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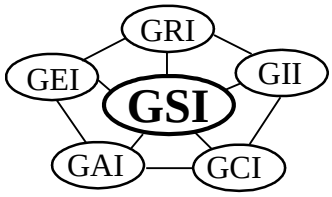

Revision 1: January 5, 2016

GRI -GS15 Standard Specification*

Standard Specification for

"Test Methods, Test Properties and Testing Frequency for Geocells Made From High Density Polyethylene (HDPE) Strips" SM

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers geocells made from high density polyethylene (HDPE) strips which are joined together by the manufacturer at intervals such that when opened in the field form a honeycombed structure which is subsequently filled with soil, stone or concrete.

Note 1: Applications of geocells are typically for paved and unpaved road support, for wall and slope reinforcement, etc.

1.2 This specification sets forth a set of minimum, physical, mechanical and endurance properties that must be met, or exceeded by the geocell being manufactured. In a few cases a range is specified.

1.3 In the context of quality systems and management, this specification represents manufacturing quality control (MQC).

Note 2: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this specification.

*This GRI standard specification is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 5-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version and it is kept current on the Institute's Website <<geosynthetic-institute.org>>.

1.4 This standard specification is intended to ensure good quality and performance of geocells in general applications, but is possibly not adequate for the complete specification in a specific situation. Additional tests, or more restrictive values for the tests indicated, may be necessary under conditions of a particular application.

2. Referenced Documents

2.1 ASTM Standards

D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1603 Test Method for Carbon Black in Olefin Plastics
D 3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
D 7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus

2.2 GRI Standards

GS13 Guide for Geomembrane-Related Geocell Seam Strength and Its Efficiency with Respect to the Perforated Sheet Strength

GS14 Test Method for Average Wall Thickness of a Geomembrane-Related Geocell by Indirect Measurement

2.3 EPA Standards

U. S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Definitions

3.1 Geocell, n – a three-dimensional compartmentalized geosynthetic structure resulting in discrete cells when opened which are subsequently filled with soil, concrete or other infill material for civil engineering applications; see Figure 1.

