**BEDFORD**
**13527**

January 27, 2011

# S P E C I A L  P R O V I S I O N

## SECTION 592 -- RETAINING WALL

### Item 592.1 – Mechanically Stabilized Earth Retaining Wall

### Description

**1.1** This work consists of designing, furnishing and constructing a mechanically stabilized earth (MSE) retaining wall system in accordance with these specifications and in close conformance with the lines, grades, design and dimensions shown on the plans or established by the Engineer. The MSE wall includes a non-structural cast in place concrete leveling pad, precast concrete facing panels, tensile reinforcement mechanically connected to each facing panel, concrete slip joint posts, reinforced cast-in-place and precast concrete coping, impervious membrane with non-woven geotextile and perforated pipe, and all incidental materials, as detailed on the plans.

**1.1.1** Inextensible reinforcement refers to metallic reinforcement, and extensible reinforcement refers to polymeric reinforcement. Approved MSE wall systems based on the wall application are provided in 1.2. The type of reinforcement used for the systems listed in 1.2 shall be as previously approved by the Department for a particular system. More detailed information regarding the Department's approved wall systems with associated applications, requirements and limitations are provided in the following memorandums and letters, which can be obtained through NHDOT Bureau of Bridge Design:

1. Memorandum dated November 30, 2007, entitled "Review and Summary of Recommendations for Additional MSE Retaining Wall Systems"

2. Memorandum dated March 6, 2008 entitled "Review, Summary and Recommendations for T&B Structural MSE Retaining Wall System"

3. Letter dated June 30, 2009 entitled "Tricon MSE Retaining Wall, NHDOT Response to Recent Discussions and Issues with Tricon System"

**1.1.2** An impervious membrane with perforated pipe shall be provided above inextensible tensile reinforcement. The MSE wall item includes the requirement to design the rows of inextensible tensile reinforcement located above the impervious membrane for a 125 year design life, as described in this specification, and all other tensile reinforcement for a 100 year design life.

**1.1.3** The MSE wall items include the cost of designing the MSE wall, providing design calculations and shop drawings, site visits by the wall supplier's technical representative and concrete and granular backfill testing.

**1.1.4** As described in 2.2, the precast concrete facing panels shall be reinforced with steel bars that are galvanized.

**1.1.5** The material requirements for Item 209.5 Granular Backfill for MSE Walls are provided in the Special Provision Amendment to Section 209.

**1.1.6** As described in 1.4, the MSE Walls shall be designed in accordance with the applicable provisions of the 2007 AASHTO LRFD Bridge Design Specifications as amended through 2010.

**1.1.7** Exposed MSE panels shall have an Ashlar Stone form liner pattern that conforms to Ashlar Stone P/C 30664, Symons Dura-Tex as manufactured by Symons Corporation; or Ashlar Stone No. 330 Multi-Cast, as manufactured by Greenstreak; or approved equal. The form liner pattern shall extend to a minimum of 12 inches below the finished grade at the face of the wall.

**1.1.8** Item 534.3, Water Repellant (Silane-Siloxane), shall be applied to the entire wall coping, and to exposed MSE panel surfaces to 12 inches below the finished grade at the face of the wall.

**1.1.9** All wall systems shall have a precast or cast-in-place concrete coping at the top of wall.

**1.2 Approved Wall Systems.** The following proprietary MSE wall systems are approved for the following applications for this project.

**1.2.1 Walls Supporting Overlying Structures** – The following precast concrete panel wall systems are approved for retaining walls that support overlying structures including bridge abutments and soundwalls:

A. Reinforced Earth® by The Reinforced Earth Company
133 Park Street, North Reading, Massachusetts 01864
(978) 664-2830

B. Retained Earth™ by The Reinforced Earth Company
133 Park Street, North Reading, Massachusetts 01864
(978) 664-2830

C. TBSS Permanent MSE Retaining Wall System
T&B Structural Systems LLC
6800 Manhattan Blvd., No. 304, Fort Worth, Texas 76120
(888) 280-9858

**1.2.2 Stand Alone Walls With No Overlying Structures** – In addition to the wall systems listed in 1.2.1, the following precast concrete panel wall systems are approved for stand alone walls with no overlying structures.

