**Designation: D7556 – 10**

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

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D76 Specification for Tensile Testing Machines for Textiles
D123 Terminology Relating to Textiles
D579 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

[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.

engineering related material as an integral part of a man made project, structure, or system.

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, ($\alpha_f$) , 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 Terminology 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 Methods A or B. Some modification of techniques may be necessary for a given geogrid depending upon its physical make-up. 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 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 1⁄10 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),

$v$ = reliable estimate of the coefficient of variation of individual observations on similar materials in the user's laboratory under conditions of single-operator precision, %,
$t$ = the value of Student's t for one-sided limits, a 95 % probability level, and the degrees of freedom associated with the estimate of $v$, and
$A$ = 5.0 % of the average, the value of allowable variation.

8.3.3 *No Reliable Estimate of v*—When there is no reliable estimate of $v$ for the user's laboratory, Eq 1 should not be used directly. Instead, specify the fixed number of five specimens for the required direction. The number of specimens is calculated using $v$ = 9.5 % of the average for the required direction. This value for $v$ is somewhat larger than usually found in practice. When a reliable estimate of v for the user's laboratory becomes available, Eq 1 will usually require fewer than the fixed number of specimens.

## 9. Conditioning

9.1 Expose the specimens to the atmosphere for testing geosynthetics for a period long enough to allow the geogrid or geotextile to reach equilibrium within this standard atmosphere. Consider the specimen to be at moisture equilibrium when the change in mass of the specimen in successive weighings made at intervals of not less than 2 h does not exceed 0.1 % of the mass of the specimen. Consider the specimen to be at temperature equilibrium after 1 h of exposure to the atmosphere for testing geosynthetics.

9.2 Specimens to be tested in the wet condition shall be immersed in water for a minimum of one hour, maintained at a temperature of 21 ± 2°C (70 ± 4°F). The time of immersion shall be sufficient to wet-out the specimens thoroughly, as indicated by no significant change in strength or elongation following a longer period of immersion (at least 2 min). To obtain thorough wetting, it may be necessary or advisable to use distilled water and to add not more than 0.05 % of a nonionic neutral wetting agent to the water.

9.3 Geogrids may be received in the laboratory rolled, thus it is important to flatten the specimens to avoid misleading elongation measurements. Geogrids which exhibit curl memory should be laid flat and weighted, until the geogrid remains flat without weight.

## 10. Procedure

10.1 *Conditioned Specimens*—Test adequately conditioned specimens in the atmosphere for testing geotextiles.

10.2 *Wet Specimens*—Test thoroughly wet specimens in the normal machine set-up within 20 min after removal from the water.

10.3 Zero the testing system.

10.4 *Machine Set-Up Conditions:*

10.4.1 *Test Methods A and B*—At the start of the test, adjust the distance between the clamps to the greater distance of three junctions or 200 ± 3 mm (8.0 ± 0.1 in.), such that at least one transverse rib is contained centrally within the gauge length. At least one clamp should be supported by a free swivel or universal joint which will allow the clamp to rotate in the plane of the geogrid. Select the force range of the testing machine so the maximum applied force occurs between 10 and 90 % of full-scale force. The test shall be conducted at a strain rate of 10 ± 3 % per minute of the gauge length based on the gauge length as depicted in Fig. 1.

10.4.2 *Test Method C*—At the start of the test, adjust the distance between the clamps to the greater distance of three junctions or 100 ± 3 mm (4.0 ± 0.1 in.). At least one clamp should be supported by a free swivel or universal joint which will allow the clamp to rotate in the plane of the geotextile. Select the force range of the testing machine so the maximum applied force occurs between 10 and 90 % of full-scale force. The test shall be conducted at a strain rate of 10 ± 3 % per minute of the gauge length based on the gauge length as depicted in Fig. 1.

10.5 Mount the specimen centrally in the clamps and tighten sufficiently to prevent damage to the specimen, see Note 4 and Note 5. For geotextile specimens (Test Method C), use the two lines previously drawn on the specimen as alignment guides for the upper and lower jaws. Measure the distance between clamp faces or centerline to centerline of the roller grips to determine test specimen gauge length. External extensometers or other external means of measurement (for example, photo methods) are encouraged and shall be used to determine displacement when roller clamps are used in testing. Documentation should be provided if a discrepancy arises when extensometers are not used during testing.

NOTE 4—Some modifications of clamping techniques may be necessary for a given geogrid depending upon its construction. Special clamping configurations may be necessary for geogrids constructed of coated fibers or yarns to prevent them from slipping in the clamps or being damaged as a result of being gripped too tightly in the clamps.

NOTE 5—Care shall be taken while testing multiple geogrid layers to assure even tensioning of the layers and uniform clamping pressure. The test result shall be discarded if the result is a load at a small displacement or peak strength is reached without having all of the layers evenly tensioned.