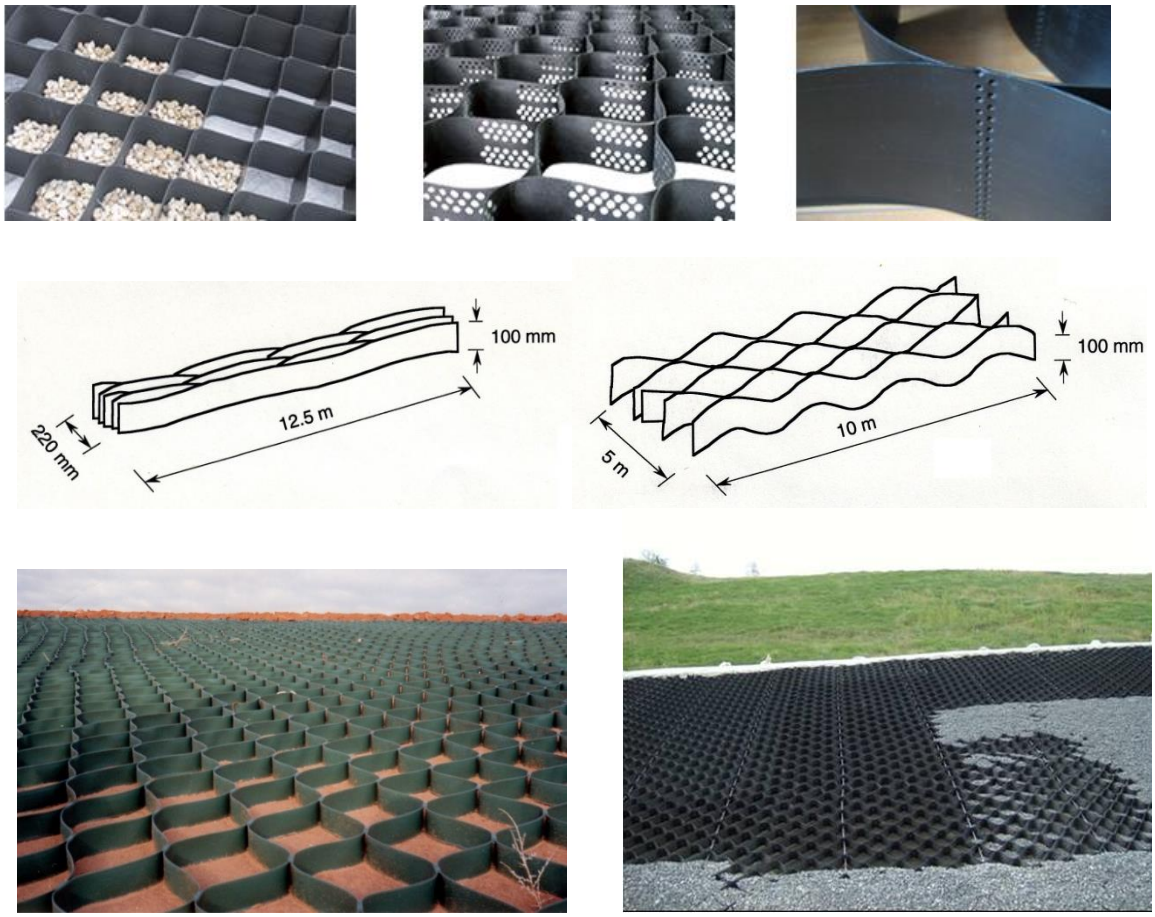

Figure 1 - Diagrams and photographs of three-dimensional geocells used for civil engineering applications.
(Compliments of In-Line Plastics/GeoProducts, Syntec Corp. and InterGeo/Golder)

Note 2: Geocell heights are typically 75, 100, 150 or 200 mm (3, 4, 6 or 8 in.) but can be others as well. Length and width dimensions of the collapsed and opened structure vary according to the specific manufacturer.

3.2 Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to

determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications.
ref. EPA/600/R-93/182

3.3 Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project.
ref. EPA/600/R-93/182

3.4 Formulation, n - The mixture of a unique combination of ingredients identified by type, properties and quantity. For HDPE polyethylene strips, a formulation is defined as the exact percentages and types of resin(s), additives and carbon black.

4. Material Classification and Formulation

4.1 This specification covers geocells made from high density polyethylene strips with a formulated sheet density of 0.940 g/cc, or higher. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

4.2 The polyethylene resin from which the geocell is made will generally be in the density range of 0.932 g/cc or higher, and have a melt index value per ASTM D1238 of less than 1.0 g/10 min.

4.3 The resin shall be virgin material with no more than 25% rework. If rework is used, it must be a similar HDPE as the parent material.

4.4 No post consumer resin (PCR) of any type shall be added to the formulation.

5. Physical, Mechanical and Chemical Property Requirements

5.1 The geocell walls, being made from HDPE strips shall conform to the test property requirements prescribed in Table 1. The table presents units in both S.I. and Standard (aka, U.S.) units.

Note 4: The thickness of the HDPE strips, per GRI-GS14, is a new test method necessitated by the various strip manufacturing methods, e.g., embossing, texturing, etc. As such, it is an average thickness resulting from a calculation using the measured mass and density of the test specimen.

Note 5: The walls of HDPE strips which form the geocell are invariably perforated, using different patterns and spacings, for the purpose of drainage from one cell to another.

Note 6: Additionally, an aligned pattern of holes in these walls is often done for the purpose of inserting cabling which is sometimes necessary to anchor the completed and filled geocell to a concrete beam for stability on steep slopes.

5.2 The strength of the factory joining of the geocell strips by thermal, ultrasonic or other methods, per GRI-GS13, is a new test method necessitated by the various joining methods. It is a tensile peel test and its value is compared to the perforated sheet strength of the product being evaluated. An efficiency calculated using these two results is specified accordingly.

5.3 The table calls for direct shear friction tests, per ASTM D5321, to assure that soil infill of the individual cells will be stable and not allow the soil to be lost or the geocell to rise out of position. A checklist of conditions for the tests are as follows;

a. Procedure: "B" soil to geosynthetic
b. Samples materials to be tested: Geocell wall to Sand (AASHTO 2A or USCS SW)
c. Orientation of Geocell: Machine direction
d. Normal pressures: 14 kPa (2 psi), 38 kPa (5 psi) and 69 kPa (10 psi)
e. Moisture conditions: Saturated
f. Consolidation conditioning: No requirement because sand is free draining
g. Shear rate: 1 mm/minute (0.04 in./min.)

