
USACE / NAVFAC / AFCEA UFGS-02332 (August 2004)

Preparing Activity: USACE (CW) Superseding
UFGS-02332A (July 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

Latest change indicated by CHG tags

SECTION 02332

REINFORCED SOIL SLOPE 08/04

NOTE: This guide specification covers the requirements for steepened soil slopes using geosynthetic soil reinforcement.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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 REFERENCES

NOTE: Issue (date) of references included in
project specifications need not be more current than
provided by the latest guide specification. Use of
SpecsIntact automated reference checking is
recommended for projects based on older guide
specifications.

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 (2002) Corrugated Polyethylene Drainage Pipe

AASHTO M 288 (2000) Geotextile Specifications for Highway Applications

ASTM INTERNATIONAL (ASTM)

ASTM C 136 (2001) Sieve Analysis of Fine and Coarse Aggregates

ASTM D 1556 (2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D 2487 (2000) Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D 2488 (2000) Description and Identification of Soils (Visual-Manual Procedure)

ASTM D 2922 (2001) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

ASTM D 4355 (2002) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus

ASTM D 448 (2003) Sizes of Aggregate for Road and Bridge Construction

ASTM D 4491 (1999a) Water Permeability of Geotextiles by Permittivity

ASTM D 4595 (1986; R 2001) Tensile Properties of Geotextiles by the Wide-Width Strip Method

ASTM D 4632 (1991; R 1996) Grab Breaking Load and Elongation of Geotextiles

ASTM D 4751 (1999a) Determining Apparent Opening Size of a Geotextile

ASTM D 4873	(2002) Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D 5035	(1995; R 2003) Breaking Force and Elongation of Textile Fabrics (Strip Method)
ASTM D 5199	(2001) Measuring Nominal Thickness of Geosynthetics
ASTM D 5261	(1992; R 1996) Measuring Mass Per Unit Area of Geotextiles
ASTM D 5321	(2002) Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
ASTM D 698	(2000a) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GG1	(1987; R 1988) Geogrid Rib Tensile Strength
GSI GRI GG5	(1991) Test Method for Geogrid Pullout
GSI GRI GG6	(1996) Grip Types for Use in Wide Width Testing of Geotextiles and Geogrids
GSI GRI GT6	(1992) Geotextile Pullout

NATIONAL CONCRETE MASONRY ASSOCIATION (NCMA)

NCMA TR127	(1997) Design Manual for Segmental Retaining Walls
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U.S. ARMY CORPS OF ENGINEERS (USACE)

COE EM 385-1-1	(2003) Safety -- Safety and Health Requirements
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U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act	(1940; R 1988; R 1998) Federal Seed Act
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U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

FHWA SA-96-071	(2001) Mechanically Stabilized Earth Walls and Reinforced Soil Slopes: Design and Construction Guidelines
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1.2 DEFINITIONS

NOTE: Subparagraph "e. Reinforcement" - This guide

specification only applies to geosynthetic (extensible) reinforcement. There are differences in design and construction applicable to steel soil (inextensible) reinforcement.

- a. Drainage Aggregate. Granular soil or aggregate which is placed in or around drains.
- b. Fill. Soil or aggregate placed in, behind, or below the embankment or slope will be referred to as fill.
- c. Reinforced Fill. Soil which is placed and compacted within the neat line volume of reinforcement as outlined on the plans.
- d. Retained Fill. Soil which is placed and compacted behind the reinforced fill.
- e. Reinforcement. Reinforcement shall consist of a geogrid or a geotextile product manufactured for use as reinforcing. Reinforcement shall not include steel products.
- g. 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 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

1.3 SUBMITTALS

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detailed Drawings[; G][; G, [____]].

The fabrication and installation drawings shall be submitted as specified.

Shoring

Plans and design computations for all shoring used shall be submitted [at least 30 days prior to installation].

SD-03 Product Data

Geotextile Reinforcement

The Contractor shall submit descriptive technical data on the reinforcement and geotextile filter materials. The submittal shall include all material properties specified under paragraph PRODUCTS.

Field Testing Results

The Contractor shall submit testing data specific to the reinforcement to be supplied.

a. 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 shall be established in accordance with ASTM D 5321.

b. 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 shall be established in accordance with GSI GRI GG5 or GSI GRI GT6.

Calculations[; G][; G, [____]].

The Contractor shall submit calculations of the long term design strength for the reinforcement, as specified.

