



Designation: D8269 – 21

Standard Guide for the Use of Geocells in Geotechnical and Roadway Projects¹

This standard is issued under the fixed designation D8269; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is intended to cover basic considerations for the use of geocells in various geotechnical and roadway projects to bring a unified understanding of efficient and appropriate ways to utilize this type of ground improvement technology for a variety of geotechnical-related applications, including but not limited to: load support for pavements, subgrade improvement, slope stability, retaining walls, earth retention, and slope and channel protection. Engineers and owners interested in using this manufactured product can refer to the information in this guide to learn about key design principles, properties, mechanisms, and methodologies for applicable geotechnical applications. Geotechnical designs that incorporate geocells should take into consideration the specific attributes of each product. The engineer is encouraged to utilize design methodologies based on reliable test results and research.

1.2 This guide offers a collection of information and does not recommend a course of action. This guide cannot replace education or experience, and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances.

1.3 This guide is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this guide be applied without consideration of a project's many unique aspects.

1.4 The word “standard” in the title of this guide means only that this guide has been approved through the ASTM International consensus process.

1.5 The values given in SI units are to be regarded as standard. Values in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

- D1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics
- D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
- D4355/D4355M Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc-Type Apparatus
- D4439 Terminology for Geosynthetics
- D4595 Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
- D5199 Test Method for Measuring the Nominal Thickness of Geosynthetics
- D5262 Test Method for Determining the Unconfined Tension Creep and Creep Rupture Behavior of Planar Geosynthetics Used for Reinforcement Purposes
- D5397 Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
- D5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
- D5885/D5885M Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry
- D5994/D5994M Test Method for Measuring Core Thickness of Textured Geomembranes
- D6392 Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

¹ This guide is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.01 on Mechanical Properties. Current edition approved July 15, 2021. Published August 2021. DOI: 10.1520/D8269-21.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D6992 Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method

D7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus

E2254 Test Method for Storage Modulus Calibration of Dynamic Mechanical Analyzers

2.2 *ISO Standards*:³

ISO 6721-1 Plastics—Determination of Dynamic Mechanical Properties—Part 1: General Principles

ISO 10319 Geosynthetics—Wide-Width Tensile Test

ISO 13426-1 Geotextiles and Geotextile-Related Products—Strength of Internal Structural Junctions—Part 1: Geocells

2.3 *GRI Standards*:⁴

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

GRI GS15 Specification for Test Methods, Test Properties and Testing Frequency for Geocells Made from High Density Polyethylene (HDPE) Strips

3. Terminology

3.1 *Definitions*—For definitions of common geosynthetics terms used in this guide, refer to Terminology **D4439**.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *geocell, n*—a three-dimensional, compartmentalized, polymeric structure having discrete cells that are formed by expanding the structure, that is subsequently filled with soil, aggregate, concrete, pulverized debris, recycled asphalt pavement, or other infill material for geotechnical applications such as: (1) load support for unpaved and paved roads, railways, ports, heavy-duty pavements, container yards, and basal embankment stabilization; (2) retaining structures, free-standing structures, and fascia walls; and (3) slope, channel, and geomembrane protection.

4. Summary of Guide

4.1 This guide covers some of the major considerations associated with the design of geotechnical projects where the soil, aggregate, concrete, or other infill materials may be improved through the three-dimensional mechanical stabilization of geocells.

4.2 Common geocell applications include: (1) load support for unpaved and paved roads, railways, ports, heavy-duty pavements, container yards, and basal embankment stabilization; (2) retaining structures, free-standing structures, and fascia walls; and (3) slope, channel, and geomembrane protection.

5. Significance and Use

5.1 This guide covers applications, support mechanisms, and design principles associated with geocells to help designers and engineers determine when and how to appropriately use this technology.

5.2 A better understanding of the key design principles, material properties, mechanisms of improvement, and methodologies will help engineers and owners interested in using geocells understand the most efficient and appropriate ways to utilize this type of ground improvement for a variety of geotechnical-related applications.

