



Standard Test Method for Flexural Rigidity of Geogrids, Geotextiles and Related Products¹

This standard is issued under the fixed designation D7748/D7748M; 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.

^{ε1} NOTE—Equation 4 in Section 11.5 was editorially corrected in June 2016.

1. Scope

1.1 This test method covers the measurement of stiffness properties of geogrids, geotextiles and geogrid-geotextile composites all of which are referred to as geosynthetics within this test method. Bending length is measured and flexural rigidity is calculated through use of the cantilever test procedure.

1.1.1 This test method employs the principle of cantilever bending of the geosynthetic under its own mass.

1.2 This test method applies to geogrids, geotextiles and geogrid-geotextile composites.

1.3 This test method is for manufacturing quality control purposes only, to ensure uniformity and consistency of flexural rigidity for a specific product from roll to roll and lot to lot.

1.4 The values stated in either SI units or inch-pound units are to be regarded 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.

1.5 *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

[D123 Terminology Relating to Textiles](#)

[D1776 Practice for Conditioning and Testing Textiles](#)

[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 For common definitions of terms in this test method, refer to Terminology [D123](#) and Terminology [D4439](#).

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *bending length, n*—a measure of the interaction between geosynthetic weight and geosynthetic stiffness as shown by the way in which a geosynthetic bends under its own weight.

3.2.1.1 *Discussion*—Bending length reflects the stiffness of a geosynthetic when bent in one plane under the force of gravity.

4. Summary of Test Method

4.1 A specimen is slid at a specified rate in a direction parallel to its long dimension, until its leading edge projects from the edge of a horizontal surface. The length of the overhang is measured when the tip of the specimen is depressed under its own mass to the point where the line joining the top to the edge of the platform makes a 0.724 radians [41.5°] angle with the horizontal. From this measured length, the bending length and flexural rigidity are calculated.

5. Significance and Use

5.1 This test method is considered satisfactory for manufacturing quality control testing of a specific geosynthetic; however, caution is advised since information about between-laboratory precision is incomplete. Comparative tests as directed in [5.1.1](#) may be advisable.

5.1.1 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

¹ This test method is under the jurisdiction of ASTM Committee [D35](#) on Geosynthetics and is 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.

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 statistical analysis 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 with consideration to the known bias.

5.2 This test method is not suitable for very limp geosynthetics or those that show a marked tendency to curl or twist at a cut edge.

5.3 The stiffness of a geosynthetic may change with storage.

5.4 No evidence has been found showing that bending length is dependent on specimen width. The tendency for specimens to curl or twist will affect the result, because of the rigidity provided at the edge. Consequently, the edge effect is less of an issue for a wider strip.

6. Apparatus

6.1 Flexural Rigidity Tester (Fig. 1).

6.1.1 *Horizontal Platform*, with a minimum area of 100 by 900 mm [4 by 36 in.] and having a smooth low-friction, flat aluminum surface. A leveling bubble shall be incorporated in the platform.

6.1.1.1 *Indicator*, inclined at an angle of 0.724 ± 0.01 radians [$41.5 \pm 0.5^\circ$] below the plane of the platform surface.

6.1.1.2 *Movable Slide*, consisting of a metal plate not less than 50 by 200 mm [2 by 8 in.] by approximately 3 mm [$1/8$ in.] thick and having a mass of 270 ± 5 g [0.6 ± 0.01 lb].

6.1.1.3 *Scale and Reference Point*, to measure the length of the overhang.

6.1.1.4 *Specimen Feed Unit*, motorized set to 120 mm/min [4.75 in./min] $\pm 5\%$, or manual equivalent.

7. Sampling and Test Specimens

7.1 *Lot Sample*—As a lot sample for acceptance testing, randomly select the number of rolls or pieces of geosynthetic directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider the rolls or pieces of geosynthetic to be the primary sampling units. In the absence of such an agreement, take the number of geosynthetic rolls specified in Practice D4354.

7.2 For acceptance testing, take a swatch extending the width of the geosynthetic and approximately 2 m [6 ft] along the machine direction from each roll or piece in the lot sample. For rolls of geosynthetic, take a sample that will exclude geosynthetic from the outer wrap of the roll or the inner wrap around the core of the roll of geosynthetic, or any end piece.

