Designation: D7966/D7966M – 16

# Standard Test Method for Resistance to Creep of Adhesives in Static Shear by Compression Loading (Wood-to-Wood)[1]

This standard is issued under the fixed designation D7966/D7966M; 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 creep properties of structural adhesives in wood-to-wood bonds when a standardized specimen is subjected to shearing stresses at various levels of static load, constant temperature, and relative humidity. Apparatus and procedures are provided for shear deformation (creep) of adhesive bonds under static load. This test method is used under the indicated conditions to evaluate resistance to creep properties of a structural wood adhesive.

1.2 The test method is used to evaluate creep performance of adhesives suitable for the bonding of wood, including treated wood, into structural wood products for general construction, marine use, or for other uses where a high-strength general construction, creep-resistant, durable adhesive bond is required. Individual block shear specimens are prepared from adhesively bonded laminations, subjected to a constant load under various combinations of temperature and relative humidity, and the amount of creep measured.

1.3 Creep of structural wood adhesives as measured by this test method may not be comparative to other ASTM methods and is limited to the conditions of the test and procedures contained herein.

1.4 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.

1.5 *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]

D905 Test Method for Strength Properties of Adhesive Bonds in Shear by Compression Loading

D907 Terminology of Adhesives

D1101 Test Methods for Integrity of Adhesive Joints in Structural Laminated Wood Products for Exterior Use

D2395 Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials

D2559 Specification for Adhesives for Bonded Structural Wood Products for Use Under Exterior Exposure Conditions

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials

E4 Practices for Force Verification of Testing Machines

2.2 *Other Document:*[3]

CSA O112.9 Evaluation of Adhesives for Structural Wood Products (Exterior Exposure)

2.3 *ASTM Adjuncts:*

Compression-Shear Creep Test Apparatus[4]

## 3. Terminology

3.1 *Definitions:* Many terms in this test method are defined in Terminology D907.

3.1.1 *laminated wood, n*—the fabricated product resulting from the bonding of two or more laminations, with each lamination made from one or more pieces bonded either lengthwise, edgewise, or both, and all with the direction of the grain essentially parallel, to form a larger piece such as a structural member.

3.1.1.1 *Discussion*—Laminated wood as defined in D1101.

3.1.2 *stress, n*—the force exerted per unit area at a point within a plane.

3.2 *Definitions of Terms Specific to This Standard:*

[1] This test method is under the jurisdiction of ASTM Committee D14 on Adhesives and is the direct responsibility of Subcommittee D14.30 on Wood Adhesives.

Current edition approved May 1, 2016. Published June 2016. Originally approved in 2014. Last previous edition approved in 2014 as D7966/D7966M – 14. DOI: 10.1520/D7966_D7966-16.

[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] Available from APA – The Engineered Wood Association, 7011 S.19th St., Tacoma, WA 98466-5333, www.apawood.org.

[4] Available from ASTM International Headquarters. Order Adjunct No. ADJ-ADJD4680. Original adjunct produced in 1987.

3.2.1 *average creep of specimen, n*—calculated creep displacement in the bondline of a specimen as shown in Fig. 1 [$(D_1+D_2)/2$].

3.2.2 *maximum average creep, n*—the largest average creep observed with any one test specimen from a test assembly.

3.2.3 *overall average creep, n*—the average creep observed in the test assembly based on the average creep of the tested specimens.

3.2.4 *laminated test assembly, n*—an assembly formed by bonding layers of lumber with an adhesive so that the grain of all laminations is essentially parallel.

## 4. Summary of Test Method

4.1 An adhesive to be evaluated for suitability in structural wood products in terms of resistance to creep is used to prepare block shear test specimens which will then be loaded to a prescribed level of stress.

4.2 Following the adhesive manufacturers recommendations two 2–ply test assemblies of a designated species are laminated following specific recommendations of wood selection and preparation.

