Designation: C365/C365M – 16

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 facings 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 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.

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

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 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)

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

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[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.

3.2.9 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 7 mm [0.16 to 0.28 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 (e.g. the bag-side of a thin facing 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 (e.g. 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 (e.g. 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 (self-aligning) platen. The platens shall be well-aligned and shall not apply eccentric forces. A satisfactory type of apparatus is shown in Figs. 1 and 2. The platen surfaces shall extend beyond the test specimen periphery. If the platens are not sufficiently hardened, or simply to protect the platen surfaces, a hardened plate (with parallel surfaces) can be inserted between each end of the fixture and the corresponding platen.

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

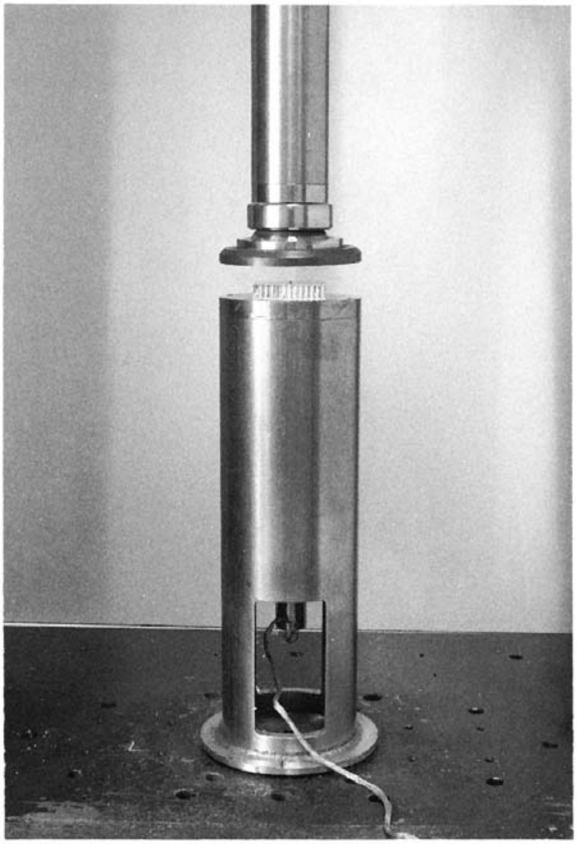

FIG. 1 Platen, Transducer, and Rod Setup

FIG. 2 Close-up of Specimen Between Loading Platens

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 velocity of the movable head shall be capable of being regulated in accordance with 11.5.

7.3.3 *Force Indicator*—The testing machine load-sensing device shall be capable of indicating the total force being carried by the test specimen. This device shall be essentially free from inertia lag at the specified rate of testing and shall indicate the force with an accuracy over the force range(s) of interest of within ±1 % of the indicated value.

7.4 *Crosshead Displacement Indicator*—The testing machine shall be capable of monitoring and recording the crosshead displacement (stroke) with a precision of at least ±1 %. If machine compliance is significant, it is acceptable to measure the displacement of the movable head using an LVDT, compressometer, or similar device with ±1 % precision on displacement. A transducer and rod setup, shown in Figs. 1 and 2, has been found to work satisfactorily. In the example shown, a small hole is drilled in the center of the core specimen and in the bottom loading platen, and a transducer rod is inserted through the hole, such that it contacts the upper loading platen.

NOTE 1—Bonded resistance strain gages are not usually considered satisfactory for measuring strain in this application because of their stiffness. The reinforcing effect of bonding gages to some cores can lead to large errors in measurement of strain.

7.5 *Conditioning Chamber*—When conditioning materials at non-laboratory environments, a temperature/vapor-level controlled environmental conditioning chamber is required that shall be capable of maintaining the required temperature to within ±3°C [±5°F] and the required relative humidity level to within ±3 %. Chamber conditions shall be monitored either on an automated continuous basis or on a manual basis at regular intervals.

7.6 *Environmental Test Chamber*—An environmental test chamber is required for test environments other than ambient testing laboratory conditions. This chamber shall be capable of maintaining the gage section of the test specimen at the required test environment during the mechanical test.

8. Sampling and Test Specimens

8.1 *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 E122. Report the method of sampling.

