



Designation: D7249/D7249M – 16^{ε1}

Standard Test Method for Facing Properties of Sandwich Constructions by Long Beam Flexure¹

This standard is issued under the fixed designation D7249/D7249M; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

^{ε1} NOTE—Equation 4 was corrected editorially in April 2017.

1. Scope

1.1 This test method covers determination of facing properties of flat sandwich constructions subjected to flexure in such a manner that the applied moments produce curvature of the sandwich facing planes and result in compressive and tensile forces in the facings. 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 The values stated in either 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. Combining values from the two systems may result in non-conformance with the standard.

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

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

NOTE 1—Alternate procedures for determining the compressive strength of unidirectional polymer matrix composites materials in a sandwich beam configuration may be found in Test Method [D5467/D5467M](#).

1.4 *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 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. Referenced Documents

2.1 *ASTM Standards*:²

- [C393 Test Method for Flexural Properties of Sandwich Constructions](#)
- [D3878 Terminology for Composite Materials](#)
- [D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials](#)
- [D5467/D5467M Test Method for Compressive Properties of Unidirectional Polymer Matrix Composite Materials Using a Sandwich Beam](#)
- [D7250/D7250M Practice for Determining Sandwich Beam Flexural and Shear Stiffness](#)
- [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](#)
- [E251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages](#)
- [E456 Terminology Relating to Quality and Statistics](#)

3. Terminology

3.1 *Definitions*—Terminology [D3878](#) defines terms relating to high-modulus fibers and their composites. 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*:

- b = specimen width
- c = core thickness
- CV = coefficient of variation statistic of a sample population for a given property (in percent)

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.

d	= sandwich total thickness
$D^{F,nom}$	= effective sandwich flexural stiffness
E^f	= effective facing chord modulus
ε	= measuring strain in facing
F^u	= facing ultimate strength (tensile or compressive)
F_s	= core shear allowable strength
F_c	= core compression allowable strength
k	= core shear strength factor to ensure facing failure
l	= length of loading span
L	= length of support 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_{n-1}	= standard deviation statistic of a sample population for a given property
σ	= facing stress
t	= facing thickness
x_j	= 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 Test Method

4.1 This test method 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. Deflection and strain versus force measurements are recorded.

4.2 The only acceptable failure modes for sandwich facesheet strength are those which are internal to one of the facesheets. Failure of the sandwich core or the core-to-facesheet bond preceding failure of one of the facesheets is not an acceptable failure mode. Careful post-test inspection of the specimen is required as facing failure occurring in proximity to the loading points can be caused by local through-thickness compression or shear failure of the core that precedes failure of the facing.

5. Significance and Use

5.1 Flexure tests on flat sandwich construction may be conducted to determine the sandwich flexural stiffness, the core shear strength, and shear modulus, or the facings' compressive and tensile strengths. Tests to evaluate core shear strength may also be used to evaluate core-to-facing bonds.

5.2 This test method is limited to obtaining the strength and stiffness of the sandwich panel facings, and to obtaining load-deflection data for use in calculating sandwich beam flexural and shear stiffness using Standard Practice **D7250/D7250M**. Due to the curvature of the flexural test specimen when loaded, facesheet compression strength from this test may not be equivalent to the facesheet compression strength of sandwich structures subjected to pure edgewise (in-plane) compression.

5.3 Core shear strength and shear modulus are best determined in accordance with Test Method C273 provided bare core material is available. Test Method **C393** may also be used to determine core shear strength. Standard Practice **D7250/**

D7250M may be used to calculate the flexural and shear stiffness of sandwich beams.

5.4 This test method can be used to produce facing strength data for structural design allowables, material specifications, and research and development applications; it may also be used as a quality control test for bonded sandwich panels.

