****
USACE / NAVFAC / AFCESA | **UFGS-02375 (August 2004)**

Preparing Activity: USACE | **Superseding UFGS-02375A (July 2004)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

Latest change indicated by CHG tags
****

SECTION 02375

GEOGRID SOIL REINFORCEMENT
08/04

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

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

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.

ASTM INTERNATIONAL (ASTM)

ASTM D 4355	(2002) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D 4595	(1986; R 2001) Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D 4873	(2002) Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D 5262	(2002a) Evaluating the Unconfined Tension Creep Behavior of Geosynthetics
ASTM D 5321	(2002) Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GG1	(1987; R 1988) Geogrid Rib Tensile Strength
GSI GRI GG4a	(1991) Determination of the Long-Term Design Strength of Stiff Geogrids
GSI GRI GG4b	(1991) Determination of the Long-Term Design Strength of Flexible Geogrids
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

1.2 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.

1.3 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

Installation[; G][; G, [_____]]

Geogrid layout plan along with anchorage and joint details. Sequencing and construction procedures shall also be included. Proposed geogrid layout shall be provided a minimum of 7 days prior to geogrid placement.

SD-03 Product Data

Allowable Strength

Geogrid allowable strength calculated in accordance with GSI GRI GG4a or GSI GRI GG4b. The calculations shall itemize each reduction factor. Splice efficiency shall be accounted for in the calculations. Calculations shall be provided a minimum of 7 days prior to delivery of geogrid to the site.

Manufacturer

Summary of manufacturer's qualifications a minimum of 7 days prior to delivery of geogrid to the site. Manufacturer's quality control (QC) manual a minimum of 7 days prior to the delivery of geogrid to the site.

SD-04 Samples

Geogrid Reinforcement

****
NOTE: 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.
****

One properly identified 600 by 600 mm 24 by 24 inches minimum size geogrid sample. The fasteners proposed for use shall also be submitted.

SD-06 Test Reports

Geogrid Reinforcement

Manufacturer's certified raw and roll material test reports. Roll material tests shall include ultimate strength performed in accordance with GSI GRI GG1 or ASTM D 4595 (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. Certified test reports shall be provided a minimum of 7 days prior to delivery of geogrid to the site.

Coefficient of Interaction

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. The coefficient of interaction shall be established in accordance with GSI GRI GG5. Certified test results shall be provided a minimum of 7 days prior to delivery of geogrid to the site.

Interface Friction Testing

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.

Splices

Test data showing splice efficiency. Certified test results shall be provided a minimum of 7 days prior to delivery of geogrid to the site.

Conformance Testing

Results of conformance testing.

SD-07 Certificates

Certificates of Compliance

The Contractor shall 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 shall 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, 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. Affidavit shall be provided a minimum of 7 days prior to delivery of geogrid to the site.

1.5 MANUFACTURER

The Contractor shall submit a summary of the manufacturer's qualifications and [_____] copies of the manufacturer's quality control manual, as specified in the Submittals paragraph. The reinforcement manufacturer shall provide a qualified and experienced representative to be available on an as-needed basis during 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 dry and 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

Geogrid 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

Geogrid shall be protected 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, the rolls shall be elevated from the ground surface. Geogrids, except for extruded grids, shall be protected with an opaque waterproof cover.

PART 2 PRODUCTS

2.1 GEOGRID 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 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."

****

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, polyester, or other approved material 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. The Contractor shall submit Certificates of Compliance for the materials provided as specified in the Submittals paragraph.

2.1.1 Geogrid 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
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 D 4355
Coefficient of Interaction for Pullout	[0.85]	GSI GRI GG5
Interface Friction at [Peak] [Residual], Degrees	[_____]	ASTM D 5321

2.1.1.1 Allowable Strength

Ta shall be based on reduction factors for installation damage, durability, and creep that are applicable to site specific conditions. Reduction factors shall be determined in accordance with the test procedures documented in GSI GRI GG4a or GSI GRI GG4b. The minimum reduction factor for durability shall be 1.1 for polyethylene and polypropylene geogrids and 1.15 for coated polyester geogrids. The minimum reduction factor for installation damage shall be 1.1 for all polymers. The reduction factor for creep shall be based on testing performed in accordance with ASTM D 5262 at the strain specified in Table 1.