A. Tricon Precast Ltd.
15055 Henry Road
Houston, TX 77060
(281) 931-9832
(Approved in accordance with the design requirements in the letter from the NHDOT Bridge Design Bureau to Tricon Precast Ltd, dated June 30, 2009)

B. Tensar Ares MSE Retaining Wall System
Tensar International
5883 Glenridge Drive, Suite 200
Atlanta, Georgia 30328
(404) 250-1290

**1.2.3 Stand Alone Walls With No Overlying Structures in Non-Salt Spray Locations –** In addition to the wall systems listed in 1.2.1 and 1.2.2, the following dry cast modular concrete block systems are approved for stand alone walls in non-salt spray locations (outside the clear zone).

A. Tensar Mesa MSE Retaining Wall System
Tensar International
5883 Glenridge Drive, Suite 200
Atlanta, Georgia 30328
(404) 250-1290

B. Keysystem I (with either galvanized steel welded wire, or HDPE geogrid)
Keystone Retaining Wall Systems
4444 West 78th Street
Minneapolis, MN 55435
(952) 897-1040

C. Keystone Standard (with HDPE geogrid)
Keystone Retaining Wall Systems
4444 West 78th Street
Minneapolis, MN 55435
(952) 897-1040

**1.3 Requirements for Supplier Prepared Design and Plans.** The Design-Builder shall submit plans and calculations for the selected MSE wall system for approval in accordance with Section 105.02, the design criteria in section 1.4 of this specification and the requirements listed below.

**1.3.1** The fully detailed plans shall be prepared in ink on permanent, archival quality, 22 inch by 34 inch (559 by 864 mm) double matte mylar (minimum 4 mil thickness) with Project Name, Number and Proprietary Firm Name. All dimensions and elevations shall use the English system of units and the project datum.

**1.3.2** The plans and calculations shall be prepared, stamped and signed by a Licensed Professional Engineer in the State of New Hampshire and shall be submitted a minimum of 45 days prior to beginning any wall related construction.

**1.3.3** The MSE wall design calculations shall include a complete and thorough set of hand calculations that are specific to this project to support any computer generated calculations. The calculations shall include all applicable references to the LRFD code. A detailed explanation of any symbols and computer programs used in the design shall be provided. The design calculations shall be provided for external stability (sliding, overturning, and maximum bearing pressure) of the final wall configuration, and internal stability within each layer of reinforcement (tensile stress, pullout resistance and tensile stress at the connection with the facing) for the applicable strength and extreme event limit states. Calculations shall be performed in English units, with the final calculation results shown in English units.

**1.3.3.1** The design calculations for internal and external stability of the MSE wall shall incorporate the effects of the guardrail system loads, stub abutment spread footing loads, rail support slab/barrier loads and stub abutment pile loads, where applicable.

**1.3.3.2** The design calculations and associated design parameters, including the pullout resistance of the tensile reinforcement shall account for the frictional, gradation and strength characteristics of the specific reinforced backfill materials that are provided by the Design-Builder for the project.

**1.3.4** Plan and elevation sheets shall be provided and shall contain the following information:

A. Elevation view of the wall that shall indicate the elevation at the top of the wall at all horizontal and vertical break points and at least every 50 feet (20 m) along the wall, elevations at the top of leveling pads, the designation as to the type of panel, the length, size and number of tensile reinforcement strips or grids, and the location of the original and final ground line.

B. Plan view of the wall that shall indicate the offset from the construction centerline to the face of the wall at all changes in horizontal alignment, the limit of the tensile reinforcement, the centerline of any drainage structure or drainage pipe that is behind or passes under or through the wall, and the location of bearing piles.

C. Any general notes required for design and construction of the wall.

D. All horizontal and vertical curve data affecting wall construction.

E. Summary listing of quantities provided on the elevation sheet of each wall for all items including subsidiary items.

F. Cross section showing limits of construction and the limits and extent of the tensile reinforcement and associated granular backfill.

**1.3.5** Detail sheets shall be provided and shall contain the following information:

A. All details for foundations and leveling pads, including the maximum calculated bearing pressures (factored).

B. All details for the facing panels including all dimensions necessary to fabricate the panels and all reinforcing steel in the panels and the location of tensile reinforcement connection devices embedded in the panel.