7.3 *Direction of Test*—Consider the long dimension of the specimen as the direction of test.

7.4 *Number of Test Specimens*—From each laboratory sampling unit, take five specimens from the machine direction and five specimens from the cross-machine direction as applicable to a material specification or contract order.

7.5 *Cutting Test Specimens*—Cut the specimens to be used for the measurement of machine direction with the longer dimension parallel to the machine direction. Cut the specimens to be used for the measurement of the cross-machine direction with the longer dimension parallel to the cross-machine direction. Label to maintain specimen identity.

7.5.1 Take specimens, representing a broad distribution across the width and length, preferably along the diagonal of the laboratory sample, and no nearer the edge than one-tenth its

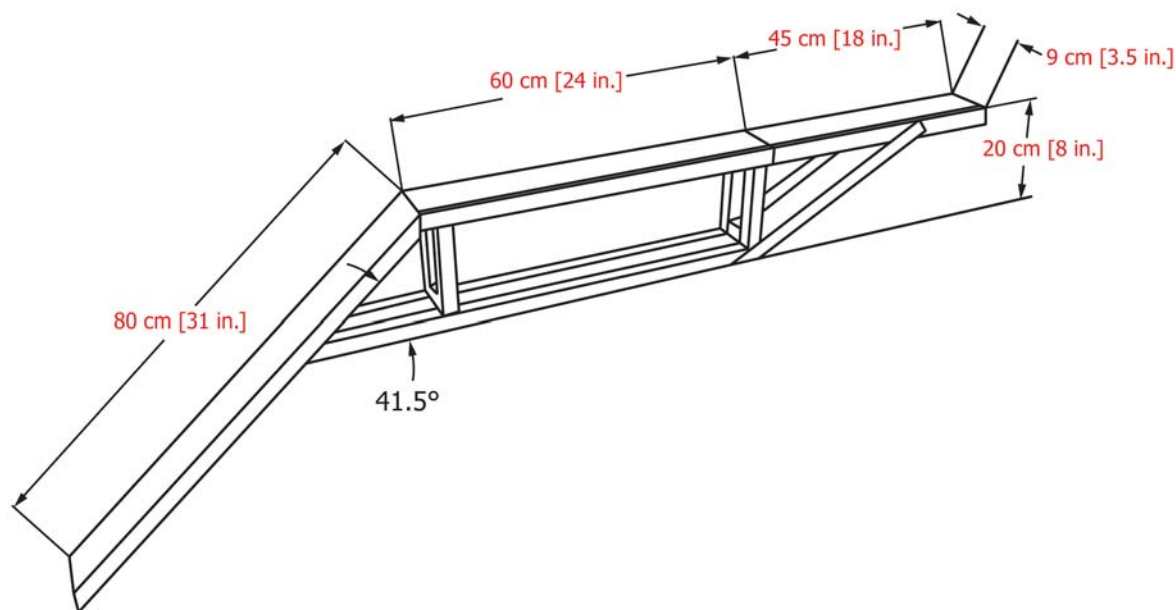


FIG. 1 Example Test Rig Setup

width. Ensure specimens are free of folds, creases, or wrinkles. Avoid getting oil, water, grease, etc. on the specimens when handling.

7.5.2 For *geogrids* and *geotextile-geogrid composites* cut specimen such that the specimen include two (2) geogrid apertures in width or a minimum of 5 by 90 cm \pm 0.1 cm [minimum of 2 by 36 in. \pm 0.04 in.].

7.5.2.1 It is important to cut the ribs of the specimens in both the width and the length direction exactly midway between junctions such that a representative mass per unit area can be obtained for each specimen.

7.5.3 For *geotextiles* cut test specimens 5 by 90 cm \pm 0.1 cm [2 by 36 in. \pm 0.04 in.].

8. Preparation of Test Apparatus and Calibration

8.1 Set the tester on a table or bench with the horizontal platform and inclined reference lines. Adjust the platform to horizontal as indicated by the leveling bubble.