10.6 Start the test by applying 0.5 % axial strain by applying monotonic load to the specimen. Apply 1000 cycles of load between axial strain limits of ±0.1 % of the prescribed permanent axial strain of 0.5 %. Continue the test by applying a total axial strain (prescribed permanent axial strain) of 1.0 % by applying additional monotonic load to the specimen. Apply

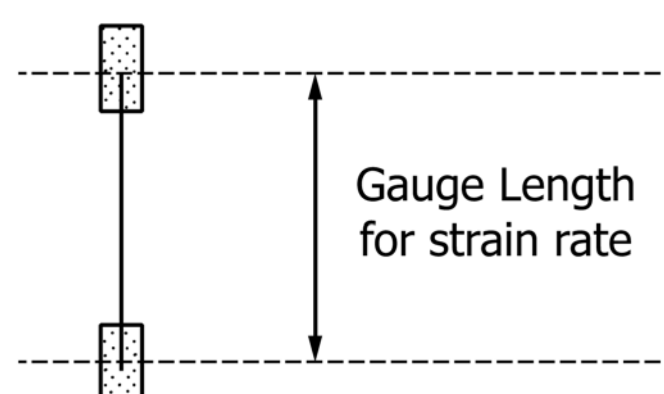


**FIG. 1 Gauge Length for Fixed and Roller Grip Clamping Systems**

1000 cycles of load between axial strain limits of ±0.1 % of the prescribed permanent axial strain of 1.0 %. Continue the test by repeating the monotonic and cyclic load applications with prescribed permanent axial strain values of 1.5, 2.0, 3.0 and 4.0 %, or until rupture occurs in the specimen. The loadings described above are performed on a single specimen (see Note 6).

NOTE 6—Data is not currently available to substantiate that similar results will be obtained for all materials by using new specimens for each of the six strain levels described above. It is recommended that a new specimen be used for one of the strain levels to show that similar results are obtained.

10.6.1 If a specimen of one or more layers slips in the jaws, breaks at the edge of or in the jaws, or if for any reason attributed to faulty operation the result falls markedly below the average for the set of specimens, see 10.6.2.

10.6.2 The decision to discard the results as discussed in 10.6.1 shall be based on observation of the specimen during the test. In the absence of other criteria for such tests, any test which results in a value below 20 % of the average of all the other breaks shall be discarded. No other break shall be discarded unless the test is known to be faulty.

10.6.3 It is difficult to determine the precise reason why certain specimens break near the edge of the jaws. If a jaw break is caused by damage to the specimen by the jaws, then the results should be discarded. If, however, it is merely due to randomly distributed weak places, it is a perfectly legitimate result. In some cases, it may also be caused by a concentration of stress in the area adjacent to the jaws because they prevent the specimen from contracting in width as the force is applied. In these cases, a break near the edge of the jaws is inevitable and shall be accepted as a characteristic of the particular method of test.

10.6.4 For instructions regarding the preparation of specimens made from glass fiber to minimize damage in the jaws, see Specification D579.

10.6.5 If a geotextile manifests any slippage in the jaws or if more than 24 % of the specimens break at a point within 5 mm (0.25 in.) of the edge of the jaw, then (*1*) the jaws may be padded, (*2*) the geotextile may be coated under the jaw face area, or (*3*) the surface of the jaw face may be modified. If any of the modifications listed above are used, state the method of modification in the report.

10.7 *Measurement of Elongation*—Measure the elongation of the geogrid at any stated force by means of a suitable recording device at the same time as the tensile strength is determined, unless otherwise agreed upon, as provided for in an applicable material specification. Measure the elongation to three significant figures.

10.7.1 The strain within the specimen is calculated from the measurement of elongation as discussed in 10.4 and shown in Fig. 1. It shall be obtained independently of the cross head movement. These measurements can be made with extensometers or area measuring devices which are set to read the center portion of the specimen and containing at least one transverse rib for geogrid specimens. When used, the minimum extensometer gauge length shall be 60 mm.

## 11. Calculation

11.1 Calculate the tensile strength for Points $P_2$ and $P_1$ (see Fig. 2) from a cycle of load. Point $P_2$ corresponds to the maximum load seen for the load cycle. Point $P_1$ corresponds to the minimum load seen at the end of the cycle.

11.2 Calculate the equivalent force per unit width expressed in N/m (lbf/in.) of width:

11.2.1 *Test Methods A and B*—Use Eq 2:

$$\alpha_f = [(P_2 - P_1)/N_r] \times N_t \quad (2)$$

*where:*

$\alpha_f$ = equivalent force per unit width, N/m (lbf/in.),
$P_2$ = observed maximum force for the cycle, N (lbf),
$P_1$ = minimum tensile load at the end of the cycle, N (lbf),
$N_r$ = number of tensile elements being tested, and
$N_t$ = number of tensile elements per unit width, equal to $N_c/b$ (see 11.2.2).

