRY WHITE TRAFFIC PAINT

| Pigment | Percent by Mass (Weight) | |
|---|---|---|
| | Minimum | Maximum |
| Rutile Titanium Dioxide | 15.0 | --- |
| Calcined Kaolin Clay | --- | 18.0 |
| Calcium Carbonate | Remainder | |
| Wetting and Suspension Agents | --- | 1.4 |

VT 7.02 REGULAR DRY YELLOW TRAFFIC PAINT

| Pigment | Percent by Mass (Weight) | |
|---|---|---|
| | Minimum | Maximum |
| Medium Chrome Yellow | 15.0 | --- |
| Calcined Kaolin Clay | 16.0 | 18.0 |
| Calcium Carbonate | Remainder | |
| Wetting and Suspension Agents | 1.2 | 1.4 |

VEHICLE FOR WHITE AND YELLOW TRAFFIC PAINT

| Pigment | Percent by Mass (Weight) | |
|---|---|---|
| | Minimum | Maximum |
| Alkyd Resin Solution (50% Solids) | 83 | 85 |
| Petroleum Distillate Thinners, Driers, and Anti-Skinning Agents | --- | 17 |

The white and yellow paint shall have a minimum of 75 percent total non-volatile when tested in accordance with FED-STD-141C and ASTM D 2369.

Samples of shipment may be subjected to other tests such as x-ray analysis, infrared, and/or ultraviolet spectral analysis.

(3) Laboratory and Field Tests.

a. Consistency. The consistency of the paint shall be not less than 67 or more than 77 Krebs units at 25 °C (77 °F) when tested in accordance with ASTM D 562.

b. Density. The density of the paint shall be 1.40 kg/L (11.7 pounds per gallon) minimum when tested in accordance with ASTM D 1475.

c. Flexibility. The paint shall not show cracking or flaking when subjected to the flexibility test of Federal Specification TT-P-115E.

d. Grind. The paint shall have a minimum fineness grind of three as determined on the North Standard Fineness of Grind Gage when tested in accordance with ASTM D 1210.

e. Dry Opacity.

1. White Paint. When applied with a suitable doctor blade capable of producing a uniform wet film thickness of 75 μm (3 mils) and tested in accordance with FED-STD-141C, white paint shall have a minimum dry contrast of 0.88.

2. Yellow Paint. When tested in the above manner, yellow paint shall have a minimum dry contrast of 0.94.

f. Bleeding Test. To determine the resistance to bleeding and discoloration, 100 by 100 mm (4 × 4 inch) glass panels shall be coated with a film of RC 800* cutback asphalt. The bituminous film shall be applied with a suitable doctor blade capable of producing a uniform wet film thickness of 25 to 50 μm (1 to 2 mils). After curing for 24 hours, the panels shall be baked in an oven at 66 to 71 °C (150 to 160 °F) for five hours. The baked film shall be aged in the laboratory for 72 hours prior to application of paint. The paint shall be applied on the bituminous-coated panel by means of a suitable doctor blade capable of producing a uniform wet film thickness of 230 to 305 μm (9 to 12 mils). After 24 hours of air curing, the painted panels shall be rated by comparison with ASTM D 868. A minimum rating of five is required.

* A sample of the bituminous material will be furnished upon request by the Vermont Agency of Transportation, Materials and Research Section, National Life Building, Montpelier, Vermont 05633-5001.

g. Drying Time. Using normal application procedures on dry pavement during daylight hours, a wet paint film thickness of 380 ± 25 μm (15 ± 1 mil), with a glass bead density of 600 g/L (5 pounds per gallon) of paint, shall dry to no-pick-up in a maximum of 30 minutes when the pavement temperature is between 15 and 50 °C (60 and 120 °F) and relative humidity is 70 percent or less.

The no-pick-up time shall be determined by passing over the line, applied as specified above, in a simulated passing maneuver with a passenger car. If there is no visible resultant deposition of the paint onto the adjacent pavement surface when viewed from a distance of 15 m (50 feet), it shall be considered as showing no-pick-up and conforming to this drying time requirement.

h. Color.

1. White Paint. The color after drying shall be pure white, free from tint, and shall not darken under service.

2. Yellow Paint. The color shall conform to the so-called "highway yellow" as approved by FHWA. The yellow color shall be obtained by the use of lead chromate pigment only; no iron oxide will be permitted.

i. Settlement. Anti-settling and wetting agents shall be used in sufficient quantity so that after a 100-day storage period in the original, unopened, filled container, the paint shall not show settlement or caking in the container to the extent that it cannot be readily and quickly broken up with a paddle to a uniform consistency.

j. Skinning. An anti-skinning agent shall be used in sufficient quantity so that the paint will not skin within 48 hours in a closed container 75 percent full.

k. Water Resistance Test. Three panels shall be prepared as in the flexibility test. One shall then be placed in water at room temperature for 48 hours; the second in hot water at 93 °C (200 °F) for one hour, and the third in boiling water for 15 minutes. The condition of the paint on each panel shall be noted two hours after removal from the water. There shall be no marked disintegration of the paint.

(b) Fast Dry White and Yellow Traffic Paint (66 to 71 °C (150 to 160 °F) Application Temperature). This traffic paint shall be a fast setting, non-tracking paint, properly formulated and manufactured from first grade materials and free from defects that might adversely affect the application and serviceability of the finished product. When used with reflecting glass beads, the paint shall bind the beads in such a fashion that it will produce maximum adhesion, refraction, and reflection. 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 600 g/L (5 pounds per gallon) of paint.

The paint shall be well ground; shall not settle excessively or cake in the container; and shall not thicken, thin, liver or curdle, or otherwise change in consistency while in storage. It shall not skin in storage. The quality shall be such that it will cause no bleeding of a bituminous road surface over which it may be applied, sufficient to impair the color or visibility of the paint.

(1) Materials.

a. Pigments. The pigments used shall be those described below and shall conform to the following requirements:

1. Titanium Dioxide. Titanium dioxide shall be of the rutile type and shall meet the requirements specified in ASTM D 476, Type II, Class II.

2. Medium Chrome Yellow. Medium chrome yellow shall conform to ASTM D 211, Type III.

3. Calcium Carbonate. Calcium carbonate shall be a natural, non-reactive, low oil absorption product with a minimum $CaCO_3$ content of 97 percent.

4. Siliceous Extenders. Siliceous extenders shall conform to ASTM D 34, D 718, and D 719.

b. Vehicle. The alkyd resin shall be a pure oxidizing phthalic anhydride, air dry type.

The composition of the resin solids by analysis shall conform to the following requirements:

| | |
|---|---|
| Phthalic Anhydride: (ASTM D 563) | 34.0% Minimum |
| Fatty Acids: (FED-STD-141C) | 31.0% Minimum |
| Iodine Number of Fatty Acids: | 115 Minimum |
| Rosin and Rosin Derivatives: | None |
| Natural Resins: | None |
| Other Synthetic Resins: | None |

The solvent shall be free from insoluble matter, lubricating oil, wax, and water.

(2) Composition. The specified materials shall be mixed in proportion by mass (weight) according to the following formulae, and the paint shall be furnished ready-mixed.

| | Percent by Mass (Weight) | |
|---|---|---|
| | Minimum | Maximum |
| Pigment | 53.0 | 57.0 |
| Vehicle | 43.0 | 47.0 |

VT 7.05 FAST DRY WHITE TRAFFIC PAINT

| Pigment | Percent by Mass (Weight) | |
|---|---|---|
| | Minimum | Maximum |
| Rutile Titanium Dioxide | 15.0 | --- |
| Siliceous Extenders | 34.0 | 36.0 |
| Calcium Carbonate | --- | 49.0 |
| Wetting and Suspension Agents | 1.2 | 1.4 |

VT 7.06 FAST DRY YELLOW TRAFFIC PAINT

| Pigment | Percent by Mass (Weight) | |
|---|---|---|
| | Minimum | Maximum |
| Siliceous Extenders | --- | 40.0 |
| Medium Chrome Yellow | 15.0 | --- |
| Calcium Carbonate | --- | 46.0 |
| Wetting and Suspension Agents | 1.2 | 1.4 |

All pigments shall comply with the following applicable requirements:

a. Up to 1.5 percent titanium oxide may be added to obtain a brighter yellow color. Iron oxide shall not be used.

b. The white and yellow paint shall have a minimum of 70 percent total non-volatiles when tested in accordance with FED-STD-141C.

VEHICLE FOR WHITE AND YELLOW FAST DRY TRAFFIC PAINT

| Pigment | Percent by Mass (Weight) | |
|---|---|---|
| | Minimum | Maximum |
| Non-Volatiles | 39.0 | --- |
| Thinners, Driers, and Anti-Skinning Agents | --- | 61.0 |

(3) Laboratory Tests.

a. Consistency. The consistency of the paint shall be not less than 90 or more than 110 Krebs units at 25 °C (77 °F) when tested in accordance with ASTM D 562. The pigmented binder shall have good spraying characteristics when material is heated to application temperature of between 66 and 71 °C (150 and 160 °F).

b. Density. The density of the paint shall be 1.44 kg/L (12.0 pounds per gallon) minimum when tested in accordance with ASTM D 1475.

c. Flexibility. The paint shall not show cracking or flaking when subjected to the flexibility test of Federal Specification TT-P-115E.

d. Directional Reflectance. The daylight directional reflectance of the paint (without glass beads) shall be not less than 84 percent for white and not less than 50 percent for yellow relative to magnesium oxide when tested in accordance with FED-STD-141C. Furthermore, the yellow paint, after drying, shall essentially match Color No. 33538 of FED-STD-595B.

e. Dry Opacity. When applied with a suitable doctor blade capable of producing a uniform wet film thickness of 127 μm (5 mils) and tested in accordance with FED-STD-141C, the paint shall have a minimum dry contrast of 0.96 for both white and yellow paint.

f. Bleeding Test. To determine the resistance to bleeding and discoloration, 100 by 100 mm (4 × 4 inch) glass panels shall be coated with a film of RC 800* cutback asphalt. The bituminous film shall be applied with a suitable doctor blade capable of producing a uniform wet film thickness of 25 to 50 μm (1 to 2 mils). After curing for 24 hours, the panels shall be baked in an oven at 66 to 71 °C (150 to 160 °F) for five hours. The baked film shall be aged in the laboratory for 72 hours prior to application of paint. The paint shall be applied on the bituminous-coated panel by means of a suitable doctor blade capable of producing a uniform wet film thickness of 230 to 305 μm (9 to 12 mils). After 24 hours of air curing, the painted panels shall be rated by comparison with ASTM D 868. A minimum rating of four is required.

* A sample of the bituminous material will be furnished upon request by the Vermont Agency of Transportation, Materials and Research Section, National Life Building, Montpelier, Vermont 05633-5001.

g. Drying Time. Under actual operating conditions on dry pavement during daylight hours, a wet paint film thickness of 380 ± 25 μm (15 ± 1 mil), with a glass bead density of 600 g/L (5 pounds per gallon) of paint, shall dry to no-pick-up in a minimum of 20 seconds and a maximum of 60 seconds when the pavement temperature is between 5 and 50 °C (40 and 120 °F) and relative humidity is 80 percent or less. The paint shall be applied such that it is at a temperature of 66 to 71 °C (150 to 160 °F) at the spray gun.

The no-pick-up time shall be determined by passing over the line, applied as specified above, in a simulated passing maneuver with a passenger car. If there is no visible resultant deposition of the paint onto the adjacent pavement surface when viewed from a distance of 15 m (50 feet), it shall be considered as showing no-pick-up and conforming to this drying time requirement.

(c) Epoxy Paint. This paint shall be one of the paints on the approved list on file at the Agency's Materials and Research Section.

708.09 GLASS BEADS.

(a) General Requirements for Beads. The beads shall be manufactured from glass and furnished in waterproof containers. They shall be clean and dry and not caked in the containers. They shall be moisture resistant.

(b) Color. The glass beads shall be colorless, clean, and transparent. They shall be free from milkiness, pits, and excessive air bubbles.

(c) Shape. The glass beads shall be smooth and spherical in shape, and containing not more than 20 percent of irregular or fused particles. At least 80 percent shall be true spheres when tested in accordance with ASTM D 1155.

(d) Gradation. The glass beads shall conform to the following gradation when tested in accordance with ASTM D 1214:

| Sieve Designation | Percentage by Mass (Weight) Passing Sieves |
|---|---|
| 850 μm (No. 20) | 100 |
| 600 μm (No. 30) | 80 to 95 |
| 300 μm (No. 50) | 15 to 35 |
| 150 μm (No. 80) | 0 to 5 |

(e) Refractive Index. The glass beads when tested by liquid immersion method at 25°C (77 ºF) shall show an index of refraction within the range of 1.50 to 1.60.

(f) Silica Content. The silica ($SiO_2$) content of the glass beads shall be not less than 60 percent.

(g) Physical Stability. True spheres (determined as specified in part (c) above) passing an 850 μm (No. 20) sieve and retained on 600 μm (No. 30) and 425 μm (No. 40) sieves shall be tested in accordance with ASTM D 1213. The minimum crushing strength shall be:

| | |
|---|---|
| Passing 850 μm (No. 20), Retained on 600 μm (No. 30): | 178 N (40 pounds) |
| Passing 600 μm (No. 30), Retained on 425 μm (No. 40): | 133 N (30 pounds) |

(h) Flow Characteristics. Beads shall flow properly when tested in accordance with the following procedures:

(1) Beads for Reflectorizing Traffic Paint and Beads for Incorporation into Thermoplastic. Flow shall meet the requirements of AASHTO M 247, Section 4.4.1.

(2) Beads for "Drop On" to Thermoplastic. Flow shall meet the requirements of AASHTO M 247, Section 4.4.2.

(i) Adherence Coating Test. Prepare a solution by measuring 0.2 g of dansyl chloride and dissolving it in 25 mL of acetone. This solution can be used for several tests during the day, but must be kept refrigerated in a closed dark container between uses. Make a fresh solution daily.

(1) Measure 10 g of beads and place on a filter paper in a Buchner funnel.

(2) Saturate the glass bead sample with dansyl chloride solution using an eyedropper.

(3) Allow to stand for 30 seconds and then rinse off the excess reagent by pouring 100 mL of acetone over the beads in the funnel. Suction should be on during this step. All yellow color must be removed from the bead surface.

(4) Allow the beads to dry at room temperature for five to ten minutes.

(5) Place glass beads on glass filter paper and inspect under ultraviolet light. Inspection must be in a dark room. A yellow-green fluorescence will be observed with properly coated beads.

a. U-V Light of Intensity. 7000 μW/cm (from a unit such as a Model B-100-R from Fisher Scientific).

(j) Flotation. Beads for "drop on" to thermoplastic shall meet the flotation requirements of AASHTO M 247, Section 4.5.

708.10 THERMOPLASTIC. Acceptable thermoplastic pavement markings shall be one of the thermoplastic pavement markings on the approved list on file at the Agency's Materials and Research Section.

708.11 RAISED PAVEMENT MARKERS. Acceptable Type II markers shall be one of the raised pavement markers on the approved list on file at the Agency's Materials and Research Section, telephone: (802) 828-2561.

708.12 PAVEMENT MARKING TAPE. Type I tape shall be one of the non-removable pavement marking tapes on the approved list on file at the Agency's Materials and Research Section.

Type II tape shall be one of the removable pavement marking tapes on the approved list on file at the Agency's Materials and Research Section.

708.13 PREFORMED TRAFFIC MARKINGS AND SYMBOLS. Preformed traffic markings made of the same material as that of an approved permanent Type I tape will be accepted under a Type B Certification by the manufacturer identifying that the material is the same as the approved product.

708.14 LINE STRIPING TARGETS. Line striping targets shall be one of the line striping targets on the approved list on file at the Agency's Materials and Research Section.

## 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 the requirements of 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 material entering into a finished structure shall be 20 percent.

(2) Treated Lumber and Timber. The maximum moisture content of material prior to treatment shall be 20 percent. Material treated with water-borne preservatives in accordance with AWPA standards shall be dried after treatment to a moisture content not exceeding 20 percent and shall be maintained at a moisture content of 20 percent 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 following requirements:

(1) Southern and Western Material. The material shall meet the allowable unit stress requirements for "Select Structural Grade" material as specified in AASHTO *Standard Specifications for Highway Bridges*.

(2) Eastern (Local) Material. The material shall be a grade capable of meeting a minimum fiber stress in bending of 8.3 MPa (1200 pounds per square inch).

(d) Dimensions.

(1) Full-Sawn. Full-sawn lumber sizes are nominal sawn sizes before either seasoning or planing. Pieces shall be rough-sawn to 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. Rough-sawn lumber is typically 3 mm (1/8 inch) larger in each dimension than standard dressed lumber. Thickness and width dimensions are somewhat variable depending upon the sawmill equipment used.

(3) Dressed. Dressed lumber sizes are the finished planed dimensions of material after seasoning. Net finished dimensions for dressed lumber shall be 13 mm (1/2 inch) less than nominal, except that the net width of dressed

lumber exceeding 152 mm (6 inches) shall be 19 mm (3/4 inch) less than nominal.

(e) Soundness. Material shall be sound and free from any incipient or advanced form of decay.

(f) Preservative Treatment. Preservative treatment of lumber and timber materials shall conform to Subsection 726.01. Unless otherwise specified, the treatment for lumber and timber materials shall conform to Type IV preservative.

(g) Miscellaneous Hardware.

(1) Structural steel shapes and fabricated materials shall conform to the requirements of the Contract and the specific material requirements as specified in Sections 714 and 715.

(2) Bolts, nuts, and washers shall conform to the requirements of Subsection 714.04.

(3) Nails, spikes, and lag screws shall be of low to medium carbon steel and shall be of good commercial quality.

Unless otherwise specified, all hardware shall be galvanized in accordance with AASHTO M 111M/M 111 or AASHTO M 232M/M 232, whichever is applicable.

(h) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

709.02 NONSTRUCTURAL LUMBER. Material furnished under this Subsection shall be for non load-carrying, structural applications with a maximum nominal thickness of 50 mm (2 inches) (e.g., boarding, siding, trim, etc.). Lumber shall be seasoned or kiln dried Spruce, Southern Pine, or Western Fir, unless otherwise specified in the Contract.

(a) Dimensions.

(1) Full-Sawn. When required in the Contract, lumber shall be furnished to the full-sawn nominal dimensions specified.

(2) Dressed. Unless otherwise specified, all lumber shall be S4S.

(b) Moisture Content. The moisture content shall be as specified in Subsection 709.01(b).

(c) Soundness. Lumber shall be sound and free from any incipient or advanced form of decay.

(d) Preservative Treatment. Preservative treatment of lumber shall conform to Subsection 726.01. Unless otherwise specified, the treatment shall conform to Type IV preservative.

(e) Hardware. Hardware shall be as specified in Subsection 709.01(g).

(f) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

709.03 STRUCTURAL GLUED LAMINATED TIMBER.

(a) Material. Unless otherwise shown on the Plans, structural glued laminated timber shall be fabricated from Southern Pine, Coastal Douglas Fir, Western Hemlock, or Western Larch and shall meet the requirements of Division II, Section 16 of the AASHTO *Standard Specifications for Highway Bridges*.

Adhesives used in the lamination process shall be for wet-use conforming to ASTM D 2559 and shall comply with all other requirements of AITC A190.1.

(b) Seasoning. All material shall have a moisture content not exceeding 20 percent prior to preservative treatment.

(c) Preservative Treatment. All timber shall be treated with Type II pentachlorophenol preservative (heavy oil solvent) conforming to Subsection 726.01.

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.

(1) Connections, splices, and miscellaneous hardware shall be fabricated from material conforming to Subsection 714.02 and shall be galvanized in accordance with AASHTO M 111M/M 111.

(2) Bolts, nuts, and washers shall be either material conforming to Subsection 714.04 and galvanized in accordance with AASHTO M 232M/M 232 or stainless steel conforming to ASTM F 738M, Property Class A1-70, Condition CW, with nuts conforming to ASTM F 836M, Property Class A1-70, Condition CW.

(3) All welding shall conform to the requirements of Subsection 506.10.

(e) Dimensions. The designated dimensions for glued laminated timber shall be taken as the actual net dimensions.

(f) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## 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 170M with the following notes or exceptions:

(a) Design Requirements. The circumferential reinforcement in Table 3 of AASHTO M 170M for 600 mm (24 inch), Class III, Wall B pipe shall be 210 $mm^2/m$ (0.1 square inch per foot) of pipe wall. Elliptical reinforcement shall not be used in circular pipes.

All pipe 600 mm (24 inches) in diameter or smaller shall be of the bell and spigot type. Pipes larger than 600 mm (24 inches) in diameter may be either of the tongue and groove or bell and spigot type.

In all sizes of bell and spigot pipe, and in tongue and groove pipe 750 mm (30 inches) in diameter and larger, there shall be a line of circumferential reinforcement in the bell or groove, equal in area to that of a single line within the barrel of the pipe.

(b) Marking. The exterior and interior of each length of pipe shall be clearly marked with the following data: pipe class; day, month, and year of manufacture; and name or trademark of the manufacturer. The method shall be by either clear, legible impressions in the pipe, or by clear, legible data stencilled with waterproof paint.

(c) Basis of Acceptance. All pipe shall be accepted on the basis of plant load bearing tests, material tests, and inspection of manufactured pipe for visual defects and imperfections.

(d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02 for the pipe. Certifications for constituent materials shall be furnished in accordance with normal requirements for those types of materials.

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 170M, 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.

Certification. Certification shall conform to the requirements of Subsection 710.01(d).

710.03 CORRUGATED POLYETHYLENE PIPE. Corrugated polyethylene pipe and fittings shall conform to the following requirements:

(a) Pipe. Storm drain and culvert pipe shall conform to the latest revisions of AASHTO M 294.

(b) Underdrain. Underdrain shall conform to the requirements of AASHTO M 294, Type SP, and all sizes less than 300 mm (12 inches) diameter shall have a minimum pipe stiffness of 344 kPa (50 pounds per square inch).

(c) Couplings.

(1) All culvert coupling bands, except for underdrain and slope pipes, shall be a minimum of 300 mm (12 inches) long, shall engage a minimum of two full corrugations of each pipe section being joined, shall be reinforced with a minimum of two high-strength nylon ties, and in all other respects shall meet the criteria for the "Erodible Special Joint" category of Division II, Section 26 of the AASHTO *Standard Specifications for Highway Bridges*.

(2) Slope pipe coupling bands shall be a minimum of 600 mm (24 inches) long, shall engage a minimum of four full corrugations of each pipe section being joined, shall be reinforced with a minimum of four high-strength nylon ties, and in all other respects shall meet the criteria for the "Downdrain Joint" category of Division II, Section 26 of the AASHTO *Standard Specifications for Highway Bridges*.

(3) Underdrain coupling bands shall be a minimum of 180 mm (7 inches) long, shall engage a minimum of two full corrugations of each pipe section being joined, shall be reinforced with a minimum of two high-strength nylon ties, and in all other respects shall meet the criteria for the "Erodible Special Joint" category of Division II, Section 26 of the AASHTO *Standard Specifications for Highway Bridges*.

(d) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

710.04 VITRIFIED CLAY PIPE. Vitrified clay pipe shall conform to the requirements of AASHTO M 65.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

710.05 ACRYLONITRILE-BUTADIENE-STYRENE (ABS) PLASTIC PIPE. ABS pipe shall conform to the following requirements:

| | |
|---|---|
| Storm or Sanitary Sewer Pipe (solid wall): | ASTM D 2751 |
| Storm or Sanitary Sewer Pipe (composite wall): | AASHTO M 264 |

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

710.06 POLYVINYL CHLORIDE (PVC) PLASTIC PIPE. PVC pipe shall conform to the following requirements:

| | |
|---|---|
| Smooth wall, perforated or unperforated | |
| 100 to 400 mm (4 to 16 inches): | AASHTO M 278 |

| | |
|---|---|
| 450 to 700 mm (18 to 28 inches): | ASTM F 679* |
| Corrugated, with smooth interior | |
| All sizes: | ASTM F 949 |
| | ASTM F 794 |

* Pipe with other cell classifications that meet or exceed the performance requirements of ASTM D 3034 will be permitted provided the wall thickness is not less than 94 percent of that specified in Table I of AASHTO M 278.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## 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 36M. Material furnished under this Subsection shall be formed from sheet material coated in accordance with AASHTO M 218M, M 274M, or M 289M.