8.1.1 Verify that the apparatus bend angle is at the 0.724 radians [41.5°] angle.

9. Conditioning

9.1 For *Geogrids and Geogrid-geotextile Composites*—Do not fold or bend the lab sample. If the lab sample must be obtained from roll inventory, it shall be conditioned by counter rolling and taping the cut specimens in the opposite direction of the curl for a minimum of 24 h within a laboratory exhibiting the proper atmosphere for testing geosynthetics. Counter roll specimen to a diameter that is not more than that of the diameter from the original manufactured roll. For most products a diameter of 150 mm [6 in.] is adequate. Alternately, the

sample can be conditioned by placing weights to restrain the specimen in a flat position for the 24-h period.

9.2 For *Geotextiles*—Precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning geotextiles as directed in Practice D1776, unless otherwise directed in a material specification or contract order.

9.3 After preconditioning, bring the test specimens to equilibrium for testing in the standard atmosphere as, unless otherwise directed in a material specification or contract order. directed in Practice D1776 or, if applicable, in the specified atmosphere in which the testing is to be performed.

10. Procedure

10.1 Test the conditioned specimens in the standard atmosphere for testing geosynthetics, which is $21 \pm 2^\circ\text{C}$ [$70 \pm 4^\circ\text{F}$] and 50 to 70 % relative humidity, unless otherwise directed in a material specification or contract order.

10.2 Remove the movable slide. Place the specimen on the horizontal platform with the length of the specimen parallel to the platform edge and the specimen face side up. Align the edge of the specimen with the line scribed on the right-hand edge of the horizontal platform.

10.2.1 Place the movable slide on the specimen, being careful not to change its initial position.

10.2.2 For automatic testers, turn the tester switch on and watch the leading edge of the specimen closely. Turn the switch off the instant the edge of the specimen touches the inclined portion of the tester.

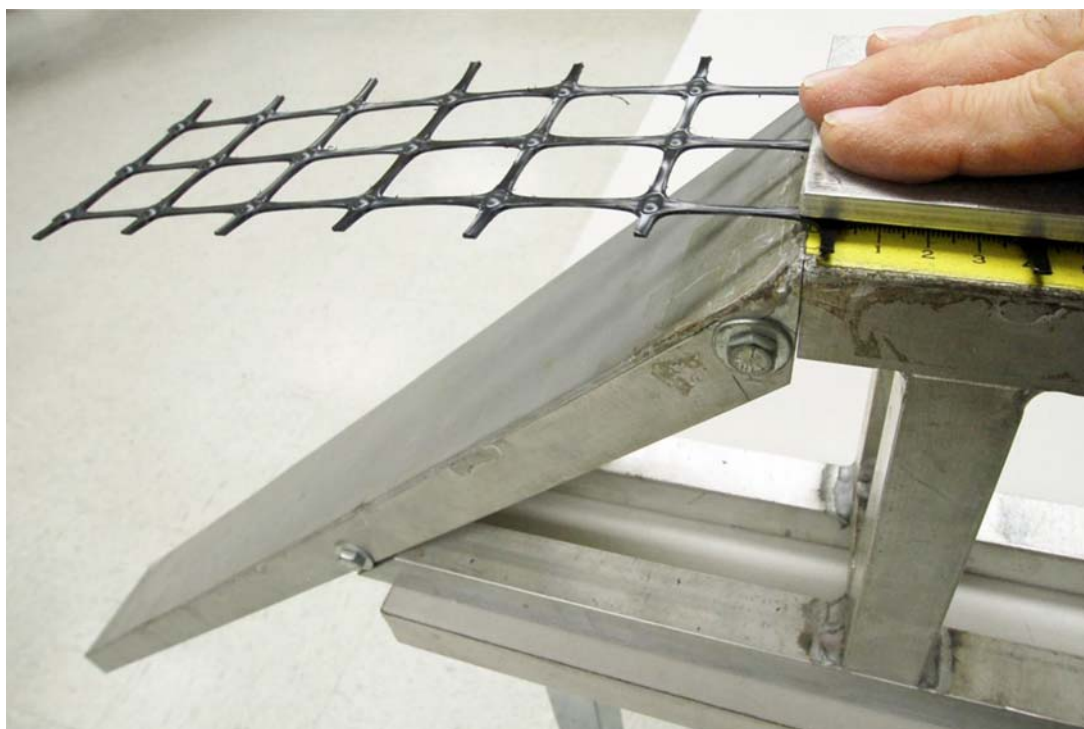


FIG. 2 Test in Progress

10.2.3 For manual testers, move the clamped specimen by hand in a smooth manner at approximately 12 cm/min [4.75 in./min] $\pm 5\%$ until the edge of the specimen touches the inclined portion of the tester, as shown in Fig. 2 and Fig. 3.