5.3 This guide does not preclude the judgment and practice of those competent in geotechnical design.

6. Overview of the Geocell Technology and Basic Construction Considerations

6.1 Geocells are supplied as a group of connected strips (referred to as a “panel” or “section”) that, when opened, form a network of open cells (see **Fig. 1**). Individual geocell sections can be connected using suitable, manufacturer-approved connection devices that provide sufficient strength to prevent panel separation during installation and throughout the entire design life. Geocells may differ in terms of their basic physical and material characteristics, including but not limited to: open cell/section dimensions, number of cells per unit area (cell density), cell depth (height), or presence/absence of perforations or texture. Geocells have been used successfully in practice since the 1980s. Selection of a geocell product should be based on a detailed evaluation of project-specific needs and circumstances as performed by a geotechnical engineer or other qualified professional, and geocell use should be consistent with the manufacturer’s recommendations that are based on reliable test results and research **(1, 2)**.⁵

6.2 Individual cells consist of two strips that are connected together on either end, and held open prior to filling through lateral forces applied to the cell walls from the adjacent sets of cell walls that are connected to them. In application, two types of hoops are present in any configuration that involves the installation of multiple adjoining geocell panels. These include factory-welded hoops, and mechanically joined hoops using manufacturer-recommended methods (refer to **6.5**). Located within the body of individual geocell panels, factory-welded hoops consist of the cell wall material and the seams on either end. Located around the perimeter of the individual geocell panels, mechanically joined hoops are formed in the field during connection of adjoining panels. The primary mechanism by which geocells provide benefit is through lateral confinement of the infill; therefore, it is necessary that the entire hoop of material that makes up each individual cell and the connection devices remains intact during construction and throughout the life of the structure. The entire hoop, including the seams, must remain intact and be sufficiently strong to carry the applied hoop stresses without breaking, deforming excessively, relaxing, or degrading during construction and for

³ Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

⁴ Available from Geosynthetic Institute (GSI), 475 Kedron Ave, Folsom, PA 19033, <https://www.geosynthetic-institute.org>.

⁵ The boldface numbers in parentheses refer to a list of references at the end of this standard.

