MECHANICALLY STABILIZED EARTH (MSE) RETAINING WALL

**From Morristown STP F 029-1(2) C/1

xx. DESCRIPTION. This work shall consist of designing, detailing, fabricating, furnishing, erecting, and monitoring mechanically stabilized earth retaining walls constructed in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown on the Plans or as directed by the Engineer.

The mechanically stabilized earth retaining wall system shall consist of placement and compaction of select granular backfill, a non-structural leveling pad, precast concrete face panels, and membrane and soil reinforcement elements mechanically connected to each facing panel. The soil reinforcement shall have sufficient strength, length, and frictional resistance as required by the design as specified herein.

xx. APPROVED WALL SYSTEM. The approved wall system for this project is the ReCon™ retaining wall by ReCon™ Retaining Wall Systems as specified in the Contract Documents.

The mechanically stabilized earth retaining walls for this Contract shall be built in accordance with the Agency approved plans and panel Fabrication Drawings for the specified wall system.

xx. GENERAL REQUIREMENTS. All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown on the Plans shall be accounted for in the stability design of the wall.

The mechanically stabilized earth retaining wall design shall follow the dimensions of the wall envelope shown on the Plans. The design shall locate the leveling pad at or below the minimum wall embedment. Where a coping or barrier is utilized, the wall face panel shall extend up into the coping or barrier the minimum distance specified on the Plans. The top of the face panels may be level or sloped to meet the top of the wall. Cast-in-place concrete will not be acceptable replacement for panel areas, except for minor grouting of pipe penetrations and leveling required for coping.

Where walls or wall sections intersect with an angle of 130° or less, a special vertical corner element panel shall cover the joint of the panels that abut the corner, and allow for independent movement along the abutting panels.

The face panels and wall system shall be designed to accommodate the appropriate magnitude of differential settlement. The spacing between adjacent panels shall be designed to be 19 mm. When shown on the Plans, slip joints to accommodate excessive differential settlement shall be included.

xx. DESIGN REQUIREMENTS. The design by the wall system supplier shall consider the internal stability of the wall mass and shall be performed in accordance with the appropriate sections of the most recent edition of the AASHTO *LRFD Bridge Design Specifications*.

The mechanically stabilized earth retaining wall system shall be designed for a design life of 75 years using the corrosion rates given in the AASHTO *LRFD Bridge Design Specifications* for non-aggressive soil.

(a) Backfill. The friction angle of the select granular backfill used in the reinforced fill zone for the internal stability of the wall shall be assumed to be 34°, unless determined otherwise by tests. When a friction angle greater than 34° is proposed, the friction angle shall be determined by the standard direct shear test, AASHTO T 236, utilizing a sample of the material compacted to 95 percent of AASHTO T 99, Methods C or D (with oversize correction per AASHTO T 224), at the optimum moisture content. Before construction begins, the select granular backfill material selected shall be subject to approval by the Engineer. Compliance with the test requirements shall be the responsibility of the Contractor. The wall supplier shall be furnished a copy of the test results for the backfill prior to construction.

(b) Connections. All connections shall be positive, structural connections subject to the same loss rates and tension requirements as the primary soil reinforcement for mechanically stabilized earth retaining walls.

xx. SUBMITTALS. The Contractor shall submit two (2) copies of the design computations and five (5) sets of panel Fabrication Drawings and wall construction drawings for approval prior to beginning of construction.

(a) Working Drawings and design calculations shall be submitted to the Engineer for review and approval a minimum of four (4) weeks before work is to begin and shall include the following:

(1) Complete design calculations substantiating that the proposed design satisfies the design parameters specified in the Contract Documents.

(2) Details of revisions or additions to drainage systems or other facilities required to accommodate the wall system.

(3) An elevation view of the wall, which shall include the elevation at the top of the wall at all horizontal and vertical break points and at least every 15 m along the face of the wall, all steps in the leveling pads, the designation as to the type of panel, the length of soil reinforcing elements, the distance along the face of the wall to where changes in length of the soil reinforcing elements occur, and an indication of the final ground line and maximum calculated bearing pressures.

(4) A typical cross-section or cross-section showing the elevation relationship between ground conditions and proposed grades, including existing ground elevations that have been verified by the Contractor for each location involving construction wholly or partially in original ground.

(5) General notes pertaining to design criteria and wall construction.

(6) A listing of the summary of quantities on the elevation sheet for each wall.

