Designation: ~~D4533 – 11~~ D4533/D4533M – 15

Standard Test Method for
Trapezoid Tearing Strength of Geotextiles[1]

1. Scope

1.1 This test method is an index test used to measure the force required to continue or propagate a tear in woven or non-woven geotextiles by the trapezoid method. While useful for quality control and acceptance testing, the trapezoid tear test does not provide all the information needed for all design applications and other test methods should be used.

1.2 This test method is applicable to most geotextiles that include woven fabrics, nonwoven fabrics, layered fabrics, knit fabrics, and felts that are used for geotextile applications.

1.3 The values stated in either SI units or inch-pound units are to be regarded ~~as the standard. No other units of measurement are included in this~~ 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 non-conformance with the standard.

1.4 *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~~D76/D76M Specification for Tensile Testing Machines for Textiles

D123 Terminology Relating to Textiles

D1776 Practice for Conditioning and Testing Textiles

D2905 Practice for Statements on Number of Specimens for Textiles (Withdrawn 2008)[3]

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

D4439 Terminology for Geosynthetics

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 *atmosphere for testing geotextiles, n*—air maintained at a relative humidity of 65 ± 5 % and a temperature of ~~21 ± 2°C (70 ± 4°F).~~21 ± 2°C [70 ± 4°F].

3.1.2 *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 product, structure, or system.

3.1.3 *tearing strength, n*—the force required to either (*1*) start, or (*2*) continue or propagate a tear in a fabric under specified conditions.

3.1.3.1 *Discussion*—

This test method uses the maximum value of the tearing force as the tearing strength.

3.1.4 For definitions of other terms used in this test method, refer to Terminology D123 or Terminology D4439.

4. Summary of Test Method

4.1 An outline of an isosceles trapezoid is marked on a rectangular specimen cut for the determination of tearing strength (see Fig. 1), and the nonparallel sides of the trapezoid marked on the specimen are clamped in parallel jaws of a tensile testing machine. The separation of the jaws is continuously increased so the tear propagates across the specimen. At the same time, the force developed is recorded. The tearing strength, which is the maximum value of the tearing force, is obtained from the autographic force – extension curve (see Fig. 2).

5. Significance and Use

5.1 The trapezoid tear method is a test that produces tension along a reasonably defined course such that the tear propagates across the width of the specimen. The trapezoid tearing strength for woven fabrics is determined primarily by the properties of the yarns that are gripped in the clamps. In nonwoven fabrics, because the individual fibers are more or less randomly oriented and capable of some reorientation in the direction of the applied load, the maximum trapezoid tearing strength is reached when the resistance to further reorientation is greater than the force required to rupture one or more fibers simultaneously.

5.2 The trapezoid tearing strength method is useful for estimating the relative tear resistance of different fabrics or different directions in the same fabric.

5.3 This test method may be used for acceptance testing of commercial shipments; however, caution is advised since information about between-laboratory precision is incomplete. Comparative tests as directed in 5.3.1 may be advisable.

5.3.1 In case of a dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and the 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 that are as homogeneous as possible and that are from a lot of material of the type in question. 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 the appropriate Student's *t*-test and an acceptable probability level chosen by the two parties before testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results in the light of the known bias.

5.4 Most geotextile fabrics can be tested by this test method. Some modification of clamping techniques may be necessary for a given fabric, depending upon its structure. Special adaptation may be necessary with strong fabrics, or fabrics 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 This test method may be used with constant-rate-of-traverse (CRT) or constant-rate-of-extension (CRE) type tension machines. However, there may be no overall correlation between the results obtained with the CRT machine and the CRE machine. Consequently, these two tension testers cannot be used interchangeably. In case of controversy, the CRE machine shall prevail.

6. Apparatus

6.1 *Tensile Testing Machine,* of the constant-rate-of-extension (CRE) or constant-rate-of-traverse (CRT) type with autographic recorder conforming to the requirements of Specification ~~D76~~D76/D76M.

