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Preparing Activity: USACE Superseding
UFGS-35 42 34 (January 2008)

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2023**
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SECTION 35 42 34

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**08/20**

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**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

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SECTION 35 42 34

REINFORCED SOIL SLOPE
**08/20**

**NOTE: This guide specification covers the requirements for steepened soil slopes using geosynthetic soil reinforcement. It does not include soil reinforcements such as segmented type retaining walls, metal reinforcing strips, soil nails, and combi walls. This section was originally developed for USACE Civil Works projects.**

**Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

**Remove information and requirements not required in respective project, whether or not brackets are present.**

**Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).**

PART 1 GENERAL

**NOTE: This guide specification does not address requirements for dewatering, shoring, or earthwork below foundation level. Geometric requirements such as slope height, crest, toe, length, and construction limits should be shown on the drawings.**

**Notes before paragraphs are provided to present assumptions in preparation of the guide specification, make suggestions for conditions that warrant revisions, and provide background technical**

**information or references for further information. They should be consulted prior to revising wording for project specifications.**
**********

## 1.1 MEASUREMENT AND PAYMENT

### 1.1.1 Excavation

The unit of measurement for excavation is the cubic meter (CM) yard (CY), computed by the average end area method from cross sections taken before and after the excavation operations. The volume to be paid for will be the material measured in its original position and removed from the excavation areas when the material is acceptably utilized or disposed of as herein specified. The excavation is unclassified and includes material of all types. The measurement will not include material excavated without authorization. Payment will be made at the respective unit price listed on the bidding schedule. Payment will be full compensation for furnishing all material, labor, equipment, supplies and incidentals to complete the work. Shoring is incidental to excavation.

### 1.1.2 Fill

Material of all types not otherwise paid for is included under the unit price for fill. The unit of measurement for fill is the cubic meter (CM) yard (CY) computed by the average end area method from cross sections taken of the final slope and after the excavation operations. The volume to be paid for will be the material measured in its final position and placed within the designated areas when the material is acceptably placed and compacted as herein specified. Payment will be made at the respective unit price listed on the bidding schedule. Payment will be full compensation for furnishing all material, labor, equipment, supplies and incidentals to complete the work.

### 1.1.3 Soil Slope Reinforcement

The unit of measurement for reinforcement is the square meter (SM) yard (SY). The pay lines of the reinforcement will be neat lines taken off the approved shop drawings. Overlaps for splicing (if allowed) and for the Contractors convenience will not be measured for payment. Overlaps in curved sections will be measured assuming the slope is linear. Payment will be made at the respective unit price listed on the bidding schedule. Payment will be full compensation for furnishing all material, labor, equipment, supplies and incidentals to complete the work.

### 1.1.4 Soil Slope Drainage System

The drainage system, including associated pipe, geotextile, and aggregate will not be measured for payment and will be paid for on a job basis (JB), complete. Payment will be full compensation for furnishing all material, labor, equipment, supplies and incidentals to complete the work.

### 1.1.5 Soil Slope Facing and Seeding

Facing and seeding of the soil slope will be measured by the square meter (SM) yard (SY) of exposed face, measured in the plane of the slope face. The pay lines will be neat lines taken off the approved shop drawings. The work includes [seed, mulch, turf reinforcement mat, erosion control blankets, erosion control netting, and staples]. Payment will be made at

the respective unit price listed on the bidding schedule, and will be full compensation for furnishing all material, labor, equipment, supplies and incidentals to complete the work.

## 1.2 REFERENCES

**********

**NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.**

**Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.**

**References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.**

**********

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

| | |
|---|---|
| AASHTO M 252 | (2009; R 2017) Standard Specification for Corrugated Polyethylene Drainage Pipe |
| AASHTO M 288 | (2021) Standard Specification for Geosynthetic Specification for Highway Applications |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM C136/C136M | (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates |
| ASTM D448 | (2012; R 2017) Standard Classification for Sizes of Aggregate for Road and Bridge Construction |
| ASTM D698 | (2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.)) |
| ASTM D1238 | (2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer |
| ASTM D1505 | (2018) Standard Test Method for Density of |

| | |
|---|---|
| | Plastics by the Density-Gradient Technique |
| ASTM D1556/D1556M | (2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method |
| ASTM D1557 | (2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3) |
| ASTM D2216 | (2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass |
| ASTM D2487 | (2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D2488 | (2017; E 2018) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) |
| ASTM D4355/D4355M | (2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus |
| ASTM D4491/D4491M | (2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity |
| ASTM D4595 | (2017) Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method |
| ASTM D4632/D4632M | (2015a) Grab Breaking Load and Elongation of Geotextiles |
| ASTM D4751 | (2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile |
| ASTM D4873/D4873M | (2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples |
| ASTM D4884/D4884M | (2014a) Strength of Sewn or Thermally Bonded Seams of Geotextiles |
| ASTM D5035 | (2011) Breaking Force and Elongation of Textile Fabrics (Strip Method) |
| ASTM D5199 | (2012) Measuring Nominal Thickness of Geosynthetics |
| ASTM D5261 | (2010; R 2018) Standard Test Method for Measuring Mass Per Unit Area of Geotextiles |
| ASTM D5321/D5321M | (2020) Standard Test Method for |

| | |
|---|---|
| | Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear |
| ASTM D6637 | (2011) Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method |
| ASTM D6706 | (2001; R 2013) Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil |
| ASTM D6938 | (2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) |