(7) The details for diverting soil reinforcements around obstructions such as piles, catch basins, and other utilities.

(8) The details for connection between the concrete panel and the soil reinforcements.

(9) Other information required in the Contract Documents or requested by the Engineer.

(b) Panel Fabrication Drawings shall show all dimensions necessary to construct the element, all reinforcing steel in the element, the location of soil reinforcing connection devices embedded in the panels, and an indication of the architectural treatment.

(c) The Contractor shall submit, for review and approval by the Engineer prior to construction, wall design calculations, signed and sealed by a Professional Engineer registered in the State of Vermont and directly employed by the wall system supplier. The Contractor shall not start work on any earth retaining system for which Working Drawings are required until the Engineer has approved such drawings.

Approval of the Contractor's Working Drawings shall not relieve the Contractor of any responsibility under the Contract for the successful completion of the work.

xx. MATERIALS. The Contractor shall make arrangements to purchase from the wall system supplier the materials covered herein, including concrete panels, reinforcing strips, attachment devices, fasteners, joint materials, and all necessary incidentals. The Contractor, or the supplier as the Contractor's agent, shall furnish the Engineer a certificate of compliance certifying that the applicable materials comply with these provisions. Materials not conforming to these provisions shall not be used without the written consent of the Engineer.

(a) Concrete Facing Panels. Concrete facing panels shall meet the requirements of Section 540.

(1) Reinforcing Steel. Reinforcing steel used in the concrete facing panels and panel copings shall be epoxy coated in accordance with Sections 507 and 713.

(2) Casting. The panels shall be cast face down in level forms supported on a flat working surface. Guides shall be used to locate and support attachment devices set in the back face of the panel.

The concrete in each panel unit shall be placed without interruption.

(3) Concrete Finish. The panel surfaces shall be free of open pockets of aggregate and surface distortions in excess of 6 mm.

(b) Soil Reinforcing and Attachment Devices. All reinforcing and attachment devices shall be carefully inspected to ensure they are true size and free from defects that may impair their strength and durability.

(1) Reinforcing Mesh Elements. Reinforcing mesh elements shall be shop fabricated from cold drawn steel rod conforming to the minimum requirements of AASHTO M 32M/M 32 and shall be welded at the junctions between longitudinal and transverse wires in accordance with AASHTO M 55M/M 55. Galvanizing shall be applied after mesh fabrication and shall conform to the minimum requirements of AASHTO M 111M/M 111. The galvanizing thickness shall be determined and specified based on the design life requirements of the structure.

(2) Loop Embeds. Loop embeds shall be fabricated from cold drawn steel rod conforming to AASHTO M 32M/M 32. Loop embeds shall be welded in accordance with AASHTO M 55M/M 55. Loop embeds shall be galvanized in accordance with AASHTO M 232M/M 232.

(3) Reinforcing Strips. Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Their physical and mechanical properties shall conform to ASTM A 572/A 572M Grade 450 or equal. Galvanizing shall conform to the minimum requirements of AASHTO M 111M/M 111. The galvanizing thickness shall be determined and specified based on the design life requirements of the structure.

(4) Tie Strips. Tie strips shall be shop fabricated from hot rolled steel conforming to the minimum requirements of ASTM A 570, Grade 50 or equivalent. Galvanizing shall conform to AASHTO M 111M/M 111 or AASHTO M 232M/M 232. The minimum coating thickness shall be 0.610 kg/m^2.

(5) Fasteners. Fasteners shall consist of galvanized hexagonal cap screw bolts and nuts conforming to the requirements of AASHTO M 164M (M 164) or equivalent. Fasteners shall be galvanized in accordance with AASHTO M 232M/M 232.

(c) Joint Materials. Joint materials shall be installed to the dimension and thickness indicated in the Plans.

(1) Bearing Pads. Bearing pads shall be preformed EDPM rubber pads conforming to ASTM D 2000 M2AA 807 and having a durometer hardness equal to 80±5.

(2) Joint Cover. Horizontal and vertical joints between panels shall be covered by a geotextile. The geotextile may be either a non-woven needle punched polyester geotextile or a woven monofilament polypropylene geotextile meeting the requirements of Section 720 for Geotextile Under Stone

Fill. The wall supplier shall approve adhesive used to hold the geotextile filter fiber material to the rear of the facing panels prior to backfill placement.

