Designation: D7406 – 07 (Reapproved 2012)

Standard Test Method for Time-Dependent (Creep) Deformation Under Constant Pressure for Geosynthetic Drainage Products[1]

1. Scope

1.1 This test method is used to determine the unconfined compressive creep characteristics of drainage geotextiles, geocomposites, geonets, or any other geosynthetic associated with drainage at a constant temperature, when subjected to a constant compressive stress.

1.2 This test method is intended for use as an unconfined compressive performance creep test only. For a detailed procedure on how to establish an index test see the EN standard 1897. For performance tests, the specimen shall be subjected to the site-specific liquid and/or the site-specific stress (normal and potentially shear stress).

NOTE 1—Results achieved from unconfined compressive performance creep may differ from testing performed under confined conditions.

1.3 Because of the changing nature of the geosynthetic industry, and the wide variety of products already available, this particular test method may have to be slightly modified for unconfined compression creep testing of some products..

1.4 The values given in SI units are to be considered as the standard. The values given in parentheses are for information only.

1.5 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
D4439 Terminology for Geosynthetics
D5199 Test Method for Measuring the Nominal Thickness of Geosynthetics
D5261 Test Method for Measuring Mass per Unit Area of Geotextiles
D5262 Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
D6364 Test Method for Determining Short-Term Compression Behavior of Geosynthetics

2.2 *EN Standard:*

EN 1897

3. Terminology

3.1 For definitions related to geosynthetics, see Terminology D4439.

3.2 For definitions related to creep, see Test Methods D2990 and D5262.

3.3 *Definitions:*

3.3.1 *compressive creep, n*—time-dependent deformation or compressive strain of a material subjected to a constant compressive stress.

3.3.2 *compressive creep rupture, n*—failure by collapse of a material subjected to a constant compressive stress.

4. Summary of Test Method

4.1 In this performance test method, a geosynthetic drainage product is subjected to a sustained normal and potentially shear stresses. Deformations of the specimen are recorded at designated time intervals, and a graph is drawn.

4.2 The specimen may be immersed in a site-specific water or permeant, to simulate actual field conditions.

4.3 For long-term testing it is recommended that the test be run for at least 1000 h. Dwell times up to 10000 hr have been used, if that longer time data is required.

4.4 Creep load (normal as well as potentially shear) should reflect the actual field conditions

4.5 The test will be conducted at site specific temperatures.

5. Significance and Use

5.1 The performance characteristics of a drainage geosynthetic are directly related to the integrity under compressive

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.02 on Endurance Properties.

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[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.

loading. If the product is sensitive to compressive creep, its flow capacity could be greatly reduced or even shut off completely.

5.2 The creep sensitivity of a candidate geosynthetic can be tested at field-simulated normal stress and potentially shear stresses.

5.3 This test method does not evaluate the effect of creep of a geotextile filter or adjacent membrane.

5.4 Compression creep as it relates to reduction in flow capacity of a geosynthetic drainage product is manufacturer and product specific. For example, a 10% reduction in original thickness of a geonet made by manufacturer A does not necessarily equal the same reduction in flow capacity as a 10% reduction in thickness of the same or another type of geonet made by manufacturer B.

5.5 This creep data has is merit directly to the end user, because it can be easily interpreted to result into a reduction factor for creep[3] . The Reduction factor can then be used to derive an allowable flow rate[4].

6. Apparatus

6.1 *Overall System*— Fig. 1 shows a compression creep test setup. It consists of a loading platen, a normal stress assembly, potentially a shear load assembly (not shown in Fig. 1), potentially a specimen container, and three digital gages (one shown in Fig. 1).

6.2 *Specimen Container*— The specimen container shall have a flat, rigid surface on which the base platen is placed. The container shall be deep enough to allow the test specimen to be completely immersed during testing. The container shall be large enough to hold a minimum specimen size of 150 by 150 mm (6.0 by 6.0 in.), but can have size of 300 by 300 mm (12.0 by 12.0 in.) or larger to assure the test setup remains unconfined.

