SECTION 715 -- MECHANICALLY STABILIZED EARTH (MSE) WALLS WITH MODULAR BLOCK FACING UNITS

715.01 -- Description

1. This work shall consist of designing, furnishing materials, and constructing mechanically stabilized earth (MSE) modular concrete block facing unit walls in accordance with these *Specifications* and with the lines, grades, dimensions, and details shown in the plans.

2. The MSE wall shall consist of a nonstructural leveling pad, modular block facing units, and soil reinforcement elements. Soil reinforcement shall have sufficient strength and frictional resistance and length as required by the design and as outlined in these *Specifications*.

3. The approved proprietary mechanically stabilized earth retaining wall systems are shown in the plans.

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

5. The MSE wall design shall follow the general dimensions of the wall envelope shown in the plans. The plans will locate the theoretical leveling pad at or below the theoretical leveling pad elevation. The minimum wall embedment below ground shall be 600 mm or as shown in the plans. The top of the block units shall be at or above the top of the wall elevation shown in the plans. The front face of walls may employ a setback or an incline from the vertical. The maximum slope on the front face of the wall shall be 11 degrees unless otherwise required by the Engineer. Cast-in-place concrete will not be an acceptable replacement for block areas noted by the wall envelope, except for minor grouting of pipe penetrations and leveling required for traffic barriers. For walls with metallic reinforcement elements, the design height of the wall shall be from the top of the leveling pad to the top of the potential surface where the failure surface intercepts the ground surface. For walls with polymeric soil reinforcement elements in the design, wall height shall be the vertical distance from the top of the leveling pad to the point where the finish ground surface meets the back face of the wall. The failure plane for such a wall shall rise at an angle of 45 degrees + ø/2 from the intersection of the back face of the wall with the leveling pad.

6. The block units shall be designed to accommodate differential settlements along the length of the wall and transverse to the wall alignment. Differential settlements along the length of the wall shall not exceed 1 m per 100 m of wall length. When differential settlements transverse to the wall exceed 75 mm, the lower level reinforcement connections shall be designed to accommodate the increased tensile forces due to the settlement. Where shown in the plans or determined by the MSE wall supplier, vertical joints to accommodate excessive differential settlement shall be included.

7. Working Drawings and Shop Drawings:

a. The Contractor shall submit to the Engineer for review:

(1) 6 sets of working drawings and shop drawings.

(2) 6 sets of design calculations.

(3) Explanatory notes.

(4) Specifications.

(5) Proposed component materials for the wall system.

b. The shop drawings and design calculations shall be signed, sealed, and dated by a Professional Engineer registered in Nebraska.

c. These drawings shall include a block unit layout for fabrication and erection purposes, as well as for any required coping when it is prefabricated.

d. They shall further include the horizontal and vertical alignment of the walls as well as the existing and proposed ground lines, all as shown in the plans.

e. The drawings will also reflect:

(1) All information needed to fabricate and erect the walls including the proposed leveling pad elevations.

(2) The shape and dimensions of the modular blocks.

(3) The size, number, and details of the reinforcing steel.

(4) The number, size, type, and details of the soil reinforcing system and anchorage.

(5) The size, details, and manufacturer of all fillers and filter cloth.

(6) The size of leveling pad.

(7) The dimensions of structural backfill required.

(8) Any additional details pertaining to coping, railing, drainage, or electrical conduit required by the plans.

f. Leveling pad elevations may vary from footing elevations shown in the plans. However, the leveling pad elevations shall be such as to allow for transverse and longitudinal drainage structures shown in the plans and shall provide 600 mm minimum cover from the top of the leveling pad to finish grade.

g. (1) The Contractor shall not start work on any earth retaining system until the shop drawings and working drawings are reviewed and returned by the Engineer.

(2) It is expressly understood that the review of the Contractor's drawings shall not relieve the Contractor of any responsibility under the contract for the successful completion of the work in conformity with the requirements of the plans and specifications.

(3) The Contractor shall allow 30 calendar days for the review of the drawings by the Engineer.

