PART 1 GENERAL

1.01 SECTION INCLUDES
A. Segmental retaining walls made of modular concrete units with or without soil reinforcement.
B. Engineering design.

1.02 RELATED REQUIREMENTS
A. Section 31.10.00 - Site Clearing: Removal of unwanted trees, bushes, and debris.
B. Section 31.20.00 - Earthwork: Rough and finish grading.
C. Section 31.25.00 - Erosion and Sedimentation Controls: Requirements for compliance with erosion control protocols per State of Tennessee SWPPP.

1.03 REFERENCE STANDARDS
B. ASCE 7 - Minimum Design Loads for Buildings and Other Structures; American Society of Civil Engineers; 2010, with 2013 Supplements and Errata.
D. ASTM C1262 - Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units; 2010.
G. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft³ (600 kN-m/m³)); 2012.
I. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System); 2011.

1.04 ADMINISTRATIVE REQUIREMENTS
A. Preinstallation Meeting: Prior to erection of retaining walls, hold a meeting at the site with the retaining walls materials supplier, the retaining wall installer, and the Design Engineer to review the retaining wall requirements.
   1. Notify the Owner and Architect at least three days in advance of the time of the meeting.

1.05 SUBMITTALS
A. See Section 01.30.00 - Administrative Requirements, for submittal procedures.
B. Concrete Units:
   1. Manufacturer's product data.
   2. Test data on freeze-thaw durability.
   3. Test data on unit strength and shear resistance between units.
   4. Test data on soil reinforcement connection.
   5. Manufacturer's certification that units meet requirements of specification.
   6. Storage and handling requirements and recommendations.
   7. Installation methods.
C. Soil Reinforcement:
   1. Manufacturer's product data.
   2. Manufacturer's certification that product meets requirements of specification.
   3. Preparation instructions and recommendations.
   4. Storage and handling requirements and recommendations.
   5. Installation methods.
D. Shop Drawings: Engineering drawings for installation, including elevations, large-scale details of elevations, typical sections, details, and connections, soil reinforcement, and drainage provisions.
   1. Include marked up contract drawings showing exact dimensions for blocks, required coping, and other minor revisions.
   2. Design Data: Submit detailed design calculations showing compliance with specified design criteria and material evaluations performed in accordance with specified design standard, signed and sealed by Design Engineer.
E. Preconstruction Soil Test Reports.
F. Unit Sample for Selection: Minimum 3 inch square pieces of actual units showing colors and finish textures available.
G. Soil Reinforcement to Unit Connector: One connector.
H. Design Engineer's Qualification Statement.
I. Concrete Unit Manufacturer Qualification Statement.
J. Installer Qualification Statement.
1.06 QUALITY ASSURANCE

A. Design Engineer Qualifications: Provide design by or under direct supervision of Professional Engineer experienced in the work of this section and licensed in Tennessee and:
   1. Having minimum of five years documented experience in design of reinforced soil structures.
B. Geotechnical Engineer: Employed by Owner; licensed in Tennessee.
C. Preconstruction Soil Testing: Engage a qualified independent testing agency to test soil reinforcement and backfill materials for compliance with design criteria.
D. Product Testing: Performed by qualified independent testing agency or by manufacturer and witnessed by qualified independent testing agency.
E. Manufacturer Qualifications -- Concrete Units: Firm specializing in manufacturing products specified in this section and:
   1. With not less than 2 years experience.
   2. Having a minimum of 1,000,000 square feet of successfully completed retaining walls.
F. Installer Qualifications: Firm specializing in design and installation of segmental retaining walls and:
   1. With a minimum of five previously constructed successful projects, similar in size and magnitude, using specified retaining wall system; provide contact names and numbers.
   2. Approved by retaining wall system manufacturer.

1.07 MOCK-UP

A. Prior to erection of retaining walls, provide mock-up for evaluation of installation workmanship.
B. Erect 4 by 4 ft sample wall using materials specified.
C. Locate mock-up where directed by Architect.
D. Do not start masonry work until mock-up has been approved by Architect.
E. Retain mock-up during construction as standard for judging completed work. Do not alter or destroy mock-up until work is completed.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Store products above ground on wood pallets or blocking, in manufacturer's unopened packaging, until ready for installation.
B. Prevent excessive soil and mud from coming in contact with face of concrete units.
C. Protect material from damage. Do not use damaged material. Remove damaged material from the site.
D. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Segmental Concrete Units:
B. Soil Reinforcement:
   1. Versa-Grid by Versa-Lok.