(d) Select Granular Backfill. Select granular backfill material used in the mechanically stabilized earth structure shall be reasonably free from organic and otherwise deleterious materials, and shall conform to the following gradation limits as determined in accordance with AASHTO T 27:

SIEVE SIZE	PERCENT PASSING
101.6 mm	100
75 mm	75 – 100
0.425 mm	0-60
75 µm	0 - 12

In addition, the backfill shall conform to the following requirements:

(1) Plasticity Index. The Plasticity Index (P.I.), as determined by AASHTO T 90, shall not exceed six.

(2) Soundness. The material shall be substantially free of shale or other soft particles with poor durability characteristics. The material shall have a sodium sulfate soundness loss of less than 8 percent after five (5) cycles, as determined by AASHTO T 104.

(3) Electrochemical Requirements. The backfill material shall conform to the following requirements:

PROPERTY	REQUIREMENT	TEST METHOD
Resistivity at 100% saturation	Minimum 3000 ohm-cm	AASHTO T288
pH	Acceptable Range 5 - 10	AASHTO T289
Sulfates	Maximum 200 ppm	AASHTO T290
Chlorides	Maximum 100 ppm	AASHTO T291
Organic Content	<1%	AASHTO T267

Backfill not conforming to these provisions shall not be used without the written consent of both the Engineer and the wall supplier.

(4) Uniformity Coefficient. Backfill material shall have a minimum uniformity coefficient, C_u, of 2.

xx. CONSTRUCTION REQUIREMENTS.

(a) Manufacturer’s Representative. The Contractor shall make the necessary arrangements with the wall supplier to have a technical representative on the project to supervise the initial placement of the mechanically stabilized earth retaining wall system. The

technical representative shall also be required to be on-site any time during wall installation as requested by the Engineer. The representative shall be available for a minimum of 20 work days.

(b) Wall Excavation. Common excavation shall be in accordance with the requirements of specifications for embankment excavation and in reasonable close conformity with the limits shown on the Plans.

(c) Foundation Preparation. The foundation for the structure shall be graded level for a width equal to or exceeding the length of the soil reinforcements, or as shown on the Plans. The Contractor shall proof roll the foundation using a minimum 4500 kg, self-propelled vibratory roller to compact soils disturbed by excavation. Areas exhibiting excess weaving or soft, unsuitable soils should be excavated and replaced with compacted granular fill. Wet foundation soils should be proof rolled without vibration. Any foundation soils found to be unsuitable shall be removed and replaced as directed by the Engineer.

At each panel foundation level, an unreinforced concrete leveling pad shall be provided as shown on the Plans. The leveling pad shall have nominal dimensions of 150 mm thickness and 300 mm width, and shall be cast using minimum 13.8 MPa 28 day compressive strength concrete. The leveling pad shall be cast to the design elevations as shown on the Plans. Allowable elevation tolerances are +3 mm and -6 mm from the design elevation. Prior to placement of the leveling pad, the Agency’s Geotechnical Engineer or designated representative shall inspect the foundation soils to evaluate the suitability of the bearing soils.

Leveling pads shall be allowed to cure a minimum of 24 hours before wall panels are erected on them.

(d) Wall Erection. Precast concrete panels shall be placed vertically with the aid of a light crane. For erection, panels shall be handled by means of lifting devices set into the upper edge of the panels. Panels shall be placed in successive horizontal lifts in the sequence shown on the Plans as backfill placement proceeds.

As the backfill material is placed behind the panels, the panels shall be maintained in a vertical position by means of temporary wooden wedges placed in the joint at the junction of the two adjacent panels on the external side of the wall. External bracing is required for the initial lift. Vertical tolerance (plumbness) and horizontal alignment tolerances shall not exceed 20 mm. The allowable offset in any panel joint shall be 20 mm. The overall vertical tolerance of the wall (plumbness from top to bottom) shall not exceed 13 mm per 3 m of wall height.

(e) Placement of Reinforcements. Prior to the first layer of reinforcements, backfill shall be placed and compacted in accordance with part (f) of this Subsection.

Soil reinforcements shall be placed normal to the face of the wall, unless otherwise shown on the Plans or directed by the Engineer.

If skewing of the soil reinforcements is required due to obstructions in the reinforced fill, or in other cases justified by calculation, the maximum skew angle shall not exceed 15 degrees from the normal position, except in case of acute corners where redundant reinforcements are used, or in other cases justified by calculation.