8.2 *Geometry*—Test specimens shall have a square or circular cross-section not exceeding 10 000 mm^2 [16.0 in.^{2}], and shall be equal in thickness to the sandwich core thickness. Minimum specimen cross-sectional areas for various types of core materials are as follows:

NOTE 2—The specimen's cross-sectional area is defined in the facing plane, in regard to the orientation that the core would be placed in a structural sandwich construction. For example, for a honeycomb core the cross-sectional area is defined in the plane of the cells, which is perpendicular to the orientation of the cell walls.

8.2.1 *Continuous Bonding Surfaces (for example, Balsa Wood, Foams)*—The minimum facing area of the specimen shall be 625 mm^2 [1.0 $in.^2$].

8.2.2 *Discontinuous Cellular Bonding Surfaces (for example, Honeycomb)*—The required facing area of the specimen is dependent upon the cell size, to ensure a minimum number of cells are tested. Minimum facing areas are recommended in Table 1 for the more common cell sizes. These are intended to provide approximately 60 cells minimum in the test specimen. The largest facing area listed in the table (5625 mm^2 [9.0 $in.^2$]) is a practical maximum for this test method. Cores with cell sizes larger than 9 mm [0.375 in.] may require a smaller number of cells to be tested in the specimen.

8.3 *Specimen Preparation and Machining*—Prepare the test specimens so that the loaded surfaces will be parallel to each other and perpendicular to the sides of the specimen. Take precautions when cutting specimens from large sheets of core to avoid notches, undercuts, and rough or uneven surfaces due to inappropriate machining methods. Obtain final dimensions by water-lubricated precision sawing, milling, or grinding. The use of diamond tooling has been found to be extremely effective for many material systems. Record and report the specimen cutting preparation method.

NOTE 3—In order to prevent local crushing of some honeycomb cores, it is often desirable to reinforce the facing plane surfaces with a suitable material. In such instances, the facing plane surfaces may be dipped in a thin layer of resin, or thin facings may be bonded to the facing plane surfaces of the core. When either of these stabilization techniques is used, the test shall be reported as a stabilized compression test, and the method, configuration, and process of stabilization utilized shall be reported. When honeycomb core facing plane surfaces are not stabilized, the test shall be reported as a bare compression test. It is customary aerospace industry practice to determine compression modulus only when using stabilized specimens.

NOTE 4—Testing of core materials with typical manufacturing thickness tolerances (±0.08 to ±0.13 mm [±0.003 to ±0.005 in.]) may produce variant flatwise compressive modulus values, as this tolerance is too large to preclude specimen seating effects within the specified displacement range. Such effects are often characterized by the presence of toe regions in the force versus displacement data (see Annex A1). To minimize the toe region and provide Hookean (linear) behavior in the specified displacement range, it is recommended that the core be produced or machined with a facing area thickness tolerance equal to ±0.05 % of the nominal core thickness (for example, ±0.013 mm [±0.0005 in.] for 1.0 inch thick core).

8.4 *Labeling*—Label the test specimens so that they will be distinct from each other and traceable back to the sheet of origin, and will neither influence the test nor be affected by it.

TABLE 1 Recommended Minimum Specimen Cross-Sectional Area

Minimum Cell Size (mm [in.])	Maximum Cell Size (mm [in.])	Minimum Cross-Sectional Area (mm^2 [$in.^2$])
...	3.0 [0.125]	625 [1.0]
3.0 [0.125]	6.0 [0.250]	2500 [4.0]
6.0 [0.250]	9.0 [0.375]	5625 [9.0]

9. Calibration

9.1 The accuracy of all measuring equipment shall have certified calibrations that are current at the time of use of the equipment.

10. Conditioning

10.1 The recommended pre-test condition is effective moisture equilibrium at a specific relative humidity as established by Test Method D5229/D5229M; however, if the test requestor does not explicitly specify a pre-test conditioning environment, no conditioning is required and the test specimens may be tested as prepared.

10.2 The pre-test specimen conditioning process, to include specified environmental exposure levels and resulting moisture content, shall be reported with the test data.

NOTE 5—The term moisture, as used in Test Method D5229/D5229M, includes not only the vapor of a liquid and its condensate, but the liquid itself in large quantities, as for immersion.