SD-04 Samples

Reinforcement

NOTE: 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 meter (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.

The Contractor shall submit samples of each type of reinforcement. The samples shall be labeled and have a minimum size 200 by 250 mm 8 by 10 inches. Geogrid shall include at least 2 apertures in each direction.

SD-07 Certificates

Certificates of Compliance

The Contractor shall submit an affidavit certifying that the reinforcement meets the project specifications. The affidavit shall be signed by an official authorized to certify on behalf of the manufacturer and shall be accompanied by 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, the supplier shall attach a statement certifying that the affidavit addressed to the wholesale company is representative of the material supplied.] The documents shall include a statement confirming that all purchased resin used to produce reinforcement is virgin resin. The mill certificate shall include the tensile strength tested in accordance with either ASTM D 4595 or GSI GRI GG1.

1.4 MEASUREMENT AND PAYMENT

1.4.1 Excavation

The unit of measurement for excavation will be 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 shall be unclassified and include 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 shall be incidental to excavation.

1.4.2 Fill

Materials of all types not otherwise paid for shall be included under the unit price for fill. The unit of measurement for fill will be 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.

1.4.3 Soil Slope Reinforcement

The unit of measurement for reinforcement will be 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.

1.4.4 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.

1.4.5 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 shall include [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.

1.5 MANUFACTURER'S REPRESENTATIVE

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

1.6 DELIVERY, STORAGE AND HANDLING

The Contractor shall check products upon delivery to assure that the proper material has been received and is undamaged. The Contractor shall protect the materials from damage and exposure following the guidelines presented in ASTM D 4873.

1.6.1 Labeling

Each roll shall be labeled with the manufacturer's name, product identification, roll dimensions, lot number, and date manufactured.

1.6.2 Handling

Geosynthetic rolls shall be handled and unloaded by hand, or with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Geosynthetic rolls shall not be dragged, lifted by one end, lifted by cables or chains, or dropped to the ground.

1.6.3 Storage

Geosynthetics shall be protected 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 may degrade the physical properties. If stored outdoors, the rolls shall be elevated from the ground surface. Geosynthetics, except for extruded grids, shall be protected with an opaque waterproof cover. Geosynthetics shall be delivered to the site in a dry and undamaged condition. Geotextiles shall not be exposed to direct sunlight for more than 7 days.

1.7 SHORING

Shoring shall be constructed in accordance with the safety requirements of COE EM 385-1-1. The Contractor shall be responsible for design and maintenance of all shoring which the Contractor proposes to install. Unless otherwise authorized, all sheeting and bracing shall be removed when backfill is completed.

1.8 DETAILED DRAWINGS

The Contractor shall submit Shop 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 shall be subject to the following:

- a. All features indicated in the contract documents shall be incorporated in the final design and construction.
- b. Each reinforcement level shall run as continuous as practical throughout the profile. If a geotextile filter is present, the reinforcement shall be laid out so that interference with the geotextile is minimized.
- c. Any reinforcement not placed with the machine direction as the design reinforcement direction shall be identified on the shop drawings.

PART 2 PRODUCTS

2.1 REINFORCEMENT

NOTES: 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 D 4603, "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 D 4833), the trapezoidal tear strength (ASTM D4533) 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 Contractor shall submit Certificates of Compliance for the materials as specified in the Submittals paragraph; and calculations of the long term design strength for the reinforcement in accordance with the NCMA TR127 or FHWA SA-96-071. The ultimate strength or index strength shall be based on the minimum average roll value tensile strength of the product using the wide width strength test in ASTM D 4595 or the single rib test in GSI GRI GG1. The calculation shall itemize each reduction factor and include backup data to justify each reduction factor. Splice efficiency shall be demonstrated from testing if used.

2.1.1 Geogrid Reinforcement

Geogrid shall be a geosynthetic manufactured for reinforcement applications. The geogrid shall 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 shall be dimensionally stable and able to retain its geometry under manufacture,

transport and installation. The geogrid shall be manufactured with 100 percent virgin resin consisting of polyethylene, polypropylene, or polyester, and with a maximum of 5 percent in-plant regrind material. Polyester resin shall have a minimum molecular weight of 25,000 and a carboxyl end group number less than 30. Polyethylene and polypropylene shall be stabilized with long term antioxidants.