5.5 Factors that influence the facing strength and shall therefore be reported include the following: facing material, core material, adhesive material, methods of material fabrication, facing stacking sequence and overall thickness, core geometry (cell size), core density, adhesive thickness, specimen geometry, specimen preparation, specimen conditioning, environment of testing, specimen alignment, loading procedure, speed of testing, facing void content, adhesive void content, and facing volume percent reinforcement. Further, facing strength may be different between precured/bonded and co-cured facesheets of the same material.

NOTE 2—Concentrated forces on beams with thin facings and low density cores can produce results that are difficult to interpret, especially close to the failure point. Wider loading blocks and rubber pressure pads may assist in distributing the forces.

NOTE 3—To ensure that simple sandwich beam theory is valid, a good rule of thumb for the four-point bending test is the span length divided by the sandwich thickness should be greater than 20 ($L/d > 20$) with the ratio of facing thickness to core thickness less than 0.1 ($t/c < 0.1$).

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 *Geometry*—Specific geometric factors that affect sandwich facing strength include facing thickness, core cell geometry, and facing surface flatness (toolside or bagside surface in compression).

6.3 *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 specific combination of core material, facing material, and core-to-facing interfacial adhesive (if used) that is tested.

6.4 *Core Material*—If the core material has insufficient shear or compressive strength, it is possible that the core may locally crush at or near the loading points thereby resulting in facesheet failure due to local stresses. In other cases, facing failure can cause local core crushing. When there is both facing and core failure in the vicinity of one of the loading points it can be difficult to determine the failure sequence in a post-mortem inspection of the specimen as the failed specimens look very similar for both sequences.

7. Apparatus

7.1 *Micrometers and Calipers*—A micrometer having a flat anvil interface, or a caliper of suitable size, shall be used. The instrument(s) shall have an accuracy of $\pm 25 \mu\text{m}$ [$\pm 0.001 \text{ in.}$] for thickness measurement, and an accuracy of $\pm 250 \mu\text{m}$ [$\pm 0.010 \text{ in.}$] for length and width measurement.

NOTE 4—The accuracies given above are based on achieving measurements that are within 1 % of the sample length, width and thickness.

7.2 *Loading Fixtures*

7.2.1 *Standard Configuration*—The standard loading fixture shall consist of a 4-point loading configuration with two support bars that span the specimen width located below the specimen, and two loading bars that span the specimen width located on the top of the specimen (Fig. 1). The force shall be applied vertically through the loading bars, with the support bars fixed in place in the test machine. The standard loading fixture shall have the centerlines of the support bars separated by a distance of 560 mm [22.0 in.] and the centerlines of the loading bars separated by a distance of 100 mm [4.0 in.].

7.2.2 *Non-Standard Configurations*—All other loading fixture configurations (see Fig. 2) are considered non-standard and details of the fixture geometry shall be documented in the test report. Figs. 3-5 show typical test fixtures. Non-standard 3- and 4-point loading configurations have been retained within this standard a) for historical continuity with previous versions of Test Method C393, b) because some sandwich panel designs require the use of non-standard loading configurations to achieve facesheet failure modes, and c) load-deflection data from non-standard configurations may be used with Standard Practice D7250/D7250M to obtain sandwich beam flexural and shear stiffnesses.

7.2.3 *Support and Loading Bars*—The bars shall be designed to allow free rotation of the specimen at the loading and support points. The bars shall have sufficient stiffness to avoid significant deflection of the bars under load; any obvious bowing of the bars or any gaps occurring between the bars and the test specimen during loading shall be considered significant deflection. The recommended configuration has a 25 mm [1.0 in.] wide flat steel loading block to contact the specimen (through rubber pressure pads) and is loaded via either a cylindrical pivot (see Fig. 3) or a V-shaped bar riding in a V-groove in the top of the flat-bottomed steel loading pad. The tips of the V-shaped loading bars shall have a minimum radius of 3 mm [0.12 in.]. The V-groove in the loading pad shall have a radius larger than the loading bar tip and the angular opening of the groove shall be such that the sides of the loading bars do not contact the sides of the V-groove during the test. Loading bars consisting of 25 mm [1.0 in.] diameter steel cylinders may