GEOSYNTHETIC INSTITUTE (GSI)

| | |
|---|---|
| GSI GRI GG6 | (1996) Grip Types for Use in Wide Width Testing of Geotextiles and Geogrids |

NATIONAL CONCRETE MASONRY ASSOCIATION (NCMA)

| | |
|---|---|
| NCMA TR127B | (2010) Design Manual for Segmental Retaining Walls |

U.S. ARMY CORPS OF ENGINEERS (USACE)

| | |
|---|---|
| EM 385-1-1 | (2014) Safety -- Safety and Health Requirements Manual |

U.S. DEPARTMENT OF AGRICULTURE (USDA)

| | |
|---|---|
| AMS Seed Act | (1940; R 1988; R 1998) Federal Seed Act |

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

| | |
|---|---|
| FHWA NHI-00-043 | (2000) Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines (ISDDC) |
| FHWA NHI-10-024 | (2009) Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I |
| FHWA NHI-10-025 | (2009) Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume II |

## 1.3 DEFINITIONS

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**NOTE: Subparagraph "Reinforcement" - This guide specification only applies to geosynthetic (extensible) reinforcement. There are differences in design and construction applicable to steel soil (inextensible) reinforcement.**

**********

1.3.1 Drainage Aggregate

Granular soil or aggregate which is placed in or around drains.

1.3.2 Fill

Soil or aggregate placed in, behind, or below the embankment or slope will be referred to as fill.

1.3.3 Reinforced Fill

Soil which is placed and compacted within the neat line volume of reinforcement as outlined on the plans.

1.3.4 Retained Fill

Soil which is placed and compacted behind the reinforced fill.

1.3.5 Reinforcement

Reinforcement consisting of a geogrid or a geotextile product manufactured for use as reinforcing. Reinforcement does not include steel products.

1.3.6 Long Term Design Strength

The long term design strength (LTDS) is:

$$LTDS = T_{ult} / (RF_D * RF_{ID} * RF_{CR})$$

where:

$T_{ult}$ is the ultimate tensile reinforcement strength
$RF_D$ is the reduction factor for chemical and biological durability
$RF_{ID}$ is the reduction factor for installation damage
$RF_{CR}$ is the reduction factor for creep

1.4 SUBMITTALS

**********

**NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.**

**For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for**

**Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.**

**The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.**

**Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.**

**********

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Drawings; G[, [_____]].

Shoring; G[, [_____]]

SD-03 Product Data

Geotextile Reinforcement

Geogrid Reinforcement

Reinforcement Testing

Geotextile Filter

Calculations; G[, [_____]].

SD-04 Samples

Reinforcement

SD-06 Test Reports

Field Testing Results

SD-07 Certificates

Certificates of Compliance

## 1.5 QUALITY ASSURANCE

### 1.5.1 Manufacturer Representative

Provide a qualified and experienced representative from the reinforcement manufacturer available on an as-needed basis during the construction. Visit the site for consultation [at least once during construction] [as requested by the Contracting Officer].

### 1.5.2 Detailed Drawings

Submit the fabrication and installation drawings indicating fabrication and erection details for the slope, including sequencing and construction procedures. If approved by the Contracting Officer, shop drawings may consist of marked up contract drawings showing exact dimensions for the reinforcement supplied, and other minor revisions. The design and layout of the internal reinforcement are subject to the following:

a. Incorporate all features indicated in the contract documents in the final design and construction.

b. Run each reinforcement level as continuous as practical throughout the profile. If a geotextile filter is present, lay out the reinforcement so that interference with the geotextile is minimized.

c. Identify any reinforcement not placed with the machine direction as the design reinforcement direction on the shop drawings.

### 1.5.3 Classification of Soil Materials

Perform classification of soil materials in accordance with ASTM D2488. The Contracting Officer reserves the right to revise the Contractor classifications. In the case of disagreement, the Contracting Officer's classification will govern unless the soils are classified in accordance with ASTM D2487. All testing completed by the Contractor in conjunction with soil material classification is considered incidental to the contract work.

## 1.6 DELIVERY, STORAGE, AND HANDLING

Check products upon delivery to assure that the proper material has been received and is undamaged. Protect the materials from damage and exposure following the guidelines presented in ASTM D4873/D4873M.

### 1.6.1 Labeling

Label each roll with the manufacturer's name, product identification, roll dimensions, lot number, and date manufactured.

### 1.6.2 Handling

Handle and unload geosynthetic rolls by hand, or with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Do not drag, lift by one end, lift by cables or chains, or drop geosynthetic rolls to the ground.