8. Design Requirements:

a. The design by the wall system supplier shall consider the internal stability of the wall's retained mass. In conjunction with these *Specifications*, the following publications will be used by the Engineer when reviewing the wall system supplier's design and shop plans:

(1) *Reinforced Soil Structures, Volume I*. *Design and Construction Guidelines* FHWA-RD-89-043, Chapter 3;

(2) AASHTO's *Standard Specifications for Highway Bridges*, Division I, Section 5 and Division II, Section 7;

(3) *Design Manual for Segmental Retaining Walls* National Concrete Masonry Association, Washington, D.C.

b. The Engineer shall indicate on the contract plans the "external site factors" which include:

(1) Settlement both along and perpendicular to the MSE structure alignment;

(2) Allowable bearing capacity of the foundation soil;

(3) External drainage beneath and behind the MSE volume;

(4) The design parameters for the foundation soils.

c. Design Height: The structure's design height, H, shall be from the top of the leveling pad to the top of the wall where the ground surface intercepts the wall facing.

d. Soil Reinforcement Length: The soil reinforcement length shall be the same length from top to bottom of the wall. The minimum soil reinforcement length shall be greater than or equal to 70 percent of the design height as measured from the front face of the wall to the end of the soil reinforcements.

e. Inclination of Failure Surface:

(1) Metallic reinforcements: In design, a bilinear failure surface shall be assumed to pass through the base of the wall behind the facing units to a point 0.3H behind and 0.5H above the base of the wall and shall be assumed vertical above this point to the ground surface.

(2) Polymeric reinforcements: In design, a linear failure surface at an angle of 45 degrees + ø/2 from the horizontal shall be assumed to pass through the base of the wall behind the facing units to the ground surface at or above the top of the wall.

f. Design Parameters: The following soil parameters shall be assumed for the design unless otherwise shown in the plans or specified by the Engineer.

Reinforced fill: unit mass = 2000 kg/m³, ø = 34 degrees, C = 0
Random backfill: unit mass = 2000 kg/m³, ø = 30 degrees, C = 0

g. Minimum Factors of Safety for Internal Stability:

(1) Reinforcement yield or reinforcement rupture: FS = 1.5 at end of service life.

(2) Reinforcement pullout: FS = 1.5 at 12.5 mm deformation.

(3) Connection of inextensible reinforcements to facing units: FS = 1.5 at 12.5 mm deformation. The maximum allowable reinforcement tension shall not exceed two-thirds of the connection strength determined at 12.5 mm deformation or less.

(4) Connection of extensible reinforcements to facing units: FS = 1.0 at 19 mm deformation.

h. The safety factors for external stability are:

(1) Sliding: FS = 1.5.

(2) Bearing Capacity: FS = 2.0.

(3) Overturning: FS = 2.0.

(4) Slip Circle: FS = 1.5.

i. Allowable Reinforcement Tension:

(1) Metallic reinforcements: The reinforcement tensile stress at the end of the service life shall not exceed 67 percent of the yield strength of the steel (i.e., FS = 1.5 against yield of the steel at the end of the service life). A sacrificial thickness of 1.4 mm shall be considered in the analysis of the allowable reinforcement tension.

(2) Polymeric reinforcements: The allowable reinforcement tension shall conform to AASHTO *Standard Specifications for Highway Bridges*, Section 5.8.7.2 and shall be the lesser of limit state determination or the serviceability state determination.

j. State of Stress:

(1) The lateral earth pressure to be resisted by the reinforcements at each reinforcement layer shall be calculated using the appropriate coefficient of earth pressure, K, times the vertical stress at each reinforcement layer.

(2) The vertical soil stress at each reinforcement layer shall consider the local equilibrium of all the forces acting above the layer under investigation and shall be computed using the Meyerhof bearing pressure equation.

k. Metallic reinforcements - the coefficient of earth pressure, K, shall vary from an at rest earth pressure coefficient, K, at the ground surface and shall decrease linearly to an active earth pressure coefficient, Ka, at a depth of 6.0 m. The coefficients of earth pressure shall be based on level top conditions and shall be independent of surcharge slope.

l. Polymeric reinforcements - a coefficient of active earth pressure, Ka, shall be used from top to bottom of the wall. The coefficient of active earth pressure, Ka, shall include the effects of sloping surcharges.

