Preparing Activity: USACE Superseding without Revision
UFGS-31 05 21 (August 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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02/21

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SECTION 31 35 19.13

GEOGRID SLOPE PROTECTION
02/21

NOTE: This guide specification covers the requirements for geogrid reinforcement to enhance the veneer soil stability for landfill liners and covers.

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: Geometric requirements such as slope length, and construction limits should be shown on the drawings.

1.1 MEASUREMENT AND PAYMENT

The unit of measurement for soil slope reinforcement will be square meters (SM) yards (SY). Overlaps for splices (if allowed) and for the Contractor's convenience will not be measured for payment. 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.

1.2 REFERENCES

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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.

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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.

ASTM INTERNATIONAL (ASTM)

ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4595	(2017) Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D5262	(2007; R 2016) Standard Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics
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

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GG4a	(2012) Determination of the Long-Term Design Strength of Stiff Geogrids
GSI GRI GG4b	(2012) Determination of the Long-Term Design Strength of Flexible Geogrids
GSI GRI GG6	(1996) Grip Types for Use in Wide Width Testing of Geotextiles and Geogrids

1.3 SUBMITTALS

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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.

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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

Installation; G[, [_____]]

SD-03 Product Data

Allowable Strength

Manufacturer

SD-04 Samples

Geogrid Reinforcement

SD-06 Test Reports

Geogrid Reinforcement

Coefficient of Interaction

Interface Friction Testing

Splices

Conformance Testing

SD-07 Certificates

Certificates of Compliance

1.4 QUALITY ASSURANCE

Submit a summary of the manufacturer's qualifications and [_____] copies of the manufacturer's quality control (QC) manual a minimum of 7 days prior to delivery of geogrid to the site. The reinforcement manufacturer must provide a qualified and experienced representative to be available on an as-needed basis during construction. Visit the site for consultation [at least once during construction] [as requested by the Contracting Officer].

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.5.1 Labeling

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

1.5.2 Handling

Handle and unload geogrid 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.

1.5.3 Storage

Protect geogrid from deleterious materials, 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, elevate the rolls from the ground surface. Protect geogrids, except for extruded grids, with an opaque waterproof cover.

PART 2 PRODUCTS

2.1 GEOGRID REINFORCEMENT

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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."

The geogrid sample is intended to be for visual demonstration prior to product delivery. Conformance testing samples, if required, 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.

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Submit one properly identified 600 by 600 mm 24 by 24 inches minimum size geogrid sample with the fasteners proposed for use. Provide a geogrid that is a geosynthetic manufactured for reinforcement applications and 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.

a. Submit manufacturer's certified raw and roll material test reports including ultimate strength performed in accordance with ASTM D6637 or ASTM D4595 (modified). Test results not meeting the requirements in Table 1 or in the approved Manufacturer's Quality Control Manual will result in rejection of applicable rolls. Provide certified test reports a minimum of 7 days prior to delivery of geogrid to the site.

b. Provide geogrid structure that is dimensionally stable and able to retain its geometry under manufacture, transport and installation.

Manufacture geogrid with 100 percent virgin resin consisting of polyethylene, polypropylene, polyester, or other approved material and with a maximum of 5 percent in-plant regrind material. Provide polyester resin with a minimum molecular weight of 25,000 and a carboxyl end group number less than 30. Stabilize polyethylene and polypropylene with long term antioxidants.

c. Submit Certificates of Compliance for the materials provided and results of conformance testing. Submit an affidavit certifying raw and roll material test results submitted are accurate and that the reinforcement meets the requirements of the project specifications. The affidavit must be signed by an official authorized to certify on behalf of the manufacturer. [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. Provide affidavit a minimum of 7 days prior to delivery of geogrid to the site.