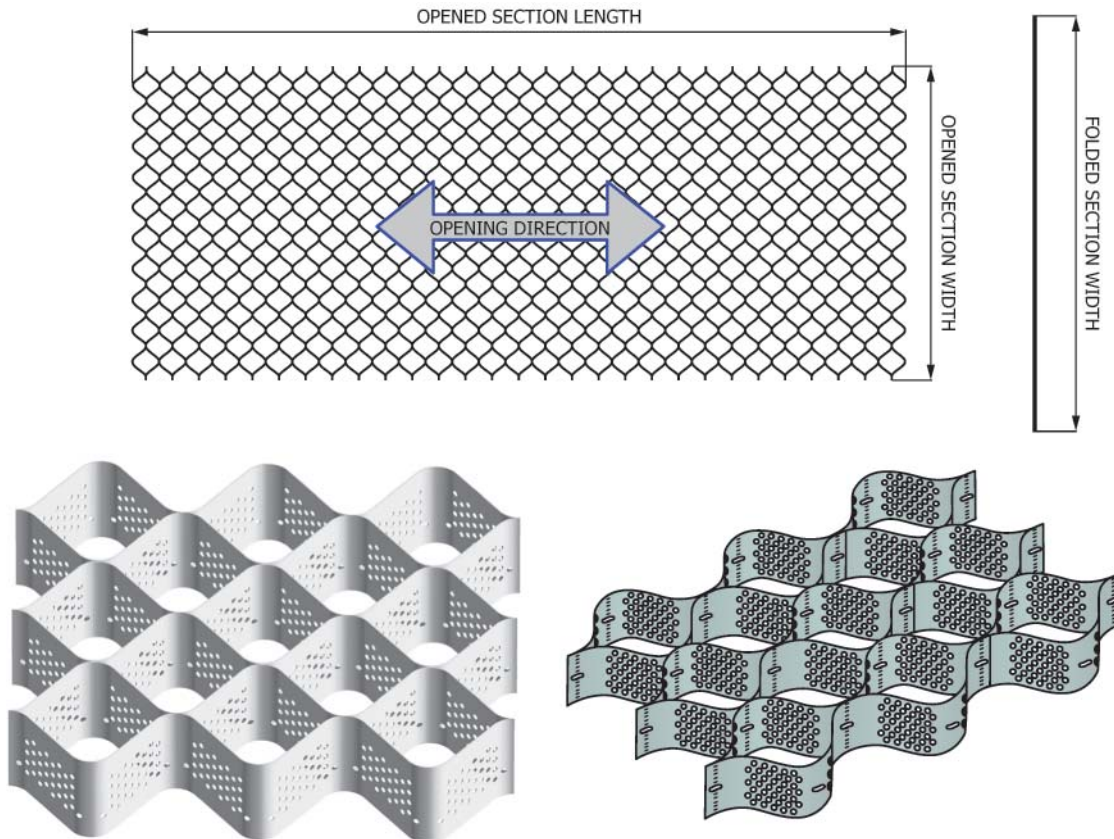


FIG. 1 Plan View and 3D View of Geocells
(layout of perforations in 3D view may vary between different manufacturers)

the entire design life of the structure. Any of these failure modes in either the cell wall, seams, or connectors will allow the infill to expand laterally, rendering individual cells or the entire geocell layer ineffective.

6.3 Lateral restraint (or confinement) of the infill material is provided by the hoop of material that forms the cell wall, and the improved lateral support of adjacent cells (that is, the slab/mattress effect), as reported in Refs (3-6). The suitability of the geocell in specific design cases and the magnitude of confinement provided by the geocell are directly dependent on the key material properties outlined in 6.8, the geometry of the individual cells, and the position of the geocell layer within the geotechnical structure.

6.4 The mattress effect mentioned in 6.3 relies on the composite behavior of an integrated infill-geocell system in which lateral earth pressures are mobilized and transferred across a three-dimensional network of interconnected cells. In this regard, the properties of the infill material (that is, particle size/distribution, angle of internal friction, relative density, etc.) act in conjunction with the discrete elements/characteristics of the geocell material (comprised of cell walls, seams/joints, connection devices, perforations/texture, and in some cases, earth anchoring devices) to facilitate the desired ground improvement effect. The infill materials, along with each of the above-referenced discrete elements of the geocell system, will each impart some level of influence over system performance. Accordingly, the behavior of the composite

system is similarly influenced by these factors, along with the geometry of the machine-welded geocells (which are not exactly circular shaped, as shown in Fig. 1); the number of adjacent geocells acting in response to an applied load; and the stiffness of system components. In general, with increasing numbers of adjacent cells (cell density) surrounding the location of an applied load, the resulting horizontal pressure is distributed over a wider area. Emersleben and Meyer (7) observed that the horizontal pressure in a single cell was distributed to the 24 closest surrounding cells, exemplifying the mattress effect of the composite behavior. Individual cells limit lateral movement of the infill, which reduces vertical settlement and increases stiffness within the reinforced layer. As these individual cells work in concert with other adjacent cells (that is, the mattress effect), applied loads are more widely spread, resulting in a more uniform distribution of applied stresses as well as a reduction in the magnitude of these stresses to underlying layers, the result of which is a decrease in the overall settlement and a reduction in differential settlement.

6.5 A single group of geocells has a finite length and width depending on how it was manufactured. As mentioned in 6.1, a larger continuous area can be covered by attaching single groups of geocells to one another from end to end, side to side, or both. Common methods of attachment include stapling and locking devices, as well as the use of specialized manufacturer-specific connection devices. Manufacturers' connection devices

for attachment should be followed as long as they are durable and provide sufficient connection strength, pullout/separation resistance, resistance to lateral and vertical movement, and resistance to node rotation between subsequent geocell groups.

6.6 Geocell section opening size in the field is determined by the distance that the geocell is stretched from side to side. For typical load support projects, geocells are temporarily held open by staking the edges in a manner that ensures that all geocell openings can be filled. Stakes can be left in place or removed and reused as the construction advances. Slope and channel protection applications typically require that permanent stakes, tendons, or both, be installed to hold the geocells in place. Temporary staking, bent frames, or both are typically used to hold geocells open for retaining wall applications.

6.7 The bulk of the background and research information used to develop this guide is based on geocells made of extruded plastic strips. Geocells are also made of nonwoven geotextiles (as shown in Fig. 2) and, where appropriate, specific guidelines for these materials are also included in the guide. It is important to note that geocells made from different types of materials, sizes, strengths, etc. may behave or perform differently from one another; therefore, it is important to understand and utilize proper material properties that relate to its performance for each of the applications outlined below. Manufacturer's recommendations for each material type should be based on reliable test results and research for their specific material.

