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Standard Guide for Specifying Drainage Geocomposites[1]

This standard is issued under the fixed designation D7931/D7931M; 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 presents a guideline specifying a drainage geocomposite product; it specifically provides recommendations to determine the allowable flow rate of a candidate drainage geocomposite. The resulting value is then compared to a required (or design) flow rate for a product-specific and site-specific factor of safety.

1.2 This guide is intended to aid designers, purchasers, installers, contractors, owners, operators, and agencies in establishing minimum guidelines for drainage geocomposite materials. This guide is not to be used for manufacturer's quality control purposes, nor is it a construction quality assurance specification.

1.3 This guide does not address the required (or design) flow rate value, nor the subsequent factor of safety values, which are typically design specific.

1.4 The procedures recommended in this guide use ASTM test methods.

1.5 This guide is applicable to all types of drainage geocomposites regardless of their core configuration or geotextile type. It can also be used to evaluate thick, nonwoven geotextiles that provide drainage.

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.7 This guide offers an organized collection of information or a series of options and does not recommend a specific 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. 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. The word 'standard' in the title of this guide means only that the guide has been approved through the ASTM International consensus process.

1.8 *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.*

1.9 *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.*

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1987 Test Method for Biological Clogging of Geotextile or Soil/Geotextile Filters
D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
D4354 Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
D4439 Terminology for Geosynthetics
D4716/D4716M Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
D4873/D4873M Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
D5321/D5321M Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
D5322 Practice for Laboratory Immersion Procedures for Evaluating the Chemical Resistance of Geosynthetics to Liquids
D6243/D6243M Test Method for Determining the Internal and Interface Shear Strength of Geosynthetic Clay Liner by the Direct Shear Method
D6388 Practice for Tests to Evaluate the Chemical Resistance of Geonets to Liquids
D6389 Practice for Tests to Evaluate the Chemical Resistance of Geotextiles to Liquids
D6747 Guide for Selection of Techniques for Electrical Leak Location of Leaks in Geomembranes
D7001 Specification for Geocomposites for Pavement Edge Drains and Other High-Flow Applications
D7273/D7273M Guide for Acceptance Testing Requirements for Geonets and Geonet Drainage Geocomposites
D7361 Test Method for Accelerated Compressive Creep of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method
D7406 Test Method for Time-Dependent Compressive Deformation Under Constant Pressure for Geosynthetic Drainage Products
D7852 Practice for Use of an Electrically Conductive Geotextile for Leak Location Surveys

2.2 *Other Standards:*

GRI GC8 Determination of the Allowable Flow Rate of Drainage Geocomposites[3]
ISO 18228-4 Design Using Geosynthetics—Part 4: Drainage (in press)[4]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms related to geosynthetics, refer to Terminology D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *agency, n*—in geosynthetics, the organization that reviews the permit application for compliance with the agency's regulation and all quality assurance documentation before and after construction.

3.2.2 *contractor, n*—in geosynthetics, the party or organization that has the responsibility for the construction of the man-made project, structure, or system.

3.2.3 *designer, n*—in geosynthetics, the person or organization that designs a man-made project, structure, or system that fulfills the owner/operator's requirements and meets or exceeds the minimum requirements of the agency.

3.2.4 *installer, n*—in geosynthetics, the party that installs, or facilitates installation of, any materials purchased from manufacturers or suppliers.

3.2.5 *operator, n*—in geosynthetics, the person or organization that operates the man-made project, structure, or system.

3.2.6 *owner, n*—in geosynthetics, the person or organization that owns the man-made project, structure, or system.

[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.

[3] Available from Geosynthetic Institute, 475 Kedron Ave, Folsom, PA 19033, http://www.geosynthetic-institute.org.

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

3.2.7 *purchaser, n*—in geosynthetics, the person, company, or organization that purchases any materials or work to be performed.

3.2.8 q_{100}, *n*—initial flow rate for a drainage geocomposite as determined under simulated conditions for 100-h duration.

3.2.9 q_{allow}, *n*—allowable flow rate for a drainage geocomposite.

4. Significance and Use

4.1 This guide is intended to aid designers, purchasers, installers, contractors, owners, operators, and agencies in establishing the minimum criteria to specify drainage geocomposites. Specifically, this guide presents a methodology for determining the allowable flow rate of a candidate drainage geocomposite. The resulting value is then compared to a required (or design) flow rate for a product-specific and site-specific factor of safety.

4.2 It is recognized that there are other products that may achieve the same performance requirements but are not listed in this document. Manufacturers of such products are invited to implement this standard guide with the appropriate information.