10.2.4 Read the overhang length by measuring the length still lying on the horizontal surface after the specimen has touched the inclined surface and subtracting that measurement from the initial specimen length. Record from the linear scale to the nearest 0.1 cm [0.1 in.].

NOTE 1—If the specimen has a tendency to twist, take the reference point at the center of the leading edge. Do not measure specimens that twist more than 0.785 radian [45°].

10.2.5 Test the face and back of both ends of each specimen for a total of four readings per specimen.

10.3 *Specimen Mass*—Determine the geosynthetic mass per unit area as directed in 11.2 to the nearest 0.1 mg.

10.4 *Specimen Area*—Determine the area of the specimens in 10.4 to the nearest 1 cm².

10.5 *Number of Specimens*—Continue as directed in 10.1–10.5 as applicable, until five specimens have been tested for each testing direction for each laboratory sampling unit (A total of 20 readings for each direction).

11. Calculation

11.1 *Length of Overhang, Individual Specimens*—For each specimen, average the five readings obtained to the nearest 0.1 cm as the length of overhang, unless otherwise agreed upon between the purchaser and supplier.

NOTE 2—In some cases it may be of interest to differentiate between the sides of the geosynthetic by averaging those readings made with the

geosynthetic face side up (out) separately from those with the geosynthetic face side down (in).

11.2 *Mass per Unit Area*—Determine the mass per unit area to the nearest 0.1 mg/cm² using Eq 1.

$$W = \text{specimen mass} / (\text{specimen length} \times \text{specimen width}) \quad (1)$$

11.3 *Bending Length, Individual Specimens*—Calculate the bending length for each testing direction to the nearest 1 mm, using Eq 2.

$$c = O/2 \quad (2)$$

where:

c = bending length, cm, and
 O = length of overhang (total specimen length minus the remaining horizontal length of specimen at the conclusion of the test, Fig. 3), cm.

11.4 *Flexural Rigidity, Individual Specimens*—Calculate the flexural rigidity for each testing direction to three significant digits using Eq 3.

$$G = W \times c^3 \quad (3)$$

where:

G = flexural rigidity, mg-cm,
 W = geosynthetic mass per unit area, mg/cm², and
 C = bending length, cm.

11.5 *Overall Flexural Rigidity*—Calculate the overall flexural rigidity using Eq 4.

Overall Flexural Rigidity =

$$\left(G_{\text{machine direction}} \times G_{\text{cross machine direction}} \right)^{1/2} \quad (4)$$