(a) Coupling Bands. Coupling bands shall conform to AASHTO M 36M, 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 Division II of the AASHTO *Standard Specifications for Highway Bridges*.

(2) The only approved methods of connection and connection details at the ends of the bands shall be:

a. 51 by 51 by 4.8 mm (2 × 2 × 3/16 inch) galvanized steel angles extending the full width of the band.

b. 2.77 mm (12 gage) die-cast angle with a configuration that provides at least the same section modulus as the 51 by 51 by 4.8 mm (2 × 2 × 3/16 inch) angle, extending the full width of the band.

c. Minimum of two bolts for a 180 mm (7 inch) wide band, three bolts for a 300 mm (12 inch) wide band, and five bolts for a 600 mm (24 inch) wide band, uniformly spaced. Bolts, nuts, and other threaded items used with coupling bands shall be coated by the electroplating process as provided in ASTM B 633, Class Fe/Zn 25, the zinc coating process as provided in AASHTO M 232M/M 232 or the mechanical zinc coating process as provided in AASHTO M 298, Class 25.

d. Angles will be connected to bands by one of the following:

1. spot welds spread over full width of the band,

2. stitch-welded over the full width of the band, or

3. attached by rivets.

(3) Minimum band thickness shall be 1.63 mm (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.

(4) The use of projection pipe coupling (dimpled) bands or preformed channel bands is not allowed.

(5) The Contractor may submit for approval to the Agency alternate coupling bands. The Contractor shall allow 30 days for a testing and evaluation period. Coupling bands shall not be shipped to projects until the Contractor has been notified that the proposed band has been approved by the Agency.

(6) For attaching metal end sections to corrugated steel pipe, the Contractor may supply 25 mm wide by 2.77 mm thick (1 inch by 12 gage) galvanized straps connected by a 12 mm (1/2 inch) galvanized bolt and nut for 300 through 600 mm (12 through 24 inch) diameter round pipes, and for 710 by 510 mm (28 × 20 inch) pipe arches and smaller.

(b) End Sections. Materials used in the manufacture of end sections shall conform to AASHTO M 36M, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.

(c) Reducer Units. Materials used in the manufacturer of concentric metal reducer units shall conform to AASHTO M 36M, 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 AASHTO M 36M. Minimum sheet metal thickness required is 1.32 mm (0.052 inch) for 150 mm (6 inch) diameter underdrain and 1.63 mm (0.064 inch) for 200 mm (8 inch) diameter and larger.

(e) Underdrain Risers and Flushing Basins. Underdrain risers and flushing basins, including all connectors, fittings and covers shall conform to AASHTO M 36M, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract, and the pipe shall not be perforated.

(f) 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.

(g) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

711.02 CORRUGATED ALUMINUM ALLOY PIPE, PIPE ARCHES, AND UNDERDRAINS. Corrugated aluminum alloy pipe, elbows, end sections, reducer units, pipe arches, underdrain, risers, flushing basins, and coupling bands shall conform to the requirements of AASHTO M 196M.

(a) Coupling Bands. Coupling bands shall conform to AASHTO M 196M, 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 Division II of the AASHTO *Standard Specifications for Highway Bridges*.

(2) Coupling band connections:

a. Shall be 51 by 51 by 6.4 mm (2 × 2 × 1/4 inch) aluminum angles (Alloy 6061-T6) extending the full width of the band or 2.77 mm (12 gage) minimum die-cast aluminum angles, extending the full width of the band.

b. Shall have a minimum shear strength capacity of 28.1 kN (6.3 kips).

c. Shall be connected with a minimum of two bolts for a 180 mm (7 inch) wide band, three bolts for a 300 mm (12 inch) wide band and five bolts for a 600 mm (24 inch) wide band. Bolts shall be uniformly spaced across the width of the band. Bolts, nuts, and other threaded items shall be coated in accordance with the requirements of Subsection 711.01(a)(2)c.

d. 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) Minimum band thickness shall be 1.52 mm (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 196M, 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 196M, 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 196M, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract, and the pipe 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.

(f) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

711.03 POLYMERIC COATED CORRUGATED STEEL PIPE AND PIPE ARCHES. Polymeric coated corrugated steel pipe, elbows, reducer units, and pipe arches shall conform to AASHTO M 245M. Polymeric coating shall conform to AASHTO M 246M, 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 218M, M 274M, M 289M, or M 245M.

(2) Coupling bands formed from AASHTO M 274M or M 289M 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 245M 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 218M 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 Subsection 711.01(b).

(c) Reducer Units. Materials used in the manufacturer of concentric reducer units shall conform to AASHTO M 245M, 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.

(e) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

711.04 BITUMINOUS PAVING FOR PIPE INVERTS. When shown on the Plans, inverts of polymeric coated corrugated steel units shall be paved with bituminous material in accordance with AASHTO M 190M, as follows:

| | |
|---|---|
| Pipe: | Type B Coating |
| Pipe Arches: | Type B Coating |
| Reducer Unit: | Type B Coating |
| Elbows: | Type B Coating |
| Couplings: | Uncoated |
| End Sections: | Uncoated |

Wherever Type B coating is specified, coating on the exterior of the pipe may be omitted.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

711.05 COAL-TAR BASED COATING. The coal-tar based coating used to repair damaged areas of polymeric coating shall meet the requirements of AASHTO M 243M.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

711.06 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 167M.

Structural aluminum alloy plate, bolts, and nuts for pipe, pipe-arches, arches, and box culverts shall conform to the requirements of AASHTO M 219M.

(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 so punched that all plates having like dimensions, curvature, and the same number of bolts per meter (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 300 mm (12 inches). The minimum distance from center of hole to edge of the plate shall be not 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 3 mm (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 percent greater than the nominal diameter of the pipe. Pipe arches shall not be elongated.

(c) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 712 - CRIBBING MATERIALS

712.01 METAL BIN-TYPE RETAINING WALL.

(a) Galvanized Metal Units. The various units of metal bin-type retaining wall shall conform to the requirements of AASHTO M 218M. The metal sheets used to form the members of the metal wall shall be of the thickness indicated in the Contract.

(b) Bolts and Nuts. Bolts and nuts shall conform to the requirements of Subsection 714.08 and shall be galvanized in accordance with the requirements of AASHTO M 232M/M 232.

(c) Fabrication. All units shall be so fabricated that units of the same nominal size shall be interchangeable. Drilling, punching, or drifting to correct defects in manufacture will not be permitted. Any units improperly manufactured shall be replaced at the Contractor's expense.

Whenever possible in the manufacture of the units, a minimum forming radius of 25 mm (1 inch) shall be maintained. All units that are formed with less than a 25 mm (1 inch) radius shall be hot-dip galvanized after forming.

(d) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

712.02 CONCRETE BIN-TYPE RETAINING WALL. The materials, design details, and dimensions shall be as shown on the Plans and approved working drawings.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

712.03 TIMBER CRIBBING.

(a) Material. Dimensional timber furnished for cribbing shall be seasoned Red (Norway) Pine, White Pine, Eastern Hemlock, or Southern Pine, straight, sound, and cut from live timber. Red Pine, White Pine, and Eastern Hemlock shall meet

number 1 grade requirements specified by the Northeastern Lumber Manufacturers Association (NELMA). Southern Pine shall meet number 2 grade requirements specified by the Southern Pine Inspection Bureau (SPIB).

Structural timber furnished for glue laminated members shall be seasoned Southern Pine, Coastal Douglas Fir, or Hem-Fir, meeting the requirements of Division II of the AASHTO *Standard Specifications for Highway Bridges*, with a minimum fiber stress in bending, about either axis, of 8.3 MPa (1200 pounds per square inch).

Dimensional timber shall be full-sawn S2E (uniformly surfaced two edges to the dimensions specified).

Structural glued laminated timber shall be S4S (uniformly surfaced four sides to the dimensions specified). Surfaces to be exposed in the finished product shall be uniformly rough finish, coarse texture. Maximum unevenness in surface shall be 6 mm (1/4 inch) (process to be performed prior to preservative treatment).

Adhesive used in the lamination process shall be for wet-use conforming to ASTM D 2559 and shall comply with all other requirements of AITC A190.1.

(b) Seasoning. All material shall have a moisture content not exceeding 20 percent prior to preservative treatment.

(c) Preservative Treatment. Timber cribbing shall be pressure treated in accordance with AASHTO M 133 and AWPA Standards C1, C2, and C14 using Type IV preservative, chromated copper arsenate, Type C, conforming to AWPA Standard P5 as specified in Subsection 726.01.

Treatment, inspection, and testing of the treated timber materials shall conform to the requirements of Subsection 728.01.

(d) Miscellaneous Hardware.

(1) Connection and washer plates shall be fabricated from material conforming to Subsection 714.02 and galvanized in accordance with AASHTO M 111M/M 111.

(2) Bolts, nuts, and washers shall conform to Subsection 714.04 and shall be galvanized in accordance with AASHTO M 232M/M 232.

(3) Threaded rods with nuts shall be either material conforming to Subsection 714.04 and be galvanized in accordance with AASHTO M 232M/M 232 or stainless steel conforming to ASTM F 738M, Property Class A1-70, Condition CW, with nuts conforming to ASTM F 836M, Property Class A1-70, Condition CW.

(4) Bolts and threaded rods shall have a minimum of 100 mm (4 inches) of thread. Threads shall be wrapped with a minimum of two layers of Teflon tape prior to installation. All threads shall be Metric Coarse, 6g (UNC 2).

(5) Sleeve nuts may conform to Subsection 714.04 and be galvanized or may be fabricated from stainless steel rod ASTM A 276, Type 304.

(6) All nuts shall be the heavy hex type.

(e) Certification. A Type D Certification shall be furnished for all treated timber in accordance with Subsection 700.02. A Type A Certification shall be furnished for all miscellaneous hardware in accordance with Subsection 700.02.

## SECTION 713 - REINFORCING STEEL AND WIRE ROPE

713.01 BAR REINFORCEMENT. Bar reinforcement for concrete structures shall be Grade 420 (Grade 60) conforming to AASHTO M 31M/M 31 including supplementary requirements.

Samples. Where indicated in the Contract, samples of bar reinforcement at least 1.5 m (60 inches) long shall be submitted to the laboratory for testing.

713.02 MECHANICAL OR WELDED SPLICES FOR BAR REINFORCEMENT. Mechanical or welded splices for bar reinforcement, when shown on the Plans, shall consist of welded splices or other positive connections instead of lapped splices. In bars required for compression only, the compressive stress may be transmitted by bearing of square-cut ends held in concentric contact by a suitably welded sleeve or mechanical device. Splicing with mechanical devices shall be done in accordance with the manufacturer's recommendations as approved by the Engineer.

The Contractor shall make three test splices in the presence of the Engineer of each of the bar sizes to be spliced by a welded sleeve or mechanical device. The test splices shall be submitted to the Agency's Materials and Research Section and tested in tension.

An approved welded splice is one in which the bars are butted and welded so as to develop in tension at least 90 percent of the minimum tensile strength of the reinforcing bar. Approved positive connections for bars designed to carry critical tension or compression shall be equivalent in strength to an approved welded splice.

713.03 WIRE ROPE OR CABLE. Wire rope or cable for guardrail shall conform to the requirements of AASHTO M 30, Type I, 19 mm (3/4 inch), Class B coating.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

713.04 COLD DRAWN STEEL WIRE. Cold drawn steel wire shall conform to the requirements of AASHTO M 32M/M 32.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

713.05 WELDED STEEL WIRE FABRIC. Welded steel wire fabric shall conform to the requirements of AASHTO M 55M/M 55.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

713.06 PRESTRESSING REINFORCEMENT. Prestressing elements shall be uncoated, high tensile strength, seven "low relaxation" wire strand of the grade and diameter shown on the Plans, conforming to the requirements of AASHTO M 203M/M 203. Wire for post tensioning shall conform to the requirements of AASHTO M 204M/M 204.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

713.07 COATED BAR REINFORCEMENT. Coated Bar Reinforcement shall conform to the applicable requirements of Section 713 and Section 507, and to the following requirements:

(a) Galvanizing. Where shown on the Plans, galvanizing shall conform to the requirements of AASHTO M 111M/M 111.

(b) Epoxy Coating. Where shown on the Plans, reinforcing steel shall have an electrostatically applied organic epoxy protective coating, which has been prequalified, fabricated, tested, and installed in accordance with AASHTO M 284/M 284M.

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02 for the coating and coating process.

## 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 shall be tested for impact properties by the longitudinal Charpy V-Notch test. Sampling and testing procedures shall be in accordance with AASHTO T 243/T 243M.

Main members are tension members and members subject to reversals of stress including stringers, girders, cover plates, rigid frames, floor beams, and curved girder cross frames. Other members may be indicated in the Contract as main load carrying members.

References to AASHTO sections in this Section refer to the AASHTO *Standard Specifications for Highway Bridges*.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

714.02 STRUCTURAL STEEL. Structural carbon steel shall conform to the requirements of AASHTO M 270/M 270M, Grade 250 (Grade 36).

714.03 HIGH-STRENGTH LOW-ALLOY STRUCTURAL STEEL. High-strength low-alloy structural steel with a 345 MPa (50 kips per square inch) minimum yield point up to 100 mm (4 inches) in thickness shall conform to the requirements of AASHTO M 270/M 270M, Grade 345 (Grade 50) and/or Grade 345W (Grade 50W) as required.

714.04 CARBON STEEL BOLTS AND NUTS. Carbon steel bolts shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307). Carbon steel nuts shall conform to the requirements of AASHTO M 291M (AASHTO M 291).

714.05 HIGH-STRENGTH BOLTS, NUTS, AND WASHERS. High-strength bolts, nuts, and circular washers shall conform to the requirements/dimensions of AASHTO M 164M (ASTM A 325M) [AASHTO M 164 (ASTM A 325)].

Bolts for structural components that have been painted prior to being erected shall be Type 1 or Type 2, shall be provided with appropriate nuts and washers, as required, and the combination of bolt, nut, and washer shall be coated in accordance with AASHTO M 298, Class 50, Type I.

Bolts, nuts, and washers shall be Type 3 for all unpainted applications of AASHTO M 270/M 270M, Grade 345W (Grade 50W) steel.

All high-strength 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 marking(s) on each piece.

Nuts for galvanized fasteners shall be overtapped 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 must be "oily" to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

Certification and Test Requirements. The Type D Certification is required and shall be provided by the manufacturer, the fabricator, or the supplier, or some combination of two or more of these parties. The complete Type D Certification shall cover the entire assembly provided, as well as the individual units.

The Type A Certification(s) provided shall identify the corresponding lot number(s) of the material(s) represented by the shipping invoice(s); the corresponding manufacturer's identification marking(s); and the corresponding Type C Certification(s); as well as providing all the information required under Subsection 700.02(b).

Each combination of bolt production lot, nut lot, and washer lot shall be tested as an assembly. Where washers are not required by the installation procedures, they need not be included in the lot identification. A separate rotational-capacity lot number shall be assigned to each combination of lots tests. The minimum frequency of testing shall be two assemblies per rotational-capacity lot.

All required tests for galvanized bolts, nuts, and washers shall be performed after they have been galvanized.

In addition to all the information required under Subsection 700.02(b), the Type C Certification(s) provided shall identify the corresponding Type A Certification(s); shall show the name of the entity performing each chemical or physical analysis or test on the supplied material(s) and the place(s) and date(s) of performance; and shall include the results of the following tests, in addition to any other analyses or test results required:

(a) Rockwell Hardness Test. Each lot of bolts shall be tested for hardness. The hardness of high-strength bolts shall be within the limits indicated for Rockwell C Hardness in AASHTO M 164M (AASHTO M 164).

(b) Tensile Strength Test. Each lot of bolts shall be tested for tensile strength. The tensile strength of the furnished bolts shall meet the requirements of AASHTO M 164M (AASHTO M 164).

(c) Rotational-Capacity Test. Except as modified below, each lot of fasteners, black or galvanized, shall be subject to the rotational-capacity test specified in AASHTO M 164M (AASHTO M 164), and shall meet the following requirements:

(1) Each test specimen shall be rotated from a snug tight condition (plys of joint are in firm contact) the following number of turns in a Skidmore-Wilhelm Calibrator or equivalent tensioning device, without stripping or failure:

| Bolt Length (Under Head to End of Bolt) | Number of Turns (Snug Tight) | Number of Turns Beyond Snug Tight |
|---|---|---|
| 0 to 4 diameters | 1/3 turn (120°) | 2/3 turn (240°) |
| 4 to 8 diameters | 1/2 turn (180°) | 1 turn (360°) |
| 8 to 12 diameters | 2/3 turn (240°) | 1 1/3 turns (480°) |

(2) At the required test rotation, the maximum recorded tension shall be equal to or greater than the following:

| Bolt Diameter (mm) | Tension (kN) | Bolt Diameter (inches) | Tension (kips) |
|---|---|---|---|
| | | 1/2 | 13.8 |
| M16 | 105 | 5/8 | 21.9 |
| M20 | 163 | 3/4 | 32.2 |
| M22 | 202 | 7/8 | 44.9 |
| M24 | 236 | 1 | 58.7 |
| M27 | 307 | 1 1/8 | 64.4 |
| M30 | 375 | 1 1/4 | 81.7 |
| | | 1 3/8 | 97.8 |
| M36 | 546 | 1 1/2 | 118.5 |

(3) The torque measured to produce the required fastener tension shall not exceed the following values:

| Bolt Diameter (mm) | Torque = the measured bolt tension in kilonewtons times the following factor: | Bolt Diameter (inches) | Torque = the measured bolt tension in pounds times the following factor: |
|---|---|---|---|
| | | 1/2 | 0.0104 |
| M16 | 4.0 | 5/8 | 0.0130 |
| M20 | 5.0 | 3/4 | 0.0156 |
| M22 | 5.5 | 7/8 | 0.0182 |
| M24 | 6.0 | 1 | 0.0208 |
| M27 | 6.75 | 1 1/8 | 0.0234 |
| M30 | 7.5 | 1 1/4 | 0.0260 |
| | | 1 3/8 | 0.0286 |
| M36 | 9.0 | 1 1/2 | 0.0313 |
| | yielding a result expressed in joules (J) | | yielding a result expressed in pounds-force foot (lbf•ft) |

(d) Proof Load Tests. Proof load tests for bolts are required and shall be performed in accordance with ASTM F 606M (ASTM F 606), Method 1.

Proof load tests for nuts are required and shall be performed in accordance with ASTM F 606M (ASTM F 606). Galvanized nuts shall be tested after the nuts have been overtapped, galvanized, and lubricated.

(e) Wedge Test. Wedge tests for tensile strength of full size bolt specimens are required and shall be performed in accordance with AASHTO M 164M (AASHTO M 164).

(f) Zinc Thickness Test. The thickness of the zinc coating shall be measured on all galvanized bolts, nuts, and washers. The measurements shall be made on a minimum of three test specimens randomly selected from each lot supplied. The thickness of the zinc shall conform to the requirements of AASHTO M 232M/M 232.

714.06 HEAT-TREATED STRUCTURAL BOLTS. Heat-treated steel structural bolts, with 1040 MPa (150 kips per square inch) minimum tensile strength, nuts, and washers shall conform to the requirements of AASHTO M 253M (ASTM A 490M) [AASHTO M 253 (ASTM A 490)].

Bolts, nuts, and washers shall be Type 3 for all unpainted applications of AASHTO M 270/M 270M, Grade 345W (Grade 50W) steel.

All heat-treated structural steel bolts furnished for Agency projects and nuts and washers furnished with them 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 marking(s) on each piece.

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 must be "oily" to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

Certification and Test Requirements. The Type D Certification is required and shall be provided by the manufacturer, the fabricator, or the supplier, or some combination of two or more of these parties. The complete Type D Certification shall cover the entire assembly provided, as well as the individual units.

The Type A Certification(s) provided shall identify the corresponding lot number(s) of the material(s) represented by the shipping invoice(s); the corresponding manufacturer's identification marking(s); and the corresponding Type C Certification(s); as well as providing all the information required under Subsection 700.02(b).

Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly. Where washers are not required by the installation procedures, they need not be included in the lot identification. A separate rotational-capacity lot number shall be assigned to each combination of lots tested. The minimum frequency of testing shall be two assemblies per rotational-capacity lot.

All required tests for galvanized bolts, nuts, and washers shall be performed after they have been galvanized.

In addition to the information required under Subsection 700.02(b), the Type C Certification(s) provided shall identify the corresponding Type A Certification(s); shall show the name of the entity performing each chemical or physical analysis or test on the supplied material(s) and the place(s) and date(s) performed; and shall include the results of the following tests in addition to any other analyses or test results required:

(a) Rockwell Hardness Test. Each lot of bolts shall be tested for hardness. The hardness of heat-treated structural bolts shall be within the limits indicated for Rockwell C Hardness in AASHTO M 253M (AASHTO M 253)

(b) Tensile Strength Test. Each lot of bolts shall be tested for tensile strength. Acceptable bolts shall have a value which is at least 1040 MPa (150 kips per square inch) and which is not greater than 1200 MPa (175 kips per square inch).

(c) Rotational-Capacity Test. Except as modified below, each lot of fasteners, black and galvanized, shall be subject to the rotational-capacity test specified in AASHTO M 164M (AASHTO M 164), and shall meet the following requirements:

(1) Each test specimen shall be rotated from a snug tight condition (plys of joint are in firm contact) the following number of turns in a Skidmore-Wilhelm Calibrator or equivalent tensioning device, without stripping or failure:

| Bolt Length (Under Head to End of Bolt) | Number of Turns (Snug Tight) | Number of Turns Beyond Snug Tight |
|---|---|---|
| 0 to 4 diameters | 1/3 turn (120°) | 2/3 turn (240°) |
| 4 to 8 diameters | 1/2 turn (180°) | 1 turn (360°) |
| 8 to 12 diameters | 2/3 turn (240°) | 1 1/3 turns (480°) |

(2) At the required test rotation, the maximum recorded tension shall be equal to or greater than the following:

| Bolt Diameter (mm) | Tension (kN) | Bolt Diameter (inches) | Tension (kips) |
|---|---|---|---|
| | | 1/2 | 17.3 |
| M16 | 131 | 5/8 | 27.6 |
| M20 | 205 | 3/4 | 40.3 |
| M22 | 254 | 7/8 | 56.4 |
| M24 | 295 | 1 | 73.6 |
| M27 | 384 | 1 1/8 | 92.0 |
| M30 | 469 | 1 1/4 | 117.3 |
| | | 1 3/8 | 139.2 |
| M36 | 684 | 1 1/2 | 170.2 |

(3) The torque measured to produce the required fastener tension shall not exceed the following values:

| Bolt Diameter (mm) | Torque = the measured bolt tension in kilonewtons times the following factor: | Bolt Diameter (inches) | Torque = the measured bolt tension in pounds times the following factor: |
|---|---|---|---|
| | | 1/2 | 0.0104 |
| M16 | 4.0 | 5/8 | 0.0130 |
| M20 | 5.0 | 3/4 | 0.0156 |
| M22 | 5.5 | 7/8 | 0.0182 |
| M24 | 6.0 | 1 | 0.0208 |
| M27 | 6.75 | 1 1/8 | 0.0234 |
| M30 | 7.5 | 1 1/4 | 0.0260 |
| | | 1 3/8 | 0.0286 |
| M36 | 9.0 | 1 1/2 | 0.0313 |
| | yielding a result expressed in joules (J) | | yielding a result expressed in pounds-force foot (lbf•ft) |

(d) Proof Load Tests. Proof load tests for bolts are required and shall be performed in accordance with ASTM F 606M (ASTM F 606), Section 3.2.1, Method 1. Proof load tests for nuts are required and shall be performed in accordance with ASTM F 606M (ASTM F 606), Section 4.2. Galvanized nuts shall be tested after the nuts have been overtapped, galvanized, and lubricated.

(e) Wedge Test. Wedge tests of full size bolt specimens are required and shall be performed in accordance with AASHTO M 253M (AASHTO M 253).

(f) Zinc Thickness Test. The thickness of the zinc coating shall be measured on all galvanized bolts, nuts, and washers. The measurements shall be made on a minimum of three test specimens randomly selected from each lot supplied. The thickness of the zinc shall conform to the requirements of AASHTO M 232M/M 232.

714.07 ANCHOR BOLTS, BRIDGE RAILING. Anchor bolts for bridge railing shall conform to the requirements of either AASHTO M 164M (ASTM A 325M) [AASHTO M 164 (ASTM A 325)] or ASTM F 568M, Property Class 8.8 (ASTM A 449). Nuts and washers shall conform to the requirements of AASHTO M 164M (ASTM A 325M) [AASHTO M 164 (ASTM A 325)].

