



# Standard Practice for Determining Sandwich Beam Flexural and Shear Stiffness<sup>1</sup>

This standard is issued under the fixed designation D 7250/D 7250M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice covers determination of the flexural and transverse shear stiffness properties of flat sandwich constructions subjected to flexure in such a manner that the applied moments produce curvature of the sandwich facing planes. 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). The calculation methods in this practice are limited to sandwich beams exhibiting linear force-deflection response. This practice uses test results obtained from Test Methods **C 393/C 393M** and/or **D 7249/D 7249M**.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

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.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- C 273** Test Method for Shear Properties of Sandwich Core Materials
- C 274** Terminology of Structural Sandwich Constructions
- C 393** Test Method for Flexural Properties of Sandwich Constructions
- D 883** Terminology Relating to Plastics
- D 3878** Terminology for Composite Materials

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- D 7249/D 7249M** Test Method for Facing Properties of Sandwich Constructions by Long Beam Flexure
- E 6** Terminology Relating to Methods of Mechanical Testing
- E 122** Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for a Characteristic of a Lot or Process
- E 177** Practice for Use of the Terms Precision and Bias in ASTM Test Methods
- E 456** Terminology Relating to Quality and Statistics
- E 1309** Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases
- E 1434** Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases

## 3. Terminology

3.1 *Definitions*—Terminology **D 3878** defines terms relating to high-modulus fibers and their composites. Terminology **C 274** defines terms relating to structural sandwich constructions. Terminology **D 883** defines terms relating to plastics. Terminology **E 6** defines terms relating to mechanical testing. Terminology **E 456** and Practice **E 177** define terms relating to statistics. In the event of a conflict between terms, Terminology **D 3878** shall have precedence over the other terminologies.

### 3.2 Symbols:

- $b$  = sandwich width, mm [in.]
- $c$  = core thickness, mm [in.]
- $d$  = sandwich thickness, mm [in.]
- $D$  = flexural stiffness, N-mm<sup>2</sup> [lb-in.<sup>2</sup>]
- $\Delta$  = beam mid-span deflection, mm [in.]
- $G$  = core shear modulus, MPa [psi]
- $S$  = support span length, mm [in.]
- $L$  = load span length, mm [in.] ( $L = 0.0$  for 3-point mid-span loading configuration)
- $n$  = number of specimens
- $P$  = total applied force, N [lb]
- $t$  = facing thickness, mm [in.]
- $U$  = transverse shear rigidity, N [lb]

## 4. Summary of Practice

4.1 This practice consists of calculating the flexural stiffness, transverse (through-thickness) shear rigidity and core shear modulus of a sandwich beam using deflection and/or

strain data from two or more flexure tests of different loading configurations conducted under Test Methods **C 393/C 393M** and/or **D 7249/D 7249M**. This practice also includes equations for calculating the shear rigidity and core shear modulus of a sandwich beam using deflection data from a single flexure test conducted under Test Method **C 393/C 393M** when the facing modulus is known.

## 5. Significance and Use

5.1 Flexure tests on flat sandwich constructions 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 practice provides a standard method of determining sandwich flexural and shear stiffness and core shear modulus using calculations involving measured deflections of sandwich flexure specimens. Tests can be conducted on short specimens and on long specimens (or on one specimen loaded in two ways), and the flexural stiffness, shear rigidity and core shear modulus can be determined by simultaneous solution of the complete deflection equations for each span or each loading. If the facing modulus values are known, a short span beam can be tested and the calculated bending deflection subtracted from the beam's total deflection. This gives the shear deflection from which the transverse shear modulus can be determined.

NOTE 1—Core shear strength and shear modulus are best determined in accordance with Test Method **C 273** provided bare core material is available.

NOTE 2—For cores with high shear modulus, the shear deflection will be quite small and ordinary errors in deflection measurements will cause considerable variations in the calculated shear modulus.

NOTE 3—To insure that simple sandwich beam theory is valid, a good rule of thumb for a four-point bending test is the span length divided by the sandwich thickness should be greater than 20 ( $L_1/d > 20$ ) 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*—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 stiffness and thereby the sandwich flexural stiffness 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 stiffness. 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*—For some core materials, the core shear modulus is a function of the direction that the core is oriented relative to the length of the specimen. Another material factor that affects sandwich core stiffness is variability in core density.

## 7. Sampling and Test Specimens

7.1 *Sampling*—Test at least five specimens per test condition unless valid results can be gained through the use of fewer specimens, as in the case of a designed experiment. For statistically significant data, consult the procedures outlined in Practice **E 122**. Report the method of sampling.

7.2 *Specimen Geometry*—The test specimens shall be rectangular in cross section. The depth of the specimens shall be equal to the thickness of the sandwich construction, and the width shall be not less than twice the total thickness, not less than three times the dimension of a core cell, nor greater than one half the span length. The specimen length shall be equal to the span length plus 50 mm [2 in.] or plus one half the sandwich thickness whichever is the greater.

