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Standard Test Methods for Determining Small-Strain Tensile Properties of Geogrids and Geotextiles by In-Air Cyclic Tension Tests[1]

This standard is issued under the fixed designation D7556; 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 These test methods cover the determination of small-strain tensile properties of geogrids and geotextiles by subjecting wide-width specimens to cyclic tensile loading.

1.2 These test methods (A, B, and C) allow for the determination of small-strain cyclic tensile modulus by the measurement of cyclic tensile load and elongation.

1.3 This test method is intended to provide properties for design. The test method was developed for mechanistic-empirical pavement design methods requiring input of the reinforcement tensile modulus. The use of cyclic modulus from this test method for other applications involving cyclic loading should be evaluated on a case-by-case basis.

1.4 Three test methods (A, B, and C) are provided to determine small-strain cyclic tensile modulus on geogrids and geotextiles.

1.4.1 *Test Method A*—Testing a relatively wide specimen of geogrid in cyclic tension in kN/m (lbf/ft).

1.4.2 *Test Method B*—Testing multiple layers of a relatively wide specimen of geogrid in cyclic tension in kN/m (lbf/ft).

1.4.3 *Test Method C*—Testing a relatively wide specimen of geotextile in cyclic tension in kN/m (lbf/ft).

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses are provided for information only and are not considered standard.

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]

D76/D76M Specification for Tensile Testing Machines for Textiles

D123 Terminology Relating to Textiles

D579/D579M Specification for Greige Woven Glass Fabrics

D4354 Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing

D4439 Terminology for Geosynthetics

3. Terminology

3.1 *Definitions:*

3.1.1 *atmosphere for testing geosynthetics, n*—air maintained at a relative humidity of 50 to 70 % and a temperature of 21 ± 2 °C (70 ± 4 °F).

3.1.2 *corresponding force, n*—synonym for *force at specified elongation*.

3.1.3 *force at specified elongation (FASE), n*—force associated with a specific elongation on the force-elongation curve. (Synonym for *corresponding force*.)

3.1.4 *force-elongation curve, n—in a tensile test*, graphical representation of the relationship between the magnitude of an externally applied force and the change in length of the specimen in the direction of the applied force. (Synonym for *stress-strain curve*.)

3.1.5 *geogrid, n*—geosynthetic formed by a regular network of integrally connected elements with apertures greater than 6.35 mm (¼ in.) to allow interlocking with surrounding soil, rock, earth, and other surrounding materials to primarily function as reinforcement.

3.1.6 *geosynthetic, n*—product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering-related material as an integral part of a man-made project, structure, or system.

[1] These test methods are under the jurisdiction of ASTM Committee D35 on Geosynthetics and are the direct responsibility of Subcommittee D35.01 on Mechanical 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.

3.1.7 *geotextile, n*—any permeable textile material used with foundation, soil, rock, earth, or any other geotechnical engineering-related material, as an integral part of a man-made project, structure, or system.

3.1.8 *integral, adj—in geosynthetics*, forming a necessary part of the whole; a constituent.

3.1.9 *junction, n*—point where geogrid ribs are interconnected to provide structure and dimensional stability.

3.1.10 *rib, n—for geogrids*, continuous elements of a geogrid which are either in the machine or cross-machine direction as manufactured.

3.1.11 *tensile, adj*—capable of tensions, or relating to tension of a material.

3.1.12 *tensile strength, (α_f), n—for geogrids*, maximum resistance to deformation developed for a specific material when subjected to tension by an external force. Tensile strength of geogrids is the characteristic of a sample as distinct from a specimen and is expressed in force per unit width.

3.1.13 *tensile test, n—for geosynthetics*, test in which a material is stretched uniaxially to determine the force elongation characteristics, the breaking force, or the breaking elongation.

3.1.14 *tension, n*—force that produces a specified elongation.