All anchor bolts for bridge railing 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 marking(s) on each piece.

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 must be "oily" to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

All bolts, nuts, and washers furnished under this Subsection as meeting the requirements of AASHTO M 164M (AASHTO M 164) shall meet all the requirements, including testing and certification, specified in Subsection 714.05.

714.08 ANCHOR BOLTS, BEARING DEVICES. Anchor bolts for bridge bearings shall conform to the requirements of AASHTO M 183M/M 183. Nuts shall be heavy hex and conform to the requirements of AASHTO M 291M (AASHTO M 291), and washers shall conform to the requirements of ASTM F 844 and ANSI B18.22M (ANSI B18.22.1). Washers shall be a minimum of 10 mm (3/8 inch) in thickness.

All anchor bolts for bearing devices 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 marking(s) on each piece.

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 must be "oily" to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

When the bolts furnished under this Subsection are required to conform to the requirements of AASHTO M 183M/M 183, the bolts, nuts, and washers furnished shall be tested and certified as meeting the requirements of the Zinc Thickness Test as specified in Subsection 714.05, in addition to any other test and certification requirements.

If bolts furnished for use under this Subsection are required to conform to the requirements of AASHTO M 164M (AASHTO M 164), then all bolts, nuts, and washers furnished shall meet all the requirements, including testing and certification, specified in Subsection 714.05. Bolts larger than 36 mm (1 1/2 inches) in diameter shall have all required tests performed in accordance with the requirements of Sections 6 and 8 of AASHTO M 164M (AASHTO M 164) as modified by Subsection 714.05.

Anchor bolts shall be swedged or threaded and shall conform to the shape, length, and diameter specified in the Contract.

714.09 ANCHOR BOLTS, TRAFFIC SIGNALS, LIGHTING, AND OVERHEAD SIGN STRUCTURES. Anchor bolts and washers shall be an austenitic grade of stainless steel conforming to the chemistry of ASTM A 276, Type 304 with the following physical properties:

| | |
|---|---|
| Tensile Strength, Minimum: | 550 MPa (80,000 psi) |
| Yield Strength, Minimum: | 380 MPa (55,000 psi) |
| Elongation in 50 mm (2 inches), Minimum: | 30 percent |
| Rockwell B Hardness, Minimum: | 86 |
| or | |
| Charpy V-Notch, Minimum: | 20.5 N•m at 5 °C |
| (AASHTO T 243M/T 243 | (15 lbf•ft at 40 °F) |
| using "H" frequency testing) | |

Nuts for the anchor bolts shall be the heavy hex type conforming to the requirements of AASHTO M 292M/M 292, Grade 8 and dimensions of ANSI B18.2.4.6M.

All anchor bolts for traffic signal, street lighting, and overhead sign installations 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 marking(s) on each piece.

714.10 WELDED STUD SHEAR CONNECTORS. Shear connectors shall conform to the requirements of AASHTO Division II and ANSI/AWS D1.5.

Prior to installation of any shear connectors by a fabricator in a shop or by a Contractor in the field the Engineer shall be furnished:

(a) The stud manufacturer's certification that the studs, as delivered, conform to the applicable requirements of ANSI/AWS D1.5.

(b) Certified copies of the stud manufacturer's test reports of in-plant quality control mechanical tests as specified by ANSI/AWS D1.5.

Studs that do not meet the above requirements will be rejected.

714.11 STEEL TUBING. Steel tubing shall conform to the requirements of ASTM A 500, Grade B, or ASTM A 501.

## SECTION 715 - MISCELLANEOUS METALS

715.01 IRON CASTINGS.

(a) General Requirements. 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 sandblasted or otherwise effectively cleaned of scale and sand so as to present a smooth, clean, and uniform surface.

(b) Gray Iron Castings. Gray iron castings shall conform to the requirements of AASHTO M 105, Class No. 30B, unless otherwise specified.

(c) Ductile Iron Castings. Ductile iron castings for frames and covers shall conform to the requirements of ASTM A 536, Grade 65-45-12. They must be designed to pass the following mechanical strength criteria and the design criteria:

(1) Mechanical Test Criteria. The castings shall be capable of supporting a load of 391 kN (88,000 pounds), when tested in accordance with Vermont Test Method (VTM) VT-AOT-MRD #43.

(2) Design Criteria. The dimensions of the frames and covers shall substantially conform to the dimensions for cast iron covers and frames as shown in the Plans. The covers shall be flush with the upper surface of the frame when seated. The seatings shall be machined or made quiet by the use of 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 50 mm (2 inches) ±.

Covers used on storm drainage systems shall be identified by the words "STORM SEWER" in raised cast letters.

As a minimum, the covers and frames shall meet the M-18 (H 20) loading requirements of AASHTO and the proof load requirements of Federal Specification A-A-60005.

Ductile iron castings for uses other than frames and covers shall conform to the requirements of ASTM A 536, Grade 60-40-18. In addition to the specified test coupons, test specimens from parts integral with the castings, such as risers, shall be tested for castings with a mass (weight) of more than 450 kg (1000 pounds) to determine that the required quality is obtained in the castings in the finished condition.

(d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

715.02 BRONZE CASTINGS. Bronze castings shall conform to the requirements of AASHTO M 107, Alloy 91300 or Alloy 91100.

Self-lubricating bronze bearing plates shall conform to the following requirements:

(a) The bronze alloy shall conform to the requirements of AASHTO M 107, Alloy 91100, except that a maximum lead content of 2.5 percent is allowable.

(b) The lubricant shall be of the solid type and shall consist of graphite, metallic substances having lubricating properties and a lubricating binder. Materials that do not have lubricating qualities or promote chemical or electrolytic reactions will

not be acceptable. The lubricant shall be integrally molded and compressed into the lubrication recesses with hydraulic pressure of at least 41.5 MPa (6000 pounds per square inch) to form a dense, non-plastic lubricant.

(c) The recesses for the lubricant shall be arranged in a geometric pattern such that successive rows shall overlap in the direction of motion and the distance between extremities of recesses shall be closer in the direction of motion than that perpendicular to motion. The entire bearing area of all surfaces that have provision for motion shall be lubricated by means of these lubricant filled recesses. The total area of these recesses shall comprise not less than 25 or more than 35 percent of the total bearing area of the plate.

(d) The bearing plates shall be furnished to the sizes shown on the Plans. Bearing surfaces shall be machine finished and the surface roughness shall not exceed 3 μm (125 micro inches)when measured in accordance with ANSI B46.1. The bearing surfaces of the opposing steel plates shall also be finished as above. The lay of the tool marks shall be in the direction of motion. All machine surfaces shall be flat within 0.05 percent tolerance of length and width.

(e) For mating curved surfaces of steel and bronze, the concave surface shall have a positive tolerance not exceeding 250 μm (10 mils) and the convex surface shall have a negative tolerance of 250 μm (10 mils).

(f) The coefficient of friction between the bronze self-lubricating plates and the steel plates in contact with them shall not exceed 0.10 when subjected to the designed unit loading and also at twice the designed unit loading.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

715.03 CAST IRON PIPE. Cast iron pipe and fittings shall conform to either the requirements of ASTM A 74 or the requirements of ASTM A 377, unless otherwise specified.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

715.04 ALUMINUM ALLOY. Material shall be fabricated from Alloy 6061-T6.

(a) Sheet and Plate. Aluminum alloy sheet and plate shall conform to the requirements of ASTM B 209M (ASTM B 209).

(b) Drawn Seamless Tubes. Aluminum alloy drawn seamless tubes shall conform to the requirements of ASTM B 210M (ASTM B 210).

(c) Bars, Rods, and Wire. Aluminum alloy bars, rods, and wire shall conform to the requirements of ASTM B 211M (ASTM B 211).

(d) Extruded Bars, Rods, Shapes, and Tubes. Aluminum alloy extruded bars, road, shapes, and tubes shall conform to the requirements of ASTM B 221M (ASTM B 221).

(e) Seamless Pipe and Seamless Extruded Tube. Aluminum alloy seamless pipe and seamless extruded tube shall conform to the requirements of ASTM B 241/B 241M.

(f) Welding Rods and Electrodes. Aluminum and aluminum alloy welding rods and bare electrodes shall conform to the requirements of AWS.

(g) Standard Structural Shapes. Aluminum alloy standard structural shapes, rolled or extruded, shall conform to the requirements of ASTM B 308/B 308M.

(h) Extruded Structural Pipe and Tube. Aluminum alloy extruded structural pipe and tube shall conform to the requirements of ASTM B 429.

(i) Sand Castings. Aluminum alloy sand casting shall conform to the requirements of ASTM B 26/B 26M.

(j) Permanent Mold Castings. Aluminum alloy permanent mold castings shall conform to the requirements of ASTM B 108.

(k) Rivets. Aluminum alloy rivet shall conform to the requirements of ASTM B 316/B 316M.

(l) Bolts, Nuts, and Screws. Aluminum alloy bolts, nuts, and screws shall be made from rod conforming to the requirements of ASTM B 211M (ASTM B 211). Bolt heads shall conform to the American Standard heavy hexagon, ANSI B18.2.3.6M (ANSI B18.2.1), and nuts shall conform to ANSI B18.2.4.6M in accordance with ANSI B18.2M (ANSI B18.2.1 and B18.2.2). Bolt threads shall conform to ANSI B1.13M (ANSI B1.1). Both bolts and nuts shall be given an anodic coating at least 5 μm (0.2 mil) in thickness with 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 B 209M (ASTM B 209).

Aluminum alloy shims shall be made from aluminum alloy sheet or plate conforming to the requirements of ASTM B 209M (ASTM B 209) or ASTM B 221M (ASTM B 221).

(n) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 719 - EPOXY RESIN MATERIALS

719.01 EPOXY MORTAR COMPOUND AND EPOXY MORTAR. Epoxy mortar compound shall consist of a two-component, 100 percent solids, filled, non-sag,

pigmented, epoxy resin system. The material shall not be sensitive to moisture in adjacent surfaces. It shall be formulated for use as a binder in the preparation of epoxy mortar or patching compounds. The material shall be supplied with mineral fillers or thixotropic additives incorporated in the formulation so that upon the addition of the manufacturer's recommended maximum ratio of aggregate to produce an epoxy mortar, vertical applications in lifts up to 50 mm (2 inches) in thickness are possible. Mineral filler shall be nonsettling, inert substances that have no deleterious effect on the properties of the compound, and 100 percent shall pass a 45 μm (No. 325) sieve.

(a) Packaging. The components of the epoxy mortar compound shall be supplied in separate containers that are nonreactive with the material contained therein and which contain exact quantities such that when the entire contents of the Component B container is added to the container of Component A, the correct proportions are attained. The ratio of resin to hardener shall be either 1:1 or 2:1 by volume.

(b) Marking. Containers shall be identified as "Component A - Epoxy" and "Component B - Hardener." The labels shall show the type of use for which the material is intended, data on how to use the material, mixing directions, usable temperature range, name of manufacturer, the lot or batch number, the date of manufacture, shelf life, pigmentation if any, and the quantity contained therein in kilograms (pounds) or liters (gallons).

Special formulations prepared for vertical or overhead patch work, specific temperature ranges and those formulated for special application shall be clearly and conspicuously labeled with the appropriate information.

(c) Instructions. The Contractor shall furnish to the Engineer two copies of the complete instructions, prepared by the epoxy resin manufacturer, for the surface preparation, mixing, and application of the compound for the specified use. One copy shall accompany samples furnished for testing purposes.

(d) Sampling, Testing, and Certification.

(1) Sampling. If requested by the Engineer, samples for laboratory testing purposes of each component will be taken at random by an Agency representative from each batch or lot furnished and shall contain (at the ratio specified on the containers) sufficient material to provide for a minimum mixed volume of 4 L (1 gallon) of compound. Each component sample shall be separately packaged and clearly identified for future mixing and testing purposes.

(2) Testing. Definition of terms and test methods referred to below are described or supplemented as follows:

All samples shall be tested at or within the temperature range designated.

a. Viscosity. Viscosity shall be determined according to ASTM D 2393, using Brookfield Viscometer Model RVT. The temperature of each sample during the test shall be 25 ± 1 °C (77 ± 2 °F).

b. Gel Time. After samples of the two components have been conditioned at 25 ± 1 °C (77 ± 2 °F), 100 ± 0.4 g total of Components A and B in the proportions recommended by the manufacturer shall be measured into an unwaxed paper cup. The time is recorded and they shall be immediately mixed, stirring for three minutes, taking care to periodically scrape the walls and bottom of the cup and the mixer. The sample is then poured into an unwaxed paper cup, allowed to set, and probed every two minutes with a small stick, starting five minutes from the time mixing is started. The time at which a soft ball forms in the center of the container is recorded as the pot life or gel time.

Where a 500 mL (1 pint) volume is specified, the mixed sample shall be placed in a standard container having a diameter of approximately 85 mm (3 3/8 inches) and probed as described above.

c. Compressive Strength. Compressive strength of epoxy mortars shall be determined from 50 mm (2 inch) cube specimens as follows: One part by mass (weight) of the mixed compound shall be blended with the specified ratio of sand (conforming to Section 3 of AASHTO T 106). The test age of the specimen shall be 24 hours cured at 25 ± 1 °C (77 ± 2 °F) and tested in accordance with ASTM D 695. Six 50 mm (2 inch) cube test specimens shall be prepared.

(e) Certification. A Type A Certification will be furnished in accordance with Subsection 700.02(c).

(f) Properties and Requirements of Components. Properties and requirements of the components shall be:

(1) Component A - Epoxy Resin. The epoxy resin shall consist of a blend of epoxy resin, plasticizers and fillers.

(2) Component B - Hardener. The hardener (curing agent) shall consist of an amine adduct capable of curing the epoxy system at -1 °C (30 °F) and above when mixed according to the manufacturer's recommendations.

(3) Sand for Epoxy Mortar. The sand shall conform to the requirements of ASTM C 778 or any dry natural silica sand packaged in waterproof bags and approved by the Engineer.

(g) Properties of Mixed Compound. Properties of the mixed compound, when mixed at the ratio specified by the manufacturer at 25 ± 1 °C (77 ± 2 °F), shall conform to the requirements of the following table:

TABLE 719.01A - EPOXY MORTAR COMPOUND WITHOUT AGGREGATE

| Mixed Properties | Min. | Max. | Test Method |
|---|---|---|---|
| Gel time, minutes | 20 | --- | 500 mL (1 pint) volume<br>See part (d)(2)b. above |
| Viscosity, cP | 15 000 | --- | See part (d)(2)a. above and Note below |
| Color: Gray | 16314 | 16492 | FED-STD-595B |

Note: Components A and B shall be conditioned at 25 ± 1 °C (77 ± 2 °F) prior to mixing and the reading taken two minutes after mixing.

The properties of the epoxy mortar, when mixed according to the manufacturer's recommended proportions by mass (weight) with sand (conforming to Section 3 of AASHTO T 106) and cured for 24 hours at 25 ± 1 °C (77 ± 2 °F), shall conform to the requirements of the following table:

TABLE 719.01B - EPOXY MORTAR COMPOUND WITH AGGREGATE (EPOXY MORTAR)

| Mixed Properties | Min. | Max. | Test Method |
|---|---|---|---|
| Compressive strength, MPa (psi) | 55.2 (8000) | --- | See part (d)(2)c. above |
| Splitting tensile strength, MPa (psi) | 10.3 (1500) | --- | ASTM C 496 |

719.02 EPOXY BONDING COMPOUND. Epoxy bonding compound shall meet the requirements of ASTM C 881 for the application and temperature range for which it is to be used.

Certification. A Type A Certification will be furnished in accordance with Subsection 700.02(c).

## SECTION 720 - GEOTEXTILES

720.01 GENERAL. The geotextile shall be composed of a polymeric yarn or fiber oriented into a stable network, which retains its relative structure during handling, placement, and design service life. Geotextiles may be rejected by the Engineer if dimensional stability or resistance of the geotextile to ambient temperatures, acid and alkaline conditions, and micro-organisms/insects does not appear to be satisfactory for the intended purpose. The geotextile shall meet or exceed the properties specified below and in the Contract. The geotextile shall be free of any chemical treatment or coating which might significantly reduce permeability. The selvage of geotextiles shall be finished such that the outer fibers are prevented from pulling away from the fabric. The geotextile shall be free of defects or tears. The material shall be protected from damage and deterioration until incorporated into the project.

720.02 DEFINITIONS.

(a) Geotextile. A fabric manufactured specifically for use in civil engineering applications. Fibers used in the manufacture of geotextiles shall consist of long chain synthetic polymers. At least 85 percent by mass (weight) of the long chain polymers shall be polyolephins, polyesters, or polyamides.

(1) Drainage Geotextile. Geotextile for installation in underdrains or other drainage locations, as directed.

(2) Stone Fill or Riprap Geotextile. Geotextile for installation behind and beneath stone fill or riprap and other erosion control applications, rock placed for slope stabilization, and rock shear keys.

(3) Subgrade Geotextile. Geotextile for installation on roadway subgrades, under railroad ballast, and in other material separation applications.

(b) Machine Direction. The long (or warp) direction of the geotextile. The cross-machine (or fill) direction is perpendicular to the machine direction.

(c) Minimum Average Roll Values. The minimum average roll value of any specific geotextile property is the minimum average of the test results from any roll within a lot.

(d) Nonwoven Geotextile. A textile produced by bonding or interlocking of fibers, or both, accomplished by mechanical, heat, or chemical means.

(e) Seam Allowance. The minimum distance from the edge of a geotextile to the stitch line nearest to that edge.

(f) Seam Type. A designation relating to the essential characteristics of geotextile positioning and rows of stitching in a specified sewn seam, as shown on the Plans.

(g) Selvage. The finished edge of a geotextile parallel to the machine direction.

(h) Stitch Type. A designation relating to the essential characteristics of the interlacing of sewing thread(s) in a specified seam, as shown on the Plans.

(i) Woven Geotextiles. A textile comprising two or more sets of filaments or yarns interlaced in such a way that they result in a uniform pattern.

720.03 FACTORY SEAMS. Where factory seams are made, the sheets of geotextile shall be sewn together using a lock-type stitch. The seams shall be sewn with a polymeric thread, i.e., at least 85 percent by mass (weight) of the long chain polymers shall be polyolephins, polyesters, or polyamides, and shall be as resistant to deterioration as the geotextile being sewn. Nylon threads will not be allowed. The strength of the seam shall be determined by the wide strip tensile test method and shall be at least equal to the larger of the minimum required tensile strengths for the intended application.

720.04 SAMPLING, TEST CERTIFICATION, AND ACCEPTANCE REQUIREMENTS.

(a) Sampling. The manufacturer shall sample all geotextiles in accordance with ASTM D 4354. The production unit used for sampling shall be a roll.

(b) Testing. Tests shall be performed to determine geotextile properties specified below for the intended application(s). All geotextile property requirements are average minimum roll values. The tensile strengths shall be determined in both machine and cross-machine directions.

(c) Acceptance Requirements. If the average minimum roll value for any lot is less than the average minimum roll value specified for the application, then the lot shall be rejected. All rolls shall be clearly labeled as being part of a lot that has been certified as meeting all applicable requirements below.

(d) Minimum Average Roll Value. Average minimum roll values of each of the geotextiles used shall meet the requirements specified in the following table:

TABLE 720.04A - VAOT MINIMUM AVERAGE ROLL VALUES FOR GEOTEXTILES (METRIC)

| Geotextile Property | Test Method | Pay Item 649.11 For Roadbed Separator | | Pay Item 649.21 Under Railroad Ballast | | Pay Item 649.31 Under Stone Fill | | Pay Item 649.41 For Underdrain Trench Lining (Note 3) | Pay Item 649.51 For Silt Fence | Pay Item 649.61 For Filter Curtains |
|---|---|---|---|---|---|---|---|---|---|---|
| Elongation (Note 2) | | | | | | | | | | |
| Elongation Criteria at Failure (Note 1) | ASTM D 4632 | <50% | ≥50% | <50% | ≥50% | <50% | ≥50% | 20% Min. | (Note 4) | 20% Max. |
| 1. Grab Tensile Strength (N) | ASTM D 4632 | 1100 | 700 | 1400 | 900 | 1400 | 900 | 400 | 400 | 900 |
| 2. Burst Strength (kPa) | ASTM D 3786 | 2700 | 1300 | 3500 | 1700 | 3500 | 1700 | 580 | 650 | 1425 |
| 3. Puncture (N) | ASTM D 4833 | 400 | 250 | 500 | 350 | 500 | 350 | 115 | 180 | 360 |
| 4. Trapezoidal Tear Strength (N) | ASTM D 4533 | 400 | 250 | 500 | 350 | 500 | 350 | 110 | 135 | 225 |
| 5. Apparent Opening Size (mm) | ASTM D 4751 | 0.42 Max. | | 0.21 Max. | | 0.21 Max. | | 0.21 Max. | 0.60 Max. | 0.21 Max. |
| 6. Permittivity ($s^{-1}$) | ASTM D 4491 | 0.02 | | 0.30 | | 0.40 | | 0.50 | 0.05 | 0.40 |
| 7. UV Resistance (% Strength Retained) | ASTM D 4355 | 50% @ 500 hours | | 50% @ 500 hours | | 50% @ 500 hours | | 50% @ 500 hours | 70% @ 500 hours | 70% @ 500 hours |
| 8. Other | | | | | | Woven or Nonwoven; slit film not permitted | | Nonwoven only, slit film not permitted | Woven only | Woven only |

1. Elongation corresponds to Maximum Grab Tensile Strength as measured in accordance with ASTM D 4632.
2. Only one criteria applies per Pay Item.
3. Where angular aggregate larger than 100 mm size or sharp objects come in contact with the geotextile, or if the trench is deeper than 3 m, then the minimum Grab Tensile, Burst, Puncture, and Trapezoid Tear Strengths shall be increased to 800 N, 2000 kPa, 360 N, and 225 N, respectively.
4. Where Elongation is ≥50%, post spacing shall not exceed 1.2 m. Where Elongation is <50%, post spacing shall not exceed 2 m.

TABLE 720.04A - VAOT MINIMUM AVERAGE ROLL VALUES FOR GEOTEXTILES (ENGLISH)

| **Geotextile Property** | **Test Method** | **Pay Item 649.11 For Roadbed Separator** | | **Pay Item 649.21 Under Railroad Ballast** | | **Pay Item 649.31 Under Stone Fill** | | **Pay Item 649.41 For Underdrain Trench Lining (Note 3)** | **Pay Item 649.51 For Silt Fence** | **Pay Item 649.61 For Filter Curtains** |
|---|---|---|---|---|---|---|---|---|---|---|
| Elongation (Note 2) | | | | | | | | | | |
| Elongation Criteria at Failure (Note 1) | ASTM D 4632 | <50% | ≥50% | <50% | ≥50% | <50% | ≥50% | 20% Min. | (Note 4) | 20% Max. |
| 1. Grab Tensile Strength (lbs.) | ASTM D 4632 | 250 | 160 | 315 | 200 | 315 | 200 | 90 | 90 | 200 |
| 2. Burst Strength (psi) | ASTM D 3786 | 390 | 190 | 510 | 250 | 510 | 250 | 85 | 95 | 205 |
| 3. Puncture (lbs.) | ASTM D 4833 | 90 | 55 | 110 | 80 | 110 | 80 | 25 | 40 | 80 |
| 4. Trapezoidal Tear Strength (lbs.) | ASTM D 4533 | 90 | 55 | 110 | 80 | 110 | 80 | 25 | 30 | 50 |
| 5. Apparent Opening Size (mils) | ASTM D 4751 | 16.5 Max. | | 8.3 Max. | | 8.3 Max. | | 8.3 Max. | 23.6 Max. | 8.3 Max. |
| 6. Permittivity ($s^{-1}$) | ASTM D 4491 | 0.02 | | 0.30 | | 0.40 | | 0.50 | 0.05 | 0.40 |
| 7. UV Resistance (% Strength Retained) | ASTM D 4355 | 50% @ 500 hours | | 50% @ 500 hours | | 50% @ 500 hours | | 50% @ 500 hours | 70% @ 500 hours | 70% @ 500 hours |
| 8. Other | | | | | | Woven or Nonwoven; slit film not permitted | | Nonwoven only, slit film not permitted | Woven only | Woven only |

1. Elongation corresponds to Maximum Grab Tensile Strength as measured in accordance with ASTM D 4632.
2. Only one criteria applies per Pay Item.
3. Where angular aggregate larger than 4 inch size or sharp objects come in contact with the geotextile, or if the trench is deeper than 10 feet, then the minimum Grab Tensile, Burst, Puncture, and Trapezoid Tear Strengths shall be increased to 180 lbs., 290 psi, 80 lbs., and 50 lbs., respectively.
4. Where Elongation is ≥50%, post spacing shall not exceed 4 feet. Where Elongation is <50%, post spacing shall not exceed 6 feet.

