



Designation: ~~D4761-05~~ Designation: D4761 - 11

Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material¹

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INTRODUCTION

Numerous evaluations of the mechanical properties of wood-based structural material have been satisfactorily conducted since the late 1920s, using Test Methods D198. Those methods are best suited to a laboratory environment and are adaptable to a variety of products such as stress-graded lumber, sawn timber, laminated timbers, wood-plywood composite members, reinforced and prestressed timbers.

The procedures presented in these test methods have been derived from those set forth in Test Methods D198. They are intended primarily for application to stress-graded lumber, but can be used for other wood-base structural material as well. The procedures are more flexible than those in Test Methods D198, making testing in a nonlaboratory environment more feasible. Thus the test methods can be used on production sites for field testing and quality control, as well as in laboratories for research applications. Key differences from Test Methods D198 are the testing speed, the deflection-measuring procedures for test specimens under load, and the detail of data reporting. Furthermore, the test methods do not require that specimens be loaded to ~~failure (Note 1).~~ failure.

Since these test methods allow latitude in testing procedures, the procedures used shall be fully documented in the test report. It may also be desirable to correlate the results from tests carried out according to these test methods with test results obtained through the use of a traditional procedure, such as that set forth in Test Methods D198.

1. Scope

~~Note 1—A proof load may be used, which will permit the determination of a specified strength percentile without testing the total sample to destruction. Designing a test program on the basis of proof loading can be complex, requiring consideration in relation to the objectives of the test program. Guidance on this matter can be found in the paper by Johnson, Scope~~

1.1 These test methods cover the determination of the mechanical properties of stress-graded lumber and other wood-base structural material.

1.2 These test methods appear in the following order:

Bending edge-wise 6-11	Section
Bending edge-wise	6
Bending flat-wise:	
—Center point loading	12-17
—Center point loading	7
—Third point loading	18-23
—Third point loading	8
Axial strength in tension	24-29
Axial strength in tension	9
Axial strength in compression	30-35
Axial strength in compression	10

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility*

¹ These test methods are under the jurisdiction of ASTM Committee D07 on Wood and are the direct responsibility of Subcommittee D07.01 on Fundamental Test Methods & Properties.

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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

- D9 Terminology Relating to Wood and Wood-Based Products
- D198 Test Methods of Static Tests of Lumber in Structural Sizes
- D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products
- D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials
- D7438 Practice for Field Calibration and Application of Hand-Held Moisture Meters
- 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

2.2 Other Document:³

NIST Voluntary Product Standard PS20 American Softwood Lumber Standard

NOTE 2—The 1—The current version of PS20 is given as an example of a product standard applicable to stress-graded lumber. Other product standards may apply to stress-graded lumber. For wood-base structural materials other than stress-graded lumber, relevant product standards may apply.

3. Terminology

3.1 *Definitions*—See Terminologies D9 and E6 and Practices E4 and E177 for definitions of terms used in these test methods.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *breadth*—that dimension of the test specimen in the direction perpendicular to the span and perpendicular to the direction of an applied bending load.

3.2.2 *depth*—that dimension of the test specimen in the direction perpendicular to the span and parallel to the direction of an applied bending load.

3.2.3 *span*—the distance between the center lines of end reactions on the pivot points upon which the test specimen is supported to accommodate a transverse bending load or, for tension loading, the distance between the grips.

4. Significance and Use

4.1 These test methods provide procedures that are applicable under true field conditions, such as in a plant with specimens not at moisture equilibrium.

4.2 The data established by these test methods can be used as follows:

4.2.1 Develop strength and stiffness properties for the population represented by the material being tested (that is, individual grades, grade combinations, species, species groups, or any other defined, identifiable sample).

4.2.2 Confirm the validity of strength and stiffness properties for the population represented by the material being tested.

4.2.3 Investigate the effect of parameters that may influence the strength and stiffness properties of the material, such as moisture content, temperature, knot size and location, or slope of grain.

4.3 The procedures chosen in accordance with these test methods shall be fully documented in the report to facilitate correlation with test results obtained through the use of traditional procedures, such as those set forth in Test Methods D198.

