Designation: D8067/D8067M – 17

Standard Test Method for In-Plane Shear Properties of Sandwich Panels Using a Picture Frame Fixture[1]

This standard is issued under the fixed designation D8067/D8067M; 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 determination of apparent in-plane shear strength and stiffness properties of flat sandwich constructions with composite face sheets. 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 square test specimen with corner notches is mechanically fastened to a pinned metal frame along each edge. The frame is loaded in uni-axial tension which produces tensile forces in the frame elements at a 45° angle to the applied tension. These tensile forces act along the edges of the specimen to cause a state of predominately shear stress to transfer the applied force through the specimen. Procedure A uses a specimen without edge doublers; Procedure B uses a specimen with four discrete edge doublers; Procedure C uses a specimen with a continuous edge doubler.

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, 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]

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
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, 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 *Acronyms:*

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

3.2.2 F^{su}—face sheet ultimate shear stress

3.2.3 G_f—effective face sheet chord shear modulus

3.2.4 γ—measured engineering shear strain in face sheet

3.2.5 *L*—length of specimen between doubler edges

3.2.6 *n*—number of specimens

3.2.7 *P*—applied force

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

[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.

Current edition approved Jan. 1, 2017. Published January 2017. DOI: 10.1520/D8067_D8067M–17.

[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 q—running shear force per unit width along specimen edge

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

3.2.11 τ—face sheet shear stress

3.2.12 t—face sheet thickness

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

3.2.14 $\bar{x}$—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 square panel of sandwich construction to a set of forces along the panel edges such that the applied force is transferred through the panel via a state of predominately shear stresses. The tensile forces are applied using a picture-frame loading fixture. By placing two strain gage rosettes in the center of the specimen, the apparent shear stress-strain response of the panel can be measured. Out-of-plane panel deflection can be measured to assist in detecting panel buckling. It is noted that engineering shear strain, as opposed to tensorial shear strain, is used throughout this standard.

NOTE 1—Tensorial shear strain may be used in analysis and reporting of results from tests using this standard, but requires the appropriate inclusion of the factor of 2, and clear documentation shall be made in the test report.

4.2 Procedure A uses a specimen without edge doublers. Procedure B uses a specimen with four discrete edge doublers; the data analysis for this procedure assumes that the doublers do not carry significant shear force. Procedure C uses a specimen with a continuous edge doubler; the data analysis for this procedure assumes that the doublers carry some shear force, and a correction is made to the applied force before calculating the shear stress in the panel.

4.3 The acceptable failure modes are face sheet fracture, face sheet dimpling, face sheet wrinkling or core shear instability. Failure of the sandwich core-to-face sheet bond preceding one of the previous listed modes is not an acceptable failure mode. Failure originating at the panel corner notches is not an acceptable failure mode. Buckling of the panel prior to face sheet or core failure is not an acceptable failure mode, unless otherwise specified as an acceptable response by the test requestor. The test specimen face sheet thicknesses, core thickness, core material and adhesive material must be selected to avoid the unacceptable failure modes.

5. Significance and Use

5.1 In-plane shear loading tests on flat sandwich constructions may be conducted to determine the sandwich panel in-plane shear stiffness, the face sheets' in-plane strength, the core shear instability strength, or panel buckling response.

5.2 This test method can be used to produce face sheet 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.

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

6. Interferences

6.1 *Fixture Geometry*—The basic configuration with through-pins and corner notches may exhibit large deviations from uniform stress. For example, in a configuration relative close in geometry to Method C, the shear stress at the center was predicted by finite element analysis (FEA) to be more than 25 % lower than the value obtained from Eq 2, while the shear stress increases near the edges and corners so that local buckling or material failure is likely to originate at the periphery of the gage area. Farley and Baker reported on the strong influence of the location of the pivot pins on the stress distribution.[3] Moving the pivots to the corners of the gage area, while requiring a significantly more complicated test fixture, provides a greatly improved stress distribution. Furthermore it was reported that stiff edge doublers (e.g. steel rather than composite) increased the uniformity of the stresses.

6.2 *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.

6.3 *Geometry*—Specific geometric factors that affect sandwich face sheet strength include face sheet thickness, core cell geometry, and face sheet surface flatness. This test has been mainly used on panels with relatively thin face sheets (0.5 mm [0.020 in.]). The reliability of testing panels with thicker face sheets is unknown.

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 specific

[3] 1. G.L. Farley and D.J. Baker, "In-Plane Shear Test of Thin Panels," *Experimental Mechanics*, Vol. 23, No. 1, 1983, pp. 81–87.

combination of core material, face sheet material, and core-to-face sheet interfacial adhesive (if used) that is tested.

