SECTION 02___

GEOGRID REINFORCEMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Geosynthetic to provide reinforcement for mechanically stabilized earth retaining structures (walls, slopes and embankments).

B. Reinforced Backfill.

1.2 RELATED SECTIONS

A. Document 00300 - Information Available to Bidders: Geotechnical Report; Bore hole locations and findings of subsurface materials.

B. Section 01400 - Testing and Inspection Services.

C. Section 02200 - Site Preparation.

D. Section 02300 - Earthwork; Excavation and subgrade preparation.

E. Section 02310 - Grading.

F. Section 02315 - Excavation.

G. Section 02316 - Fill and Backfill.

H. Section 02920 - Lawns and Grasses; Ground cover at finished grade.

1.3 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO)
   1. AASHTO T289 - Determining pH of Soil for Use in Corrosion Testing.

B. ASTM, International
   1. ASTM D 422 – Gradation of Soils.
   2. ASTM D 424 – Atterberg Limits of Soils.
   3. ASTM D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.
   4. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
   5. ASTM D 2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
   6. ASTM D 2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

7. ASTM D 3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
8. ASTM D 4354 - Standard Practice of Sampling Geosynthetics for Testing.
9. ASTM D 4595 - Standard Test Method of Tensile Properties of Geotextiles by the Wide Width Strip Method.
10. ASTM D 4759 - Standard Practice for Determining the Specification Conformance of Geosynthetics.
11. ASTM D 5262 - Standard Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics.
12. ASTM D 5818 - Standard Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage.
13. ASTM D 6637 – Determining Tensile Properties of Geogrids by the Single or Multi-Rib Test Method.
14. ASTM D 6706 – Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil.
15. ASTM D 6992 - Standard Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method.

C. Geosynthetic Research Institute (GRI)
1. GRI-GG7 - Carboxyl End Group Content of PET Yarns.
2. GRI-GG8 - Determination of the Number Average Molecular Weight of PET Yarns Based on a Relative Viscosity Value.

D. National Concrete Masonry Association (NCMA)
1. NCMA TR127B – Design Manual for Segmental Retaining Walls.
2. NCMA TR160 – Segmental Retaining Walls – Seismic Design Manual.
3. NCMA TR204 – Drainage Manual for Segmental Retaining Walls.

E. National Highway Institute (NHI) / Federal Highway Administration
1. NHI-00-024 and NHI-00-025 – Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines.

1.4 Design Requirements

A. Design Requirements: Design reinforced soil structure in conformance with the design guidelines of NHI-00-024, NHI-00-025, or National Concrete Masonry Association. Design shall be prepared by a professional engineer registered in the state in which the project is located.

1.5 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Manufacturer's certification that the reinforced soil system components meet the requirements of this specification and the structure design.

C. Mill certification from the polyester fiber manufacturer certifying the molecular weight and carboxyl end group count as specified herein.

D. A set of detailed design plans sealed by a registered professional engineer licensed in the state of the project. The plans shall include plan and elevation views of each structure, cross sections and all details, dimensions and quantities necessary to construct the structure.

E. Samples: Two samples of each component including:
1. Geogrid: Nominal 6 inch by 10 inch (150 mm by 250 mm) of each type required.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: System components manufactured by licensees or by companies approved and authorized by the component supplier.

B. Installer Qualifications: Firm with documented experience of at least five projects of similar construction and scope. Include brief description of each project and name and phone number of owner's representative knowledgeable in each listed project.

C. Reinforced Soil System Engineer: Firm with documented experience of at least five projects of similar construction and scope. Include brief description of each project and name and phone number of owner's representative knowledgeable in each listed project.

D. Owner shall provide soil testing and quality assurance inspection during earthwork and slope construction operations. Installer shall provide any quality control testing or inspection not provided by the Owner. Owner's quality assurance program does not relieve the installer of responsibility for quality control and structure performance.

E. Pre-Construction Meeting: Prior to construction of reinforced soil structures, conduct a meeting at the site with the material suppliers, reinforced soil structure installer, and the Contractor to review the reinforced soil structure requirements. Notify the Owner and the Architect at least 3 days in advance of the time of the meeting.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

B. Prevent excessive mud, fluid concrete, epoxy, or other deleterious materials from coming in contact with system components.