5. Precision and Bias

5.1 The precision and bias of these test methods have not yet been established. **BENDING EDGE-WISE**

6. Scope **BENDING EDGE-WISE**

6.1 *Scope*

6.1.1 This test method provides procedures for the determination of the strength and modulus of elasticity of stress-graded lumber and other wood-base structural material in bending edge-wise. 7-

6.2 *Summary of Test Method/Methods*

7-1The 6.2.1 The test specimen is simply supported and loaded by two concentrated forces spaced equidistant from the supports. The specimen is loaded at a prescribed rate and, as applicable, observation of load or deflection, or both, is made until failure occurs or a preselected load is reached. 8-

6.3 *Apparatus*

² Johnson, R. A., "Current Statistical Methods for Estimating Lumber Properties by Proof Loading," *Forest Products Journal*, Vol 30, No. 1, 1980, pp. 14-22.

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 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 National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 3460, Gaithersburg, MD 20899-3460.

8.16.3.1 Testing Machine—A device that combines (1) a reaction frame to support the test specimen, (2) a loading mechanism for applying load at a specified rate, and (3) a force-measuring apparatus that can be calibrated to the accuracy requirements of ~~8.3.2~~ 6.3.3.2 following the procedures outlined in Practices E4.

~~8.1.1~~

~~6.3.1.1 Load and Support Apparatus~~ ~~including bearing plates at least as wide as the specimen is broad and not exceeding 8 in. (200 mm) in length. It is recommended that, under this test method, the bearing plate length of the loading apparatus be no less than one half the specimen depth. The apparatus shall also include appropriate mechanisms, such as rollers or pivots, to minimize the development of axial forces in the test specimen.~~

~~8.1.2, including bearing plates at least as wide as the specimen is broad and not exceeding the member depth in length. The bearing plates shall have eased edges and sufficient bearing lengths to avoid a localized crushing failure at the load and support points. The apparatus shall also include appropriate mechanisms, such as rollers or pivots, to minimize the development of axial forces in the test specimen. Each bearing point shall include an in-plane pivot point. Bearing plates and rollers shall be initially centered about their pivot points.~~

6.3.1.2 Loading Configuration—The simply supported test specimen shall be subjected to two equal transverse concentrated loads spaced equidistant from the supports.

~~NOTE 3—The 2—~~The apparent modulus of elasticity varies for different loading configurations (see Practice D2915). While the loading configuration that commonly serves as the basis for assigning design values assumes a uniformly distributed load, a configuration with two concentrated loads symmetrically placed within the test span usually is more suitable for structural tests. This configuration also produces a constant bending moment, free of shear, in the portion of the specimen between the load points.

~~8.1.3~~

6.3.1.3 Lateral Supports, when necessary, to restrict the specimen lateral deflection. Specimens having a depth-to-breadth ratio of three or greater are subject to lateral instability during loading and may require lateral supports. These supports shall allow movement of the specimen in the direction of load application and have minimal frictional restraint.

~~8.2~~

6.3.2 Deflection-Measuring Apparatus, for modulus of elasticity calculations, to monitor the deflection of the test specimen. Deflection may be measured directly as the displacement of the loading head of the testing machine. In this case, deflection is expressed as the average deflection of the load points with respect to the end reaction plates. If, because of the design of the apparatus, the deflection measurement includes extraneous components, the deflection data may be adjusted for such extraneous components (~~NOTE 4~~ Note 3). In all instances, the report shall include a complete description of test conditions, extraneous components, and data adjustment procedures.

~~NOTE 4—If 3—~~If the extraneous components are an appreciable portion of the total measurement, the test apparatus should be reexamined for its suitability.

~~8.36.3.3 Accuracy:~~

~~8.3.1~~The

6.3.3.1 The two load points shall be located within $\frac{1}{8}$ in. (3 mm) of the distance determined in accordance with ~~8.1.2~~ 6.3.1.2 and ~~9.2.26.4.2.2.~~

~~8.3.2~~

6.3.3.2 The force-measuring apparatus shall be such as to permit load measurements with an error not to exceed ± 1.0 % of the load for loads greater than or equal to 1000 lbf (4450 N). For loads smaller than 1000 lbf, the error shall not exceed ± 10 lbf (45 N).