715.02 -- Material Requirements

1. The Contractor shall provide all materials necessary to construct the specified walls.

2. Modular Concrete Block Units:

a. Minimum face shell thickness of the modular concrete block units shall be 75 mm except at holes for connection pins. Minimum rear and side shell thickness shall be 75 mm. Block dimensions shall be within 3.0 mm except for height, which shall be within 1.5 mm.

b. Cement shall be Type I, II, or III in accordance with ASTM C 150.

c. All units shall be sound and free of cracks or other defects that may interfere with proper placement of units or that may impair their strength or durability. Units shall be tested for compressive strength in accordance with ASTM C 140. Concrete modular blocks shall be accepted for use in wall construction provided the block's compressive strength exceeds 30 MPa.

3. Soil Reinforcements and Attachment Devices:

a. Ladder reinforcing strips shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of ASTM A 82 and welded into the finished strip configuration in accordance with ASTM A 185. Galvanizing shall conform to the minimum requirements of ASTM A 123.

b. Geostrap reinforcements shall be fabricated of high tenacity polyester yarns woven into a strap configuration and coated while under tension with polyvinylchloride (PVC).

c. Geogrid reinforcements shall be of the type and size designated in the approved plans. Polyester geogrids shall be fabricated of high tenacity polyester yarns woven into a geogrid structure. The geogrid shall be coated with either polyvinylchloride (PVC) or latex. Polyoleofin geogrids shall be fabricated of high density polyethylene (HDPE) resin and shall be extruded into a geogrid configuration.

d. Connector pins shall be fabricated from cold drawn steel wire conforming to the requirements of ASTM A 82 and shall be galvanized in accordance with ASTM A 123.

e. U-shape reinforcement connectors used as yokes to connect geostrap reinforcements to modular blocks shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of ASTM A 82. Geostrap connector plates shall be shop fabricated of hot rolled steel conforming to the minimum requirements of ASTM A 570/A 570M, Grade 345, or equivalent. Galvanizing shall conform to the minimum requirements of ASTM A 123.

f. Fiberglass alignment pins shall be fabricated of thermoset polyester resin and shall be of a diameter and length recommended by the wall manufacturer.

4. a. Reinforced backfill and modular block/drainage fill shall be select granular backfill materials reasonably free from organic and otherwise deleterious materials and shall conform to the gradation limits as determined by AASHTO T 27 and shown in Table 715.01:

Table 715.01

Modular Block Select Granular Backfill Gradations			
Reinforced Backfill		**Modular Block/Drainage Fill**	
Sieve Size	**Percent Passing**	**Sieve Size**	**Percent Passing**
19.0 mm	100	19.0mm	100
75 µm	0 - 15	75 µm	0 - 5

b. In addition, the backfill material must conform to all of the following additional requirements:

(1) The plasticity index (P.I.), as determined by AASHTO T 90, shall not exceed 6.

(2) The material shall exhibit an angle of internal friction of not less than 34 degrees as determined by the standard direct shear test, AASHTO T 236, utilizing a sample of the material compacted to 95 percent of the maximum density as determined by AASHTO T 99 at optimum moisture content.

c. Select granular backfill shall also conform to the following criteria:

(1) Soundness -- The materials shall be substantially free of shale or other soft, poor durability particles, and shall have a sodium sulfate soundness loss of less than 30 percent after 5 cycles, as determined by AASHTO T 104.

(2) Electrochemical Requirements -- The backfill material shall have a minimum resistivity of 3000 ohm-cm at 100 percent saturation when tested in accordance with ASTM G 57. In addition, the pH of the backfill material shall be in the range of 5 to 10 as determined in accordance with ASTM G 51. The maximum soluble salt content of the reinforced backfill material shall not exceed 100 ppm chlorides and 200 ppm sulfates as determined in accordance with ASTM D 512 and ASTM D 516, respectively. For polymeric materials, the requirements for resistivity, chlorides, and sulfates shall be waived. All other backfill requirements in Paragraph 4. of this Subsection shall be met.

(3) Chloride and sulfate content shall be determined following the required ASTM test method. However, in each method, the select granular backfill material shall be prepared for testing by first accomplishing the following extraction procedure. Dry the sample material in an over at 110°C for 8 hours. Measure 100 g of the material and transfer to a 500 mL Erlenmeyer flask. Add 300 mL of distilled water and shake the mixture for 5 minutes. Repeat the shaking after 1 hour. Allow the mixture to settle for 8 hours. Vacuum filter the liquid layer through a filter apparatus containing a No. 42 Whatman filter paper. Pour the remaining solid material into the filter paper without the use of an additional water rinse. Reserve the filtrate for testing.

d. The Contractor shall furnish to the Engineer a Certificate of Compliance certifying that the select granular backfill materials comply with this Section of the *Specifications*. A copy of all test results performed by the Contractor which are necessary to assure compliance with the *Specifications* shall also be furnished to the Engineer. Backfill not conforming to this *Specification* shall not be used without the written consent of both the Engineer and the wall supplier. The frequency of sampling of select granular backfill necessary to assure gradation control throughout construction shall be as directed by the Engineer.

