SECTION 02832
MECHANICALLY STABILIZED EARTH WALLS AND SLOPES
RINOX PAVERS, LLC, Douglassville, PA

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Concrete segmental retaining wall units Rinox 'Trinity' Wall System
B. Geosynthetic reinforcement
C. Leveling pad base
D. Drainage aggregate
E. Reinforced Backfill
F. Drainage pipe
G. Pre-fabricated Drainage Composite
H. Geotextile Filter
I. Construction Adhesive
J. Impervious Materials

1.02 RELATED SECTIONS

Note to Specifier: Include Section 01270 only if Article 3.12 is included

A. Section 01270 - Unit Prices

Note to Specifier: Include Section 02200 below for finish grading, and/or add other paving or surfacing related Sections if required

B. Section 02200 - Earthwork: For finish grading.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO)
1. AASHTO M288 Geotextile Specification for Highway Applications
2. AASHTO Standard Specifications for Highway Bridges
3. AASHTO T-27 Test Method for Gradation Limits

B. American Society for Testing and Materials (ASTM)

1. ASTM C33 Standard Specification for Concrete Aggregates
2. ASTM C90 Standard Specification for Loadbearing Concrete Masonry Units
3. ASTM C140 Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
4. ASTM C150 Standard Specification for Portland Cement
5. ASTM C595 Standard Specification for Blended Hydraulic Cements
6. ASTM C1262 Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units
7. ASTM C1372 Standard Specification for Segmental Retaining Wall Units
8. ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
9. ASTM D448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction
10. ASTM D698 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/f^3)(600 kN-m/m^3)

11. ASTM D1248 Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
12. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil In Place by the Sand Cone Method
13. ASTM D1557 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/f^3)(2700 kN-m/m^3)
14. ASTM D2166 Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
15. ASTM D2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)
17. ASTM D2922 Standard Test Method for Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)
18. ASTM D3034 Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer pipe and Fittings
19. ASTM D3080 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
20. ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
21. ASTM D4491 Standard Test Method for Water Permeability of Geotextiles by the Permittivity Method
22. ASTM D4595 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
23. ASTM D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
24. ASTM D4873 Standard Guide for Identification, Storage and Handling of Geosynthetics
25. ASTM D5084 Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
26. ASATM D6992 Accelerated Tensile Creep and Creep Rupture of Geosythetic materials based on time temperature superposition using the stepped isothermal method.
27. ASTM D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
28. ASTM D5818 Standard Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage
29. ASTM D6637 Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method
30. ASTM D6638 Standard Test method for Determining Connection Strength between Geosynthetic Reinforcement and Segmental Concrete Units
31. ASTM D6706 Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
32. ASTM F405 Standard Specification for Corrugated Polyethylene (PE) Tubings and Fittings
33. ASTM G51 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing
34. ASTM G57 Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

C. Federal Highway Administration
1. Mechanically Stabilized Earth Walls and Reinforced Soil Slope Design and Construction Guidelines (FHWA NHI-00-043, March 2001)

D. National Concrete Masonry Association (NCMA)
1. NCMA Design Manual For Segmental Retaining Walls, Third Edition.
2. NCMA SRWU-1 Connection Strength of Segmental Retaining Wall Units and Geosynthetic
3. NCMA SRWU-2 Determination of Shear Strength Between Segmental Concrete Units

E. Geo-synthetic Research Institute (GRI)
1. GG1 Standard Test Method for Geosynthetic Rib Tensile Strength
2. GG2 Standard Test Method for Geosynthetic Junction Strength
3. GG4-91 Determination of Geosynthetic Long Term Design Strength
4. GG5-91 Geosynthetic Pullout

1.03 DEFINITIONS

A. Mechanically Stabilized Earth (MSE): Successive horizontal layers of high tensile strength reinforcement placed between layers of compacted soil or gravel to form an earth structure which acts as a gravity mass enabling grade changes of near vertical faces.
B. Concrete Segmental Retaining Wall (SRW) Units: Dry-stacked masonry units used as the retaining wall fascia. Manufactured by **RINOX PAVERS, LLC**, Douglassville, PA 610-323-6600 (Trinity Wall System)
C. Reinforced Backfill: Soil which is used as fill behind the SRW unit, and within the reinforced soil mass (if applicable).
D. Drainage Aggregate: Material used (if applicable) within, between, and directly behind the concrete retaining wall units as well as within sub drains, blanket and chimney drains.
E. Geotextile Filter: Material used for separation and filtration of dissimilar soil/gravel types.
F. Foundation Soil: Soil mass supporting the leveling pad and reinforced soil zone of the retaining wall system.
G. Geosynthetic Reinforcement: Polymeric material designed specifically to reinforce the soil mass. Preferred grids for design Mirafi or Strata products.
H. Pre-fabricated Drainage Composite: three-dimensional geosynthetic drainage medium encapsulated in a geotextile filter, used to transport water.
I. Impervious Materials: Clay soil or low permeability soil (ML, CL, CH) as well as geosynthetic used to prevent water percolation into the drainage zone behind the wall.
J. Global Stability: The general mass movement of a soil reinforced structure and adjacent soil mass.
K. Project Geotechnical Engineer: A registered engineer who provides site observations, recommendations for foundation support, and verifies soil shear strength parameters.