10.3 If no explicit conditioning process is performed, the specimen conditioning process shall be reported as "unconditioned" and the moisture content as "unknown."

11. Procedure

11.1 *Parameters to be Specified Before Test:*

11.1.1 The specimen sampling method, specimen geometry, and conditioning travelers (if required).

11.1.2 The properties and data reporting format desired.

NOTE 6—Determine specific material property, accuracy, and data reporting requirements prior to test for proper selection of instrumentation and data recording equipment. Estimate the specimen strength to aid in transducer selection, calibration of equipment, and determination of equipment settings.

11.1.3 The environmental conditioning test parameters.

11.2 *General Instructions:*

11.2.1 Report any deviations from this test method, whether intentional or inadvertent.

11.2.2 If core density is to be reported, then obtain these samples from the same sheet of core being tested. Density may be evaluated in accordance with Test Method C271/C271M.

11.2.3 Following final specimen machining, but before conditioning and testing, measure the specimen length and width (or diameter) and thickness. The accuracy of these measurements shall be within 1.0 % of the dimension. Measure the specimen length and width (or diameter) with an accuracy of ±250 µm [±0.010 in.]. Measure the specimen thickness with an accuracy of ±13 µm [±0.0005 in.]. Record the dimensions to three significant figures in units of millimetres [inches].

11.3 Condition the specimens as required. Store the specimens in the conditioned environment until test time, if the test environment is different than the conditioning environment.

11.4 Following final specimen conditioning, but before testing, re-measure the specimen length and width (or diameter) and thickness as in 11.2.3.

11.5 *Speed of Testing*—Set the speed of testing so as to produce failure within 3 to 6 min. If the ultimate strength of the material cannot be reasonably estimated, initial trials should be conducted using standard speeds until the ultimate strength of the material and the compliance of the system are known, and speed of testing can be adjusted. The suggested standard head displacement rate is 0.50 mm/min [0.020 in./min].

11.6 *Test Environment*—If possible, test the specimen under the same fluid exposure level used for conditioning. However, cases such as elevated temperature testing of a moist specimen place unrealistic requirements on the capabilities of common testing machine environmental chambers. In such cases, the mechanical test environment may need to be modified, for example, by testing at elevated temperature with no fluid exposure control, but with a specified limit on time to failure from withdrawal from the conditioning chamber. Record any modifications to the test environment.

NOTE 7—When testing a conditioned specimen at elevated temperature with no fluid exposure control, the percentage moisture loss of the specimen prior to test completion may be estimated by placing a conditioned traveler coupon of known weight within the test chamber at the same time the specimen is placed in the chamber. The traveler coupon should be configured to mimic the specimen, such that moisture evaporation is comparable to that of the test specimen. Upon completion of the test, the traveler coupon is removed from the chamber, weighed, and the percentage weight calculated and reported.

11.7 *Specimen Installation*—Mark a rectangle or circle (depending upon the specimen's cross-sectional shape) on the lower platen to help center the specimen between the platens. Place the specimen on the lower platen, accommodating the LVDT or compressometer as necessary.

NOTE 8—Take care to align specimens well between the platens, in order to distribute the applied force as uniformly as possible over the entire loading surface. This will help to ensure that the specimen edges are loaded uniformly. Non-uniform loading often results in failures that are confined to one corner or one edge of the specimen.

11.8 *Pre-loading*—Move the actuator or crosshead such that the loading platen contacts the LVDT/compressometer and specimen, and apply a standard initial load of 45 N [10 lbf]. Zero and balance the LVDT or compressometer.

11.9 *Loading*—Apply a compressive force to the specimen at the specified rate while recording data. Load the specimen until failure, or until the measured LVDT/compressometer deflection equals 2 % of the initial core thickness.

11.10 *Data Recording*—Record force versus head displacement and force versus LVDT/compressometer deflection data continuously, or at frequent regular intervals; for this test method, a sampling rate of 2 to 3 data recordings per second, and a target minimum of 100 data points per test are recommended. If a compliance change or initial failures are noted, record the force, displacement, and mode of damage at such points. Record the maximum force, the failure force, the head displacement and the LVDT/compressometer deflection at, or as near as possible to, the moment of failure. Also record the force and head displacement at 2 % deflection, if that deflection level is achieved prior to failure.