### 1.6.3 Storage

Protect geosynthetics from cement, paint, excessive mud, chemicals, sparks

and flames, temperatures in excess of 70 degrees C 160 degrees F, and any other environmental condition that can degrade the physical properties. If stored outdoors, elevate the rolls from the ground surface. Protect geosynthetics, except for extruded grids, with an opaque waterproof cover. Deliver geosynthetics to the site in a dry and undamaged condition. Do not expose geotextiles to direct sunlight for more than 7 days.

## PART 2 PRODUCTS

### 2.1 REINFORCEMENT

**********

**NOTE: Polyester is susceptible to hydrolysis in alkaline conditions. A high molecular weight and low carboxyl end group number limit the hydrolysis. Normally, a mill certificate or certification of these properties is adequate. The molecular weight of polyester geosynthetics is determined from GSI GRI GG6, "Determination of the Number Average Molecular Weight of Polyethylene Terephthalate (PET) yarns Based on a Relative Viscosity Value", and ASTM D4603, "Determining Inherent Viscosity of Poly(Ethylene Terephthalate) (PET) by Glass Capillary Viscometer." The carboxyl end group number is determined from GSI GRI GG7, "Carboxyl End Group Content of Polyethylene Terephthalate (PET) Yarns."**

**Survivability - The AASHTO M 288 requirements are minimum requirements and will not normally control in the product selection. The AASHTO reference can be avoided by listing the grab, tear, burst, and puncture strengths. These properties are listed in AASHTO M 288. The puncture strength (ASTM D4833/D4833M), the trapezoidal tear strength (ASTM D4533/D4533M/D4533M) and the mullen burst strength (ASTM D3786) are recognized as important geotextile properties. For the intended application, the commonly specified values for puncture, burst and tear seldom control the product selection.**

**Geosynthetic Selection - The Federal Acquisition Regulations require full and open competition. Usually justification is not necessary if 3 products meet the specifications. In combining various material requirements, it is easy to specify a geosynthetic product that does not exist. Design utilizing geosynthetics should include a listing with the calculations that verify the specified products are commercially available. The Geosynthetics Fabrics Report magazine publishes an annual specifiers guide that is ideal for this purpose.**

**The geogrid sample is intended to be for visual demonstration prior to product delivery. Quality assurance testing, if performed, should be obtained from material actually delivered to the job. If**

**testing is to be performed for pre qualification, the minimum sample size should be 1 m 36 inches in length and the full roll width. Although 1 square meter yard will provide enough material for testing, the full roll width should be sampled since it provides a better selection of specimen locations, it clearly shows the machine and cross directions, and the difference in waste and shipping costs is negligible.**

**********

Submit Certificates of Compliance for the materials; and calculations of the long term design strength for the reinforcement in accordance with the NCMA TR127B or FHWA NHI-00-043. Submit an affidavit certifying that the reinforcement and seams meets the project specifications. Provide the certificates and affidavits a minimum of 30 days prior to delivery of materials. Have the affidavit signed by an official authorized to certify on behalf of the manufacturer and include a mill certificate that verifies physical properties were tested during manufacturing and lists the manufacturer's quality control testing. [If the affidavit is dated after award of the contract and/or is not specific to the project, attach a statement certifying that the affidavit addressed to the wholesale company is representative of the material supplied.] Include a statement confirming that all purchased resin used to produce reinforcement is virgin resin. Include the tensile strength tested in accordance with either ASTM D4595 or ASTM D6637 in the mill certificate. Base the ultimate strength or index strength on the minimum average roll value tensile strength of the product using the wide width strength test in ASTM D4595 or the single rib test in ASTM D6637. Itemize each reduction factor and include backup data to justify each reduction factor in the calculations. Demonstrate splice efficiency from testing, if used. Submit and label samples of each type of reinforcement with a minimum size of 200 by 250 mm 8 by 10 inches. Include at least 2 apertures in each direction for the geogrid.

### 2.1.1 Geogrid Reinforcement

Provide geogrid, which is a geosynthetic manufactured for reinforcement applications. The geogrid must be a regular network of integrally connected polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil, aggregate, or other fill materials. The geogrid structure must be dimensionally stable and able to retain its geometry under manufacture, transport and installation. Manufacture the geogrid with 100 percent virgin resin consisting of polyethylene, polypropylene, or polyester, and with a maximum of 5 percent in-plant regrind material. Polyester resin must have a minimum molecular weight of 25,000 and a carboxyl end group number less than 30. Stabilize polyethylene and polypropylene with long term antioxidants.