1.04 SUBMITTALS

Due to the design-build nature of Segmental Retaining Wall Systems, contractors shall provide a system specific submittal package to the Civil Engineer for approval. The MSE structure contractor shall provide to the Owner a minimum of 10 business days prior to the anticipated start date a submittal package. Incomplete or late submittal packages will not be permitted to bid on the project.

A. Submit the following for approval
1. Product Data
a. Material description and installation instructions for each manufactured product specified including Segmental Retaining Wall Units (SRW), if applicable, and Geosynthetic Reinforcement.

b. Name and address of the production facility where the proposed SRW units, if applicable, will be manufactured. All units to be manufactured at the same facility.
c. Notarized letter from the SRW manufacturer stating that the units supplied for this project are manufactured in complete compliance with Section 2.01 of this specification. The letter shall state that the SRW units shown in the attached test reports are representative samples of the plants normal mix design and regular production runs.

2. Samples:
   a. Furnish one unit demonstrating the color, face pattern, and texture of the SRW unit if specified by the project Architect or Owner.
   b. Furnish 12-inch square or larger piece of the geosynthetic reinforcement specified.
   c. Furnish one structural earth anchor as specified.
3. Test Reports:
   a. Independent laboratory reports indicating compressive strength and moisture absorption of the concrete retaining wall units from the proposed production facility. Only test performed within the past 6 months will be considered current and valid.
   b. Independent test reports verifying the long-term design strength properties (creep, installation damage, and durability) and soil interaction properties of the geosynthetic reinforcement.
   c. Independent test reports verifying the connection capacity between the geosynthetic reinforcement and the concrete retaining wall units, if applicable.
4. Wall Design Engineer Qualifications:
   a. Current insurance policy verifying professional liability and errors and omissions insurance coverage for an aggregate and per claim limit of at least two million dollars ($2,000,000).
   b. Notarized letter certifying the proposed SRW Design Engineer is a licensed professional engineer in the state of wall installation and has a minimum of 10 years and 10,000,000 square feet of SRW system design experience.
5. Retaining Wall Installer Qualifications:
   a. Notarized statement showing that the retaining wall installer has installed a minimum of 1,000,000 square feet of segmental retaining walls.
   b. The Retaining Wall Installer shall furnish five (5) project references of similar size and scope to this project including the wall(s) height and square footage. The referenced projects must have structural earth anchors installation experience if structural anchors are required on the project. References shall include the contact information of Owner or General Contractor.
6. Shop Drawings:
   a. Four (4) sets of the retaining wall system design, including wall elevation views, geosynthetic reinforcement and/or structural earth anchor layout, pertinent details, and drainage provisions. A registered professional engineer licensed in the state of wall installation shall sign and certify that the shop drawings are designed in accordance with the project civil plans and specifications.
   b. Propriety product literature indicating which Segmental Retaining Wall (SRW) units and soil reinforcement and/or structural earth anchors are proposed for use on the project including color, face style and texture. Architect or Owner shall select color, face style and texture.

7. Design Calculations:
   a. Four (4) sets of engineering design calculations prepared in accordance with the NCMA Design Manual for Segmental Retaining Walls, Third Edition. Analysis shall include Internal, External, Global Stability, and Bearing Capacity Calculations.
   b. The computer program MSEW 3.0 based on FHWA NHI-00-043 is acceptable. Detailed hand calculations demonstrating compliance with this Specification must be submitted if no computer program is used.
   c. Overall stability calculations with respect to global external, compound internal and translation stability can be determined using the following computer program: ReSSA (v2.0).

1.05 DESIGN REQUIREMENTS

A. Designs for MSE structures shall be in accordance with FHWA NHI-00-043 Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines.

B. Soil design parameters shall be as provided in the construction documents. The wall Design Engineer of Record shall be responsible for selecting and specifying reinforced fill material. Reinforced and retained fill material shall have a minimum angle of internal friction of 30 degrees. Contractor is responsible for ensuring and documenting the reinforced fill meets the specified parameters for both strength and compaction.