C. All reinforcing bar bending details.

D. All details for construction of the wall around bearing piles, drainage facilities, rail posts, utilities or other items located within the reinforced soil volume.

E. All details for connections to traffic barriers, copings, parapets, attached lighting and other structures.

F. Details for tensile reinforcement connections to stub abutments, if applicable.

**1.4 Design Criteria.** The MSE wall design shall meet all applicable requirements from the 2007 AASHTO LRFD Bridge Design Specifications as amended through 2010 for the applicable strength and extreme event limit states. Design criteria shall include the following:

A. Traffic loads shall be based on LRFD Section 11.10.10.2 with a soil unit weight of 125 pounds per cubic foot (19.7 kilonewtons per cubic meter).

B. The Extreme Event limit state shall be included in the wall analysis.

C. The reinforced soil shall assume a soil friction angle of 34 degrees and a soil unit weight of 125 pounds per cubic foot (19.7 kilonewtons per cubic meter). The retained soil shall assume a soil friction angle of 30 degrees and a soil unit weight of 120 pounds per cubic foot (18.9 kilonewtons per cubic meter).

D. The design life of the MSE structure based on corrosion shall be 125 years for inextensible tensile reinforcement located above the impervious membrane, and 100 years for all inextensible tensile reinforcement located below the impervious membrane, and all extensible tensile reinforcement.

E. The nominal bearing resistance ($q_n$) for the MSE walls shall be based on the site specific geotechnical evaluation. The associated resistance factor shall be equal to 0.65 as defined in Table 11.5.6-1 of the LRFD code for the strength limit states and 1.0 for the Extreme Event limit states as defined in Section 11.5.7 of the LRFD code.

F. The coefficient of sliding resistance at the base of the MSE wall shall be based on Sections 11.10.5.3 of the LRFD code using $\varphi_f$ equal 30 degrees. The associated resistance factor shall be equal to 1.0 as defined in Table 11.5.6-1 of the LRFD code.

G. MSE walls shall be designed so that the tensile reinforcement does not conflict with stub abutment footings, bridge approach slabs, rail support slabs or soundwalls. The contract plans should be referenced for relevant design information for stub abutment footings, approach slabs, rail support slabs or soundwalls. The uppermost level of tensile reinforcement shall be located a minimum of 6 inches below the bottom of an overlying slab or footing. Calculations that demonstrate sufficient structural capacity shall be provided for MSE panels that require an extended cantilevered section above the uppermost row of tensile reinforcement.

H. The MSE wall design shall include any temporary loads or conditions that may occur during the construction phase, including equipment loads, and the effects of any surface or subsurface water infiltration into the MSE wall construction site.

## Materials

**2.1** The Design-Builder shall make all arrangements to purchase the materials covered by this section of the specifications, including concrete facing panels, concrete coping, concrete cap slab, concrete slip joint posts, tensile reinforcement, connection devices, fasteners, joint materials, impervious membrane, perforated and non-perforated pipe, geotextile and all necessary incidentals from the approved MSE wall system supplier. The Design-Builder shall furnish the Engineer a Certificate of Compliance, meeting the requirements of Section 106.04, certifying that the applicable materials comply with this section of the specifications. Materials not conforming to this section of the specifications shall not be used without the written consent of the Engineer.

**2.2 Concrete Facing Panels** Precast concrete facing panels shall have a minimum thickness of 5 1/2 inches (140 mm) exclusive of the form liner pattern, and a minimum concrete cover on reinforcing steel of 1-1/2 inches (38 mm). Cement shall be Type II and shall conform to the requirements of AASHTO M 85. Concrete shall have a minimum compressive strength of 5000 psi (35 MPa) at 28 days and meet all other requirements of Concrete Class A as specified in Section 520. A corrosion inhibitor (calcium nitrate) admixture from the Qualified Products List shall be used at the rate recommended by the manufacturer, and as approved. Panels shall be reinforced with steel bars that are galvanized in accordance with AASHTO M111 or ASTM A767/767M. Lifting devices shall be set in place to the dimensions and tolerances shown on the approved shop drawings prior to casting. All concrete components shall meet or exceed specifications listed in Section 520.

