Supplemental Technical Specification for

# Geogrid Soil Reinforcement

## SCDOT Designation: SC-M-203-2 (01/20)

**APPROVED:**
**Division Administrator**
THADDEUS W KITOWICZ Digitally signed by THADDEUS W KITOWICZ Date: 2019.10.01 15:49:48 -04'00'
**By:** ______________________
**FEDERAL HIGHWAY ADMINISTRATION**

## 1.0 DESCRIPTION

The requirements of this specification consist of furnishing all necessary submittals and materials for providing geogrid soil reinforcement in accordance with the details shown on the plans and the requirements of the Specifications, Special Provisions or as directed by the Resident Construction Engineer (RCE). For geogrid used for subgrade stabilization see Supplement Technical Specification for *Geosynthetic Materials for Separation and Stabilization* (SC-M-203-1).

## 2.0 TESTING STANDARDS

2.1 Use the latest edition of the testing standards indicated in this specification. Substitution of standards will require the prior written approval of the Materials and Research Engineer (MRE) with concurrence of the Geotechnical Engineer-of-Record (GEOR). Provide copies of all substituted standards to the Resident Construction Engineer (RCE) if requested. The RCE will provide the copies to the MRE and GEOR for approval and concurrence.

2.2 **References:** The evaluation of this work will be based on, but not limited to, the following references:

2.2.1 American Association of State Highway and Transportation Officials, (2017), Standard Specification for Transportation Materials and Methods of Sampling and Testing and AASHTO Provisional Standards, American Association of State Highway and Transportation Officials, Washington, D.C.

**2.2.1.1** R-69 – *Standard Practice for Determination of Long-Term Strength of Geosynthetic Reinforcement*

**2.2.1.2** M-288 – *Standard Specification for Geosynthetic Specification for Highway Applications*,

2.2.2 South Carolina Department of Transportation, Geotechnical Design Manual (GDM), Latest Version, see the SCDOT website.

## 3.0 MATERIAL

3.1 Geogrid soil reinforcement consists of a regular network of integrally connected polymer tensile elements with aperture geometry (apertures > 0.25 inches) sufficient to permit significant mechanical interlock with the surrounding soil, aggregate, or other material. The structure of the geogrid reinforcements shall be dimensionally stable and able to retain its geometry under construction stresses and have high resistance to damage during construction, to ultraviolet degradation, and to all forms of chemical and biological degradation encountered in the soil being reinforced. Geogrids come in 2 basic configurations, uniaxial and biaxial (includes both biaxial (square and rectangular) and triaxial (triangular)). Geogrid design requirements and placement shall be as shown in the plans and shall meet the properties specified in Section 3.2 or 3.3.

3.2 Provide uniaxial geogrids meeting the following minimum available long-term reinforcement tension load, $T_{al}$ in the machine direction as indicated in the table below.

**Table 1 –Available Long-term Uniaxial Geogrid Tension Load**

| Property | U1 | U2 | U3 | U4 | U5 | U6 | U7 | U8 | U9 | U10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Available Long-term Tension Load, $T_{al}$[1, 2] (lb/ft) | 450 | 800 | 1450 | 2300 | 3000 | 3600 | 4000 | 6000 | 9000 | 13000 |

1. Minimum $T_{al}$ in machine direction unless otherwise specified
2. Minimum pullout friction factor F*= 0.67*tan $\phi$; based on $\phi \geq 28°$ and $C_u \geq 4$

3.3 Provide biaxial geogrids meeting the following minimum available long-term reinforcement tension load, $T_{al}$ in the strong and weak axis as indicated in the following table.

**Table 2 –Available Long-term Biaxial Geogrid Tension Load**

| Property | B1 | | B2 | | B3 | | B4 | |
|---|---|---|---|---|---|---|---|---|
| | XMD[1] | MD[1] | XMD[1] | MD[1] | XMD[1] | MD[1] | XMD[1] | MD[1] |
| Available Long-term Tension Load, $T_{al}$[1,2] (lb/ft) | 100 | 65 | 200 | 130 | 400 | 265 | 700 | 465 |

1. XMD – Cross-machine Direction; MD – Machine Direction
2. Minimum pullout friction factor F*= 0.67*tan $\phi$; based on $\phi \geq 28°$ and $C_u \geq 4$