(f) Backfill Placement. Backfill placement shall closely follow erection of each course of panels. Backfill shall be placed in such a manner as to avoid any damage or disturbance to the wall materials or misalignment of the facing panels. Any wall materials which become damaged or disturbed during backfill placement shall be corrected or removed and replaced at the Contractor's expense, as directed by the Engineer.

No backfill shall be placed until test results from a qualified independent testing laboratory have been submitted for the proposed material. Test results shall demonstrate conformance with the backfill friction angle requirements included in these provisions (if friction angle greater than 34° is being proposed) and meet the requirements for Select Granular Backfill.

Backfill shall be compacted to 95 percent of the maximum density as determined in accordance with AASHTO T 99, Method C or D (with oversize correction).

The moisture content of the backfill material prior to and during compaction shall be uniform throughout each layer. Backfill material shall have a placement moisture content less than or equal to the optimum moisture content. Backfill material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniform and acceptable throughout the entire lift.

The optimum moisture content shall be determined in accordance with AASHTO T 99, Method C or D (with oversize correction).

The frequency of sampling of Select Granular Backfill material, necessary to assure gradation control throughout construction, shall be as directed by the Engineer. If 30 percent or more of the Select Granular Backfill material is greater than 19 mm in size, AASHTO T 99 is not applicable. For such material, the acceptance criterion for control of compaction shall be either a minimum of 70 percent of the relative density of the material, as determined by ASTM D 4253 and D 4254 or a method specification (based on a test compaction section) which defines the type of equipment, lift thickness, number of passes of the specified equipment, and placement moisture content.

The maximum lift thickness after compaction shall not exceed 250 mm, regardless of the vertical spacing between the reinforced soil layers. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density. Prior to

placement of the soil reinforcements, the backfill elevation, after compaction, shall be 50 mm above the attachment device elevation from a point approximately 300 mm behind the back face of the panels to the free end of the soil reinforcements, unless otherwise shown on the Plans.

Compaction within 1 m of the back face of the panels shall be achieved by a minimum of three (3) passes of a lightweight mechanical tamper, roller or vibratory system. The specified lift thickness shall be adjusted as warranted by the type of compaction equipment actually used, but no soil density tests need be taken within this area. Care shall be exercised in the compaction process to avoid misalignment of the panels or damage to the attachment devices. Heavy compaction equipment shall not be used to compact backfill within 1 m of the wall face.

At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing to direct runoff of rainwater away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

(g) Horizontal and Vertical Control. Immediately following the erection of the mechanically stabilized earth retaining wall system, the Contractor shall establish horizontal and vertical survey points at three locations across the top and at mid-elevation on the wall to monitor future movements. These points shall be tied into a minimum of two control markers that are sufficiently removed from the wall so as not to be influenced by wall movement. The control shall be located to allow additional measurements to be made after all construction is complete. A plan with the locations of all survey points and ties, along with distances and elevations recorded to the nearest 0.001 m, shall be provided to the Engineer within 48 hours of the completion of the mechanically stabilized earth retaining wall system.

xx. METHOD OF MEASUREMENT. The quantity of Special Provision (Mechanically Stabilized Earth Retaining Wall, ReCon) to be measured for payment will be the number of square meters (square feet) of wall surface area in the complete and accepted work, measured as the sum of the areas of panels actually erected in the wall.

xx. BASIS OF PAYMENT. The accepted quantity of Special Provision (Mechanically Stabilized Earth Retaining Wall, ReCon) will be paid for at the Contract unit price per square meter (square foot). Payment shall include full compensation for designing, detailing, fabricating, furnishing, transporting, erecting, and monitoring the mechanically stabilized earth retaining wall system, including precast half connectors, precast concrete coping, and cast-in-place moment slabs; for preparing all required submittals; for materials required including but not limited to select granular backfill, PVC pipe, drainage aggregate, concrete facing panels, soil reinforcements, attachment devices, fasteners, bearing blocks, shims, joint materials, geomembrane, and geotextiles; for preparing the wall foundation, proof rolling foundation soils, and constructing the concrete leveling pad; all required excavation; and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

Pay Item	Pay Unit
900.670 Special Provision (Mechanically Stabilized Earth Retaining Wall, ReCon)	Square Foot
900.675 Special Provision (Mechanically Stabilized Earth Retaining Wall, ReCon)	Square Meter