NOTE: This specification covers the installation of both conventional gravity and reinforced soil Segmental Retaining Wall (SRW) systems. As such, not all information may be applicable to the given wall installation.

PART 1—GENERAL SPECIFICATIONS

1.01 Description

A. Work consists of furnishing and construction of a Celtik Pro™ Retaining Wall System in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown on the plans.

B. Earthwork includes:
   a. Preparing Foundation Soil and Retained Soil to the lines and grades shown on the construction drawings;
   b. Furnishing and installing Leveling Pad, Gravel Fill, Reinforced Fill (where required) and Low Permeability Soil (where required) to the lines and grades shown on the construction drawings; and,
   c. Installing Compacted Native Backfill, or designated alternative, as required between the Retained Slope and Retaining Wall System.

C. Installation work includes:
   a. Furnishing and installing Celtik Pro™ Modular Retaining Wall Blocks, coping and corners to achieve the lines and grades shown on the construction drawings.
   b. Furnishing and installing Drainage Collection Pipe, including necessary fittings, of the type, size, and location designated on the construction drawings.
   c. Furnishing and installing Geogrid Soil Reinforcement and Separation Geotextiles of the type, size, location, and lengths designated on the construction drawings (where required).

1.02 Related Sections

A. Section 31 00 00 Earthwork
B. Section 32 06 30.13 Site Improvements, Schedule of Exterior Improvements - Retaining Wall Schedule
C. Section 32 31 00 Site Improvements, Fences and Gates
D. Section 35 42 53.16 Waterway Construction and Equipment, Segmental Wall Bank Protection
E. Section 35 43 53.16 Waterway Construction and Equipment, Segmental Waterway Scour Protection

1.03 Reference Documents

A. American Society for Testing and Materials (ASTM)
   1. ASTM C-140 Sampling and Testing Concrete Masonry Units and Related Units
   2. ASTM C-1262 Evaluating the Freeze Thaw Durability of Dry-Cast Segmental Retaining Wall Units and Related Concrete Units
   3. ASTM C-1372 Dry-Cast Segmental Retaining Wall Units
   4. ASTM D-422 Particle Size Analysis of Soils
   5. ASTM D-698 Laboratory Compaction Characteristics of Soil Using Standard Effort
   6. ASTM D-1557 Laboratory Compaction Characteristics of Soil Using Modified Effort
   7. ASTM D-3034 Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
   8. ASTM D-3350 Polyethylene Plastic Pipe and Fittings Materials
   9. ASTM D-4318 Liquid Limit, Plastic Limit and Plasticity Index of Soils
   10. ASTM D-5818 Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics
   11. ASTM D-6637 Tensile Properties of Geogrids by the Single or Multi Rib Tensile Method
   12. ASTM D-6638 Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)
   13. ASTM D-6706 Measuring Geosynthetic Pullout Resistance in Soil
   14. ASTM D-6916 Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)

B. Geosynthetic Research Institute (GRI)
   1. GRI-GG4(b) Determination of Long Term Design Strength of Flexible Geogrids
   2. GRI-GG7 Carboxyl End Group Content of PET Yarns
   3. GRI-GG8 Determination of the Number Average Molecular Weight of PET Yarns Based on a Relative Viscosity Value

C. Federal Highway Administration (FHWA)
   1. FHWA SA-96-071 Mechanically Stabilized Earth Walls and Reinforced Soil Slope Design Construction Guidelines
   2. FHWA SA-96-072 Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes

1.04 Submittals/Certification

A. Contractor shall submit to the owner for approval, and retain for the balance of the project, a minimum of four Wall Blocks that represent the range of texture and color permitted.

B. Contractor shall submit construction drawings and design calculations for the retaining wall system prepared and stamped by a Professional Engineer registered in the state of the project. The engineering designs, techniques, and material evaluations shall be in accordance with the Manufacturer’s Design Manual, NCMA’s Design Manual for Segmental Retaining Walls (3rd Edition), or the AASHTO Standard Specifications for Highway Bridges, Section 5.8 (whichever is applicable to designer). The construction drawings and design calculations shall include, at a minimum:
   a. Wall profile(s), including the grading at the top and bottom of the wall, the physical elevations of the top and bottom of the structure to be retained, the elevation(s) and length(s) of Geogrid Soil Reinforcement (where required), and the elevation of the Drain Collection Pipe. Sufficient wall profiles will be included to adequately cover the variation of design heights encountered along the length of the wall.
b. A wall plan, including geometry for curved wall lengths, the proximity of any existing or proposed surcharges, structures or utilities that may effect wall construction or performance, and all discharge points for the Drainage Collection Pipe.

c. Details on how and where sleeves are to be installed behind the wall (in particular if within the Reinforced Fill) for fences, traffic barriers or other similar items.

d. Copies of any geotechnical investigation reports and/or laboratory soil testing data used in the design.

e. A notation stating what, if any, seismic potential and recommended design acceleration was used.

f. Gradations for the Leveling Pad, Gravel Fill, Reinforced Fill (where required), Low Permeability Soil (where required) and designated alternative for the Compacted Native Backfill (where required).