6.5 *Elastic Modulus Measurement*—Shear modulus calculations in this test method assume a uniform distribution of shear stress and engineering shear strain in the center region of the specimen. The actual uniformity is dependent on the material orthotropy, the panel geometry, and doubler material and thickness.

6.6 *Potting*—Edge potting of open cell cores (filling the core cells with resin type material) may be used in the areas under the loading bars. The use of potting may be necessary to avoid crushing the panel when the edge fasteners are installed.

6.7 *Edge Doublers*—These are used to increase the thickness of the face sheets to avoid bearing failures in the face sheets at the edge fastener holes.

6.8 *Edge Doubler Adhesive*—A suitable adhesive shall be selected for the test environment. The cure temperature of the adhesive should not exceed the face sheet material dry glass transition temperature, *Tg*, to avoid changes to the face sheet material. The limitation on cure temperature should also consider any exothermic temperature increases in the adhesive during cure (exothermic reactions are not unusual for adhesives used in secondary bonding).

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 when face sheets are bonded to the core and at least one surface is irregular (e.g. 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 when face sheets are bonded to the core and both surfaces are smooth (e.g. tooled surfaces). A micrometer or caliper with a flat anvil interface shall be used for measuring length and width. 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 instruments shall be suitable for reading to within 1 % of the sample dimensions. For typical specimen geometries, an instrument with an accuracy of ±0.025 mm [±0.001 in.] is adequate for the length, width, and thickness measurements.

NOTE 2—The accuracies given above are based on achieving measurements that are within 1% of the sample length, width, and thickness.

7.2 *Loading Fixture*—The loading fixture shall be self-aligning and shall not apply eccentric forces. A satisfactory type of apparatus for testing relatively thin face sheet panels is shown in Fig. 1. It consists of a steel frame with four corner pins and 40 panel mounting fastener holes, see Fig. 2. Before using the test fixture, a stress analysis of the entire fixture should be performed, using a conservative estimated failure load for the panel to be tested.

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

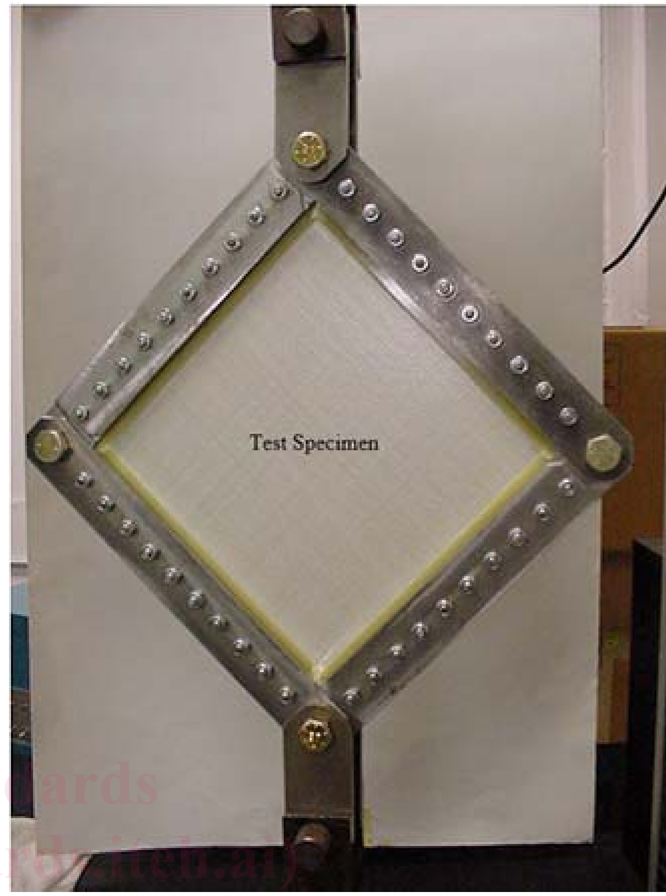


FIG. 1 Panel In-Plane Shear Test Specimen and Test Fixture - Procedure C shown (Procedure A is the same except without the doublers Procedure B is the same except with discrete doublers on each edge)