C. Polymeric Materials: During storage, geosynthetic rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, excess temperatures, and any other environmental conditions that may damage the physical property values of the geosynthetic.

D. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.8 PROJECT CONDITIONS

A. Do not place or compact fill material during wet or freezing weather that prevents achievement of specified compaction requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Geogrid: StrataGrid and MicroGrid: Strata Systems, Inc., 380 Dahlonega Road, Suite 200, Cumming, Georgia, 30040. Tel: (770) 888-6688, Toll Free: (800) 680-7750. Fax: (770) 888-6680. Web Site: www.geogrid.com. E-mail: strata@geogrid.com.

B. Substitutions: Not permitted.

2.2 MATERIALS

A. System Description: Reinforced soil structure consists of a mechanically stabilized engineered backfill reinforced with StrataGrid or MicroGrid polyester soil reinforcement products.

B. Geogrid: StrataGrid shall provide the following minimum properties:
1. StrataGrid Tensile Requirements

Property	Method	SG150 lb/ft (kN/m)	SG200 lb/ft (kN/m)	SG350 lb/ft (kN/m)	SG500 lb/ft (kN/m)	SG550 lb/ft (kN/m)	SG600 lb/ft (kN/m)	SG700 lb/ft (kN/m)
T_{ult}, Ultimate Tensile Strength	ASTM D6637 (Method A)	1875 (27.4)	3600 (52.5)	5000 (73.0)	6400 (93.4)	8150 (118.9)	9100 (132.8)	11800 (172.2)
T_a, Allowable Design Strength								
Soil: SW, SP, SM, SC [D_{max}=25mm, D_{50} < 0.2mm]		939 (13.7)	1919 (28.0)	2666 (38.9)	3412 (49.8)	4346 (63.4)	4852 (70.8)	6292 (91.8)
Soil: GW, GP, GM, GC, SW, SP, SM, SC [D_{max}=25mm, D_{50} < 8mm]		898 (13.1)	1836 (26.8)	2550 (37.2)	3264 (47.6)	4157 (60.7)	4641 (67.7)	6018 (87.8)
Soil: GW, GP, GM, GC [D_{max}=50mm, D_{50} < 20mm]		765 (11.2)	1564 (22.8)	2172 (31.7)	2780 (40.6)	3541 (51.7)	3954 (57.7)	5127 (74.8)

a. Allowable Tensile Strength (T_a) shall be defined as T_{ult} / RF. Where RF = RF_{CR} x RF_D x RF_{ID}. Reduction Factor for Creep (RF_{CR}), Reduction Factor for Durability (RF_D), and Reduction Factor for Installation Damage (RF_{ID}).
b. Ultimate Tensile Strength (T_{ult}) shall be the minimum average roll value (MARV) as tested per ASTM D 6637 (Method A).
c. Reduction Factor for Creep (RF_{CR}) shall be based on 75-year design life determined in accordance with ASTM D 5262 or ASTM D 6992. Reduction Factor for Creep (RF_{CR}) shall not be less than 1.5.
d. Reduction Factor for Installation Damage (RF_{ID}) shall be based on reinforced backfill type designated above or reinforced backfill gradation as indicated in

the approved shop drawings or specifications. Installation damage testing and material sampling shall be in conformance with ASTM D 6637 and ASTM D 5818. Reduction Factor for Installation Damage (RF_{ID}) shall not be less than 1.05.

e. Reduction Factor for Durability (RF_D) shall be based on polyester fiber testing. Polyester fiber shall have a molecular weight ≥ 25,000 g/m per GRI-GG8 and a carboxyl end group (CEG) number ≤ 30 per GRI- GG7. Reduction Factor for Durability (RF_D) shall not be less than 1.10.

2. Soil Interaction Coefficient (C_i) value shall be determined from short-term effective stress pullout tests per ASTM D 6706 over the range of normal stresses encountered. The minimum C_i value shall not be less than 0.7, determined as follows:

$$C_i = \frac{F}{2L\sigma_N \tan(\phi)}$$

a. F = Pullout force per ASTM D 6706, lb/ft (kN/m).
b. L = Geosynthetic embedment length during test, ft (m).
c. σ_N = Effective normal stress, psf (kPa).
d. ϕ = Effective soil friction angle, degrees.

