



Designation: D8069 – 17

# Standard Test Method for Determining Flexural Modulus of Full Section Pultruded Fiber Reinforced Polymer (FRP) Composite Members with Doubly Symmetric Cross Sections under Bending<sup>1</sup>

This standard is issued under the fixed designation D8069; 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 This test method covers the determination of Flexural Modulus of pultruded open and closed fiber reinforced polymer (FRP) composites of doubly symmetrical cross sections about their geometric centroid subjected to flexure and shear. This test method utilizes a three-point loading system applied to a simply supported beam.

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

1.3 *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:*<sup>2</sup>

D883 Terminology Relating to Plastics

D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D3878 Terminology for Composite Materials

D4000 Classification System for Specifying Plastic Materials

D4762 Guide for Testing Polymer Matrix Composite Materials

D7290 Practice for Evaluating Material Property Characteristic Values for Polymeric Composites for Civil Engineering Structural Applications

E4 Practices for Force Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing  
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

E1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases (Withdrawn 2015)<sup>3</sup>

E1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases (Withdrawn 2015)<sup>3</sup>

E2309/E2309M Practices for Verification of Displacement Measuring Systems and Devices Used in Material Testing Machines

## 3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites. Terminology D883 defines terms relating to plastics. Terminology E6 defines terms relating to mechanical testing. In the event of a conflict between terms, Terminology D3878 shall have precedence over the other terminologies.

3.2 Definitions of variables used in calculations as shown in Section 11 and 12 are as follows:

$P_{20\%}$   $\cong$  20% of estimated ultimate load, N (lbf)

$I$  = moment of inertia about the neutral axis, mm<sup>4</sup> (in.<sup>4</sup>)

$L$  = test span length, mm (in.)

$h$  = total height of test specimen, mm (in.)

$P_{5\%}$   $\cong$  5% of estimated ultimate load, N (lbf)

$P$  = load value used to calculate  $E$ , N (lbf)

$\delta$  = deflection value used to calculate  $E$ , mm (in.)

$\delta_{20\%}$   $\cong$  deflection at 20% of estimated ultimate load, mm (in.)

$\delta_{5\%}$   $\cong$  deflection at 5% of estimated ultimate load, mm (in.)

$E$  = Flexural modulus, MPa (psi)

## 4. Summary of Test Method

4.1 The full-scale specimen rests on two rounded solid metal cylindrical supports or pivoted end supports and is loaded by means of a loading ram located midway between the

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<sup>2</sup> 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.

<sup>3</sup> The last approved version of this historical standard is referenced on www.astm.org.

supports. The beam span-to-depth ratio ( $L/h$ ) should be within the range of  $20 \leq L/h \leq 32$  to determine the flexural modulus.

4.2 The maximum load placed on the specimen shall be approximately equal to 20 percent of the estimated ultimate load determined in accordance with 11.10.

4.3 Load and deflection are recorded at mid-span during all stages of the test procedure as outlined in Section 11.

4.4 If a span specified by the user, in the contract for a particular application, is under the span-to-depth ratio of 20 ( $L/h < 20$ ) or over 32 ( $L/h > 32$ ), the flexural modulus shall be reported as apparent flexural modulus.

## 5. Significance and Use

5.1 Determination of flexural modulus by this test method is especially useful for quality control and specification purposes.

5.2 Experimental values for flexural modulus will vary with specimen depth, span length, loading rate, ambient test temperature, and other atmospheric conditions.

5.3 Before proceeding with this test method, reference should be made to the specification of the material being tested, including constituent materials of the specimen. Any test specimen preparation, environmental or loading conditioning, dimensions, or testing parameters covered in the material specification, or both, shall take precedence over those mentioned in this test method. If there are no material specifications, then these default conditions apply. Table 1 in Classification D4000 lists the ASTM materials standards that currently exist.