C. Where Connection Strength test results between Celtik Pro™ and the specified Geogrid Soil Reinforcement are not available from the Manufacturer, Contractor shall have specified Geogrid Soil Reinforcement tested in accordance with ASTM D6638 for use in the design. The maximum connection load of the Geogrid shall be equal to the laboratory tested connection capacity at the wall elevation divided by a safety factor of 1.5.

1.05 Quality Assurance

A. Contractor shall submit a list of five (5) previously constructed projects of similar size and magnitude by the wall installer where the Celtik Pro™ or similar retaining wall system has been constructed successfully. Contact names and telephone numbers shall be listed for each project.

B. Contractor shall provide evidence that the design engineer has a minimum of five years of documented experience in the design for reinforced soil structures. The design engineer shall provide proof of current professional liability insurance with an aggregate coverage limit of not less than $2,000,000, or an amount as defined by the local jurisdiction (whichever is greater).

C. Owner shall/may provide soil testing and quality assurance inspection during earthwork and wall construction operations. Contractor shall provide any quality control testing or inspection not provided by the Owner. Owner's quality assurance program does not relieve the contractor of responsibility for quality control and wall performance.

1.06 Delivery, Storage and Handling

A. Contractor shall check all materials upon delivery to assure that the proper type, grade, color, and certification have been received.

B. Contractor shall protect all materials from damage or contamination due to jobsite conditions and in accordance with manufacturer's recommendations. Damaged or contaminated materials shall not be incorporated into the work.
PART 2 – PRODUCTS

2.01 Definitions

A. Compacted Native Backfill – compacted native soil, or designated alternative, which is placed between the SRW System and Retained Soil.

B. Drainage Collection Pipe – horizontal pipe at or near the base of Gravel Fill to facilitate water drainage.

C. Foundation Soil – compacted native soil that supports the Leveling Pad and Compacted Native Backfill for a conventional SRW, and the Leveling Pad, Reinforced Soil Zone and Compacted Native Backfill for a reinforced SRW.

D. Geogrid Soil Reinforcement - a structural element formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with the Retained Soil and Gravel Fill, and function primarily as reinforcement.

E. Gravel Fill – Free draining granular material placed inside and immediately behind the Modular Retaining Wall Units to facilitate the removal of incidental groundwater, minimize buildup of hydrostatic pressure, increase the weight and sheer capacity of the system, and allow compaction to occur without exerting large forces on the Modular Retaining Wall Units.

F. Leveling Pad – A level surface, consisting of crushed stone or unreinforced concrete, which distributes the weight of the Modular Retaining Wall Units over a wider area of the Foundation Soil and provides a working surface during construction.

G. Low Permeability Soil – compacted layer of soil above the Gravel Fill, Reinforced Fill Zone (where required) and Compacted Native Backfill to prevent surface water infiltration into the System.

H. Modular (Segmental) Retaining Wall Units - a concrete retaining wall element machine made from Portland cement, water, and aggregates that are used to create the mass necessary for structural stability in a conventional SRW, and a facing for a reinforced SRW.

I. Reinforced Fill – Compacted structural fill used for the full length of the Geogrid Soil Reinforcement behind the Gravel Fill.

J. Retained Soil – the undisturbed soil behind the retaining wall system.

K. Separation Geotextile - A geotextile filter installed between the Gravel Fill or Reinforced Soil Zone and the Compacted Native Backfill or Retained Soil to protect the initial from clogging. Also required below the Low Permeability Soils (where required).

2.02 Modular Concrete Retaining Wall Units

A. Modular Wall Blocks shall conform to the following architectural requirements:
   a. Face color – concrete grey unless otherwise specified. The Owner may specify one or multiple face colors for blending from the local Belgard supplied color catalog.
   b. Face finish – Owner to select either straight split or 3-way split. If both face finishes are selected, Owner to identify percentage of each.
   c. Bond configuration – running bonds nominally located at midpoint of vertically adjacent units in both straight and curved alignment.
   d. Exposed surfaces of units shall be free of cracks or major imperfections when viewed from a distance of 20 feet under diffused lighting. Chips and imperfections are expected with the “weathered” rock face texture and are acceptable unless adversely affecting installation or structural performance.

