Designation: D8058 – 17

Standard Test Method for Determining the Flexural Strength of a Geosynthetic Cementitious Composite Mat (GCCM) Using the Three-Point Bending Test[1]

This standard is issued under the fixed designation D8058; 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 This test method provides guidelines for testing the flexural strength of cured geosynthetic cementitious composite mat (GCCM) products in a three (3)-point bend apparatus.

1.2 The values in SI units are to be regarded as the standard. Values in inch-pound units are in parentheses for information.

1.3 This standard may involve hazardous operations, equipment, and climates. *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.*

1.4 *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

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

D4439 Terminology for Geosynthetics

D8030/D8030M Practice for Sample Preparation for GCCM

3. Terminology

3.1 For definitions of common technical terms used in this standard, refer to Terminology D4439.

3.2 *Definitions:*

3.2.1 *cured, adj*—a description of the state of a GCCM after hydration for a specified period of time and quantity of water when known under specified conditions, followed by a period of time where the GCCM is kept under a specified environmental condition during which the cementitious material continues to cure and develop compressive strength.

3.2.2 *curing time, n*—the time subsequent to initial hydration of the GCCM and immediately prior to the testing of the material, during which the cementitious material is allowed to harden and form its final strength using the specific process for curing as specified in 8.3.

3.2.3 *dry, adj*—a description of the state of a GCCM before it has been exposed to a hydration source and typically describes the "as-received" dry product after conditioning in a prescribed manner.

3.2.4 *final breaking load, n*—the maximum load achieved prior to rupture of materials.

3.2.5 *final deflection*—the deflection of the specimen from its initial position (before testing begins) measured at mid span at the final breaking load.

3.2.6 *final flexural strength, n*—the final flexural strength, expressed in megapascals (pound-force per square inch), is calculated from the final breaking load of a hydrated and cured GCCM specimen, oriented in either the machine or cross-machine direction, loaded as simple beams, when breaks occur perpendicular to the specimen length, with the load applied at the center, in a three-point loading fixture.

3.2.7 *geosynthetic cementitious composite mat (GCCM), n*—a factory-assembled geosynthetic composite consisting of a cementitious layer contained within a layer or layers of geosynthetic materials that becomes hardened when hydrated.

3.2.8 *hydration, n*—exposure of the GCCM, in this case, to water in prescribed conditions for a prescribed time and water quantity when known.

3.2.9 *initial breaking load, n*—the maximum load at which the first crack in the cementitious matrix of the GCCM forms.

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.05 on Geosynthetic Erosion Control.

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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.

3.2.10 *initial deflection, n*—the deflection of the specimen from its initial position (before testing begins) measured at mid span at the initial breaking load.

3.2.11 *initial flexural strength, n*—the initial flexural strength, expressed in megapascals (pound-force per square inch), is calculated from the initial breaking load (maximum load at first crack) of a hydrated and cured GCCM specimen, oriented in either the machine or cross-machine direction, loaded as simple beams, with the load applied at the center, in a three-point loading fixture.

3.2.12 *initial modulus of elasticity, n*—a measure of a specimen's resistance to elastic deformation, measured in the region of linear response, before the initial breaking load.

3.2.13 *mean final flexural strength, n*—the mean final flexural strength is the average result of ten or more final flexural strength values expressed in megapascals (pound-force per square inch).

3.2.14 *mean initial flexural strength, n*—the mean initial flexural strength is the arithmetic mean of ten or more initial flexural strength values when breaks occur perpendicular to the specimen length. Breaks expressed in megapascals (pound-force per square inch).

3.2.15 *topside, n*—the side of the material that would face upwards in a normal installation.

4. Summary of Test Method

4.1 A hydrated and cured GCCM specimen is loaded as a simple beam in a three-point loading fixture, with the load applied at the center. The load level is recorded simultaneously with the deflection to characterize the initial and final flexural strength, the deflection of the specimen at those loads, and the initial modulus of the specimen.

5. Significance and Use

5.1 This test method is applicable for testing geosynthetic cementitious composite mats in a cured state. It is used with a constant rate of extension-type tension apparatus.

5.2 This test is an index test that may be used for manufacturing quality control (MQC). This test is appropriate for characterizing the flexural properties of a GCCM.

6. Apparatus

6.1 *Flexural Testing Machine*—A constant rate of extension (CRE)-type of testing machine described in Specification D76/D76M shall be used. When using the CRE-type tensile tester, the recorder must have adequate pen response to properly record the force-elongation curve as specified in Specification D76/D76M.