4.3 After a designated curing period, eight 25 mm [1.0 in.] by 25 mm [1.0 in.] block shear specimens are prepared from each assembly and preconditioned.

4.4 Both sides of the geometric center of each specimen are marked with a scribe.

4.5 The block shear specimens from each assembly are loaded to the required stress in a prescribed compression-shear creep test jig and then subjected to a designated test environment in terms of temperature, moisture level and time.

4.6 At the completion of the designated exposure time, the amount of creep for each specimen is measured and reported along with the average creep for the group of specimens.

## 5. Significance and Use

5.1 This test method evaluates the performance of the adhesive in laminated wood as measured by resistance to creep under static load.

5.2 Test results from the evaluation of adhesive creep resistance, under designated environmental conditions of the test, provide a measure of the adhesive's ability to withstand constant loading over a relatively long period of time.

5.3 Creep measured with this test method is normally used in conjunction with specifications such as, but not limited to Specification D2559 and CSA O112.9 to confirm suitability of an adhesive to resist creep under designed loads when subjected to specific levels of stress, load duration and environmental conditions.

## 6. Apparatus

6.1 *Testing Machine*—A testing machine, or other suitable loading machine, capable of applying compression loads from 0 to 22 kN (5000 lbf) having an accuracy of ±1 % when calibrated in accordance with Practice E4, and cross-head speeds from 0.3 to 10 mm/min [0.01 to 0.40 in./min] is sufficient for this test method. A minimum vertical space of 510 mm [20 in.] is required to compress the loading spring in the creep-test apparatus.

6.2 *Creep-Test Apparatus*—Static loads shall be applied and maintained on block-shear specimens by means of the compression-loaded creep-test cylinder shown in Fig. 2. The specific spring used in the apparatus shown in Fig. 2 has a design load of 2300 lbf (10 kN) and is made of corrosion-resistant components so that is can be used in high-temperature and humid environments for prolonged periods without concern for damaging the apparatus or interfering with the effectiveness. The apparatus is spring-loaded and shall contain a mechanism to provide a self aligning surface to account for specimens where the two bearing surfaces are not perfectly parallel.

NOTE 1—Although this particular spring has a design load of 10 kN (2300 lbf) others of greater or less capacity may be substituted. Varying spring capacities with outside diameters no greater than the cylinder inside diameter are available. Additional details, including options for providing self aligning surface can be found in Adjunct ADJD4680.

6.2.1 For creep testing up to 50°C [122°F], it is not necessary to adjust the spring or load to compensate for the effects of changing temperature. It is only necessary that the