**2.2.1 Testing and Inspection.** Acceptability of the panels shall be determined on the basis of compliance with the properties specified for Class A concrete in Section 520, compliance with the requirements in Section 2.2 of this specification, and visual inspection. The Design-Builder shall furnish all necessary facilities and access for the Engineer to sample, test and inspect the panels in an expeditious and satisfactory manner. The Design-Builder shall furnish all necessary facilities and shall perform sampling and testing to measure the compressive strength of the concrete in an expeditious and satisfactory manner as outlined in Section 2.2.7.

**2.2.2 Casting.** The concrete in each panel shall be placed without interruption and shall be consolidated by the use of an approved vibrator, supplemented by such hand tamping as may be necessary to force the concrete into the corners of the forms and to prevent the formation of stone pockets or cleavage planes. Clear form oil or release agent shall be used on the forms prior to each casting operation.

**2.2.3 Curing.** The panels shall be cured as specified in Section 520.3.10, and as approved. Any production lot which does not conform to the strength requirements shall be rejected.

**2.2.4 Removal of Forms.** The forms shall remain in place until they can be removed without damage to the panel.

**2.2.5 Concrete Finish.** The front face of the panels shall have a form liner finish as described in 1.1.7. The rear face of the panels shall have an unformed finish and shall be free of open pockets of aggregate and surface distortions in excess of 1/4 inch (6 mm). The front face of the panels shall be coated with water repellent, as described in 1.1.8.

**2.2.6 Tolerances.** All panels shall be manufactured within the following tolerances with respect to the dimensions shown on the approved shop drawings:

A. Connection Device Locations and Alignment. Individual reinforcing strip connection devices shall be positioned within one inch (25 mm). Multiple connection points for a single reinforcement grid shall be positioned within 1/8 inch (3 mm). Embedment measured from the back face of the panel shall be within + 1/4 inch to –1/2 inch (+6 mm to –12 mm).

B. Panel Dimensions. All panel dimensions shall be within 1/4 inch (6 mm). All hardware embedded in the panel with the exception of connection devices shall be within 1/4 inch (6 mm).

C. Panel Squareness. Squareness, as determined by the difference between the two diagonals, shall not exceed 1/2 inch (12 mm).

D. Panel Surface Finish. Surface defects on smooth-formed surfaces, measured on a length of 5 feet (1.5 m) shall not exceed 1/4 inch (6 mm). Surface defects on textured-finished surfaces, measured on a length of 5 feet (1.5 m) shall not exceed 5/16 inch (8 mm).

**2.2.7 Compressive Strength.** Acceptance of the panels, with respect to compressive strength, shall be determined on the basis of production lots. A production lot is defined as a group of panels that shall be represented by a single set of compressive strength samples and shall consist of not more than 20 panels or a single day's production, whichever is less.

**2.2.7.1** During the production of the panels, the manufacturer shall randomly sample the concrete in accordance with AASHTO T 141. A single set of compressive strength samples, consisting of a minimum of four cylinders, shall be made for every production lot.

**2.2.7.2** For every compressive strength sample, a minimum of two cylinders shall be cured in the same manner as the panels and tested at 7 days or less. The average compressive strength of these cylinders, when tested in accordance with AASHTO T 22, will determine the initial strength of the concrete. In addition, a minimum of two cylinders shall be cured in accordance with AASHTO T 23 and tested at 28 days. The average compressive strength of these cylinders, when tested in accordance with AASHTO T 22, will determine the compressive strength of the production lot.

**2.2.7.3** If the initial strength test result indicates a compressive strength greater than or equal to the required 28-day strength, then this test result will be utilized as the compressive strength test results for that production lot, and the requirement for testing at 28 days will be waived for that particular production lot.

**2.2.7.4** Acceptance of a production lot will be made if the compressive strength test result is greater than or equal to the required 28-day strength. If the compressive strength test results is less than the required 28-day strength, the acceptance of the production lot will be based on its meeting the following acceptance criteria in its entirety:

A. Ninety percent of the compressive strength test results for the overall production shall exceed 1.0375 times the required 28-day strength.