(e) Manufacturer's Certification. The Contractor shall furnish the geotextile manufacturer's certified test results attesting that the geotextile and all factory seams meet the requirements stated in these Specifications. A Type D Certification shall be furnished provided the information required under Subsection 700.02 including minimum average roll values for each type of geotextile used.

## SECTION 725 - CONCRETE CURING MATERIALS AND ADMIXTURES

### 725.01 CONCRETE CURING MATERIALS.

(a) White Burlap-Polyethylene Sheet. White burlap-polyethylene sheet shall conform to the requirements of AASHTO M 171.

(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 AASHTO M 171.

(d) Liquid Membrane-Forming Compounds. Liquid membrane-forming compounds shall conform to the requirements of AASHTO M 148, Type 1-D or Type 2, Class B.

(1) Sampling and Testing. Upon request, the Agency will furnish a list of products that have been previously evaluated and are considered satisfactory. Should the Contractor wish to use a product other than those previously approved, a 4 L (1 gallon) sample of the product shall be submitted to the Agency's Materials and Research Section for testing purposes. A minimum period of 30 days shall be allowed for testing purposes. Tests for daylight reflectance will not be required.

(2) Certification. A Type B Certification shall be furnished in accordance with Subsection 700.02.

### 725.02 CHEMICAL ADMIXTURES.

(a) General.

(1) Packaging. The admixture shall be delivered in the manufacturer's original containers that shall be marked with the manufacturer's name and trade name of the material. Bulk deliveries will be allowed provided a copy of the delivery slip accompanies the manufacturer's certification or sample submitted for testing.

(2) Sampling and Testing. Upon request, the Agency will furnish a list of products that have been previously tested and are considered satisfactory. Should the Contractor wish to use a product other than those previously approved, a 4 L (1 gallon) sample or the equivalent in powder form shall be submitted to the Materials and Research Section for testing purposes. Tests for bleeding and length change will not be required. A minimum period of 60 days shall be allowed for testing purposes.

(3) Certification. A Type B Certification shall be furnished in accordance with Subsection 700.02.

(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, Type B.

(d) Latex Admixture. The formulated latex admixture shall be a homogeneous, nontoxic, film-forming, polymeric emulsion to which all stabilizers have been added at the point of manufacture.

When some degree of flexibility of the composition is considered desirable in the intended use, it shall conform to the requirements of the following table or shall have been approved by the FHWA Fairbank Research Station:

TABLE 725.02A - LATEX ADMIXTURE A

| Physical Properties | Min. | Max. |
|---|---|---|
| Polymer Type | Styrene butadiene | --- |
| Stabilizers: | | |
| (a) Latex | Nonionic surfactants | --- |
| (b) Portland cement composition | Polydimethyl siloxane | --- |
| Solids, % | 46.0 | 49.0 |
| Density, kg/L at 25 °C (lbs./gal at 77 °F) | 1.0 (8.3) | --- |
| Color | White | --- |

Latex admixture shall be stored in suitable enclosures which will protect it from freezing and from prolonged exposure to temperatures in excess of 30 °C (86 °F). It shall not be used after two years from the date of manufacture.

(e) Silicone Admixture. The formulated admixture shall be of a liquid silicone type that conforms to the following chemical description: N-beta (aminoethyl) gamma-Aminopropyltrimethoxy-silane. Its use is intended to prolong the life of portland cement concrete by increasing its resistance to deicing chemicals and by reducing spalling, scaling, and surface failure due to freeze-thaw cycling.

Silicone admixture shall be stored in suitable containers that prevent contamination of any kind. It shall not be used after one year from the date of manufacture or if the liquid is cloudy or milky in color.

(f) Water-Reducing Admixture. Water-reducing admixtures shall conform to the requirements of AASHTO M 194, Type A.

(g) Water-Reducing and Retarding Admixture. Water-reducing and retarding admixtures shall conform to the requirements of AASHTO M 194, Type D.

(h) Water-Reducing, High Range Admixture. Water-reducing, high range admixtures shall conform to the requirements of AASHTO M 194, Type F.

(i) Water-Reducing, High Range, and Retarding Admixture. Water-reducing, high range, and retarding admixtures shall conform to the requirements of AASHTO M 194, Type G

(j) Accelerating Admixture. Accelerating admixtures shall conform to the requirements of AASHTO M 194, Type C.

(k) Water-Reducing and Accelerating Admixture. Water-reducing and accelerating admixtures shall conform to the requirements of AASHTO M 194, Type E.

725.03 MINERAL ADMIXTURES.

(a) Pozzolans. Pozzolans and fly ash shall conform to the requirements of AASHTO M 295. The supplier shall provide the State with the test results of the ten consecutive samples preceding the one submitted for approval to demonstrate compliance with the uniformity requirements shown in Table 2 of AASHTO M 295.

The Contractor shall provide suitable means for storing and protecting the pozzolans from contamination with foreign materials. Fly ash containing oil shall be rejected.

The combining of different types of fly ash or 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 following chemical and physical requirements:

| | |
|---|---|
| Silicon Dioxide ($SiO_2$), Minimum %: | 85.0 |
| Sulfur Trioxide ($So_3$), Maximum %: | 3.0 |
| Moisture Content, Maximum %: | 3.0 |
| Loss on Ignition, Maximum %: | 6.0 |
| Available Alkalies as $Na_2O$, Maximum %: | 1.5 |
| Specific Surface, Air Permeability, $m^2/kg$: | 6000 |
| Pozzolanic Activity Index: | |
| With portland cement, at 28 days when tested in accordance with ASTM C 311, Minimum, % control: | 100 |
| Soundness: | |
| Autoclave expansion or contraction, Maximum %: | 0.8 |
| Specific Gravity, Maximum variation from average, %: | 5 |

When silica fume is delivered in packages or drums, the name brand of the manufacturer and the mass (weight) of the silica fume, if dry, or the concentration, if a slurry, shall be clearly marked on the package or drum.

(c) Ground Granulated Blast-Furnace Slag. Ground granulated blast-furnace slag (GGBFS) shall conform to the requirements of AASHTO M 302.

The Contractor shall provide suitable means for storing and protecting the GGBFS from contamination by foreign materials and/or moisture.

(d) Certification. All mineral admixtures shall be certified by submittal of a Type D Certification in accordance with Subsection 700.02 for each shipment of mineral admixture. If the supplier's operations do not permit strict compliance with the above requirements, alternate procedures for certification, if approved, may be established with the Agency Materials and Research Section, at the request of the supplier.

## SECTION 726 - PROTECTIVE COATINGS AND WATERPROOFING MATERIALS

726.01 TIMBER PRESERVATIVE. Preservatives and pressure treatment processes for timber shall conform to the requirements of AASHTO M 133. Preservatives acceptable for treatment are as follows with retentions and penetrations as specified for ground contact in AWPA Standard C14:

| Preservative Type | AWPA Standard |
|---|---|
| I. Creosote | |
| (a) Creosote | P1 |
| (b) Creosote - Coal Tar Solution | P2 |
| (c) Creosote - Petroleum Solution | P3 |
| II. Pentachlorophenol Solvent - Heavy Oil Hydrocarbon Solvent, Type A | P8<br>P9 |
| III. Pentachlorophenol Solvent - Light Oil Hydrocarbon Solvent, Type C | P8<br>P9 |
| IV. Chromated Copper Arsenate | P5 |

Glued laminated timber shall be treated in compliance with AWPA Standard C28 with retentions and penetrations specified for ground contact.

Any field treatment required by the Engineer shall be performed in accordance with the provisions of AWPA Standard M4.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

726.02 BOILED LINSEED OIL. Boiled linseed oil shall conform to the requirements of ASTM D 260.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

726.03 MINERAL SPIRITS. Mineral spirits shall conform to the requirements of ASTM D 235.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

726.05 WATERPROOFING PITCH. Waterproofing pitch shall conform to the requirements of AASHTO M 118. Type II pitch shall be furnished.

Primer for use with waterproofing pitch shall conform to the requirements of AASHTO M 121.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

726.06 WOVEN COTTON FABRIC. Woven cotton fabric shall conform to the requirements of ASTM D 173.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

726.07 WOVEN GLASS FABRIC. Woven glass fabric shall conform to the requirements of ASTM D 1668.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 727 - FENCING MATERIALS

727.01 WOVEN WIRE FENCE.

(a) Woven Wire Fabric for Fencing and Gates. Woven wire fabric shall be rectangular mesh and shall conform to the requirements of AASHTO M 279, Class 3 coating, Design Number 939-6-11. At the option of the Contractor, the woven wire fabric may be aluminum coated and shall conform to the requirements for ASTM A 584, Class 2 coating.

(b) Barbed Wire. Barbed wire shall conform to the requirements of AASHTO M 280, two strand, standard size 2.51 mm (0.099 inch or 12 1/2 gage) diameter,

Coating Class 3, with four point, 2.03 mm (0.08 inch or 14 gage) diameter, round barbs spaced at approximately 125 mm (5 inch) intervals.

The Contractor may also elect to furnish aluminum coated barbed wire, which shall conform to the requirements of ASTM A 585, Class 2 aluminum coating.

(c) Wood Posts and Braces. 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 115 mm (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, the nominal dimensions shall be at least 100 mm (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 treated full length with a Type IV preservative as specified in Subsection 726.01. Any cut portions shall receive a field application of the type of preservative used.

(d) Steel Posts and Braces. Intermediate or line posts shall be standard commercial T-Type steel posts conforming to the length shown on the Plans, and shall have a nominal mass (weight) of 2 kg/m (1.3 pounds per linear foot) of post length.

End posts, corner posts, and pull posts shall be standard rolled steel angles, 64 by 64 by 6.4 mm (2 1/2 × 2 1/2 × 1/4 inch). They shall conform to the length shown on the Plans and shall have a nominal mass (weight) of 6.1 kg/m (4.1 pounds per linear foot).

Braces shall be standard rolled steel angles 51 by 51 by 4.8 mm (2 × 2 × 3/16 inch) having a nominal mass (weight) of 3.63 kg/m (2.44 pounds per linear foot).

The nominal masses (weights) stated for the several types of posts do not include anchors, plates, or other metal fittings. Intermediate posts or line posts shall be provided with an anchor plate having a length and/or width of 100 to 130 mm (4 to 5 inches) with a net area of not less than 12 900 $mm^2$ (20 square inches). The anchor plates shall be securely fastened to the post by welding or by a minimum of two rivets per plate.

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 111M/M 111 or AASHTO M 232M/M 232, whichever is applicable.

(e) 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 at least 38 mm (1 1/2 inches) long of 3.76 mm (0.1483 inch) diameter (9 gage) galvanized wire. Galvanizing shall be in accordance with AASHTO M 232M/M 232, where applicable. Galvanized wire and clips produced from galvanized wire shall have a Class 1 coating in accordance with AASHTO M 279.

(f) Gates. The frames, diagonal tie bars, braces, and hardware for gates shall conform to the design shown on the Plans and shall be zinc coated on all inner and outer surfaces in accordance with ASTM A 53/A 53M, AASHTO M 111M/M 111, or AASHTO M 232M/M 232, whichever is applicable. Woven wire fabric used for gates shall be of the same material used in fences.

(g) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

727.02 CHAIN-LINK FENCE. Chain-link fence shall conform to the requirements of AASHTO M 181. The chain-link fence shall conform to the design, dimensions, and details shown on the Plans.

(a) Chain-Link Fabric. Chain-link fabric shall consist of 3.76 mm (0.1483 inch) diameter (9 gage) wire woven into a 50 mm (2 inch) mesh. The bottom selvage of all chain-link fabric shall be knuckled. When the height of the fabric is 1.2 m (4 feet) or less, the top edge shall also be knuckled. When vinyl coated fabric is used, the wire shall be 3.76 mm (0.1483 inch) diameter (9 gage) prior to coating with vinyl. Galvanized chain-link fabric shall be Type I, Class D, as specified in AASHTO M 181.

(b) Posts, Gate Frames, Rails, Braces, and Miscellaneous Hardware. Posts, gate frames, rails, braces, and miscellaneous hardware furnished for use in conjunction with zinc or vinyl coated steel fabric shall be of zinc coated steel. Zinc coated steel shall conform to the requirements of AASHTO M 181, Grade 1 or Grade 2.

Posts, gate frames, rails, braces, and miscellaneous hardware shall conform to the requirements of the following table:

TABLE 727.02A - ZINC COATED STEEL MATERIAL (METRIC)

| Use and Section | | Outside Diameter or Dimensions (mm) | Nominal Mass per Meter (kg) |
|---|---|---|---|
| End, Corner, and Pull Post for fabric heights: | | | |
| Less than 1.8 m: | Round, Grade 1 | 60.3 | 5.43 |
| | Round, Grade 2 | 60.3 | 4.64 |
| | Square | 50.8 by 50.8 | 5.36 |
| | Roll Formed | 88.9 by 88.9 | 7.59 |
| 1.8 m and greater: | Round, Grade 1 | 73.0 | 8.62 |
| | Round, Grade 2 | 73.0 | 6.91 |
| | Square | 63.5 by 63.5 | 8.48 |
| | Roll Formed | 88.9 by 88.9 | 7.59 |
| Line Posts for fabric heights: | | | |
| Less than 1.8 m: | Round, Grade 1 | 48.3 | 4.05 |
| | Round, Grade 2 | 48.3 | 3.39 |
| | Roll Formed | 47.6 by 41.3 | 3.39 |
| | H-Section | 57.2 by 43.2 | 4.85 |
| 1.8 m and greater: | Round, Grade 1 | 73.0 | 5.43 |
| | Round, Grade 2 | 48.3 | 4.64 |
| | Roll Formed | 47.6 by 41.3 | 3.39 |
| | H-Section | 57.2 by 43.2 | 4.85 |
| Gate Posts for nominal width of gate, single gate, or one leaf of double gate: | | | |
| 1.8 m and less: | Round, Grade 1 | 73.0 | 8.62 |
| | Round, Grade 2 | 73.0 | 6.91 |
| | Square | 63.5 by 63.5 | 8.48 |
| | Roll Formed | 88.9 by 88.9 | 7.54 |
| Over 1.8 to 4.0 m: | Round, Grade 1 | 101.6 | 13.54 |
| | Round, Grade 2 | 88.9 | 8.47 |
| | Square | 76.2 by 76.2 | 13.54 |
| Over 4.0 to 5.5 m: | Round | 168.3 | 28.23 |
| Over 5.5 m: | Round | 219.1 | 36.76 |
| Gate Frames for fabric heights: | | | |
| Less than 1.8 m: | Round, Grade 1 | 42.2 | 3.38 |
| | Round, Grade 2 | 42.2 | 2.74 |
| | Square | 38.1 by 38.1 | 2.83 |
| 1.8 m and greater: | Round, Grade 1 | 48.3 | 4.05 |
| | Round, Grade 2 | 48.3 | 3.39 |
| | Square | 50.8 by 50.8 | 3.13 |
| Top Rails and Brace Rods: | Round, Grade 1 | 42.2 | 3.38 |
| | Round, Grade 2 | 242.2 | 2.74 |
| | Roll Formed | 41.3 by 31.8 | 2.00 |
| Truss Rods: | Round with Turnbuckle | 9.5 | --- |
| Tension Wire: | Wire | 3.8 | --- |
| Tension Bars: | Bar | 6.4 by 19.1 | --- |

TABLE 727.02A - ZINC COATED STEEL MATERIAL (ENGLISH)

| Use and Section | | Outside Diameter or Dimensions (inches) | Weight Per Foot (pounds) |
|---|---|---|---|
| End, Corner, and Pull Post for fabric heights: | | | |
| Less than 6 feet: | Round, Grade 1 | 2.375 | 3.65 |
| | Round, Grade 2 | 2.375 | 3.12 |
| | Square | 2.00 × 2.00 | 3.60 |
| | Roll Formed | 3.50 × 3.50 | 5.14 |
| 6 feet and greater: | Round, Grade 1 | 2.875 | 5.79 |
| | Round, Grade 2 | 2.875 | 4.64 |
| | Square | 2.50 × 2.50 | 5.70 |
| | Roll Formed | 3.50 × 3.50 | 5.14 |
| Line Posts for fabric heights: | | | |
| Less than 6 feet: | Round, Grade 1 | 1.90 | 2.72 |
| | Round, Grade 2 | 1.90 | 2.28 |
| | Roll Formed | 1.875 × 1.625 | 5.14 |
| | H-Section | 1.875 × 1.625 × 0.113 | 2.70 |
| 6 feet and greater: | Round, Grade 1 | 2.875 | 3.65 |
| | Round, Grade 2 | 2.375 | 3.12 |
| | Roll Formed | 1.875 × 1.625 | 5.14 |
| | H-Section | 2.25 × 1.95 × 0.143 | 4.10 |
| Gate Posts for nominal width of gate, single gate, or one leaf of double gate: | | | |
| 6 feet and less: | Round, Grade 1 | 2.875 | 5.79 |
| | Round, Grade 2 | 2.875 | 4.64 |
| | Square | 2.50 × 2.50 | 5.70 |
| | Roll Formed | 3.50 × 3.50 | 5.14 |
| Over 6 to 13 feet: | Round, Grade 1 | 4.00 | 9.10 |
| | Round, Grade 2 | 3.50 | 5.71 |
| | Square | 3.00 × 3.00 | 9.10 |
| Over 13 to 18 feet: | Round | 6.625 | 18.97 |
| Over 18 feet: | Round | 8.625 | 24.70 |
| Gate Frames for fabric heights: | | | |
| Less than 6 feet: | Round, Grade 1 | 1.660 | 2.27 |
| | Round, Grade 2 | 1.660 | 1.84 |
| | Square | 1.50 × 1.50 | 1.90 |
| 6 feet and greater: | Round, Grade 1 | 1.90 | 2.72 |
| | Round, Grade 2 | 1.90 | 2.28 |
| | Square | 2.00 × 2.00 | 2.10 |
| Top Rails and Brace Rods: | Round, Grade 1 | 1.660 | 2.27 |
| | Round, Grade 2 | 1.660 | 1.84 |
| | Roll Formed | 1.625 × 1.25 | 1.34 |
| Truss Rods: | Round with Turnbuckle | 0.375 | --- |
| Tension Wire: | Wire | 0.1483 | --- |
| Tension Bars: | Bar | 1/4 × 3/4 | --- |

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 728 - GUARDRAIL, GUIDE POSTS, AND BARRIERS

### 728.01 POSTS AND POST ACCESSORIES.

(a) Wood Posts and Offset Blocks for Rail, Guardrail, Barriers, and Guide Posts. Wood posts and offset blocks shall be seasoned Red (Norway) Pine or Southern Pine, straight, sound, and cut from live timber. Red Pine shall meet number 1 grade requirements specified by the Northeastern Lumber Manufacturer's Association (NELMA). Southern Pine shall meet number 2 grade requirements specified by the Southern Pine Inspection Bureau (SPIB). Preservatives and pressure treatment shall conform to AASHTO M 133 and AWPA Standards C1, C2, and C14. Inspection of treated material shall, at minimum, conform to AWPA Standards M2, M3, and M4.

Material shall be of the proper grade prior to beginning any fabrication operation.

Material shall be fabricated prior to treatment in conformance with the dimensions as details shown on the Plans.

Material shall be treated with a Type IV preservative as specified in Subsection 726.01.

Field repairs shall be made in accordance with AWPA Standard M4. Cuts, holes, and injuries may be saturated with copper napthenate containing a minimum of 2 percent copper metal. Bored holes shall be plugged with treated tight fitting wooden plugs.

Timber material shall be produced in accordance with American Lumber Standards Committee (ALSC) approved grading standards. Acceptable material shall be grade stamped with an appropriate tag or mark identifying conformance with ALSC requirements.

Retention by assay shall be not less than 9.6 $kg/m^3$ (0.60 pound per cubic foot)

All lumber and timber shall be treated in a plant participating in an independent inspection program designed to provide continuous supervision, testing, and inspection for establishing acceptable quality control. Competency and performance of the inspection agency shall be overviewed by an approved organization, such as the American Wood-Preservers' Association (AWPA). Material meeting compliance with applicable specifications shall bear the quality mark of the authorized inspection agency.

Tags and marks identifying compliance shall, at a minimum, be placed on each post in a location that will be visible after installation.

Each and every charge of treated material shall be inspected in accordance with the applicable requirements for soil use specified in AWPA Standard C2. The treater shall perform laboratory analysis for measured penetration and retention of each charge. A copy of each analysis report shall accompany the certificates covered under Subsection 728.01(e).

It is the responsibility of the producer to arrange for all independent inspection. All inspection costs shall be included in the unit price of the material.

(b) Wood Posts for Cedar Log Rail. Wood posts shall be seasoned Cedar, straight, sound, and cut from live timber. The posts shall conform to the diameter and length shown on the Plans. They shall be shaved to an even surface and shall be free from bark or skin.

(c) Steel Posts and Post Accessories. Steel posts, offset blocks, splice plates, brackets, channel anchors, and other post accessories shall conform to the requirements of AASHTO M 183M/M 183. They shall conform to the details shown on the Plans. After fabrication, all posts, post accessories, and channel anchors shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.

(d) Alternative Blockouts. As an alternative to steel or wood blockouts in part (a) or (c) above, blockouts made of recycled wood-polymer composite materials conforming to the dimensions shown on the Plans are allowed.

Acceptable blockouts shall meet specific test criteria and shape details and shall be on the approved list on file at the Agency's Materials and Research Section.

(e) Certification. For wood posts and accessories, a Type D Certification shall be furnished in accordance with Subsection 700.02. For steel posts and accessories, a Type D Certification shall be furnished. For alternative blockouts, a Type B Certification shall be furnished.

728.02 RAIL ELEMENTS.

(a) Plank Rail. The plank for rail shall be seasoned Red (Norway) Pine or Southern Pine, planed on four sides, and of the dimensions shown on the Plans. Wood shall be treated full length in accordance with Subsection 726.01, Type I, II, III, or IV.

(b) Log Rail. The log for rail shall be seasoned Cedar, straight, sound, and cut from live timber. The rail shall conform to the diameter and length shown on the Plans. They shall be shaved to an even surface and be free from bark or skin.

(c) Cable Rail. Cable shall conform to the requirements of Subsection 713.03.

(d) Steel Beam and Thrie Beam Rail. Steel beam (W-beam) and thrie beam rail elements shall conform to AASHTO M 180, Class A, Type II zinc coated, except that when a heavy duty steel beam is specified, the rail elements shall conform to AASHTO M 180, Class B, Type II.

When corrosion resistant steel is specified, Type IV rail having the corrosion resistance of AASHTO M 270M/M 270, Grade 345W (Grade 50W) shall be used.

(e) Box Beam Rail. Box beam rail shall conform to the requirements of Subsection 714.11. The rail shall conform to the details shown on the Plans as to size and shape and all holes and slots shall be punched, drilled, burned, or cut as indicated. After fabrication, the rail shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.

(f) Certification. For Cedar log and cable rail, a Type A Certification shall be furnished in accordance with Subsection 700.02. For plank rail, a Type D Certification shall be furnished. For cable, beam, and box beam rail, a Type D Certification shall be furnished.

728.03 HARDWARE.

(a) Hardware for Plank Rail. Miscellaneous hardware such as spikes, lag screws, bolts, nuts, and washers shall conform to the dimensions shown on the Plans. They shall be of low to medium carbon steel, galvanized and shall be of good commercial quality. The metal brackets shall be fabricated from 6 mm (1/4 inch) steel plate and shall be galvanized after fabrication.

(b) Hardware for Cedar Log Rail. Miscellaneous hardware such as lag screws shall be of low to medium carbon steel and shall be of good commercial quality. The metal straps shall be fabricated from 6 mm (1/4 inch) steel plate.