### 2.1.2 Geotextile Reinforcement

Submit descriptive technical data on the reinforcement and geotextile filter materials. Include all material properties specified under paragraph PRODUCTS. Geotextile must be a pervious sheet of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polyethylene, polypropylene, or polyesters. Manufacture the geotextile with 100 percent virgin resin, and with a maximum of 5 percent in-plant regrind material. Form geotextile into a

network such that the filaments or yarns retain dimensional stability relative to each other, including the selvages. Polyester resin must have a minimum molecular weight of 20,000 and a carboxyl end group number less than 50. Stabilize polyethylene and polypropylene with long term antioxidants. For survivability during installation, and in addition to installation damage used in calculating the long term design strength, the geotextile must meet the minimum requirements in AASHTO M 288 Class 1, and have a minimum mass per unit area of 270 g/m$^2$ 8 oz/sy.

### 2.1.3 Reinforcement Properties

**********
**NOTE: Permittivity - Reinforcement geotextiles should not puddle or impede infiltration or seepage. AASHTO M 288 provides some default guidance.**
**********

#### 2.1.3.1 Primary Reinforcement Properties

Meet the property requirements listed in Table 1 for reinforcement shown on the contract drawings. Reinforcement strength requirements represent minimum average roll values in the machine direction.

TABLE 1

| PROPERTY | REQUIREMENT | TEST DESIGNATION |
|---|---|---|
| Long Term Design Strength | [_____] kN/m lb/inch | NCMA TR127B, Method A |
| Permittivity | [0.5][_____] per second | ASTM D4491/D4491M |
| UV Resistance | 70 percent after 500 hours | ASTM D4355/D4355M |
| Coefficient of Interaction for Pullout | [.85][_____] | ASTM D6706 |
| Coefficient for Direct Shear | [_____] | ASTM D5321/D5321M |

#### 2.1.3.2 Secondary Reinforcement Properties

Meet the property requirements listed in Table 2 for reinforcement shown on the contract drawings. Reinforcement strength requirements represent minimum average roll values in the machine direction.

TABLE 2

| PROPERTY | REQUIREMENT | TEST DESIGNATION |
|---|---|---|
| Long Term Design Strength | [_____] kN/m lb/inch | NCMA TR127B, Method A |

| TABLE 2 | | |
|---|---|---|
| PROPERTY | REQUIREMENT | TEST DESIGNATION |
| Permittivity | [0.5][_____] per second | ASTM D4491/D4491M |
| UV Resistance | 70 percent after 500 hours | ASTM D4355/D4355M |
| Seam Strength | [90 percent][_____] | ASTM D4884/D4884M |
| Coefficient of Interaction for Pullout | [.85][_____] | ASTM D6706 |
| Coefficient for Direct Shear | [_____] | ASTM D5321/D5321M |

2.1.3.3 Long Term Design Strength

Base the long term design strength on reduction factors for installation damage and durability that are applicable to the fill that will be used. Minimum reduction factors for durability include: 1.1 for polyethylene and polypropylene geosynthetics, 1.15 for coated polyester geogrids, and 1.6 for polyester geotextiles. Minimum reduction factors for creep include: 2.5 for polyester, 4 for polupropylene, and 2.6 for high density polyethylene.

Ranges for damage reduction factors in accordance with FHWA NHI-10-024 are listed in Table 3.

| TABLE 3 | | |
|---|---|---|
| GEOSYNTHETIC | Type 1 Backfill<br>Max. Size 10 cm 4 in.<br>D50 about 3 cm 1-1/4 in. | Type 2 Backfill<br>Max. Size 1.9 cm 3/4 in.<br>D50 about No. 30 |
| HDPE uniaxial geogrid | 1.20 - 1.45 | 1.10 - 1.20 |
| PP biaxial geogrid | 1.20 - 1.45 | 1.10 - 1.20 |
| PVC coated PET geogrid | 1.30 - 1.85 | 1.10 - 1.30 |
| Acrylic coated PET geogrid | 1.30 - 2.05 | 1.20 - 1.40 |
| Woven geotextiles (PP&PET)[a] | 1.40 - 2.20 | 1.10 - 1.40 |
| Non woven geotextiles (PP&PET)[a] | 1.40 - 2.50 | 1.10 - 1.40 |
| Slit film woven PP geotextile[a] | 1.60 - 3.00 | 1.10 - 2.00 |
| [a] Minimum weight 270 g/m2 8.0 oz/yd2. | | |

2.1.4 Reinforcement Splices

Provide reinforcement splices consisting of a standard method or device recommended and approved by the manufacturer of the reinforcing. Splices

less than 90 percent efficient (width wide tensile strength of splice to mean average roll value tensile strength of reinforcing) are not acceptable. Demonstrate and submit the splice efficiency. Splicing may consist of overlaps, fusion wedge welding, sewing, or bodkin connections. Splicing methods that are dependent on installer experience and skill level, such as hot air and torch-applied open flame, are not acceptable. Perform sewing by 2 lines of stitching with a Federal 401 double thread lock stitch with a thread of the same polymer type and UV protection as the geotextile. [Perform overlaps as indicated on the drawings.][Overlaps must be a minimum of[ 300][600] mm[ 12][ 24] inches for linear runs along the slope face where the primary design strength axes of adjacent reinforcement panels are parallel.] The overlap is to be protected from folding and/or bunching during installation of fill..