11.2.2 $N_t$ is determined by taking the average of three measurements from samples that are 95 % of the manufactured product roll width. Each measurement is performed by measuring the distance from the central point of the starting aperture (center line to center line aperture dimension divided by 2) to the center point of the aperture a distance equal to 95 % of the manufactured product roll width away from the starting aperture (this establishes the *b* value). As such, this measurement will result in a fractional value. The number of tensile elements, $N_c$, within this distance, *b*, are counted and $N_t$ is determined by dividing the $N_c$ value by the *b* value. For multiple layer geogrids, *b* should be measured using the single layer. The number of tensile elements, $N_c$, within this distance, *b*, are counted and multiplied by the number of layers found in the test specimen.

11.2.3 *Test Method C*—Use Eq 3:

$$\alpha_f = (P_2 - P_1)/W_s \quad (3)$$

*where:*

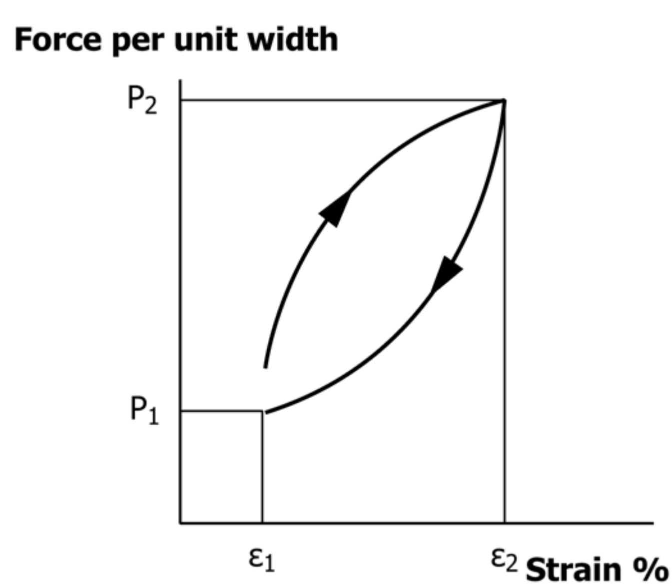


FIG. 2 Stress-Strain Cyclic Curve

$\alpha_f$ = equivalent force per unit width, N/m (lbf/in.),
$P_2$ = observed maximum force for the cycle, N (lbf),
$P_1$ = minimum tensile load at the end of the cycle, N (lbf), and
$W_s$ = specimen width, m (in.).

11.3 *Strain*—Calculate the percent strain corresponding to Points $P_1$ and $P_2$ (see Fig. 2).

11.4 Gauge marks or extensometers are required to define a specific test section of the specimen, per Fig. 1; when these devices are used, only the length defined by the gauge marks or extensometers shall be used in the calculation. Gauge marks shall not damage the geosynthetic.

11.5 *Cyclic Modulus*—Calculate cyclic tensile modulus using Eq 4.

$$J_{cyclic} = (\alpha_f \times 100)/(\varepsilon_2 - \varepsilon_1) \quad (4)$$

$J_{cyclic}$ = cyclic tensile modulus, N/m (lbf/ft), for a corresponding cycle,
$\alpha_f$ = equivalent force per unit width, N/m (lbf/in.) from Eq 2 or Eq 3,
$\varepsilon_2$ = percent strain corresponding to Point 2 in Fig. 2, and
$\varepsilon_1$ = percent strain corresponding to Point 1 in Fig. 2.

11.6 Repeat the calculations above for cyclic modulus for the last ten cycles of each of the six cyclic load steps.

11.7 Determine the average cyclic modulus for the last ten cycles of each of the six cyclic load steps.

## 12. Report

12.1 Report that the specimens were tested as directed in this test method, or any deviations from this test method. Describe all materials or products sampled and the method of sampling for each material.

12.2 Report all of the following applicable items for the machine direction and where appropriate, the cross machine direction of all materials tested:

12.2.1 Average cyclic modulus in kN/m (lbf/ft) for each of the six load cycles, see Fig. 2 and Section 11.

12.2.2 The standard deviation or the coefficient of variation of the test results.

12.2.3 Number of tensile elements, ribs, within the width of specimens.

12.2.4 Number of specimens tested.

12.2.5 Make and model of the testing machine.

12.2.6 Grip separation (initial).

12.2.7 Type, size, and facing of grips, and description of any changes made to the grips.

12.2.8 Conditioning of specimens, including details of temperature, relative humidity, and conditioning time.

12.2.9 Anomalous behavior, such as tear failure or failure at the grip.

## 13. Precision and Bias

13.1 *Precision*—The precision of these test methods is being established.

13.2 *Bias*—These test methods have no bias since the values of those properties can be defined only in terms of a test method.

## 14. Keywords

14.1 geogrid; geogrid rib; geosynthetic; geotextile; index test; tensile test