B. The average of any six consecutive compressive strength test results, including the one in question, shall exceed 1.0625 times the required 28-day strength.

C. No individual compressive strength test result shall fall below 0.9 times the required 28-day strength.

**2.2.7.5** In the event that a production lot fails to meet the specified compressive strength requirements, the production lot shall be rejected. Such rejection shall prevail unless the Design-Builder, at no cost to the Department, obtains and submits evidence of a type acceptable to the Engineer that the strength and quality of the concrete placed in the panels within a production lot is acceptable. If such evidence consists of tests made on cores taken from the panels within the production lot, the cores shall be obtained and tested in accordance with AASHTO T 24.

**2.2.8 Rejection.** Panels shall be subject to rejection because of failure to meet any of the requirements specified above. In addition, any or all of the following defects may be sufficient cause for rejection:

A. Defects that indicate imperfect molding.

B. Defects indicating honeycombed or open-texture concrete.

C. Defects in the physical characteristics of the concrete, such as broken or chipped concrete.

**2.2.9** The Engineer shall determine whether spalled, honeycombed, chipped or otherwise defective concrete shall be repaired or be cause for rejection. Repair of concrete, if allowed, shall be done in a manner satisfactory to the Engineer. Repair to concrete surfaces which will be exposed to view after completion of construction must be approved by the Engineer.

**2.2.10 Marking.** The date of manufacture, the production lot number, and the piece-mark shall be clearly scribed on the rear face of each panel.

**2.2.11 Handling, Storage and Shipping.** All panels shall be handled, stored and shipped in such a manner as to eliminate the potential for chips, cracks, fractures and excessive bending stresses. Panels shall be stored and shipped in stacks, front face down. Firm blocking, of sufficient thickness to prevent the attachment devices from contacting the panel above, shall be located immediately adjacent to the attachment devices. Lifting inserts shall be installed on the top edge of the panels to permit lifting at the project site. Reinforcement connection inserts (tie strips or loop inserts) shall not be used for lifting or handling the panel.

**2.3 Tensile Reinforcement and Connection Devices.** All tensile reinforcement and panel connection devices shall be carefully inspected to ensure they are true to size and free from defects that may impair their strength and durability.

**2.3.1 Ribbed Reinforcing Strips.** Ribbed reinforcement 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 65 (450) or equal. Galvanizing shall conform to the requirements of AASHTO M 111 (ASTM A 123). The minimum coating thickness shall be 2 ounces per square foot (605 grams per square meter ).

**2.3.2 Ladder Reinforcing Strips.** Ladder reinforcement strips shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of AASHTO M 32/M 32M (ASTM A 82) and welded into the finished strip configuration in accordance with AASHTO M 55/M 55M (ASTM A 185). The longitudinal and transverse wires shall be of the same size. Galvanizing shall be applied after the ladder strips are fabricated and shall conform to the minimum requirements of AASHTO M 111 (ASTM A 123). The minimum coating thickness shall be 2 ounces per square foot (605 grams per square meter).

**2.3.3 Wire Grid Reinforcement.** Wire grid reinforcement shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of AASHTO M 32/M 32M (ASTM A 82) and welded into the finished grid in accordance with AASHTO M 55/M 55M (ASTM A 185). The longitudinal and transverse wires shall be of the same size. The maximum spacing between longitudinal wires shall be 6 inches (150 mm) and the maximum spacing between transverse wires shall be 24 inches (600 mm). A minimum of 4 longitudinal wires shall be provided for each grid, unless otherwise approved for unique panel locations that cannot accommodate a 4 wire configuration. For grids with less than 4 longitudinal wires, the tensile load calculated using the methods defined in 1.4 shall be multiplied by the ratio of 4 divided by the number of provided longitudinal wires to determine the tensile load used for the internal stability analysis. Galvanizing shall be applied after the grid is fabricated and shall conform to the minimum requirements of AASHTO M 111 (ASTM A 123). The minimum coating thickness shall be 2 ounces per square foot (605 grams per square meter).