2.1.1.2 Geotextile Reinforcement

Geotextile shall be a pervious sheet of polymeric material and shall consist of long-chain synthetic polymers composed of at least 95 percent by weight polyethylene, polypropylene, or polyesters. The geotextile shall be manufactured with 100 percent virgin resin, and with a maximum of 5 percent in-plant regrind material. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the selvages. Polyester resin shall have a minimum molecular weight of 20,000 and a carboxyl end group number less than 50. Polyethylene and polypropylene shall be stabilized with long term antioxidants. For survivability during installation, and in addition to installation damage used in calculating the long term design strength, the geotextile shall meet the minimum requirements in AASHTO M 288 Class 1, and shall have a minimum mass per unit area of 270 g/m² 8 oz/sy.

2.1.1.3 Reinforcement Properties

NOTES: 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

The reinforcement shown on the contract drawings shall meet the property requirements listed in Table 1. 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 TR127, Method A
Permittivity	[0.5] per second	ASTM D 4491
UV Resistance	70 percent after 500 hours	ASTM D 4355
Coefficient of Interaction for Pullout	[.85]	GSI GRI GG5 or GSI GRI GT6
Coefficient for Direct Shear	[_____]	ASTM D 5321

2.1.3.2 Secondary Reinforcement Properties

The reinforcement shown on the contract drawings shall meet the property

requirements listed in Table 2. 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 TR127, Method A
Permittivity	[0.5] per second	ASTM D 4491
UV Resistance	70 percent after 500 hours	ASTM D 4355
Coefficient of Interaction for Pullout	[.85]	GSI GRI GG5 or GSI GRI GT6
Coefficient for Direct Shear	[_____] kN/m lb/inch	ASTM D 5321

2.1.3.3 Long Term Design Strength

The long term design strength shall be based 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.

2.1.4 Reinforcement Splices

Splices in reinforcement shall consist of a standard method or device recommended and approved by the manufacturer of the reinforcing. Splices shall be not less than 90 percent efficient (width wide tensile strength of splice to mean average roll value tensile strength of reinforcing). The splice efficiency shall be demonstrated from testing and shall be submitted. 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. Sewing shall include 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. Overlaps shall be separated by 50 mm 2 inches of soil.

2.2 GEOTEXTILE FILTER

Geotextiles used as filters shall meet the requirements specified in Table 3. The property values (except for AOS) represent minimum average roll values (MARV) in the weakest principal direction. For survivability during installation, the geotextile shall meet the minimum requirements in AASHTO M 288 Class 2, and shall have a minimum mass per unit area of 270 g/m² 8 oz/sy.

TABLE 3. GEOTEXTILE PHYSICAL PROPERTIES

PROPERTY	TEST REQUIREMENT	TEST METHOD
Grab Tensile, N	[700 nonwoven]	ASTM D 4632

TABLE 3. GEOTEXTILE PHYSICAL PROPERTIES

PROPERTY	TEST REQUIREMENT [1100 woven]	TEST METHOD
Apparent Opening Size (um)	[150 - 212]	ASTM D 4751
UV Resistance	80 percent after 500 hours	ASTM D 4355
Permittivity, sec ⁻¹	[0.5]	ASTM D 4491

TABLE 3. GEOTEXTILE PHYSICAL PROPERTIES

PROPERTY	TEST REQUIREMENT	TEST METHOD
Grab Tensile, lbs.	[160 nonwoven] [250 woven]	ASTM D 4632
Apparent Opening Size (U.S. Sieve)	[70 - 100]	ASTM D 4751
UV Resistance	80 percent after 500 hours	ASTM D 4355
Permittivity, sec ⁻¹	[0.5]	ASTM D 4491

2.3 TURF REINFORCEMENT MAT

Turf Reinforcement Mat (TRM) shall consist of nondegradable monofilaments; and shall meet the requirements specified in Table 4. The property values (except for AOS) represent minimum average roll values (MARV) in the weakest principal direction.

TABLE 4. TRM PHYSICAL PROPERTIES

PROPERTY	TEST REQUIREMENT	TEST METHOD
Tensile Strength, kN/m	[_____]	ASTM D 5035
UV Resistance	80 percent after 500 hours	ASTM D 4355
Thickness, mm	[8]	ASTM D 5199

TABLE 4. TRM PHYSICAL PROPERTIES

PROPERTY	TEST REQUIREMENT	TEST METHOD
Tensile Strength, lbs/ft	[_____]	ASTM D 5035
UV Resistance	80 percent after 500 hours	ASTM D 4355
Thickness, mils	[300]	ASTM D 5199

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) shall consist of biodegradable open weave blankets used for establishing vegetation. The ECB shall have a minimum mass per unit area of [_____] g/m² oz/SY, determined in accordance with ASTM D 5261.