(c) Hardware for Cable, Steel Beam, and Thrie Beam Rail. Miscellaneous hardware and fittings such as bolts, nuts and washers, cable splices, hook bolts, anchor rod assemblies, and cable end units shall conform to the dimensions shown on the Plans. All cable fittings and anchorages shall be capable of developing the minimum tensile strength shown on the Plans when properly installed.

Bolts, nuts, and washers shall conform to:

(1) Steel bolts shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307, Grade A). Steel nuts shall conform to the requirements of AASHTO M 291M (AASHTO M 291). Steel washers shall conform to the requirements of ASTM F 436M (ASTM F 844).

(2) Steel cast bolts, nuts, and washers shall conform to the requirements of ASTM A 27/A 27M, Grade 65-35 full annealed.

All hardware shall be galvanized in accordance with AASHTO M 232 M/M 232. All bolts, nuts, and washers shall be either hot-dip galvanized in accordance with the requirements of AASHTO M 232M/M 232 or mechanically galvanized using a mechanically deposited process conforming to the requirements of AASHTO M 298, Class 50.

When corrosion resistant steel Type IV rail is specified and galvanized hardware is not desirable, black, ungalvanized bolts shall be used and shall conform to

ASTM F 568M, Class 4.6 (ASTM A 307, Grade C); nuts shall conform to AASHTO M 291M (AASHTO M 291); and washers shall conform to ASTM F 436M (ASTM F 844); or bolts, nuts, and washers shall conform to ASTM A 27/A 27M, Grade 65-25, full annealed.

(d) Hardware for Box Beam Rail. Bolts shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307, Grade A); nuts shall conform to the requirements of AASHTO M 291M (AASHTO M 291); and washers shall conform to the requirements of ASTM F 436M (ASTM F 844). Bolts, nuts, and washers for rail splice connections shall conform to the requirements of ASTM A 325M (ASTM A 325). All bolts, nuts, and washers shall be either hot-dip galvanized in accordance with AASHTO M 232M/M 232 or mechanically galvanized using a mechanically deposited process conforming to the requirements of AASHTO M 298, Class 50.

All bolts, nuts, and washers required to conform to AASHTO M 164M (AASHTO M 164) shall meet all requirements of Subsection 714.05, except that the rotational capacity tests, the proof load tests, and the wedge tests will not be required.

(e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

728.04 DELINEATION DEVICES. Delineators for wood posts shall be an approved reflective sheeting conforming to Subsection 750.08.

Delineators for steel posts or guardrail shall be flat sheet aluminum conforming to Subsection 751.04 and the details shown on the Plans, or high impact polycarbonate thermoplastic conforming to Subsection 751.07 and the details shown on the Plans.

The face of each delineator shall be reflectorized with reflective sheeting conforming to Subsection 750.08 and of the type shown on the Plans.

As an aid to installation, reflectors for use in the valley of W-shaped steel beam guardrail may have a 19 mm (3/4 inch) slot extending horizontally from the bolt hole in the base to the end of the base away from the reflectorized surface or extending vertically down from the bolt hole to the lower edge of the base. The directions indicated are viewed looking at the installed reflector unit from the point on the roadway centerline, which is the intersection of the perpendicular to the centerline that passes through the reflector unit base.

The Contractor may propose other materials as backing for traffic barrier reflectors.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

728.05 CONCRETE ANCHORS. Precast or cast-in-place concrete anchors for guardrail shall conform to the details shown on the Plans as to size, shape, and placement of the bar reinforcement.

(a) Concrete. The concrete shall conform to Section 501 for Concrete, Class B.

(b) Curing. The concrete anchors shall be cured in accordance with AASHTO M 199M (AASHTO M 199), Section 10, and for a sufficient length of time so that the concrete will develop the specified compressive strength within 28 days.

(c) Bar Reinforcement. Bar reinforcement shall conform to Subsection 713.01.

(d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02 for precast anchors.

## 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.

(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 2 m (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 3 mm (1/8 inch).

The bottom surface may be sawn or split.

The top front arris line shall be rounded as shown on the Plans. The exposed arris lines shall be pitched straight and true, with no variations from a straight line greater than 3 mm (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 25 mm (1 inch) or depressions greater than 13 mm (1/2 inch), measured from the vertical plane of the face through the top arris line for a distance of 200 mm (8 inches) down from the top. For the remaining distance, there shall be no projections or depressions greater than 25 mm (1 inch) measured in the same manner.

The back surface of the curb stones shall have no projection for a distance of 75 mm (3 inches) down from the top which would fall outside of a plane having a batter of one horizontal to three vertical 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 25 mm (1 inch) shall show in the joint for the full width of the top or down on the face for 200 mm (8 inches). The remainder of the end may break back a maximum of 150 mm (6 inches) from the plane of the joint.

Curbing stones to be set on a radius of 25 m (80 feet) or less shall be cut to the curve required, and their ends shall be cut on radial lines.

729.02 GRANITE BRIDGE CURB. Granite bridge 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 stones in any one structure shall be of uniform color and acceptable to the Engineer. The curb stones shall be thoroughly cleaned of any iron rust or sand particles.

(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 on any one structure or in any continuous run. The individual curb stones shall be furnished in random lengths between 1 and 3 m (3 and 10 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 3 mm (1/8 inch). The bottom of the curb stones shall be parallel to the top and sawed or dressed to lay with not more than a 25 mm (1 inch) joint at the face for the full length of the stone. The remainder of the bottoms may break back not over 25 mm (1 inch).

The top front arris line shall be rounded as shown on the Plans. The exposed arris lines shall be pitched straight and true, with no variations from a straight line greater than 3 mm (1/8 inch).

The front face shall be battered as shown on the Plans and shall be smooth quarry split or sawed for the full depth. Drill holes in the front face shall not be permitted. The front face shall have no projections or depressions greater than 13 mm (1/2 inch), measured from the plane of the face through the top arris line for the full depth of the stone.

The back surface of the curb stones shall have no projections or depressions greater than 25 mm (1 inch), measured from the plane of the face through the top arris line for the full depth of the stone.

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 10 mm (3/8 inch) shall show in the joint for the full width of the top and full depth of the front face. The remainder of the ends may break back a maximum of 50 mm (2 inches) from the plane of the joint. Where shown on the Plans or where the curb butts metal expansion joints, the ends shall be sawed to an approximately true plane.

Curb stones to be set on a radius of 50 m (160 feet) or less shall be cut to the curve required, and their ends shall be cut on radial lines.

729.03 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.

(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 600 mm (2 feet).

The tops and bottoms shall be not under the square more than 100 mm (4 inches), or over the square at the back more than 25 mm (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 then to extend upward from the edge not over 75 mm (3 inches). The exposed face shall have no projections or depressions greater than 25 mm (1 inch), measured from a 600 mm (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 25 mm (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 5 mm (1/4 inch).

729.04 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.

The precast 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 1 m (3 feet) or greater than 3 m (10 feet). Random lengths of curb of not less than 1 m (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 50 m (160 feet) or less shall be precast to fit the curve as required.

(b) Marking. Each pour shall be identified with a registration number cast in the curb showing the name or trademark of the manufacturer and the manufacturer's date of manufacture by a six digit number indicating in order the year, month, and day of month. A pour shall be considered as one day's production.

(c) Materials. The concrete shall conform to the requirements of Section 501 for Concrete, Class AA and when sampled and tested in accordance with AASHTO T 24, shall have a minimum compressive strength of 35 MPa (5000 pounds per square inch). The manufacturer shall obtain a minimum of one core per pour for testing purposes. The core specimens shall be taken horizontally below the exposed face. The core holes shall be backfilled with Type I mortar conforming to the requirements of Subsection 707.01. Bar reinforcement shall conform to the requirements of Subsection 713.01.

(d) Curing. The precast curb units shall be cured in accordance with the requirements of ASTM C 478M (ASTM C 478), Section 10, and for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less. Liquid membrane-forming compounds will not be allowed.

(e) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

729.05 BITUMINOUS CONCRETE CURB. Bituminous concrete curb shall consist of blended aggregate, polyester fibers, asphalt cement, and mineral filler if required, combined in such proportions that the resulting mixture conforms to the requirements of Subsection 406.03(a), Type IV except that the percent of asphalt cement shall be between 7.0 and 9.0 percent.

(a) Aggregate. The aggregate shall conform to the requirements of Subsection 704.10.

(b) Asphalt Cement. The grade of asphalt cement shall be as directed by the Engineer and shall conform to the requirements of Section 702.

(c) Polyester Fibers. The type of fiber used shall be approved by the Materials and Research Section, shall be uniformly incorporated into the dry mix. The fiber percent used shall be 0.25 percent per ton of mix. Dry mix times shall be increased to the satisfaction of the Engineer.

729.06 TREATED TIMBER CURB. Treated timber curb and stakes shall be either seasoned Red (Norway) Pine, Eastern (Northern) 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 the requirements of Subsection 728.01(a).

(a) Miscellaneous Hardware. All spikes, U-bolts, nuts, and washers 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.

(b) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 730 - PILING

730.01 STEEL PILING. Steel piling shall be rolled steel sections of the mass (weight) and shape shown on the Plans. Piles, splice plates, and point reinforcement shall be new material conforming to the requirements of AASHTO M 270M/M 270, Grade 250 (Grade 36). When cast steel shoes are used, they shall conform to the requirements of AASHTO M 103M/M 103, Grade 485-275 (Grade 70-40) or ASTM A 148/A 148M, Grade 550-275 (Grade 80-40).

Certification. A Type C Certification shall be furnished in accordance with Subsection 700.02.

730.02 STEEL SHEET PILING. Steel sheet piling shall be rolled steel sections of the type, shape, and mass (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 202M/M 202. Reconditioned steel sheet piling may be used if authorized by written order by the Engineer.

Certification. Permanent steel sheet piling furnished under this Subsection shall be covered by a Type C Certification in accordance with Subsection 700.02.

## SECTION 731 - BEARING PADS FOR STRUCTURES

731.01 PREFORMED FABRIC BEARING PADS. Preformed fabric bearing pads shall be manufactured from all new materials comprised of multiple layers of prestressed duck impregnated and bound with high quality oil resistant rubber vulcanized and cured under pressure to form a resilient pad of uniform thickness. The duck material shall have a mass (weight) of at least 270 $g/m^2$ (8 ounces per square yard) with a filling of 50 ± 1 warp threads per 25 mm (1 inch) and a filling of 40 ± 2 woof threads per 25 mm (1 inch). The finished product shall have 64 plies per 25 mm (1 inch) of thickness, and withstand a compressive load perpendicular to the plane of

the laminations of 69 MPa (10,000 pounds per square inch). Load deflection shall not exceed 10 percent at 6.9 MPa (1000 pounds per square inch) and the material shall perform effectively from -54 to 93 °C (-65 to 200 °F). The test sample for measuring load deflection shall be 50 by 50 mm (2 × 2 inches).

Bearing pads over 13 mm (1/2 inch) in thickness may be manufactured by laminating vulcanized sheets together to obtain the designed pad thickness. The number of laminated joints shall be not greater than:

| Bearing Pad Thickness | | Number of Laminated |
|---|---|---|
| millimeters | inches | Joints Permitted |
| 13 to 25 | 1/2 to 1 | 1 |
| 29 to 38 | 1 1/8 to 1 1/2 | 2 |
| 41 to 50 | 1 5/8 to 2 | 3 |
| Over 50 | Over 2 | 4 |

Certification. A Type A Certification will be furnished in accordance with Subsection 700.02.

731.02 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 48.2 MPa (700 pounds per square inch). The surface hardness shall have a Shore A Durometer of 80 ± 10 in accordance with ASTM D 2240.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

731.03 ELASTOMERIC MATERIAL. Elastomeric material shall conform to the requirements of Division II of the AASHTO *Standard Specifications for Highway Bridges*. Unless otherwise shown on the Plans or specified in the Contract, the elastomeric compound shall be neoprene conforming to Table 18.2.3.1B with a Shore A Durometer hardness of 50 ± 5.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

731.04 TFE MATERIAL. Tetrafluoroethylene (TFE) material incorporated in bearing devices shall be all new material consisting of 800 μm (1/32 inch) minimum thickness unfilled resin sheets conforming to the requirements of Division I, Section 15 and Division II, Section 18.8 of the AASHTO *Standard Specifications for Highway Bridges*.

TFE material used on guide bars or similar applications where it is required to sustain horizontal loading shall be glass fiber or carbon filled.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

731.05 STAINLESS STEEL. Stainless steel used as a mating surface with TFE and incorporated in bearing devices shall conform to the requirements of ASTM A 240/A 240M, Type 304.

The surface finish on the contact (sliding) face of the stainless steel shall have a mirror finish of less than 0.25 μm (10 micro inches) rms (Root Mean Square).

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

731.06 SOCKET-HEAD CAP SCREWS. Socket-head cap screws shall conform to the requirements of ASTM A 574M, with M profile thread series per ANSI B18.3.1M (ASTM A 574, with a Unified Coarse Thread series per ANSI B1.1).

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

731.07 BRASS RINGS. Brass bar material shall conform to ASTM B 19, Standard Temper H92 or ASTM B 36/B 36M, Copper Alloy UNS No. C26000, Standard Temper H02.

Brass rod material shall conform to ASTM B 16M (ASTM B16), Standard Temper H02.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 732 - RAILING MATERIALS

732.01 METAL HAND RAILING. Material for metal hand railing and sleeves shall conform to ASTM A 53/A 53M.

732.02 ALUMINUM BRIDGE RAILING.

(a) Aluminum Alloy. Aluminum alloy for aluminum bridge railing shall conform to the requirements of Subsection 715.04.

(b) Stainless Steel Bolts, Nuts, Washers, and Set Screws. Bolts and washers for post, rail, and offset block connections shall conform to the requirements of ASTM F 738M, Property Class A1-50, Condition AF, Alloy 304 (ASTM A 593, Alloy Group 1, Condition AF, Alloy 304).

Nuts shall conform to the requirements of ASTM F 836M, Property Class A1-50, Condition AF, Alloy 304 (ASTM F 594, 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 F 880M, Property Class A1-70, Condition CW, Alloy 304 (ASTM F 880, Alloy Group 1, Condition CW, Alloy 304).

Stainless steel anchor bolts and washers shall conform to the requirements of ASTM F 738M, Property Class A1-70, Condition CW, Alloy 304 (ASTM A 593, Alloy Group 1, Condition CW, Alloy 304). Heavy hex stainless steel nuts for stainless steel anchor bolts shall conform to the requirements of ASTM F 836M, Property Class A1-70, Condition CW, Alloy 304 (ASTM A 594, Alloy Group 1, Condition CW, Alloy 304).

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02 for any and all stainless steel bolts, nuts, washers, and set screws.

(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 183M/M 183.

(d) Steel Pipe. Steel pipe for anchor bolt sleeves shall conform to the requirements of Subsection 740.05.

(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 731.02.

(g) Aluminum Impregnated Caulking Compound. Aluminum impregnated caulking compound shall conform to the requirements of Subsection 707.13.

732.03 GALVANIZED BOX BEAM BRIDGE RAILING.

(a) Structural Steel Tubing. Tubing for posts and rails shall conform to ASTM A 500, Grade B, except as modified below:

(1) General Requirements for Rail and Post Sections.

a. 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.

b. Longitudinal welds may be made by the resistance, gas shielded arc, submerged arc, or plasma arc process. Welds shall be sound, free from defects, and have no repairs. Transverse mill welds will not be permitted.

c. Longitudinally welded tubing shall have a tensile strength of 400 MPa (58,000 pounds per square inch) when tested in accordance with AASHTO T 68.

d. Fabrication welding shall comply with the requirements of Subsection 506.10.

e. A traceable identification number shall be placed on each piece of material in a form that can be read after the galvanizing process.

(2) Post Sections.

a. Post and baseplate material (ASTM A 500, AASHTO M 183M/M 183, AASHTO M 222M/M 222, or other) shall be tested for impact properties in accordance with the requirements for Charpy Impact Testing in ASTM A 370, using a Type A specimen. Tubular posts that are fine grained fully killed aluminum ASTM A 500 material with a minimum aluminum content of 0.025 percent by heat analysis will not require testing for impact properties.

b. Sampling procedure shall be in accordance with AASHTO T 243M/T 243 using frequency "H" testing.

c. Full size [10 by 10 mm (3/8 × 3/8 inch)] specimens shall be used whenever thickness permits. Subsize specimens may be used when material thickness is less than 10 mm (3/8 inch).

d. To qualify, the average energy absorbed by a full size specimen shall be not less than 33.9 J at 5 °C (25 pounds-force foot at 40 °F). The average energy absorbed by a subsized specimen shall be prorated for the actual thickness of the specimen.

(3) Rail Sections.

a. Material shall be tested in accordance with ASTM E 436. Test samples shall be galvanized in accordance with AASHTO M 111M/M 111 prior to testing.

b. Sampling procedure shall be in accordance with AASHTO T 243M/T 243 with one test (a set of three specimens) for each heat.

c. Tests shall be conducted at -18 °C (0 °F), without removing the galvanizing.

d. Specimens shall be 50 by 230 mm (2 × 9 inches) supported at a span of 180 mm (7 inches).

e. The percent shear area shall be determined from testing nine specimens, three from each of three sides not containing a weld.

f. The final percent shear area shall be an average of the two sides having the highest average shear.

g. The minimum average shear area shall be 50 percent.

h. If any ASTM E 436 test averages between 30 and 50 percent shear, the manufacturer will be permitted to retest the heat. For each original heat test, three sets of nine specimens shall be retested. For the heat to be accepted, each set must show a minimum average shear of 50 percent for the two best sides.

(4) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

(b) Structural Carbon Steel. Structural carbon steel for plates and angles shall conform to the requirements of AASHTO M 183M/M 183.

(c) Bolts, Nuts, and Washers. Bolts, nuts, and washers for railing and rail to post connections shall conform to the requirements of Subsection 714.04.

(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 rail shall be Class B.

(b) 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 222M/M 222, Grade 345 (Grade 50) or AASHTO M 223M/M 223, Grade 345 (Grade 50).

(c) Steel Pipe. Steel pipe for anchor bolt sleeves shall conform to the requirements of Subsection 740.05.

(d) Anchor Bolts, Nuts, and Washers. Anchor bolts, nuts, and washers shall conform to the requirements of Subsection 714.07.

(e) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02 for the materials supplied under part (b) above.

## SECTION 735 - INSULATING MATERIALS

735.01 POLYSTYRENE INSULATION BOARD. Polystyrene insulation board shall conform to the requirements of AASHTO M 230. It shall be formed by the expansion of polystyrene base resin in an extrusion process and shall be homogeneous and unicellular. It shall be furnished in nominal 600 by 2400 mm (2 × 8 foot) boards and shall be of the thickness shown on the Plans.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

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 0.039 W/[m•ºC] (0.27 BTU inch per hour square foot degree Fahrenheit) at a mean temperature of 24 °C (75 °F).

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## 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 AWWA C 901. The material grade selected shall be capable of withstanding a minimum sustained water pressure of 1.1 MPa at 23 °C (160 pounds per square inch at 73 °F). The pipe shall be inside diameter controlled. Fittings may be either nylon, copper, or bronze. Clamps shall be stainless steel.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

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 C 900. The material grade selected shall be capable of withstanding a minimum sustained water pressure of 1.1 MPa at 23 °C (160 pounds per square inch at 73 °F). Fittings shall be PVC plastic conforming to ANSI/AWWA C 110/A 21.10.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.03 THIS SUBSECTION RESERVED

740.04 COPPER TUBE, SEAMLESS. Seamless copper water tube shall conform to ASTM B 88M (ASTM B 88), Type K.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.05 STEEL PIPE, GALVANIZED. Galvanized steel pipe shall be suitable for the transportation of potable water and shall be the standard weight class conforming to ASTM A 53/A 53M.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.06 PLASTIC TUBING, FLEXIBLE. The tubing shall be a flexible transparent PVC material meeting the following requirements:

| Property | Test Method | Requirement |
|---|---|---|
| Inside Diameter | --- | 13 mm (1/2 inch) |
| Wall Thickness | --- | 4 mm (5/32 inch) |
| Color | --- | clear |
| Durometer Hardness (Shore A) | ASTM D 2240 | 55 to 65 |
| Tensile Strength | ASTM D 638 | 11 to 14.5 MPa (1600 to 2100 psi) |
| Ultimate Elongation | ASTM D 638 | 450% |

The material shall have an operating temperature range between -43 and 65 °C (-45 and 150 °F).

Shop or field splices of tubing will not be permitted when installation lengths are less than 150 m (500 feet). When installation lengths in excess of 150 m (500 feet) are required one field splice per each 150 m (500 feet) length, or fraction thereof, will be allowed. Splices shall be made with 13 mm (1/2 inch) inside diameter by 75 mm (3 inch) long nipple inserts. Inserts may be stainless steel or copper tubing with a minimum wall thickness of 1.25 mm (0.049 inch). Inserts shall be centered on the splice and fastened each side with stainless steel clamps.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.07 DUCTILE IRON PIPE, CEMENT LINED. Ductile iron pipe shall be cement lined and centrifugally cast in metal or sand-lined molds. It shall conform to the requirements of ANSI/AWWA C 151/A 21.51. The class of pipe shall be as specified in the contract.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.08 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 0.039 W/[m•°C] (0.27 BTU inch per hour square foot degree Fahrenheit) at a mean temperature of 24 °C (75 °F).

The thickness and jackets shall be as specified in the Contract.

Pipe insulation used as bond breakers for structures shall conform to the requirements of ASTM C 534.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.09 EXTENSION SERVICE BOX, CAST IRON. Cast iron extension service boxes shall conform to the dimensions specified in the Contract and shall be a standard commercial type. A suitable key or rod shall be furnished for removing the cover and operating the curb stop.

The type and details of extension service boxes shall be approved by the Engineer prior to purchase.

740.10 CURB STOP, BRASS. Brass curb stops shall be compatible with the pipe being used and be a standard commercial type.

The type and details of curb stops shall be approved by the Engineer prior to purchase.

740.11 GATE VALVES. Gate valves shall conform to the details specified in the Contract.

The type and details of gate valves shall be approved by the Engineer prior to purchase.

740.12 TAPPING SLEEVE. Tapping sleeves shall be compatible with the pipe being used and be a standard commercial type.

The type and details of tapping sleeves shall be approved by the Engineer prior to purchase.

740.13 HYDRANT. Hydrants shall conform to the details specified in the Contract.

The type and details of hydrants shall be approved by the Engineer prior to purchase.

740.14 CORPORATION STOPS. Corporation stops shall be a standard commercial type compatible with the water main and the service line pipes being used.

When used with seamless copper water tube service lines, the outlet shall have a copper compression joint with iron pipe threads under the tube nuts.

The type and details of corporation stops shall be approved by the Engineer after consultation with the utility owner before any purchase is made by the Contractor.

## SECTION 741 - WELLS AND PUMPS

741.01 WELL CASING. Well casing shall conform to the requirements of ASTM A 53/A 53M.

Certification. A Type A Certification will be furnished in accordance with Subsection 700.02.

741.02 WATER PUMPS. Water pumps (jet, submersible, or shallow well) shall be of a standard commercial quality. The capacity of the pump shall be such that it will be capable of discharging water at the rate and pressure for the pumping depth specified for the installation.

The motor voltage of the pump shall be compatible with the voltage available at the electrical source.

The Contractor shall submit the name of the manufacturer, the specifications for the pump, accessories, and electrical equipment that is proposed to be furnished, for approval to the Engineer five days before placing any purchase orders .

741.03 WATER STORAGE TANKS. Water storage tanks shall be of steel (galvanized, vinyl or epoxy coated, and lined) or of molded fiber glass and shall be of a standard commercial quality. The tanks shall be capable of withstanding 1.1 MPa (160 pounds per square inch) test pressure.

The Contractor shall submit for approval to the Engineer five days before placing any purchase orders the name of the manufacturer and the specifications for the water storage tank that is proposed to be furnished.

741.04 PRECAST REINFORCED CONCRETE WELL RINGS AND COVERS. Precast reinforced concrete well rings and covers shall conform to the requirements of Subsection 710.01, Class III pipe, with the following notes or exceptions:

Only one line of circumferential reinforcement will be required with an area of not less than 380 $mm^2/m$ (0.18 square inch per linear foot) of wall.

The concrete covers shall be reinforced with one line of fabric reinforcement with an area of not less than 2800 $mm^2/m^2$ (0.40 square inch per square foot) of cross-sectional area. They shall have hand holes on both sides.

## 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 percent 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 nontoxic and nonirritating. It shall be approved before use.