2.1.1 Geogrid Reinforcement Properties

The reinforcement shown on the contract drawings must 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
Allowable Strength (Ta) at [5] [10] percent strain	[_____] kN/m lb/inch	GSI GRI GG4a or GSI GRI GG4b
UV Resistance	70 percent after 500 hours	ASTM D4355/D4355M
Coefficient of Interaction* for Pullout	0.85	ASTM D6706
Interface Friction at [Peak] [Residual], Degrees	[_____]	ASTM D5321/D5321M

*Submit the coefficient of interaction for pull-out resistance of the proposed geogrid in a soil of similar gradation and texture to the material that will be used for fill in the reinforced zone. Establish the coefficient of interaction in accordance with ASTM D6706. Provide certified test results a minimum of 7 days prior to delivery of geogrid to the site.

2.1.1.1 Allowable Strength

Submit Geogrid allowable strength calculated in accordance with GSI GRI GG4a or GSI GRI GG4b. Itemize each reduction factor. Account for splice efficiency in the calculations. Provide calculations a minimum of 7 days prior to delivery of geogrid to the site. Allowable strength is based on reduction factors for installation damage, durability, and creep that are applicable to site specific conditions. Determine reduction factors in accordance with the test procedures documented in GSI GRI GG4a or GSI GRI GG4b. The minimum reduction factor for durability is 1.1 for

polyethylene and polypropylene geogrids and 1.15 for coated polyester geogrids. The minimum reduction factor for installation damage is 1.1 for all polymers. Base the reduction factor for creep on testing performed in accordance with ASTM D5262 at the strain specified in Table 1.

2.1.1.2 Interface Friction Testing

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NOTE: If the geogrid will not be placed in an anchor trench, interface friction testing should be conducted to determine the runout length for the geogrid. All potential slip interfaces beneath the geogrid need to be tested in computing the required runout length. Normal stresses specified should be representative of anticipated field conditions. Selection of peak versus residual values should be based on anticipated interface displacements.

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Submit certified laboratory interface friction test results including description of equipment and test method, a minimum of 7 days prior to delivery of geogrid to the site. Conduct laboratory interface friction tests on the following interfaces: [_____]. The frequency of testing for each interface must be at a rate of [1] [_____] per project. Conduct tests in accordance with ASTM D5321/D5321M. Use normal stresses of [_____], [_____], and [_____] kPa [_____], [_____], and [_____] psi along with a displacement rate of [5.0] [_____] mm [0.2] [_____] inches per minute. Orient geosynthetics such that the shear force is parallel to the down slope orientation of these components in the field.

2.2 SPLICES

Provide splices consisting of a standard method or device recommended by the manufacturer of the geogrid. Splices will not be allowed unless identified on the approved layout drawings. Splices must be at least 75 percent efficient. Demonstrate the splice efficiency through tests performed in accordance with GSI GRI GG4a or GSI GRI GG4b. 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. Construct overlap splices by placing a minimum of 50 mm 2 inches of soil between the layers of geogrid.

PART 3 EXECUTION

3.1 INSTALLATION

Submit Geogrid layout plan along with anchorage and joint details, sequencing and construction procedures, a minimum of 7 days prior to geogrid placement.

3.1.1 Subgrade Preparation

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NOTE: For landfill slope reinforcement applications, geogrids are typically placed directly on the underlying geosynthetic surface.

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Immediately prior to placement of the geogrid, place the geogrid on a surface that is free of rock and other material that could damage the geogrid or the underlying geosynthetics.

3.1.2 Anchor Trench

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NOTE: Delete this paragraph if an anchor trench is not required. Anchor trench dimensions need to be determined on a site specific basis.

Anchor trench dimensions must be computed based on the pull-out resistance of the geogrid. However, pull-out resistance tests (ASTM D6706) are typically not performed due to the cost and complexity of this test procedure. Data bases of interaction coefficients for different geogrids, soils, and loading conditions are kept by geogrid manufacturers. Information from these data bases should be used to design the anchorage system.

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Place the anchor trench a minimum of [610] [_____] mm [24] [_____] inches back from the edge of the slope to be covered. The anchor trench must be a minimum of [610] [_____] mm [24] [_____] inches deep and [610] [_____] mm [24] [_____] inches wide. Remove ponded water from the anchor trench while the trench is open. Round trench corners to avoid sharp bends in the geogrid. Remove loose soil, rocks larger than [51] [_____] mm [2] [_____] inches in diameter, and any other material which could reduce the effectiveness of the geogrid from the surfaces of the trench. Extend the geogrid down the front wall and across the bottom of the anchor trench. Perform backfilling and compaction of the anchor trench in accordance with Section 31 00 00 EARTHWORK.

