



Standard Test Method for Mixed Mode I-Mode II Interlaminar Fracture Toughness of Unidirectional Fiber Reinforced Polymer Matrix Composites¹

This standard is issued under the fixed designation D 6671; 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 describes the determination of interlaminar fracture toughness, G_c , of continuous fiber-reinforced composite materials at various Mode I to Mode II loading ratios using the Mixed-Mode Bending (MMB) Test.

1.2 This test method is limited to use with composites consisting of unidirectional carbon fiber tape laminates with brittle and tough single-phase polymer matrices. This test is further limited to the determination of fracture toughness as it initiates from a delamination insert. This limited scope reflects the experience gained in round robin testing. This method may prove useful for other types of toughness values and for other classes of composite materials; however, certain interferences have been noted (see Section 6). This test method has been successfully used to test the toughness of both glass fiber composites and adhesive joints.

1.3 The values stated in SI units are to be regarded as standard. The values provided in parentheses are for information 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.*

2. Referenced Documents

2.1 ASTM Standards:

- D 883 Terminology Relating to Plastics²
- D 2651 Guide for Preparation of Metal Surfaces for Adhesive Bonding³
- D 2734 Test Method for Void Content of Reinforced Plastics⁴
- D 3171 Test Method for Constituent Content of Composite Materials⁵
- D 3878 Terminology for High-Modulus Reinforcing Fibers

and their Composites⁵

D 5229 Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials⁵

D 5528 Test Method for Mode I Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites⁵

E 4 Practices for Force Verification of Testing Machines⁶

E 6 Terminology Relating to Methods of Mechanical Testing⁶

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process⁷

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods⁷

E 456 Terminology Relating to Quality and Statistics⁷

3. Terminology

3.1 Terminology D 3878 defines terms relating to high-modulus fibers and their composites. Terminology D 883 defines terms relating to plastics. Terminology E 6 defines terms relating to mechanical testing. Terminology E 456 and Practice E 177 define terms relating to statistics. In the event of conflict between terms, Terminology D 3878 shall have precedence over the other Terminology standards.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *crack opening mode (Mode I)*—fracture mode in which the delamination faces open away from each other and no relative crack face sliding occurs.

3.2.2 *crack sliding mode (Mode II)*—fracture mode in which the delamination faces slide over each other in the direction of delamination growth and no relative crack face opening occurs.

3.2.3 *mode mixture*, G_{II}/G —fraction of Mode II to total strain energy release rate. The mixed-mode ratio, G_I/G_{II} , is at times referred to instead of the mode mixture.

3.2.4 *Mode I strain energy release rate*, G_I —the loss of strain energy associated with Mode I deformation in the test specimen per unit of specimen width for an infinitesimal increase in delamination length, da , for a delamination growing under a constant displacement.

¹ This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.06 on Interlaminar Properties.

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² *Annual Book of ASTM Standards*, Vol 08.01.

³ *Annual Book of ASTM Standards*, Vol 15.06.

⁴ *Annual Book of ASTM Standards*, Vol 08.02.

⁵ *Annual Book of ASTM Standards*, Vol 15.03.

⁶ *Annual Book of ASTM Standards*, Vol 03.01.

⁷ *Annual Book of ASTM Standards*, Vol 14.02.