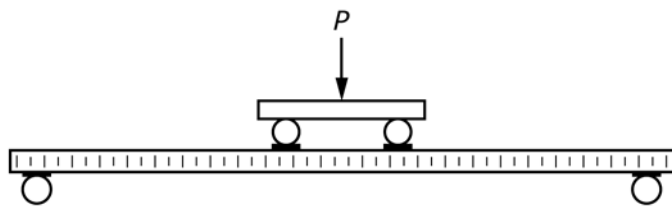
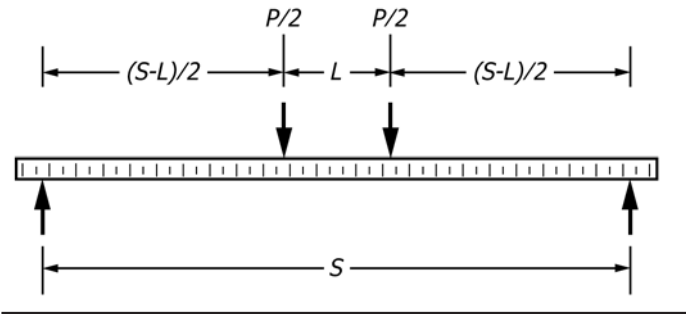


FIG. 1 Test Specimen and Fixture



Configuration		Support Span (S)	Load Span (L)
Standard	4-Point	560 mm [22.0 in.]	100 mm [4.0 in.]
Non-Standard	3-Point (Mid-span)	S	0.0
	4-Point (Quarter-Span)	S	S/2
	4-Point (Third-Span)	S	S/3

FIG. 2 Loading Configurations

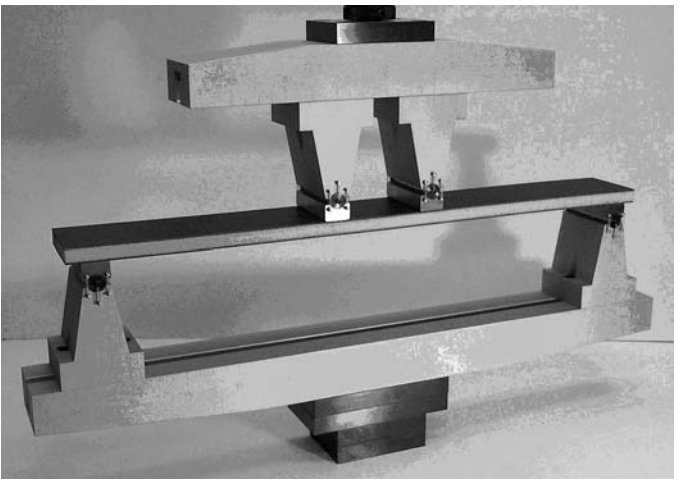


FIG. 3 Standard 4-Point Loading Configuration

also be used, but there is a greater risk of local specimen crushing with cylindrical bars. Also, the load and support span lengths tend to increase as the specimen deflects when cylindrical loading bars without V-grooved loading pads are used (e.g., rolling supports).

7.2.4 *Pressure Pads*—Rubber pressure pads having a Shore A durometer of 60, a width of 25 mm [1.0 in.], a nominal thickness of 3 mm [0.125 in.] and spanning the full width of the specimen shall be used between the loading bars and specimen to prevent local damage to the facings.

7.3 *Testing Machine*—The testing machine shall be in accordance with Practices E4 and shall satisfy the following requirements:

7.3.1 *Testing Machine Configuration*—The testing machine shall have both an essentially stationary head and a movable head.

7.3.2 *Drive Mechanism*—The testing machine drive mechanism shall be capable of imparting to the movable head a controlled velocity with respect to the stationary head. The