3.2 For definitions of other terms used in these test methods, refer to Terminologies D123 and D4439.

4. Summary of Test Method

4.1 *Test Method A*—In this test method, a relatively wide geogrid specimen is gripped across its entire width in the clamps of a constant rate of extension type tensile testing machine operated at a prescribed rate of extension, applying a uniaxial cyclic load to the specimen over specified limits of cyclic axial strain and centered around six successively greater levels of prescribed or permanent axial strain. Tensile modulus in kN/m (lbf/ft) of the test specimen can be calculated at each level of prescribed axial strain from the last cycles of load from machine scales, dials, recording charts, or an interfaced computer.

4.2 *Test Method B*—A relatively wide, multiple-layered geogrid specimen is gripped across its entire width in the clamps of a constant rate of extension type tensile testing machine operated at a prescribed rate of extension, applying a uniaxial cyclic load to the specimen over specified limits of cyclic axial strain and centered around six successively greater levels of prescribed or permanent axial strain. Tensile modulus in kN/m (lbf/ft) of the test specimen can be calculated at each level of prescribed axial strain from the last cycles of load from machine scales, dials, recording charts, or an interfaced computer.

4.3 *Test Method C*—A relatively wide geotextile specimen is gripped across its entire width in the clamps of a constant rate of extension type tensile testing machine operated at a prescribed rate of extension, applying a uniaxial cyclic load to the specimen over specified limits of cyclic axial strain and centered around six successively greater levels of prescribed or permanent axial strain. Tensile modulus in kN/m (lbf/ft) of the test specimen can be calculated at each level of prescribed axial strain from the last cycles of load from machine scales, dials, recording charts, or an interfaced computer.

5. Significance and Use

5.1 Test Methods A, B, and C provide a means of evaluating the tensile modulus of geogrids and geotextiles for applications involving small-strain cyclic loading. The test methods allow for the determination of cyclic tensile modulus at different levels of prescribed or permanent strain, thereby accounting for possible changes in cyclic tensile modulus with increasing permanent strain in the material. These test methods shall be used for research testing and to define properties for use in specific design methods.

5.2 In cases of dispute arising from differences in reported test results when using these test methods for acceptance testing of commercial shipments, the purchaser and supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens which are as homogeneous as possible and which are from a lot of material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the testing began. If a bias is found, either its cause shall be found and corrected or the purchaser and supplier shall agree to interpret future test results in light of the known bias.

5.3 All geogrids can be tested by Test Method A or B. Some modification of techniques may be necessary for a given geogrid depending upon its physical makeup. Special adaptations may be necessary with strong geogrids, multiple-layered geogrids, or geogrids that tend to slip in the clamps or those which tend to be damaged by the clamps.

5.4 Most geotextiles can be tested by Test Method C. Some modification of clamping techniques may be necessary for a given geotextile depending upon its structure. Special clamping adaptations may be necessary with strong geotextiles or geotextiles made from glass fibers to prevent them from slipping in the clamps or being damaged as a result of being gripped in the clamps.

5.5 These test methods are applicable for testing geotextiles either dry or wet. It is used with a constant rate of extension type tension apparatus.

5.6 These test methods may not be suited for geogrids and geotextiles that exhibit strengths approximately 100 kN/m (600 lbf/in.) due to clamping and equipment limitations. In those cases, 100-mm (4-in.) width specimens may be substituted for 200-mm (8-in.) width specimens.

6. Apparatus

6.1 *Testing Clamps*—The clamps shall be sufficiently wide to grip the entire width of the specimen and with appropriate

clamping power to prevent slipping or crushing (damage). Fixed clamps shall be used.

6.1.1 *Size of Jaw Faces*—Each clamp shall have jaw faces measuring wider than the width of the specimen.

6.2 *Tensile Testing Machine*—A testing machine of the constant rate of extension type as described in Specification D76/D76M shall be used. The testing machine shall be capable of applying cyclic loads between specified limits of deformation as specified in 10.4 and 10.6. The machine shall be equipped with a device for recording the tensile force and the amount of separation of the grips. Both of these measuring systems shall be accurate to ±1.0 % and, preferably, shall be external to the testing machine. The rate of separation shall be uniform and capable of adjustment within the range of the test. A stroke of approximately 100 to 150 mm (4 to 6 in.) and a load rating of approximately 50 kN (11 kips) is recommended for these types of tests.

6.3 *Distilled Water and Nonionic Wetting Agent*—Used for wet specimens only.