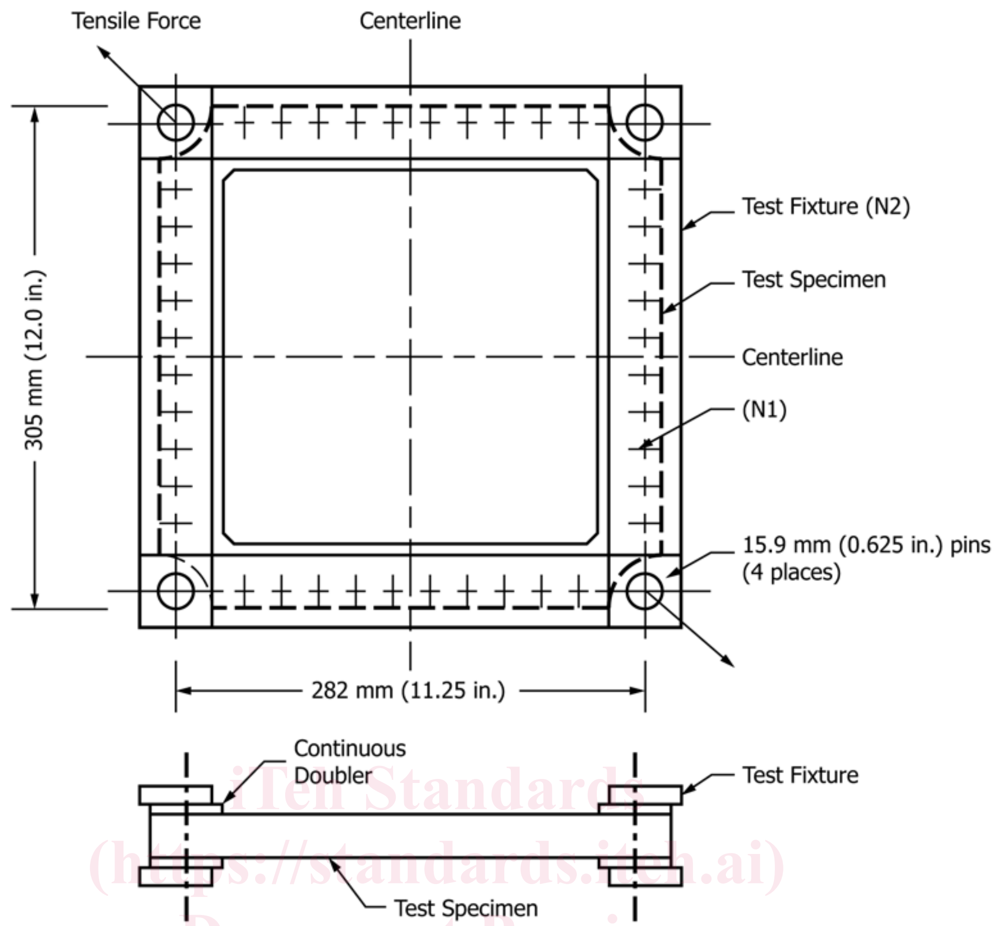
7.3.1 *Testing Machine Configuration*—The testing machine shall have both an essentially stationary head and a movable head.

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 11.4.

7.3.3 *Force Indicator*—The testing machine force-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 *Deflectometer*—When required by the test requestor, the out-of-plane deflection shall be measured in the center of the specimen by a properly calibrated device having an accuracy of ±1 % or better of the indicted value.

7.5 *Strain-Indicating Device*—When required by the test requestor, strain data shall be determined by the specified means. When using bonded resistance strain gages, one tri-axial gage rosette shall be located on each face at the center of the specimen. Full field digital image correlation or laser strain measurement methods may be used.



N1. Locate and drill through test specimens and doublers to match fixture:
6.1 – 6.2 mm (0.250-0.254 in.) dia holes
24 mm (0.95 in.) center – center distance between holes
6 mm (0.250 in.) diameter bolts; tighten to 4 +/– 0.6 N-m (35 +/– 5 in.-lbs) torque
(10 places each side)

N2. Test fixture made from steel (recommend 4130 Rockwell C40 for RTA testing; stainless steel for elevated temperature testing)
330 mm long by 43 mm wide by 8.6 mm thick (13 in. long by 1.7 in. wide by 0.34 in. thick)
8 parts required

FIG. 2 Panel In-Plane Shear Test Specimen and Test Fixture - Procedure C

7.6 *Out-of-Plane Displacement*—When required by the test requestor, for cases where panel buckling response is to be measured, moire fringe methods or Digital Image Correlation may be used to provide images of the panel buckle shape. An applied force readout visible in the recorded images or video is required.

7.7 *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.

7.8 *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 (plus when using Procedure C one additional specimen with the center portion removed, according to 8.6) 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 E251. Report the method of sampling.

8.2 *Geometry*—The standard specimen configuration should be used whenever the specimen design will produce a material fracture prior to panel buckling. In cases where the standard specimen configuration may buckle prior to fracture, a non-standard specimen may be designed.