C. Design Criteria for All MSE Structures including segmental block designs shall be performed in compliance with FHWA NHI-00-043 (2001) design method. Submittals not meeting these design criteria as specified will be rejected until resubmittals compliance is verified. The owner's review engineer reserves all rights in determining compliance for plan approval. MSE structures involving segmental blocks shall also be performed in strict accordance with the procedures presented in the NCMA Design Manual for Segmental Retaining Walls.

1. Internal Stability:
   a. Minimum Factor of Safety on Tensile Overstress 1.0
   b. Minimum Factor of Safety on Geogrid Pullout (peak load criterion) 1.5
   c. Minimum Factor of Safety on Facing Shear (peak load criterion) 1.5
   d. Minimum Factor of Safety Geogrid/Block Connections (peak load criterion) 1.5
   e. Minimum Factor of Safety for Uncertainties 1.5
   f. Minimum Factor of Safety for Sliding 1.5

2. External Stability:
   a. Minimum Factor of Safety Against Base Sliding 1.5
   b. Minimum Factor of Safety Against Overturning 2.0
   c. Minimum Factor of Safety for Bearing Capacity 2.0

3. Global Stability:
   a. Minimum Factor of Safety for Global Stability 1.3
   b. Minimum Factor of Safety for Compound Detail 1.3
   c. Minimum Factor of Safety for Translational 2-Part Wedge 1.3
   d. Minimum Factor of Safety for 3-Part Wedge 1.3

D. Design shall also address hydrostatic loading, seismic loading, rapid drawdown, surcharge, and backslopes where appropriate. Minimum Design Live Load of 150 psf shall be used for all MSE structures supporting landscape areas. Minimum Design Live Load of 250 psf shall be used for MSE structures supporting parking lots, entrance drives, service drives and other areas subject to traffic.

E. Minimum reinforcement length shall be 70 percent of the MSE structure height. Reinforcement coverage at each layer shall be 100 percent (no gaps).

F. Seismic analyses must be performed if the project is located in a seismic impact zone, i.e., a horizontal acceleration coefficient greater than or equal to 0.1g. Seismic factors of safety to be 75% of the minimum static factors of safety. Refer to NEHRP seismic maps.

G. The maximum vertical distance between layers of soil reinforcement shall be limited to a maximum of 24" (inches) for segmental block systems and 36" (inches) for reinforced slopes.

H. Drainage Aggregate shall be placed within, between, and a minimum of 12" (inches) behind all segmental concrete facing units to provide not only drainage but as a compaction aid.

1.06 DELIVERY, STORAGE AND HANDLING

A. Segmental Concrete Facing Units and Accessories: Deliver, store, and handle materials in accordance with manufacturer's recommendations, in such a manner as to prevent damage. Check the materials upon delivery to assure that proper material has been received. Store above ground on wood pallets or blocking. Remove damaged or otherwise unsuitable material, when so determined, from the site.
   1. Exposed faces of concrete wall units shall be free of chips, cracks, stains, and other imperfections
      detracting from their appearance, when viewed from a distance of 10 feet.
   2. Prevent mud, wet cement, adhesives and similar materials that may harm appearance of units, from coming in contact with system components.

B. Geosynthetics (including geosynthetic reinforcement, geotextile filter, pre-fabricated drainage composite) shall be delivered, stored, and handled in accordance with ASTM D4873.

1.07 EXTRA MATERIALS

A. Furnish Owner with 10 replacement segmental concrete facing units, when applicable, Identical and from the same lot run as those installed on the Project.