2.02 RETAINING WALLS

A. Contractor is responsible for design of the retaining walls.
B. Design Standard: Design retaining walls to be capable of withstanding the effects of gravity loads due to soil pressures resulting from grades indicated, determined in accordance with NCMA TR 127 Design Manual for Segmental Retaining Walls; perform all stability analyses specified in this standard.
1. Include effects of sloped backfill as indicated on the drawings.
2. In addition, comply with applicable local, state, and federal codes and regulations.
3. This design method considers potential failure modes categorized by external, internal, local, compound, and global stability.
5. Provide engineering services as required for analysis for all modes of stability.
6. Use of design software for calculations is permitted.
7. Submit complete shop drawings showing all features of the design.

C. Shear Resistance: Design the wall not to exceed the capacity of materials and soils to resist shear:
1. Shear Resistance Between Units: Determine in accordance with NCMA SRWU-2.
2. Connection Between Units and Soil Reinforcement: Determine in accordance with NCMA SWRU-1.
3. Coefficient for Direct Shear of Reinforcement on Soil: Determine in accordance with ASTM D5321/D5321M using soil similar in gradation and texture to that to be used for fill in the reinforced zone.

D. Soil Reinforcement:
1. Test reinforcement to be used in accordance with ASTM D6706 using soil taken from project site.
2. Do not use more than one type of reinforcement attached to units within the same wall; do not use products made by different manufacturers in the same wall; minimize the number of different reinforcement and filter products to avoid confusion in placement.
3. Walls Less Than 12 Feet (3.5 M) High: Use only one type of reinforcement of one grade and strength.
4. Length Back from Wall: Not less than dimensions shown on the drawings.
5. Long Term Design Strength of Reinforcement: Determine in accordance with NCMA TR 127:
   \[ \text{LTDS} = \frac{\text{Tult}}{(\text{RFd} + \text{RFid} + \text{RFcr})} \]
   a. \( \text{Tult} \) = Ultimate (tensile) strength,
   b. \( \text{RFd} \) = Reduction Factor for chemical and biological durability; minimum 1.1 for polyethylene and polypropylene, 1.15 for coated polyester geogrids, and 1.6 for polyester geotextiles;
   c. \( \text{RFid} \) = Reduction Factor for Installation Damage;
   d. \( \text{RFcr} \) = Reduction Factor for Creep; consistent with test procedure used for determining the ultimate strength.

E. Drainage: Design to prevent water accumulation in retained soil; use drainage fill and drainage pipe as required; provide outlets at 50 foot intervals along length of wall, minimum.

2.03 MATERIALS
A. Retaining Wall Units: Machine-formed concrete blocks of shapes and sizes suitable for the retaining wall configuration required and complying with ASTM C1372 and the following:
1. Face Color: To be selected by Architect.
2. Texture: Split face, on exposed surfaces.
3. Face Shape: Straight (flat).
4. Curved Walls: Provide unit shapes that accommodate the required curves without cutting and with gaps between faces of adjacent units of not more than 1/8 inch.
5. Acute Corners: Provide special shapes to form corners without cutting; exposed faces finished to match.
6. Unit Face Area: 2/3 sq ft, minimum.
7. Height: 6 inches, minimum.
8. Length (Face Width): 16 inches, minimum.
9. Width (Depth from Face): 11 inches, minimum, not including textured finish.
10. Batter Dimensional Control: Provide integral positive control to maintain consistent batter dimension.
12. Moisture Absorption: 8 percent, maximum.
13. Freeze-Thaw Resistance: Maximum of 1 percent or less weight loss after 100 cycles for each of 5 specimens or maximum of 1.5 percent or less weight loss after 150 cycles for 4 of 5 specimens, when tested in accordance with ASTM C1262
15. Concrete Density: 125 pounds per cubic ft, minimum, oven dry.
17. Appearance: No visible chips, cracks, or other imperfections when viewed from 10 feet under diffuse lighting.

B. Cap Units: Portland cement concrete machine-formed solid blocks, matching segmental concrete units, complying with ASTM C1372, with abutting edges saw cut or formed to provide tight fitting, flush end-to-end joints.
   1. Height: 4 inches, minimum.
   2. Width: Same as wall units.
   3. Depth: To fully cover wall units.
   4. Masonry Adhesive: To secure cap units as top course of wall.
      a. Expected Life Span: 30 years.
      b. Provide adhesive conforming to ASTM C920, Type S, Grade NS, Class 25, and as approved by unit manufacturer.

C. Shear Connectors: Connection method to withstand design stresses and prevent movement of segmental units, and to hold soil reinforcement in proper design position during grid pre-tensioning and backfilling.
   1. Maintain strength over design temperature range of minus 10 degrees F to plus 100 degrees F.