**2.3.4 Tie Strips.** Tie strips shall be shop fabricated of hot rolled steel conforming to the minimum requirements of ASTM A 1011/A 1011M SS, Grade 50 or equivalent. Galvanizing shall conform to the minimum requirements of AASHTO M 111 (ASTM A 123), or AASHTO M 232 (ASTM A 153). The minimum coating thickness shall be 2 ounces per square foot (605 grams per square meter).

**2.3.5 Wire Tie Strips and Loop Inserts.** Wire tie strips and loop inserts shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of AASHTO M 32/M 32M (ASTM A 82). Galvanizing shall conform to the minimum requirements of AASHTO M 111 (ASTM A 123). The minimum coating thickness shall be 2 ounces per square foot (605 grams per square meter).

**2.3.6 Fasteners.** Fasteners shall consist of ½-inch (12 mm) minimum diameter hexagonal cap screw bolts and nuts conforming to the minimum requirements of AASHTO M 164 (ASTM A 325) or equivalent. Galvanizing shall conform to the minimum requirements of AASHTO M 232 (ASTM A 153).

**2.3.7 Connector Bars and Pins.** Connector bars and pins shall be fabricated from cold drawn steel wire conforming to the minimum requirements of AASHTO M 32/M 32M (ASTM A 82) and shall be galvanized in accordance with the requirements of AASHTO M 111 (ASTM A 123). The minimum coating thickness shall be 2 ounces per square foot (605 grams per square meter).

**2.3.8 Structural Connectors.** Structural plate connectors and fasteners used for yokes to connect soil reinforcing to facing panels around pile or utility conflicts shall conform to the material requirements of 2.3.4 Tie Strips and 2.3.6 Fasteners, stated above.

**2.4 Joint Materials.** Joint materials shall be as specified by the wall supplier subject to the following requirements:

**2.4.1 Bearing Pads.** Bearing pads shall be preformed rubber pads having a durometer hardness of 80 ± 5.

**2.4.2 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 as approved by the wall supplier. Adhesive used to hold the geotextile filter fabric material to the rear of the panels prior to backfill placement shall be approved by the wall supplier.

**2.5 Granular Backfill for MSE Walls (Item 209.5).** Material used for Item 209.5 within the reinforced soil volume or within other areas as detailed on the plans shall conform to the material requirements contained in the Special Provision Amendment to Sections 209 for Item 209.5. Construction requirements for Item 209.5 are provided below in 3.6.

**2.6 Clean Stone for Structural Fill (Item 508).** Material used within MSE structures for Clean Stone for Structural Fill below the stub abutment footing shall conform to applicable requirements of Section 508 and to the plasticity, soundness and electrochemical requirements defined in the Special Provision Amendment to Section 209 for Item 209.5.

**2.7 Concrete for Leveling Pads.** Concrete for cast in place leveling pad shall conform to the requirements of Concrete Class B as specified in Section 520.

**2.8 Non-Woven Geotextile.** Geotextile used directly above the impervious membrane shall be a medium strength, non-woven geotextile that meets the property requirements of Item 593.1.2.1.

**2.8.1** At least two weeks prior to installation of the geotextile, the Design-Builder shall submit a certificate of compliance in accordance with 106.04. Each roll shall be clearly labeled so as to easily identify the product in the field. The label shall include as a minimum, the manufacturer's name, product name and number and the contract item name and number.

**2.9 Impervious Membrane.** The impervious membrane shall be a 0.75 mm (30 mil) PVC sheet, compounded from first quality domestic virgin material of single ply construction, having polyvinyl chloride as its principal polymer. The membrane shall be produced so as to be free of holes, undispersed raw materials or blisters and shall meet the following physical requirements:

| Property | Test Method | Property Requirements |
|---|---|---|
| Thickness [mil (mm)] | ASTM D 1593 | 30 (0.75) ± 5% min. |
| Specific Gravity | ASTM D 792 | 1.20 min. |
| Dimensional Stability (% change) | ASTM D1204 | 5 max. |
| Tensile Strength [pounds per square inch (kPa)] | ASTM D 882 | 2300 (16,000) min. |

| | | |
|---|---|---|
| Tear Resistance [pounds (N)] | ASTM D 1004 Die C | 8 (35) min. |
| Low Temperature Brittleness [°F (°C)] | ASTM D 1790 | -20 (-30) min. |
| Resistance to Soil Burial (% strength retained) | ASTM D 3083 | 95 min. |
| Hydrostatic Resistance [pounds per square inch (kPa)] | ASTM D 751 Method A | 75 (520) min. |

**2.9.1** At least two weeks prior to installation of the impervious membrane, the Design-Builder shall submit a certificate of compliance in accordance with 106.04. The membrane shall be clearly labeled so as to easily identify the product in the field. The label shall include as a minimum, the manufacturer's name, product name and number and the contract item name and number.