PART 2 PRODUCTS

2.01 MATERIALS

A. Segmental Retaining Wall units shall be Trinity as manufactured by RINOX, 23 Quarry Road, Douglassville, PA 19518, Tel:610-323-6600 and meeting the following requirements:
   Physical Requirements: Rinox Trinity Wall System,
   a. Compressive strength and Absorption: Concrete retaining wall units shall be tested in accordance with ASTM C140, Sections 6, 8 and 9. Concrete retaining wall units shall meet requirements of ASTM C1372, except the compressive strength requirements will be increased to a minimum of 4,000 psi and the maximum water absorption shall be limited to 8 percent, and unit height dimensions shall not vary more than plus or minus 1/16 inch from that specified in the ASTM reference, not including textured face. Dimensions shall not vary more than +/- 1/16 inch as measured from the lowest to highest point across the top surface of the unit from a level base plane. Test shall be performed within the past 6 months to be considered current and valid.
   b. Modular units provide an in-place weight of 100-pcf to 120-pcf including the unit fill (vertical core systems only), which is contained within the nominal dimension of the unit. Units shall have angled sides capable of concave and convex alignment curves with a minimum radius of 3.5 feet.
   c. Minimum inter-unit shear strength of 500 lbs/ft at 2 psi normal pressure per NCMA SRWU-2 and minimum geosynthetic to SRW unit peak connection strength of 500 lbs/ft at 2 psi normal pressure per NCMA SRWU-1.
   d. SRW units exposed faces shall be free of chips, cracks, or other imperfections when viewed from a distance of 10 feet under diffused lighting.
   e. The wall supplier shall demonstrate by laboratory testing and engineering calculations that the strength of the connection between geosynthetic reinforcement and segmental

concrete block units is capable of meeting or exceeding the maximum tensile force within a given geosynthetic reinforcement layer with a minimum Factor of Safety of 1.5.

f. Segmental Retaining Wall unit Trinity Standard unit.
g. Color: Mojave Dawn, Scarlet Night, Stormy Grey, Midnight Gold, Buff, Natural [other]
h. Face Pattern Geometry: **Straight Face**
i. Texture: Split Rock Face that exposes the natural aggregates.
j. Batter: Segmental wall units must include an integral batter control shear connector to provide a consistent setback for each wall course. Initial wall batter shall not exceed 8 degrees.

B. Geosynthetic Reinforcement shall be manufactured with high-tenacity polyester in a grid structure. No high strength geotextiles are allowed. For segmental block unit designs, the geosynthetic reinforcement must meet the long-term design strength, soil interaction, and connection capacity requirements as required by the design of the retaining wall.

1. Geosynthetic Reinforcement – The geosynthetic strength used in the design shall follow FHWA NHI-

00-043 where:

$$T_{Allowable} = \frac{T_{Ultimate}}{RF \times FS} = \frac{T_{Ultimate}}{RF_{CR} \times RF_{ID} \times RF_{D} \times FS}$$

2. Tult shall be the minimum average roll value (MARV) ultimate tensile strength per ASTM D4595.
3. RFcr, Creep Reduction Factor shall be extrapolated to a 75 year design life using ASTM D 6992, accelerated tensile creep and creep rupture of at least one geosynthetic material type/strength based on time temperature superposition using the stepped isothermal method.
4. RFid, Installation Damage reduction factor, shall be obtained from construction damage tests for each product proposed for use with project specific, representative or more severe backfill and construction techniques. The backfill soil used, if other than project specific, shall have a D50>0.6mm (No. 30 sieve). Testing shall be consistent with ASTM D5818. Default Rfid value of 3.0 shall be used if such testing has not been conducted. The minimum RFid allowed shall be 1.10.
5. RFd, Durability reduction factor, is the combined partial factor for potential biological and chemical degradation. A default Rfd of 2.0 shall be used if durability testing has not been conducted. The minimum RFd allowed shall be as follows:

    1. PET…… 1.1

6. Direct Sliding Coefficient, Cds value shall be determined from pullout tests per GRI:GS-6. The maximum pullout force used to determine Cds shall be limited to the lesser of Ta or the force that yields 1.5 inches displacement. The minimum Cds value shall not be greater than 1.0 where the Cds value is determined as follows:

$$C_{ds} = \frac{F}{L\sigma_N \tan\varphi}$$ Where

Φ = Effective Soil Friction Angle, Degrees

σ_N = Effective Normal Stress (psf) at range from 500 to 1000 psf

F = Maximum shear resistance from direct shear test (lb/ft), per GRI:GS-6

L = Geosynthetic Embedment Length in Test (ft)

7. Soil/Geosynthetic Interaction Coefficient, Ci value shall be obtained from pullout tests per GRI:GG-5. The maximum pullout force used to determine Ci shall be limited to the lesser of Ta or the force that yields 1.5 inches displacement. The minimum Ci value in silty-sand shall be 0.9 where the Ci value is determined as follows:

$$C_i = \frac{F}{2Le\sigma_N \tan\varphi}$$ Where

σ_N = Effective Normal Stress (psf) at range from 500 to 1000 psf

F = Pullout force (lb/ft), per GRI:GG-5

Le = Geosynthetic Embedment Length in the Anchorage Zone in Test (ft)