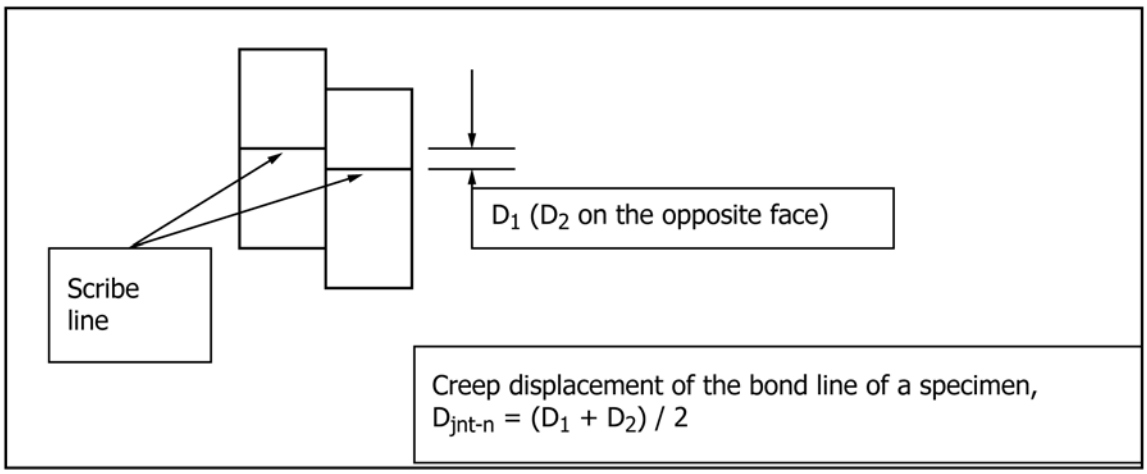



**FIG. 1 Creep Measurement of Test Specimen**

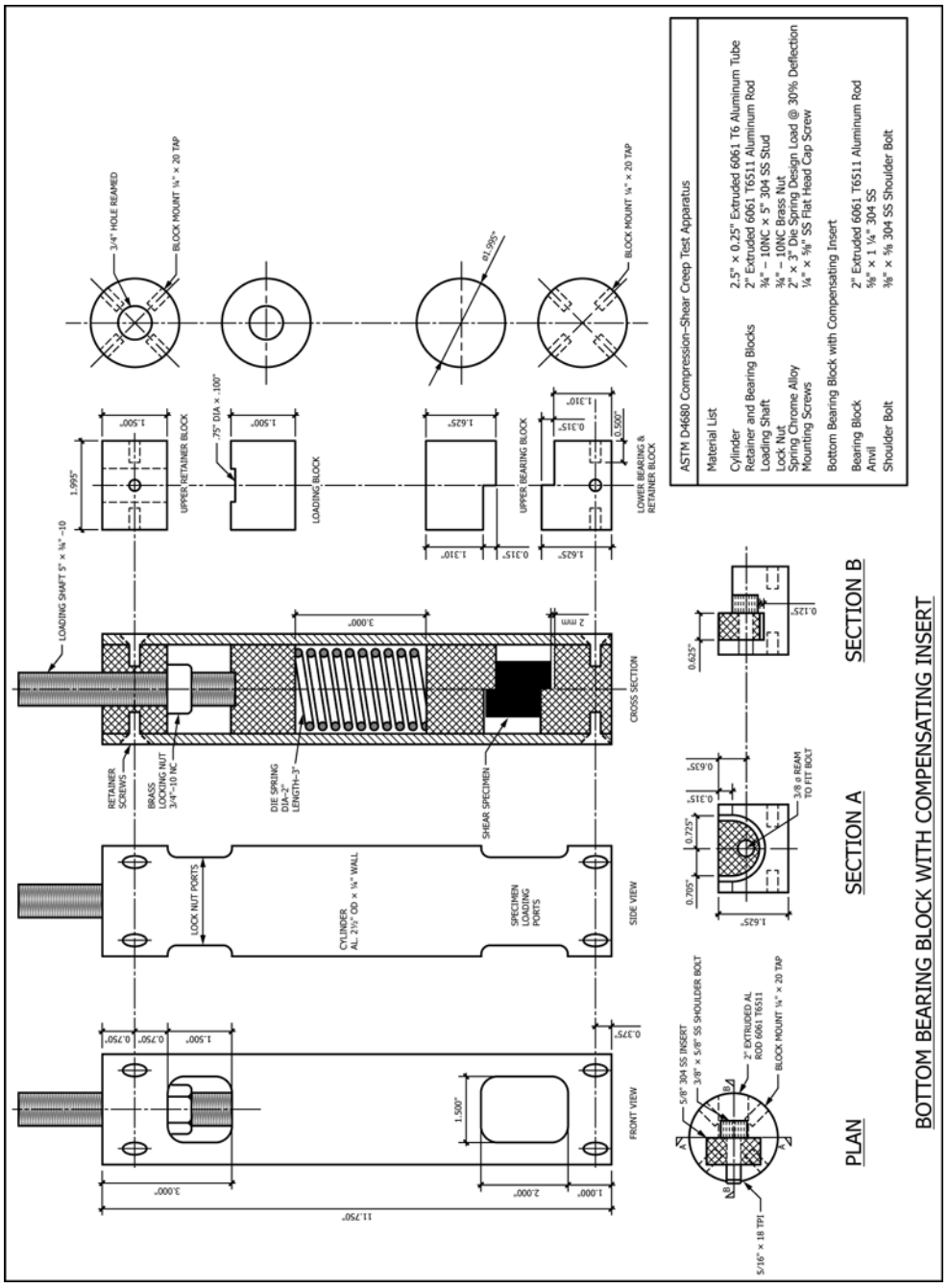



**FIG. 2 Creep Test Apparatus**

**TABLE 1 Standard Environmental Conditions**

| Test Condition | Temperature | Relative Humidity (%) | Time (days) | Stress Level |
|---|---|---|---|---|
| A[A] | 20 ± 2.0°C [68 ± 3.6°F] | 95 | 7 | 2.5 MPa (360 psi) |
| B[A] | 70 ± 2.0°C [158 ± 3.6°F] | ambient humidity | 7 | 2.5 MPa (360 psi) |
| C[A] | 50 ± 2.0°C [122 ± 3.6°F] | 100 | 28 | 2.1 MPa (300 psi) |

[A] Conditions for A, B, and C are the same as those found in CSA O112.9–10.

apparatus, with included specimen, be preconditioned to the test temperature before the test load is applied to the spring. The preheated apparatus must be wrapped with a piece of flexible thermal insulation material while the test load is applied to the specimen. After loading and measurements, return the loaded apparatus to the test environment.

NOTE 2—Since there are no significant changes in temperature before or after loading, no adjustments are needed in the spring.

6.2.1.1 When conducting creep testing a temperatures of 50°C [122°F] or higher the applied stress level shall be increased to compensate for the decrease in the spring constant. This can be determined by comparing the spring constant for the spring at room temperature to that when the spring is heated to the specified temperature. Laboratories shall establish that the spring constant, when repeatedly heated to the specified temperature, is consistent between each use. Compensation for spring stiffness at temperature shall be determined by the testing laboratory.

6.3 *Microscope*—A microscope with an objective lens of at least 7× magnification or a magnifying glass, such as a 10× loupe is required to measure displacement of scribe marks across the two adherends of a specimen to measure and record any creep that has occurred. A linear traveling binocular microscope is ideally suited to creep measurements; however, a microscope fitted with an appropriately graduated scale is satisfactory.