### 2.1.5 Seams

Test seams in accordance with method ASTM D4884/D4884M.

## 2.2 GEOTEXTILE FILTER

Meet the requirements specified in Table 4. The property values (except for AOS) represent minimum average roll values (MARV) in the weakest principal direction. For survivability during installation, meet the minimum requirements in AASHTO M 288 Class 2, and have a minimum mass per unit area of 270 g/m$^2$ 8 oz/sy.

TABLE 4. GEOTEXTILE PHYSICAL PROPERTIES

| PROPERTY | TEST REQUIREMENT | TEST METHOD |
|---|---|---|
| Grab Tensile | [700 N160 lbs. nonwoven] | ASTM D4632/D4632M |
| | [1100 N250 lbs. woven] | |
| Apparent Opening Size | 150 - 212 um70 - 100 U.S. Sieve | ASTM D4751 |
| UV Resistance | 80 percent after 500 hours | ASTM D4355/D4355M |
| Permittivity, sec$^{-1}$ | 0.5 | ASTM D4491/D4491M |

## 2.3 TURF REINFORCEMENT MAT

Turf Reinforcement Mat (TRM) must consist of nondegradable monofilaments and meet the requirements specified in Table 5. The property values (except for AOS) represent minimum average roll values (MARV) in the weakest principal direction.

| TABLE 5. TRM PHYSICAL PROPERTIES | | |
|---|---|---|
| PROPERTY | TEST REQUIREMENT | TEST METHOD |
| Tensile Strength | [_____] kN/mlbs/ft | ASTM D5035 |
| UV Resistance | 80 percent after 500 hours | ASTM D4355/D4355M |
| Thickness | 8 mm300 mils | ASTM D5199 |

## 2.4 EROSION CONTROL BLANKET

**********

**NOTE: In 1999, there are 4 proposed ASTM standards for ECB's: (1) Measuring Mass per Unit Area of Erosion Control Blankets, (2) Determination of Erosion Control Blanket (ECB) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion, (3) Determination of Erosion Control Blanket (ECB) Performance in Protecting Hillslopes from Rainfall-Induced Erosion, and (4) Tensile Properties Breaking Force and Elongation of Erosion Control Blankets.**

**********

Erosion control blanket (ECB) must consist of biodegradable open weave blankets used for establishing vegetation and have a minimum mass per unit area of [_____] $g/m^2$ oz/SY, determined in accordance with ASTM D5261.

## 2.5 SOILS AND AGGREGATES

Classify all material placed as fill by ASTM D2487 as GW, GP, GC, GM, SP, SM, SC, CL, ML, or SW and be free of ice; snow; frozen earth; trash; debris; sod; roots; organic matter; contamination from hazardous, toxic or radiological substances; or stones larger than 75 mm 3 inches in any dimension. Obtain each material entirely from one borrow source, unless the Contracting Officer determines that quality control is adequate and the alternate source produces material that is similar in gradation, texture, and interaction with the reinforcement. All materials must be of a character and quality satisfactory for the purpose intended.

a. Reinforced Fill. Soil placed in the reinforced fill zone must consist of [soils with less than 50 percent passing the 75 µm No. 200 sieve, maximum particle size of 1.9 cm 3/4-inch, and Plasticity Index less than or equal to 20] [alternate properties of available fill soils consistent with soil strengths and reinforcement damage assessment utilized in design]. The reinforced fill soils must have a minimum drained friction angle of 28 [_____] degrees.

b. Retained Fill. Soil in the retained fill zone [consists of existing in-situ soils][meets the material classification and requirements listed above].

[c. Drainage Aggregate. Meet the requirements of ASTM D448, size No.7].

## 2.6 DRAINAGE PIPE

Corrugated polyethylene pipe meeting requirements of AASHTO M 252.

## 2.7 SEED

Provide state-certified seed of the latest season's crop in original sealed packages bearing the producer's guaranteed analysis for mixture percentage, purity, germination, weed seed content, and inert material. Provide labels that are in conformance with AMS Seed Act and applicable state seed laws. Proportion the seed mix by weight as follows: [_____].

# PART 3 EXECUTION

## 3.1 SHORING

Construct shoring in accordance with the safety requirements of EM 385-1-1. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations[ at least 30 days prior to installation]. Also include sequencing and methods of shoring installation and removal that will facilitate verification that the methods will not leave voids, seepage paths, or other deficiencies. The Contractor is responsible for design and maintenance of all shoring to be installed. Do not negatively impact existing and proposed work during installation. Unless otherwise authorized, remove all sheeting and bracing when backfill is completed. Do not negatively impact completed work during removal.