4.3 It should be recognized that parties, organizations, or representatives may perform additional tests other than those required in this guide. In this case, the more stringent project-specific tests will then take precedence.

4.4 By simulating site-specific conditions (inclusive of site-specific liquids and temperatures except for load duration beyond 100 h, chemical/biological clogging, and geotextile intrusion), additional reduction factors need not be explicitly accounted for in certain products.

5. Classification

5.1 *General*—This guide covers geocomposite drainage products or structures intended for blanket subsurface drainage applications. Five distinctly different product designs are included in this guide as geocomposite drainage products:

5.2 *Biaxial Geonet Geocomposite*—A geonet consisting of an integrally connected parallel set of ribs overlying a similar set of ribs at typically opposite angles, typically heat laminated with nonwoven geotextiles on the top and bottom to form the geocomposite. Note that single-sided biaxial geonet geocomposites are available in the marketplace as well; in that particular case, only one side of the geonet will be heat laminated with a nonwoven geotextile.

5.3 *Triaxial Geonet Geocomposite*—A geonet consisting of an integrally connected parallel set of ribs, or forming an integrated web with a flow direction mainly oriented in the machine direction, typically heat laminated with nonwoven geotextiles on the top and bottom to form the geonet geocomposite. It should be noted that single-sided triaxial geonet geocomposites are available in the marketplace as well; in that particular case, only one side of the geonet will be heat laminated with a nonwoven geotextile.

5.4 *Multilinear Drainage Geocomposite*—A manufactured product composed of a series of parallel single drainage conduits regularly spaced across its width sandwiched between two or more geosynthetics.

5.5 *Structured Geomembrane System*—A geomembrane with integrated drainage nubs, spikes, or both. The drainage nubs, when overlain or heat laminated by a filter fabric (heat burnished on one side), will form the structured geomembrane drainage geocomposite.

5.6 *Sheet Drain Geocomposite*—A three-dimensional structured core consisting of integrally connected voids, typically heat laminated with a nonwoven geotextile or monofilament filter either on the top or bottom (or both) to form the drainage geocomposite. It should be noted that single-sided sheet drain geocomposites are available in the marketplace as well; in that particular case, only one side of the structure will be laminated with a nonwoven geotextile or monofilament filter geotextile.

5.7 *Geocomposite Edge Drain*—A geotextile wrapped around a structural polymer drainage core used for subsurface drainage applications in highway, turf, and environmental applications. The product is typically 1 in. [25 mm] thick and available in 6 in. [150 mm], 12 in. [300 mm], 18 in. [450 mm], 24 in. [600 mm], 30 in. [750 mm], and 36 in. [900 mm] widths.

6. Determination of the q_{allow} of a Candidate Drainage Geocomposite

6.1 *Basic Formulation*[5]—This guide is focused on determination of a q_{allow} value using the following formula:

$$q_{allow} = q_{100}\left[\frac{1}{RF_{CR} \times RF_{CC} \times RF_{BC} \times RF_{GI}}\right] \quad (1)$$

$$q_{allow} = \left[\frac{q_{100}}{RF_{CR} \times RF_{CC} \times RF_{BC} \times RF_{GI}}\right] \quad (1)$$

where:

q_{allow} = allowable flow rate for a drainage geocomposite,
q_{100} = initial flow rate determined under simulated conditions for 100-h duration,
RF_{CR} = reduction factor for creep to account for long-term behavior,
RF_{CC} = reduction factor for chemical clogging,
RF_{BC} = reduction factor for biological clogging, and
RF_{GI} = reduction factor for long-term geotextile intrusion past the initial 100-h seating time.

6.1.1 The value of q_{allow} is typically used to determine the product-specific and site-specific flow rate factor of safety as follows:

$$FS = \frac{q_{allow}}{q_{reqd}} \quad (2)$$

6.1.2 The value of q_{reqd} is a design issue and is not addressed in this guide. Likewise, the numeric value of the factor of safety is not addressed in this guide. Suffice it to say that, depending on the duration and criticality of the situation, *FS* values should be conservative unless experience allows otherwise.

NOTE 1—The value of A reduction factor for laboratory uncertainties, qRF_{allowL}, is typically used to determine the product-specific and site-specific flow rate factor of safety as follows:exists in other design standards such as ISO 18228-4 to cover differences in tests caused by variability of test results between laboratories. This reduction factor is necessary in particular because ISO standards do not include a Precision and Bias statement; therefore, the variability of the test can

$$FS = \frac{q_{allow}}{q_{reqd}} \quad (2)$$

The value only be captured with a specific reduction factor. In this guide, addition of qRF_{reqdL} is a design issue and is not addressed in this guide. Likewise, the numeric value of the factor of safety is not addressed in this guide. Suffice it to say that, depending on the duration and criticality of the situation, not necessary because the laboratory uncertainties are known through the precision and bias of each test procedure. This uncertainty can be accounted for when selecting the initial flow value considered in the design (FSq_{100} values should be conservative unless) or the global safety factor, *experience* *FS*.allows otherwise.