D. Soil Reinforcement: Polymeric geosynthetic specifically fabricated for use as soil reinforcement, dimensionally stable and able to retain geometry under manufacture, transport, and installation.
   1. Polymeric Material: 100 percent virgin resin with maximum of 5 percent in-plant regrind material; polypropylene, polyethylene, or polyester.
      a. Polyethylene and Polypropylene: Stabilized with long term antioxidants.
      b. Polyester: Minimum molecular weight of 25,000 and carboxyl end group number less than 30.
   2. Permittivity: 0.5 per second, minimum, when tested in accordance with ASTM D4491.
   3. UV Resistance: 70 percent after 500 hours, when tested in accordance with ASTM D4355/D4355M.
   4. Durability: Comply with minimum requirements of AASHTO M 288 Class 1; minimum mass of 8 oz/sq yard.

E. Drainage Filter: Geosynthetic textile.
   1. Tensile Strength (Grab) - Woven: 250 pounds, when tested in accordance with ASTM D4632/D4632M.
   2. Apparent Opening Size: 70 to 100 U.S. Sieve size, when tested in accordance with ASTM D4751.
   3. Permittivity: 0.5 per second, minimum, when tested in accordance with ASTM D4491.
   4. Durability: Comply with minimum requirements of AASHTO M 288 Class 1; minimum mass of 8 oz/sq yard.

F. Aggregate for Leveling Pad: Compacted sand, gravel, or crushed rock complying with one of the following:
   1. Meeting requirements of ASTM D1241, Gradation C.
   2. Do not use pea gravel.

G. Concrete for Leveling Pad: Unreinforced concrete with compressive strength of 3,000 psi
H. Drainage Fill: Clean, freely draining aggregate placed within, between, or immediately behind segmental units; do not use pea gravel; use one of the following:
   1. Aggregate as approved by Architect.
   2. Aggregate meeting requirements of ASTM D448, Size No. 57.
   3. Crushed stone or coarse gravel, 3/8 to; no more than 5 percent passing No. 200 sieve.
   4. Crushed stone or coarse gravel, meeting requirements of ASTM D422.

I. Backfill: Compacted soil placed behind drainage fill; do not use heavy clay or organic soils; comply with one of the following:
   1. Use site-excavated or other soil approved by Architect.
   2. Granular soil with less than 5 percent passing No. 200 sieve.
   3. Inorganic ASTM D2487 soil types GP, GW, SP, or SM, free of debris.
      a. Maximum Size: 3/4 inch, unless approved by Design Engineer, and design strength reduced to account for additional installation damage.
      b. Plasticity of Fines: Less than 10. Liquid Limit: Less than 40, when tested in accordance with ASTM D4318.

J. Drainage Pipe: Perforated PVC, complying with ASTM D3034; or corrugated PE complying with ASTM F405; with geotextile filter wrap.

PART 3 EXECUTION

3.01 EXAMINATION
   A. Verify location of existing structures and utilities prior to excavation.
   B. Protect adjacent structures from the effects of excavation.
   C. Verify that layout dimensions are correct and substrate is in proper condition for installation.
   D. Notify Architect of unsatisfactory conditions.
   E. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 PREPARATION
   A. Excavation:
      1. Excavate to lines and grades shown on drawings.
      2. Do not disturb embankment or foundation beyond lines. Minimize over-excavation; fill over-excavated areas with compacted reinforced backfill or leveling pad material at Contractor's expense.
      3. After excavation, and prior to placement of leveling materials, Geotechnical Engineer will examine bearing soil surface to verify strength meets or exceeds design requirements and assumptions.
      4. Replace unsuitable bearing soil as directed by Geotechnical Engineer.
   B. Leveling Pad:
      1. Depth: As approved by Design Engineer.
      2. Width: 6 inches minimum extension beyond front and back faces of units.
      3. In lieu of pad made solely of aggregate or concrete, pad may be 3 inches, minimum, of thick compacted sand or crushed rock, covered with 2 inches to 3 inches of unreinforced concrete.
      4. Location: Top of pad at 1 inch below grade for each 8 inches that wall extends above grade.
      5. Compact aggregate to lines and grades on drawings, in lifts 6 inches thick, maximum.
      6. Compact aggregate to a minimum of 95 percent standard Proctor density, when determined in accordance with ASTM D698 at moisture content within 2 percent of optimum.
      7. Use only hand-operated compaction equipment within 36 inches of back of wall.
   C. Verify level grade before proceeding.
D. Install drainage collection pipe with a continuous fall in the direction of flow. Cap open ends as necessary to prevent soil and debris from entering.

