



Designation: D8388/D8388M – 22

Standard Practice for Flexural Residual Strength Testing of Damaged Sandwich Constructions¹

This standard is issued under the fixed designation D8388/D8388M; 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 practice provides instructions for modifying the long beam flexure test method to determine the tensile or compressive residual strength properties of sandwich constructions that have been subjected to quasi-static indentation or drop-weight impact per Practice D7766/D7766M. The tensile or compressive strength result is determined by which facesheet contains the damage, either the loaded-span or support-span facesheet, based on how the specimen is positioned in the fixture.

1.2 This practice supplements Test Method D7249/D7249M with provisions for testing damaged sandwich specimens. Several important test specimen parameters (for example, facesheet thickness, core thickness and core density) are not mandated by this practice; however, repeatable results require that these parameters be specified and reported.

1.3 *Units*—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.

1.3.1 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.*

¹ This practice 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. Referenced Documents

2.1 ASTM Standards:²

- D883 Terminology Relating to Plastics
- D3410/D3410M Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading
- D3878 Terminology for Composite Materials
- D5687/D5687M Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation
- D7249/D7249M Test Method for Facesheet Properties of Sandwich Constructions by Long Beam Flexure
- D7766/D7766M Practice for Damage Resistance Testing of Sandwich Constructions
- 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

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

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, $[\theta]$ 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

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.



may have other definitions when used without the brackets.

3.2 Symbols:

b —specimen width
 c —calculated core thickness
 CV —coefficient of variation statistic of a sample population for a given property (in percent)
 d —sandwich total thickness
 F^{CAI} —facesheet ultimate residual strength (compressive)
 F^{TAI} —facesheet ultimate residual strength (tensile)
 k —core shear strength factor to ensure facesheet failure
 L —length of loading span
 l_{pad} —length of loading pad
 n —number of specimens
 P —applied force
 P_{max} —maximum force carried by test specimen before failure
 S —length of support span
 S_{n-1} —standard deviation statistic of a sample population for a given property
 σ —facesheet stress
 t —facesheet thickness
 x_i —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

4. Summary of Practice

4.1 This test practice consists of subjecting a long beam of sandwich construction to a bending moment normal to the plane of the sandwich, using a 4-point loading fixture in accordance with Test Method [D7249/D7249M](#). The sandwich beam has been damaged and inspected prior to testing. The damage state is imparted through out-of-plane loading caused by quasi-static indentation or drop-weight impact.

4.1.1 *Quasi-Static Indentation*—The rectangular beam is damaged due to application of an out-of-plane static indentation force in accordance with Practice [D7766/D7766M](#) Procedure A or Procedure B.

4.1.2 *Drop-Weight Impact*—The rectangular beam is damaged due to application of an out-of-plane drop-weight impact in accordance with Practice [D7766/D7766M](#) Procedure C.

4.2 Preferred failure modes pass through the damage in the sandwich beam. However, acceptable failures may initiate away from the damage site in instances when the damage produces a relatively low stress concentration, if the extent of damage is small, or both.

5. Significance and Use

5.1 This practice provides supplemental instructions that allow the use of Test Method [D7249/D7249M](#) to determine residual compressive or tensile strength properties of damaged sandwich constructions. Susceptibility to damage from concentrated out-of-plane forces is one of the major design concerns of many structures made using sandwich constructions. Knowledge of the residual strength properties of a sandwich panel is useful for product development, establishing design allowables, and material selection.

5.2 The residual compressive or tensile strength data obtained using this test practice is most commonly used in material selection, research and development activities, and establishing design allowables.

5.3 The properties obtained using this test practice can provide guidance in regard to the anticipated compressive or tensile residual strength capability of sandwich constructions of similar facesheet and core material, adhesive, facesheet and core thickness, facesheet stacking sequence, and so forth. However, it must be understood that the residual strength of sandwich constructions is highly dependent upon several factors including geometry, thickness, stiffness, support conditions, and so forth. Significant differences in the relationships between the damage state and the residual compressive or tensile strength can result due to differences in these parameters.

5.4 The compression strength from this test may not be equivalent to the compression strength of sandwich structures subjected to pure edgewise (in-plane) compression.

5.5 The reporting section requires items that tend to influence residual strength to be reported; these include the following: facesheet and core materials, core density, cell size and wall thickness if applicable, film adhesive, methods of material fabrication, accuracy of lay-up orientation, facesheet stacking sequence and thickness, core thickness, overall specimen thickness, specimen geometry, specimen preparation, specimen conditioning, environment of testing, type, size and location of damage (including method of non-destructive inspection), specimen/fixture alignment, time at temperature, and speed of testing.

6. Interferences

6.1 The response of a damaged specimen is dependent upon many factors, such as facesheet material, facesheet thickness, facesheet ply thickness, facesheet stacking sequence, facesheet surface flatness (toolside or bagside surface), core material, core thickness, core density, cell size, cell wall thickness, adhesive, construction methods, environment, damage type, damage geometry, damage location, and loading/support conditions. Consequently, comparisons cannot be made between materials unless identical test configurations, test conditions, and sandwich constructions are used. Therefore, all deviations from the standard test configuration shall be reported in the results. Specific structural configurations and boundary conditions must be considered when applying the data generated using this practice to design applications.

6.2 *Material and Specimen Preparation*—Poor material fabrication practices, lack of control of fiber alignment, and damage induced by improper specimen machining are known causes of high material data scatter in composites in general. Specific material factors that affect sandwich constructions include variability in core density and degree of cure of resin in both the facesheet matrix material and core bonding adhesive. Important aspects of sandwich panel specimen preparation that contribute to data scatter are incomplete or nonuniform core bonding to facesheets, misalignment of core and facesheet elements, the existence of joints, voids or other core