6.4 *Environmental Chambers*—An environmental chamber is required to precondition test specimens to their intended test environment and subject the conditioned specimens, after loading to a specified shear stress, to the required conditions of temperature and relative humidity. In the absence of specific required test conditions of temperature, relative humidity, applied shear stress and time under test, Table 1 provides examples of standard conditions that are considered appropriate.

6.4.1 Conditioning equipment, such as but not limited to ovens and humidity cabinets, should be capable of maintaining a constant temperature within ±2.0°C [±3.6°F] of the set-point and constant relative humidity within ±5 % of the set-point at a given temperature for each of the test conditions selected for evaluation.

NOTE 3—The standard conditions listed in Table 1 are considered appropriate to evaluate the suitability of a structural wood adhesive for creep resistance when exposed to a variety of environmental exposure conditions up to and including continuous exposure to the weather. Other conditions of temperature, humidity, load duration and stress level may be used or specified provided that the conditions and their precision has been determined and reported. Specific and appropriate product standards, qualified evaluation and code approval agencies, or combinations thereof, may specify the targeted stress level for a particular species or species group, including exposure duration, when adopting this test method.

NOTE 4—Section 8.6 provides requirements for preconditioning specimens prior to testing.

## 7. Materials

7.1 *Wood Selection, Preparation and Conditioning*—Use any softwood or hardwood single species planned for bonding and intended for use and considered suitable for bonded structural wood products. The selected species shall be compatible with the test structural wood adhesive and determined suitable to evaluate resistance to creep using this test method as required, specified or desired. Bond only to vertical grain wood surfaces (Note 6).