8. Geogrid shall have minimum junction strength of 40 pounds per foot per GRI:GG2. If this minimum value is not met then the geogrid shall have a minimum mass of 8 oz/sy and meet the strength requirements of AASHTO M-288-96 Class 1 geotextile.
9. All reinforcement shall have a minimum stiffness (flexural rigidity) of 30,000 mg-cm per ASTM D1388.
10. Polymer reinforcement shall be coated with a suitable coating providing impregnation into the bundles. The coating shall contain a minimum of 1% carbon black measured per ASTM 4218. Otherwise the minimum RFd shall be 1.6.
11. PET geosynthetics shall posses a Molecular Weight greater than or equal to 25,000 grams/mole as per GRI:GG8 and a carboxyl end group number less than or equal to 30 as per GRI:GG7. Otherwise a minimum value of RFd=2.0 shall be used.
12. HDPE geogrids shall possess a melt flow index value greater than or equal to 0.88. Otherwise HDPE geogrids shall use a minimum RFd=2.0 value.

C. Leveling Pad Base

1. Aggregate Base: Crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D448:

Sieve Size	Percent Passing
1 inch	100
No. 4	35 to 70
No. 40	10 to 35
No. 200	3 to 35

b. Base Thickness: 6 inches (minimum compacted thickness).

2. Concrete Base: Nonreinforced lean concrete base.
   a. Base Thickness: At least 2 inches

D. Drainage Aggregate/Unit Fill: Clean crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D448:

Sieve Size	Percent Passing
1 inch	100
3/4 inch	75 to 100
No. 4	0 to 60
No. 40	0 to 50
No. 200	0 to 5

Unit fill must extend a minimum distance of 12 inches behind the segmental block.

E. Reinforced Backfill: Suitable reinforced backfill soils shall be free of organics and debris and consisting of either GP, GW, SP, SW, or SM type, classified in accordance with ASTM D2487 and the USCS classification system. Soils classified as Ml, SC and CL are considered suitable soils for segmental retaining walls with a total height of less than 10 feet.
   1. The Plasticity Index (PI) of the reinforced backfill soils shall not be greater than 20 as measured in accordance with ASTM D4318.
   2. Unsuitable soils are organic soils and those soils classified as CH, OH, MH, OL, or PT.
   3. The pH of the reinforced backfill shall be between 3 and 10 and be tested in accordance with ASTM G51.
   4. Backfill gradation shall meet the following:

Sieve Size	Percent Passing
¾ inch	75-100
No.4	20-100
No. 40	0-60
No. 200	0-35

   5. Fill containing brush, sod, peat, roots, or other organic, perishable, or deleterious matter including, but not limited to snow, ice, or frozen soils, shall be considered unsuitable material and shall be removed. Less than 0.5% organic material.
   6. Materials passing the No. 40 sieve should have a liquid limit less than 35 and a plasticity index less than 10 as per ASTM D4318.
   7. An effective internal angle of friction greater than or equal to 30 degrees per ASTM D2166 or D3080 at the compaction standard. The 30 degrees shall be verified by appropriate testing submitted to and approved by the Owners engineer prior to construction.

F Drainage Pipe: Perforated or slotted PVC or corrugated HDPE pipe manufactured in accordance with D3034 and/or ASTM F405. The pipe must be encapsulated with free draining #57 stone with the free draining stone covered with a geotextile filter to prevent fines migration into the stone from surrounding backfill.

G. Geotextile Filter: The geotextile filter shall be in accordance with AASHTO M288 guidelines.

H. Impervious Material: Clay soil and/or low permeability soil (ML, CL, or CH) geosynthetic shall be placed above the drainage/unit fill stone to prevent surface runoff from entering the segmental block unit fill and 12 inch zone of stone.Construction Adhesive: Exterior grade adhesive as recommended by the retaining wall unit manufacturer.

I. Subsurface Drain: Located to the bottom rear of the reinforced zone. Subsurface drain to consist of perforated or slatted PVC or corrugated HDPE pipe manufactured in accordance with D304 and/or ASTM F405 surrounded with 3 foot wide and 1 foot high washed #67 or #57 drain stone covered on top side only with 3.5oz minimum needle-punched non-woven geotextile filter fabric.

PART 3 - EXECUTION

3.01 EXAMINATION

Note to Specifier: In Paragraph below, select appropriate entity

A. The Project Geotechnical Engineer shall examine the areas and conditions under which the retaining wall system is to be erected, and notify the Owner and Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

B. Promptly notify the wall design engineer of site conditions that may affect wall performance, soil conditions observed other than those assumed, or other conditions that may require a reevaluation of the wall design.