6.3 *Base Platen*— The base platen shall be rigid enough to resist bending and, in turn, support a uniform normal stress. A thick steel plate is advisable. The base platen shall be placed in the specimen container to support the tested specimen. When shear stress is applied it is necessary to avoid slippage of the tested specimen with the base platen (rough surfaces on the platen are recommended). Ideally the base platen will be larger than the specimen size to support the specimen during draping and flexing under the stress assembly.

6.4 *Loading Platen*— The loading platen shall be rigid enough to resist bending and, in turn, apply a uniform normal stress. When shear stress is applied it is necessary to avoid slippage of the tested specimen with the loading platen (rough surfaces on the platen are recommended). The loading platen shall be slightly larger than the specimen to provide even compression during the entire duration of the test. In addition the loading platen will be attached to the stress assembly in such a way that no stress is placed on the specimen until the commencement of the test and the weight of which is included in the measurement of the applied stress when appropriate for the loading system used.

6.5 *Digital Gages*— At least 3 digital gages accurate to 0.01 mm (0.0005 in.) shall be used to measure specimen deformation for the normal stress assembly. Alternatively, any device that can measure deformations to an accuracy of 0.01 mm (0.0005 in.) may be substituted for a digital gage (for example, a linear variable differential transformer (LVDT)). If a shear stress assembly is used 1 digital gages shall be used to measure that deformation.

6.6 *Normal Stress and Potentially Shear Stress Assembly* — The compressive stress may be applied mechanically, pneumatically, or hydraulically. The loading device, however, shall be capable of applying the full magnitude of test stress in one controlled step (with no significant impact). Some systems may use dead weights to apply stress. At high stress levels, the

[3] Giroud, J.-P., Zhao, A. and Richardson, G. N. (2000), "Effect of Thickness Reduction on Geosynthetic Hydraulic Transmissivity," Geosynthetics International, Vol. 7, Nos. 4-6, pp. 433-452.

[4] GRI GC-8 standard (2001), "Standard guide for determination of the allowable flow rate of a drainage geocomposite"