8.2.1 *Standard Configuration*—The standard test specimen shall be of constant thickness (face sheets and core), with a width and a length of 305 mm [12.0 inch], as in Fig. 3. The depth of the specimen (not including any doublers) shall be equal to the thickness of the sandwich construction.

8.2.2 *Non-Standard Configurations*—Larger or smaller non-standard specimens using correspondingly sized test fixtures may be tested using the procedures of this method.

8.3 *Face Sheets*

8.3.1 *Material*—The face sheets may be any continuous, constant thickness composite laminate.

8.3.2 *Composite Layup*—The apparent shear strength and stiffness obtained from this method may be dependent upon the face sheet stacking sequence. For the standard test configuration, face sheets consisting of a laminated composite material shall be balanced and symmetric about the sandwich panel mid-plane.

8.3.3 *Stiffness*—For the standard specimen, the two face sheets shall be the same material, thickness, and layup. The calculations assume constant and equal face sheet stiffness properties. This assumption may not be applicable for certain face sheet materials which exhibit significant non-linear stress-strain behavior.

8.3.4 *Face Sheet Thickness*—Accurate measurement of face sheet thickness is difficult after bonding or co-curing of the face sheets and core. The test requestor is responsible for specifying the face sheet thicknesses to be used for the calculations in this test method. For precured composite face sheets that are secondarily bonded to the core, the face sheet thickness should be measured prior to bonding. In these cases