C. Verify the location of existing structures and utilities prior to excavation.

3.02 PREPARATION

A. Ensure surrounding structures are protected from the effects of wall excavation.
B. Excavation support, if required, is the responsibility of the Contractor, including the stability of the excavation and it's influence on adjacent properties and structures.

3.03 EXCAVATION

Note to Specifier: In Paragraph below, select appropriate entity

A. Excavate to the lines and grades shown on the Drawings. The General Contactor shall replace any unsuitable soils discovered during excavation. Use care in excavating to prevent disturbance of the base beyond the lines shown.
B. Where structural earth anchors are required, follow design guidelines on top down construction including temporary facing installation where required.

3.04 FOUNDATION PREPARATION

A. Excavate foundation soil as required for footing or base dimension shown on the Drawings, or as directed by the Project geotechnical engineer.
B. The Project geotechnical engineer will examine foundation soil to ensure that the actual foundation soil strength meets or exceeds that indicated on the Drawings. Remove soil not meeting the required strength. Oversize resulting space sufficiently from the front of the block to the back of the reinforcement, and backfill with suitable compacted backfill soils.
C. The Project geotechnical engineer will determine if the foundation soils will require special treatment or correction to control total and differential settlement.
D. Fill over-excavated areas with suitable compacted backfill, as recommended by the Project geotechnical engineer.
E. Comply with all state and local requirements for execution of the work, including local building codes and current OSHA excavation regulations. The General Contractor is responsible for stability of the area during excavation and wall construction. Any excavation support required to maintain/protect existing structures, utilities, landscape features or property shall be the responsibility of the General Contractor.
F. Prior to undertaking any grading or excavation of the site, confirm the location of the retaining walls and all underground features, including utility locations within the area of construction. Ensure surrounding structures are protected from effects of wall excavation.
G. Control surface water drainage and prevent inundation of the MSE wall area during construction.
H. Coordinate installation of underground utilities with wall installation.
I. Foundation bearing capacity shall be inspected by project geotechnical engineer. The engineer shall confirm with a field inspection that the foundation has been properly prepared and the bearing capacity requirements are appropriate before placement of the geosynthetic reinforced zone.
J. Contractor shall have an approved set of plans and specifications on site at all times during construction of the wall.

3.05 BASE COURSE PREPARATION

A. Place base materials to the depths and widths shown on the Drawings, upon undisturbed soils, or foundation soils prepared in accordance with Article 3.04.
    1. Extend the leveling pad laterally at least 6 inches in front and behind the lowermost concrete retaining wall unit.
    2. Provide aggregate base compacted to 6 inches thick (minimum) meeting 95% Standard Proctor density per ASTM D698.
    3. The Contractor may at their option, provide a concrete leveling pad as specified in Subparagraph 2.01.C.2, in lieu of the aggregate base.
    4. Where a reinforced footing is required by local code official, place footing below frost depth.

B. Compact aggregate base material to provide a level, hard surface on which to place the first course of units.
C. Prepare base materials to ensure complete contact with retaining wall units.

3.06 ERECTION

A. General: Erect units in accordance with manufacturer's instructions and recommendations, and as specified herein.
B. Place first course of concrete wall units on the prepared base material. Check units for level and alignment. Maintain the same elevation at the top of each unit within each section of the base course.
C. Ensure that foundation units are in full contact with leveling pad.
D. Place concrete wall units side-by-side for full length of wall alignment. Do not leave gaps between adjacent units. Alignment may be accomplished by using a string line measuring from the back of the block.
E. Place 12 inches (minimum) of drainage aggregate directly behind the concrete wall units. Fill voids in and between retaining wall units with drainage aggregate. Provide a drainage zone behind the wall units to within 12 inches of the final grade. Cap the backfill and drainage aggregate zone with 6 inches of impervious material.
F. Install drainage pipe at the lowest elevation possible, to maintain gravity flow of water to outside of the reinforced zone. Slope the main collection drainage pipe, located just behind the concrete retaining wall units, 2 percent (minimum) to provide gravity flow to the daylighted areas. Daylight the main collection drainage pipe to an appropriate location away from the wall system at each low point or at 50-foot (maximum) intervals along the wall length.
G. Remove excess fill from top of units and install next course. Ensure drainage aggregate and backfill are compacted before installation of next course. Where segmental block units have a continuous vertical core of uniformed dimension, a maximum of three courses or two feet may be backfilled with infill drain stone at one time.
H. Check each course for level and alignment. Adjust units as necessary to maintain level and alignment prior to proceeding with each additional course. Install alignment devices (pins) if required.
I. Install each succeeding course. Backfill as each course is completed. Pull the units forward until the locating surface of the unit contacts the locating surface/device of the units in the preceding course. Interlock wall segments that meet at corners by overlapping successive courses.
J. Install geosynthetic reinforcement in accordance with geosynthetic manufacturer's recommendations and the shop drawings.
    1. Orient geosynthetic reinforcement with the highest strength axis perpendicular to the wall face.
    2. Prior to geosynthetic reinforcement placement, place the backfill and compact to the elevation of the top of the wall units at the elevation of the geosynthetic reinforcement.
    3. Place geosynthetic reinforcement at the elevations and to the lengths shown on the Drawings.
    4. Lay geosynthetic reinforcement horizontally on top of the concrete retaining wall units and the compacted backfill soils. Place the geosynthetic reinforcement out to the face of the concrete retaining wall units. Place the next course of concrete retaining wall units on top of the geosynthetic reinforcement.
    5. The geosynthetic reinforcement shall be in tension and free from wrinkles prior to placement of the backfill soils. Pull geosynthetic reinforcement hand-taut and secure in place with staples, stakes, or by hand tensioning until the geosynthetic reinforcement is covered by 6 inches of loose fill.
    6. The geosynthetic reinforcements shall be continuous throughout their embedment lengths. Splices in the geosynthetic reinforcement strength direction are not allowed.
    7. Do not operate tracked construction equipment directly on the geosynthetic reinforcement.