6.2 *Three-Point Flexural Fixture*—A fixture designed for use with the flexural testing machine with two bottom supports and a third edge which is used to load the specimen from the top at mid span. The fixture is designed so that the specimen is loaded and can be analyzed as a simple beam. The supports are cylindrical on the specimen contact surface with a 3.2-mm (⅛-in.) minimum radius and a 12.7-mm (½-in.) maximum radius. These support points must be designed so that they cannot exert longitudinal or vertical constraints (rocker-type bearing edges, rollers, etc.). The loading surface must have a similar edge bearing. The test span shall be 100 ± 1.6 mm (4 ± 1/16 in.) and the load line and support shall be parallel. Mount a dial micrometer reading to 0.25 mm (0.01 in.), or an equally sensitive apparatus, to bear on the loading member or on the specimen at mid span to determine the deflection of the specimen at the center of the test span as the load is measured.

6.3 *Sample Containers*—Suitable containers which are resistant to corrosion and change in mass upon repeated exposure to moisture, materials of varying pH, and cleaning.

6.4 *Die*—A sample-cutting device of dimensions consistent with 8.2.

6.5 *Rotary Tile Saw,* with diamond-tipped blades capable of dry cutting samples, used for cutting cured samples to predetermined dimensions using pattern marked on cured specimen with template and markers.

6.6 *Miscellaneous – Knives, Templates, Markers, Rulers, Saw,* as required for marking, measuring, and cutting specimens to fixed dimensions before measurement of weight. A knife with a "snap off" type blade is recommended for cutting GCCMs, which can dull blade tips rapidly.

6.7 *Thickness Gage*—A measurement device for characterizing the thickness of the specimens in the vicinity of the breaks which occur during the flexural test. The thickness gage shall have flat parallel anvils of between 10-mm (0.4-in.) and 15-mm (0.6-in.) diameter with an accuracy of ±0.05 mm (±0.002 in.).

6.8 *Micrometer*—A calibrated measurement device used for precise measurement of components with a required accuracy of ±0.25 mm (±0.01 in.), or an equally sensitive apparatus.

7. Sampling, Test Specimens, and Test Units

7.1 *Lot Sample*—For the lot sample, refer to Practice D4354 for discussion of recommended practice for breaking up shipments of GCCMs into lots for testing.

7.2 *Laboratory Samples*—For the laboratory sample, take a full-width sample approximately 1 m (40 in.) long in the machine direction from each roll in the lot sample. The exact length must be chosen to ensure enough sample is cured to cut the required number of specimens for both the machine and cross-machine directions. 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. In cases of dispute, take a sample that will exclude material from the outer wrap of the roll or the inner wrap around the core, of at least 30 in. from the interior end of the roll (wrapped around the core) or exterior end of the material roll, measured from the edge of the cementitious portion of the material.

7.3 *Test Specimens*—For tests in the machine direction and the cross-machine direction, respectively, take from each sample in the laboratory sample the number of specimens directed in Section 8. Take specimens at random from the laboratory sample, with those for the measurement of the machine direction tensile properties from different positions

across the sample width, and the specimens for the measurement of the cross-machine direction tensile properties from different positions along the length of the sample. Specimens must not be taken near the edge of the material. Specimens must be taken a minimum of 4 in. from the edge of the material, measured from the edge of the cementitious portion of the material. Specimens shall be collected for testing in both the topside and bottom-side direction facing up.

8. Test Specimen Preparation

8.1 *Number of Specimens:*

8.1.1 Unless otherwise agreed upon, the fixed number of ten (10) specimens for each the machine direction and the cross-machine direction tests should be used.

8.2 *Test Specimen Size:*

8.2.1 Prepare each finished specimen a minimum of 40 ± 1.6 mm (1.6 ± 1⁄16 in.) wide by at least 160 ± 1.6 mm (6.3 ± 1⁄16 in.) long with the length dimension being designated and accurately parallel to the direction for which the flexural strength is being measured. Specimens may be prepared using a die, saw, or knives.

8.2.2 The orientation of the specimen in the flexural test will affect which face of the GCCM is under tensile load. The specimens should have a mark applied on the topside face which is to be up when loaded into the three-point flexural fixture.

8.3 *Specimen Preparation:*

8.3.1 The specimens cut from the sample should be in satisfactory condition and representative of the bulk of the product delivered to the facility. For example, exclude inner and outer wraps of the roll, any material containing folds, crushed areas, imperfections on either face, tears in either the top or bottom material surrounding the cementitious material, or other distortions not representative of the sampled lot.