7.3 *Loading Configurations, Unknown Facing Modulus*—For cases where the facing modulus is not known, a minimum of two loading configurations must be selected. Refer to Test Methods **C 393/C 393M** and **D 7249/D 7249M** for the equations used to size the specimen lengths and loading configurations so that facing failure and core shear failures do not occur below the desired maximum applied force level. It is recommended that one loading configuration use a short support span and specimen and the other loading configuration use a long support span and specimen. The purpose of this recommendation is to obtain force-deflection data for one test with relatively high shear deflection and one test with relatively high flexural deformation. If two short configurations or two long configurations are tested, measurement errors may be large relative to the difference in shear and flexural deflections between the two tests and may lead to significant errors in the calculated flexural and shear stiffness values.

7.4 *Loading Configurations, Known Facing Modulus*—For cases where the facing modulus is known for sandwich beams with identical facings, a short support span loading configuration test should be conducted per Test Method **C 393/C 393M**.

## 8. Procedure

8.1 *Unknown Facing Modulus*—Conduct tests on sandwich beam specimens per Test Methods **C 393/C 393M** and/or **D 7249/D 7249M** using two or more different loading configurations; **Fig. 1**. It is preferable to conduct each of the loading conditions on each test specimen. This requires that the applied forces for all but the last loading condition to be kept sufficiently low to avoid failure and permanent deformations of the specimen.

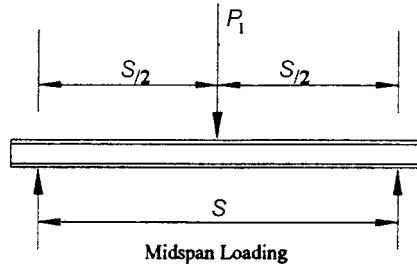
8.2 *Known Facing Modulus*—Conduct tests on sandwich beam specimens per Test Methods **C 393/C 393M** using a single short support span loading configuration.

8.3 *Data Recording*—Record force-deflection curves for each test specimen using a transducer, deflectometer, or dial gage to measure the mid-span deflection.

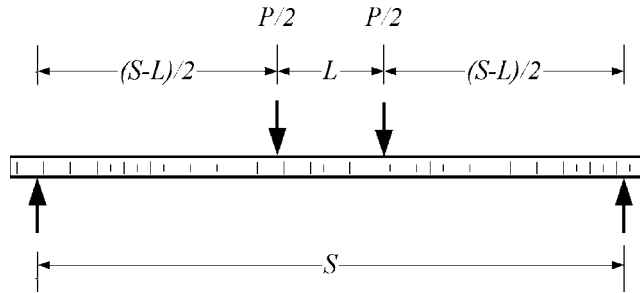
NOTE 4—The use of crosshead or actuator displacement for the beam mid-span deflection produces inaccurate results; the direct measurement of the deflection of the mid-span of the beam must be made by a suitable instrument.

## 9. Validation

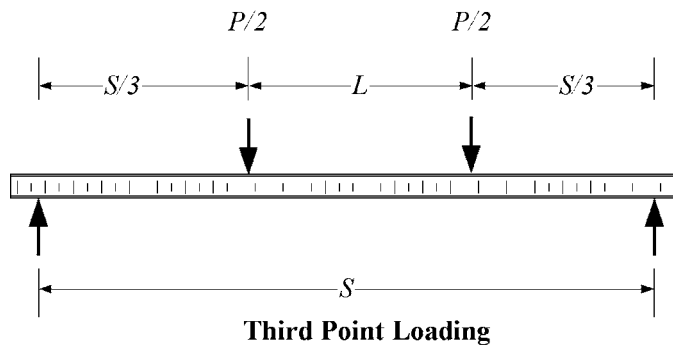
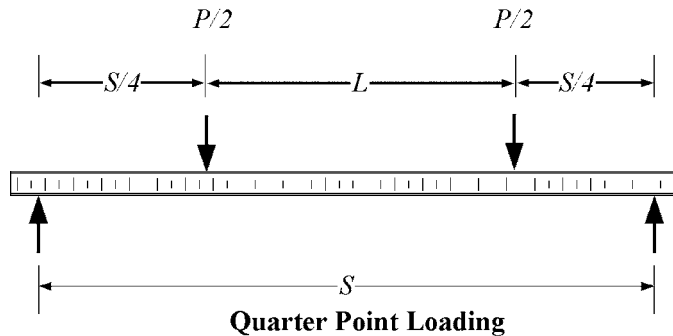
9.1 Values for stiffness properties shall not be calculated at any applied force level above or beyond the point of initial



(a) 3-Point Loading (C 393/C 393M Standard Configuration)



(b) 4-Point Loading (D 7249/D 7249M Long Beam Flexure Standard Configuration)



(c) 4-Point Loading (C 393/C 393M and D 7249/D 7249M Non-Standard Configuration)

**FIG. 1 Loading Configurations**

specimen failure, or above a point where the specimen exhibits obvious non-linear deflection response due to excessive local or overall deflection. Retests shall be performed for any specimen on which values are not calculated.

## 10. Calculation

10.1 *General Instructions, Unknown Facing Modulus*—Calculation procedures for flexural stiffness and transverse

shear rigidity for cases where the facing modulus values are not known are given in 10.1-10.2. Calculation procedures for transverse shear rigidity and core shear modulus for cases where the facing modulus is known are given in 10.3.

NOTE 5—The equations in this section assume linear force-deflection response for both the facing and core materials. If the force-deflection