TECHNICAL SPECIFICATIONS FOR
Reinforced Earth ® MECHANICALLY STABILIZED EARTH (MSE) RETAINING WALLS with Galvanized Steel Earth Reinforcements

1.0 DESCRIPTION

The Reinforced Earth® mechanically stabilized earth (MSE) wall shall consist of a non-structural plain concrete leveling pad, select backfill, precast concrete facing panels, and soil reinforcement elements mechanically connected to each facing panel. Soil reinforcement shall have sufficient length, strength, and frictional resistance as required by the design.

2.0 WALL SYSTEM SUPPLIER QUALIFICATIONS

MSE wall system (design, soil reinforcements, precast facing panels and accessories) shall be designed and supplied by a single entity, to ensure a single source of responsibility, with demonstrated experience in projects of similar scope and size with the project to be bid.

Minimum system experience requirements:
100 completed projects of 5,000 SF or more
5 projects in the state in which the project is located
15 years of experience with the specific soil reinforcement and connections being proposed for the project.
Demonstrated long term durability of specific soil reinforcement proposed for project

Engineer Requirements:
The Wall Designer (responsible for internal stability design and the design of MSE wall components) employed by the MSE wall system supplier shall have the following minimum qualifications:

Valid P.E. License in the state which project is located
5 years of experience in designing the MSE wall system proposed for the project
5 projects of similar size and scope to the proposed project

Field Representative Qualification:
5 years of experience in constructing the MSE wall system being proposed for the project.

2.1 APPROVED WALL SYSTEM and SUPPLIER

Reinforced Earth®
Geoquest USA, Inc.
45610 Woodland Road, Suite 200
Tel. (703) 547-8797
Email: info.us@geoquest-group.com

3.0 GENERAL REQUIREMENTS

The mechanically stabilized earth wall design shall follow the general dimensions of the wall envelope shown in the contract plans. The top of leveling pad shall be located at or below the theoretical leveling pad elevation (as determined by the minimum wall embedment requirements). The minimum wall embedment shall be 1 foot as measured to the top of leveling pad or as shown on the plans, as determined by the Owner's Geotechnical Engineer (Reference AASHTO Section 11.10.2.2 and Table C11.10.2.2-1 for additional information), whichever is greater. The top of the face panels shall be at or above the top of panel elevation shown on the plans. Where coping or barrier is utilized, the wall face panels shall extend up into the coping or barrier a minimum of 2 inches. The top of the face panels may be level and stepped or sloped to follow the top of wall line noted.

4.0 DESIGN REQUIREMENTS

The MSE Wall design shall be in accordance with AASHTO LRFD Bridge Design Specifications, 10th Edition, section 11.10 – Mechanically Stabilized Earth Walls.

The design by the wall system supplier shall consider the internal stability and local external stability (check base sliding, limiting eccentricity and determination of applied bearing pressure) of the wall mass as outlined below.

Internal Stability Design and Local External Stability Check of the Structure shall be based on the design parameters (soil properties, external loads and other constraints) provided to Supplier by the Owner or the Owner's Geotechnical Engineer of Record.

The external stability of the structure, including slope stability, global stability, bearing capacity, total and differential settlement, and defining design parameters is the responsibility of the Owner or the Owner's Geotechnical Engineer of Record (GEOR).

Internal and External drainage systems shall be designed by the Engineer of Record (EOR) and shown on the contract plans. The MSE Wall Designer/Supplier shall accommodate the drainage elements in the MSE wall design.

4.1 Geotechnical Design Parameters

For internal stability design of the wall, the friction angle of the select backfill used in the reinforced fill zone shall be assumed to be 34° unless shown otherwise substantiated by material testing. In no case shall the design friction angle for the select reinforced fill be greater than 40°. The unit weight and friction angle of the retained fill and the friction angle of the foundation soils and the retained backfill shall be determined by the GEOR and provided in the plans.

