SECTION 02834

MODULAR CONCRETE RETAINING WALLS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Work includes furnishing and installing concrete modular block retaining wall units to the lines and grades shown on the construction drawings and as specified herein.

B. Work includes preparing foundation soil, furnishing and installing leveling pad, unit fill and backfill to the lines and grades shown on the construction drawings.

C. Work includes furnishing and installing geogrid reinforcement and backfill to the lines and grades designated on the construction drawings.

1.2 RELATED SECTIONS

A. Section 02300 - Earthwork.

B. Section 03300 - Cast-In-Place Concrete.

1.3 REFERENCES

A. ASTM C 33 - Standard Specification for Concrete Aggregates.

B. ASTM C 150 - Standard Specification for Portland Cement.

C. ASTM C 331 - Standard Specification for Lightweight Aggregates for Concrete Masonry Units.

D. ASTM C 618 - Standard Specification for Fly Ash and Raw Calcined Natural Pozzolan for Use As a Mineral Admixture in Portland Cement Concrete.

E. ASTM C 989 - Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.

F. ASTM D 698 - Standard Method of Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3) 600kN-m/m3)).

G. ASTM D 1557 - Standard Specification for Laboratory Compaction Characteristics of Soils Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

1.4 DEFINITIONS

A. Structural Geogrid: A structural element formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth and to function primarily as reinforcement.

B. Modular Unit: A concrete retaining wall element machine made from Portland cement, water, and aggregates.

C. Unit Fill: A drainage aggregate which is placed within and immediately behind the modular concrete units.

D. Reinforced Backfill: A compacted soil which is placed within the reinforced soil volume as outlined on the plans.

1.5 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Product Data: Submit manufacturer's product data for proposed materials and method of installation.

C. Samples: Submit samples of each product used in the work of this section.

D. Certifications: Submit a manufacturer's certification, prior to start of work, that the retaining wall system components meet the requirements of this specification.
   1. Contractor's submittal package shall include but not be limited to actual test results for tension/creep, durability/aging, construction damage, geogrid/facing connection, pullout, and quality control.
   2. Contractor shall submit certification, prior to start of work, that the retaining wall system (modular concrete units and specific geogrid):
      a. Has been successfully utilized on a minimum of five (5) similar projects, i.e., height, soil fill types, erection tolerances, etc.; and

b. Has been successfully installed on a minimum of 1 million (1,000,000) square feet (92,000 sq m) of retaining walls.

E. Test Reports: Submit test reports documenting strength of specific modular concrete unit and geogrid reinforcement connection. The maximum design tensile load of the geogrid shall be equal to the laboratory tested ultimate strength of geogrid/concrete retaining wall unit connection at a maximum normal force limited by the "Hinge Height" of the structure divided by a safety factor of 1.5. The connection strength evaluation shall be performed in accordance with NCMA test method SRWU-1.

F. Contractor shall submit engineering plans prepared by a professional engineer experienced with Mechanically Stabilized Earth retaining wall systems and registered in the state of the project location. The engineering designs, techniques, and material evaluations shall be in accordance with the KEYSTONE Design Manual, 1995, NCMA Design Guidelines For Segmental Retaining Walls, 1997, or the AASHTO Standard Specifications for Highway Bridges, Section 5.8, 1993 Interim, whichever is applicable.

G. Submit a list of previous projects totaling of 500,000 square feet (46,000 sq m) or more where the specific retaining wall system has been used successfully. Contact names and telephone numbers shall be listed for each project.

1.6 QUALITY ASSURANCE

A. Owner will engage and pay for independent soil testing services during earthwork operations.

1.7 DELIVERY, STORAGE AND HANDLING

A. Contractor shall check the materials upon delivery to assure that proper materials have been received.

B. Contractor shall prevent excessive mud, wet cement, epoxy, and similar materials (which may affix themselves) from coming in contact with the materials.

C. Contractor shall protect the materials from damage. Damaged materials shall not be incorporated into the retaining wall structure.

D. Geogrids shall be stored above minus 20 degrees F.

E. Rolled geogrid material may be laid flat or stood on end for storage.

PART 2 PRODUCTS

2.1 MANUFACTURER

A. Provide modular concrete retaining wall units and accessory materials fabricated by authorized licensed manufacturers of Keystone Retaining Wall Systems, 4444 West 78th Street, Minneapolis, MN 55435. Telephone 612-897-1040. ASD. FAX 612-897-3858.
   1. Substitutions will not be acceptable.

