

Revised: October 15, 2003

SPECIAL PROVISION

**SPECIFICATION 990
MECHANICALLY STABILIZED EARTH RETAINING WALL**

990-1 DESCRIPTION

990-1.01 Scope

a. This work shall consist of designing, furnishing materials and construction of mechanically stabilized earth (MSE) retaining walls in conformity with the lines, dimensions, typical sections, design and construction criteria and other details shown on the plans, standard plans and in accordance to these specifications or as established by the Engineer.

b. The MSE retaining wall shall consist of a nonstructural leveling pad, granular material fill, concrete face panels, wall top concrete parapet and/or coping, and soil reinforcement elements mechanically connected to each panel. Soil reinforcement shall have sufficient strength, frictional resistance and quantity as required by the design.

c. This item shall also include any material and incidentals required by the proprietary MSE walls for the proper completion of the item.

d. The Contractor shall submit design calculations and shop drawings, duly signed and sealed by a Licensed Engineer in the Commonwealth of Puerto Rico prior the beginning of the works. The Contractor and his supplier shall be responsible for the internal and external stability of the MSE wall structure, including reinforcement tension anchor length and connection between the reinforcement and the block. No construction may begin until the Contractor submit the design.

e. A complete set of installation and construction procedures shall be submitted by the Contractor prior to the beginning of the works. This procedure shall be strictly followed during the MSE retaining wall and embankment construction.

990-2 MATERIALS

990-2.01 General -

The Contractor shall make all necessary arrangements to purchase or manufacture the facing elements, reinforcing mesh or strips, attachment devices, joint filler, and all other necessary components. Materials not conforming to this section of the specifications shall not be used without written consent from the Engineer.

Comment [IM1]:

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990-2.02 Reinforced Concrete Facing Panels -

The panels shall be fabricated in accordance with Section 7, Division II, AASHTO Standard Specifications for Highway Bridges, with the following exceptions and additions.

a. Portland Cement concrete for panels shall be Class A-4 or as called for in the plans and shall meet the requirements of Specifications 601 - Structural Concrete.

b. The units shall be fully supported until the concrete reaches a minimum compressive strength of 1,000 psi (6.9 MPa). The units may be shipped after reaching a minimum compressive strength of 3,400 psi (23.4 Mpa). At the option of the Contractor, the units may be installed after the concrete reaches a minimum compressive strength of 3,400 psi (23.4 MPa).

c. Marking - The date of manufacture, the production lot number, and the piece mark shall be clearly scribed on an unexposed face of each panel.

d. Handling, Storage, and Shipping - All units shall be handled, store, and shipped in such a manner as to eliminate the dangers of chipping, discoloration, cracks, fractures, and excessive bending stresses. Panels in storage shall be supported in firm blocking to protect the panel connection devices and the exposed exterior finish.

e. Tolerances - All units shall be manufactured within the following tolerances:

1. Panel Dimensions - Position of panel connection devices within 1 inch (25.4 mm), except for coil and loop imbeds which shall be 3/16 inch (4.8 mm). All other dimensions within 3/16 inch (4.8 mm).

2. Panel Squareness as determined by the difference between the two diagonals shall not exceed 1/2 inch (12.7 mm).

3. Panel Surface Finish - Surface defects on smooth formed surfaces measured over a length of 5 feet (1.52 m) shall not exceed 1/8 inch (3.2 mm). Surface defects on the textured-finish surfaces measured over a length of 5 feet (1.52 m) shall not exceed 5/16 inch (7.9 m).

f. Reinforcing Steel - Reinforcing steel bars for panels shall meet requirements of Specification 602 - Reinforcing Steel.

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g. Acceptance of concrete panels shall be in accordance and compliance with the applicable requirements of Specification 601 - Structural Concrete.

h. Rejection - units shall be rejected because of failure to meet any of the requirements specified above. In addition, any or all of the following defects shall be sufficient cause for rejection:

1. Defects that indicate imperfect molding.
2. Defects indicating honeycombing or open texture concrete.
3. Cracked or severely chipped panels.
4. Color variation on front of face panel due to excess form oil or other reasons.