Upon request, the Agency's Materials and Research Section will furnish a list of products that are considered satisfactory.

## SECTION 745 - WATER

745.01 WATER. All water used shall be clear and free of harmful amounts of oil, salt, acids, alkalies, 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.

If the quality of the mixing water for concrete or mortar is questioned, comparative tests will be made with distilled water. Any indication of unsoundness, marked change in time of setting or reduction of more than 10 percent in mortar cube compressive strength, shall be sufficient cause for rejection of the water under test.

## SECTION 746 - CALCIUM CHLORIDE

746.01 CALCIUM CHLORIDE. Calcium chloride shall conform to the requirements of AASHTO M 144. Either regular flake calcium chloride, Type 1, or concentrated flake, pellet, or other granular calcium chloride, Type 2, may be used.

## SECTION 747 - SODIUM CHLORIDE

747.01 SODIUM CHLORIDE. Sodium chloride shall conform to the requirements of AASHTO M 143. Type I, Grade 1 shall be used, unless otherwise specified.

(a) Moisture Content. Moisture content shall not exceed 1 percent at the point of delivery.

(b) Anti-Caking Agent. In order to retard caking while in storage, all bulk salt shall be uniformly treated with an approved anti-cake conditioner prior to delivery. The residual amount of anti-cake conditioner should not be less than 50 parts per million. The supplier shall notify the Agency's Materials and Research Section

as to the anti-cake agent used and shall furnish the laboratory method for determining the presence of the anti-cake agent.

## SECTION 750 - TRAFFIC SIGNS

750.01 SIGN POSTS.

(a) Steel Posts. Steel posts consisting of standard rolled steel structural shapes shall conform to the requirements of AASHTO M 270M/M 270, Grade 250 (Grade 36). Steel posts consisting of flanged channels shall conform to the mechanical requirements of ASTM A 499, Grade 60. The chemical requirements shall conform to the 45 to 60 kg/m (91 to 120 pounds per yard) rail class in ASTM A 1. They shall conform to the details shown on the Plans as to size, shape, and mass (weight), and they shall be punched or drilled as shown on the Plans. After fabrication, all steel posts shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.

(b) Aluminum Posts. Aluminum posts shall conform to the requirements of ASTM B 308/B 308M, Alloy 6061-T6 for structural shapes, rolled or extruded, and ASTM B 221M (ASTM B 211) extruded tubes. They shall conform to the details shown on the Plans as to size, shape, and mass (weight), and they shall be punched or drilled as shown on the Plans.

(c) Wood Posts. Wood posts shall be seasoned Oak, Cedar, Spruce, Western Fir, or other approved wood, straight, sound, and cut from live timber. The posts shall conform to the dimensions shown on the Plans. They shall be shaved to an even surface and shall be free from bark or skin.

All wood posts shall be preservative treated full length as specified in Subsection 726.01, Type I, II, III, or IV. All cut ends or notches shall be field treated with preservative. Depending on size and location, wood posts may have to be drilled as shown on the Plans.

(d) Sleeves. Sleeves for sign posts consisting of structural tubing shall conform to the requirements of ASTM A 501. They shall conform to the details shown on the Plans as to size, shape, and mass (weight), and they shall be punched or drilled as shown on the Plans. After fabrication, all steel sleeves shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.

(e) Certification. A Type D Certification shall be furnished for steel posts and sleeves in accordance with Subsection 700.02. A Type A Certification shall be furnished for all other material.

750.02 EXTRUDED ALUMINUM PANELS. Extruded aluminum panels shall conform to the requirements of ASTM B 221M (ASTM B 221). Alloy 6063-T6 shall be used when reflective sheeting is to be applied to the face of the sign.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.03 FLAT SHEET ALUMINUM. Flat sheet aluminum shall conform to the requirements of ASTM B 209M (ASTM B 209) for either Alloy 6061-T6 or Alloy 5052-H38.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.04 GALVANIZED FLAT SHEET STEEL. Galvanized flat sheet steel shall conform to the requirements of ASTM A 606. Structural steel shapes and welded sections shall conform to the requirements of ASTM A 242/A 242M. The steel shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111 (ASTM A 123/A 123 M). The galvanized steel shall be given a light and tight phosphate coating by continuous mill process having not less than 1.1 $g/m^2$ (100 milligrams per square foot) of surface area.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

750.05 FORMED GALVANIZED STEEL PANELS. Formed galvanized steel panels shall conform to the requirements of ASTM A 606 or ASTM A 607, Grade 310 or Grade 340. The panels shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111. The galvanized panels shall be given a light and tight phosphate coating by continuous mill process having not less than 1.1 $g/m^2$ (100 milligrams per square foot) of surface area.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

750.06 HIGH DENSITY OVERLAID PLYWOOD. High density overlaid plywood shall consist of Douglas Fir plywood, exterior type, grade B or better, with both surfaces overlaid with cellulose fiber sheets or sheet, in which not less than 40 percent by mass (weight) of the laminate shall be a thermosetting resin of the phenol or melamine type. The resin impregnated material shall have not less than 300 $g/m^2$ (60 pounds per 1000 square feet) of single face before pressing. All materials and construction shall conform to the requirements of Voluntary Product Standard PS-1 published by the National Institute of Standards and Technology. The color of the overlay may be either natural or black.

No press caul, lubricants, release agents, or other contaminants shall be introduced during manufacture or subsequent handling of the high density overlaid plywood either within or on the surface which will affect adhesion or cause discoloration or other degradation of reflective sheeting or plastic lettering film.

(a) Quality Assurance. The suitability of the plywood for application of reflective sheeting shall be verified by laboratory test:

(1) Adhesion Test. Panels of the plywood, approximately 300 by 300 mm (1 × 1 foot) shall be cut from the plywood to be tested. The application surfaces of the panels shall be cleaned as specified in Subsection 675.05. An application of reflective sheeting or plastic lettering film shall be made to completely cover the properly prepared, dust-free plywood surface in accordance with the recommendations of the sheeting or film manufacturer. The panels shall be submitted to accelerated conditioning in an oven for one hour at 66 °C (150 °F). Following conditioning, the panels shall be allowed to cool to room temperature. With a test spatula, evenly strike the sheeting or plastic lettering film with short sharp jabs. The adhesive bond shall resist removal other than in small pieces at the point of spatula impact.

(2) Plywood Contamination Test. Panels of the plywood to be tested shall be cut 75 mm (3 inches) long and 50 mm (2 inches) wide. The panels shall be wiped with a tack rag to remove any dust or loose particles and reflective sheeting of the type or types to be used shall be applied to both faces of the test panels. Following conditioning for 24 hours at room temperature, approximately 24 °C (75 °F), the test panels shall be placed in a pressure vessel and held submerged in cold tap water. A vacuum of 610 mm (24 inches) of mercury shall be drawn and maintained for 45 minutes. This shall be followed immediately by the application of 275 to 350 kPa (40 to 50 pounds per square inch) of water pressure for 45 minutes. Proper test procedures are assured if the panel does not float after the above treatment. Test panels shall then be removed and each shall be placed in a glass container (400 mL beaker) filled with approximately 50 mL of water. Cover the container with a glass lid such as a petri dish and place in an oven at 66 °C (150 °F) for 24 hours. Remove panel and wipe the sheeting surface to remove any residue. Upon examination, any evidence of staining, discoloration, or other degradation of the applied sheeting shall constitute failure of the plywood to meet the specification. Some bubbling of the applied sheeting shall be permissible.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.07 ACRYLIC PLASTIC REFLECTORS. Acrylic plastic reflectors shall consist of methyl methacrylate plastic conforming to the requirements of Federal Specification LS-500 A, Type I, Class 3.

They shall consist of a clear and transparent acrylic plastic face, hereinafter referred to as the lens, and an opaque acrylic plastic back of identical material fused to the lens under heat and pressure around the entire perimeter to form a homogeneous unit permanently sealed against dust, water, or water vapor. Reflector units assembled with gaskets will not be acceptable. The reflectors shall be colorless, yellow or amber, red, blue, or green as shown on the Plans, and the colors shall conform to the standards approved by FHWA.

The lens shall consist of a smooth front surface free from projections or indentations other than for identification, and a rear surface bearing a prismatic configuration such

that it will effect total internal reflection of light without the aid of any plating or separate reflector.

(a) Optical Performance Requirements. The specific brightness of each colorless reflector shall be equal to or exceed the minimum values of the following table. All measurements shall be made with the reflectors spinning.

TABLE 750.07A - OPTICAL PERFORMANCE REQUIREMENTS FOR COLORLESS REFLECTORS

| Observation Angle (degrees) | Entrance Angle (degrees) | Specific Brightness ($cd/m^2/lux$) | Specific Brightness (candlepower/square inch/footcandle) |
|---|---|---|---|
| 0.10 | 0 | 2020 | 14.0 |
| 0.10 | 20 | 810 | 5.6 |
| 0.17 | 0 | 1440 | 10.0 |
| 0.17 | 20 | 580 | 4.0 |
| 0.33 | 0 | 1010 | 7.0 |
| 0.33 | 20 | 400 | 2.8 |

Failure to meet the specific brightness minimum shall constitute failure of the reflector being tested; failure of more than two reflectors out of 50 subjected to test shall constitute failure of the lot.

Entrance Angle shall mean the angle at reflector between direction of light incident on it and direction of reflector axis.

Observation Angle shall mean the angle at reflector between observer's line of sight and direction of light incident on reflector.

Specific Brightness shall mean candelas (candlepower) returned at the chosen observation angle by a reflector per each 60 $mm^2$ (1 square inch) of reflecting surface for each lux (footcandle) of illumination at the reflector.

For yellow or amber reflectors, the specific brightness minimum shall be 60 percent of the value shown for colorless; for either red, blue, or green reflectors, the specific brightness minimum shall be 25 percent of the value shown for colorless.

The brightness of the reflectors totally wet, as by rain, shall be not less than 90 percent of the values specified above.

The reflector to be tested shall be located at a distance of 30 m (100 feet) from a single uniformly bright light source having an effective diameter of 50 mm (2 inches); the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by means of a photoelectric photometer having a minimum sensitivity of $1.08\times10^8$ lux/mm ($1\times10^7$ footcandles per millimeter) scale division.

The photometer shall have a receiver aperture of 13 mm (1/2 inch) diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 53 mm (2.1 inches) for a 0.10-degree observation angle, 89 mm (3.5 inches) for a 0.17-degree observation angle, and 175 mm (6.9 inches) for a 0.33-degree observation angle. During testing, the reflectors shall be spun so as to average orientation effect.

If a test distance other than 30 m (100 feet) is used, the source and aperture dimensions and the distance between source and aperture shall be modified in the same proportion as the test distance.

(b) Physical Test Requirements. The reflectors shall withstand the following physical tests:

(1) Seal Test. Fifty reflectors out of any one shipment shall be selected at random for the following test:

Fifty reflectors shall be submerged in a water bath at room temperature. The submerged samples shall be subjected to a vacuum of 127 mm (5 inch) gage for five minutes. The atmospheric pressure then shall be restored and the samples left submerged for five minutes, after which they shall be examined for water intake. Failure of more than 2 percent of the number tested shall be cause for rejection.

(2) Heat Resistant Test. Three reflectors out of any one shipment shall be selected at random for the following test:

Three reflectors shall be tested for four hours in a circulating air oven at 80 °C (175 °F). The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples after exposure to heat shall show no significant change in shape and general appearance when compared with unexposed control standards. No failures will be permitted.

(3) Corrosion Test. Fifty reflectors out of any one shipment shall withstand the corrosion test without any observable effects when tested in accordance with ASTM B 117. The exposure period shall be 48 hours.

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.08 REFLECTIVE SHEETING. Reflective sheeting shall conform to the applicable requirements of AASHTO M 268, except as follows:

Silver is an acceptable designation for white.

(a) Packaging Requirements. Reflective sheeting shall be furnished in both rolls and sheets. The packaging in which the sheeting is shipped shall protect the sheeting

from damage and/or distortion in accordance with commercially acceptable standards and shall be suitable for storing the sheeting until it is used.

When reflective sheeting is furnished in continuous rolls, the material shall have a maximum of three splices in any 45 m (50 yards) of length. Splices shall be butted or overlapped and shall be suitable for continuous application.

When stored under normal conditions, the reflective sheeting shall be suitable for use for a period of at least one year after purchase.

(b) Classification. Reflective sheeting (white or colored) shall meet the requirements of the appropriate AASHTO M 268 (ASTM D 4956) classifications below:

(1) TYPE I. A medium intensity retroreflective sheeting often referred to as "engineering grade."

(2) TYPE II. A medium-high intensity retroreflective sheeting often referred to as "super engineering grade." The product exceeds the minimum requirements for Type I, but does not meet all TYPE III requirements.

(3) TYPE III. A high intensity retroreflective sheeting often referred to as "high intensity."

(4) TYPE IV. A high intensity retroreflective sheeting typically referred to as "micro prismatic retroreflective element material."

(5) TYPE V. A super high intensity retroreflective sheeting.

(6) TYPE VI. An elastomeric high-intensity retroreflective sheeting without adhesive. This is a vinyl material commonly used for traffic cone collars, post bands, etc.

(c) Reflective Requirements. Reflective sheeting shall meet or exceed the minimum brightness and color requirements of AASHTO M 268.

(d) Physical Requirements. Reflective sheeting shall meet the physical requirements of AASHTO M 268.

(e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.09 DEMOUNTABLE CHARACTERS. Individual letters, digits, symbols, and borders as shown on the Plans for the text of the sign shall be shaped from 810 μm (0.032 inch) sheet aluminum conforming to the requirements of ASTM B 209M (ASTM B 209), Alloy 3003-H12. The design of the characters or sections listed above shall conform to standards approved by FHWA.

Flat characters shall be reflectorized with white Type III retroreflective sheeting conforming to the requirements of Subsection 750.08. All characters with stroke width 19 mm (3/4 inch) or less shall be supplied with sealed edges.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.10 PLASTIC LETTERING FILM. Plastic lettering film shall consist of a smooth, flexible, pigmented plastic sheeting with a precoated adhesive on one side for application by the heat vacuum method. The plastic film shall be readily cut with scissors, knife blade, or shears without cracking, crazing, checking, or flaking to form the letters, digits, symbols, and borders comprising the text of the various types of signs shown on the Plans. The cutout shapes shall be free from ragged edges, cracks, scales, and blisters. The color of the plastic film shall be as shown on the Plans for the text of each sign involved and shall conform to the standards approved by FHWA. The thickness of the plastic film with adhesive shall be not less than 66 μm (2.6 mils).

The precoated adhesive shall have a mass (weight) of not less than per 68 $\mu g/mm^2$ (1.05 grams per 24 square inches) and shall have a minimum thickness of 50 μm (2.0 mils) when dry. It shall form a durable bond to clean well painted surfaces, unpainted high density overlaid plywood, reflective sheeting (flat surface), or unpainted corrosion-proof metals such as galvanized, phosphate coated steel, or aluminum. The precoated adhesive, after 48 hours of aging at 24 °C (75 °F) from the time of application, shall be strong enough to resist peeling the plastic lettering film from the application surface, tough enough to resist scuffing and marring during normal handling, elastic enough at low temperatures to resist shocking off when struck at -7 °C (20 °F), moisture resistant enough to withstand eight hours of soaking in water at 24 °C (75 °F) without appreciable decrease in adhesion, and heat resistant enough to retain adhesion to the application surface after eight hours at 49 °C (120 °F). The precoated adhesive shall have no staining effect on the plastic lettering film and shall be mildew resistant.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.11 EXTRUDED ALUMINUM MOLDING. Extruded aluminum molding to be used with extruded aluminum panel signs shall conform to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6. Moldings shall be finished with baked-on enamel or sheeting of the color shown on the Plans for the background of the sign. The molding shall be extruded in the standard commercial form to fit the type of extruded aluminum panel used.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.12 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 F 738M, Property Class A1-70, Condition CW. The alloy shall have a nickel content between 8.0 percent and 10.5 percent.

Nuts shall be stainless steel conforming to the requirements of and its supplementary requirements for S5. The alloy shall be ASTM F 836M, Property Class A1-70, Condition CW, Alloy 304.

(b) Rivets. Rivets shall be of aluminum conforming to the requirements of ASTM B 316/B 316M, Alloy 6053-T61.

(c) Clips. Clips used to fasten extruded aluminum panels to the supporting posts shall be of aluminum conforming to the requirements of ASTM B 108, Alloy 356-T6.

Clips used to fasten formed galvanized steel panels to the supporting posts shall be of aluminum conforming to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6 or of steel conforming to the requirements of ASTM A 242/A 242M that, after fabrication, is galvanized in accordance with the requirements of AASHTO M 232M/M 232 (ASTM A 153/A 153M).

(d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 751 - DELINEATORS

751.01 DELINEATOR POSTS.

(a) Steel Posts. Steel posts consisting of flanged channels shall conform to the mechanical requirements of ASTM A 499, Grade 60. The chemical requirements shall conform to the 45 to 60 kg/m (91 to 120 pounds per yard) rail class in ASTM A 1. They shall conform to the details shown on the Plans. After fabrication, all steel posts shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111 (ASTM A 123/A 123M).

(b) Flexible Posts. Flexible posts shall conform to the type or types shown on the Plans.

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.02 ACRYLIC PLASTIC REFLECTORS. Acrylic plastic reflectors shall conform to the requirements of Subsection 750.07. They shall be mounted in an aluminum housing with a center hole having an aluminum grommet for mounting purposes and shall conform to the details shown on the Plans. The aluminum housing shall conform to the requirements of Subsection 751.04.

751.03 REFLECTIVE SHEETING. Reflective sheeting shall conform to the requirements of Subsection 750.08.

751.04 BACK PLATES AND HOUSING. Back plates and housing used for the mounting of reflective material shall consist of aluminum conforming to the

requirements of ASTM B 209M (ASTM B 209), Alloy 3003-H14. They shall conform to the details shown on the Plans and shall be given a corrosion resistant finish after fabrication in accordance with standard commercial processes. They shall not be painted.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.05 PLAQUES. Plaques used for the numbering of delineators between distance markers shall conform to the design shown in the Plans.

The substrate shall be 1.6 mm (1/16 inch) thick aluminum sheet conforming to the requirements of Subsection 750.03 and fabricated in accordance with the requirements of Subsection 675.04.

Reflective sheeting shall be Type I or Type II conforming to the requirements of Subsection 750.08. The text shall be 25 mm (1 inch) Series D Numerals conforming to the Standard Alphabets for Highway Signs and shall be silk screened lettering, plastic lettering film, or lettering paint.

Colors shall be white background with green text and shall conform to the Standard Color Tolerance Charts approved by FHWA.

Application of the reflective sheeting and text shall conform to the requirements of Subsection 675.09.

Transportation and handling in of the plaques after fabrication shall conform to the requirements of Subsection 675.10.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.06 ASSEMBLY HARDWARE. Unless otherwise shown on the Plans, the assembly hardware used for connecting the components of the housing, if required, and for fastening reflectors and plaques to posts shall conform to the designs and sizes used in standard commercial practices for the materials involved.

(a) Bolts and Nuts. Bolts and nuts shall consist of aluminum conforming to the requirements of ASTM B 211M (ASTM B 211), Alloy 2024-T4. Both bolts and nuts shall be given another coating at least 5 μm (0.2 mil) in thickness with dichromate or boiling water seal.

(b) Washers. Washers shall consist of aluminum conforming to the requirements of ASTM B 209M (ASTM B 209), Alloy 2024-T4.

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.07 POLYCARBONATE SUBSTRATE FOR GUARDRAIL DELINEATORS.

(a) Polycarbonate substrate for delineation devices shall conform to the following requirements when tested in accordance with the designated tests.

(b) Polycarbonate substrate shall conform to the following physical properties and designated tests:

| | | ASTM |
|---|---|---|
| Thickness, Minimum | 2 mm (79 mils) | N/A |
| Tensile Strength at Break | 65 MPa (9.43 ksi) | D 638M |
| Elongation at Break | 110% | D 638M |
| Tensile Yield Strength | 62 MPa (9.0 ksi) | D 638M |
| Compressive Strength (Rupture Yield) | 86 MPa (12.47 ksi) | D 695M |
| Flexural Strength | 93 MPa (13.49 ksi) | D 790M |
| Tensile Module | 2390 MPa (346.6 ksi) | D 638M |
| Rockwell Hardness | M 70 | D 785 |
| Specific Gravity | 1.2 | D 792 |

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 752 - TRAFFIC CONTROL SIGNALS

752.01 PEDESTAL POSTS AND BASES. Steel posts shall utilize cast iron bases; aluminum posts shall utilize cast aluminum bases.

(a) Pedestal Posts.

(1) Steel Posts. Steel posts shall consist of 115 mm (4 1/2 inch) outside diameter galvanized steel pipe conforming to the dimensional requirements of ASTM A 501 or ASTM A 53/A 53M, Type S, Grade B standard weight. The post shall have no taper and shall be threaded at the lower end to fit the base.

(2) Aluminum Posts. Aluminum posts shall consist of 115 mm (4 1/2 inch) outside diameter aluminum structural pipe conforming to the requirements of ASTM B 429, Alloy 6063-T6. Tapered aluminum posts may be used if approved by the Engineer. Posts that have no taper shall be threaded at the lower end to fit the base.

(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 A 126, Class A. Galvanizing shall be in accordance with AASHTO M 111M/M 111 (ASTM A 123/A 123M).

Bases shall be galvanized by the same procedure used for steel posts and may be galvanized with the posts.

(2) Cast Aluminum Bases. Cast aluminum bases shall conform to the requirements of ASTM B 26/B 26M or ASTM B 108, Alloy SG70A-T6.

(c) Certification. A Type D Certification shall be furnished for steel posts in accordance with Subsection 700.02. A Type A Certification shall be furnished for all other materials.

752.02 STRAIN POLES.

(a) Wood Poles. Wood poles for span wire mounted signal heads shall be either Western Red Cedar or Southern Pine. The poles to be used shall be Class 3 and shall be a minimum of 11 m (35 feet) in length, unless otherwise specified. The material requirements for the poles shall be in accordance with ANSI. Specifications and dimensions for wood poles shall be as approved by the National Electrical Code.

(1) Quality. Outer bark shall be completely removed from all poles. No patch or inner bark more than 25 mm (1 inch) wide and 150 mm (6 inches) long shall be left on the pole surface between the top and 600 mm (24 inches) below the groundline.

All poles shall be neatly sawed at the top and at the butt along a plane which shall not be out of square with the axis of the pole by more than one unit per six units of diameter of the sawed surface. Beveling is permitted at the edge of the sawed butt surface not more than 8.33 percent of the butt diameter in width, or an equivalent area unsymmetrically located.

Completely overgrown knots, rising more than 25 mm (1 inch) above the pole surface, branch stubs, and partially overgrown knots shall be trimmed close. Completely overgrown knots less than 25 mm (1 inch) high need not be trimmed. Trimming may be done by a shaving machine or by hand.

(2) Dimensions. The dimensions for the poles required shall be not more than 75 mm (3 inches) shorter or more than 150 mm (6 inches) longer than the nominal length. The lengths shall be measured between the extreme ends of the pole.

The minimum circumference at 2 m (6 feet) from the butt shall be 950 mm (36 inches) for Western Red Cedar and 860 mm (34 inches) for Southern Pine. The minimum circumference at the top of the pole shall be 580 mm (23 inches) for both Western Red Cedar and Southern Pine. The circumference at 2 m (6 feet) from the butt of the pole shall be not more than 180 mm (7 inches) larger than the specified minimum. The top circumference requirements shall remain 580 mm (23 inches) at a point corresponding to the minimum length permitted for the pole.

The true circumference class shall be determined as follows: Measure the circumference at 2 m (6 feet) from the butt. This dimension will determine the true class, provided its top (measured at the minimum length point) is large enough. Otherwise, the circumference at the top will determine the true class, provided the circumference at 2 m (6 feet) from the butt does not exceed the specified minimum by more than 180 mm (7 inches).

(3) Preservative Treatment. All wood posts shall be treated over their full length in accordance with Subsection 726.01, using Type I, II, III, or IV preservatives.

