Designation: C365/C365M – 22

Standard Test Method for Flatwise Compressive Properties of Sandwich Cores[1]

This standard is issued under the fixed designation C365/C365M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers the determination of compressive strength and modulus of sandwich cores. These properties are usually determined for design purposes in a direction normal to the plane of the face sheets (also referred to as the facing plane) as the core would be placed in a structural sandwich construction. The test procedures pertain to compression in this direction in particular, but also can be applied with possible minor variations to determining compressive properties in other directions. 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 does not cover the determination of compressive core crush properties. Reference Test Method D7336/D7336M for determination of static energy absorption properties of honeycomb sandwich core materials.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C271/C271M Test Method for Density 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

D7336/D7336M Test Method for Static Energy Absorption Properties of Honeycomb Sandwich Core Materials

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

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.

3.2 *Symbols:*

3.2.1 *A*—cross-sectional area of a test specimen

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

[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.

3.2.3 E_z^{fc} —flatwise compressive modulus

3.2.4 F_z^{fcu} —ultimate flatwise compressive strength

3.2.5 $F_z^{fc\ 0.02}$—flatwise compressive strength at 2 % LVDT/compressometer deflection

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

3.2.7 $P_{0.02}$—force carried by test specimen at 2 % LVDT/compressometer deflection

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

3.2.9 t—thickness of a test specimen

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

3.2.11 $\bar{x}$—mean or average (estimate of mean) of a sample population for a given property

3.2.12 δ—LVDT or compressometer deflection

3.2.13 $\sigma_z^{fc0.02}$—flatwise compressive stress at 2 % LVDT/compressometer deflection

4. Summary of Test Method

4.1 This test method consists of subjecting a sandwich core to a uniaxial compressive force normal to the plane of the facings as the core would be placed in a structural sandwich construction. The force is transmitted to the sandwich core using loading platens attached to the testing machine.

5. Significance and Use

5.1 Flatwise compressive strength and modulus are fundamental mechanical properties of sandwich cores that are used in designing sandwich panels. Deformation data can be obtained, and from a complete force versus deformation curve, it is possible to compute the compressive stress at any applied force (such as compressive stress at proportional limit force or compressive strength at the maximum force) and to compute the effective modulus of the core.

5.2 This test method provides a standard method of obtaining the flatwise compressive strength and modulus for sandwich core structural design properties, material specifications, research and development applications, and quality assurance.

5.3 In order to prevent local crushing of some honeycomb cores, it is often desirable to stabilize the facing plane surfaces with a suitable material, such as a thin layer of resin or thin facings. Flatwise compressive strength data may be generated using either stabilized specimens (reported as stabilized compression strength) or non-stabilized specimens (reported as bare compression strength). It is customary aerospace industry practice to determine compression modulus only when using stabilized specimens.

5.4 Factors that influence the flatwise compressive strength and shall therefore be reported include the following: core material, methods of material fabrication, core geometry (cell size), core density, specimen geometry, specimen preparation, specimen conditioning, environment of testing, specimen alignment, loading procedure, and speed of testing.

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 and sandwich structures in general. A specific material factor that affects sandwich cores is variability in core density. Important aspects of sandwich core specimen preparation that contribute to data scatter include the existence of joints, voids or other core discontinuities, out-of-plane curvature, and surface roughness.

6.2 *System Alignment*—Non-uniform loading over the surface of the test specimen may cause premature failure. Non-uniform loading may result from non-uniform specimen thickness, failure to locate the specimen concentrically in the fixture, or system or fixture misalignment.

6.3 *Geometry*—Specific geometric factors that affect sandwich flatwise compressive strength include core cell geometry, core thickness, and specimen shape (square or circular). Flatwise compressive strength and modulus measurements are particularly sensitive to thickness variations over the cross-sectional area of the specimen, which can cause local loading eccentricities, as well as toe regions in the force versus displacement curves due to specimen seating.

6.4 *Environment*—Results are affected by the environmental conditions under which specimens are conditioned, as well as the conditions under which the tests are conducted. Specimens tested in various environments can exhibit significant differences in both strength behavior and failure mode. Critical environments must be assessed independently for each core material tested.

7. Apparatus

7.1 *Micrometers and Calipers*—A micrometer with a 4 to 8 mm [0.16 to 0.32 in.] nominal diameter ball-interface or a flat anvil interface shall be used to measure the specimen thickness. A ball interface is recommended for thickness measurements of stabilized specimens (in accordance with 8.3) when at least one facing plane surface is irregular (for example, the bag-side of a thin face sheet laminate that is neither smooth nor flat). A micrometer or caliper with a flat anvil interface is recommended for thickness measurements of stabilized specimens when both facing plane surfaces are smooth (for example, tooled surfaces). A micrometer or caliper with a flat anvil interface shall be used for measuring length and width (or diameter), as well as the specimen thickness when the facing plane surfaces are not stabilized (for example, bare). The use of alternative measurement devices is permitted if specified (or agreed to) by the test requestor and reported by the testing laboratory. The accuracy of the instrument(s) shall be suitable for reading to within 1 % of the sample length and width (or diameter) and thickness. For typical specimen geometries, an instrument with an accuracy of ±0.012 mm [±0.0005 in.] is adequate for thickness measurement, whereas an instrument with an accuracy of ±0.25 mm [±0.010 in.] is adequate for length and width (or diameter) measurement.

7.2 *Loading Platens*—Force shall be introduced into the specimen using one fixed flat platen and one spherical seat