## 4.0 CERTIFICATION

4.1 Prior to construction submit to the GEOR a Certification Package prepared by the geogrid reinforcement manufacturer. Allow 21 calendar days from the day the submittals are received by the GEOR for review and acceptance. State in the Certification Package that the furnished geogrid soil reinforcement is in full compliance with the design requirements as stated in this specification and the design drawings and is fit for use in long-term critical soil reinforcement applications. Certify and document the submittal values for the following items for each geogrid soil reinforcement used on the project:

1. The ultimate tensile strength, $T_{ULT}$, for geogrid soil reinforcements.
2. The available long-term tensile load, $T_{al}$, for geogrid soil reinforcements
3. The geogrid's pullout coefficients (F*, $\alpha$)

4.2 Provide the written manufacturer's certification that the manufactured geosynthetics (polypropylene (PP); polyethylene (HPDE) or polyester (PET)) meet the requirements of Table 3. Include in the submittal package, actual test results for tension, creep, durability, construction damage, joint strength, pullout, quality control and any other tests required by the Department. A person having the legal authority to bond the manufacturer shall attest to the certificate. If in the opinion of the GEOR, the required documentation is not provided for individual reduction factors (RF) or pullout coefficients (F*, $\alpha$), use default values for these design parameters in accordance with this specification.

4.3 For products currently listed by the National Transportation Product Evaluation Program (NTPEP) Geosynthetic Reinforcement (REGEO) plan, base the submittal package on the posted independent product line evaluation report (see www.ntpep.org). For products that are not currently listed by the NTPEP, include in the submittal package all of the information required in the following Sections.

4.4 Certify in the submittal package the following values and document for each geogrid soil reinforcement used on the project:

4.4.1 Determine the ultimate tensile strength, $T_{ult}$, from multi-rib tensile test for geogrids (ASTM D6637, Method B). Laboratory test results documenting the ultimate tensile strength, $T_{ult}$, in the reinforcement direction shall be based on the Minimum Average Roll Values (MARV) for the product.

4.4.2 Compute the available tensile load, $T_{al}$, per unit width of geogrid soil reinforcement for the specific backfill type used as follows:

$$T_{al} = \frac{T_{ult}}{RF}$$

4.4.3 The total reduction factor, RF, is the combined reduction factor for long-term degradation due to installation damage, creep, and durability. The total reduction factor, RF, is defined as follows:

$$RF = RF_{ID} \times RF_{CR} \times RF_{D}$$

4.4.4 Document the individual reduction factors in accordance with the site conditions, design calculations, and specifications. When sufficient documentation is not provided (i.e. the geogrid is not listed on the NTPEP website) for individual reduction factors, $RF_{ID}$, $RF_{CR}$, and $RF_{D}$, use a reduction factor RF of 7.0. Certify and document the individual reduction factors as follows:

4.4.4.1 Document the reduction factor for installation damage, $RF_{ID}$, using the requirements of AASHTO R-69 for various soils. The installation damage reduction factor, $RF_{ID}$, shall range between 1.1 and 1.7 ($1.1 \leq RF_{ID} \leq 1.7$), regardless of product specific test results.

4.4.4.2 Document the Creep Reduction Factor ($RF_{CR}$) using the requirements of AASHTO R-69. Conduct creep testing on samples of sufficient width to be representative of overall product creep response (fiber creep testing will not be accepted).

4.4.4.3 The creep-limiting strength, $T_l$, is based on extrapolating the 10,000 hours (or longer duration) tension creep tests to a 75-year design life, unless a 100-year design life is specified in the plans. Base the creep extrapolation method on the methods described in AASHTO R-69. Document laboratory test results and extrapolation methodology used.

4.4.4.4 The total reduction factor for durability, $RF_{D}$, is defined as the combined effects of chemical and biological degradation. Document laboratory test results, extrapolation techniques, and a review of available literature to determine the reduction factor for durability for all material components in accordance with AASHTO R-69. The durability reduction factor, $RF_{D}$, shall range between 1.3 and 2.0 ($1.3 \leq RF_{D} \leq 2.0$), regardless of product specific test results and is based on a pH range of 3.0 to 9.0 ($3.0 \leq pH \leq 9.0$) for the proposed backfill materials.

4.4.5 For granular backfill, determine pH values in accordance with AASHTO T-289. For stone backfill, follow SC-T-143 for producing supernate and analyze the supernate according to ASTM D1293.

4.4.6 Document in the Certification Package the determination of whether the pullout coefficients (F*, $\alpha$) meet or exceed the required coefficients necessary to obtain the $T_{al}$ provided above.