B. Modular concrete materials shall conform to the requirements of ASTM C1372.
C. Modular concrete units shall conform to the following structural and geometric requirements measured in accordance with ASTM C140:
   a. Compressive strength = 3,000 psi minimum for an average of three units with a minimum of 2,500 psi for an individual unit;
   b. Absorption = 8% maximum (6% in northern states) for standard weight aggregates;
   c. Unit size (excluding interlock at back of unit) - 8" (H) x 18" (W) x 12" (D).
   d. Dimensional tolerances = ± 1/8" from the specified standard overall dimension for width height and length, not including rough split face;
   e. Unit weight – 75 lbs per unit minimum for standard weight aggregates.
   f. Inter-unit shear strength in accordance with ASTM D6916 (NCMA SRWU-2) - 600 plf minimum at 2 psi normal pressure.
   g. Geogrid/unit peak connection strength in accordance with ASTM D6638 (NCMA SRWU-1) - 400 plf minimum at 2 psi normal force.

D. Where freeze thaw testing is required, the units shall meet the following when tested in accordance with ASTM C1262:
   a. Weight loss of each of five test specimens at the conclusion of 100 cycles ≤ 1% of its initial weight; or,
   b. Weight loss of each of four of the five test specimens at the conclusion of 150 cycles ≤ 1.5% of its initial weight.

E. Modular concrete units shall conform to the following constructability requirements:
   a. Vertical setback = minimum 1 inch per course (7.125 degree);
   b. Alignment and grid positioning mechanism – intrinsic lip at back of each unit;
   c. Maximum horizontal gap between erected units shall be ≤1/2 inch.

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

2.04 Gravel Fill
   A. Gravel Fill shall consist of clean 1” minus crushed stone or crushed gravel meeting the following gradation tested in accordance with ASTM D-422:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch</td>
<td>100</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>75-100</td>
</tr>
<tr>
<td>No. 4</td>
<td>0 - 60</td>
</tr>
<tr>
<td>No. 40</td>
<td>0 - 50</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 – 5</td>
</tr>
</tbody>
</table>

   B. Gravel Fill shall be placed within cores of, between, and a minimum of 12 inches behind Modular Retaining Wall Blocks.

2.05 Reinforced Fill
   A. Reinforced Fill shall be free of debris and meet the following gradation tested in accordance with ASTM D-422:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch</td>
<td>100-75</td>
</tr>
<tr>
<td>No. 4</td>
<td>100-20</td>
</tr>
<tr>
<td>No. 40</td>
<td>0-60</td>
</tr>
<tr>
<td>No. 200</td>
<td>0-35</td>
</tr>
</tbody>
</table>

   Plasticity Index (PI) <15 and Liquid Limit <40 per ASTM D-4318.
B. The maximum aggregate size shall be limited to 1 inch unless field tests have been performed to evaluate potential strength reductions to the Geogrid Soil Reinforcement design due to damage during construction per ASTM D-5818.

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.

D. Contractor shall submit samples and laboratory test results to the Architect/Engineer for approval prior to the use of any proposed Reinforced Fill material.

2.06 Geogrid Soil Reinforcement

A. Geosynthetic reinforcement shall consist of geogrids manufactured specifically for soil reinforcement applications and shall be manufactured from high tenacity polyester yarn. Polyester geogrid shall be knitted from high tenacity polyester filament yarn with a molecular weight exceeding 25,000 Meg/m and a carboxyl end group values less than 30. Polyester geogrid shall be coated with an impregnated PVC coating that resists peeling, cracking, and stripping.

| B. | The Long Term Design Strength (LTDS) is calculated using the following equation:
|    | \[ LTDS = \frac{T_{ult}}{(RF_{id} \cdot RF_{cr} \cdot RF_{d} \cdot FS)} \]
|    | 1. T_{ult}, Ultimate Tensile Strength in the primary direction of strength as determined using ASTM D6637.
|    | 2. RF_{id}, Reduction Factor for Installation Damage
|    | Default value for RF_{id} = 1.4, unless product specific construction damage testing is performed in accordance with GRI-GG4(b), Section 8.1. Test results shall be provided for each product to be used with project specific or more severe soil type. The minimum tested RF_{id} value permitted is 1.05.
|    | 3. RF_{cr}, Reduction Factor for Creep Deformation
|    | Default value for RF_{cr} = 3.0, unless product specific testing is determined using a 10,000 hour creep test in accordance with GRI-GG4(b), Section 8.2. RF_{cr} shall be based on a 100-year design life. The minimum tested RF_{cr} value permitted is 1.0.
|    | 4. RF_{d}, Reduction Factor for Durability
|    | Default value for RF_{d} = 3.0, unless polyester yarn testing per FHWA durability guidelines is provided. Polyester yarns shall have a Molecular Weight > 25,000 g/m per GRI-GG8 and a carboxyl end group number < 30 per GRI-GG7. The minimum tested RF_{d} value permitted shall be 1.1.
|    | 5. FS, Overall Design Factor of Safety
|    | FS shall be 1.5 unless otherwise noted for the maximum allowable working stress calculation.