990-2.03 Soil Reinforcing and Attachment Devices

a. All reinforcing and attachment devices shall be carefully inspected to ensure they are true to size and free from defects that may impair their strength and durability.

b. Reinforcing Strips – Reinforcing strips shall be hot rolled from bars to the required shape and dimensions and shall conform to AASHTO M-223. Galvanization shall conform to the minimum requirements of AASHTO M-111.

c. Reinforcing Mesh – Shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of AASHTO M-32 and shall be welded into the finished mesh fabric in accordance with AASHTO M-55. Galvanization shall be applied after the mesh is fabricated and conform to the minimum requirements of AASHTO M-111.

d. Tie Strips - The tie strips shall be shop fabricated of a hot rolled steel conforming to the minimum requirement of ASTM 570 Grade 50 or equivalent. Galvanization shall conform to AASHTO M-111.

e. Coil Embed Grease - The cavity of each coil embed shall be completely filled with no-oxide type grease or equal.

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f. Coil Bolt - The Coil bolts shall have 2 inches (51 mm) of thread. They shall be cast of 80-55-06 ductile iron conforming to ASTM A-536. Galvanization shall conform to ASTM B-633 or equal.

g. Fasteners - Fasteners shall consist of hexagonal cap screw bolts and nuts, which are galvanized and conform to the requirements of AASHTO M-164 or equivalent.

h. Connector Pins - Connector pins and mat bars shall be fabricated from A-36 steel and welded to the soil reinforcement mats as shown on the plans. Galvanization shall conform to AASHTO M-111. Connector bars shall be fabricated of cold drawn steel wire conforming to the requirements of AASHTO A-82 and galvanized in accordance with AASHTO M-111.

990-2.04 Joint Materials

Installed to the dimensions and accordance with ASTM A-153 thickness in accordance with the plans or approved shop drawings.

a. Provide flexible foam strips for filler for vertical joint between panels, and in horizontal joints where pads are used.

b. Provide either preformed cord conforming to AASHTO M-153, Type II in horizontal joints between panels, preformed EPDM rubber pads conforming to ASTM D-2000 for 4AA, 812 rubbers, neoprene elastomeric pads having a Durometer Hardness of 55 ± 5 or high density polyethylene pads with a minimum density of 0.946 g/cm^2 in accordance with ASTM 1505.

c. Cover all joints between panels on the back side of the wall with a geotextile meeting the minimum requirements for filtration applications as specified by AASHTO M-288. The minimum width and lap of the fabric shall be as follows:

Vertical and horizontal joints: 12 inches (305 mm); lap 4 inches (102 mm).

990-2.05 Select Granular Material

The granular material used in the structure volume shall be free from organic or otherwise deleterious materials and shall conform to the following gradation limits as determined by AASHTO T-27.

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<u>U.S. Sieve Size</u>	<u>Percent Passing</u>
4 in (102 mm)	100
No. 40 mesh sieve	0 - 60
No. 200 mesh sieve	0 - 15

The granular material shall also conform to the following additional requirements:

- a. The plasticity index (P.I.) as determined by AASHTO T-90 shall not exceed 6.
- b. The material shall exhibit an angle of internal friction of not less than 34°, as determined by the standard direct shear test AASHTO T-236 on the portion finer than the No. 10 sieve, using a sample of the material compacted to 95 percent of AASHTO T-99, Methods C or D (with oversized correction as outlined in Note 7 at optimum moisture content). No testing is required for granular materials where 80 percent o sizes are greater than ¾ in (19 mm).
- c. Soundness – The materials shall be substantially free of shale or other soft, poor-durability particles. The material shall have a magnesium sulfate soundness loss of less than 30 percent after four cycles, measured in accordance with AASHTO T-104 or a sodium sulfate loss of less than 15 percent after five cycles determined in accordance with AASHTO T-104.
- d. Electrochemical requirement – The granular material shall meet the following criteria:

<u>Requirement</u>	<u>Test-Method</u>
Resistivity > 3,000 ohm-cm	AASHTO T 288-91
ph 5 – 10	AASHTO T 289-91
Chlorides < 100 parts per million	AASHTO T 291-91
Sulfates < 200 parts per million	AASHTO T 290-91
Organic Content < 1%	AASHTO T 267-86

If the resistivity is greater or equal to 5,000 ohm-cm, the chlorides and sulfates requirements may be waived.