4.2 Connections

All connections shall be positive, structural connections subject to the same metal loss rates and allowable tension requirements as outlined in Section 4.5. Adequacy and capacity of panel connections shall be demonstrated by providing connection test data.

4.3 Reinforcement Length

The GEOR shall provide the minimum reinforcement length to wall height ratio (L/H) required for external and global stability. The reinforcement length defines the width of the reinforced soil mass and may vary with wall height along the length of wall. For walls with level surcharge, and retaining normal weight fills behind the reinforced zone, the minimum length embedded in the soil shall be 60 percent of the facing height, H, or 6 feet, whichever is greater, unless otherwise specified by the GEOR.

4.4 State of Stress and Pullout Resistance

The lateral earth pressure to be resisted by the reinforcements shall be calculated using the appropriate coefficient of earth pressure, K, based on the type of reinforcement used, multiplied by vertical soil stress at each reinforcement layer. The vertical soil stress shall be calculated using the Coherent Gravity method.

The soil reinforcement length shall be sufficient to satisfy the above requirements, to meet the sliding, overturning and pullout resistances, and to meet any minimum reinforcement lengths required for external stability if required by the Owner.

4.5 Permissible Reinforcement Tension

For determination of the permissible reinforcement tension, metal loss rates shall be applied to exposed sections of soil reinforcements and connections. Metal loss rates shall be substantiated by historical sampling data and laboratory tests and applied to the reinforcements for the specified design life of the structure. Fy used for design shall not exceed 65 ksi.

5.0 SUBMITTALS

The Contractor shall submit the design calculations and design drawings (prepared by the wall supplier) for review by the Owner (or the Owner's engineer). Approval by the Owner shall be obtained prior to beginning construction.

6.0 MATERIALS

The Contractor shall make his own arrangements to purchase the materials covered by this section, including concrete facing panels, reinforcing strips, attachment devices, fasteners, joint materials and all necessary incidentals, from the Geoquest USA, Inc..

6.1 Concrete Facing Panels

Concrete facing panels shall have a minimum thickness of 5½ inches and a minimum concrete cover on reinforcing steel of 1½ inches Cement shall be Types I, II or III and shall conform to the requirements of AASHTO M-85. Concrete shall have a minimum compressive strength at 28 days 4,000 psi.

Reinforcing steel for concrete facing panels shall be deformed rebar conforming to AASHTO M31 (ASTM A615), grade 60, uncoated.

If site conditions warrant additional concrete cover, special concrete mix designs, epoxy coated rebar or other requirements, the EOR shall indicate the requirements on the plans.

6.2 Soil Reinforcing and Attachment Devices

(a) High Adherence (HA) Ribbed Reinforcing Strips. Ribbed 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 grade 65 (AASHTO M-223) or equivalent. Galvanizing shall conform to the requirements of ASTM-A123 (AASHTO M-111). The minimum galvanizing coating thickness shall be 2.0 oz/ft²

(b) Ladder Reinforcement, shall be cold drawn steel wire milled to the required shape and dimensions. The physical and mechanical properties shall conform to ASTM A1064/A1064M-17, (AASHTO M 32M/M 32) plain wire Gr. 65, Minimum yield 65ksi, tensile 75ksi, longitudinal and transverse wires shall be of equal size. Minimum shear strength of welds shall be 35ksi. Connector plate material (for HA Ladders) shall comply with ASTM A1011/A1011M-15, SS Type 1, Gr.50 or HSLAS Class 1, Gr. 50, minimum yield 50ksi, tension 65ksi. Welding shall comply with provisions listed within the latest edition of ANSI/AWS D1.1, A5.18 . The minimum galvanizing coating thickness shall be 2.0 oz/ft².

