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Standard Test Method for Node Tensile Strength of Honeycomb Core Materials[1]

This standard is issued under the fixed designation C363/C363M; 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 covers the determination of the tensile-node bond strength of honeycomb core materials.

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.

1.3 *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:*[2]

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
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 σ—tensile node strength, MPa [psi].

3.2.2 P—ultimate tensile force, N [lb].

3.2.3 b—initial width of specimen, mm [in.].

3.2.4 t—thickness of specimen, mm [in.].

3.2.5 $\bar{x}$—sample mean (average).

3.2.6 S_{n-1}—sample standard deviation.

3.2.7 CV—sample coefficient of variation (in percent).

3.2.8 n—number of specimens.

3.2.9 x_1—measured or derived property.

4. Summary of Test Method

4.1 This test method consists of subjecting a honeycomb construction to a uniaxial tensile force parallel to the plane of the honeycomb. The force is transmitted to the honeycomb through pins, which are placed in cell rows on the top and bottom portions of one specimen.

4.2 The only acceptable failure mode for tensile-node bond strength is the tensile failure of the node-to-node honeycomb bond within the body of the honeycomb specimen. Failure of the honeycomb material at the loading pin location is not a valid failure mode.

5. Significance and Use

5.1 The honeycomb tensile-node bond strength is a fundamental property than can be used in determining whether honeycomb cores can be handled during cutting, machining and forming without the nodes breaking. The tensile-node bond strength is the tensile stress that causes failure of the honeycomb by rupture of the bond between the nodes. It is usually a peeling-type failure.

5.2 This test method provides a standard method of obtaining tensile-node bond strength data for quality control, acceptance specification testing, and research and development.

[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.

6. Interferences

6.1 *System Alignment*—Excessive bending will cause premature failure. Every effort should be made to eliminate excess bending from the test system. Bending may occur as a result of misaligned grips, poor specimen preparation, or poor alignment of the loading fixture.

6.2 *Geometry*—Specific geometric factors that affect the tensile-node bond strength include cell geometry, cell size, cell wall thickness and, specimen dimensions (length, width and thickness).

6.3 *Environment*—Results are affected by the environmental 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.

7. Apparatus

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

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

7.1.2 *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 11.3.

7.1.3 *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.

7.2 *Grips*—Refer to Fig. 1 for an example grip configuration.

7.3 *Calipers*—The caliper(s) shall use a flat anvil interface to measure specimen length, width and thickness. The accuracy of the instruments shall be suitable for reading to within 1 % of the sample width and thickness. For typical specimen geometries, an instrument with an accuracy of ±25 µm [±0.001 in.] is desirable for both thickness and width measurements.

8. Sampling and Test Specimens

8.1 *Sampling*—The number of test specimens and the method of their selection depend on the purpose of the particular test under consideration, and no general rule can be given to cover all cases. However, when specimens are to be used for acceptance tests, at least five specimens shall be tested, and these specimens shall be selected from that portion of the material which appears to have a maximum of distorted cells or misalignment of bond areas. For statistically significant data, consult the procedures outlined in Practice E122. Report the method of sampling.

8.2 *Geometry*—The test specimens shall be 130 ± 5 mm [5 ± 0.2 in.] wide. The test specimens shall have a minimum length of 260 [10 in.] with a minimum test section outside the grips of 200 mm [8 in.]. The standard thickness of the core slice shall be 12 ± 1 mm [0.500 ± 0.04 in.] for nonmetallic cores and 16 ± 1 mm [0.625 ± 0.04 in.] for metallic cores. Nonstandard thicknesses are within the scope of this test method provided the actual thickness value is reported. Nonstandard thickness specimens shall have uniform thickness within ±1 mm [±0.04 in.].

FIG. 1 Honeycomb Core Tensile-Node Bond Strength Test Setup

NOTE 1—The standard thickness values listed above are based on historical values for metallic and nonmetallic core thicknesses used for qualification and allowable test programs.