C. Soil Interaction Coefficient, Ci

Ci values shall be determined per ASTM D6706 at a maximum 0.75 inch displacement.

D. Manufacturing Quality Control - The geogrid manufacturer shall have a manufacturing quality control program that includes QC testing by an onsite Geosynthetic Accreditation Institute (GAI) Accredited Laboratory. The QC testing shall include:

1. Tensile Strength Testing per ASTM 6637 at a minimum frequency of 10,000 square yards.
2. Melt Flow Index (HDPE)
3. Molecular Weight (Polyester)

E. Material Identification – The geogrid shall be labeled on the material indicating product style. Roll labels shall also be provided indicating manufacturer, style and roll number.
2.07 Compacted Native Backfill
   A. Material is typically site-excavated soils, unless they are unsuitable soils for backfill (high plastic clays or organic soils). Where unsuitable soils exist, design engineer shall specify a designated alternative.
   B. Contractor shall submit samples and laboratory test results to the Architect/Engineer for approval prior to the use of any imported Backfill material.

2.08 Low Permeability Soil
   A. Material is typically clay soil suitable for the intended purpose.
   B. Contractor shall submit samples and laboratory test results to the Architect/Engineer for approval prior to the use.

2.09 Drainage Collection Pipe
   A. The Drainage Collection Pipe shall be perforated or slotted PVC pipe manufactured in accordance with ASTM D-3034, or corrugated HDPE pipe manufactured in accordance with ASTM D-3350.

2.10 Separation Geotextile
   A. When required, Geotextile filter fabric shall be 4.0 oz/sy, polypropylene, needlepunched nonwoven fabric.
PART 3 – EXECUTION

3.01 Inspection
A. Prior to the commencement of work, Contractor shall verify that all site-specific conditions have been considered in the design. Unique design considerations include:
   a. Structures that will exert surcharge loads behind the wall (buildings, fences, trees).
   b. Live loads (traffic, snow piles).
   c. Utilities that will be located near, or pass under, the retaining wall.
   d. Presence of surface water flows, or groundwater discharge, in the area of the wall.
B. Where unique design considerations are identified, the Contractor shall notify the design engineer in writing. The Contractor will not proceed with the work until the design engineer has either confirmed the original design accounted for the unique design element, or adjusts the design accordingly.

3.02 Excavation and Foundation Soil Preparation
A. Contractor shall excavate to the lines and grades shown on the construction drawings.
B. Owner's representative shall inspect the excavation and approve prior to placement of Leveling Pad or Compacted Native Backfill. Proof roll Foundation Soils as directed to determine if remedial work is required.
C. Over-excavation and replacement of unsuitable Foundation Soils and replacement with approved compacted fill will be compensated as agreed upon with the Owner.

3.03 Leveling Pad
A. Leveling pad material shall be placed to the lines and grades shown on the construction drawings.
B. Leveling pad shall extend a minimum of 6 inches beyond both the toe and heel of the lowermost SRW unit and have a minimum thickness of 6 inches.
C. Soil leveling pad materials shall be compacted to a minimum of 95 % Standard Proctor density per ASTM D-698.
D. Leveling pad shall be prepared to insure full contact to the base surface of the concrete units and have a tolerance within +/- 1 inch over a 10 foot span.

3.04 Modular Unit and Gravel Fill Installation
A. For the first course, the lips at the back of each unit need to be removed prior to installation. First course of units shall be placed on the Leveling Pad at the appropriate line and grade. Alignment and level shall be checked in all directions and insure that all units are in full contact with the Leveling Pad and properly seated.
B. For subsequent courses, pull each unit forward to insure the lip at the back of the unit is tight against the back of the underlying units.
C. Place the front of units side-by-side. Do not leave gaps between adjacent units along the exposed face(s). Layout of corners and curves shall be in accordance with manufacturer’s recommendations.
D. Place and compact Gravel Fill within, and a minimum of 12 inches behind, wall units for each course. Do not try to fill more than one layer of Modular Units at a time. Fill to top of Modular Unit, then brush surface clean.
E. Place the Drainage Collection Pipe within the Gravel Fill at the elevations shown on the design drawings. Insure proper slope to create gravity flow of water, and verify there are
no low spots or dips in the Pipe. Provide outlets through the face of the wall where required.