6.2 Upon selecting the candidate drainage geocomposite product, one must obtain the 100-h duration flow rate according to the Test Method D4716/D4716M transmissivity test or other appropriate transmissivity test method such as Specification D7001, which is more appropriate for high-flow applications. (See 6.2.2 for more background on which transmissivity test method to select.) This establishes the base value to which drainage core creep beyond 100 h, clogging from chemicals and biological matter, and geotextile intrusion must be accounted for.

6.2.1 It is recognized that the default duration listed in Test Method D4716/D4716M is 15 min. This guide purposely requires that the test conditions be maintained for 100 h, and simulating site-specific loading and boundary conditions.

6.2.2 While Test Method D4716/D4716M has historically been the "default" transmissivity test for geosynthetic drainage geocomposites, this transmissivity test method is limited to the size of the specimen being tested. Zimmel et al. (2011)(1)[6]

[5] This guide is updated and modified from GRI-GC-8GRI GC8 "Determination of the Allowable Flow Rate of a Drainage Geocomposite"Geocomposites" to reflect different products in the marketplace today. For referenced GRI standards, visit the GSI website, http://www.geosyntheticinstitute.org/,http://www.geosynthetic-institute.org, or contact GSI Customer Service at (610) 522-8440. GRI standards are developed by the Geosynthetics Research Institute through consultation and review by the member organizations.

[6] Bourges-Gastaud, S., Blond, E., Touze-Foltz, N., "Multiscale Transmissivity Study of Drain-Tube Planar Geocomposites: Effect of Experimental Device on Test Representativeness," *Geosynthetics International*, Vol 20, No. 3, 2013, pp. 119–128.The boldface numbers in parentheses refer to a list of references at the end of this standard.

identified that specimen size can significantly affect transmissivity tests performed in accordance with Test Method D4716/D4716M; however, recent research has shown that Test Method D4716/D4716M typically underestimates the actual flow rates at a certain hydraulic gradient (tested with a large-scale transmissivimeter), at least for unidirectional drainage geocomposites, and as a result Test Method D4716/D4716M transmissivity results are typically conservative.

6.2.3 Furthermore, standard engineering practice identifies that the transmissivity is only valid for laminar flow conditions, specifically when Darcy's law is valid, and then the transmissivity is an intrinsic property of the product and not dependent on external conditions such as the hydraulic gradient. According to Darcy's law, transmissivity should be a constant. However, transmissivity testing of drainage geocomposites has shown that transmissivity is not a constant, but is associated not only with the normal load but also with the hydraulic gradient and selected boundary conditions. In fact, transmissivity decreases as the hydraulic gradient increases, because of the development of turbulent flow conditions within the water path of the product being tested. Typically, for hydraulic gradients used in transmissivity tests (greater than 0.1), the flow is non-laminar for drainage geonets or drainage geonet geocomposites ~~(Giroud~~**(2).** ~~et al., 2012).~~ Therefore, the water flow rate of a drainage geocomposite can be better expressed as a discharge (flow rate) at a given hydraulic loss ~~(van~~**(3)** ~~der Sluys and Dierickx, 1987)~~ than as a ~~transmissivity.~~transmissivity **(4).**

6.3 *Reduction Factor for Creep*—Focuses on the stability or deformation (or both) of the drainage core without the covering geotextiles. Stress orientation can be perpendicular or at an angle to the test specimen depending upon site-specific conditions.

6.4 *Chemical/Biological Clogging*—The issue of long-term reduction factors to account for clogging within the core space is a site-specific issue.

6.5 *Chemical Resistance/Durability*—This procedure results in a "go/no-go" decision as to potential chemical reactions between the permeating liquid and the polymers comprising the drainage core and geotextiles. The issue will be addressed in this guide but is not a reduction factor, per se.

7. Determination of the q_{100}

7.1 Using the Test Method D4716/D4716M transmissivity test under simulated field conditions, as stated below (unless otherwise agreed upon by the parties involved, such as potentially using Specification D7001 for appropriate high-flow applications), determine the q_{100} flow rate of the drainage geocomposite under consideration.