990-2.06 Concrete Leveling Pad

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The concrete footing shall be Class B conforming to the requirements of Specification 601 - Structural Concrete.

990-2.07 Acceptance of Material

The Contractor shall furnish the Engineer a Certificate of Compliance certifying the above materials, excluding the granular material, comply with the applicable contract specification. A copy of all test results performed by the Contractor necessary to assure contract compliance shall be furnished to the Engineer.

990-3 CONSTRUCTION

990-3.01 Wall Excavation

Excavation for the construction of mechanically stabilized walls shall be performed in accordance to the requirements of Specification 206 - Excavation for Structures.

990-3.02 Foundation Preparation

a. The foundation for the structure shall be graded level for a width equal to the length of reinforcement elements plus 1 foot (305 mm), as shown on the plans or approved by the Engineer. Prior to wall construction, except where constructed on rock, the foundation shall be compacted with a smooth wheel vibratory roller. Any foundation soils found to be unsuitable shall be removed and replaced with foundation fill in accordance to Specification 207 - Foundation Fill.

b. At each panel foundation level, a precast reinforced or a cast-in-place unreinforced concrete leveling pad as shown on plans or approved by the Engineer shall be provided. The leveling pad shall be cured a minimum of 12 hours before placement of wall panels.

990-3.03 Wall Erection

a. Where a proprietary wall system is used, an experienced engineer field representative shall be available during the erection of the wall to assist the Fabricator, Contractor and Engineer in the construction and quality control monitoring.

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b. Precast concrete panels shall be placed so that their final position is vertical or battered as shown on the plans or approved by the Engineer. For erection, panels shall be handled by means of lifting devices connected to the upper edge of the panel. Panels should be placed in successive horizontal lifts in the backfill granular material is placed behind the panels, the panels shall be placed according to the wall supplier's recommendations. Concrete facing vertical tolerances and horizontal alignment tolerances shall not exceed $\frac{3}{4}$ inch (19 mm) when measured with a 10 feet (3 m) straight edge. During construction, the maximum allowable offset in any panel joint shall be $\frac{3}{4}$ inch (19 mm). The overall vertical tolerance of the wall (top to bottom) shall not exceed $\frac{1}{2}$ inch (12.7 mm) per 10 feet (3m) of wall height. Reinforcement elements shall be placed normal to the face of the wall, unless otherwise shown on the plans. Prior to placement of the reinforcing elements, the fill material shall be compacted in accordance with these specifications.

c. Reinforcing geogrids shall be placed normal to the wall face, unless otherwise shown on the plans or as directed by the Engineer. The geogrid shall be installed from the side of the panel by inserting the transverse bar in the slot provided. Before the placement of any fill material, the reinforcing geogrids shall be pulled taut perpendicular to the orientation of the geogrid with enough force to remove slack. Construction equipment shall not operate directly on the geogrid.

990-3.04 Granular Material Placement

a. The fill granular material shall closely follow the erection of each course of panels. The granular material shall be placed in such a manner as to avoid any damage or disturbance of the wall materials or misalignment of the facing panels or reinforcing elements. Any wall materials which become damaged during the granular material placement shall be removed and replaced at the Contractor's expense. Any misalignment or distortion of the wall facing panels due to placement of granular material outside the limits of this specification shall be corrected by the Contractor at his expense. At each reinforcement level, the granular material shall be placed to the level of the connection. The granular material placement methods near the facing shall assure that no voids exist directly beneath the reinforcing element.

b. Granular material shall be compacted to 95 percent of the maximum density as determined by AASHTO T-180, Method D (with oversize corrections as outlined in Note 7 of that test). For fill materials containing more than 30 percent retained on the $\frac{3}{4}$ inch (19 mm) sieve, a method compaction consisting of at least four passes by a heavy roller shall be used. For applications where spread footing are used to support bridge or other structural loads, the top 5 feet (1.5 m) below the footing elevation should be compacted to 100 percent AASHTO T-180.