## 6. Apparatus

6.1 *Testing Machine*—A properly installed and operated hydraulic or mechanical load actuator, ideally one which can be operated at constant rates of load or deflection, is used in combination with a properly calibrated load cell. Error in the load measuring system shall not exceed  $\pm 1\%$  of the maximum load expected to be measured. The test setup shall also be equipped with deflection measuring devices. The stiffness of the testing apparatus shall be such that the total elastic deformation of the load frame does not exceed 1% of the total deflection of the test specimen during testing, or appropriate corrections shall be made. The accuracy of the testing machine shall be calibrated and verified in accordance with Practices E4.

6.2 *Reaction Supports and Loading Nose*—The beam specimen shall be placed over two rounded metal cylindrical supports or over pivoted bearing surfaces which can accommodate free rotation at the ends of the beam specimen. If the metal cylindrical supports or pivoted bearing surfaces cause any local crushing to the test specimen under loading, the beam specimen shall be supported by metal bearing plates to prevent damage to the beam at the point of contact between the beam specimen and reaction support. The plates shall be of sufficient length, thickness, and width to provide a firm bearing surface and ensure a uniform bearing stress across the flange width of the beam specimen. The bearing plates shall be supported by devices that provide unrestricted longitudinal deformation and rotation of the beam specimen at the reactions due to loading.

6.3 *Loading Nose*—The transverse loading at the center of the test specimen span shall be applied through a metal block with 4 in. width (along the length of the beam specimen) by  $\frac{1}{2}$  in. thick, with rounded edges or with a radius of curvature approximately equal to two times the beam specimen depth, extending across the entire specimen flange width. If the user chooses to test the specimen by placing an elastomeric pad in between the metal block and the top flange surface of the beam specimen to avoid any local crushing of the sample, a  $\frac{1}{2}$  in. thick Shore A durometer hardness 40 to 60 shall be used and the deflection shall be measured at the bottom flange surface of the test specimen using a dial gauge or LVDT.

6.4 *Measuring Devices for Sectional Dimensions*—All measuring devices used to measure cross-sectional dimensions shall be accurate to within  $\pm 0.0254$  mm ( $\pm 0.001$  in.). Devices used to measure span length shall be accurate to within  $\pm 1.5875$  mm ( $\pm \frac{1}{16}$  in.).

6.5 *Deflection Measuring Device*—A properly calibrated device to measure the deflection of the beam at mid-span shall be used. The device shall record the deflection during the test for certain magnitude of applied load (in accordance with 11.10). In the absence of an automated system, a properly calibrated deflection dial gauge may be used with at least one reading for every five seconds throughout the duration of the test. The deflection dial gauge shall be accurate to  $\pm 0.0254$  mm ( $\pm 0.001$  in.).

## 7. Sampling and Test Specimens

7.1 *Sampling*—Test at least five specimens per test condition unless valid results within 1% can be gained through the use of at least three specimens, as in the case of a designed experiment.

7.2 *Specimens*—The test beam specimens shall be molded shapes manufactured using a pultrusion process. Specimens shall be full-scale samples, tested at the desired span length. The span-to-depth ratio of specimens shall never be less than 20 or greater than 32 unless the sample needs to be tested in accordance with 13.4 for apparent modulus. Sufficient overhang (a length of 5% - 10% of the test span) shall be provided over each end support to prevent sample from slipping from the supports.

7.3 *Specimen Preparation*—Take precautions when cutting beam specimens to the desired span length to avoid notches, rough or uneven surfaces, or delaminations due to inappropriate test specimen preparation methods. The use of diamond coated machining tools are recommended in the preparation of test specimens.

7.4 *Labeling*—Label the test specimens (date, batch number, line number) so that they will be distinct from each other and traceable back to the specimen of origin of manufacturing, and will neither influence the test nor be affected by it.

## 8. Hazards

8.1 Precautions shall be taken to prevent the sample from kicking out of place under increasing transverse load resulting in lateral torsional movement, to avoid any accidents while testing under 3-point bending.