715.03 -- Construction Methods

1. Wall Excavation:

Unclassified excavation shall be in accordance with the requirements of the specifications and in reasonably close conformity with the limits shown in the plans.

2. Foundation Preparation:

The foundation for the structure shall be graded level for a width equal to or exceeding the length of the soil reinforcement or as shown in the plans. Before wall construction, the foundation, if not in rock, shall be compacted in accordance with Subsection 205.03, Paragraph 14.b.(3). Any foundation soils found to be unsuitable shall be removed and replaced as directed by the Engineer. At each foundation level, a compacted granular leveling

pad shall be provided as shown in the plans. The leveling pad shall be constructed to the design elevations shown on the working drawings. Allowable elevation tolerances are +3.0 mm and - 6.0 mm from the design elevation.

3. Wall Erection:

The wall system components shall be constructed in accordance with the wall supplier's recommendations and construction manual. The wall shall be constructed vertical or as near vertical as the wall system will allow. The overall vertical tolerance of the wall and the horizontal alignment tolerance shall not exceed 30 mm per 3 m.

4. Backfill Placement:

a. Backfill placement shall closely follow erection of each course of facing blocks. Backfill material placed within the reinforced soil mass which does not meet the requirements of this *Specification* shall be corrected or removed and replaced at no additional cost to the Department as directed by the Engineer.

b. Reinforced backfill shall be compacted to 95 percent of the maximum density as determined by AASHTO T 99 Method C or D (with oversize correction, as outlined in Note 7). Reinforced 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. The maximum lift thickness after compaction shall not exceed 250 mm, regardless of the vertical spacing between layers of soil reinforcements. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density.

c. Before placement of the soil reinforcements, the reinforced backfill elevation, after compaction, shall be 50 mm above the connection elevation from a point approximately 300 mm behind the back face of the facing blocks to the free end of the soil reinforcements, unless otherwise shown in the plans. Modular block/drainage fill shall be placed and tamped directly behind, between, and within the cells of the facing units. Granular fill shall not be placed within the holes provided for the connection pins. Compaction of modular block fill shall be achieved by hand tamping or rodding.

d. Compaction within 1 m of the back face of the facing blocks shall be achieved by at least 3 passes of a lightweight mechanical tamper, roller, or vibratory system. No soil density tests need be taken within this area. Care shall be exercised in the compaction process to avoid misalignment of the facing blocks. 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.

715.04 -- Method of Measurement

1. The quantity of wall materials is measured by the square meter and computed using the plan dimensions. No adjustment in the pay quantity will be made if the computed quantity, based on the working drawings, varies from the plan quantity. The wall surface area, as shown in the plans, includes wall penetrations such as pipes and other utilities.

2. The quantity of compacted earth leveling pads is measured by the meter and is computed using the plan dimensions. No adjustment in the pay quantity will be made if the computed quantity, based on the working drawings, varies from the plan quantity.

3. The quantity of granular backfill is measured by the cubic meter and is computed using the plan dimensions. The "Select Granular Backfill for Retained Earth Structure" shall include both "reinforced backfill" and "modular block/drainage fill". No adjustment in the pay quantity will be made if the computed quantity, based on the working drawings, varies from the plan quantity. The quantity shown in the plans is based on a volume equal to the height of the wall times the length of the wall times a width equal to 70 percent of the height.

715.05 -- Basis of Payment

1.

Pay Item	Pay Unit
Wall Materials	Square Meter (m^2)
Compacted Earth Leveling Pad	Meter (m)
Select Granular Backfill for Retained Earth Structure	Cubic Meter (m^3)

2. Excavation for the leveling pads will not be measured and paid for separately, but shall be subsidiary to the appropriate pay item requiring the excavation.

3. Payment is full compensation for all work prescribed in this Section.