2.5 SOILS AND AGGREGATES

All material placed as fill shall consist of material classified by ASTM D 2487 as GW, GP, GC, GM, SP, SM, SC, CL, ML, or SW. The material shall 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. Each material shall be obtained 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 shall be of a character and quality satisfactory for the purpose intended.

a. Reinforced Fill. Soil placed in the reinforced fill zone shall consist of [granular material with less than 35 percent passing the 75 µm No. 200 sieve].

b. Retained Fill. Soil placed in the retained fill zone shall [meet the minimum requirements above].

[c. Drainage Aggregate shall meet the requirements of ASTM D 448, size No.7].

2.6 DRAINAGE PIPE

The drainage pipe shall be corrugated polyethylene pipe meeting requirements of AASHTO M 252.

2.7 SEED

State-certified seed of the latest season's crop shall be provided in original sealed packages bearing the producer's guaranteed analysis for mixture percentage, purity, germination, weed seed content, and inert material. Labels shall be in conformance with AMS Seed Act and applicable state seed laws. The seed mix shall be proportioned by weight as follows: [_____] .

PART 3 EXECUTION

3.1 CLASSIFICATION OF SOIL MATERIALS

Classification of soil materials shall be performed by the Contractor in accordance with ASTM D 2488. 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 D 2487. All testing completed by the Contractor in conjunction with soil material classification will be considered incidental to the contract work.

3.2 EARTHWORK

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 shall be notified, it is assumed qualified assistance will be utilized to assess the situation when necessary.

The reinforced fill zone shall bear 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, the Contracting Officer shall be notified prior to work and an adjustment in the contract price will be considered in accordance with the contract. Additional work not authorized by the Contracting Officer shall be at the Contractor's expense.

3.2.1 Excavation

Foundation soil shall be excavated to the lines and grades shown on the construction drawings, and as required for reinforcement placement. Material for backfilling shall be stockpiled 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. Excavation and fill shall be performed 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 Contractor's operations or softened due to exposure to the elements and water.

3.2.2 Stockpiles

Stockpiles of all material to be incorporated into the work shall be kept in a neat and well drained condition, giving due consideration to drainage at all times. The ground surface at stockpile locations shall be cleared, grubbed, and sealed. Topsoil shall be stockpiled separately from suitable backfill material. Stockpiles of aggregates and granular soils shall be protected from contamination which may 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, such material shall be removed and replaced with new material from approved sources at no additional cost to the Government.

3.3 SUBGRADE PREPARATION

Material shall not be placed on surfaces that are muddy, frozen, contain frost, or where unsatisfactory material remains in or under the fill. For cohesionless soils, the subgrade surface shall be compacted with the same compactor and rolling pattern to be used for compaction of the fill. For cohesive soils, the subgrade shall be proof rolled with rubber tired equipment and any soft areas shall be brought to the Contracting Officer's attention.

3.4 REINFORCEMENT INSTALLATION

- a. Before placing reinforcement, the subgrade or subsequent lift of fill shall be compacted and graded level. The surface shall be smooth and free of windrows, sheepsfoot impressions, and rocks.
- b. Reinforcement shall be placed at the elevations and to the extent shown on the construction drawings and the approved shop drawing submittal. Reinforcement shall be oriented with the design strength axis perpendicular to the slope face. Reinforcement strips shall be placed immediately next to adjacent strips to provide 100 percent coverage.
- c. The reinforcement shall be installed in tension. The reinforcement shall be pulled taut and anchored with staples or stakes prior to placing the overlying lift of fill. The tension shall be uniform along the length of the slope and consistent between layers.
- d. All reinforcement shall be 100 percent covered by soil so that reinforcement panels do not contact in overlaps. Where the slope bends, a veneer of fill shall be placed to a nominal thickness of 75 mm 3 inches to separate overlapping reinforcement.
- e. Splicing. Splicing shall not be allowed unless identified on the shop drawings. Splicing shall be limited to only one splice per reinforcing strip and no two consecutive reinforcing strips shall include a splice. Splices shall be located randomly without a pattern. Individual reinforcing lengths less than 3 meters 10 feet shall be discarded. Seams shall be placed facing upward for inspection purposes.