## 3.2 EARTHWORK

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**NOTE: Notification of the Contracting Officer - It is beyond the scope of a specification to provide remedies to all possible problems. If the specification indicates the Contracting Officer must be notified, it is assumed qualified assistance will be utilized to assess the situation when necessary.**

**********

Bear the reinforced fill zone on undisturbed native soils, or acceptably placed and compacted fill. In the event that it is necessary to remove material or place fill below the excavation lines shown on the drawings, or not otherwise provided for in the contract, notify the Contracting Officer prior to work and an adjustment in the contract price will be considered in accordance with the contract. It is at the Contractor's expense if additional work not authorized by the Contracting Officer is performed.

### 3.2.1 Excavation

Excavate to contours, elevation, and dimensions indicated. Reuse excavated materials that meet the specified requirements for the material type required at the intended location. Keep excavations free from water. Excavate soil disturbed or weakened by Contractor's operations, soils softened or made unsuitable for subsequent construction due to exposure to weather. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. [_____][Remove as directed] unsatisfactory material encountered below the grades shown.[ Refill with [backfill and fill material][satisfactory material][select

material][porous fill] and compact to [95][_____] percent of [ASTM D698][ ASTM D1557] maximum density.][ Unless specified otherwise, refill excavations cut below indicated depth with [backfill and fill material][satisfactory material][select material][porous fill] and compact to [95][_____] percent of [ASTM D698][ASTM D1557] maximum density.] Replace satisfactory material removed below the depths indicated, without specific direction of the Contracting Officer, with satisfactory materials to the indicated excavation grade; except as specified for spread footings. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated will be done under the direction of the Contracting Officer. Perform excavation and fill in a manner and sequence that will provide proper drainage at all times. The Contractor is responsible for disposal of surplus material, waste material, and material that does not meet specifications, including any soil which is disturbed by the work operations or softened due to exposure to the elements and water.

### 3.2.2 Stockpiles

Stockpile material for backfilling in a neat and orderly manner at a sufficient distance from the banks of the excavation to avoid overloading and to prevent slides or caving. Keep stockpiles of all material to be incorporated into the work in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal the ground surface at stockpile locations. Stockpile topsoil separately from suitable backfill material. Protect stockpiles of aggregates and granular soils from contamination which can destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes frozen, saturated, intermixed with other materials, or otherwise out of specification or unsatisfactory for the use intended, remove such material and replace with new material from approved sources at no additional cost to the Government.

## 3.3 SUBGRADE PREPARATION

Remove unsatisfactory material in surfaces to receive fill or in excavated areas and replace with satisfactory materials as directed by the Contracting Officer. Scarify the surface to a depth of 150 mm 6 inches before the fill is placed. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 150 mm 6 inches), pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 300 mm 12 inches and compact as specified for the adjacent fill. Do not place material on surfaces that are muddy, frozen, or contain frost. Accomplish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material or aerate as necessary [to plus or minus [_____] percent of optimum moisture][to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used]. Minimum subgrade density is as specified herein. Smooth the surface to be free of windrows, sheepsfoot impressions, and rocks. Do not place reinforcement directly on native soil unless the upper 0.3 meter 1 foot of soil meets specification of fill materials.

## 3.4 PROOF ROLLING

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**NOTE: Specify proof rolling when the quality of the existing subgrade is questionable. Proof rolling can be used to verify that no unsatisfactory material is present (no bid quantity required, location shown or specified) or to locate suspected unsatisfactory material (indicate a bid quantity to be removed).**

**********

Perform proof rolling on an exposed subgrade free of surface water at near optimum, or at the moisture content that was used to achieve the required compaction.[ If proof-rolling is performed after installation of pipe underdrains, do not use the proof-roller within 0.5 m 1-1/2 feet of the underdrains.] Perform proof-rolling with a 22,680 kg 25 ton pneumatic-tired tandem axle roller with at least three wheels on each axle, a minimum tire pressure of 5.2 kg per square centimeter 75 pounds per square inch, and a minimum rolling width of 1.9 m 75 inches. Operate proof-rolling equipment at a speed between 2.4 to 4.8 km per hour 1.5 to 3 miles per hour. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Carry out proof-rolling in two directions at right angles to each other with no more than 60 cm 24 inches between tire tracks of adjacent passes. Operate the proof-roller in a pattern that readily allows for the recording of deformation data and complete coverage of the subgrade.

Take the following actions based on the results of the proof-rolling activity in accordance with FHWA NHI-10-025:

1. Rutting less than 6 mm 1/4 inch – The grade is acceptable.

2. Rutting greater than 6 mm 1/4 inch and less than 38 mm 1-1/2 inches – Scarify and re-compact the grade.

3. Rutting greater than 38 mm 1-1/2 inches – Remove and reconstruct the compacted area.

4. Pumping (deformation that rebounds, or materials that are squeezed out of a wheel’s path) greater than 25 mm 1 inch – Remediate the area as directed by the Engineer.