NOTE 5—This test only measures resistance to creep; for characterizing additional adhesive properties related to the selected species, such as bondability, an alternative test method or specification, including but not limited to Specification D2559 should be considered.

NOTE 6—The bond face is considered vertical grain when the growth rings make an angle of between 45° and 90° to the face.

7.1.1 For the species under evaluation, each piece of wood selected for use in resistance to creep testing and in accordance with this test method shall have a minimum specific gravity as indicated in Table 1, Required Shear Strength for Structural Laminated Wood Products, in Specification D2559. For species not included in Table 1 of Specification D2559 consult the USDA Wood Handbook[5] for the reported specific gravity at 12 % moisture content (Note 7).

NOTE 7—For the species selected for evaluation, the wood quality selected is such that it is able to sustain the applied stress under the selected environmental conditions. For species not found in Table 1 of Specification D2559, trial tests should be conducted to confirm the wood has adequate strength for the specific test. Wood with higher specific gravity and slower growth rate (relatively large number of growth rings per inch) have been found to be effective metrics for selecting suitable wood substrate for resistance to creep testing.

7.1.2 The wood shall have a slope of grain not steeper than 1 in 15 on any face or any edge. The wood shall contain no knots larger than 3 mm [⅛ in.] in diameter and shall be free of decay, machining defects (such as chipped grain, dubbed ends, feed roll polish, coarse knife marks, and feed roll compression), and any drying defects such as case hardening, collapse, splits, or checks.

7.1.3 Condition the wood at 23 ± 2°C [73 ± 3.6°F] and a relative humidity of 50 to 70 % (preferably 65 %) until a moisture content of 8 to 14 % has been obtained.

7.1.3.1 Conditioning for wood used for sample preparation by hot press adhesives that require a moisture content less than 8 %, should be in accordance with the adhesive manufacturer's recommendations.

[5] Available from USDA, Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53726, http://www.fpl.fs.fed.us.

## 8. Test Specimens

8.1 The standard specimen shall be the block-shear specimen illustrated in Fig. 3.

8.2 The test adhesive is used to bond the selected wood species together following procedures found in 8.4. The shear area of the standard specimen shall be 25 by 25 mm [1.0 by 1.0 in.] equaling 625 $mm^2$ [1.0 $in^2$].

8.3 *Preparation of Test Assemblies:*

8.3.1 Prepare two laminated test assemblies, each providing eight test specimens.

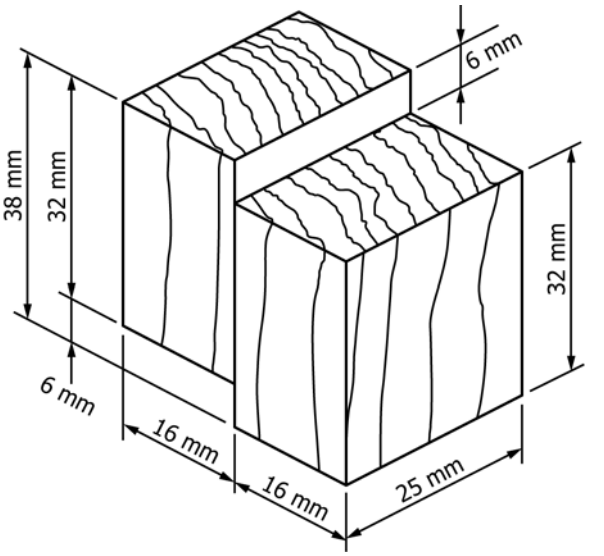
8.3.2 Billets 16 mm [0.63 in.] thick, 38 mm [1.5 in.] wide and 380 mm [15.0 in.] in length along the grain shall be prepared from a single piece of lumber and of a length suitable for planing. Freshly knife plane both sides of each lamination to the designated thickness. The machining tolerances for each lamination used in preparing the test specimen shall be no greater than 0.25 mm [0.01 in.] between laminations and 0.20 mm [0.008 in.] within laminations.