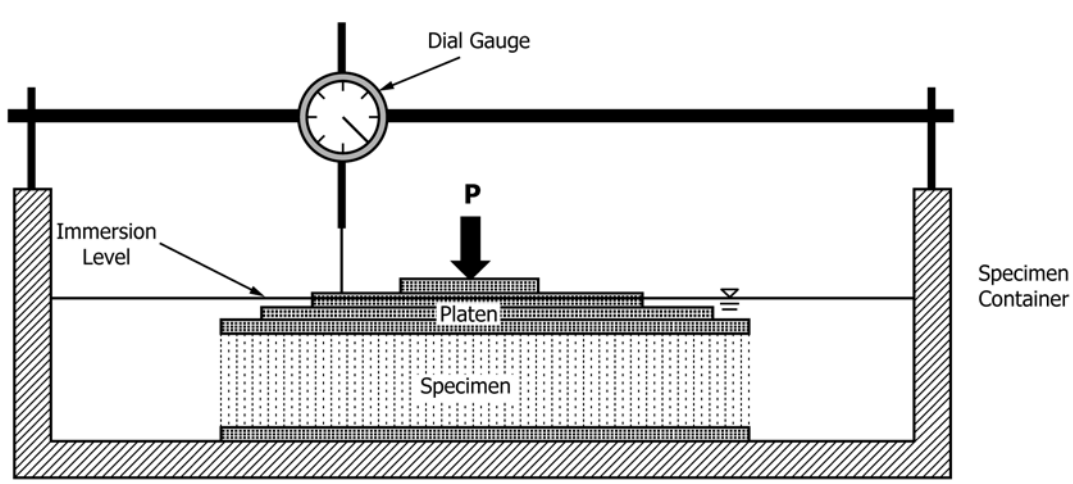

FIG. 1 Creep Apparatus Cross Section

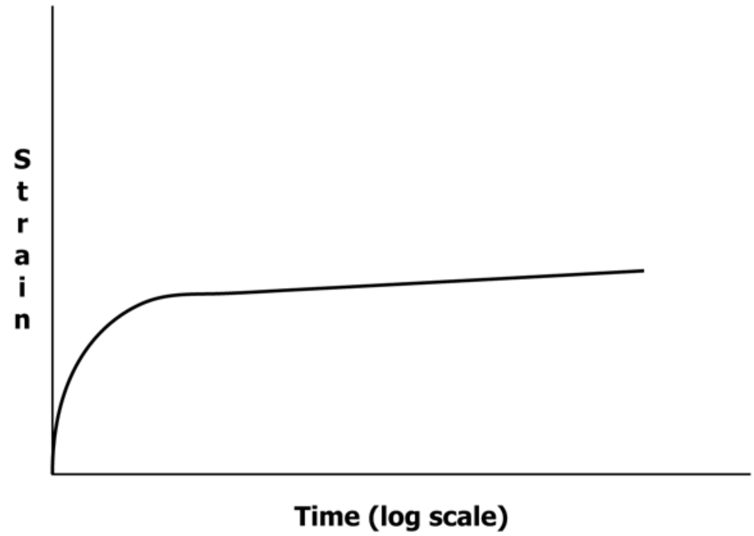

FIG. 2 Typical Geocomposite Creep Response

magnitude of the weight required may make it difficult or impossible to load the system in a controlled manner. In this case, a hydraulic jack can be used to support the weights until the test is commenced.

NOTE 2—Given the large variety of shear stress assemblies in use, it was not the intent to eliminate some units in use, by describing here only some. From movable platens, to inclined plates, to block assemblies have been used successfully to collect shear deformations and ultimately shear strains. Key is to assure that the shear stress is transferred into the specimen, hence extra care has to be taken to assure there is no slippage.

7. Sampling, Test Specimens, and Test Units

7.1 *Test Specimens-* Remove at least two specimen normally taken equally spaced across the laboratory sample. The specimen shall be cut square, a minimum of 150 by 150 mm (6.0 by 6.0 in.). The specimen shall be taken no less than 300 mm (12 in.) from the edge of the stock and shall be examined before testing to verify that it is representative of the stock from which it is taken.

NOTE 3—Given that the compressive units described in this test method have sizes ranging from 150 mm to 300mm square, it is recommended that the largest size specimen is tested that will fit within the testing device. In addition for some very high stresses, the available pressure might limit the size of the tested sample. However that minimum cannot be less than 150 mm by 150mm.

7.2 Test specimens that are to be immersed during testing shall be saturated in the site-specific liquid or leachate at the temperature desired by the end user until equilibrium is reached (typically within a tolerance of ± 0.5°C for 24 h before testing).

8. Conditioning

8.1 Testing shall be conducted at the site specific temperature ± 0.5°C. If the laboratory cannot be controlled within this range, tests need to be performed in a suitable environmental chamber capable of controlled cooling and heating. The environmental chamber shall have a programmable or set-point controller so as to maintain the desired temperature to ±0.5°C.

8.2 Allow the specimen adequate time to come to temperature equilibrium in the laboratory or environmental chamber. Generally, this can be accomplished within a few hours.

8.3 Record the relative humidity in the laboratory or environmental chamber if moisture sensitive products are tested and are not immersed into the permeant.

9. Procedure

9.1 Place specimen to be tested onto the loading base. If the specimen is to be immersed, it shall be done so during this step and placed into a specimen container.

9.2 Insert the specimen container into Normal Stress-and potentially shear stress assembly.

9.3 Set the loading platen into position over the specimen and adjust the dial over the loading platen. The 3 digital gauges are positioned on 3 different sides of the loading platen. It is recommended that the dial gauges are zeroed more or less at the same time when the desired level of stress is applied to the specimen.