7.1.1 The test specimen shall be the entire geocomposite or system as installed in the field. If geotextiles are bonded to the drainage core, they shall not be removed and the entire geocomposite shall be tested as a unit; vice versa, if the geotextile is overlain the structured geomembrane, it should be tested as installed in the field. A minimum of three replicate samples in the site-specific orientation shall be tested and the results averaged for the reported value.

7.1.2 The specimen orientation is to be agreed upon by the designer, testing laboratory, and manufacturer. In this regard, it should be recognized that the specimen orientation during testing has to match the proposed installation orientation. Thus, the site-specific design governs both the testing orientation and subsequent field installation orientation.

7.1.3 Determining the base transmissivity of the candidate drainage geocomposite per Test Method D4716/D4716M (or approved alternate test method) involves specifying a set of site-specific parameters: specimen boundary conditions, applied stress level, hydraulic gradient, seating or loading time, temperature, and the permeating liquid.

7.1.3.1 Typically, specimen boundary conditions shall be one of the following options: (*1*) rigid platen, (*2*) standardized sand, or (*3*) site-specific or other earth material which is typically based on what will most closely simulate field conditions.

(1) If a rigid platen is used, the choices are usually plastic or metal. The testing laboratory must identify the specifics of the material used.

(2) If sand is used, it shall be Ottawa test sand at a relative density of 85 %, water content of approximate 10 %, and compacted thickness of 25 mm [1.0 in.].

(3) If site-specific soil or other material is used, it must be carefully considered and agreed upon between the parties involved. Compaction, moisture content, water content, etc., are all important considerations but should simulate anticipated conditions in the field.

7.1.3.2 The applied stress level is at the discretion of the designer, testing organization, and manufacturer. Unless otherwise stated, the orientation shall be normal to the test specimen. Typically, the selected applied stress level will be based on the maximum anticipated stress that the drainage geocomposite will undergo in the field, inclusive of a factor of safety.

7.1.3.3 The hydraulic gradient at which the above data is taken (or a range of hydraulic gradients) is at the discretion of the designer, testing organization, and manufacturer. But typically, the hydraulic gradient is selected based on the slope gradient that the drainage geocomposite will be placed in the field.

7.1.4 Seating or loading time is 100 h, while it is not necessary to perform intermediate flow rate testing, unless otherwise specified by the various parties involved.

7.1.5 The permeating liquid is typically tap water, unless site-specific fluids need to be used, which should be agreed upon by the designer, testing organization, and manufacturer.

7.1.6 The resulting allowable transmissivity value shall then be compared to a required (or design) transmissivity (flow rate) for a product-specific and site-specific factor of safety. This guide does not address the required (or design) transmissivity (flow rate) value, nor the subsequent reduction factors and the overall product safety value, which is highly project specific and should be risk based.

8. Reduction Factor for Creep, RF_{CR}

8.1 Depending on the site-specific situation and applied stresses, the drainage core of the geocomposite might creep, which leads to a reduction of its in-plane flow capacity. The creep phenomenon is core dependent. Some products, like multilinear drainage geocomposites, may not be sensitive to creep when confined into a soil matrix because of their core structures.

8.2 For geonets, structured geomembranes, and sheet drain cores, the reduction of thickness of the core can be estimated with Test Method D7406 or D7361. The candidate product is placed under compressive stress and its thickness is monitored over time. This is not a flow rate test, although the test specimen can be immersed in a liquid to be agreed upon by the designer, testing organization, and manufacturer. However, it is usually a test conducted without liquid.

8.3 The obtained reduction in thickness of the core itself does not give the reduction of transmissivity of the geocomposite. The relationship between hydraulic transmissivity reduction and thickness reduction is not linear, and it is product specific. Interpretation must be done based on the type of product.

8.4 Normal stress magnitude(s) shall be the same (or greater) as the anticipated service load.

8.5 The load inclination shall be normal to the test specimen. If there exists a tendency for the core structure to deform laterally, separate tests at the agreed-upon load inclinations shall also be performed at the discretion of the parties involved. Contact the manufacturers for reduction factors for creep as they are product and core dependent.

8.6 When the thickness reduction with time is measured using Test Method D7406, the duration of the test shall reflect the design life of the product and be a minimum of 1000 h with up to 10 000 h.

8.6.1 To extrapolate creep deformation response to time frames longer than the test duration, such as 25 or 100 years or longer, there are a number of different techniques for analyzing time-dependent deformation and essentially "creep" which will model that behavior (for example, Appendix X5 of Test Methods D2990 for prediction of long-term properties, the three-element model, curve extrapolation, and so forth).