8.3.3 The billets shall be weighed and billets of approximately the same weight shall be assembled into two plies to be bonded to each other. Surfaces to be bonded shall not be sanded and shall be free of contaminants.

8.3.4 Bonding shall be performed within 24 h after the lumber is planed.

8.3.5 The average of the minimum and maximum assembly times recommended by the adhesive manufacturer shall be used in preparing the assemblies. If necessary, the ambient conditions shall be adjusted to meet this requirement. The ambient conditions under which the assemblies are prepared shall be recorded.

8.3.6 The entire assembly shall be pressed in compliance with the time-temperature schedule and pressure recommended by the adhesive manufacturer. The recommended pressure shall be maintained throughout the curing period.




Inch-Pound Equivalents

| | | | | | |
|---|---|---|---|---|---|
| mm | 25 | 16 | 32 | 38 | 6 |
| in. | 1.0 | 0.63 | 1.25 | 1.25 | 0.25 |

**FIG. 3 Test Specimen Dimensions, mm**

8.4 *Preparation of Test Specimens:*

8.4.1 The pressed assemblies shall be conditioned at 20 ± 2°C [68 ± 3.6°F] and 65 ± 5 % relative humidity for at least 2 days before further processing is performed.

NOTE 8—Conditioning of test specimens under the indicated conditions will provide an estimated EMC of 11 to 13 % to provide conditions similar to wood properties as listed in the USDA Wood Handbook. The conditions listed are the same as found in CSA O112.9–10. Consult 7.1 on wood selection.

8.4.2 After conditioning, the assemblies shall be removed from the conditioning atmosphere for specimen preparation. Each assembly shall be reduced to a width of 25 ± 1 mm [1.0 ± 0.05 in.] by trimming along both of its longer sides, after which the length of the assembly shall be reduced by trimming approximately 25 mm [1 in.] from one end of the assembly.

8.4.3 Eight specimens, each 38 mm [1.5 in.] long, shall be cut from the trimmed end of the assembly, as shown in Fig. 4. The specimens shall be cut so that the direction of the cuts are perpendicular to the direction of loading during the test. The surfaces to be loaded shall be smooth and parallel to each other.

8.4.4 In the making of the notch on one end of the specimen, the saw cut shall extend through the thickness of one ply to the bondline, and on the other end the saw cut shall also extend through the thickness of the other ply to the bondline. Care shall be taken to ensure that neither saw cut extends beyond the bondline and the depth of the notch on the prepared specimen does not exceed 6 mm (Fig. 3).

NOTE 9—The machining on the upper and lower loading blocks in the test apparatus, with a notch of 8.0 mm [0.315 in.] will allow 2 mm of space for creep in the test apparatus.

8.4.5 A line perpendicular to the exposed bondlines across the middle of each of the lapped areas shall be scribed using a square and razor blade. The line shall be marked within ±0.5 mm [±0.02 in.] of the mid-length of the bondline.

8.5 *Number of Specimens:*

8.5.1 Test 16 specimens, eight for each assembly, at each set of test conditions, that is, each combination of stress level, temperature, relative humidity and time for each creep test.

8.6 *Preconditioning of Test Specimens:*

8.6.1 Since creep specimens of wood undergo dimensional changes in environment, it is essential that specimens be preconditioned to, and in equilibrium with, those test conditions at the time creep tests begin. Condition specimens at the test conditions until specimens reach equilibrium moisture content (indicated by no change in weight) and temperature.

8.6.2 Specimens for Test Condition A are preconditioned for at least seven days at 20 ± 2°C [68 ± 2°F] and a minimum relative humidity of 95 %.

8.6.3 Specimens for Test Condition B are preconditioned at 20 ± 2°C [68 ± 3°F] and 65 ± 5 % relative humidity until a constant weight is attained.