(b) Steel Poles and Baseplates. Steel poles shall consist of tapered tubular shafts or a series of two to three different diameter pipes welded together with baseplates. The pole shall be of such length that the clearance from the pavement to the bottom of the lowest hanging mounted signal head shall be 5.0 m (16 feet), when span wire sag is within the allowable range of 5 to 7 percent of the span. The shafts after fabrication shall have a minimum yield strength of 330 MPa (48 kips per square inch). The metal thickness shall be not less than 6.4 mm (0.25 inch) for tapered poles and not less than 7.6 mm (0.30 inch) for the bottom section of multiple pipes. The steel poles shall withstand the stringing tension of the span wire with its signal load without exceeding a deflection of 150 mm (6 inches) and a bending stress limit of 66 percent of 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 100 by 150 mm (4 × 6 inches), complete with cover, shall be provided in the pole approximately 450 mm (18 inches) above the base and located at 90 degrees to the span wire on the side away from approaching traffic. A lip shall be provided around the handhole opening to prevent the cover from tipping and falling inside the hole. 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 50 mm (2 inch) blind half-coupling shall be welded through the side of the shaft 150 to 300 mm (6 to 12 inches) below the span wire attachment height. A grounding nut shall be located inside the shaft easily accessible from the handhole. Each steel strain pole and the neutral or common grounding electrode conductor shall be bonded to a soft drawn, bare, copper wire with a cross-sectional area of 13.30 $mm^2$ (No. 6 AWG). The No. 6 AWG soft drawn, bare, copper wire shall be connected to a grounding electrode(s) which will be driven at each strain pole location.

The baseplate shall be of adequate shape and size to carry the full bending moment of the pole at its yield point. It shall consist of heat treated cast steel conforming to the requirements of ASTM A 27/A 27M or steel plate conforming to the requirements of ASTM A 36/A 36M. The baseplate shall be attached to the shaft by two continuous electric welds, one inside the base at the end of the shaft and the other on the outside at the top of the base. The design shall be such that

the welded connection shall develop the full strength of the adjacent shaft section. A four anchor bolt pattern shall be used, unless otherwise shown on the Plans.

After fabrication, the shaft and baseplates shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111 (ASTM A 123/A 123M).

Pole diameter height, yield, strength, and wall thickness shall be stamped on a metal tag attached near the handhole. If stepped poles are used, the stamping shall indicate the equivalent tapered pole.

(c) Certification. A Type D Certification shall be furnished for steel poles and baseplates in accordance with Subsection 700.02. A Type A Certification shall be furnished for wood poles.

752.03 TRAFFIC SIGNAL POLES WITH MAST ARMS OR BRACKET ARMS.

(a) Steel Poles and Baseplates. Steel poles shall consist of tapered tubular shafts or multiple pipe poles with baseplates and shall conform to the requirements of Subsection 752.02(b), except the minimum wall thickness shall be not less than 4.55 mm (0.179 inch or 7 gage).

(b) Cantilever Mast Arms. Material for the mast arms shall conform to the requirements of Subsection 752.02(b) fabricated either as a tapered tube or multi-diameter pipe with a minimum metal thickness of 4.55 mm (0.179 inch or 7 gage). Both types shall have a flange plate welded on the large end for attaching to the vertical pole. A removable cap shall be attached to the far end. Wire outlets with rubber grommets shall be provided for each indicated signal location.

(c) Aluminum Poles, Bases, and Mast Arms. Aluminum poles with anchor bases and mast arms shall conform to the requirements of Subsection 753.01(b).

(d) Luminaire Bracket Arms. Luminaire bracket arms shall be the same type of material as the upright support. Steel brackets shall conform to the requirements of Subsection 753.01(c)(4), and aluminum brackets shall conform to the requirements of Subsection 753.01(b)(4). The bracket arms shall be either truss or tapered tubes as shown on the Plans. The main member of a truss-type arm shall be an oval shaped tapered tube securely joined by means of vertical struts to its companion member.

(e) Identification. Pole diameter, height, yield strength, and wall thickness shall be stamped on a metal tag attached near the handhole. Cantilever arm dimensions, length, and diameter/wall thickness shall also be included on the tag. If stepped poles are used, the stamping shall also indicate the equivalent tapered pole/arm.

(f) Certification. A Type D Certification shall be furnished for steel poles, baseplates, mast arms, and luminaire bracket arms in accordance with Subsection 700.02. A Type A Certification shall be furnished for aluminum poles, baseplates, mast arms, and luminaire bracket arms.

752.04 SPAN WIRE. Span wire shall consist of 10 mm (3/8 inch) diameter galvanized steel cable conforming to the requirements of ASTM A 475, Class A coating, seven wire strand, utilities grade. The signal cable shall be attached to the span wire with a stainless alloy 1.2 mm (18 gage) lashing (spinning) wire.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.05 TRAFFIC SIGNAL HEADS. Traffic signal heads shall be self-contained assemblies that are expandable and adjustable. The signal heads may contain one or more signal faces as shown on the Plans. All traffic signal lenses shall be 305 mm (12 inches) in diameter, unless otherwise shown on the Plans.

Each traffic signal face shall consist of a number of signal sections rigidly fastened together in such a manner as to be watertight and dust proof. It shall be possible to assemble one or more signal faces into a multidirectional traffic signal head.

The components of the signal head consisting of housings; doors; visors; optical units consisting of lenses, reflectors, lamp sockets, and lamps; wiring; trunnions; and brackets shall conform to the latest requirements of the ITE technical report "Adjustable Face Traffic Control Signal Head Standards." Standard 8000-hour traffic signal lamps shall be used, unless otherwise specified. The Contractor shall use 116 W lamps in 305 mm (12 inch) units and 67 W lamps in 203 and 229 mm (8 and 9 inch) units, unless otherwise specified. Lamp socket lead wires shall be stranded. The Contractor shall use 135 W lamps with internal reflector and 1750 rated initial lumen output for those faces having arrow lenses.

The components of the signal head shall be rigidly constructed of a diecast aluminum alloy in accordance with ASTM B 85, Alloys S-12A, S-12B, SC-84A, SC-84B, or SG-100B or polycarbonate with a smooth outer surface and shall be capable of holding the optical units securely in place. The polycarbonate material shall be such that it will withstand 95 J (70 pounds-force foot) of impact without fracture or permanent deformation.

(a) Polycarbonate Signal Heads. When a polycarbonate signal head is utilized, it shall conform to the following requirements:

(1) Housing. The housing of each section shall be a one piece polycarbonate resin material with front, sides, top, and bottom integrally molded. The housing shall be of substantial thickness and shall be ribbed so as to produce the strongest possible assembly consistent with low density. Two sets of internal bosses shall be provided in each section for mounting of terminal strip facilities. The terminal bosses shall have threaded inserts sonically welded into each boss.

(2) Housing Door. The housing door of each signal section shall be of the same material as the housing.

(b) Aluminum or Polycarbonate Traffic Signals. For either aluminum or polycarbonate traffic signals, all requirements of the ITE technical report

"Adjustable Face Traffic Control Signal Head Standards" shall be met as well as the following:

(1) Optical System. The optical system shall consist of a polycarbonate lens (red, yellow, or green) with a nominal size of 203 or 305 mm (8 or 12 inches).

The lenses and optical system shall be capable of withstanding continuous illumination from a 150 W standard traffic signal lamp without distortion of the lenses. Lens design shall be such that it conforms to American Standards Association #D-10.1-1958UDC 656.057 optical specifications.

(2) Wiring. Terminal blocks shall be placed in the center of a three section signal, unless otherwise specified, and shall be a five-position, ten-terminal, barrier type strip with the following terminal designations clearly marked "R-A-G-RC-AC." Terminal blocks shall be secured on both ends.

(3) Visors. Each signal door shall be equipped with a tunnel or cutaway type polycarbonate resin visor duralocked at four points to the door. The type shall be as shown on the Plans.

(4) Traffic Signal Backplates. All backplates shall be louvered and painted flat black.

(5) Signal Color. Signal color shall be Federal Yellow body, unless otherwise shown on the Plans, with dull black door, visor, and back plate.

(6) Signal Dimmer. When 305 mm (12 inch) diameter signal faces are specified, an integral means shall be provided for gradually regulating the intensity for nighttime operation to approximately 75 percent of that required for daytime operation. This shall apply only to the yellow lens and only when in the flashing mode.

(c) Programmable Traffic Signal Heads. Where applicable, all requirements of ITE technical report "Adjustable Face Traffic Control Signal Head Standards" shall be met as well as those of part (b) above and the following:

When shown on the Plans, programmed visibility traffic signal heads shall be furnished. A signal head may consist of a standard signal head with an optically programmed adapter in place of the lens or may be a commercial assembly designed to provide for programmed visibility. In either case, visibility of the signal indication shall be limited by optical methods and not by hoods or louvers. A rigid mounting attachment or method shall be provided for masked signal assemblies containing programmed visibility signal heads. The visibility of the signal indication shall be adjustable within the signal head to fit the approach to be controlled. During daylight hours the signal indications shall be visible only in those areas designated. During dusk and darkness, a faint glow is permissible when the signal is viewed from outside the designated area. External illumination shall not cause a signal indication, and a signal indication in one signal head shall not cause an indication in another signal head.

When unprogrammed, the indication of each signal head shall be visible from anywhere within 15 degrees of the optical axis.

(d) LED Signals. LED signal units shall be either complete 300 or 200 mm (12 or 8 inch) polycarbonate or aluminum sections for new installation or retrofit module kits for existing signal sections, as shown on the Plans. Each unit shall be a self-contained, sealed, dust and watertight enclosure not requiring on-site assembly prior to installation. Independent units shall be sized such that they may be combined with standard 300 or 200 mm (12 or 8 inch) incandescent sections built to ITE's "Vehicle Traffic Control Signal Heads" (VTCSH) equipment and materials standards. Retrofit kits shall fit within existing standard 300 or 200 mm (12 or 8 inch) housings without modification of either the housing or the LED unit.

The installation of a retrofit replacement LED signal module into an existing signal housing shall require only removing the existing lens and incandescent bulb, fitting the new unit securely in the housing and connecting the module to the existing electrical wiring or a terminal block by means of simple connectors.

The LED signal module shall have a prominent and permanent directional marking(s), such as an UP arrow, for correct indexing and orientation within the housing.

The manufacturer's name, trademark, serial number, and other necessary identification shall be permanently marked on the back of the module. A label shall also be placed on the module certifying compliance with this specification.

LED signal units shall meet the following requirements:

(1) Performance. The units shall meet or exceed the following minimum performance levels:

a. New signal output at room temperature shall not fall below 85 percent of the intensity requirements over the operating voltage range.

b. New signal output at nominal voltage conditions shall not fall below 70 percent of the intensity requirements over the operating ambient temperature range.

c. The maximum signal output loss resulting from a single LED failure shall not exceed 20 percent.

(2) Physical and Mechanical Requirements. The assembly and manufacturing processes for the signal assembly shall ensure that all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

Each LED signal module shall be composed of a smooth surfaced, UV stabilized, polycarbonate outer shell, multiple LED light sources, a regulated power supply, and a polycarbonate back cover assembled in a sealed silicon

unit. The polycarbonate outer shell shall be red for red lenses, yellow for yellow lenses, and clear for green lenses. The LEDs shall be mounted on a polycarbonate positioning plate. A mechanical alignment and assembly mechanism shall be used to ensure that each LED is retained in a pre-determined position. The light distribution of each LED shall be maximized by the use of an internal beam controlling, optical faceted lens.

When the LEDs are installed, the legs of the LEDs shall remain at the original manufactured full length to improve heat dissipation.

The replacement of one or more LEDs as well as the replacement of one or more LED circuits shall be possible without soldering.

For safety purposes, if any one LED or LED circuit fails, the failure shall be easily identifiable by visual inspection to facilitate replacement or repair.

(3) Optical and Light Output Requirements. A module shall consist of an assembly containing an internal beam controlling, optical faceted lens with a maximum of 320 LEDs for 300 mm (12 inch) ball indications, 155 LEDs for 200 mm (8 inch) ball, and a maximum of 110 LEDs for 300 mm (12 inch) arrow indications.

The minimum luminous intensity values and light output distribution shall be as specified in Section 11.04 and Table 1 of ITE's VTCSH. The chromaticity of the LED signal modules shall conform to the requirements of Section 8.04 and Figure 1 of ITE's VTCSH.

Each LED signal module shall be tested for light output at 90 and 120 V. Each LED shall not fall below the minimum intensity values at any of the 44 measuring points designated by Table 1 of Section 11.04 of ITE's VTCSH when the lamp is turned on cold for measurement and after a 30 minute warm-up period at 100 percent duty cycle. Any LED that fails to meet this requirement shall be immediately replaced by the Contractor at no cost to the Agency.

(4) Electrical Requirements. Each module shall incorporate a regulated power supply engineered to both electrically protect the LEDs and maintain safe reliable operation of the unit. The power supply shall provide capacitor filtered direct current to the LEDs in accordance with the LED manufacturer's specification. The module shall meet UL No. 1012 and/or CSA C22.2, No. 205 standards.

The LED signal module shall operate on a nominal 60 Hz AC line voltage ranging from 89 to 135 V rms. The module circuitry shall prevent flicker over this line voltage range. Nominal rated voltage for all measurements shall be 117 V rms.

LED signal modules shall be operationally compatible with currently used controllers, conflict monitors and flashers. Power requirements shall not exceed 20 W for 300 mm (12 inch) ball green and red indications, 25 W for

300 mm (12 inch) yellow ball indications, 12 W for 205 mm (8 inch) ball, and 9 W for 300 mm (12 inch) arrow indications.

The module shall be provided with two captive, two-color coded, jacketed wires for electrical connection. These wires shall be at least No. 18 AWG, 1 m (3 feet) long and shall be rated for 600 V and service at 105 °C (221 °F). All wiring shall conform to the National Electrical Code.

(5) Environmental Requirements. The LED signal module shall operate over an ambient temperature range of -40 to 74 °C (-40 to 165 °F).

(e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.06 TRAFFIC SIGNAL CONTROLLERS.

(a) General. In order to prevent the State from becoming a testing ground for newly developed traffic signal equipment, it is required that the manufacturer provide certification that the particular type/model of controller to be used shall have been in actual field operation at a minimum of five locations for no less than one year each prior to its introduction in Vermont. This requirement does not apply to minor software updates of an existing unit.

Each controller shall be designated to operate on 115 V AC, 60 Hz, single-phase, and shall be delivered completely wired and enclosed in a weatherproof housing. Controllers shall be of the same type and manufacture conforming to the standard used by the town, city, or village when extensions or improvements of existing traffic control facilities are contracted.

Prior to bench testing, the Contractor shall provide the proposed controller settings for approval. Each controller shall be bench-tested with a NEMA test board that simulates all possible sequencing of signal intervals, corresponding to those for which the controller is to be used, for at least seven continuous calendar days prior to installation. The manufacturer or distributor shall have such bench testing performed by an independent testing company which shall certify that such test has been made and that the 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. A representative of the manufacturer shall be on the project site for turn-on of the unit(s).

The controller shall be bench tested after it has been completely installed in its cabinet and all wiring internal to the cabinet has been completed. The bench test results shall include actual test results for all functions that the Plans require the controller to be able to perform. Failure to test any required function will result in rejection of the controller without exception. Rejected controllers will not be permitted to remain on the project, and rejected controllers shall not be reworked and subsequently reinstalled on the project. The controller shall not be shipped

until the manufacturer has received full written approval of all the bench tests results from the Agency. Shipment of the controller prior to receipt of full written approval for all bench test results will result in the suspension of all payments for the traffic control signal items in the Contract until a fully approved controller is completely installed in place and functioning properly.

Traffic signal equipment design and performance shall meet or exceed all requirements of the latest NEMA standards for traffic control systems. Performance of the equipment shall be consistent with the MUTCD. The controller along with all auxiliary equipment shall be capable of producing the timing plan(s) and coordination shown on the Plans.

(1) Controller/Auxiliary Equipment. All controllers shall be actuated menu driven, keyboard entry and solid state. They shall have a minimum of eight phases with dual maximum capabilities, and an internal time-based coordinator capable of providing at least four cycle lengths with multiple programs per cycle. The communication modem shall be approved over the same temperature range as the controller, -34 to 74 °C (-30 to 165 °F). All controllers at isolated intersections shall have all necessary hardware/software for the connection of two-way telephone communications. For coordinated systems with hardwire and/or telemetry interconnect, communications capability is required only at the master cabinet. The controllers shall be programmed so as to automatically adjust for daylight savings time changes (April: first Sunday; October: last Sunday).

Each installation shall include the following:

a. Time clock(s) with battery backup,

b. Twelve-channel conflict monitor with stop timing function, liquid crystal display and the capability of recording at least nine “events,”

c. Sufficient load switches and flash transfer relays for all eight phases,

d. LED display load switches (input side) labeled on the cabinet wall,

e. Remote flasher, and

f. Vehicle detector amplifiers. Rack mounted units must be used.

The conflict monitor and the controller shall be wired to ensure that the “events” logged by the conflict monitor and the controller indications at the time of failure can be uploaded directly to a computer.

(2) Cabinets. The controller and all auxiliary equipment shall be enclosed within a pre-wired, rainproof NEMA (3R) controller cabinet. The cabinet(s) shall have a polished aluminum alloy natural finish and a police door. The size of the cabinet shall be such as to provide ample space for housing all equipment necessary to provide the timings shown on the Plans.

The cabinet shall have a main door within which an auxiliary door shall be placed. The auxiliary door (police door) shall house a compartment with the following switches: "Flash-Automatic;" "Power, On-Off;" "Signal, On-Off."

A metal plaque listing ownership and emergency telephone numbers shall be attached to the outside of the cabinet. The plaque is as shown in the Plans.

Each cabinet shall have a weatherproof plastic envelope of sufficient size, 450 by 600 mm (18 × 24 inches), to store wiring diagrams, program manuals, etc. The cabinet shall contain a suitably designed vent fan and thermostat [50 to 75 °C (120 to 167 °F)]. The thermostat shall be set initially to 50 °C (120 °F).

The controller cabinet shall contain a strong mounting table, sliding track, hinged adjustable fixed or a 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 connection or interrupting normal operation of the controller.

A flexible arm lamp receptacle capable of illuminating all areas of the cabinet, two convenience outlets, ground fault interruption protection, and surge protection shall be provided.

A wiring panel shall be included in each cabinet mounted in such a way so as to provide visibility and accessibility. The lowest row of terminals shall be at least 75 mm (3 inches) from the bottom of the cabinet.

All cabinets shall include a telephone jack.

The main door lock of the cabinet shall be a #2 tumbler type lock as recommended by the manufacturer of the equipment. A police type lock shall be provided for the auxiliary door. The cabinet shall also be provided with a Master #3220 padlock. Two keys shall be furnished for each lock. The mounting of the cabinet shall be as shown on the Plans.

An intersection layout drawing to a scale of 1:6000 (1:500) shall be taped to the inside of the door, in the proper orientation and covered with plastic. It shall indicate numbers for the vehicle heads, phases, load switches, detectors, loops, and any other pertinent information.

The Contractor shall indicate on the inside of the door, the date and time of signal turn-on for new installations or switch-over for replacement installations. The door marking shall be permanent.

(3) Spare Equipment. In addition to equipment furnished to provided a functional signal system, the Contractor shall supply one of each of the following spare parts in each cabinet:

a. Flasher unit (independent of the controller),

b. Transfer relay,

c. EEPROM, programmed for the project intersection and stored in a protective container,

d. Cabinet lamp bulb,

e. Filter for ventilation system,

f. Relay,

g. Six spare bulbs (for optically programmed heads only), and

h. Loop amplifier with delay call capability.

This equipment may be used during the construction period to replace malfunctioning equipment but must be replaced and maintained in the cabinet prior to acceptance.

(4) Wiring. All panel wiring shall be neat and firm and standard entrance fuses shall be provided. Buss-type fuses shall be housed in an insulating block that may be removed as a unit and fuses removed from and inserted into the block without danger of electrical shock. Transistorized solid state circuitry may be used at the option of the manufacturer, unless otherwise shown on the Plans. When a solid state controller is used, a compatible conflict monitor shall be connected to the system.

All field terminals shall be suitably identified.

The electrical connections from the controller and other accessory equipment to the outgoing and incoming circuits shall be made either by standard multiple plug or jack.

The outgoing traffic control signal circuits shall be of the same polarity as the line side of the power supply; the common return of the signal circuits shall be of the same polarity as the ground side of the power supply.

The ground side of the power supply shall be grounded to the controller cabinet in an approved manner.

All signals shall be wired such that no more than two through faces (north/south and/or east/west) are wired into one load switch even though the two approaches may time during the same phase.

(5) Contacts. All contacts used in connection with interval indications shall be of pure coin silver or its equivalent and shall be capable of breaking and carrying 10 A at 125 V AC and shall be readily accessible and capable of being replaced in the controller without the use of any tools other than pliers and screwdrivers. Mercury tube contacts will not be accepted.

(6) 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.

(7) Motor and Lamp Leads. All motor and lamp leads shall be moisture and heat resistant type of flexible stranded copper 600 V wire meeting the requirements of the National Electrical Code.

(8) 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.

(9) Lightning Arrester. Each controller shall be equipped with a suitable effective lightning arrester that filters lightning or high voltages to ground protecting internal components of the controller.

(10) Radio and Television Interference. Electrical equipment shall be protected against interfering with radio and television reception.

(11) Wiring Diagram. Two internal connection wiring diagrams for all apparatus, and mounting and operating instructions shall be furnished.

(12) 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 be not less than 50 or more than 67 percent of the total cycle Such flashing mechanism 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. It shall be capable of flashing two inductive or tungsten loads and shall operate within a line voltage range of 95 to 135 V AC. Alternately, a NEMA flasher meeting the same operational requirements may be provided. A mercury tube contact will not be accepted for flashing indications. 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.

(13) All controllers shall have at least three spare signal light circuits.

(14) All controllers, installed in areas where other signalized intersections are nearby and there is likelihood of future coordination, shall be capable of future interconnect either by cable connection, telemetry, or the use of time based coordination. Such modifications shall not require return of the controller to the manufacturer.

(15) All time clocks shall be equipped with a solid state battery backup system that will continue the clock functions for a minimum of 30 days in the event

of power failure. When power returns, the battery shall be recharged automatically.

(16) For semi-actuated controllers, in the absence of actuation, the right-of-way shall return to and remain on the non-actuated approach, or as shown on the Plans.

(17) For fully-actuated controllers, in the absence of actuation, the right-of-way shall remain on the last actuated phase, or as specified.

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.07 FLASHING BEACONS.

(a) General Requirements. The applicable portions of Subsection 752.06 shall apply in addition to the specific functional requirements described below.

(b) Flasher. The 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 be not less than 50 and not more than 67 percent of the total cycle. The flashing mechanism shall be adequately housed and protected from the weather and shall be designed to be accessible for inspection, cleaning, and adjustment without disconnecting any part. For electro-mechanical flashers, the contacts of the flasher shall be of pure coin silver, or its equivalent, and shall be capable of breaking and carrying 40 A at 125 V AC, 60 Hz. A mercury tube contact will not be accepted for flashing indications. Time cycle variations shall not occur due to any change in outside temperature between the limits of -30 to 50 °C (-20 and 120 °F). For temperatures lower than -30°C (-20 °F) (a heater unit may be activated, if required, to keep the unit functioning.

Solid state flasher units shall meet or exceed all requirements of the latest NEMA standards.

The flashing mechanism shall be protected against interfering with radio and television reception by the use of a radio and television interference filter.

(c) Cabinets. The complete flashing mechanism and related interference filters shall be enclosed within a rainproof, NEMA (3R), cast-aluminum cabinet or a glass meter socket housing, whichever is shown on the Plans. The size of the cabinet shall be such as 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 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.

The mounting of the cabinet shall be as shown on the Plans.

(d) 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 components of the signal head consisting of housings, doors, visors, optical units (consisting of lenses, reflectors, lamp sockets, and lamps), wiring, trunnions, and brackets shall conform to the latest requirements of the ITE technical report "Adjustable Face Traffic Control Signal Head Standards," and the applicable portions of Subsection 752.05, unless otherwise specified.

(e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.08 ELECTRICAL CONDUIT. Electrical conduit shall conform to the following:

(a) Rigid Polyvinyl Chloride (PVC) Electrical Conduit. Rigid PVC electrical conduit shall be either Schedule 40 or Schedule 80 and shall meet or exceed the specifications of ASTM D 1784.

(b) Polyethylene Plastic Pipe and Fittings (HDPE) Electrical Conduit. Polyethylene plastic pipe and fittings (HDPE) electrical conduit shall be either Schedule 40 or Schedule 80 and shall meet or exceed the specifications of ASTM D 3350.