11.11 *Failure Modes*—Uniform compressive failure of the sandwich core is the only acceptable failure mode. Compressive failures confined to one corner or edge of the specimen shall be considered invalid.

12. Validation

12.1 Values for ultimate properties shall not be calculated for any specimen that breaks at some obvious flaw, unless such flaw constitutes a variable being studied. Retests shall be performed for any specimen on which values are not calculated.

12.2 A significant fraction of failures in a sample population occurring along one corner or one edge shall be cause to re-examine the means of force introduction into the specimen. Factors considered should include the loading platen alignment, specimen surface characteristics, and uneven machining of specimen surfaces and edges.

13. Calculation

13.1 *Ultimate Strength*—Calculate the ultimate flatwise compressive strength using Eq 1 and report the results to three significant figures.

$$F_z^{fcu} = P_{max}/A \quad (1)$$

where:

F_z^{fcu} = ultimate flatwise compressive strength, MPa [psi],
P_{max} = ultimate force prior to failure, N [lbf], and
A = cross-sectional area, mm^2 [$in.^2$].

13.2 *2 % Deflection Stress*—If 2 % deflection is achieved prior to stopping the test, calculate the flatwise compressive stress at 2 % deflection using Eq 2 and report the results to three significant figures.

$$\sigma_z^{fc0.02} = P_{0.02}/A \quad (2)$$

where:

$\sigma_z^{fc0.02}$ = flatwise compressive stress at 2 % deflection, MPa [psi],
$P_{0.02}$ = applied force corresponding to $\delta_{0.02}$, N [lbf],
$\delta_{0.02}$ = recorded deflection value such that δ/t is closest to 0.02, and
t = measured thickness of core specimen prior to loading, mm [in.].

13.3 *Compressive Modulus*—Calculate the flatwise compressive chord modulus using Eq 3 and report the results to three significant figures. The deflection values selected are intended to represent the lower half of the core's stress-strain curve. For core materials which fall bellow δ/t = 0.006, a deflection range of 25 to 50 % of ultimate is recommended. However, for some other materials, another range may be more appropriate. Other definitions of chord modulus may be evaluated and reported at the user's discretion. If such data are generated and reported, report also the definitions used, the deflection range used, and the results to three significant figures.

NOTE 9—To account for seating effects related to specimen thickness variance, toe: compensation may be made in accordance with Annex A1, unless it is shown that the toe region of the curve is not due to the take-up of slack, seating of the specimen, or other artifact, but rather is an authentic material response.

$$E_z^{fc} = ((P_{0.003} - P_{0.001})\cdot t)/((\delta_{0.003} - \delta_{0.001})\cdot A) \quad (3)$$

where:

E_z^{fc} = core flatwise compressive chord modulus, MPa [psi],
$P_{0.003}$ = applied force corresponding to $\delta_{0.003}$, N [lbf],
$P_{0.001}$ = applied force corresponding to $\delta_{0.001}$, N [lbf],
$\delta_{0.003}$ = recorded deflection value such that δ/t is closest to 0.003, and
$\delta_{0.001}$ = recorded deflection value such that δ/t is closest to 0.001.

13.4 *Statistics*—For each series of tests calculate the average value, standard deviation, and coefficient of variation (in percent) for ultimate flatwise compressive strength and modulus:

$$\bar{x} = \left(\sum_{i=1}^{n} x_i \right) / n \tag{4}$$

$$S_{n-1} \sqrt{\left(\sum_{i=1}^{n} x_i^2 - n\bar{x}^2 \right) / (n-1)} \tag{5}$$

$$CV = 100 \times S_{n-1}/\bar{x} \tag{6}$$

where:

$\bar{x}$ = sample mean (average),
S_{n-1} = sample standard deviation,
CV = sample coefficient of variation, %,
n = number of specimens, and
x_i = measured or derived property.

14. Report

14.1 Report the following information, or references pointing to other documentation containing this information, to the maximum extent applicable (reporting of items beyond the control of a given testing laboratory, such as might occur with material details or panel fabrication parameters, shall be the responsibility of the requestor):

14.1.1 The revision level or date of issue of this test method.

14.1.2 The name(s) of the test operator(s).

14.1.3 Any variations to this test method, anomalies noticed during testing, or equipment problems occurring during testing.