**2.9.2** All factory seams and field seams shall have a strength at least equal to the specified sheet strength. The factory fabricated panels shall be a size that can be easily handled on the job site with conventional construction equipment. The panels should be as large and as square as possible to minimize the amount of field seaming required.

**2.10 Perforated and Non-Perforated Pipe.** Perforated pipe shall be smooth-wall polyvinyl chloride (PVC) conforming to AASHTO M 278, profile-wall PVC conforming to AASHTO M 304 or corrugated polyethylene drainage tubing conforming to AASHTO M 252, with Class 2 perforations, except that the required pipe stiffness shall be a minimum of 60 psi (400 kPa). Individual pipe lengths shall not exceed 20 ft (6 m). The non-perforated pipe shall be the same as the perforated pipe, without perforations.

**2.11 Wall Coping.** Concrete for cast-in-place wall coping shall conform to the requirements of Concrete Class AA as specified in Section 520. Concrete for precast wall coping shall conform to 2.2. The wall coping shall be coated with water repellent, as described in 1.1.8.

**2.12 Reinforcing Steel.** Reinforcing steel shall conform to Section 544. Reinforcing steel in the precast concrete facing panels shall be galvanized as described in 2.2. Reinforcing steel in the wall copings shall be epoxy coated.

## Construction Requirements

**3.1 Coordination Meeting.** A coordination meeting shall be held prior to initiating the MSE wall construction and related work. The purpose of the meeting shall be to review all aspects of the MSE wall construction and to facilitate coordination between all parties involved. The coordination meeting shall not take place until the Design-Builder has submitted and received approval for the MSE wall design. Individuals attending the meeting shall include the Engineer, the Design-Builder, the MSE wall Technical Representative, the Bridge Engineer and the

Geotechnical Engineer from the Materials and Research Bureau and all other personnel deemed appropriate by the previously mentioned personnel. The Bridge Engineer and the Geotechnical Engineer shall be notified at least 7 days in advance of the meeting.

**3.2 Wall Supplier's Representative.** The Design-Builder shall make the necessary arrangements with the wall supplier to have a Technical Representative on the project to supervise the initial construction of the wall. The Technical Representative shall also be required to be on-site at any time during wall construction as requested by the Engineer. When a Technical Representative has been requested by the Engineer, no wall construction shall be allowed until the Technical Representative has arrived at the project site.

**3.3 Foundation Preparation.** The foundation for the structure shall be graded level for a width equal to or exceeding the length of the tensile reinforcement, or as shown on the plans. Prior to wall construction, the foundation, if not in rock, shall be compacted with approved compaction equipment. 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 minimum nominal dimensions of 6 inches by 12 inches (150 mm thick by 300 mm wide). The leveling pad shall be cast to the design elevations as shown on the plans. Allowable elevation tolerances are plus 1/8 inch (3 mm) and minus 1/4 inch (6 mm) from the design elevation. The leveling pad shall be cured in accordance with 520.3.10. The requirements of 520.3.11 shall be followed before placement of wall panels.

**3.4 Wall Erection.** Precast concrete facing panels may be placed in the wall when the initial strength of the panels equals or exceeds 85 percent of the 28-day requirement. 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 approved shop drawings as backfill placement proceeds. A geotextile shall be placed along each panel joint as indicated on the approved shop drawings. As backfill material is placed and compacted behind the panels, the panels shall be maintained in a vertical position by means of shoulder clamps to adjacent panels and 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.

**3.4.1** The maximum allowable offset in any panel joint shall be 3/4 inch (19 mm). Vertical and horizontal alignment tolerances shall not exceed 3/4 inch in 10 feet (19 mm in 3 m). The overall vertical tolerance of the wall (plumbness from top to bottom) shall not exceed 1/2 inch per 10 feet (12 mm per 3 m) of wall height.