3.03 INSTALLATION

A. Install in accordance with drawings, manufacturer instructions, and applicable codes and regulations.

B. Segmental Concrete Units:
   1. Place first course of units on leveling pad; check alignment and level. Check for full contact with base and for stability.
   2. Place units side by side for full length of wall, aligning back face of straight walls using string line or offset from base line and back face of curved walls using flexible pipe or other method recommended by manufacturer.
   3. Do not leave gaps between units.
   4. Lay out corners and curves in accordance with manufacturer's instructions. Do not leave gaps to produce wall batter or curvature.
   5. Cut blocks with saw; do not split units.
   6. Sweep excess material from tops of units before laying succeeding courses.
   7. Place succeeding courses. Check for proper alignment and batter.
   8. Where top of wall changes elevation, step units to match grade or turn top course into embankment.
   9. Where bottom of wall changes elevation, step base leveling pad and extend lowest course a minimum of two units into slope.

C. Soil Reinforcement: Install each layer on fully compacted fill.
   1. Orient soil reinforcement material with highest strength axis perpendicular to wall alignment.
   2. Attach to top of wall units and extend horizontally, full length, over compacted backfill.
   3. Install in one piece lengths with 100 percent coverage in each layer at each level. Do not splice or leave gaps between panels or ends of pieces.

D. Drainage Fill: Place drainage fill in, between, and behind units.
   1. Compact to lines and grades on drawings, in lifts 6 inches thick, maximum; decrease lift thickness where necessary to achieve required density.
   2. Extend drainage fill 6 inches beyond back face of units.

E. Backfill: Place, spread, and compact backfill from behind drainage fill to undisturbed soil.
   1. Use only lightweight hand-operated compaction equipment within 3 ft from back wall face, or one half of wall height, whichever is greater.
   2. Place backfill in lifts of maximum 6 inches to 8 inches loose thickness where hand compaction is used and 8 inches to 10 inches.
   3. Compact backfill to 95 percent of maximum density, standard Proctor, as determined in accordance with ASTM D698, or as recommended by Geotechnical Engineer.
   4. Moisture content of backfill prior to and during compaction to be within plus 1 or minus 3 percentage points dry of optimum and uniform throughout each layer.
   5. Do not operate tracked construction equipment directly upon soil reinforcement.
   6. At end of each day, slope top of backfill away from wall to direct runoff away from wall face. Prevent runoff from adjacent areas from entering wall site.
   7. At completion, if other work adjacent to wall is not to be done immediately (paving, landscaping, etc), grade top of backfill and provide temporary drainage to prevent water runoff toward the wall.

F. Cap Units: Install and top two courses of units with masonry adhesive.
   1. Clear cap units and top course of segmental concrete units of debris and standing water before applying adhesive.
   2. Apply masonry adhesive to top surface of top unit and place cap into position over projecting pins. Protect wall face from masonry adhesive.
3.04 TOLERANCES
   A. Top of Wall:
      1. Plan Location: Maximum of plus/minus 1 inch from plan location.
      2. Elevation: Maximum of plus/minus 1-1/2 inch from elevations shown on drawings.
   B. Face of Wall Flatness: Measured as deviation from a straight edge.
      1. In the Vertical Dimension: Plus/minus 1 inches per 10 foot section.
      2. In the Horizontal Dimension of Straight Walls: Plus/minus 1 inches per 10 foot section.
   C. Overall Wall Batter: Within 2 degrees of design, measured from the vertical.
   D. Gap Between Adjacent Units: 1/8 inch, maximum.

3.05 FIELD QUALITY CONTROL
   A. Contractor will engage inspection and testing services, including independent laboratories, to provide quality assurance and testing services during construction. Contractor will secure necessary construction control testing during construction.
   B. Correct work found deficient and not in accordance with drawings and specifications.

3.06 CLEANING
   A. Clean wall face to remove debris and stains.
   B. Leave adjacent paved areas broom clean.

3.07 PROTECTION
   A. Prevent damage to wall and earthwork by subsequent construction and uncontrolled runoff until substantial completion; repair damage due to failure to protect wall or earthwork.
   B. Do not operate heavy paving or grading equipment within 36 inches from the back of the wall face.
   C. Do not operate equipment with wheel loads in excess of 150 psf live load within 10 feet from the wall face.
   D. Do not place temporary soil or fill stockpiles adjacent to wall.
   E. Replace damaged units prior to Date of Substantial Completion.

END OF SECTION