2.2 MODULAR CONCRETE RETAINING WALL UNITS

A. Modular concrete units shall conform to the following architectural requirements:
   1. Modular concrete unit color: Manufacturer's standard color.
   2. Custom modular concrete unit color: _____.
   3. Face finish: Sculptured rock face in angular multiplanar configuration. Other face finishes will not be allowed without written approval.
   4. Bond configuration - running with bonds nominally located at midpoint vertically adjacent units, in both straight and curved alignments.
   5. Exposed surfaces of units shall be free of chips, cracks or other imperfections when viewed from a distance of 20 feet (6.1 m) under diffused lighting.
   6. Corners: Provide 90 degree corners, finished two sides, where indicated.
   7. Cap units: Provide solid cap units with parallel sides for straight walls and convex walls, angular sides for concave walls.

B. Modular concrete units shall conform to the following material requirements:
   1. Cement: Materials shall conform to the following applicable specifications.
      a. Portland Cement: ASTM C 150.
      b. Modified Portland Cement: Portland cement conforming to ASTM C 150, modified as follows:

1) Limestone - calcium carbonate, with a minimum 85 percent content, may be added to the cement, provided these requirements of ASTM C 150 as modified are met:
a) Limitation on insoluble residue 1.5 percent.
b) Limitation on air content of mortar by volume: 22 percent maximum.
c) Limitations of loss of ignition: 7 percent.

c. Blended Cements: ASTM C 618.
d. Pozzolans: ASTM C 618.
e. Blast Furnace Slag Cement: ASTM C 989.

2. Aggregates: Conform to the following specifications:
a. Normal Weight Aggregates - ASTM C 33.
b. Lightweight Aggregates - ASTM C 331.

3. Other Constituents: Air entraining agents, coloring pigments, integral water repellents, finely ground silica, and other constituents shall be previously established as suitable for use in modular concrete retaining wall units and shall conform to applicable ASTM standards or, shall be shown by test or experience to be not detrimental to the durability of the modular concrete units or any material customarily used in retaining wall construction.

C. Modular concrete units shall conform to the following structural and geometric requirements:
1. Compressive strength: 3000 pounds per square inch (20MPa) minimum.
2. Absorption: 8 percent maximum for standard weight aggregates.
3. Unit width to height ratio: 2.25 to 1.
4. Unit depth:
a. Standard units: 20 inches (508 mm) minimum.
b. Compact units: 12 inches (305 mm) minimum.
5. Unit weight:
a. Standard units: 90 pounds (40 kg) per unit minimum for standard weight aggregates.
b. Compact units: 75 pounds (34 kg) per unit minimum for standard weight aggregates.
6. Inter-unit shear strength:
a. Standard units: 1500 pounds per linear foot (21,000 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.

b. Compact units: 400 pounds per linear foot (5800 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.

7. Geogrid/unit peak connection strength:
   a. Standard units: 1000 pounds per linear foot (14600 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
   b. Compact units: 600 plf minimum at 2 psi normal force. 600 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
8. Maximum horizontal gap between erected units: 1/2 inch (13 mm).

D. Modular concrete units shall conform to the following constructibility requirements:
   1. Vertical setback: 1/8 inch (3 mm) plus/minus per course (near vertical) or 1-1/4 inch (31.3 mm) plus/minus per course per the design drawings.
   2. Alignment and grid positioning mechanism: Fiberglass pins, two per unit minimum.

2.3 SHEAR CONNECTORS

A. Strength of shear connectors between vertical adjacent units shall be applicable over a design temperature range of minus 10 degrees F (minus 23 degrees C) to plus 100 degrees F (plus 38 degrees C). Shear connectors shall be 1/2 inch (13 mm) diameter thermoset isopthalic polyester resin-pultruded fiberglass reinforcement rods. Connectors shall have a minimum flexural strength of 128,000 pounds per square inch (882 MPa) and short beam shear of 6,400 pounds per square inch (44 MPa).

B. Shear connectors shall be capable of holding the geogrid in the proper design position during grid pre-tensioning and backfilling.