2.1.1.2 Interface Friction Testing

****
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.
****

Laboratory interface friction tests shall be conducted on the following interfaces: [_____]. The frequency of testing for each interface shall be at a rate of [1] [_____] per project. Tests shall be conducted in accordance with ASTM D 5321. Normal stresses of [_____], [_____], and [_____] kPa [_____], [_____], and [_____] psi along with a displacement rate of [5.0] [_____] mm [0.2] [_____] inches per minute shall be used. Geosynthetics shall be oriented such that the shear force is parallel to the down slope orientation of these components in the field.

2.1.2 Splices

Splices shall consist of a standard method or device recommended by the manufacturer of the geogrid. Splices shall not be allowed unless identified on the approved layout drawings. Splices shall be at least 75 percent efficient. The splice efficiency shall be demonstrated 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. Overlap splices shall be constructed by placing a minimum of 50 mm 2 inches of soil between the layers of geogrid.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Subgrade Preparation

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

Immediately prior to placement of the geogrid, the surface on which the geogrid will be placed shall be free of rock and other material that could damage the geogrid or the underlying geosynthetics.

3.1.2 Anchor Trench

****
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 (GRI GG5) 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.
****

The anchor trench shall be placed a minimum of [610] [_____] mm [24] [_____] inches back from the edge of the slope to be covered. The anchor trench shall be a minimum of [610] [_____] mm [24] [_____] inches deep and [610] [_____] mm [24] [_____] inches wide. Ponded water shall be removed from the anchor trench while the trench is open. Trench corners shall be rounded to avoid sharp bends in the geogrid. Loose soil, rocks larger than [51] [_____] mm [2] [_____] inches in diameter, and any other material which could reduce the effectiveness of the geogrid shall be removed from the surfaces of the trench. The geogrid shall extend down the front wall and across the bottom of the anchor trench. Backfilling and compaction of the anchor trench shall be in accordance with Section 02300 EARTHWORK.

3.1.3 Placement

The geogrid shall be installed in accordance with the Manufacturer's recommendations. Geogrid shall be unrolled in the direction of reinforcement. After a layer of geogrid has been placed, suitable means, that do not damage the underlying geosynthetics, shall be used to hold the geogrid flat and in place until cover soil can be placed. Geogrid damaged during placement and covering shall be removed and replaced at no additional cost to the Government.

3.1.4 Overlaps and Fasteners

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

Adjacent rolls of geogrid shall be positioned edge-to-edge and loosely fastened to maintain alignment during fill placement. Adjacent rolls shall not be overlapped. Fastener type and spacing shall be as recommended by the manufacturer and approved by the Contracting Officer. Metallic fasteners will not be allowed.

3.1.5 Splices

Splices, if allowed, shall be located within the bottom one-third of the slope. Splicing shall be limited to only one splice per reinforcing strip and no two consecutive reinforcing strips shall include a splice. Individual reinforcing lengths less than 3 meters 10 feet shall not be used. Splices in geogrid reinforcement shall be pulled and held taut during cover soil placement.

3.1.6 Penetrations

For small penetrations through geogrids, only transverse members of the geogrid shall be cut. The load-carrying longitudinal (machine direction) members shall be spread around the penetration. For larger penetrations, additional geogrid shall be placed 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

****
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 entitled "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.
****

Geogrid shall be covered with soil within [5] [_____] calendar days of acceptance. The geogrid shall be kept smooth and taut during placement of cover materials. Cover soil shall not be dropped onto the geogrid from a height greater than 1 m 3 feet. The soil shall be pushed out over the geogrid in an upward tumbling motion. Soil shall be placed from the bottom of the slope upward. The initial loose soil lift thickness shall be [350] [_____] mm [12] [_____] inches. Equipment with ground pressures less than 50 kPa 7 psi shall be used to place the first lift over the geogrid. A minimum of [460] [610] [915] [_____] mm [18] [24] [36] [_____] inches of soil shall be maintained between construction equipment with ground pressures greater than 50 kPa 7 psi and the geogrid. Equipment placing cover soil shall not stop abruptly, make sharp turns, spin their wheels, or travel at speeds exceeding [2.2] [_____] m/s [5] [_____] mph. Additional cover soil material and placement requirements are described in Section 02300 EARTHWORK.

3.3 OVERSIGHT

A QA Representative shall be present at all times during geogrid installation.

3.4 CONFORMANCE TESTING

****
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.

****

Conformance testing expenses shall be the responsibility of the Contractor. Testing shall be performed by a commercial testing laboratory selected by the Contractor and approved by the Contracting Officer. The laboratory shall 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 D 4595 (mod)] [or] [GSI GRI GG1]	[_____]

ASTM D 4595 shall be modified for geogrids considering recommendations in GSI GRI GG6. The tensile strength shall be expressed 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 --