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.

Designation: C394/C394M – 16 (Reapproved 2024)

Standard Test Method for Shear Fatigue of Sandwich Core Materials[1]

This standard is issued under the fixed designation C394/C394M; 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 determines the effect of repeated shear forces on core material used in sandwich panels. 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).

1.2 This test method is limited to test specimens subjected to constant amplitude uniaxial loading, where the machine is controlled so that the test specimen is subjected to repetitive constant amplitude force (stress) cycles. Either shear stress or applied force may be used as a constant amplitude fatigue variable.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined. Within the text, the inch-pound units are shown in brackets.

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

1.5 *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]

C271/C271M Test Method for Density of Sandwich Core Materials

C273/C273M Test Method for Shear Properties of Sandwich Core Materials

D883 Terminology Relating to Plastics

D3878 Terminology for Composite Materials

D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials

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

E456 Terminology Relating to Quality and Statistics

E467 Practice for Verification of Constant Amplitude Dynamic Forces in an Axial Fatigue Testing System

E739 Guide for Statistical Analysis of Linear or Linearized Stress-Life (*S-N*) and Strain-Life (ε-*N*) Fatigue Data (Withdrawn 2024)[3]

E1012 Practice for Verification of Testing Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application

2.2 *ISO Standards*[4]

ISO 13003:2003(E) Fibre-reinforced plastics: Determination of fatigue properties under cyclic loading conditions

3. Terminology

3.1 *Definitions:*

3.1.1 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 a conflict between terms, Terminology D3878 shall have precedence over the other terminologies.

NOTE 1—If the term represents a physical quantity, its analytical

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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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

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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, [θ] 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:*

3.2.1 *constant amplitude loading, n—in fatigue*, a loading in which all of the peak values of force (stress) are equal and all of the valley values of force (stress) are equal.

3.2.2 *fatigue loading transition, n—in the beginning of fatigue loading*, the number of cycles before the force (stress) reaches the desired peak and valley values.

3.2.3 *force (stress) ratio, R [nd], n—in fatigue loading*, the ratio of the minimum applied force (stress) to the maximum applied force (stress), where positive force (stress) corresponds to the tension mode of loading.

3.2.4 *frequency, f [T^{-1}], n—in fatigue loading*, the number of force (stress) cycles completed in 1 s (Hz).

3.2.5 *peak, n—in fatigue loading*, the occurrence where the first derivative of the force (stress) versus time changes from positive to negative sign; the point of maximum force (stress) in constant amplitude loading.

3.2.6 *residual strength, [$ML^{-1}T^{-2}$], n*—the value of force (stress) required to cause failure of a specimen under quasi-static loading conditions after the specimen is subjected to fatigue loading.

3.2.7 *run-out, n—in fatigue*, an upper limit on the number of force cycles to be applied.

3.2.8 *spectrum loading, n—in fatigue*, a loading in which the peak values of force (stress) are not equal or the valley values of force (stress) are not equal (also known as variable amplitude loading or irregular loading).

3.2.9 *valley, n—in fatigue loading*, the occurrence where the first derivative of the force (stress) versus time changes from negative to positive sign; the point of minimum force (stress) in constant amplitude loading.

3.2.10 *wave form, n*—the shape of the peak-to-peak variation of the force (stress) as a function of time.

3.3 *Symbols—b* = width of specimen, mm [in]

CV = coefficient of variation statistic of a sample population for a given property (in percent)

L = length of specimen, mm [in]

N = number of constant amplitude cycles

P = force on specimen, positive for tension mode of loading, N [lb]

R = fatigue force (stress) ratio, minimum-to-maximum cyclic force (stress)

S_{n-1} = standard deviation statistic of a sample population for a given property

x_1 = test result for an individual specimen from the sample population for a given property

$\bar{x}$ = mean or average (estimate of mean) of a sample population for a given property

τ = core shear stress, MPa [psi]

4. Summary of Test Method

4.1 This test method consists of subjecting a sandwich core to cyclic shear force parallel to the plane of its faces. The force is transmitted to the core through loading plates which are bonded directly to the core (unlike the static core shear test, Test Method C273/C273M, bonding of loading plates to facesheets bonded to the core is not permitted). The number of force (stress) cycles at which failure occurs for a specimen subjected to a specific force (stress) ratio and force (stress) magnitude is determined.

NOTE 2—This test method may be used as a guide to conduct shear fatigue testing of sandwich panels consisting of facesheets and core with the Test Method C273/C273M loading plates bonded to the facesheets.

4.2 The only acceptable failure modes for shear fatigue of sandwich core materials are those which are internal to the sandwich core. Failure of the loading plate-to-core bond is not an acceptable failure mode.

5. Significance and Use

5.1 Often the most critical stress to which a sandwich panel core is subjected is shear. The effect of repeated shear stresses on the core material can be very important, particularly in terms of durability under various environmental conditions.

5.2 This test method provides a standard method of obtaining the sandwich core shear fatigue response. Uses include screening candidate core materials for a specific application, developing a design-specific core shear cyclic stress limit, and core material research and development.

NOTE 3—This test method may be used as a guide to conduct spectrum loading. This information can be useful in the understanding of fatigue behavior of core under spectrum loading conditions, but is not covered in this standard.

5.3 Factors that influence core fatigue response and shall therefore be reported include the following: core material, core geometry (density, cell size, orientation, etc.), specimen geometry and associated measurement accuracy, specimen preparation, specimen conditioning, environment of testing, specimen alignment, loading procedure, loading frequency, force (stress) ratio and speed of testing (for residual strength tests).

NOTE 4—If a sandwich panel is tested using the guidance of this standard, the following may also influence the fatigue response and should be reported: facing material, adhesive material, methods of material fabrication, adhesive thickness and adhesive void content. Further, core-to-facing strength may be different between precured/bonded and co-cured facings in sandwich panels with the same core and facing materials.

6. Interferences

6.1 *Material and Specimen Preparation*—Poor material fabrication practices and damage induced by improper specimen machining are known causes of high data scatter in composites in general. Specific material factors that affect sandwich core include variability in core density and degree of cure of core bonding adhesive. For this particular core shear test, thickness of the adhesive bond to honeycomb core (adhesive-filled depth into the honeycomb core cells), core misalignment/distortion/damage, or bonding surface roughness may affect the core shear strength and fatigue life.