6.4 *Extensometer*—When required by the test method, a device capable of measuring the distance between two reference points on the specimen without any damage to the specimen or slippage, care being taken to ensure that the measurement represents the true movement of the reference points. Examples of extensometers include mechanical, optical, infrared, or electrical devices.

7. Sampling

7.1 *Lot Sample*—Divide the product into lots, and take the lot sample as directed in Practice D4354.

7.2 *Laboratory Sample*—For the laboratory sample, take a full roll-width swatch long enough in the machine direction from each roll in the lot sample to ensure that the requirements in 8.1 can be met. The sample may be taken from the end portion of a roll, provided there is no evidence it is distorted or different from other portions of the roll.

8. Test Specimen

8.1 The specimens shall consist of three junctions or 300 mm (12 in.) in length, in order to establish a minimum specimen length in the direction of the test (either the machine, cross-machine, or some other direction, if appropriate). All specimens should be free of surface defects, etc. not typical of the laboratory sample. Take no specimens nearer the selvage edge along the geogrid than one-tenth the width of the sample.

NOTE 1—If comparing one geogrid to another, the length of each specimen shall be the same (as similar as possible) and agreed upon by all parties.

8.2 *Preparation:*

8.2.1 *Test Method A*—Prepare each finished specimen to be a minimum of 200 mm (8 in.) wide and contain at least five ribs in the cross-test direction by at least three junctions (two apertures) or 300 mm (12 in.) long in the direction of testing, with the length dimension being designated and accurately cut parallel to the direction for which the tensile strength is being measured.

8.2.2 *Test Method B*—Prepare each finished specimen to be a minimum of 200 mm (8 in.) wide and contain five ribs in the cross-test direction by at least three junctions (two apertures) or 300 mm (12 in.) long in the direction of testing, with the length dimension being designated and accurately cut parallel to the direction for which the tensile strength is being measured. This shall be repeated for each layer of geogrid included in the test.

8.2.3 *Test Method C*—Prepare each finished specimen to be a minimum of 200 mm (8 in.) wide (excluding fringe when applicable; see 8.2.5) by at least 200 mm (8 in.) long (see 8.2.5) with the length dimension being designated and accurately parallel to the direction for which the tensile modulus is being measured. Centrally, draw two lines running the full width of the specimen, accurately perpendicular to the length dimension and separated by 100 mm (4 in.) to designate the gauge area.

8.2.4 For some woven geotextiles, it may be necessary to cut each specimen 210 mm (8.5 in.) wide and then remove an equal number of yarns from each side to obtain the 200-mm (8-in.) finished dimension. This helps maintain specimen integrity during the test.

8.2.5 For geotextiles where specimen integrity is not affected, the specimens may be initially cut to the finished width.

8.2.6 When the wet tensile modulus of the geotextile is required in addition to the dry tensile modulus, cut each test specimen at least twice as long as is required for a standard test (see Note 2). Number each specimen and then cut it crosswise into two parts: one for determining the conditioned tensile modulus and the other for determining the wet tensile modulus. Each portion shall bear the specimen number. In this manner, each paired break is performed on test specimens containing the same yarns.

NOTE 2—For geotextiles which shrink excessively when wet, cut the test specimens for obtaining wet tensile strength longer in dimension than that for dry tensile strength.

8.3 *Number of Test Specimens:*

8.3.1 Unless otherwise agreed upon as when provided in an applicable material specification, take a number of test specimens per swatch in the laboratory sample such that the user may expect at the 95 % probability level that the test result is no more than 5 % above the true average for each swatch in the laboratory sample for each required direction; see Note 3.

NOTE 3—In some applications, it may be necessary to perform tensile tests in both the machine and the cross-machine directions. In all cases, the direction of the tensile test specimen(s) should be clearly noted.

8.3.2 *Reliable Estimate of* v—When there is a reliable estimate of v based upon extensive past records for similar materials tested in the user's laboratory as directed in the test method, calculate the required number of specimens using Eq 1, as follows:

$$n = (tv/A)^2 \quad (1)$$

where:

n = number of test specimens (rounded upward to a whole number),