(c) Plastic Coated, Galvanized Steel, Rigid Metallic Electrical Conduit. Plastic coated, galvanized steel, rigid metallic electrical conduit shall be hot-dip galvanized and shall have a plastic coating of at least 0.5 mm (20 mils) in thickness intimately bonded to both inside and outside galvanized surfaces. The conduit shall meet the requirements of ASTM A 53/A 53M.

(d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.09 TRAFFIC SIGNAL CONDUCTOR CABLE.

(a) Polyethylene-Insulated, Polyvinyl Chloride (PVC) Jacketed Signal Cable. Polyethylene-insulated, PVC jacketed signal cable for use in underground conduits or as an aerial cable supported by a span wire shall conform to the latest requirements of International Municipal Signal Association, Inc., Specification No. 19-1.

(b) Polyethylene-Insulated, Polyethylene Jacketed Communication Cable. Polyethylene-insulated, polyethylene jacketed communication cable for use in underground conduits or as an aerial cable supported by a span wire shall conform to the latest requirements of International Municipal Signal Association, Inc., Specification No. 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 latest requirements of International Municipal Signal Association, Inc., Specification No. 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 latest requirements of International Municipal Signal Association, Inc., Specification No. 20-3.

(e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.10 DETECTORS. Vehicle detectors used for actuating traffic signal controllers shall be of the inductive loop type or as shown on the Plans.

Inductive Loop Detectors. Inductive loop detectors shall meet or exceed all requirements of the latest NEMA standards for traffic control systems. Tuning shall be automatic. Each detector unit shall be capable of serving up to four loops.

The wire loops shall consist of 3.31 $mm^2$ (No. 12 gage) AWG minimum size, Type TW stranded wire with 600 V insulation. Loop feeder wire shall be in accordance with the loop detector manufacturer's recommendations. Loop feeder length capability shall be at least 230 m (755 feet) for one loop, or a combined total feeder length capability of at least 230 m (755 feet) for multiple loops. Single conductor shall consist of seven-strand tinned copper.

The configurations and installation of the wire loops and loop feeder wires shall be in accordance with the loop detector manufacturer's recommendations and/or as shown on the Plans. The loops shall be located as shown on the Plans.

Vehicle detector feeder wire (lead-ins) shall be enclosed in a nonmetallic conduit for underground travel from the curb to the controller.

Pedestrian Detectors. Pedestrian detectors shall be push button assemblies meeting all ADA requirements. The plunger shall have a minimum diameter of 50 mm (2 inches) and the force required to operate the plunger shall not exceed 25 N (6 pounds).

Certification. For pedestrian push-button assembly detectors, a Type A Certification shall be furnished in accordance with Subsection 700.02.

752.11 VEHICLE DETECTOR SLOT SEALANT. Vehicle detector slot sealant material shall be a standard of the trade for this purpose, and it shall have the approval of the Engineer prior to being used.

752.12 JUNCTION BOX. Junction boxes shall be constructed of fiberglass, high density polyethylene (HDPE), or acrylonitrile-butadiene-styrene (ABS). They shall be high-impact resistant at temperatures ranging from -35 to 50 °C (-30 to 120 °F), ultraviolet stabilized, and fire retardant. The side wall shall be ribbed for strength. The cover shall be non skid and shall be held down with recessed hex-head bolts. The

junction box shall be capable of withstanding a loading of 67 kN (15 kips) over any 250 by 250 mm (10 × 10 inch) area on the cover. The size of the box shall be as specified in the Contract.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.13 PEDESTRIAN AUDIO SIGNALS. Audio signals shall be capable of producing a tone measuring a minimum of 90 decibels at a distance of 1 m (3 feet).

Where both east/west and north/south walk phases are provided at different times during the signal cycle, the audio signal(s) must be capable of producing two distinctly different tones.

When an exclusive (all directions) walk phase is to be provided, the tone may be any one of those normally available (buzz, bell, whistle, beep, or chirp) unless a specific tone is shown on the Plans.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.14 PEDESTRIAN PUSHBUTTON ASSEMBLIES. Pedestrian pushbutton assemblies shall meet all ADA requirements. The plunger head shall have a minimum diameter of 50 mm (2 inches) and the force required to operate the plunger shall not exceed 22.2 N (5 pounds).

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

## SECTION 753 - HIGHWAY ILLUMINATION

### 753.01 LIGHT STANDARDS.

(a) General. The shafts of all light standards shall be designed to withstand an equivalent wind gust load of 160 km/h (100 miles per hour) velocity and when used with the listed bracket arm and luminaire, shall not produce an angular deflection of more than 70 minutes.

The bracket arms shall be able to withstand a vertical load of 450 N (100 pounds) and a horizontal load of 225 N (50 pounds) without fracture or permanent deformation.

The design of light standards shall conform to the AASHTO *Standard Specifications for the Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Breakaway poles shall yield with a change in vehicle momentum of less than 4895 N-s (1100 pound-seconds) when struck by a 1020 kg (2250 pound) vehicle traveling at speeds from 32 to 97 km/h (20 to 60 miles per hour).

(b) Aluminum Poles.

(1) Shafts. Aluminum shafts shall consist of tapered one-piece seamless tubes conforming to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6, 6061-T6, or 6005-T5. Minimum wall thickness shall be 3.2 mm (0.125 inch) for mounting heights of less than 6 m (20 feet) and 4.8 mm (0.188 inch) for mounting heights of 6 m (20 feet) or more.

When transformer bases are not shown on the Plans, a 100 by 150 mm (4 × 6 inch) reinforced handhole, complete with cover plate and stainless steel attachment screws, shall be located approximately 450 mm (18 inches) above the base at 90 degrees from the direction of the bracket arm on the side away from approaching traffic. A lip shall be provided around the handhole opening to prevent the cover from tipping and falling inside the hole. A grounding nut easily accessible from the handhole shall be located inside the shaft at each handhole. Each shaft shall be provided with a removable, ornamental, cast-aluminum, pole cap held securely in place.

(2) Baseplates. Baseplates shall consist of a one-piece aluminum casting conforming to the requirements of ASTM B 26/B 26M or ASTM B 108, Alloy SG70A-T6, 356-T6. The baseplate shall be attached to the 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 base. The welded connection shall develop the full strength of the adjacent shaft section.

(3) Transformer Bases. Transformer bases shall consist of a one-piece aluminum casting conforming to the requirements of ASTM B 26/B 26M or ASTM B 108, Alloy SG70A-T6, 356-T6. The transformer base shall be approximately 500 mm (20 inches) high, 400 mm (16 inches) square at the bottom, and 330 mm (13 inches) square at the top, unless otherwise specified. Each transformer base shall have an aluminum door attached with stainless steel screws. The bottom plate of the base shall have a grounding nut easily accessible from the door. Stainless steel bolts, nuts, and washers shall be provided to attach the transformer base to the shaft anchor base.

(4) Bracket Arms. Bracket arms shall be a single member elliptical-type or truss-type as shown on the Plans. With the exception of davit-type poles, the main or wire-carrying member shall be ovalized at the shaft end. The shaft end of the arm shall have a cast aluminum fitting welded to it to permit attachment to the shaft. Single bracket arms and the main member of truss-type arms shall be tapered, seamless tube conforming to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6 or Alloy 6061-T6. Other members of truss-type arms shall conform to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6. The bracket arm shall be provided

with a 50 mm (2 inch) slip-fit mounting of sufficient length to accommodate the luminaire.

(5) Accessories. All screws, nuts, bolts, and other hardware including anchor bolts shall be stainless steel, unless otherwise specified.

(6) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

(c) Steel Poles.

(1) Steel shafts shall consist of:

a. A tapered one-piece tube fabricated from one length of steel sheet that shall have only one longitudinal automatically electrically welded joint. The shafts shall be formed, welded longitudinally, and cold-rolled under sufficient pressure to flatten the weld and form a smooth tapered tube. The shaft shall be uniformly tapered at a rate of approximately 11.7 mm/m (0.14 inch per foot). The metal thickness shall be not less than 3.0 mm (0.119 inch).

b. A series of two or three different diameter pipes welded together. The metal thickness shall be not less than 4.8 mm (0.188 inch) for the bottom section.

After fabrication, the shafts shall have a minimum yield strength of 330 MPa (48 kips per square inch).

When transformer bases are not shown on the Plans, a 100 by 150 mm (4 × 6 inch) reinforced handhole, complete with cover plate and stainless steel attachment screws, shall be located approximately 450 mm (18 inches) above the base at 90 degrees from the direction of the bracket arm on the side away from approaching traffic. A lip shall be provided around the handhole opening to prevent the cover from tipping and falling inside the hole. A grounding nut shall be located inside the shaft easily accessible from the handhole.

(2) Baseplates. Baseplates shall consist of steel plate conforming to the requirements of ASTM A 36/A 36M or ASTM A 242/A 242M, or of a one-piece steel casting conforming to the requirements of ASTM A 27/A 27M. The baseplate shall be attached to the shaft by two continuous electric welds, one inside the base at the end of the shaft and the other on the outside at the top of the base. The welded connection shall develop the full strength of the adjacent shaft section. When bolt covers are shown on the Plans, they shall be attached to the upright portion of the base with stainless steel screws.

(3) Transformer Bases. Transformer bases shall consist of a one-piece steel casting conforming to the requirements of ASTM A 27/A 27M or shall be

fabricated from steel plate conforming to the requirements of ASTM A 36/A 36M or ASTM A 242M/A 242.

When fabricated, the side plates shall have a minimum thickness of 4.5 mm (0.178 inch). The top and bottom plates shall have a minimum thickness of 19 mm (3/4 inch). The transformer base shall be approximately 500 mm (20 inches) high, 400 mm (16 inches) square at the bottom, and 330 mm (13 inches) square at the top, unless otherwise specified. Stainless steel bolts, nuts, and washers shall be provided to attach the transformer base to the anchor base. Each transformer base shall have a steel door attached with stainless steel screws. The bottom plate of the base shall have a grounding nut easily accessible from the door.

(4) Bracket Arm. Bracket arms shall be fabricated from standard steel pipe, free from burrs and conforming to the requirements of ASTM A 120 or ASTM A 501. Single member arms and individual members of truss-type arms, when required, shall be of one-piece seamless pipe. The bracket arm shall be provided with a 50 mm (2 inch) slip-fit mounting of sufficient length to accommodate the luminaire. Bracket arm connections to the shaft shall be weather resistant.

(5) Finish. After fabrication, shafts, baseplates, transformer bases, and bracket arms shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.

(6) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

753.02 LUMINAIRES.

(a) General. All luminaires, including lamps, ballasts, photoelectric control devices, and housings, shall include the latest design improvements available at the time the Contract is awarded. They shall include an aluminum housing with easy access to the ballast assembly, photoelectric control, filtered optical assembly, and regulator ballast for the appropriate voltage. The ballast shall be matched to its starting circuit. Wiring shall be neat, bundled, and kept away from excess heat. All light distribution types shown on the Plans shall be in accordance with the latest editions of the *American Standard Practice for Roadway Lighting* by the Illuminating Engineering Society (IES) and *An Informational Guide for Roadway Lighting* (AASHTO).

(b) Mercury or Sodium Luminaires. Luminaires shall be weatherproof with a detachable reflector gasketed to the refractor and shall be optically sealed to prevent visible light leaks. The refractor shall be of heat-resistant glass or as shown on the Plans. Housings shall be of cast or formed aluminum. The unit shall be provided with a 50 mm (2 inch) slip-fitting for mounting onto a 50 mm (2 inch) bracket, unless otherwise specified. Wattage and type of light distribution to be provided shall be as shown on the Plans.

The ballast shall be of the regulated (constant wattage) type, internally mounted in the luminaire.

For a mercury vapor luminaire, the ballast shall regulate within ± 2 percent variation of the lamp wattage or a ± 13 percent variation in primary voltage. The ballast shall operate within the range of 5 percent voltage drop and have a guaranteed starting characteristic of -30 °C (-20 °F).

For a high-pressure sodium luminaire, the ballast shall regulate within ± 5 percent variation of the lamp wattage or a ± 10 percent variation in primary voltage. The ballast shall operate within the range of 5 percent voltage drop and have a guaranteed starting characteristic of -30 °C (-20 °F).

For a metal halide luminaire, the ballast shall regulate within ± 10 percent variation in primary voltage. The ballast shall operate within the range of 5 percent voltage drop and have a guaranteed starting characteristic of -30 °C (-20 °F).

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

753.03 PHOTOELECTRIC CONTROL DEVICES. Unless otherwise shown on the Plans, a twist-lock type photoelectric control device shall be an integral part of each luminaire and shall operate at a temperature of -30 °C (-20 °F). The photoelectric controls shall be of the cadmium-sulphide type, and the load capacity of the photoelectric cell relays shall be a minimum of 1000 W. They shall be suitable for operating a lighting system through load relays or oil switches when so shown on the Plans. The photoelectric cell circuitry shall be designed to be normally closed at night. The turn-on range shall be adjustable if shown on the Plans and shall be set by the Contractor as recommended by the manufacturer to meet local conditions. The turn-off setting shall be preset by the manufacturer. The relay shall have a time delay to avoid operation due to lightning and transient light. In the event of failure, the relay shall fail safe, that is, the lights are left on in the event of any failure in the electronic circuit. A suitable bracket for mounting, to orient the photoelectric cell window toward the north sky, and a lightning arrester shall be included as part of the unit.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

753.04 HIGHWAY ILLUMINATION CONDUCTOR CABLE. Highway illumination conductor cable shall be single conductors of stranded, soft-drawn, copper or single conductors of stranded aluminum with a moisture and heat resistant thermoplastic insulation such as Type THW. It shall be rated for 600 V service at 75 °C (167 °F) for either dry or wet locations. UF cable shall be used in wet areas. Where the UF cable may extend into other conditions it shall be of a type approved for the additional use.

The electrical cable in a conduit shall be single conductors of stranded, soft-drawn copper or single conductors of stranded aluminum with a moisture and heat resistant

thermoplastic insulation such as Type XHHW, Type THW, or equivalent. The electrical cable shall be rated for 600 V service at 75 °C (167 °F) for either dry or wet locations.

The cable shall not have any unnecessary kinks or bends put into the cable during installation. Any bends that are necessary shall be made according to the manufacturer's guidelines. 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 pole bases. When a conduit splice is required near termination (such as at a sweep to a pole base or a pull box), the splice shall be made with a coupling of the same or similar material as directed by the Engineer.

The single conductors shall conform to the National Electrical Code for the intended wire use and existing field conditions. Wire size shall be such that no more than a 3 percent 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 shall also be No. 10 AWG stranded copper wire.

Unless otherwise shown on the Plans, the multiple system of distribution shall be used.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

753.05 GROUNDING ELECTRODES. Grounding electrodes shall be copperclad steel rods 16 mm (5/8 inch) in diameter by 2.4 m (8 feet) long, minimum, and shall conform to UL No. 467 (ANSI C33.8).

Grounding conductor shall be installed throughout the system back to the power source. The earth shall not be used as the sole equipment grounding conductor.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

# SECTION 755 - LANDSCAPING MATERIALS

755.01 TOPSOIL. Topsoil shall be of a quality which will support healthy, vigorous plant growth. It shall be a natural, workable loam, free of refuse, roots, stones, brush, weeds, or other material that would be detrimental to the proper development of plant growth. Topsoil shall be obtained from an area that has demonstrated, by a healthy growth of grass, cultivated crops, or wild vegetation, it is of good quality and reasonably free draining.

The topsoil and its source shall be inspected and approved by the Engineer before its use.

755.02 SOD. Sod shall be of a firm, even texture, show good root development, be reasonably free from noxious weeds, and shall have a compact growth of grass. The sod shall be approved by the Engineer prior to being cut and again before it is laid.

755.03 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 shall not be accepted.

(a) Testing. The seed shall be subject to the testing provisions of the Association of Official Seed Analysts (in Lincoln, NE) shall be tested by a recognized seed testing laboratory within six months of the date of delivery to the project, and shall conform to the requirements of all State and Federal regulations.

(b) Labels. Labels shall conform to all State and Federal regulations and shall be clearly marked with the following:

Seed name
Lot number
Percentage of germination
Percentage of purity
Percentage of weed seed content

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.04 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 the Association of Official Agricultural Chemists. Fertilizer shall contain not less than the minimum percentage of nitrogen, phosphoric acid, and potash shown on the Plans.

(a) Packaging. The fertilizer shall be furnished in new, clean, sealed, and properly labeled bags not exceeding 45 kg (100 pounds) each. Caked or otherwise damaged fertilizer shall not be accepted.

Labels shall be clearly marked with the following:

Manufacturer's name
Type
Mass (weight)
Guaranteed analysis

(b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.05 AGRICULTURAL LIMESTONE. Agricultural limestone shall be a calcitic or dolomitic ground limestone containing not less than 85 percent of total (calcium or magnesium) carbonates. The limestone shall conform to the requirements of all State and Federal regulations and to the standards of the Association of Official Agricultural Chemists.

(a) Packaging. The limestone shall be furnished in new, clean, sealed, and properly labeled bags not exceeding 45 kg (100 pounds) each. Caked or otherwise damaged limestone shall not be accepted.

Labels shall be clearly marked with the following:

Manufacturer's name
Type
Mass (weight)
Guaranteed analysis

(b) Sieve Analysis. Limestone shall meet the following sieve analysis: 100 percent shall pass the 2.00 mm (No. 10) sieve with a minimum of 40 percent passing the 150 μm (No. 100) sieve.

(c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.06 MULCH MATERIALS. Mulch materials shall conform to the following requirements:

(a) Hay Mulch. Hay mulch shall consist of mowed and properly cured grass or legume mowings, reasonably free from swamp grass, weeds, twigs, debris, or other deleterious material. It shall be free from rot or mold and shall be acceptable to the Engineer.

(b) Wood Chip Mulch. Wood chip mulch shall consist of well composted hardwood chips, 3 to 6 mm (1/8 to 1/4 inch) nominal thickness, with 50 percent having an area of not less than 650 mm (1 square inch) or more than 4000 $mm^2$ (6 square inches). All wood chip mulch shall be reasonably free from leaves, twigs, shavings, bark, insect pests, eggs or larvae, or other deleterious material that are injurious to plant growth.

(c) Cedar Bark Mulch. Cedar bark mulch shall consist of well composted Cedar bark chips, 3 to 6 mm (1/8 to 1/4 inch) nominal thickness, with 50 percent having an

area of not less than 650 mm (1 square inch) or more than 4000 $mm^2$ (6 square inches). All Cedar bark mulch shall be reasonably free from leaves, twigs, shavings, bark, insect pests, eggs or larvae, or other deleterious material that are injurious to plant growth.

(d) Mulch Binder. Binder for hay mulch may be an emulsified asphalt or another type of mulch binder that has been approved by the Engineer.

755.07 EROSION MATTING. Matting for erosion control shall conform to the following requirements:

(a) Jute Matting. Jute matting shall consist of undyed and unbleached jute yarn woven into a uniform, open, plain weave mesh. Jute matting shall be furnished in rolled strips and shall conform to the following requirements:

(1) Physical Requirements.

| | |
|---|---|
| Width: | 1200 ± 25 mm (48 ± 1 inch)<br>78 warp ends per width of cloth<br>45 weft ends per meter (41 weft ends per yard) |
| Mass (Weight): | average between 600 and 900 g/m (1.2 and 1.8 pounds per linear yard); tolerance ± 5 percent. |

(2) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

(b) Excelsior Matting. Excelsior matting shall consist of a uniform web of interlocking wood excelsior fibers with a backing of mulch net fabric on one side only. The mulch net shall be woven of either twisted paper or cotton cord or formed from biodegradable plastic mesh. Excelsior matting shall be furnished in rolled strips and shall conform to the following requirements:

(1) Physical Requirements.

| | |
|---|---|
| Nominal Width: | 900 or 1200 mm (36 or 48 inches);<br>tolerance ± 25 mm (± 1 inch) |
| Average Mass (Weight): | 430 $g/m^2$ (0.80 pound per square yard);<br>tolerance ± 10 percent |

(2) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

(c) Polypropylene Net Matting. Polypropylene net matting shall be a polypropylene extruded plastic net with a square or near square mesh of approximately 19 by 19 mm (3/4 × 3/4 inch) and a nominal mass (weight) between 12 and 16 $g/m^2$ (2.5 to 3.25 pounds per 1000 square feet). It shall have a minimum tensile strength of 98 ± 26 N (22 ± 6 pounds) over a 75 mm (3 inch) width. The material shall be of a type of polypropylene that will gradually disintegrate in sunlight.

(1) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

(d) Burlap Matting. Burlap matting shall be a wide mesh [6 by 6 mm (1/4 × 1/4 inch)] low density burlap with a mass (weight) of approximately 170 g/m$^2$ (6 ounces per square yard).

(1) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.08 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 as extra heavy or clump according to the particular exception.

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. Plant materials shall be free of insects, disease, sun scald, injuries, abrasions of the bark, knots, dead or dry wood, broken terminal growth, or other objectionable disfigurements. Thin, weak plants shall not be acceptable. Plant materials shall display the appearance of normal health and vigor in strict accordance with these Specifications.

Each shipment shall be accompanied by a description of all the included plant materials or an itemized bill of lading.

All plant materials furnished by the Contractor shall be grown within hardiness Zones 1 through 4 as established by The Arnold Arboretum (in Jamaica Plain, MA) and the plant suppliers shall certify that the stock has been grown under Zone 4 or hardier conditions. 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 conform to the latest edition of *Standard Plant Names*, as adopted by the American Joint Committee on Horticultural Nomenclature. All plant materials delivered shall be true to name and legibly tagged with the names and sizes of materials. Should it be necessary to substitute a plant or plants of a different variety than the plant material specified, it will be necessary for the Contractor to secure written approval from the Engineer for the proposed substitution prior to digging the plants. An approved substitute plant shall be of a value at least equal to the specified plant for which the substitution is being made and then only when sufficient evidence is shown that the plant specified cannot be obtained.

(c) Grading Standards. Grading of plant materials shall be accomplished according to ANSI Z60.1 *American Standard for Nursery Stock* as approved by ANSI and published by the American Association of Nurserymen, Inc.

All plant measurements shall be made in conformance with the standard measurement methods in ANSI Z60.1. All plants shall correspond to the trade classification "No. 1."

If balled and burlapped trees and shrubs are not available, container grown trees and shrubs may be supplied in accordance with the requirements and limitations of ANSI Z60.1; however, all plants supplied shall be of the minimum size listed on the quantity sheet.

Unless designated 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 shall be present having a diameter exceeding 50 mm (2 inches) 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 nursery/supplier unless such plants were previously selected by the Engineer as marked by tags and seals.

The thickness of each shrub shall correspond to the trade classification "No. 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 and ground cover plants shall be of the size, age, and condition listed in the quantity sheet. Plants shall be healthy, 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 at delivery by the Contractor.

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.

The Contractor shall provide the Engineer with a copy of the installing Landscaper's License from the Vermont Department of Agriculture. Also, the Contractor shall provide the Engineer with a copy of the Nursery License and a copy of the Certificate of Nursery Inspection of each supplying nursery.

Particular attention is directed to the provisions of Title 6 VSA, Chapter 89 - Nursery Inspection, regarding the inspection of nurseries and nursery stock, and Vermont Department of Agriculture regulations regarding dealers certificates.

(e) Balled and Burlapped Plants (B & B). Balled and burlapped plants shall be dug so as 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, 248 g/m (8 ounces per 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.

Any B & B designated plant material arriving at the project with broken or loose balls or balls manufactured on the root will not be acceptable and shall be rejected at delivery by the Contractor.

(f) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

The plants shall be certified to have been grown under Zone 4 or hardier conditions, unless otherwise specified. A copy of this certification shall accompany each shipment of plant material and a copy of each shipment certification shall be attached to the Type A Certification submitted for the project. The certifications shall be identified in such a manner as to be directly traceable to the individual shipments.

755.09 ANTIDESICCANT. Antidesiccant shall be an approved emulsion that will provide a film over plant surfaces permeable enough to permit transportation. An antidesiccant shall be used only after its use has been approved by the Engineer.

755.10 WIRE RODENT GUARDS. Wire rodent guards shall be galvanized steel wire fabric with 6 mm (1/4 inch) square openings and shall be of good commercial quality.

755.11 PLANT WRAPPING. Plant wrapping material shall be an approved waterproof paper in 100 mm (4 inch) wide rolls or an approved burlap in 150 mm (6 inch) wide rolls.

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