F. Maximum stacked vertical height of wall units, prior to Reinforced Fill (where required) and Compacted Native Backfill placement and compaction, shall not exceed two courses.

3.05 Reinforced Fill and Compacted Native Backfill Placement

A. Place Separation Geotextile as required by the design drawings to prevent clogging of the Reinforced Fill and Gravel Fill.

B. Place and compact Reinforced Fill (where required) and Compacted Native Backfill behind Drainage Fill all the way back to the Retained Soil in equal lifts. Follow wall erection and Gravel Fill closely with Reinforced Fill (where required) and Compacted Native Backfill.

C. Reinforced Fill shall be placed, spread, and compacted in such a manner that minimizes the development of slack in the geogrid and installation damage.

D. Reinforced Fill and Compacted Native Backfill shall be placed and compacted in lifts not to exceed 6 inches where hand compaction is used, or 8 - 10 inches where heavy compaction equipment is used. Lift thickness shall be decreased to achieve the required density as required.

E. Reinforced Fill and Compacted Native Backfill shall be compacted to 95% of the maximum density respectively as determined by ASTM D698. The moisture content of the material prior to and during compaction shall be uniformly distributed throughout each layer and shall be within + 2%, - 1% of the optimal moisture content.

F. Only lightweight hand-operated equipment shall be allowed within 3 feet from the rear of the modular concrete unit.

G. Tracked construction equipment shall not be operated directly upon the Geogrid Soil Reinforcement. A minimum fill thickness of 6 inches 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 Soil Reinforcement at slow speeds, less than 10 MPH. 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 Fill 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.

3.06 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 strengths, lengths, and elevations shown on the construction design drawings or as directed by the Engineer.

C. Insure the Reinforced Fill is flat for the full depth, and level with the back of the Modular Unit, prior to proceeding with geogrid installation. The geogrid shall be laid horizontally across the Reinforced Fill and Modular Units. Geogrid shall be within 1 inch of the front face of the Modular Units to insure subsequent units remain level, but shall at no time be visible on the front face. Place the next course of Modular Units over the geogrid and pull Modular Unit forward to insure the lip at the back of the unit is tight against the back of the underlying units. The geogrid shall be pulled taut and anchored prior to backfill placement on the geogrid.

D. Geogrid reinforcements shall be continuous throughout their embedment lengths and placed side-by-side to provide 100% coverage at each level – directly overlapping sections of geogrid is not permitted. Spliced connections between shorter pieces of geogrid or gaps between adjacent pieces of geogrid are not permitted.
3.07 Cap and Low Permeability Soil Installation
   A. Cap units shall be glued to underlying units with an all-weather adhesive recommended by
      the manufacturer.
   B. Low Permeability Soil (where required) shall be compacted to 95% of the maximum density
      as determined by ASTM D698. The moisture content of the material prior to and during
      compaction shall be uniformly distributed throughout each layer and shall be within + 2%, -
      1% of the optimal moisture content. Surface of Low Permeability Soil shall be sloped to
      provide surface water drainage as per design drawings. Vegetate surface of Low
      Permeability Soil to prevent erosion.

3.08 As-built Construction Tolerances
   A. Vertical alignment: ± 1.25" over any 10’ distance.
   B. Wall Batter: within 2 degrees of design batter.
   C. Horizontal alignment: ± 1.25" over any 10’ distance.
   D. Corners, bends, curves ± 1 ft to theoretical location.
   E. Maximum horizontal gap between erected units shall be 1/2 inch.

3.09 Field Quality Control
   A. Quality Assurance - The Owner shall/may engage inspection and testing services, including
      independent laboratories, to provide quality assurance and testing services during
      construction. This does not relieve the Contractor from securing the necessary
      construction quality control testing.
   B. Quality assurance should include foundation soil inspection. Verification of geotechnical
      design parameters, and verification that the contractor’s quality control testing is adequate
      as a minimum. Quality assurance shall also include observation of construction for general
      compliance with design drawings and project specifications. The site geotechnical engineer
      best performs quality assurance.
   C. Quality Control – The Contractor shall engage inspection and testing services to perform
      the minimum quality control testing described in the retaining wall design plans and
      specifications. Only qualified and experienced technicians and engineers shall perform
      testing and inspection services.
   D. Quality control testing shall include soil and backfill testing to verify soil types and
      compaction and verification that the retaining wall is being constructed in accordance with
      the design plans and project specifications.

END OF SECTION