8.3.2 All sample cutting should be carried out in a clean area free of debris, and preferentially with a surface covering to collect any loose cementitious powder which may come from the material during cutting. The samples should be cut using a dry rotary diamond saw to avoid a second hydration of the samples which may affect results. The edges should be cut square and not notched or damaged by the cutter in the area that will be between the testing fixture supports.

8.3.3 Cure each GCCM sample specimen in accordance with the recommendations provided by the manufacturer before testing.

8.3.4 GCCM samples shall be prepared in accordance with Practice D8030/D8030M with a sufficient number of specimens prepared for testing.

8.3.5 It is important that the GCCM specimens be flat to obtain repeatable measurements using this procedure. If a specimen is determined to have substantial curvature, that specimen must be discarded. A new specimen must be obtained to replace it for measurement. In the case of laboratory-hardened samples, each bar shall have a tolerance of flatness of 5 mm (each surface shall lie between two parallel planes with a 5-mm separation) and in the case of field sample, each bar shall have a tolerance of flatness of 8 mm.

9. Procedure

9.1 Measure the specimen thickness, at four points along the line of break for an average result. This measurement may be completed either before or after load testing using the thickness gage.

9.2 *Measurement of the Initial and Final Breaking Load and Initial and Final Deflection:*

9.2.1 Set up a uniform deflection rate on the flexural testing machine such that the initial breaking load will occur in the specimen between 5 and 30 s.

9.2.2 The error in the load reading shall not exceed 1 % of the maximum load.

9.2.3 The supports for the three-point flexural fixture are cylindrical on the specimen contact surface with a 3.2-mm (⅛-in.) minimum radius and a 12.7-mm (½-in.) maximum radius. These support points must be designed so that they cannot exert longitudinal constraints (rocker-type bearing edges, rollers, etc.). The loading surface must have a similar edge bearing.

9.2.4 The test span shall be 100 ± 1.6 mm (4 ± 1⁄16 in.) and the load line and support shall be parallel.

NOTE 1—Alternate test specimen dimensions and span may be used, provided that the ratio of the test span to specimen thickness is not less than 18, and that the actual span used is reported.

9.2.5 Mount a micrometer reading or an equally sensitive apparatus to bear on the loading member or on the specimen at mid span to determine the deflection of the specimen at the center of the test span.

9.2.6 Position the specimen, based on previous topside marking of which side should be up, on the three-point flexural testing fixture, making sure to center the specimen on the bottom supports.

9.2.7 Move the loading fixture so that it is just making contact with the top side of the specimen. Ensure that the loading point is properly centered between the bottom two supports and that the loading fixture is parallel to the supports upon which the specimen rests.

9.2.8 Measure and record the load and deflection when the initial breaking load and final breaking load are reached.

10. Calculation or Interpretation of Results

10.1 *Calculation of Flexural Strength:*

10.1.1 Calculate the flexural strength for each specimen by the following equation:

$$R = \frac{3PL}{2bd^2} \quad (1)$$

where:

R = flexural strength, MPa (psi),
P = breaking load, N (lb),
L = length of span, mm (in.),
b = width of specimen, mm (in.), and
d = average thickness, mm (in.).

10.1.2 Calculate the average value for the initial flexural strength and coefficient of variation independently for the machine and cross-machine directions, using the data from 10.1.1.

10.1.3 Calculate the initial flexural strength of the lab sample as the arithmetic mean of the average values obtained in the two directions.

10.1.4 Calculate, using the equation in 10.1.1, the final flexural strength for each of the specimens both in the machine and cross-machine directions.

10.1.5 Calculate the average value for the final flexural strength and coefficient of variation independently for the machine and cross-machine directions, using the data from 10.1.4.

10.1.6 Calculate the final flexural strength of the lab sample as the arithmetic mean of the average values obtained in the two directions.

10.2 *Calculation of the Initial Modulus of Elasticity:*

10.2.1 For each specimen, calculate the initial modulus of elasticity by using the following equation:

$$E = (P_2 - P_1) \times L^3 / 4bd^3(y_2 - y_1) \quad (2)$$

where:

E = modulus of elasticity, n/mm^2 (psi),
P_2 and P_1 = loads N, (lb) taken from two points within the linear section of the plot before the initial breaking load,
y_2 and y_1 = deflections, mm (in.) corresponding to the loads selected,
b = width of specimen, mm (in.),
d = thickness of specimen, mm (in.), and
L = length of span, mm (in.).

10.2.2 Calculate the average value for the initial modulus of elasticity and the coefficient of variation independently for the machine and cross-machine direction test results from 10.2.1.

