Supplemental Technical Specification for

Geotextile Soil Reinforcement

SCDOT Designation: SC-M-203-3 (01/20)

APPROVED:
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FEDERAL HIGHWAY ADMINISTRATION

1.0 DESCRIPTION

1.1 The requirements of this specification consist of furnishing all necessary submittals and materials for providing geotextile soil reinforcement in accordance with the details shown on the plans and the requirements of this Supplement Technical Specification (STS, the project Specifications, Special Provisions or as directed by the Resident Construction Engineer (RCE). For geotextiles used for subgrade stabilization see STS *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*,

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

3.0 MATERIAL

3.1 A geotextile is defined as permeable planar polymeric material used with foundation, soil, rock, earth, or any other geotechnical engineering related material, as an integral part of a civil engineering project, structure, or system. Geotextiles use fibers or yarns formed into a stable network. The structure of the geotextile reinforcements shall be dimensionally stable and be able to retain its geometry including selvages (edges), during shipping, handling, placement, and 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. Geotextiles and the thread used in joining (seaming) geotextiles are manufactured from fibers consisting of long-chain polymers, composed of at least 95 percent by weight of polyolefins or polyesters. The geotextile shall be free from defects or tears. Supply only woven geotextiles unless otherwise indicated on the plans or in the Special Provisions.

Geotextile design requirements and placement shall be as shown in the plans and shall meet the properties specified in Section 3.2.

3.2 Provide woven geotextiles meeting the following minimum available long-term reinforcement tension load, T_{al} in the machine direction as indicated in the table below. T_{al} is the Minimum Average Rolled Value (MARV) T_{ult} reduced for construction installation damage, creep and durability. Obtain the following information from the grain-size testing of the proposed borrow materials and the subgrade if geotextile soil reinforcement will be placed directly on the subgrade:

D_{10} = Diameter of particle at 10% finer material, millimeter (mm)
D_{60} = Diameter of particle at 60% finer material, mm
D_{85} = Diameter of particle at 85% finer material, mm
% No. 200 = Percent material passing the No. 200 Sieve, %

$$\mathbf{C_u = \frac{D_{60}}{D_{10}}}$$

Table 1 – Available Long-Term Geotextile Tension Load

Property	GT1	GT2	GT3	GT4	GT5	GT6	GT7	GT8	GT9	GT10
Available Long-term Tension Load, T_{al}[1, 2, 3,4] (lb/ft)	450	800	1450	2300	3000	3600	4000	6000	9000	13000
Apparent Opening Size (AOS)[5,6] (mm)	$C_u \le 2$ or $C_u \ge 8$				$B = 1.0$			$AOS \le B * D_{85(soil)}$		
	$2 \le C_u \le 4$				$B = 0.5 * C_u$					
	$4 \le C_u \le 8$				$B = 8 \div C_u$					
Permeability (cm/s)[7,8]	$k_{geotextile} \ge 10 * k_{soil}$									
Permittivity (sec^{-1})[9]	% No. 200 < 15						≥ 0.5			
	15 ≤ % No. 200 ≤ 50						≥ 0.2			
	50 < % No. 200						≥ 0.1			

1. Based on the MARV T_{ult} in machine direction (ASTM D4595)
2. T_{al} in cross machine direction = 50% of MARV T_{ult} in machine direction (ASTM D4595)
3. Minimum pullout friction factor $F^* = 0.67 * \tan \phi$; based on $\phi \ge 28°$ and $C_u \ge 4$ (ASTM D6706)
4. Available tensile strength at 5 percent strain (ASTM D4595)
5. AOS determined using ASTM D4751
6. AOS requirement does not apply to geotextiles made with polyester fibers
7. Permeability determined using ASTM D4491 (geotextile); use ASTM D5084 (soil % No. 200 ≥ 15)

8. Soils with less than 15% passing No. 200, assume $k_{soil} = 1 * 10^{-3}$ cm/s
9. Permittivity determined using ASTM D4491

3.3 If sewn seams are shown in the plans, use thread that consists of either polypropylene or polyester polymers and which has a strength matching the strength of the geotextile being seamed. Do not use nylon thread. Use thread that is of contrasting color to that of the geotextile itself. Use a double row of double-thread chain stitch, Type 401 (see ASTM D6193). Use 150 to 400 stitches per yard depending on the weight of the geotextile. Consult the geotextile manufacturer or supplier for the appropriate stitch density. Use either a "butterfly" seam (Type SSd) or "J" seam (Type SSn) (see ASTM D6193). The sewn seam strength (whether field or factory sewn) shall meet the requirements indicated on the plans.