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c. The moisture content of the granular material prior to and during compaction shall be uniformly distributed throughout each layer. Granular material shall have a placement moisture content not more than 2 percentage points less than or equal to the optimum moisture content. Granular material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniformly acceptable throughout the entire lift.

d. The maximum lift thickness before compaction shall not exceed 12 inch (305 mm). The Contractor shall decrease this lift thickness if necessary, to obtain the specified density.

e. Compaction within 3 feet (0.91 m) of the back face of the wall shall be achieved by at least three passes of a lightweight mechanical tamper, roller, or vibrator system.

f. At the end of each day's operation, the Contractor's shall slope the level of the fill away from the wall facing to rapidly direct runoff away from the face. The Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

990-4 METHOD OF MEASUREMENTS

990-4.1 Mechanically Stabilized Earth (MSE) retaining walls will be measured by the square meter of paneled wall surface area, completed, in place and accepted. The area will be bounded by the top elevation of the leveling pad to the top elevation of the retaining wall and the length of wall, as determined by field measurements. This shall include the surface area of nominal panel, joint openings and wall penetrations such as pipes and other utilities. This area shall not include the leveling pads, coping or parapets.

990-4.02 The unit of measurement for MSE retaining walls shall include:

- a. Construction of the concrete leveling pads.
- b. Furnishing and installing and/or erecting all elements required by the MSE wall system including but not limited to concrete facing panels, soil reinforcement mesh (geogrid), attachment devices, fasteners, extensions, joint materials and any other MSE incidentals.
- c. All engineering costs related to the designing and construction monitoring.

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990-4.-03 Concrete parapets, barriers, moment slabs and copings will be measured and paid under the provisions of Specification 601 - Structural Concrete

990-4.04 Reinforcing steel for all parapets, moment slabs and copings will be measured and paid under the provisions of Specification 602 - Reinforcing Steel.

990-4.05 Granular material fill will be measured in cubic meters in final position, compacted and accepted. This volume will be determined according to the following cases:

Case A: Between two parallel MSE wall panels - The volume to be paid for will be the volume included between the inner faces of two parallel MSE walls, the vertical planes formed between the parallel wall ends and the inner face of abutment, and the average elevations (from wall bottom elevations to wall top elevations).

Case B: Single MSE wall panel - The volume to be paid for will be the volume included between the inner face of the MSE wall panel and a parallel vertical plane projected from the end of the longest reinforcing mesh plus 0.45 mts, the total length of the wall and the average elevation (from wall bottom elevations to wall top elevations).

990-4.06 Any excavation required for the construction of the MSE retaining wall will be measured and paid under the provisions of Specification 206 - Excavation for Structures.

990-4.07 Any backfill required between the projected vertical plane and cut-slope surface will not be measured directly for payment but shall be considered a subsidiary obligation.

990-4.08 Any required foundation fill will be measured and paid under the provisions of Specification 207 - Foundation Fill.

990-4.09 Concrete barriers along wall face and on top of roadway surface will be measured and paid under the provisions of Specification 601 - Structural Concrete.

990-5 BASIS OF PAYMENT

990-5.01 The accepted quantities of MSE retaining walls, measured as provided above, will be paid for a the contract unit price per unit of measurement as provided

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below such price and payment shall constitute full compensation for all labor, transportation, materials and equipment required for the design, construction and erection of mechanically stabilized earth retaining walls, to the lines and grades shown on the plans and approved by the Engineer.

990-5.02 Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
Mechanically Stabilized Earth (MSE) Retaining Wall	Square Meter
Granular Material	Cubic Meter