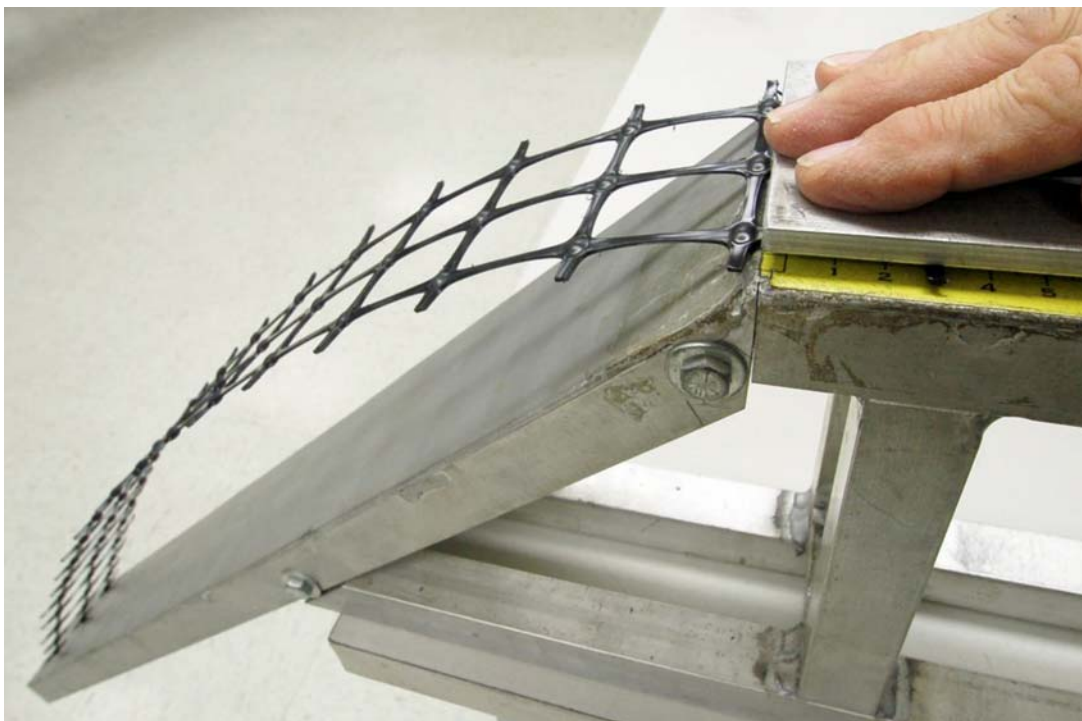


FIG. 3 Conclusion of Test

11.6 Average Values—Calculate the average bending length, flexural rigidity and overall flexural rigidity as applicable to a material specification or contract order for each laboratory sampling unit and for the lot, for each testing direction.

11.7 Standard Deviation, Coefficient of Variation—Calculate when requested.

12. Report

12.1 Report that the stiffness as bending length, flexural rigidity and overall flexural rigidity were determined as directed in Test Method D7748/D7748M. Describe the material or product sampled and the method of sampling used.

12.2 Report the following information for each laboratory sampling unit and for the lot as applicable to a material specification or contract order.

12.2.1 Bending length for each testing direction.

12.2.2 Flexural rigidity for each testing direction.

12.2.3 Number of specimens tested for each direction.

12.2.4 Overall flexural rigidity.

12.2.5 When calculated, the average and standard deviation or the coefficient of variation.

12.2.6 Any modification of the test method.

13. Precision and Bias³

13.1 Precision—The precision of this test method is based on an interlaboratory study of ASTM D7748/D7748M Standard Test Method for Flexural Rigidity of Geogrids, Geotextiles and Related Products, conducted in 2012. A single laboratory participated in this study, testing two different materials. Every “test result” represents an individual determination. The laboratory reported five replicate test results for each material and analysis. Except for the use of only one laboratory, Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report RR:D35-1015.

13.1.1 Repeatability (*r*)—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

13.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

13.1.1.2 Repeatability limits are listed in Tables 1-3.

13.1.2 Reproducibility (*R*)—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

³ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D35-1015. Contact ASTM Customer Service at service@astm.org.

TABLE 1 MD Rigidity (mg-cm)

	Average ^A	Repeatability Standard Deviation	Repeatability Limit
	\bar{x}	S_r	r
Geotextile	98890	2361	6612
Biaxial Geogrid	2196361	189691	531135

^A The average of the laboratories' calculated averages.

TABLE 2 TD Rigidity (mg-cm)

	Average ^A	Repeatability Standard Deviation	Repeatability Limit
	\bar{x}	S_r	r
Geotextile	83491	4571	12798
Biaxial Geogrid	1172764	54480	152545

^A The average of the laboratories' calculated averages.

TABLE 3 Overall Rigidity (mg-cm)

	Average ^A	Repeatability Standard Deviation	Repeatability Limit
	\bar{x}	S_r	r
Geotextile	90829	2587	7243
Biaxial Geogrid	1603442	76868	215229

^A The average of the laboratories' calculated averages.

13.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

13.1.2.2 Reproducibility limits cannot be calculated from a single laboratory's results.

13.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

13.1.4 Any judgment in accordance with statement 13.1.1 would normally have an approximate 95 % probability of being correct, however the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories reporting replicate results essentially guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. Consider the repeatability limit as a general guide, and the associated probability of 95 % as only a rough indicator of what can be expected.

13.2 Bias—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

13.3 The precision statement was determined through statistical examination of 15 results, from a single laboratory, on two geosynthetic materials.

14. Keywords

14.1 bending length; flexural rigidity; geogrid; geogrid-geotextile composite; geosynthetic; geotextile; stiffness

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