C. Intermediate or Face Wrap Geogrid: MicroGrid or StrataGrid, as indicated in the approved shop drawings, shall provide the following minimum tensile properties:

1. Intermediate or Face Wrap Geogrid Tensile Requirements

Property	Method	SG150 lb/ft (kN/m)	MicroGrid lb/ft (kN/m)
T_{ult}, Ultimate Tensile Strength	ASTM D6637 or D4595	1875 (27.4)	2000 (29.2)
T_a, Allowable Design Strength			
Soil: SW, SP, SM, SC [D_{max}=25mm, D_{50} < 0.2mm]		939 (13.7)	871 (12.7)
Soil: GW, GP, GM, GC, SW, SP, SM, SC [D_{max}=25mm, D_{50} < 8mm]		898 (13.1)	550 (8.0)
Soil: GW, GP, GM, GC [D_{max}=50mm, D_{50} < 20mm]		765 (11.2)	550 (8.0)

a. Allowable Tensile Strength (T_a) shall be defined as T_{ult} / RF. Where RF = RF_{CR} x RF_D x RF_{ID}. Reduction Factor for Creep (RF_{CR}), Reduction Factor for Durability (RF_D), and Reduction Factor for Installation Damage (RF_{ID}).
b. Ultimate Tensile Strength (T_{ult}) shall be the minimum average roll value (MARV) as tested per ASTM D 6637 (Method A) or ASTM D 4595.
c. Reduction Factor for Creep (RF_{CR}) shall be based on 75-year design life determined in accordance with ASTM D 5262 or ASTM D 6992. Reduction Factor for Creep (RF_{CR}) shall not be less than 1.5.
d. Reduction Factor for Installation Damage (RF_{ID}) shall be based on reinforced backfill type designated above or reinforced backfill as indicated in the

approved shop drawings or specifications reinforced backfill gradation. Installation damage testing and material sampling shall be in conformance with ASTM D 6637, ASTM D 4595 and ASTM D 5818. Reduction Factor for Installation Damage (RF_{ID}) shall not be less than 1.05.

e. Reduction Factor for Durability (RF_D) shall be based on polyester fiber testing. Polyester fiber shall have a molecular weight ≥ 25,000 g/m per GRI-GG8 and a carboxyl end group (CEG) number ≤ 30 per GRI- GG7. Reduction Factor for Durability (RF_D) shall not be less than 1.10.

D. Reinforced Backfill: Granular fill with a pH range of 3 to 9, when tested in accordance with AASHTO T 289 and graded as follows:
1. 100 percent passing a 2-inch (50 mm) sieve.
2. 100 to 75 percent passing a 3/4-inch (19 mm) sieve.
3. 100 to 20 percent passing a No. 4 sieve (4.75 mm).
4. 0 to 60 percent passing a No. 40 sieve (0.425 mm).
5. 0 to 35 percent passing a No. 200 sieve (0.075 mm).
6. PI ≤ 15
7. LL ≤ 30

PART 3 EXECUTION

3.1 PREPARATION

A. Do not begin installation until excavation, foundation preparation and leveling pad have been completed, properly prepared, and inspected per project specifications.

B. If subgrade preparation is the responsibility of another installer, notify Architect / Owner's Geotechnical Engineer of unsatisfactory preparation. Do not begin work until unsatisfactory conditions have been rectified as directed by the Owner's Geotechnical Engineer.

C. Excavation:
1. Excavate the subgrade vertically to the plan elevation and horizontally to the extent of the geogrid lengths.
2. Remove soils not meeting required strength and replace with approved materials by the Owner's Geotechnical Engineer.
3. Protect excavated materials to be used for backfilling the reinforcement zone from the weather.