8.6.4 Specimens for Test Condition C are preconditioned by a vacuum pressure soak treatment (see 8.6.4.1) to ensure that their moisture content is above the fiber saturation point and wrapped while wet prior to introducing into the environmental chamber.

NOTE 10—The wrapping of the specimens following the vacuum

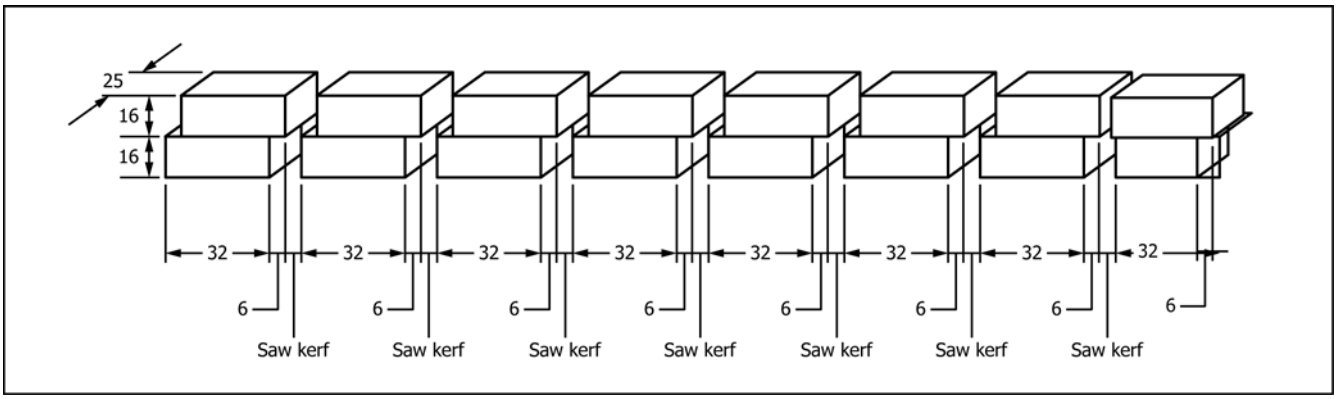



**FIG. 4 Creep Test Shear Block Assembly Dimensions, mm**

pressure soak treatment is to ensure the moisture content of the specimens is maintained above the fiber saturation point during the testing of the specimens.

8.6.4.1 *Conditioning Environment C Specimens:*

*(1)* The specimens for testing under Environment C shall undergo additional conditioning to ensure they are saturated with moisture by subjecting, before testing, to a cold water vacuum-pressure soak, as specified and following the procedures in step (2) below.

*(2)* The vacuum-pressure test shall be performed as follows:

Test specimens shall be placed in a vessel capable of withstanding the vacuum and pressure levels used in the test.

Specimens shall be separated by stickers, wire screens, or other means such that all end-grain surfaces are freely exposed to water. Specimens shall then be weighted down.

Water at 22 ± 5°C [72 ± 8°F] shall be admitted in an amount sufficient to completely submerge the specimens.

A vacuum of 75 kPa [22 in. Hg] shall be drawn and held for 30 min.

The vacuum shall be released and a pressure of 540 kPa (78 psi) shall be applied for 2 h.

If all of the specimens are not fully submerged at this stage, the vacuum-pressure cycle shall be repeated (Note 11).

After the cold water vacuum-pressure soak, the specimens shall be wrapped according to the procedure described in Note 12 to maintain the moisture condition.

The specimens shall be tested in creep while they are wet (Note 13).

NOTE 11—All vacuum and pressure levels are relative to atmospheric conditions.

NOTE 12—The wrapping shall be a clear flexible film (such as polyvinylidene chloride) with sufficient thickness to resist puncturing. The wrapping shall not be of such tightness that it will interfere with the creep movement of the specimen during sustained loading, nor decrease the load applied to the specimen (that is, the wrapping film is stressed). This condition can be met if the wrapping remains loose after the load is applied. The seams shall be sealed with sheathing tape or a similar product with sufficient flexibility and resistance to heat. During the load period, condensation should be visible on the inside surfaces of the wrap to ensure that the specimen moisture content is above the fiber saturation point.