3.5 FILL PLACEMENT

NOTE: 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. Reinforced fill shall be placed from the slope face back toward the fill area to ensure that the reinforcement remains taut. Fill shall be placed, spread, and compacted 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. Sudden braking and sharp turning shall be avoided. Tracked equipment shall not turn within the reinforced fill zone to prevent tracks from displacing the fill and damaging the reinforcement. Construction equipment shall not be operated directly upon the reinforcement as part of the planned construction sequence. Rubber tired equipment may 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, the Contractor shall slope the last lift of fill away from chimney drains in a manner that will allow drainage and direct runoff away from aggregate.

3.6 COMPACTION

Fill shall not be placed 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. Fill shall be spread and compacted in lifts not exceeding [the height of the face wrapping].

3.6.1 Degree of Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 698. The maximum density is hereafter abbreviated as the "Standard Proctor" value.

3.6.2 Moisture Control

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.

Control of moisture in the fill shall be maintained to provide acceptable compaction. Disking and plowing will not be allowed in the reinforced fill zone. Moisture content of cohesive soils shall be adjusted at the borrow source before placement. Adding water directly to the reinforced fill zone shall only be conducted under conditions where the soil has sufficient porosity and capillarity to provide uniform moisture throughout the fill during compaction.

3.6.3 Compaction

Reinforced and retained fill shall be compacted to 95 percent of the Standard Proctor Density.

3.7 SOIL TESTING

3.7.1 General

All testing expenses shall be the Contractor's responsibility. Prior to sampling and testing the work, testing laboratories shall be inspected and approved in accordance with Section 01451A CONTRACTOR 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 shall be performed. Nuclear density testing equipment shall be used in general accordance with ASTM D 2922.

3.7.2 Transmittal

The Contracting Officer shall be informed of test results daily for direction on corrective action required. Draft copies of field testing results shall be furnished to the Contracting Officer on a frequent and regular basis, as directed.

3.7.3 Corrective Action

Tests of materials which do not meet the contract requirements (failing test) will not be counted as part of the required testing. Each such failing test must be retaken at the same location as the failing test was taken. If testing indicates material does not meet the contract requirements, the material represented by the failing test shall not be placed in the contract work or shall be recompact or removed. The quantity of material represented by the failing test shall be determined by the Contracting Officer up to the quantity represented by the testing frequency. The Contractor may increase testing frequency in the vicinity of a failing test in order to reduce removal requirements, as approved by the Contracting Officer. Such increases in testing frequency shall be at the Contractor's expense and at no additional cost to the Government.

3.7.4 Testing Schedule

a. Moisture-Density Relations (ASTM D 698)

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

b. In-Place Densities (ASTM D 1556 or ASTM D 2922)

Not less than 1 test for each 670 vertical mm/100 linear m 2 vertical feet/300 linear feet along slope face.

c. Sieve Analysis, (ASTM C 136)

Drainage Aggregate, [1 test for each source].

3.8 REINFORCEMENT TESTING

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.

All testing expenses shall be the Contractor's responsibility. Testing shall be performed 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 5. REINFORCEMENT TESTING

PROPERTY	TEST DESIGNATION	FREQUENCY
Wide Width Strip Tensile Strength or Single Rib Tensile Strength	ASTM D 4595 GSI GRI GG1	[____] [____]

ASTM D 4595 shall be modified for geogrids considering recommendations in GSI GRI GG6; and the tensile strength shall be expressed on a unit length basis by substituting $n \cdot a$ for W_s , where:

W_s = 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)

3.9 DRAINAGE PIPE

Drain pipe shall be placed as indicated on the drawings. Drain lines shall be laid to true grades and alignment with a continuous fall in the direction of flow. The interior of the pipe shall be kept clean from soil and debris; and open ends shall be temporarily capped as necessary.

3.10 SEEDING

Seed shall be applied at the rate of 18 square m/kg of seed 10 square yards per pound of seed. The seed shall be evenly distributed by hand or using broadcast seeders. Seed shall be covered to a nominal 13 mm 1/2 inch depth by rakes.

3.11 CONSTRUCTION TOLERANCES

- a. Horizontal: The slope crest and toe shall be within 150 mm 6 inches of the plan location.
- b. Vertical: The slope crest elevations shall be within 90 mm 0.3 feet above to 90 mm 0.3 feet below the prescribed elevations shown on the drawings.

3.12 PROTECTION OF WORK

Work shall be protected against damage from subsequent operations.

-- End of Section --