3.1.3 Placement

Install the geogrid in accordance with the Manufacturer's recommendations. Unroll the geogrid in the direction of reinforcement. After a layer of geogrid has been placed, use suitable means, that do not damage the underlying geosynthetics, to hold the geogrid flat and in place until cover soil can be placed. Remove geogrid damaged during placement and covering and replace at no additional cost to the Government.

3.1.4 Overlaps and Fasteners

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NOTE: Adjacent rolls of uniaxial geogrid should not be overlapped. The plastic-to-plastic contact has reduced frictional resistance.

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Position adjacent rolls of geogrid edge-to-edge and loosely fasten to maintain alignment during fill placement. Do not overlap adjacent rolls. Use fastener type and spacing as recommended by the manufacturer and approved by the Contracting Officer. Metallic fasteners will not be allowed.

3.1.5 Splices

Submit test data showing splice efficiency. Provide certified test results a minimum of 7 days prior to delivery of geogrid to the site. Locate splices, if allowed, within the bottom one-third of the slope. Limit splicing to only one splice per reinforcing strip and do not include a splice for two consecutive reinforcing strips. Do not use individual reinforcing lengths less than 3 meters 10 feet. Pull and hold splices taut in geogrid reinforcement during cover soil placement.

3.1.6 Penetrations

For small penetrations through geogrids, cut only transverse members of the geogrid. The load-carrying longitudinal (machine direction) members must be spread around the penetration. For larger penetrations, place additional geogrid on each side of the penetration and spliced to the adjacent geogrid to compensate for any longitudinal tensile members that must be cut.

3.2 COVER SOIL PLACEMENT

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NOTE: The maximum acceptable particle size of cover soil is a function of the minimum aperture size of the geogrid and the acceptable maximum particle size against the underlying geosynthetic layer. The book titled "Designing with Geosynthetics" by Dr. Robert Koerner provides guidance on computing the acceptable maximum particle size of cover soil material based on the apperature size of the geogrid.

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Cover geogrid with soil within [5] [_____] calendar days of acceptance. Keep the geogrid smooth and taut during placement of cover materials. Do not drop cover soil onto the geogrid from a height greater than 1 m 3 feet. Push the soil out over the geogrid in an upward tumbling motion. Place soil from the bottom of the slope upward. The initial loose soil lift thickness must be [350] [_____] mm [12] [_____] inches. Use equipment with ground pressures less than 50 kPa 7 psi to place the first lift over the geogrid. Maintain a minimum of [460] [610] [915] [_____] mm [18] [24] [36] [_____] inches of soil between construction equipment with ground pressures greater than 50 kPa 7 psi and the geogrid. Do not use equipment placing cover soil that stops abruptly, makes sharp turns, spins their wheels, or travels at speeds exceeding [2.2] [_____] m/s [5] [_____] mph. Additional cover soil material and placement requirements are described in Section 31 00 00 EARTHWORK.

3.3 OVERSIGHT

Keep a QA Representative present at all times during geogrid installation.

3.4 CONFORMANCE TESTING

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NOTE: Conformance testing is performed to verify quality control test results submitted by the manufacturer, to detect degradation during shipping and storage, and to verify 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.
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Submit results of conformance testing. Conformance testing expenses are the responsibility of the Contractor. Perform testing using a commercial testing laboratory selected by the Contractor and approved by the Contracting Officer. The laboratory must be accredited via the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP) for the tests the laboratory will be required to perform. The Contracting Officer reserves the right to direct the location and select the material for samples. Conformance test results must equal or exceed results reported on the Manufacturer's certified roll material test reports.

TABLE 5. CONFORMANCE TESTING		
PROPERTY	TEST DESIGNATION	FREQUENCY
Wide Width Strip Tensile Strength	[ASTM D4595 (mod)][or][ASTM D6637]	[_____]

Modify ASTM D4595 for geogrids considering recommendations in GSI GRI GG6. 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)

-- End of Section --