8.6.2 If the test is performed for confirmation purposes or if a substantial database exists on similar products of the same type, the seating time can be reduced to 1000 h. This decision must be made with agreement among the designer, testing organization, and manufacturer.

8.7 When the thickness reduction with time is measured using test method Test Method D7361 (stepped isothermal method—SIM), temperature is used to accelerate the creep deformation and therefore, to significantly shorten the long creep dwell time on the product. Furthermore, a single test specimen is exposed to a series of temperature steps instead of multiple specimens, eliminating the influence of material variability.

NOTE 2—Creep reduction factors derived either via Test Method D7406 or D7361 might not be directly comparable given the limited data set derived with Test Method D7406; if creep reduction factor needs to be verified during a construction quality assurance (CQA) program, the creep testing method should be as agreed upon by the designer, testing organization, and manufacturer.

8.8 The reduction factor for creep must be determined considering the reduction of the flow capacity of the geocomposite whose thickness was reduced to the value established using Test Method D7361, or projected based on tests performed using Test Method D7406. To isolate the reduction factor for creep from the reduction factor for long-term geotextile intrusion, RF_{CR} is determined between Rigid/Rigid boundaries.

8.8.1 Two methods have proven records of performance to define a relation between the flow capacity and the residual thickness of the core, established using Test Method D7361 or D7406:

8.8.1.1 Method 1: Combining relations between 'water flow rate versus normal load' and 'normal load versus residual thickness' to establish a relation between water flow rate and thickness, for a particular product and particular boundary conditions.

8.8.1.2 Method 2: Using a thickness-controlled test, where the thickness of the core is monitored while performing a test per Test Method D4716/D4716M. Direct control of the thickness permits the development of a direct relation between residual thickness and flow rate (or transmissivity), therefore limiting the bias caused by calculations and the multiplication of uncertainties.

8.8.2 Once a relation is established between residual thickness (that is, reflecting a service life under a given load) and the flow rate, RF_{CR} is determined by dividing the flow value calculated with conditions reflecting a 100-h seating time with the flow value calculated with conditions reflecting the service life (Eq 3).

$$RF_{CR(\sigma,T)} = \frac{q\left[t_{(\sigma,100h)}\right]}{q\left[t_{(\sigma,T)}\right]} \tag{3}$$

where:

$RF_{CR(\sigma,T)}$ = reduction factor for creep after a service life T under a normal load σ,
$q[R/R, t_{(\sigma,T)}]$ = flow rate determined for Rigid/Rigid boundaries, and a thickness reflecting the thickness prevailing after a service life T under a normal load σ, and
$q[R/R, t_{(\sigma,100h)}]$ = flow rate determined for Rigid/Rigid boundaries and a seating time of 100 h under a normal load σ.

8.8.3 When the test is performed using at least one soft boundary (that is, Soft/Soft or Rigid/Soft), the reduction factor for creep calculated with Rigid/Rigid boundaries is applied on the reference flow established with realistic boundary conditions. It is understood that the flow after creep of the core may be affected to a higher magnitude when geotextile intrusion is significant. However, this bias is recovered once the reduction factor for long-term geotextile intrusion is applied.

9. Reduction Values for Chemical and Biological Clogging, RF_{CC} and RF_{BC}

9.1 There are two general types of core clogging that might occur over a long time period. They are chemical clogging and biological clogging. Chemical clogging within the drainage core space can occur with precipitates deposited from high-alkalinity soils, typically calcium and magnesium. Other precipitates can also be envisioned, such as fines from turbid liquids, although this is less likely since the turbid liquid must typically pass through a geotextile filter.

9.2 Biological clogging within the drainage core space can occur by the growth of biological organisms, or by roots growing through the overlying soil and extending downward through the geotextile filter and into the drainage core. It is a site-specific situation and depends on the local or anticipated vegetation, cover soil, hydrology, etc.

9.3 Contact the product manufacturers for reduction factors for chemical and biological clogging as they are product, geotextile, and core dependent. RF_{CC} and RF_{BC} are also likely to vary tremendously from one application to the other (that is, in a landfill or for drainage of an embankment). In the absence of relevant information, test methods such as D1987 may be useful for assessing the sensitivity of a particular geotextile filter to biological or chemical clogging in particular environmental conditions, in a direction perpendicular to the plane of the geotextile. There were no test methods available to assess the influence of a particular environment on the transmissivity of a drainage geocomposite at the time this standard was prepared. If such an assessment is needed, the appropriate procedure should be agreed on by the end user and the manufacturer, considering existing literature and experience.