6.2 *Clamps,* having all gripping surfaces parallel, flat, and capable of preventing slipping of the specimen during a test, and measuring 50.8 by no less than 76.2 mm ~~(2~~[2 by no less than 3 ~~in.),~~in.], with the longer dimension perpendicular to the direction of application of the load.
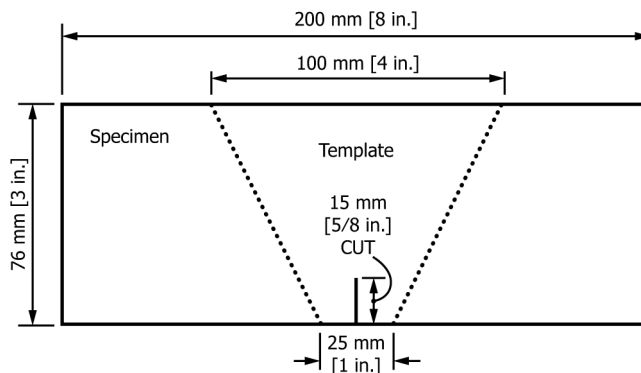

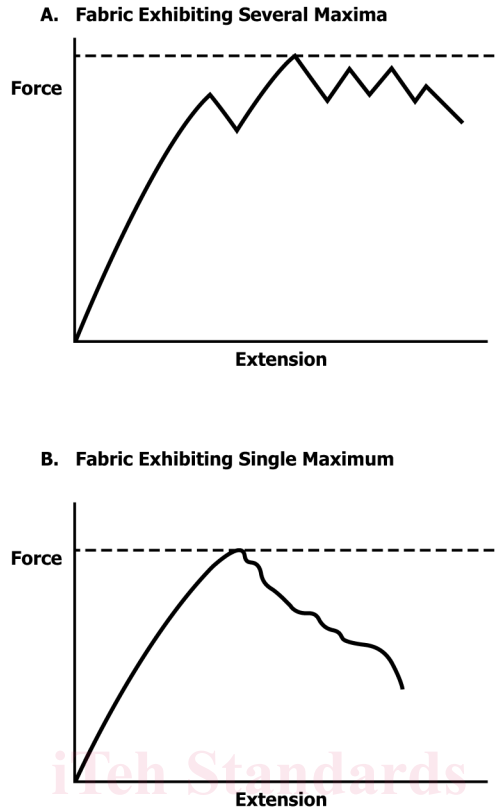**FIG. 1 Trapezoidal Template for Trapezoid Tearing Strength Test**

A. **Fabric Exhibiting Several Maxima**

Force

Extension

B. **Fabric Exhibiting Single Maximum**

Force

Extension

FIG. 2 Typical Tearing Force – Extension Curves for Individual Test Specimens

6.3 *Trapezoidal Template,* optional, having the dimensions shown in Fig. 1.

7. Sampling and Selection

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of rolls of fabric directed in an applicable material specification or other agreement between the purchaser and the supplier, such as agreement to sample as directed in Practice D4354. Consider rolls of fabric to be the primary sampling units.

NOTE 1—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of fabric and between specimens from a swatch from a roll of fabric so as to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—Take for the laboratory sample a sample extending the width of the fabric and approximately 1 m (39.37 in.)[39.37 in.] along the selvage from each roll in the lot sample. The sample may be taken from the end portion of a roll, provided there is no evidence that it is distorted or different from other portions of the roll. In cases of dispute, take a sample that will exclude fabric from the outer wrap of the roll or the inner wrap around the core.

7.3 *Test Specimens*—Take test specimens as follows:

7.3.1 *Woven Fabrics*—Take the specimens to be used for the measurement of the tearing strength of machine direction yarns from different sets of machine direction yarns. Take the specimens to be used for the measurement of the tearing strength of cross-machine direction yarns from different sets of cross-machine direction yarns and, when possible, from fabric woven from different bobbins.

7.3.2 *Nonwoven Fabrics*—Take the specimens for the measurement of the machine direction tearing strength from different positions across the fabric. Take the specimens for the measurement of the cross-machine direction tearing strength from different positions along the length of the fabric.

7.3.3 *Cutting Test Specimens*—Take no specimens nearer the selvage or edge of the fabric than 1/20th of the fabric width or, 150 mm (6 in.)[6 in.] whichever is smaller. Cut rectangular specimens 76.2 by 201.6 mm (3[3 by 8 in.].in.]. Cut the specimens to be used for the measurement of the tearing strength in the machine direction (or warp yarns), with the longer dimension parallel to the machine direction (or warp yarns). Cut the specimens to be used for the measurement of the tearing strength in the cross-machine direction (or filling yarns) with the longer dimension parallel to the cross-machine direction (or filling yarns). Mark each specimen with an isosceles trapezoid template (see Fig. 1). Make a preliminary cut 15.9 mm (0.625 in.)[0.625 in.] long at the center of the 25.4 mm (1 in.)[1 in.] edge, as shown Fig. 1.