D. Foundation Preparation:
1. Over-excavated areas of the subgrade shall be filled in maximum loose lifts of 10 inches (250 mm) and shall be compacted to a minimum of 95 percent Standard Proctor Dry Density with -1% to +2% of optimum moisture content in accordance with ASTM D 698.
2. Owner's Geotechnical Engineer will inspect the subgrade soil for the reinforced zone to ensure proper bearing strength in accordance with the specified Field Quality Control provisions.

3.2 CONSTRUCTION

A. Construct reinforced soil structure in accordance with the approved shop drawings and Construction and Quality Control Manual supplied by the manufacturer.

B. Geogrid placement:
1. Unroll the geogrid and cut to the length indicated in the approved shop drawings.
2. Place geogrid on level and compacted reinforced fill at locations indicated in the approved shop drawings.
3. Primary strength direction of the geogrid shall be placed perpendicular to the face of the structure or aligned as indicated in the approved shop drawings.
4. Pull the geogrid taut to remove slack in the geogrid.
5. Stake or pin the geogrid near the end to maintain alignment and to prevent development of slack during backfill placement.
6. Adjacent embedment lengths of geogrid shall abut to provide 100% coverage at elevations requiring geogrid reinforcement, as indicated in the approved shop drawings.
7. Place a minimum of 3 inches (75 mm) of fill between overlapping layers of geogrid where overlapping occurs behind curves and corners.
8. Construction vehicles shall not be operated directly on the geogrid. A minimum of 6 inches (150 mm) of fill cover over the geogrid is required for operation of construction vehicles in the reinforced zone.
9. Turning of vehicles should be avoided to prevent dislocation or damage to the geogrid.
10. Primary geogrid may not be overlapped or connected mechanically to form splices in the primary strength direction.

C. Reinforced backfill:
1. Place the reinforced backfill material in maximum compacted lifts of 8 inches (200 mm) and compact to a minimum Standard Proctor Dry Density of 95 percent within -1 to +2 percent of optimum moisture content, per ASTM D 698. Compaction shall be achieved throughout the full lift thickness. Minimum compaction shall meet or exceed the requirements stated or as required by the project specifications, whichever is more stringent.
2. Use only walk-behind compaction equipment within 3 feet (1 meter) of the structure facing. Use a minimum of 3 passes to compact this zone.
3. Required level of compaction shall be achieved throughout the entire reinforced backfill zone, as measured from the back of the facing unit to the end of geogrid reinforcement. Reinforced fill zone limits shall be as indicated on the approved shop drawings.
4. Smooth and level the backfill as indicated so that the geogrid lays flat. Grade shall not slope towards the front face of the structure.
5. Separate reinforced fill from the adjacent soil with geotextile, as indicated in the approved shop drawings

3.3 FIELD QUALITY CONTROL

A. Quality Assurance: Testing and Inspection will be provided by the Owners Testing Agency as specified in Section 01400 Testing and Inspection Services. Notify the Architect / Owner's Geotechnical Engineer 72 hours in advance of testing.

B. Quality Control: Testing and Inspection shall be provided by an independent laboratory provided by the Contractor and acceptable to the Architect / Owner's Geotechnical Engineer.

C. Perform laboratory material tests in accordance with ASTM D 698, D 422, and D 424.

D. Perform in place compaction tests in accordance with the following:
   1. Density Tests: ASTM D 1556, ASTM D 2167, or ASTM D 2922 as appropriate for material tested.
   2. Moisture Tests: ASTM D 3017.

E. Minimum Frequency of Tests, or as stated in the contract documents:
   1. Leveling Pad Trench: A minimum rate of one test per 100 feet (30 m) of trench.
   2. Subgrade Soil: A minimum rate of one test per 50 feet (15 m) length of structure.
   3. Reinforced Backfill:
      a. Conduct gradation and plasticity index test at a minimum rate of one test per 2000 cubic yards (1500 cubic meters) and whenever the appearance and behavior of the backfill changes noticeably.
      b. Compaction control testing of the reinforced backfill should be performed on a regular basis during the entire construction project. Conduct compaction control test (Density and Moisture) at a minimum rate of one test within the reinforced backfill zone per every 5 ft (1.5 m) of vertical height for every 100 ft (30 m) of length, approximately every 500 square feet (45 square meters) of vertical face area.

END OF SECTION