6.8 The polymeric properties of the geocell are directly related to its performance throughout the entire project design life (3). These properties include tensile strength, tensile stiffness, resistance to plastic deformation or creep, hoop strength, and environmental durability (as outlined in 6.9). Because geocells act cooperatively due to the proximity of surrounding cells (that is, mattress effect, see 6.4), it is also important to assess the performance benefits imparted to the entire layer in which the geocell is employed. Accelerated methods are available to evaluate and verify long-term performance of the geocell system itself and as part of a complete solution (for example, rolling wheel load tests, cyclic plate load tests, and full-scale laboratory test sections) (7-9). Triaxial tests have also been used to evaluate and understand the strength properties of the composite geocell-soil system (10). The entire

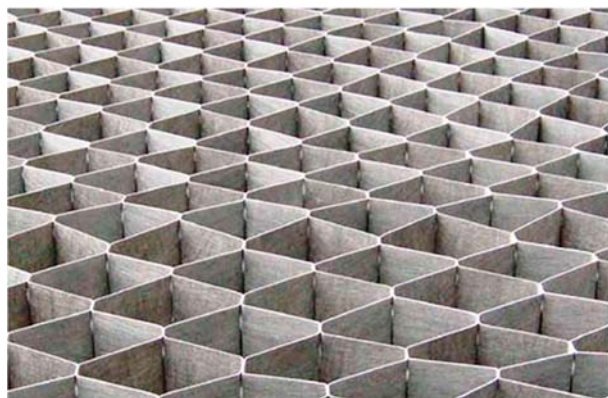


FIG. 2 Nonwoven Geotextile-Based Geocell

hoop of material forming the cellular structure must remain intact to ensure adequate performance throughout the design life, including both factory-welded hoops and hoops formed as a result of connections between adjacent panels.

6.9 Consideration should be given to the environmental conditions associated with the design. These conditions include temperature, chemical or environmental contamination, submerged conditions, prolonged exposure to sunlight, seismic activity, etc. The material properties of the geocell should be evaluated under the expected conditions to ensure proper performance throughout the design life. Tests are available to evaluate environmental stress cracking resistance (ESCR), corrosion resistance (particularly for staples or other types of metal connectors), and resistance to ultraviolet and oxidation degradation.

6.10 Infill material can include most types of non-plastic soils and sand, granular fills, concrete, and recycled materials. In pavement and retaining wall applications a free-draining granular fill is typically used, having a wide range of quality, including uniformly graded aggregates and recycled materials. Reinforced slope applications may require a graded, free-draining granular fill. Topsoil can be used in the outer cell if a vegetated fascia is desired. Topsoil, aggregate, and concrete can be used as infill for channel protection. The type of infill should be based on the slope angle and channel hydraulic conditions. Vegetated topsoil is often used in slope protection applications. Generally, geocells provide higher benefit when lower quality infill is used because the level of improvement compared to fill alone is greater. Nevertheless, the use of geocells with high-quality granular layers (in particular for surface transportation applications) may also lead to significant improvement of surface support with lower deflections, extended life in terms of increased traffic, or both. Greater load-carrying capacity, reduced thicknesses of the structural layers, extended life, or combinations thereof can be realized in roadway applications through the use of geocells with a wide range of infill quality including inferior materials, which may reduce overall project cost and reduce construction time (5).

6.11 Filling should be done without driving directly on the unfilled geocells to avoid damage. Construction equipment can advance onto the geocells once the infill material is deep enough to prevent equipment from directly contacting the top of the geocell. The drop height of infill material into the cells should be limited to prevent panel distortion. Overfill material thickness should be determined based on the design or experience, or both, and should be compacted together with geocell infill material.

6.12 Compaction should be done in a manner that prevents damage to the geocell but thoroughly densifies the infill material with sufficient energy to ensure that further densification during the life of the structure is minimized and that hoop stresses in the geocell walls are engaged. Vibratory compaction is generally preferred in load support applications to ensure the geocell infill is adequately densified. Sheepsfoot rollers should not be used to compact materials within the geocell panels.