



# Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites<sup>1</sup>

This standard is issued under the fixed designation D 7005; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 It has been widely discussed in the literature that bond strength of flexible multi-ply materials is difficult to measure with current technology. The above is recognized and accepted, since all known methods of measurement include the force required to bend the separated layers, in addition to that required to separate them. However, useful information can be obtained when one realizes that the bending force is included and that direct comparison between different materials, or even between the same materials of different thickness, cannot be made. Also, conditioning that affects the moduli of the plies will be reflected in the bond strength measurement.

1.2 This index test method defines a procedure for comparing the bond strength or ply adhesion of geocomposites. The focus is on geotextiles bonded to geonets or other types of drainage cores; for example, geomats, geospacers, etc. Other possible uses are geotextiles adhered or bonded to themselves, geomembranes, geogrids, or other dissimilar materials. Various processes can make such laminates: adhesives, thermal bonding, stitch bonding, needling, spread coating, etc.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

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.* Specific precautionary statements are given in 7.1.1.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

D 76 Specification for Tensile Testing Machines for Textiles

D 413 Test Methods for Rubber Property—Adhesion to Flexible Substrates  
D 2905 Practice for Statements on Number of Specimens for Textiles  
D 4354 Practice for Sampling of Geosynthetics for Testing  
D 4439 Terminology for Geosynthetics  
E 4 Practices for Force Verification of Testing Machines  
E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method  
F 904 Test Method for Comparison of Bond Strength or Ply Adhesion of Similar Laminates from Flexible Materials

## 3. Terminology

### 3.1 Definitions:

3.1.1 *bond strength (ply adhesion)*—amount of force required (per unit width) to separate plies of material or materials in peeling mode plus the force to bend the plies.

3.1.2 *necking*—localized reduction in cross section, which may occur in a material under tensile stress.

3.1.3 *geocomposite*—a product composed of two or more materials, at least one of which is a geosynthetic.

3.1.4 *geosynthetic*—a planar 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.

3.1.5 *geotextile*—a permeable geosynthetic comprised solely of textiles.

3.1.6 *geonet*—a geosynthetic consisting of integrally connected parallel sets of ribs overlying similar sets at various angles for planar drainage of liquids or gases.

3.1.7 *geomat/geospacer*—any three dimensional, polymeric material used with soil, rock, or other geotechnical engineering related material as an integral part of a man-made project, structure, or system.

3.1.8 *index test*—a test procedure, which may contain a known bias but may be used to establish an order for a set of specimens with respect to the property of interest.

3.1.9 *machine direction*—the direction in the plane of the fabric parallel to the direction of manufacture.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.10 *atmosphere for testing geosynthetics*—air maintained at a relative humidity between 50 to 70 % and a temperature of  $21 \pm 2^\circ\text{C}$  ( $70 \pm 4^\circ\text{F}$ ).

#### 4. Summary of Test Method

4.1 Initially the geotextile is separated from its associated material with care. The separated plies of the test specimen are placed into the grips of a tensile testing machine. The grips are then separated and the force required to further separate the plies is defined as bond strength.

NOTE 1—The force to bend the separated plies is included in the measured force.

#### 5. Significance and Use

5.1 This test method is to be used as a quality control or quality assurance test. As a manufacturing quality control (MQC) test, it would generally be used by the geocomposite product manufacturer or fabricator. As a construction quality assurance (CQA) test, it would be used by certification or inspection organizations.

5.2 This test method can also be used to verify if the adhesion or bond strength varies after exposure to various incubation media in durability and/or chemical resistance testing.

5.3 Whatever use is to be associated with the test, it should be understood that this is an index test.

NOTE 2—There have been numerous attempts to relate the results of this test to the interface shearing resistance of the respective materials determined per ASTM D 5321. To date, no relationships have been established between the two properties.

5.4 Test Method D XXXX for determining the bond strength (ply adhesion) strength may be used as an acceptance test of commercial shipments of geocomposites, but caution is advised since information about between-laboratory precision is incomplete. Comparative tests as directed in 5.4.1 are advisable.

5.4.1 In the case of a dispute arising from differences in reported test results when using the procedure in Test Method D XXXX for acceptance of commercial shipments, the purchaser and the supplier should first confirm that the tests were conducted using comparable test parameters including specimen conditioning, grip faces, grip size, etc. Comparative tests should then be conducted 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 the material in question. The test specimens should be randomly assigned to each laboratory for testing. The average results from the two laboratories should be compared to the Student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and supplier must agree to interpret future test results in the light of the known bias. Refer to Practice D 2905, Table 1.

#### 6. Apparatus

6.1 *Grips*—A gripping system that minimizes both slippage and uneven stress distribution is required. Grips lined with thin rubber, crocus clothe or pressure sensitive tape, as well as file-faced or serrated grips has been successfully used for many materials. Air-actuated grips have been found advantageous, particularly in the case of materials that tend to “neck” in the grips, since pressure is maintained at all times. Grip faces shall measure not less than 50.8 mm (2.0 in.) wide by no less than 100 mm (4 in.) long, with the longer dimension perpendicular to the direction of the applied load.

6.2 *Testing Machine*—A tensile testing machine with computer acquisition capabilities conforming to the requirements for Specification D 76.

6.3 *Specimen Cutter*—A die  $101.6 \pm 2$  mm ( $4 \pm 0.08$  in.) wide by at least 200 mm (8 in.) long.

#### 7. Sampling and Test Specs and Units

7.1 Sampling must be performed in a manner that will provide the desired information. No single procedure can be given for all situations. Therefore, Practice D 4354 should be used as a guide in planning sampling procedures.