2.4 ADHESIVE

A. Construction Adhesive: Keystone Kapseal as supplied by manufacturer of modular concrete units.

2.5 BASE LEVELING PAD MATERIAL

A. Material shall consist of a compacted crushed stone base or non-reinforced concrete as shown on the drawings.

2.6 UNIT FILL

A. Unit fill shall consist of clean 1-inch minus crushed stone or crushed gravel meeting the gradation listed below.
   1. 1 inch (25 mm) sieve, 100 percent passing.
   2. 3/4 inch (19 mm) sieve, 75-100 percent passing.
   3. No. 4 (4.75 mm) sieve, 0 - 10 percent passing.
   4. No. 50 (300 micro-m) sieve, 0 - 5 percent passing.

B. Pea rock (3/8 inch to 1/2 inch (9.5 mm to 13 mm) round stone) is not acceptable.

2.7 REINFORCED BACKFILL

A. Reinforced backfill shall be free of debris and meet the following gradation requirements:
   1. 2 inch (50 mm) sieve, 100-75 percent passing.
   2. 3/4 inch (19 mm) sieve, 100-75 percent passing.
   3. No. 4 (4.75 mm) sieve, 100-20 percent passing.
   4. No. 40 (425 micro-m) sieve, 0-60 percent passing.
   5. No. 200 (75 micro-m) sieve, 0-35 percent passing.
   6. Plasticity Index (PI) les than 10 and liquid limit less than 40.

B. The maximum aggregate size shall be limited to 3/4 inch (19 mm) unless field tests have been or will be performed to evaluate potential strength reductions to the geogrid design due to damage during construction.

C. Material can be site excavated soils where the above requirements can be met. Unsuitable soils for backfill (high plastic clays or organic soils) shall not be used in the backfill or in the reinforced soil mass.

D. Contractor shall submit reinforced fill sample and laboratory test results to the Architect/Engineer for approval prior to the use of any proposed reinforced fill material.

2.8 GEOGRID

A. Material: Geogrid products shall be high-density polyethylene or polypropylene expanded sheet or polyester woven fiber materials, specifically fabricated for use as soil reinforcement.

B. Tal, Allowable Tensile Design Load, shall be determined as follows:
   1. Tal = Tult/(Rfd x Rfcr x Rfcd x FS)
   2. Tal shall be evaluated based on a 75 year design life.

C. Rfcr, Reduction Factor for Creep Limited Tensile Load: Rfcr shall be determined from 10,000 hour creep testing performed in accordance with ASTM D 5262.

D. Rfd, Reduction Factor for Durability/Aging: Rfd shall be determined from polymer specific durability testing covering the range of expected soil environments.

E. Rfcd, Reduction Factor for Construction Damage: Rfcd shall be determined from product specific construction damage testing performed in accordance with GRI-GG4. Test results shall be provided for each product to be used with project specific or more severe soil type.

F. FS, Overall Factor of Safety: FS shall be 1.5 unless otherwise noted.

G. The maximum design tensile load of the geogrid shall not exceed the laboratory tested ultimate strength of the geogrid/facing unit connection as limited by the "Hinge Height" divided by a factor of safety of 1.5. The connection strength testing and computation procedures shall be in accordance with NCMA test methods.

H. Soil Interaction Coefficient, Ci: Ci values shall be determined per GRI:GG5 at a maximum 0.75 inch (19 mm) displacement.

I. Manufacturing Quality Control: The geogrid manufacturer shall have a manufacturing quality control program that includes QC testing for each 40,000 square feet (3700 sq m) of production, each lot, or each production day. The QC testing shall include:
   1. Tensile Modulus
   2. Specific Gravity
   3. Melt Flow Index (PP & HDPE)
   4. Molecular Weight (PETP)

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that layout dimensions are correct and substrate is in proper condition for installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 EXCAVATION

A. Contractor shall excavate to the lines and grades shown on the construction drawings. Obtain the Architect/Engineer's approval of excavation prior to placement of leveling material or fill soils.

B. Over-excavation of deleterious soils and replacement with suitable fill, when approved in advance by the Architect/Engineer, will be paid at unit cost rates.

C. Contractor shall be careful not to disturb embankment and foundation materials beyond lines shown.

3.3 BASE LEVELING PAD

A. Leveling pad material shall be placed to the lines and grades shown on the construction drawings.

B. Granular leveling pad material shall be compacted to a minimum of 95 percent Standard or 90 percent Modified Proctor.

C. Crushed stone leveling pad shall be compacted to yield (Proctor testing does not apply).

D. Concrete leveling pad shall be minimum _____ inches of unreinforced concrete.

E. Leveling pad shall be prepared to ensure full contact to the base surface of the concrete units.

3.4 MODULAR UNIT INSTALLATION

A. First course of units shall be placed on the leveling pad, and alignment and level checked. Pins or molded surfaces of modular concrete units shall be used for alignment control; do not attempt alignment from rockface split surface.