## 3.5 REINFORCEMENT INSTALLATION

a. Place reinforcement at the elevations and to the extent shown on the construction drawings and the approved shop drawing submittal. Orient the reinforcement with the design strength axis perpendicular to the slope face. Place reinforcement strips as indicated on the drawings to provide 100 percent coverage of the reinforced area. Keep reinforcement from being exposed to direct sunlight after installation. [This can be accomplished by requiring coverage with reinforced fill material during the same work shift.]

b. Install the reinforcement in tension. Pull the reinforcement taut and anchor with pins, staples, or stakes prior to placing the overlying lift of fill. Maintain uniform tension along the length of the slope and consistent between layers.

c. Where the slope bends, place a veneer of fill to a nominal thickness of

75 mm 3 inches to separate overlapping reinforcement. [Overlap a minimum of 150 mm 6 inches along the edges perpendicular to the slope for wrapped face structures.][With grid reinforcement, clip or tie the edges together.][When reinforcements are not required for face support, no overlap is required and edges should be butted.]

d. Splicing. Splicing is not allowed unless identified on the shop drawings. Limit splicing to only one splice per reinforcing strip and do not include a splice with two consecutive reinforcing. Place splices randomly without a pattern. Discard individual reinforcing lengths less than 3 meters 10 feet. Place seams facing upward for inspection purposes.

## 3.6 FILL PLACEMENT

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**NOTE: Subparagraph "b." below - Studies have documented rubber tired heavy equipment traveling on geogrids with minimal or no damage. However, it is regarded as poor practice and usually unnecessary. Problematic conditions include coarse crushed gravel and coated geogrids. The intent of the specification is to minimize equipment on the geogrid so that it occurs only when necessary.**

**********

a. Place reinforced fill from the slope face back toward the fill area to ensure that the reinforcement remains taut. Place, spread, and compact fill in such manner that minimizes the development of wrinkles in or movement of the reinforcement.

b. A minimum fill thickness of 150 mm 6 inches is required prior to operation of vehicles over the reinforcement. Avoid sudden braking and sharp turning. Do not turn tracked equipment within the reinforced fill zone to prevent tracks from displacing the fill and damaging the reinforcement. Do not operate construction equipment directly upon the reinforcement as part of the planned construction sequence. Rubber tired equipment can operate directly on the reinforcement if the travel is infrequent, equipment travels slow, turning is minimized, and no damage or displacement to the reinforcement is observed.

c. At the end of each day, slope the last lift of fill away from chimney drains in a manner that will allow drainage and direct runoff away from aggregate.

## 3.7 COMPACTION

Do not place fill on surfaces that contain mud, frost, organic soils, fill soils that have not met compaction requirements, or where the Contracting Officer determines that unsatisfactory material remains in or under the fill. Spread fill and compact in lifts[ not exceeding the height of the face wrapping].

### 3.7.1 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D698 or ASTM D1557. The maximum density is hereafter abbreviated as the "Standard Proctor" or

"Modified Proctor"value.

3.7.2 Moisture Control

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**NOTE: Moisture content limits for compaction should be included in these paragraphs when necessary for obtaining strength and stability in embankments and fill, for controlling movement of expansive soils and when, in the opinion of the project geotechnical engineer, moisture control is required for the soils being used. Specify an acceptable variation from the optimum moisture if justified from experience with similar soils or where demonstrated from moisture-density tests for the borrow material during planning.**

**********

Maintain control of moisture in the fill to provide acceptable compaction. In the stockpile, excavation or borrow areas, a minimum of two tests per day per type of material or source of materials being placed is required during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and test approved moisture content in accordance with ASTM D2216. Include moisture content test results in daily report. Disking and plowing will not be allowed in the reinforced fill zone. Adjust moisture content of cohesive soils at the borrow source before placement. Only conduct adding water directly to the reinforced fill zone under conditions where the soil has sufficient porosity and capillarity to provide uniform moisture throughout the fill during compaction. Ensure that moisture content is within plus or minus [2][_____] percentage points of optimum moisture content as determined in ASTM D698 or ASTM D1557.

3.7.3 Compaction

Compact reinforced and retained fill to 95[_____] percent of the Standard Proctor as determined in ASTM D698.

3.8 SOIL TESTING

3.8.1 General

All testing expenses is the Contractor's responsibility. Prior to sampling and testing the work, inspect testing laboratories and approve in accordance with Section 01 45 0001 45 00.00 40 QUALITY CONTROL. The Contracting Officer reserves the right to direct the location and select the material for samples to be tested and to direct where and when moisture-density tests are to be performed.

3.8.2 Transmittal

Inform the Contracting Officer of test results daily for direction on corrective action required. Provide draft copies of field testing results to the Contracting Officer on a frequent and regular basis, as directed. Submit testing data specific to the reinforcement to be supplied:

a. Establish the coefficient for direct shear of the reinforcement on a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone in accordance with

ASTM D5321/D5321M.

b. Establish the coefficient of interaction for pull-out resistance of the reinforcement in a soil similar in gradation and texture to the material that will be used for fill in the reinforced zone in accordance with ASTM D6706.

