Designation: D6992 – 16 (Reapproved 2023)

Standard Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method[1]

This standard is issued under the fixed designation D6992; 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 test method covers accelerated testing for tensile creep, and tensile creep-rupture properties using the Stepped Isothermal Method (SIM).

1.2 The test method is focused on geosynthetic reinforcement materials such as yarns, ribs of geogrids, or narrow geotextile specimens.

1.3 The SIM tests are laterally unconfined tests based on time-temperature superposition procedures.

1.4 Tensile tests are to be completed before SIM tests and the results are used to determine the stress levels for subsequent SIM tests defined in terms of the percentage of Ultimate Tensile Strength (T_{ULT}). Additionally, the tensile test can be designed to provide estimates of the initial elastic strain distributions appropriate for the SIM results.

1.5 Ramp and Hold (R+H) tests may be completed in conjunction with SIM tests. They are designed to provide additional estimates of the initial elastic and initial rapid creep strain levels appropriate for the SIM results.

1.6 This method can be used to establish the sustained load creep and creep-rupture characteristics of a geosynthetic. Results of this method are to be used to augment results of Test Method D5262 and may not be used as the sole basis for determination of long-term creep and creep-rupture behavior of geosynthetic material.

1.7 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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.*

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

D4595 Test Method for Tensile Properties of Geotextiles by the Wide-Width Method

D5262 Test Method for Determining the Unconfined Tension Creep and Creep Rupture Behavior of Planar Geosynthetics Used for Reinforcement Purposes

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 of Terms Specific to This Standard:*

3.3.1 *creep modulus—in SIM analysis*, the load divided by the percent strain at any given point in time.

3.3.2 *dwell time*—time during which conditions (particular load) are held constant between temperature steps.

3.3.3 *mean test temperature*—the arithmetic average of all temperature readings of the atmosphere surrounding the test specimen for a particular temperature step, starting at a time not later than established temperature ramp time, and finishing at a time just prior to the subsequent temperature reset.

[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.

Current edition approved Sept. 1, 2023. Published September 2023. Originally approved in 2003. Last previous edition approved in 2016 as D6992 – 16. DOI: 10.1520/D6992-16R23.

[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.

3.3.4 *offset modulus method or pointing*—data analysis method used to normalize any prestrain in the samples by shifting the origin of a stress-versus-strain curve to an axis origin of coordinates; that is, to coordinates (0,0).

3.3.5 *ramp and hold (R+H) test*—a creep test of very short duration; for example, 100 to 1000 s.

3.3.6 *shift factor*—the displacement along the log time axis by which a section of the creep or creep modulus curve is moved to create the master curve at the reference temperature. Shift factors are denoted by the symbol AT when the displacements are generally to shorter times (attenuation) or the symbol AT when the displacements are generally to longer times (acceleration).

3.3.7 *stepped isothermal method (SIM)*—a method of exposure that uses temperature steps and dwell times to accelerate creep response of a material being tested under load.

3.3.8 *tensile creep*—time-dependent deformation that occurs when a specimen is subjected to a constant tensile load.

3.3.9 *tensile creep rupture*—time dependent rupture that terminates a creep test at high stress levels.

3.3.10 *time-temperature superposition*—the practice of shifting viscoelastic response curves obtained at different temperatures along a horizontal log time axis so as to achieve a master curve covering an extended range of time.

3.3.11 *ultimate tensile strength (T_{ULT})*—short-term strength value used to normalize creep rupture strengths.

3.3.12 *viscoelastic response*—refers to polymeric creep, strain, stress relaxation, or a combination thereof.

4. Summary of Test Method

4.1 *SIM*—A procedure whereby specified temperature steps and dwell times are used to accelerate viscoelastic creep characteristics during which strain and load are monitored as a function of time.

4.1.1 *Tensile Creep*—Constant tensile load in conjunction with specified temperature steps and dwell times are used to accelerate creep strain response.

4.1.2 *Tensile Creep-Rupture*—A tensile creep test where high stress levels are used during testing to ensure rupture, while specified temperature steps and dwell times are used to accelerate creep strain response characteristics. Strain is monitored as a function of time.

4.2 *Tensile Tests*—Test specimens are rapidly loaded over a short period to achieve rupture. The selection of a suitable tensile test is dependent upon the type of material tested (see Section 8). Tensile tests to support creep and creep-rupture tests are performed under the same control of loading or strain rate as used to load or strain the test specimens during creep or creep rupture tests.

4.3 *R+H*—Test specimens are ramp loaded at a predetermined loading rate to a predetermined load and held under constant load (short-term creep test).

5. Significance and Use

5.1 Use of the Stepped Isothermal Method decreases the time required for creep to occur and the obtaining of the associated data.

5.2 The statements set forth in 1.6 are very important in the context of significance and use, as well as scope of the standard.

5.3 Creep test data are used to calculate the creep modulus of materials as a function of time. These data are then used to predict the long-term creep deformation expected of geosynthetics used in reinforcement applications.

NOTE 1—Currently, SIM testing has focused mainly on woven and knitted geogrids and woven geotextiles made from polyester, aramid, polyaramid, poly-vinyl alcohol (PVA), and polypropylene yarns and narrow strips. Additional correlation studies on other materials are needed.

5.4 Creep-rupture test data are used to develop a regression line relating creep stress to rupture time. These results predict the long-term rupture strength expected for geosynthetics in reinforcement applications.

5.5 Tensile testing is used to establish the ultimate tensile strength (T_{ULT}) of a material and to determine elastic stress, strain, and variations thereof for SIM tests.

5.6 Ramp and Hold (R+H) testing is done to establish the range of creep strains experienced in the brief period of very rapid response following the peak of the load ramp.

6. Apparatus

6.1 *Grips*—Grips for SIM and R+H tests should be the same as the grips for ultimate strength tensile tests. Neither slippage nor excessive stress causing premature rupture should be allowed to occur.

6.2 *Testing Machine*—A universal testing machine or a dead-weight loading system with the following capabilities and accessories shall be used for testing.

6.2.1 Load measurement and control,

6.2.2 Strain measurement and control,

6.2.3 Time measurement,

6.2.4 Environmental temperature chamber to facilitate control of test conditions,

6.2.4.1 Temperature measurement and control facilities,

6.2.5 Other environmental measurement and control, and

6.2.6 Computer data acquisition and control.

7. Sampling

7.1 The specimens used for tensile, R+H, and SIM tests should all be taken from the same sample.

7.2 Remove sufficient test specimens for tensile testing in accordance with the selected tensile testing procedure (see Section 8).

7.3 Remove one test specimen from the sample for each SIM test.

7.4 Remove one test specimen from the sample for each R+H test.

8. Test Specimens

8.1 Geogrid specimens should be single ribs, unless otherwise agreed upon.

8.2 Yarn specimens of geogrids or geotextiles should be single ply or multiple ply strands, unless otherwise agreed upon.