Designation: D8454/D8454M – 22

Standard Test Method for Open-Hole Compressive Strength of Sandwich Constructions[1]

This standard is issued under the fixed designation D8454/D8454M; 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 open-hole compressive strength of sandwich constructions in a direction parallel to the sandwich facesheet plane. 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 Several important test specimen parameters (for example, facesheet thickness, core thickness, and core density) are not mandated by this test method; however, repeatable results require that these parameters be specified and reported.

1.3 The method utilizes a flat, rectangular specimen, with a centrally located open through-hole, which is tested under edgewise compressive loading using a stabilization fixture.

1.4 The properties generated by this test method are highly dependent upon several factors, which include: specimen geometry, sandwich component materials and dimensions (facesheet, core, and adhesive), methods of fabrication, and boundary conditions. Thus, results are generally not scalable to other sandwich constructions, and are particular to the combination of geometric and physical conditions tested.

1.5 This test method can be used to test unnotched specimens, but care should be taken to prevent undesirable failure modes such as end crushing. ASTM Test Methods C364 or D7249/D7249M are the recommended test methods for unnotched sandwich panel compression strength or long beam flexure, respectively.

1.6 *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.

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

1.7 *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.*

1.8 *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]

C364 Test Method for Edgewise Compressive Strength of Sandwich Constructions

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D883 Terminology Relating to Plastics

D3171 Test Methods for Constituent Content of Composite Materials

D3878 Terminology for Composite Materials

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

D6484 Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates

D7249/D7249M Test Method for Facesheet Properties of Sandwich Constructions by Long Beam Flexure

D8453/D8453M Practice for Open-Hole Flexural Strength of Sandwich Constructions

E4 Practices for Force Calibration and Verification of Testing Machines

E6 Terminology Relating to Methods of Mechanical Testing

[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 service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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 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, [θ] for thermodynamic temperature, and [*nd*] for nondimensional 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 *diameter-to-facesheet thickness ratio, D/t [nd], n—in an open-hole specimen*, the ratio of the hole diameter to the facesheet thickness.

3.2.1.1 *Discussion*—The diameter-to-thickness ratio may be either a nominal value determined from nominal dimensions or an actual value determined from measured dimensions.

3.2.2 *length-to-diameter ratio, L/D [nd], n—in an open-hole specimen*, the ratio of the specimen length to the hole diameter.

3.2.2.1 *Discussion*—The length-to-diameter ratio may be either a nominal value determined from nominal dimensions or an actual value determined from measured dimensions.

3.2.3 *width-to-diameter ratio, w/D [nd], n—in an open-hole specimen*, the ratio of the specimen width to the hole diameter.

3.2.3.1 *Discussion*—The width-to-diameter ratio may be either a nominal value determined from nominal dimensions or an actual value determined from measured dimensions.

3.3 *Symbols:*

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

d—sandwich total thickness

D—diameter of hole

F^{ohcu}—facesheet ultimate open-hole (notched) compressive strength

L—length of specimen

n—number of specimens

P—applied force

P_{max}—maximum force carried by test specimen before failure

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

t—nominal 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

w—width of specimen across hole

Δ—percent difference

σ—facesheet compressive stress

ε—indicated strain from gage

4. Summary of Test Method

4.1 This test method consists of subjecting a sandwich panel, with a centrally located through-hole, to a uniaxial compressive force parallel to the plane of its faces. The specimen is installed in a multi-piece support fixture that has been aligned to minimize loading eccentricities and induced specimen bending. The specimen/fixture assembly is placed between flat platens and end-loaded under compressive force until failure. Applied force, crosshead displacement, and strain data are recorded while loading. Ultimate strength is calculated based on the nominal cross-sectional area of the two facesheets, disregarding the presence of the hole. While the hole causes a stress concentration and reduced net section, it is common aerospace practice to develop notched design allowable strengths based on gross section stress to account for various stress concentrations (flaws, damage, and so forth) not explicitly modeled in the stress analysis.

4.2 The only acceptable failure modes for ultimate open-hole sandwich compressive strength are ones which pass through the hole in the test specimen.

5. Significance and Use

5.1 This test method provides a standard method of determining the open-hole (notched) strength of the sandwich panel for structural design allowables, material specifications, and research and development.

5.2 The reporting section requires items that tend to influence notched sandwich compressive 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 (including hole diameter, diameter-to-thickness ratio, and width-to-diameter ratio), specimen preparation (especially of the hole), specimen conditioning, environment of testing, type, specimen/fixture alignment, time at temperature, and speed of testing. Further, notched sandwich compressive strength may be different between precured/bonded and co-cured facesheets of the same material.

5.3 The compression strength from this test may not be equivalent to the compression strength of sandwich structures subjected to flexural compression testing.

6. Interferences

6.1 *Hole Preparation*—Because of the dominating presence of the notch, and the lack of need to measure the material response, results from this test method are relatively insensitive