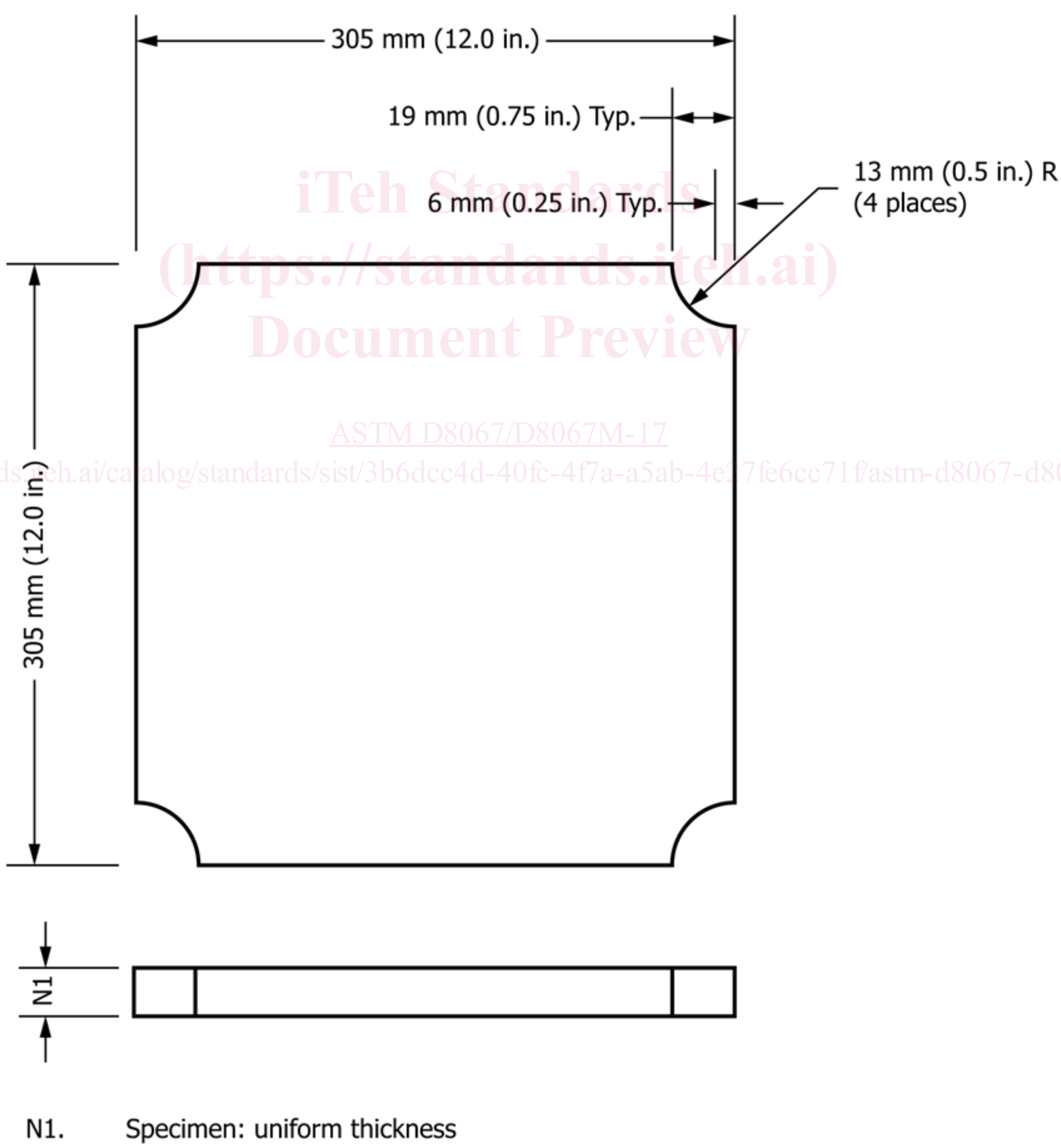


FIG. 3 Standard Specimen Dimensions

the test requestor may specify that either or both measured and nominal thicknesses be used in the calculations. For co-cured composite face sheets, the thicknesses are generally calculated using nominal per ply thickness values.

8.4 *Core*—For test specimens using a honeycomb core material, the core ribbon direction shall be specified by the test requestor on the specimen drawing. The ribbon direction is typically oriented parallel to one of the specimen edges.

8.5 *Potting*—The use of potting in the areas under the loading bars may be necessary to avoid crushing the panel when the edge fasteners are installed. The potting may be installed in the core prior to bonding the face sheets to the core, or the core on the edges of the panel may be machined out and replaced with solid potting compound or metallic bars. The test requestor must specify any required edge potting procedure to be used. The standard test procedure does not require potting.

8.6 *Edge Doublers*—May be used to increase the thickness of the face sheets to avoid bearing failures at the edge fastener holes. The test requestor may specify a different doubler configuration or material from the standard doublers specified below.

8.7 *Specimen Preparation and Machining*

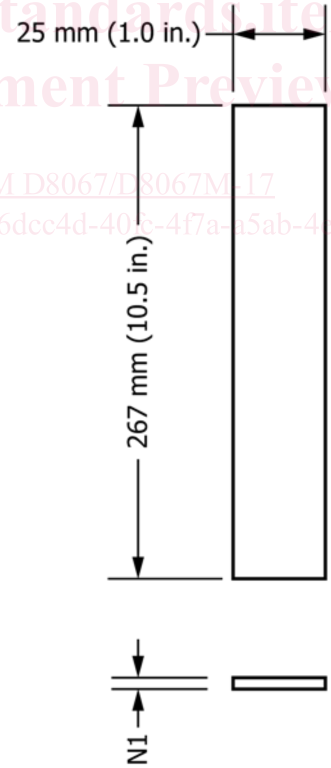
8.7.1 *Doublers—Procedure B*—Four fiberglass doublers 267 ± 1 mm by 25 ± 1 mm wide (10.5 ± 0.04 in. by 1.0 ± 0.04 in. wide) (see Fig. 4) shall be bonded to each side of the test panel specimen with a suitable adhesive (a total of eight (8) doublers are required). A room temperature curing adhesive shall be used unless otherwise specified by the test requestor.

8.7.2 *Doublers—Procedure C*—Fiberglass doublers 305 ± 1 mm by 40 ± 1 mm wide (12.0 ± 0.04 in. by 1.5 ± 0.04 in. wide) (see Fig. 5) shall be bonded to each side of the test panel specimen with a suitable adhesive. See Fig. 6. A room temperature curing adhesive shall be used unless otherwise specified by the test requestor.

8.7.3 *Machining*—After the doubler adhesive has cured, the test specimen shall be machined according to Fig. 6.

8.7.4 *General Preparation*—Specimen preparation is extremely important for this test method. Take precautions when cutting specimens from large panels to avoid notches, undercuts, rough or uneven surfaces, or delaminations due to inappropriate machining methods. Obtain final dimensions by water-lubricated precision sawing, milling, or grinding. The use of diamond coated machining tools has been found to be extremely effective for many material systems. Edges should be flat and parallel within the specified tolerances. Record and report the specimen cutting preparation method.

8.8 *Procedure C—Frame Load Specimen*—When using Procedure C, one additional specimen from each test group shall have the panel in-between the fiberglass doublers cut out. Machine along the inner edges of the doublers leaving a square "ring" specimen, see Fig. 7. This modified specimen is used to



N1. Doubler 2.5 mm (0.10 in.) thick fiberglass (recommend 181 style cloth and epoxy resin)
One doubler on each specimen edge, both faces (8 total doublers)
Bond doublers to specimen

FIG. 4 Procedure B Doubler Dimensions