9.4 Apply the desired level of stress (normal and potentially shear).

NOTE 4—Loading in a stepwise fashion could be more representative to simulate conditions in the field. If the applied stress was applied in a stepwise fashion, it should be recorded in the report.

9.5 Record deformation readings from the 3 digital gauges from the normal stress assembly, potentially also from the shear stress assembly at 1, 10, 30, 60 min and 2, 4, 8, 24, 48, 72, 96, 120, 144, and 168 h. Readings are taken at every 168 h thereafter.

9.6 Readings shall continue for a minimum of 168 h, up till 1000 hrs or more if longer-term data are required. Dwell times up to 10000 hrs have been used, but for some products even longer dwell times are recommended.

9.7 Repeat the procedure 9.1—9.6 in the remaining test specimens.

10. Calculation

10.1 Applied normal stress may be calculated as follows:

$$\sigma_n = P/A$$

where:

σ_n = normal stress in kPa (psi),
$P.$ = applied vertical load in kN (lbf), and
A = planar area of specimen in m^2 ($in.^2$)

10.2 Applied shear stress may be calculated as follows:

$$T_n = F_s/A$$

where:

T_n = shear stress in kPa (psi),
F_s = applied shear load in kN (lbf), and
A = planar area of specimen in m^2 ($in.^2$)

10.3 Normal strain may be calculated as follows:

$$\epsilon_n = (\Delta L_n/L_n) \times 100$$

where:

ε_n = strain (%) for each digital gauge (n),
n = digital gauge number,
ΔL_n = deformation in mm (in.), and
L_n = initial thickness in mm (in.).

NOTE 5—The initial thickness (for each location the digital gauge is placed) is measured in the compressive creep unit with a normal stress of 20kPa, before the desired level of stress is applied.

10.4 Shear strain may be calculated as follows:

$$g_s = (\Delta H/L_n)\ x\ 100$$

where:

g_s = shear strain (%),
ΔH = horizontal displacement of one face platen relative to the other in mm (in.), and
L_n = initial thickness in mm (in.).

10.5 The specimen test result is the average of the 3 normal strains measured from the 3 different normal digital gauge locations; or potentially the average of the shear strains measured from the different shear digital gauge locations

10.6 The sample test results is the average of the specimen test results, normal and potentially shear, respectfully.

11. Report

11.1 The report shall include a description of the material tested including its short-term compressive behavior per Test Method D6364, thickness per Test Method D5199 at 20kPa, mass per unit area per Test Method D5261, applied normal stress, potentially a shear stress. The conditions under which the test was conducted (temperature, site specific liquid if any) including conditioning of the specimens, shall also be reported.

11.2 The report shall include a plot of the average normal strain versus time for each specimen tested, if a shear stress was applied that shear strain versus time should be plotted as well. Fig. 2 shows a typical normal stress response for a single specimen of geocomposite.

11.3 The report shall include a table showing for all times steps data was collected per specimen tested: normal deformations in mm collected for each digital gauge, calculated normal strain for each digital gauge, in addition the average normal strain for all digital gauges collecting the normal deformation. If a shear stress was applied, shear deformation, and shear strain versus time as well.

11.4 If it is desired to extrapolate creep response to future times, there are a number of different techniques for analyzing creep behavior (for example Test Methods D2990 , Appendix X5 for prediction of long-term properties, the three-element model, curve extrapolation, and so forth). As they are beyond the scope of this test method, it is necessary to include the raw data in the report. See WSDOT Standard Practice T925[5] for further details in this regard.

12. Precision and Bias

12.1 The precision and bias for this test method is under development and will be available within five years.

13. Keywords

13.1 compressive creep; creep rupture; geosynthetic

[5] Washington State Department of Transportation, 2005, "Standard Practice for Determination of Long-Term Strength of Geosynthetics," WSDOT Standard Practice T925, State Materials Laboratory, Tumwater, WA, 85 pp.