4.0 CERTIFICATION

4.1 Prior to construction, submit to the GEOR a Certification Package prepared by the geotextile 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 geotextile soil reinforcement is in full compliance with the design requirements as stated in this STS 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 geotextile soil reinforcement used on the project:

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

4.2 Provide the written manufacturer's certification that the manufactured geotextiles (polypropylene (PP); polyethylene (HPDE) or polyester (PET)) meet the requirements of Table 2. Include in the submittal package, actual test results for tension, creep, durability, construction damage, seam 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*, α), use default values for these design parameters in accordance with this STS.

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 geotextile soil reinforcement used on the project:

4.4.1 The ultimate tensile strength, Tult, shall be determined from wide width tensile tests (ASTM D4595). Geotextile samples tested in accordance with ASTM D4595 shall be with an 8-inch width specimen, or a 4-inch specimen width with correlation to an 8-inch width. Correlation methodology shall be submitted to, and is subject to acceptance by the RCE and the GEOR. All geotextile strength tests (ASTM D4595) shall be conducted at a strain rate of 10% per minute based on actual gage length necessary to meet the testing sample dimension requirements. 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 geotextile 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 this STS. When sufficient documentation is not provided (i.e. the geotextile 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 be a minimum of 1.1, 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 FHWA NHI-09-087,. The durability reduction factor, RF_{D}, shall be a minimum of 1.3, 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*, α) 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, α, 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 defined previously). Document the recommended pullout coefficients for various soil types. Determine

the pullout coefficients using the quick effective stress pullout tests per ASTM D6706. When sufficient documentation is not provided for pullout coefficients, F* and α, 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 ϕ and α =0.6. 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, α.

4.4.8 If the geotextile seams are allowed and are to be sewn in the field, provide a section of sewn seam at least 6 feet in length to RCE before the geotextile is installed. Prepare and sew the field sewn seam sample in the presence of the RCE or his/her representative. If seams are to be sewn in both the machine and cross-machine direction, provide samples of seams from both directions. The sewn seam sample shall be sewn using the same equipment and procedures as will be used to sew the production seams. Determine the sewn seam shear strength in accordance with ASTM D4884. Seams to conform to the requirements of ASTM D6193.

4.4.9 If the seams are allowed and are to be sewn in the factory, provide samples of the factory seam at random from any of the rolls to be used. The seam sewn for sampling must be at least 6 feet in length. If seams are to be sewn in both the machine and cross-machine direction, provide samples of seams from both directions. Submit a sample of the seam assembly to the RCE and include a written description of the seam. This description shall include the seam type, stitch type, sewing thread type(s), and stitch density. Determine the sewn seam shear strength in accordance with ASTM D4884. Seams to conform to the requirements of ASTM D6193.

5.0 MANUFACTURING QUALITY CONTROL

5.1 Provide to the RCE a manufacturing quality control certificate and conformance testing results for all geotextile 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 geotextile manufacturer to the RCE. Sampling for quality control shall be in accordance with ASTM D4354, Table 1. Geotextile product acceptance shall be based on ASTM D4759. Test geotextile samples in accordance with ASTM D4595. 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 geotextile soil reinforcement.

Table 2 - 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 geotextile soil reinforcement is on a square yard basis and will be computed based on the total area of geotextile soil reinforcement shown in the plans, exclusive of the area of geotextiles used in any overlaps. Overlaps, any geotextile waste and the testing indicated in this STS are incidental items.

7.0 BASIS OF PAYMENT

7.1 The quantity of geotextile soil reinforcement shall be paid at the contract unit price for Geotextile Soil Reinforcement. All costs for installing the Geotextile 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
2037120	Geotextile Soil Reinforcement	SY