Designation: D8637/D8637M − 26

Standard Test Method for Mode I Dominant Facesheet-to-Core Fracture Toughness of Sandwich Constructions[1]

This standard is issued under the fixed designation D8637/D8637M; 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 the Mode I dominant fracture toughness, G_{Ic}, associated with facesheet-to-core separation of sandwich constructions using the single cantilever beam (SCB) specimen. This separation can consist of a disbond of the facesheet-to-core interface or a fracture of the core near the facesheet-to-core interface region.

1.2 This test method is limited to use with sandwich constructions with facesheets consisting of continuous-fiber or discontinuous-fiber (tape, fabric, or both) reinforced composites in which the laminate is balanced with respect to the test direction. Permissible core material forms include those with continuous bonding surfaces, such as balsa wood and foams, as well as those with discontinuous bonding surfaces, such as honeycomb. This test method may prove useful for other types and classes of sandwich constructions; however, certain interferences have been noted (see 6.8).

1.3 The measured fracture toughness of the facesheet-to-core interface region is a Mode I dominant structural property that is a function of the dimensions and constituent materials of the sandwich construction and the method of manufacturing.

1.4 Certain facesheet/core combinations may cause fracture loading conditions that deviate from a Mode I dominant condition, resulting in a fracture mode not addressed by this standard. Therefore, only combinations of facesheet and core materials that yield Mode I dominant fracture loading conditions in the SCB specimen are permissible. Further details are provided in 6.7. Mode I dominant fracture in the SCB specimen is defined as having a Mode-I component of energy release rate (ERR) equal to at least 90 % of the total ERR.

1.5 The values stated in 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, and values from the two systems shall not be combined.

1.5.1 Within the text the inch-pound units are shown in brackets.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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]

D883 Terminology Relating to Plastics
D2651 Guide for Preparation of Metal Surfaces for Adhesive Bonding
D3878 Terminology for Composite Materials
D5528 Test Method for Mode I Interlaminar Fracture Toughness of Unidirectional Fiber-Reinforced Polymer Matrix Composites
D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
D5687/D5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation
E4 Practices for Force Calibration and Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.09 on Sandwich Construction.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

E456 Terminology Relating to Quality and Statistics

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites, as well as terms relating to sandwich constructions. Terminology D883 defines terms relating to plastics. Terminology E6 defines terms relating to mechanical testing. Terminology E456 and Practice E177 define terms relating to statistics. In the event of conflict between terms, Terminology D3878 shall have precedence over the other terminology standards.

NOTE 1—If the term represents a physical quantity, its analytical dimensions are stated immediately following the term (or letter symbol) in fundamental dimension form, using the following ASTM standard symbology for fundamental dimensions, shown within square brackets: [M] for mass, [L] for length, [T] for time, [q] for thermodynamic temperature, and [nd] for non-dimensional quantities. Use of these symbols is restricted to analytical dimensions when used with square brackets, as the symbols may have other definitions when used without the brackets.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *area method, n*—the method of data reduction where the loss in strain energy, *dU*, is determined for a given incremental growth in crack area.

3.2.2 *modified beam theory method, n*—the method of data reduction where the relationship between specimen compliance and crack length is determined by measuring specimen compliance during a test at various increments of crack growth.

3.2.3 *strain energy release rate, G* [M/T²], *n*—the loss of strain energy, *dU*, in the test specimen per unit of specimen width for an infinitesimal increase in crack length, *da*, for a facesheet-to-core separation growing self-similarly under constant displacement. In mathematical form,

$$G = \frac{1dU}{bda} \quad (1)$$

where:

U = total elastic strain energy in the test specimen,
b = width of SCB specimen, and
a = crack length.

3.3 *Symbols:*

3.3.1 a—crack length, mm [in.]

3.3.2 $a_{bending}$—minimum crack length for bending dominated crack deformation, mm [in.]

3.3.3 a_{cs}—minimum crack length to meet compliance solution requirements, mm [in.]

3.3.4 a_{ext}—selected length of crack extension, mm [in.]

3.3.5 a_{fail}—maximum crack length at arm failure, mm [in.]

3.3.6 a_{max}—maximum crack length, mm [in.]

3.3.7 a_{prop}—maximum crack propagation during test, mm [in.]

3.3.8 a_o—recommended initial crack length, mm [in.]

3.3.9 b—width of SCB specimen, mm [in.]

3.3.10 β—crack length term, mm [in.]

3.3.11 C—compliance, mm/N [in./lbf]

3.3.12 CV—coefficient of variation, %

3.3.13 $E_{x,f}$—flexural modulus of separated facesheet, (see Fig. 1 for coordinate system), MPa [psi]

3.3.14 $E_{z,c}$—modulus of core material in thickness direction, MPa [psi]

3.3.15 F_{fu}—flexural strength of separated facesheet, MPa [psi]

3.3.16 G—strain energy release rate, kJ/m^2 [in.-lbf/in.^{2}]

3.3.17 G_{Ic}—Mode I fracture toughness, kJ/m^2 [in.-lbf/in.^{2}]

3.3.18 G_{Ic}^{est}—estimated value of Mode I fracture toughness, kJ/m^2 [in.-lbf/in.^{2}]

3.3.19 $G_{Ic(init)}$—Mode I initiation fracture toughness, kJ/m^2[in.-lbf/in.^{2}]

3.3.20 $G_{Ic(prop)}$—Mode I propagation fracture toughness, kJ/m^2 [in.-lbf/in.^{2}]

3.3.21 $G_{Ic(prop)}^{est}$—estimated value of Mode I propagation fracture toughness, kJ/m^2 [in.-lbf/in.^{2}]

3.3.22 $G_{xz,f}$—shear modulus of separated facesheet (see Fig. 1 for ref. coordinate system), MPa [psi]

3.3.23 h_d—distance from upper facesheet-to-core interface to crack location, mm [in.]

3.3.24 h_p—loading rod length, mm [in.]

3.3.25 $h_{p,min}$—minimum loading rod length, mm [in.]

3.3.26 L—length of SCB specimen, mm [in.]

3.3.27 $L_{b,min}$—minimum length of intact specimen after maximum crack length is reached, mm [in.]

3.3.28 L_{hinge}—length of specimen under piano hinge or end block, mm [in.]

3.3.29 m—slope of the force versus load-point displacement curve, N/mm [lbf/in.]

3.3.30 P—applied force, N [lbf]

3.3.31 P_c—applied force at the onset of crack growth, N [lbf]

3.3.32 P_{tab}—estimated maximum force on the loading tab, N [lbf]

3.3.33 R—compliance coefficient related to the bending rigidity of the separated facesheet, 1/N-mm^2[1/lbf-in.^{2}]

3.3.34 t_c—thickness of core, mm [in.]

3.3.35 t_f—thickness of separated facesheet, mm [in.]

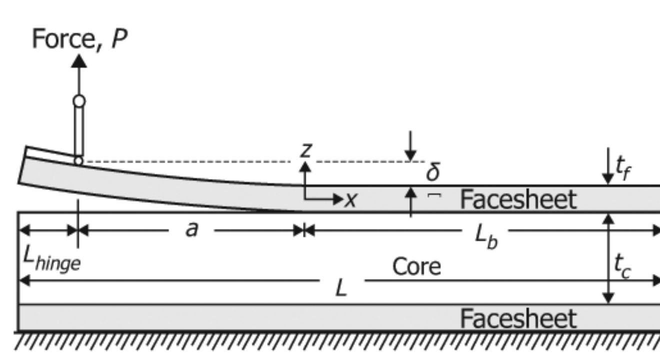

FIG. 1 Single Cantilever Beam Specimen