NOTE 13—The jig and apparatus may be stored in a vapor-impermeable bag. There should be water at the bottom of the bag at all times to maintain the high humidity conditions inside the bag during the test.

## 9. Procedure

9.1 After specimens have been preconditioned, including 8.6 for Condition C specimens, weigh each test specimen and record the preconditioned weight. Measure the dimensions of each creep specimen in order to calculate the shear area to three significant figures.

9.2 The creep jig used shall meet the requirements of 6.2 and Fig. 2.

9.3 Mount a properly preconditioned creep specimen on the loading seats of the creep-test apparatus. Position the apparatus in the testing machine to apply a compression load to the loading shaft of the apparatus. Apply the predetermined test load to the loading shaft (which compresses the loading spring) at a uniform rate of speed. Tighten the locking nut by hand to maintain spring compression. Remove the apparatus from the testing machine.

9.4 The unit shall be placed in a chamber maintained at the applicable environmental conditions.

9.5 The creep in the specimen shall be measured immediately upon the specimen's removal from the environmental chamber and from the test jig (Fig. 1).

9.5.1 Creep at the bondline shall be measured to the nearest 0.1 mm and recorded for each scribed edge of the test specimen.

9.6 At the conclusion of testing (Table 1), reweigh and record the weight of each test specimen. Dry each test specimen to a constant weight at a temperature of 103 ± 2°C [217 ± 3.6°F]. Calculate and record percent moisture content in accordance with Test Methods D4442 (Method A). For Condition C specimens, remove wrapping prior to drying and determining moisture content (Note 14).

NOTE 14—Condition C specimens are to be reweighed prior to removing wrapping and drying to determine moisture content.

9.6.1 For Condition C test specimens, the final weight of the wrapped test specimen (9.6) should be within 3 % of the initial weight (9.1) of the wrapped test specimen.

## 10. Calculations

10.1 Calculate the following for each test specimen.

10.1.1 Moisture content for selected lumber (7.1.3),

10.1.2 Moisture content after specimen preconditioning (9.1),

10.1.3 Specific gravity for selected lumber (7.1.1),

10.1.4 Specimen shear area (9.1),

10.1.5 Average creep of specimen (Fig. 1).

10.2 Calculate for each assembly and test condition.

10.2.1 Average moisture content.

10.2.2 Overall observed average creep of the test assembly.

## 11. Report

11.1 The report shall include the following:

11.2 Identification of the adhesive used by class, number, or manufacturer's mark,

11.3 Type, species of wood and method of preparation including conditioning,

11.4 The average and minimum specific gravity (oven-dry weight and volume basis) of representative wood samples taken from the boards used in the evaluation,

11.5 The moisture content at the time of bonding, as determined by representative oven dried samples,

11.6 Application, bonding conditions and assembly time used for the test assemblies,

11.7 Temperature and relative humidity at time of bonding,

11.8 The moisture content of the creep specimens (determined by the oven-drying method) at the completion of testing,

11.9 For Condition C specimens, the percent change in weight of the wrapped specimens at the conclusion of testing,

11.10 Number of specimens tested,

11.11 The applied load, specimen dimensions and calculated shear stress for each specimen, and

11.12 For each set of test conditions evaluated, the average creep at the bondline of each specimen originating from each assembly, the maximum average creep observed, and the overall average creep for each assembly.

11.13 Environmental conditions within the test chamber(s) if different than those specified in Table 1.

## 12. Precision and Bias

12.1 At the present time, there is no basis for statements concerning precision and bias of test results obtained from either within-laboratory or between-laboratory testing.

## 13. Keywords

13.1 adhesive; compression; creep; fiber saturation point; shear; stress