At least 6 inches of compacted backfill soil is required prior to operation of tracked vehicles over the geosynthetic reinforcement. Keep turning of tracked construction equipment to a minimum.

8. Rubber-tired equipment may pass over the geosynthetic reinforcement at speeds of less than
   5 miles per hour. Turning of rubber-tired equipment is not allowed on the geosynthetic reinforcement.
9. Reinforcement embedment length is measured from the front face of the segmental block wall unless noted otherwise on the construction drawings.

3.07 BACKFILL PLACEMENT

A. Place reinforced backfill, spread and compact in a manner that will minimize slack in the reinforcement.

B. Place fill within the reinforced zone and compact in lifts not exceeding 8 to 10 inches (loose thickness).
   1. Only lightweight hand-operated compaction equipment is allowed within 3feet of the back of the retaining wall units unless demonstrated large compaction equipment will not disrupt block and wall alignment. The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer and shall be within a range of 3% below to 3% above optimum moisture content. If the specified compaction cannot be achieved within 3 feet of the back of the retaining wall units, replace the reinforced soil in this zone with drainage aggregate material.

C. Compaction testing shall be done in accordance with ASTM D1556 or ASTM D2922. Refer to Article 3.10 for compaction testing.

Note to Specifier: In Paragraph below, select revised modified Proctor densities if necessary, in lieu of standard Proctor densities specified

D. Minimum Compaction Requirements for Fill Placed in the Reinforced Zone
   1. The minimum compaction requirement shall be determined by the project geotechnical engineer testing the compaction. At no time shall the soil compaction requirements be less than 95 percent of the soil's standard Proctor maximum dry density (ASTM D698) [or 92% of modified Proctor maximum dry density (ASTM D1557)] for the entire wall height
   2. Utility Trench Backfill: Compact utility trench backfill in or below the reinforced soil zone to 95 percent of the soil's standard Proctor maximum dry density (ASTM D698) [or 92% of modified Proctor maximum dry density (ASTM D1557)], or as recommended by the Project geotechnical engineer.
      a. Utilities must be properly designed (by others) to withstand all forces from the retaining wall units, reinforced soil mass, and surcharge loads, if any.
   3. Moisture Content: Within 3 percentage points of the optimum moisture content for all wall heights.

E. At the end of each day's operation, the wall installer shall slope the last level of compacted backfill away from the interior (concealed) face of the wall to direct surface water runoff away from the wall face.
   1. The General Contractor is responsible for ensuring that the finished site drainage is directed away from the retaining wall system.
   2. In addition, the General Contractor is responsible for ensuring that surface water runoff from adjacent construction areas is not allowed to enter the retaining wall area of the construction site both during and following earth structure completion until permanent site grading and storm drainage including pavement, gutters and vegetation are established.

3.08 CAP UNIT INSTALLATION

A. Apply adhesive to the top surface of the unit below and place the cap unit into desired position conforming to ASTM 2339.
B. Cut cap units as necessary to obtain the proper fit.
C. Backfill and compact to top of cap unit.