Note 2—Cutting Test Specimen option: An option to cutting rectangular specimens is to use a six sided die shown in Fig. 3 and Fig. 4. Such specimen facilitates placement alignment and alleviates the need to use a template and mark the specimen prior to testing.

7.3.4 *Number of Specimens*—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 not more than 5.0 % of the average above the true average of the swatch when testing in the machine and cross-machine directions, respectively. Determine the number of specimens per swatch as follows:

7.3.4.1 *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 method, calculate the required number of specimens for the machine and cross-machine directions as follows:

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

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 (see Table 1), 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 the allowable variation.

~~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 (see Table 1), 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 the allowable variation.~~

7.3.4.2 *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 (10) of specimens for the machine direction tests, and 10 specimens for the cross-machine direction tests. The number of specimens is calculated using *v* = 9.5 % of the average for both machine direction and cross-machine direction tests. These values for *v* are 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. ~~Table 1~~
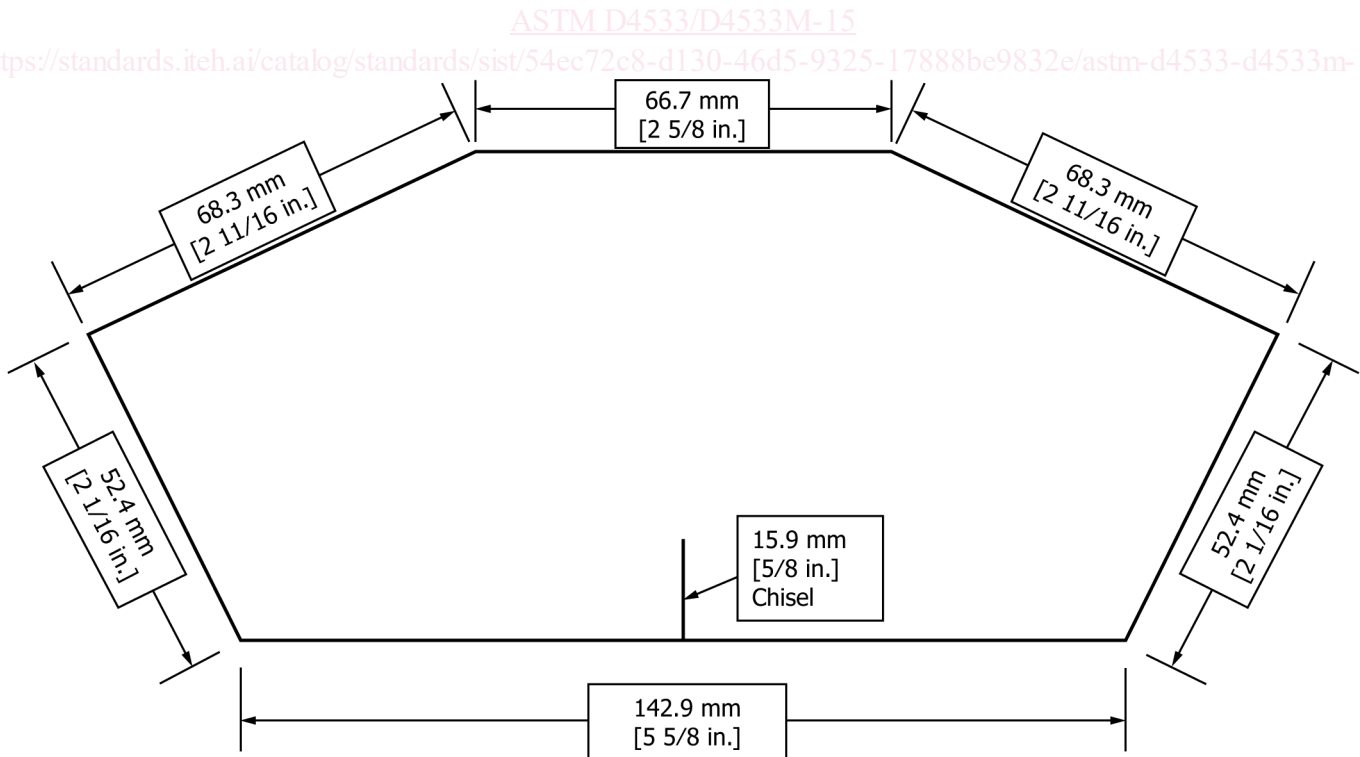

FIG. 3 Optional Trapezoidal Template for Trapezoid Tearing Strength Test

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