11. Report

11.1 Report that the specimens were tested as directed in Test Method D8058.

11.2 The report for the flexural strength shall include the following information:

11.2.1 Sample identification (for example, sample number, roll number, or other traceable identifier).

11.2.2 Type of GCCM tested (manufacturer and product number), method used for cutting specimens, size and shape of sample specimens, and number of specimens tested.

11.2.3 Curing method and conditions for the specimens.

11.2.4 Report curing time of specimens. If curing time is under 24 h, report to an accuracy of ±1 h; if curing time is longer than 24 h, report curing time ±4 h.

11.2.5 Number of tests in each direction, machine and cross-machine.

11.2.6 The orientation of the samples; whether the top side of the specimen was facing down in contact with the bottom supports of the three-point flexural fixture, or up.

11.2.7 Any unusual or out-of-standard conditions or observations during the test.

11.2.8 Identification of the testing agency, person performing the test, date of the test, and client or project identification.

11.3 Report all of the following applicable items for both the machine direction and cross direction of the material tested:

11.3.1 Average value for the initial flexural strength expressed in megapascals (pound-force per square inch).

11.3.2 Average deflection at initial breaking load.

11.3.3 Average value for the final flexural strength expressed in megapascals (pound-force per square inch).

11.3.4 Average value for the initial modulus of elasticity in n/mm^2 (psi).

11.3.5 Coefficient of variation for each of the items in 11.3.1 – 11.3.5.

12. Precision and Bias

12.1 Precision and bias have not been developed for this standard.

13. Keywords

13.1 flexural strength; GCCM; GCCM curing; CGGM hydration; GCCM sampling; GCCM testing; geosynthetic; geosynthetic cementitious composite mat; quality assurance; quality control; sampling; specification conformance; testing

APPENDIX

(Nonmandatory Information)

X1. PHOTOS AND SKETCH OF A TEST APPARATUS

X1.1 See Figs. X1.1-X1.3.

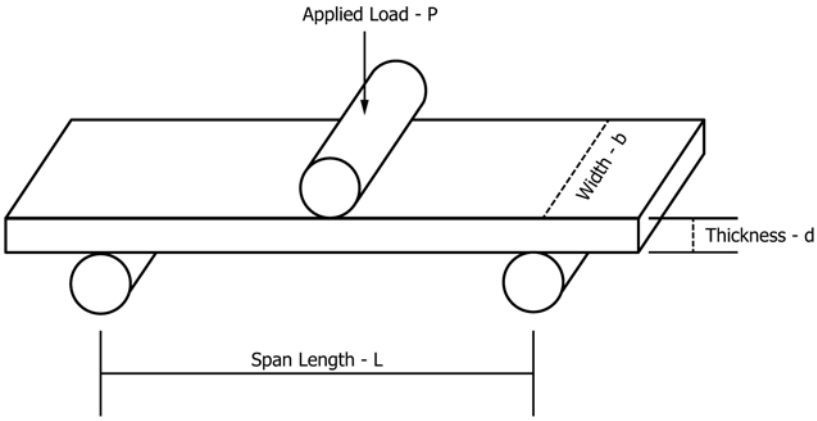

FIG. X1.1 Schematic Drawing of a Three-Point Flex Test Setup

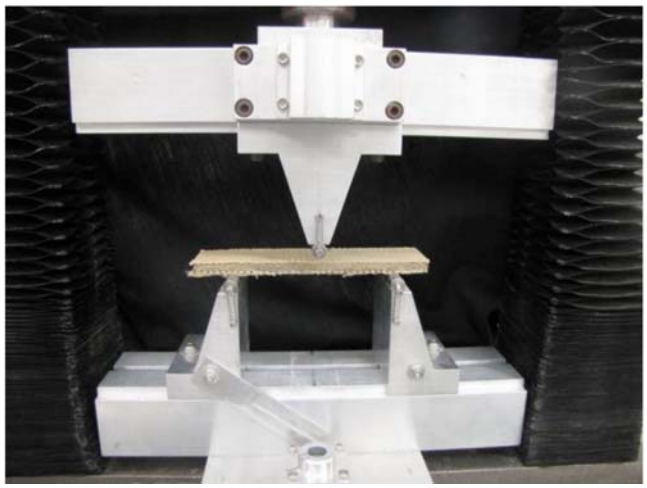

FIG. X1.2 Photo of an Example Flex Test Setup – Side View

FIG. X1.3 Photo of an Example Flex Test Setup – Overhead View