5.4 The values listed in the tables of this specification are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

5.5 The properties of the HDPE strips and their joining to form the geocell structure shall be tested at the minimum frequencies shown in Table 1. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

Note 7: This specification is focused on manufacturing quality control (MQC). Conformance testing and manufacturing quality assurance (MQA) testing are at the discretion of the purchaser and/or quality assurance engineer, respectively.

6. Workmanship and Appearance

6.1 The embossed or textured HDPE strips shall generally have uniform appearance. It shall be free from agglomerated material and such defects that would affect the specified properties of the geocell system.

6.2 Perforations of the geocell walls for drainage purposes between adjacent cells shall have a regular and repeating pattern throughout the system.

6.3 Holes for anchorage cabling (when applicable) from cell-to-cell shall be aligned and continuous such that the anchorage tendons are linearly aligned from toe to top of slope.

6.4 The intermittent joining of the adjacent HDPE strips shall be regularly spaced and aligned so as to form identical calls when deployed in the field.

6.5 General manufacturing procedures shall be performed in accordance with the manufacturer’s internal quality control guide and/or documents.

7. MQC Sampling

7.1 Sampling shall be in accordance with the specific test methods listed in Table 1. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire bundle width.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Table 1.

7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are typically the minimum average values and are designated as "min. ave."

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Packaging and Marking

9.1 The factory fabricated geocell shall be bundled according to their heights using polymer strapping or sturdy rope such that damage does not occur during handling or shipment to the project site.

9.2 Labeling of geocell bundles shall be consistent with the manufacturers quality manual but must include the product name, manufacturer, location made and specification followed.

Note 8: Both ASTM (through its various standards) and AASHTO (through its NTPEP program) give guidance in this regard.

10. Certification

10.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

Adoption and Revision Schedule
for
HDPE Specification per GRI-GS15

"Test Methods, Test Properties and Testing Frequency for Geocells Made From High Density Polyethylene (HDPE) Strips"

Adopted: May 10, 2013

Revision: January 5, 2016 - Section 5.3 was updated including a checklist of direct shear conditions to perform ASTM D5321 for soil and a geocell wall.

Table 1 –Geocells Made From High Density Polyethylene Strips

Test Properties	Test Method	Test Value (S.I. Units)	Testing Frequency (minimum)	Test Value Standard (US) Units	Testing Frequency (minimum)
Wall Thickness Nominal – 10%)	GRI-GS14	1.25 mm	per bundle	50 mils	per bundle
Density (min. ave.)	ASTM D 1505/D 792	0.940 g/cc	90,000 kg	0.940 g/cc	200,000 lb
Seam Efficiency (min. ave.)	GRI-GS13	100%	9,000 kg	100%	20,000 lb
Tensile Properties (min. ave.) *(1)* • yield strength • break strength • yield elongation • break elongation	ASTM D 6693 Type IV	 18 kN/m 13 kN/m 12% 100%	9,000 kg	 105 lb/in. 75 lb/in. 12% 100%	20,000 lb
Tear Resistance (min. ave.)	ASTM D 1004	155 N	20,000 kg	35 lbs	45,000 lb
Puncture Resistance (min. ave.)	ASTM D 4833	330 N	20,000 kg	75 lbs	45,000 lb
Direct Shear Friction Angle *(4)*	ASTM D5321	30°	20,000 kg	30°	45,000 lb
Carbon Black Content (range) *(2)*	ASTM D 4218	2-3%	9,000 kg	2-3%	20,000 lb
Carbon Black Dispersion *(3)*	ASTM D 5596	note *(5)*	20,000 kg	note *(5)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(5)* (a) Standard OIT — or — (b) High Pressure OIT	 ASTM D 3895 ASTM D 5885	 100 min. 400 min.	90,000 kg	 100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(5)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D 5721 ASTM D 3895 ASTM D 5885	 55% 80%	per formulation	 55% 80%	per formulation
UV Resistance *(6)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(8)*	ASTM D 7238 ASTM D 3895 ASTM D 5885	 N.R. *(7)* 50%	per formulation	 N.R. *(7)* 50%	per formulation

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of five test specimens each direction.
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(2) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(3) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(4) Actual geocell strip against well graded sand (see Section 5.3)

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(7) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(8) UV resistance is based on percent retained value regardless of the original HP-OIT value.