(c) Tie Strips. Tie Strips shall be shop fabricated of hot rolled steel conforming to the minimum requirements of ASTM A-1011, Grade 50 or equivalent. Galvanizing shall conform to the minimum requirements of ASTM A-123 (AASHTO M-111) or ASTM A-153 (AASHTO M-232). The minimum galvanizing coating thickness shall be 2.0 oz/ft²

(d) Fasteners. Fasteners for Tie Strips shall consist of hexagonal cap screw bolts and nuts conforming to the minimum requirements of ASTM A-449 (AASHTO M-164) or equivalent. Galvanizing shall conform to the minimum requirements of ASTM A-153 (AASHTO M-232).

All parts and reinforcements shall be in their final configuration prior to galvanizing.

6.3 Select Granular Backfill Material

The select granular backfill material used in the mechanically stabilized earth structure shall be substantially free from organic and otherwise soft, non-durable or deleterious materials (such as mica,

gypsum, coal, shale, clay, asphalt millings, etc.) as determined by the GEOR. Select Granular Backfill shall conform to the following gradation limits as determined by AASHTO T-27:

Sieve Size	Percent Passing
4”	100
3”	75-100
No. 40	0-60
No. 200	0-15

The friction angle of the select backfill used in the reinforced fill zone shall be 34° minimum, unless shown otherwise on the Plans. 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, as outlined in Note 7), at optimum moisture content.

Open graded Coarse Aggregate or Crushed Stone Backfill (such as No.2 thru No. 67), when used, shall consist of angular gravel particles. Rounded or flat rock should not be used.

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

(a) Plasticity Index -- The Plasticity Index (P.I.), as determined by AASHTO T-90, shall not exceed 6.
(b) Soundness -- The material 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 (4) cycles, as determined by AASHTO T-104.
(c) Organic Content shall not exceed 1%, measured in accordance with AASHTO T267 for material finer than the No. 10 sieve.
(d) Electrochemical Requirements -- The backfill material shall conform to the following electrochemical requirements:

(e) Property	Requirement	Applicable Test Methods
Resistivity[1]	Minimum 3000 ohm-cm, at 100% saturation	ASTM G-187-12a AASHTO T-288-12
pH	5-10	AASHTO T-289-91 ASTM G-51-95(2012)
Water Soluble Chlorides[2,3]	≤ 100 ppm	AASHTO T-291-94 ASTM D-512-12 ASTM D-4327-11
Water Soluble Sulfates[2,3]	≤ 200 ppm	AASHTO T-290-95 (2012) ASTM D-516-16 ASTM D-4327-11

[1]Resistivity testing shall be performed up to and including, but not exceeding, 100 % soil saturation. Note 6 of AASHTO T-288 (Note 5 in older editions) shall not be used.

[2]If the minimum resistivity exceeds 5000 ohm-cm, at 100% saturation, the need for testing of chlorides and sulfates is waived.

[3]ASTM D-4327-11 (Standard Test Method for Anions in Water by Suppressed Ion Chromatography) may be used in lieu of AASHTO T-291/ASTM D-512 and AASHTO T-290/ASTM D-516 for determining the concentration of Water-Soluble Chlorides and Sulfates.

7.0 CONSTRUCTION REQUIREMENTS

The contractor’s method of construction shall closely follow the construction procedure outlined in the contract documents and the specifications. Refer to the Reinforced Earth Construction Manual for general information regarding installation of Geoquest products.

Inspection of the method of construction is the responsibility of the Owner or the Owner's agent. Inspection is not the responsibility of the wall system supplier.

7.1 Foundation Preparation

The foundation for the structure shall be graded level for a width equal to or exceeding the length of the soil reinforcements (plus the leveling pad width), or greater as shown on the plans. Prior to wall construction, the foundation, if not in rock, shall be proof-rolled or compacted as directed by the Engineer. Any foundation soils found to be unsuitable shall be removed and replaced as directed by the Engineer.

At each panel foundation level, an unreinforced SMOOTH concrete leveling pad shall be provided as shown on the plans. The leveling pad shall have minimum nominal dimensions of 6 inches thickness and 12 inches width, and shall be cast using minimum 2,000 psi 28-day compressive strength concrete. The leveling pad shall be cast to the design elevations as shown on the plans. Recommended variances in elevation are +1/8 inch and -1/4 inch from the design elevation. Installation of panels may proceed 12 hours after leveling pad concrete has been poured.