4.4.7 Document the pullout friction factor, F*, and the scale effect correction factor, $\alpha$, from laboratory pullout tests. Conduct pullout testing for site-specific materials or for materials representative of the reinforced backfill at confining pressures specified by the GEOR. When laboratory tests are used from representative soils, document the representative soils by providing the soil's angle of internal friction, gradation, and coefficient of uniformity ($C_u = D_{60}/D_{10}$). Document the recommended pullout coefficients for various soil types. Determine the pullout coefficients using the quick effective stress pullout tests per ASTM D6706 and through-the-junction creep testing of the geogrid per ASTM D5262. When sufficient documentation is not provided for pullout coefficients, F* and $\alpha$, and the coefficient of uniformity, $C_u$, is greater or equal to 4 ($C_u \geq 4$) and the internal friction angle of the soil is at least 28 degrees ($\phi \geq 28°$) use $F^* = 0.67 \tan \phi$ and $\alpha = 0.8$. If the coefficient of uniformity of the reinforced backfill is less than 4 ($C_u < 4$) or the internal friction angle is less than 28 degrees ($\phi < 28°$), use a laboratory pullout test to determine pullout friction factor, F*, and the default scale effect factor, $\alpha$.

## 5.0 MANUFACTURING QUALITY CONTROL

5.1 Provide to the RCE a manufacturing quality control certificate and conformance testing results for all geogrid soil reinforcement delivered to the site. A manufacturing quality control program that includes comprehensive QC testing by on-site GAI-LAP (Geosynthetic Accreditation Institute – Laboratory Accreditation Program) accredited laboratory and documentation of this quality control program is to be provided by the geogrid manufacturer to the RCE. Sampling for quality control shall be in accordance with ASTM D4354, Table 1. Geogrid product acceptance shall be based on ASTM D4759. Test geogrid samples in accordance with ASTM D6637, Method B. Laboratory test results documenting the ultimate tensile strength, $T_{ult}$, in the reinforcement direction shall be based on the minimum average roll values (MARV) for the product. Include in the quality control certificate the roll numbers and identification, sampling procedures, and results of the quality control testing with a description of test methods used. Provide the results of index testing shown in the following table for all geogrid soil reinforcement.

**Table 3 - Applicable Index Testing**[1]

| Type | Property | Test Method | Criteria |
|---|---|---|---|
| Polypropylene (PP) | UV Oxidation Resistance | ASTM D4355 | Minimum 70% strength retained after 500 hrs. in weatherometer |
| | Thermo-Oxidation Resistance | ENV ISO 13438, Method A | Minimum 50% strength retained after 28 days |
| Polyethylene (HPDE) | UV Oxidation Resistance | ASTM D4355 | Minimum 70% strength retained after 500 hrs. in weatherometer |
| | Thermo-Oxidation Resistance | ENV ISO 13438, Method B | Minimum 50% strength retained after 56 days |
| Polyester (PET) | Hydrolysis Resistance | Intrinsic Viscosity Method (ASTM D4603 and GRI Test Method GG8) with Correlation or Determine Directly Using Gel Permeation Chromatography | Minimum Number Average Molecular Weight of 25,000 |
| | Hydrolysis Resistance | ASTM D7409 | Maximum Carboxyl End Group (CEG) Content of 30 |
| All Polymers | Survivability | ASTM D5261 | 8 oz/yd$^2$ |
| | % Post Consumer Recycled Material by Weight | Certification of Material Used | Maximum 0% |

1. Testing to be done on the finished product, except for the polyester products which should have testing done on the based (uncoated) yarns.

## 6.0 METHOD OF MEASUREMENT

6.1 Measurement of geogrid soil reinforcement is on a square yard basis and will be computed based on the total area of geogrid soil reinforcement shown in the plans, exclusive of the area of geogrids used in any overlaps. Overlaps, any geogrid waste and the testing indicated in this Specification are incidental items.

## 7.0 BASIS OF PAYMENT

7.1 The quantity of geogrid soil reinforcement shall be paid at the contract unit price for Geogrid Reinforcement. All costs for installing the geogrid soil reinforcement is to be included in the amount bid for the pay items below.

7.2 Payment will be made under:

| Item No. | Pay Item | Pay Unit |
|---|---|---|
| 2037000 | Geogrid Reinforcement (Uniaxial) | SY |
| 2037010 | Geogrid Reinforcement (Biaxial) | SY |