B. Ensure that all units are in full contact with base and properly seated.

C. Install fiberglass connecting pins and fill all voids in and around the modular units with unit fill material. Tamp or rod unit fill to ensure that all voids are completely filled.

D. Sweep excess material from top of units and install the next course. Ensure that each course is completely unit filled, backfilled and compacted prior to proceeding to next course.

E. Place each subsequent course ensuring that pins protrude into adjoining courses a minimum of 1 inch (25 mm). Two pins are required per unit. Push next course unit forward, away from the fill zone, locking against the pins in the previous course and backfill as the course is completed. Repeat procedure to the extent of wall height.

F. Follow wall erection and unit fill placement closely with any other backfilling required.

G. Position vertically adjacent modular concrete units as recommended by the manufacturer (in running bond pattern).

H. Maximum stacked vertical height of wall units, prior to wall unit fill, backfill placement and compaction, shall not exceed two courses.

I. One cubic foot, minimum, of unit fill shall be used for each square foot (0.30 cu m/sq m) of wall face. Unit fill shall be placed within cores of, between, and behind units to meet this requirement.

J. Whole, or cut, units on curves and corners to shall be erected with running bond approximately centered on units above and below.

K. Cap Installation: Apply adhesive to top surface of unit below and place cap unit into position over projecting pins from units below.

3.5 STRUCTURAL GEOGRID INSTALLATION

A. Geogrid shall be oriented with the highest strength axis perpendicular to the wall alignment.

B. Geogrid reinforcement shall be placed at the elevations and to the extent shown on the construction drawings or as directed by the Engineer.

C. The geogrid shall be laid over the fiberglass pins of the modular wall units and extended horizontally on compacted backfill. Place the next course of modular concrete units over geogrid. The geogrid shall be pulled taut, and anchored prior to backfill placement on the geogrid.

D. Follow manufacturer's guidelines relative to overlap requirements of uniaxial and biaxial geogrids.

E. Geogrid reinforcements shall be continuous throughout their embedment lengths. Spliced connections between shorter pieces of geogrid is not allowed unless pre-approved by the Architect/Engineer prior to construction.

3.6 REINFORCED BACKFILL PLACEMENT

A. Reinforced backfill shall be placed, spread, and compacted in such a manner that minimizes the development of slack in the geogrid.

B. Backfill shall be placed from the wall back towards the embankment to ensure that the geogrid remains taut.

C. Reinforced backfill shall be placed and compacted in lifts not to exceed 8 inches (200 mm) where hand compaction is used, or 12 inches (300 mm) where heavy compaction equipment is used.

D. Reinforced backfill shall be compacted to 95 percent of the maximum density as determined by ASTM D 698. The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer and shall be within +1/-3 percentage points dry of optimum.

E. Place the top 8 inches (200 mm) of the structure fill using low permeability soil.

F. Only lightweight hand-operated equipment shall be allowed within 3 feet (900 mm)from the tail of the modular concrete unit.

G. Tracked construction equipment shall not be operated directly upon the geogrid reinforcement. A minimum fill thickness of 6 inches (152 mm) is required prior to operation of tracked vehicles over the geogrid. Tracked vehicle turning should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid.

H. Rubber tired equipment may pass over geogrid reinforcement at slow speeds, less than 10 miles per hour (16 kph). Sudden braking and sharp turning shall be avoided.

I. At the end of each day's operation, the Contractor shall slope the last lift of reinforced backfill away from the wall units to direct runoff away from wall face. The Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

3.7 UNREINFORCED BACKFILL PLACEMENT

A. Place and compact backfill in lifts not to exceed 8 (200 mm) inches (200 mm).

B. Backfill shall be compacted to 95 percent of the maximum density as determined by ASTM D 698.

C. Place the top 8 inches (200 mm) of the structure fill using low permeability soil.

D. Only lightweight hand-operated equipment shall be allowed within 3 feet (900 mm) from the tail of the modular concrete units.

E. At the end of each day's operation, the Contractor shall slope the last lift of reinforced backfill away from the wall units to direct runoff away from wall face. The Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

END OF SECTION