7.2 *Laboratory Sample*—For sampling, disregard the first meter (3 ft) and the last meter (3 ft) of material from the sample roll. Consider the units in the laboratory sample. For the laboratory sample, take a swatch at a minimum of 30 cm (1 ft) in the machine direction by the roll width.

7.3 *Test Specimens*—Take no specimen nearer the selvage or edge of the sample than  $\frac{1}{20}$  of the width of the roll, or 150 mm (6 in.), whichever is larger, from the bonded material. Cut strips  $101.6 \pm 2$  mm ( $4 \pm 0.08$  in.) wide and at least 200 mm (8 in.) long, parallel to the direction under test. For geocomposites consisting of geotextiles bonded to both sides of the geonet, mark the specimens to differentiate between the two sides, typically referred to as “Side A” and “Side B.” It is important that the test specimens are precision cut with clean, uniform edges so as not to affect the test results.

7.4 *Test Unit*—Test five specimens distributed evenly from across the width of each laboratory sample in the longitudinal (machine) direction only. It may be desirable to test specimens in the transverse (cross-machine) direction for special purposes.

NOTE 3—Depending on the application of the geocomposite, transverse (cross-machine) direction specimens can be tested at the client's request, but they are not a requirement.

#### 8. Preparation of Apparatus

8.1 Equip the tensile testing machine according to manufacturer's instructions for Tensile Testing Machine- a constant rate of extension (CRE) type conforming to the requirements of Specification D 76.

8.2 Set the machine speed at  $305 \pm 10$  mm/min ( $12 \pm 0.5$  in./min).

8.3 Readings of force and time shall be taken at a minimum rate of 20 readings per second.

8.4 If necessary, also set the computer to acquire the readings from 25-mm (1-in.) of separation to 100-mm (4-in.) of

separation. The average force recorded will be used to determine the bond strength. These intervals are defined in typical software programs in terms of crosshead extension, which would be 50-mm (2-in) to 200-mm (8-in) of extension.

## 9. Conditioning

### 9.1 Specimen Conditioning:

9.1.1 Condition the test specimens at a temperature of  $21 \pm 2^\circ\text{C}$  ( $70 \pm 4^\circ\text{F}$ ) for not less than 30 min prior to testing.

9.1.2 Accelerated testing conditions for “wet” materials may be accomplished by placing the test specimens in water for 15 min, at a water temperature of  $21 \pm 2^\circ\text{C}$  ( $70 \pm 4^\circ\text{F}$ ).

## 10. Test Conditions

10.1 Conduct tests in the standard laboratory atmosphere.

## 11. Procedure

11.1 Initiate separation of the plies of the test specimens manually.

11.1.1 Using a utility knife or, some other suitable separation device which does not compromise either laminate. Initiate the separation of the laminated geocomposite at the interface of interest (that is, side A and/or side B). A pair of wide-mouth pliers may hasten this activity and add an element of safety. Pre-separate the laminated layers a maximum of 50 mm (2 in.) prior to testing.

11.2 Clamp the separated ends of the test specimen in the grips on the tensile testing machine using an initial grip separation of approximately 50 mm (2 in.). Make certain the ends are aligned with each grip as it is clamped.

11.3 The unseparated portion of each test specimen shall be left loose to move around freely.

11.4 Bend the rigid ply containing the geonet or other rigid component by hand to approximately a  $45^\circ$  angle to the axis of the grips. Be vigilant to prevent the free end of the rigid component from contacting the fixed grip or load cell during the acquisition segment of the test.

11.5 Activate the tensile testing machine and record the average force in N (lbf) to separate the test specimen from 25-mm (1-in.) of separation to 100-mm (4-in.) of separation at  $300 \pm 10$  mm/min ( $12 \pm 0.5$  in./min).

NOTE 4—100-mm (4-in.) of separation will require at least 200-mm (8-in.) of crosshead movement.

11.6 Repeat steps 11.1 through 11.5 for side “B,” if required.

11.7 Repeat steps 11.1 through 11.6 for each test specimen in the test unit.

## 12. Calculation of Results

12.1 Calculate the bond strength (ply adhesion) for each specimen and each side tested (if applicable) as follows. The reporting units shall be N/m (lbf/in.):

$$BS = BF/W \quad (1)$$

where:

*BS* = bond strength (ply adhesion), that is, the test determination,

*BF* = bond force, the average force in N (lbf) recorded from 25-mm (1-in.) of separation to 100-mm (4-in.) of separation, and

*W* = width of specimen in meters (in.).

## 13. Report

13.1 The report shall include the following:

13.1.1 Reference the test method ASTM D XXXX.

13.1.2 Project, type of geosynthetic(s) tested, product sample identification, and if applicable, specific side of material tested.

13.1.3 Complete sample identification.

13.1.4 The individual bond strength values for each specimen and each side tested when applicable, the average (the test result) and standard deviation of the five test determinations for each direction and each side tested.

13.1.5 Name and model number of tensile machine used. Include unit number if more than one of the same model numbers.

13.1.6 Statement when “wet” conditioning was used.

13.1.7 A statement of any departures from suggested testing procedure so the results can be evaluated and used. Add the suffix “(Mod.\*)” to the test method reference, if there were any modifications made to the test method, noting the modifications.

## 14. Precision and Bias

14.1 *Precision*—The interlaboratory testing program to determine the precision of this standard was in progress.

14.2 *Bias*—The procedure in this test method has no bias because the values of bond strength can only be defined in terms of a test method.

## 15. Keywords

15.1 bond strength; geocomposite; laminates; ply adhesion strength

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