**3.4.2** Joint materials and bearing pads shall be installed in accordance with the wall supplier's requirements and the details shown on the approved shop drawings.

**3.5 Placement of Tensile Reinforcement.** Prior to placing the first layer of tensile reinforcement, backfill shall be placed and compacted in accordance with Section 3.6.

**3.5.1** Bending of tensile reinforcement in the horizontal plane that results in a kink in the reinforcement shall not be allowed. Gradual bending in the vertical direction that does not kink the reinforcement is allowable.

**3.5.2** Connection of tensile reinforcement to bearing piles, or bending of reinforcement around piles will not be allowed. A minimum 3 inch (75 mm) clearance shall be provided between tensile reinforcement and adjacent steel bearing piles. Cutting of tensile reinforcement longitudinal wires to avoid conflicts with piles or utility obstructions will not be allowed. A structural connection (yoke) from the wall panel to the tensile reinforcement shall be used whenever it is necessary to avoid cutting or excessive skewing of reinforcement due to pile or other conflicts.

**3.5.3** Tensile reinforcement shall be placed normal to the face of the wall, unless otherwise shown on the approved shop drawings, or directed by the Engineer. If skewing of the reinforcement is required due to obstructions in the reinforced fill, rotatable connections shall be used. The maximum skew angle shall not exceed 15 degrees from the normal position unless specifically addressed in design calculations that support the adequacy of the skewed reinforcement.

**3.5.4** The tensile reinforcement shall be placed so as to not conflict with the subsequent installation of any driven guardrail systems located within the reinforced zone.

**3.6 Granular Backfill Placement.** The placement of granular backfill 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 either removed and replaced at the Design-Builder's expense or corrected, as directed by the Engineer. Any backfill material placed within the reinforced soil volume that does not meet the requirements of this specification shall be corrected or removed and replaced at the Design-Builder's expense, as directed by the Engineer.

**3.6.1 Testing Requirements.** The maximum dry density and optimum moisture content shall be determined in accordance with AASHTO T 99, Method C or D (with oversize correction, as outlined in Note 7 of AASHTO T 99). The in-place density determination shall be made in accordance with 304.3.7.

**3.6.1.1** 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 3/4 inch (19 mm) in size, AASHTO T 99 is not applicable. For such a material, the acceptance criteria 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.

**3.6.2 Density Requirements.** Granular backfill shall be compacted to 95 percent of maximum dry density as defined in 3.6.1.

**3.6.2.1** Compaction within 3 feet (900 mm) of the back face of the panels shall be achieved by at least three passes of a lightweight mechanical tamper, roller or vibratory system. The specified lift thickness shall be adjusted as warranted by the type of compaction equipment actually used, but no soil density tests need be taken within this area. Care shall be exercised in the compaction process to avoid misalignment of the panels or damage to the connection devices. Heavy compaction equipment shall not be used to compact backfill within 3 feet (900 mm) of the wall face.

**3.6.3 Lift Thickness and Placement Requirements.** The maximum loose lift thickness shall not exceed 12 inches (300 mm), regardless of the vertical spacing between layers of tensile reinforcement. The Design-Builder shall decrease this lift thickness, if necessary to obtain the specified density. Prior to placement of the tensile reinforcement, the backfill elevation after compaction shall be 2 inches (50 mm) above the connection device elevation from a point approximately 12 inches (300 mm) behind the back face of the panels to the free end of the reinforcement, unless otherwise shown on the plans.

**3.6.3.1** At the end of each day's operation, the Design-Builder shall slope the last lift of backfill away from the wall facing to direct runoff of rainwater away from the wall face. In addition, the Design-Builder shall not allow surface runoff from adjacent areas to enter the wall construction site. The Design-Builder shall be responsible for the repair of any damage to the MSE wall that results from surface or subsurface flow of water into the MSE wall construction site in accordance with 3.7.

**3.7 Wall Repair.** Any portion of a fully or partially constructed MSE wall that is damaged, or that does not meet the required construction tolerances shall be repaired by the Design-Builder to the satisfaction of the Engineer at no cost to the Department.