7.2 Panel Installation

Precast concrete panels shall be placed vertically with the aid of a light crane, conventional excavator or other equipment suitable for safely lifting and placing the panels. 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.

Recommended vertical and horizontal alignment of facing units shall not exceed 3/4 inch in 10 feet. The overall vertical alignment of the wall (plumbness from top to bottom) should not exceed 3/4 inch per 10 feet of wall height. Panel joint openings shall be 3/4" +/- 1/4" unless otherwise specified in the construction drawings.

7.3 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 either removed and replaced at the Contractor's expense or corrected, as directed by the Engineer. Any 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 the Contractor's expense, as directed by the Engineer.

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). 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 up to 2% less than or equal to the optimum moisture content. Backfill material with a placement moisture content more than 2% greater than the optimum moisture content shall be allowed to dry or removed and reworked until the moisture content is uniform and acceptable throughout the entire lift. If 30 percent or more of the select granular backfill material is greater than 3/4 inch in size, AASHTO T-99 is not applicable. For such a 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 frequency of sampling of select granular backfill material, necessary to assure gradation control throughout construction, shall be as directed by the Engineer.

The maximum lift thickness after compaction shall not exceed 10 inches, regardless of the vertical spacing between layers of soil reinforcements. 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 2 inches above the attachment device elevation from a point approximately 12 inches behind the back face of the panels to the free end of the soil reinforcements, unless otherwise shown on the plans.

Compaction within 3 feet of the back face of the panels shall be achieved by at least three (3) passes of a lightweight (less than 1000 lbs.) mechanical tamper, roller or vibratory system. The lift thickness may need to be a reduced as warranted by the type of backfill and compaction equipment used. 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 3 feet of the wall panels.

At the end of each day's operation, the Contractor shall slope the last level of backfill away from the back of the panels 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.

8.0 METHOD OF MEASUREMENT AND PAYMENT

8.1 MSE Wall Materials

The unit of measurement for furnishing and fabricating the materials for the MSE walls, including concrete facing panels, soil reinforcements, attachment devices, fasteners, bearing blocks and shims, joint materials and incidentals shall be the square foot of wall surface area. The wall surface area shall include the surface area of nominal panel joint openings and wall penetrations such as pipes and other utilities. The quantity to be paid for shall be measured on the basis of wall surface area supplied.

9.0 DEFINITIONS

9.1 “Owner” shall mean the entity designated as such in any of the Project documentation.

9.2 “Service Life” shall mean the period of time that the structure is expected to provide the desired function with a specified level of maintenance established at the design stage. The Service Life of any structure is dependent on the materials specified by the Engineer of Record, the environment at the structure location; proper construction of the structure by the contractor; and routine inspection and maintenance by the Owner.

9.3 “Design Life” shall mean the period of time for which the structure shall be designed to perform within permissible stresses.

Design Life for Temporary Structures = 3 Years
Design Life for Industrial Structures = 30 Years
Design Life for Permanent Structures = 75 Years
Design Life for Critical Structures (when defined in Owner’s Specifications) = 100 Years

9.4 “Engineer of Record” (EOR): shall mean the Professional Engineer engaged by the Owner or Design Build Team in responsible charge for preparation, signing, dating, sealing and issuing of engineering documents for the project. aka “Contract Documents”

9.5 “Geotechnical Engineer of Record” (GEOR): shall mean the Geotechnical Engineer engaged by the Owner or Design Build Team in responsible charge for the analysis of Bearing Capacity, Settlement, External, Compound and Global Stability and shall define the geotechnical design parameters for Internal, Local and External Stability Analysis.

9.6 “Wall Designer/Supplier”: shall mean the entity engaged by the contractor or owner to provide the internal stability design, MSE wall shop drawings, and prefabricated MSE wall materials.