3.09 SITE CONSTRUCTION TOLERANCES

A. Site Construction Tolerances
   1. Vertical Alignment: Plus or minus 1-1/2 inches over any 10-foot distance, with a maximum differential of 3 inches over the length of the wall.
   2. Horizontal Location Control From Grading Plan
      a. Straight Lines: Plus or minus 1-1/2 inches over any 10-foot distance.
      b. Corner and Radius Locations: Plus or minus 12 inches.
      c. Curves and Serpentine Radii: Plus or minus 2 feet.
   3. Immediate Post Construction Wall Batter: Within 2 degrees of the design batter of the concrete retaining wall units.
   4. Bulging: Plus or minus 1-1/4 inches over any 10-foot distance.Maximum horizontal gap between erected units shall be 1/8 inch.

3.10 FIELD QUALITY CONTROL

A. Installer is responsible for quality control of installation of system components.
B. The General Contractor, at their expense, shall retain a qualified independent testing agency to act as construction verification engineer to perform quality assurance checks, evaluation of foundation soils, and compaction testing of the installer's work. Correct reinforcement type, elevation, length, orientation, reinforcement tensioning procedures, placement of drainage materials and outlets.
C. Installer shall correct work that does not meet these specifications or the requirements shown on the Drawings at the installer's expense.
D. An independent testing agency (Construction Verification Engineer), at the general contractor's expense, shall be contracted to perform compaction testing of the reinforced backfill placed and compacted in the reinforced backfill zone.
   1. Minimum Testing Frequency
      a. One test for every 2 feet (vertical) of fill placed and compacted, for every 100 lineal feet of retaining wall.
      b. Vary compaction test locations to cover the entire area of the reinforced soil zone, including the area compacted by the hand-operated compaction equipment.
      c. Triaxial Test on every appreciable different soil type based on index testing. Run Consolidated-Undrained Triaxial Shear Test and report the stress strain test results as well as the Mohr-Coulomb failure diagram for peak and residual stress levels, as required by ASTM.
      d. Verify foundation bearing capacity by probe rod and static cone penetrometer testing every ten feet of wall length for entire reinforced soil zone. Also, use hand auger borings to a depth of 12 feet or the reinforced length, whichever is shorter, every 50 feet along the wall length at third points of the reinforcement length.
      e. For walls in excess of 20 feet tall, power auger holes with cone or SPT testing to depth equal to twice the wall height is required, every 100 feet of wall length or as required by the geotech to establish appropriate allowable bearing capacity, unless already performed in pre-wall design geotechnical investigation. If there is soft soil, it should be done to the bottom of the soft soil layer.
E. Verification of all structural earth anchors where required must be performed to confirm both depth and holding capacity as per the design by the construction verification engineer.

3.11 ADJUSTING AND CLEANING

A. Replace damaged units with new units as the work progresses.
B. Remove debris caused by wall construction and leave adjacent paved areas broom clean.

C. No changes to the masonry block or geosynthetic reinforcement layout, including but not limited to, length, geosynthetic type, or elevation shall be made without the expressed prior written consent of the wall design engineer.

Note to Specifier: Include Article 3.12 ONLY for municipal work when required

3.12 SITE DRAINAGE

A. Care shall be taken not to contaminate the filter fabric, unit fill, and/or the drainage composite with clay or other poor drainage material.
B. The engineering, design, analysis, detailing and mitigation of both surface drainage and seepage of groundwater shall be the responsibility of the owner or owner's representative
C. Drainage aggregate shall extend one foot (or as indicated on the detail drawings) behind the back of the masonry block units to alleviate the build up of possible hydrostatic pressure behind the masonry block units.
D. Backfill shall be graded a minimum of 2% away from the wall face and rolled at the end of each work day to prevent ponding of water on the surface of the reinforced soil mass. A berm at the crest of the wall shall be constructed at the end of each work day to prevent rain water from overtopping the wall. The Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

3.12 GENERAL NOTES

A. A copy of the design report and the wall drawings should be provided to future owners of the developed property to provide them with a record of the location of the reinforced zone and recommendations of permissible construction activities.
B. All liquid carrying utilities located within the reinforced backfill are to be encased in a drainage aggregate and geotextile filter. All liquid carrying utilities located outside of, but within 100 feet of the reinforced backfill shall be water tight to prevent migration of water into the surrounding soils.
C. Wall elevation views and locations and geometry of existing structures must be verified by project civil site designer prior to construction
D. General or grading contractor is responsible for location and protection of underground utilities in the vicinity of the wall and for maintaining safe excavation and working conditions.
E. Backfill and compact in front of wall prior to exceeding 5.0 feet of wall height.
F. All utilities located within the reinforced zone are to be installed concurrently with the reinforced backfill placement.

END OF SECTION