8.3 *Specimen Preparation and Machining*—Specimens shall be cut such that the number of cells along the width is constant along the specimen length. The length being defined as the specimen dimension parallel to the application of the force, Fig. 1. The specimen width shall be parallel to the node bond areas.

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

9. Calibration

9.1 The accuracy of all measuring equipment shall have certified calibrations that are current at the time of the 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 2—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 3—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.

11.1.4 If performed, sampling method, specimen geometry, and test parameters used to determine facing density and reinforcement volume.

11.2 *General Instructions:*

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

11.2.2 Following final specimen machining and any conditioning, but before testing, measure the specimen length and width. The accuracy of these measurements shall be within 0.5 % of the dimension. Measure the specimen thickness; the accuracy of this measurement shall be within ±25 µm [±0.001 in.). Record the dimensions to three significant figures in units of millimeters [inches].

11.2.3 Select pins with the largest diameters that will easily fit into the honeycomb cells.

11.2.4 Place the pins in cell rows in the top and bottom portions of the specimen. Fig. 1 shows a fixture that has been satisfactorily used to hold and load the pins.

11.3 *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 25 mm/min [1 in./min].

11.4 *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.

11.5 *Specimen Installation*—Install the specimen/fixture assembly into the test machine test fixture.

11.6 *Loading*—Apply a tensile force to the specimen at the specified rate while recording data. Load the specimen until the specimen is completely torn into two pieces or an unacceptable failure mode occurs.

11.7 *Data Recording*—Record force versus head displacement data continuously, or at frequent intervals. For this test method, a sampling rate of 3 to 10 data recordings per second and a target minimum of 300 data points per test are recommended. Record the maximum force.

11.8 *Failure Modes*—Failure of the honeycomb at the loading pin location is not an acceptable failure mode and the data shall be noted as invalid. Node bond failure is considered to be the only acceptable failure mode.

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 at the pin locations shall be cause to reexamine the means of force introduction into the material. Factors considered should include the fixture alignment, specimen surface characteristics, and uneven machining of specimen ends.

13. Calculation

13.1 *Tensile-Node Bond Strength*—Calculate the tensile node bond strength of the core material as follows:

$$\sigma = \frac{P}{bt} \tag{1}$$

13.2 *Statistics*—For each series of tests calculate the average value, standard deviation, and coefficient of variation (in percent) for tensile-node bond strength:

$$\bar{x} = \left(\sum_{i=1}^{n} X_i \right) / n \tag{2}$$

$$S_{n-1} = \sqrt{\left(\sum_{i=1}^{n} x_i^2 - n\bar{x}^2 \right) / (n-1)} \tag{3}$$

$$CV = 100 \times S_{n-1} / \bar{x} \tag{4}$$

where:

$\bar{x}$ = sample mean (average),
S_{n-1} = sample standard deviation,
CV = sample coefficient of variation (in percent),
n = number of specimens, and
x_1 = 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 Results of any nondestructive evaluation tests,

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

14.1.6 Calibration dates and methods for all measurements and test equipment,

14.1.7 Details of loading pins and apparatus, including dimensions and material used.

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

14.1.9 Measured length and width and thickness for each specimen (prior to and after conditioning, if appropriate),

14.1.10 Description of core material; cell size, density, and type,

14.1.11 Any special treatment of core before test such as boiling water, and so forth,

14.1.12 Conditioning parameters and results,

14.1.13 Relative humidity and temperature of the testing laboratory,

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

14.1.15 Test machine cross-head loading rate,

14.1.16 Number of specimens tested,

14.1.17 Speed of testing,

14.1.18 Individual tensile-node bond strengths and average value, standard deviation, and coefficient of variation (in percent) for the population,

14.1.19 Force versus crosshead displacement data for each specimen so evaluated, and

14.1.20 Failure mode and location of failure for each specimen.

15. Precision and Bias

15.1 *Precision*—The precision of the procedure in Test Method C363/C363Mfor measuring the tensile-node bond strength of honeycomb construction is not available.

15.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in this test method, bias has not been determined.

16. Keywords

16.1 honeycomb core; tensile-node bond strength