3.8.3 Corrective Action

Tests of materials which do not meet the contract requirements (failed test) will not be counted as part of the required testing. If testing indicates material does not meet the contract requirements, do not place the material represented by the failed test in the contract work or recompact or remove. Determine the quantity of material represented by the failed test by the Contracting Officer up to the quantity represented by the testing frequency. The Contractor may increase testing frequency in the vicinity of a failed test in order to reduce removal requirements, as approved by the Contracting Officer. Such increases in testing frequency are at the Contractor's expense and at no additional cost to the Government.

3.8.4 Testing Schedule

a. Moisture-Density Relations (ASTM D698or ASTM D1557)

One test for each material variation[, not less than [_____] tests total].

b. In-Place Densities (ASTM D1556/D1556M or ASTM D6938)

**********

**NOTE: Density test frequency can vary from one test per 10 square meter 100 square feet for small areas up to one test per 900 square meter 10,000 square feet. The following table will also help establish test frequency for various situations:**

| | | |
|---|---|---|
| **Borrow** | **Any** | **One test per lift per 400 cubic m placed.** |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

| Material Type | Location of Material | Test Frequency |
|---|---|---|
| Undisturbed native soil | Structures | Two random tests in native soil building footings and two tests on subgrade within building line. |
| Fills and backfills | Structures (adjacent to) | One test per structure per 2,000 sq. ft taken 12 inches below finished grade. |
| Subgrades | Site (except airfields) | One test per lift per 2,500 sq. ft |
| Embankments or borrow | Any | One test per lift per 500 cubic yds placed. |
| Native soil subgrade other than structures and parking | Any | One test or one test per 10,000 sq. ft whichever is greater. |
| Borrow | Any | One test per lift per 500 cubic yds placed. |

**********

Test each lift at randomly selected locations every [200] [_____] square meters [2000][_____] square feet of existing grade in fills for structures and concrete slabs, and every [250] [_____] square meters [2500][_____] square feet for other fill areas and every [200] [_____] square meters [2000][_____] square feet of subgrade in cut. Test density in accordance with ASTM D1556/D1556M, or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556/D1556M density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556/D1556M density test at the start of the job, and for every ten ASTM D6938 density tests thereafter. Include density test results in daily report.

c. Sieve Analysis, (ASTM C136/C136M)

Drainage Aggregate, 1 test for each source.

## 3.9 REINFORCEMENT TESTING

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**NOTE: Primary reasons for testing geosynthetics include verification of quality control by the manufacturer, detecting degradation during shipping and storage, and verifying the correct product is supplied. Verification of quality control by the manufacturer and detecting degradation during shipping and storage is not economically justified for small jobs. Unlike reinforcing steel for concrete, geosynthetics are difficult to identify in the field, and even experienced personnel can sometimes mistake the product identity of unlabeled material. Testing after delivery to verify the correct product was supplied may be advisable for critical structures. The strength is usually the most critical property to verify an acceptable product is furnished.**

**********

It is the Contractor's responsibility for all testing expenses. Perform testing by a commercial testing laboratory selected by the Contractor and approved by the Contracting Officer or performed by the Contractor if approved by the Contracting Officer. The Contracting Officer reserves the right to direct the location and select the material for samples.

| TABLE 6. REINFORCEMENT TESTING | | |
|---|---|---|
| PROPERTY | TEST DESIGNATION | FREQUENCY |
| Wide Width Strip Tensile Strength (Geotextiles) | ASTM D4595 | [_____] |
| Single Rib Tensile Strength (Geogrids) | ASTM D6637 | [_____] |
| Specific Gravity (HDPE only) | ASTM D1505 | [_____] |
| Melt Flow Index (PP & HDPE) | ASTM D1238 | [_____] |

Modify ASTM D4595 for geogrids considering recommendations in GSI GRI GG6; and express the tensile strength on a unit length basis by substituting n*a for Ws, where:

Ws = specimen width, (mm inches)
n = number of ribs in the sample (must be a whole number)
a = nominal rib spacing for the product tested, (mm inches)

## 3.10 DRAINAGE PIPE

Place drain pipe as indicated on the drawings. Lay drain lines to true grades and alignment with a continuous fall in the direction of flow. Keep the interior of the pipe clean from soil and debris; and temporarily cap open ends as necessary.

## 3.11 EROSION CONTROL

Install erosion control in accordance with the manufacturer's recommendations. Clear the ground surface of vegetation, cobbles, rubbish, or debris prior to placement.

## 3.12 SEEDING

Apply seed at the rate of 18 square m/kg 10 square yards per pound of seed. Evenly distribute the seed by hand or using broadcast seeders. Cover seed to a nominal 13 mm 1/2 inch depth by rakes.

## 3.13 CONSTRUCTION TOLERANCES

a. Horizontal: Ensure the slope crest and toe are within 150 mm 6 inches of the plan location.

b. Vertical: Ensure the slope crest elevations are within 90 mm 0.3 feet above to 90 mm 0.3 feet below the prescribed elevations shown on the drawings.

## 3.14 PROTECTION OF WORK

Protect work against damage from subsequent operations.

-- End of Section --