14.1.4 Identification of all the materials constituent to the sandwich core specimen tested (including stabilization materials if utilized), including for each: material specification, material type, manufacturer's material designation, manufacturer's batch or lot number, source (if not from manufacturer), date of certification, and expiration of certification.

14.1.5 Description of the fabrication steps used to prepare the sandwich core including: fabrication start date, fabrication end date, process specification, and a description of the equipment used.

14.1.6 If requested, core density test method, specimen sampling method and geometries, test parameters, and test results.

14.1.7 Method of preparing the test specimen, including specimen labeling scheme and method, specimen geometry, sampling method, and specimen cutting method.

14.1.8 For honeycomb core specimens, method of stabilizing the specimen (if performed), including material(s), processing cycle, specimen geometry after stabilization, and so forth.

14.1.9 Results of any nondestructive evaluation tests.

14.1.10 Calibration dates and methods for all measurements and test equipment.

14.1.11 Details of loading platens and apparatus, including dimensions and material(s) used.

14.1.12 Type of test machine, alignment results, and data acquisition sampling rate and equipment type.

14.1.13 Type, range, and sensitivity of LVDT or compressometer, or any other instruments used to measure loading platen deflection.

14.1.14 Measured length and width (or diameter) and thickness for each specimen (prior to and after conditioning, if appropriate).

14.1.15 Weight of specimen.

14.1.16 Conditioning parameters and results.

14.1.17 Relative humidity and temperature of the testing laboratory.

14.1.18 Environment of the test machine environmental chamber (if used) and soak time at environment.

14.1.19 Number of specimens tested.

14.1.20 Speed of testing.

14.1.21 Individual ultimate flatwise compressive strengths and average value, standard deviation, and coefficient of variation (in percent) for the population.

14.1.22 Individual ultimate flatwise compressive modulus values and average value, standard deviation, and coefficient of variation (in percent) for the population.

14.1.23 Force versus crosshead displacement data for each specimen so evaluated.

14.1.24 Force versus recorded LVDT/compressometer deflection data for each specimen so evaluated.

14.1.25 Failure mode, location of failure, and percentage of failure area of core for each specimen.

15. Precision and Bias

15.1 *Precision*—The data required for the development of a precision statement is not available for this test method.

15.2 *Bias*—Bias cannot be determined for this method as no acceptable reference standards exist.

16. Keywords

16.1 compressive modulus; compressive strength; core; flatwise compression; sandwich

ANNEX

(Mandatory Information)

A1. TOE COMPENSATION

A1.1 In a typical force versus displacement curve (see Fig. A1.1), there is a toe region, AC, that does not represent a property of the material. It is an artifact caused by a take-up of slack and alignment or seating of the specimen. In order to obtain correct compressive modulus values, this artifact must be compensated for to give the corrected zero point on the displacement axis.

A1.2 For core materials exhibiting a region of Hookean (linear) behavior (see Fig. A1.1), a continuation of the linear (CD) region of the curve may be constructed through the zero-force axis. This intersection (B) is the corrected zero displacement point (δ = 0.000) from which all displacements must be measured.

A1.3 For core modulus measurement, it is preferable that the toe region fall below $\delta_{0.001}$.

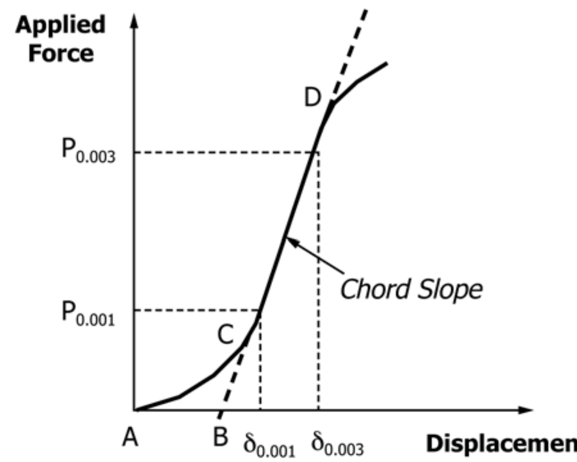

FIG. A1.1 Core Material with Hookean Region