~~8.3.3~~6.3.3.3 The deflection-measuring apparatus shall be such as to permit deflection measurements with an error not to exceed ± 2.0 % of the deflection for deflections greater than or equal to 0.150 in. (4 mm). For deflections smaller than 0.150 in., the error shall not exceed ± 0.003 in. (0.08 mm). ~~9.~~

6.4 Test Specimen

~~9.16.4.1~~ Cross Section—Unless the effect of cross-section modifications is a test evaluation objective, test the specimen without modifying the dimensions of the commercial cross section.

~~9.2~~

6.4.2 Length:

~~9.2.1~~

6.4.2.1 The minimum specimen length shall be the span, determined in accordance with ~~9.2.26.4.2.2,~~ plus an extension beyond the center lines of the end reactions to accommodate the bearing plates, such that the specimen will not slip off the end reactions during the test. In cases where the unsupported specimen length outside the test span at an end reaction (overhang) exceeds 10 times the specimen depth, report the amount of overhang at each end reaction.

~~9.2.2~~

6.4.2.2 The span will depend on the purpose of the test program. It is customary to express the span as a multiple of the test specimen depth (Note 54). While spans that currently serve as a basis suitable for testing range from 17 times the depth of the specimen to 21 times the depth, other spans may be used under this test method. Practice D2915 gives an indication of the variation of the apparent modulus of elasticity with span-to-depth ratios.

~~NOTE 5—The 4—~~The depth here refers to the relevant size specified in the size classification of the applicable product standard (for stress-graded lumber, for example, the depth here may refer to the dressed dry size specified in the size classification of the current version of PS20 for the nominal size, for example, 3.5 in. (89 mm) for a nominal 4 in.).

9.3

6.4.3 *Conditioning*—Specimens may be tested as produced or conditioned (for example, temperature, moisture content, or treatment), depending on the purpose of the test program. If the temperature of the specimens at the time of testing is less than 45°F (7°C) or more than 90°F (32°C), report that temperature.

10. Procedure

10.1

6.5 Procedure

6.5.1 Specimen Measurements:

~~10.1.1 Measure and record before testing the cross-sectional dimensions and moisture content of every specimen for which the modulus of elasticity or the modulus of rupture, or both, are to be calculated. Make measurements at midlength of the specimen unless another location is more appropriate to the purpose of the test.~~

~~10.1.2 Measure the cross-sectional dimensions of the specimen to the nearest 0.04 in. (1 mm).~~

~~10.1.3 Measure the moisture content of the specimen in accordance with the procedures outlined in Test Methods~~

6.5.1.1 Before testing, measure and record the cross-sectional dimensions of every specimen to the nearest 0.04 in. (1 mm). Make measurements at midlength of the specimen unless another location is more appropriate to the purpose of the test.

6.5.1.2 Following the test, measure the moisture content of every specimen in the vicinity of the failure zone in accordance with the procedures outlined in Test Methods D4442 or Practice D7438.

10.2

6.5.2 Test Setup:

10.2.1

6.5.2.1 *Lengthwise Positioning*—If the specimen is to be located within the test span without bias regarding defects, achieve this by centering the specimen in the span or by any other scheme suitable to the purpose of the test program.

10.2.2

6.5.2.2 *Selection of the Tension Edge*—Randomly select the edge to be subjected to tension testing.

10.3

6.5.3 *Speed of Testing*—The test rate shall be such that the sample target failure load would be achieved in approximately 1 min (~~NOTE 6~~NOTE 5). The failure load should not be reached in less than 10 s nor more than 10 min (~~NOTE 7~~NOTE 6).

~~NOTE 6—Some 5—~~Some caution is warranted here. A test rate to achieve the average failure load for the sample in approximately 1 min will differ from that to achieve a lower percentile load for the same sample in approximately 1 min.

~~NOTE 7—For 6—~~For stress-graded lumber, a rate of motion of the testing machine loading head of approximately 3 in. (75 mm)/min will usually permit the test to be completed in the prescribed time for span to depth ratios of 17:1 and in cases where the target failure load is the average failure load for the sample.

~~10.46.5.4~~ 5.4 *Load-Deflection Data*—Obtain load-deflection data, as required, using the apparatus specified in 8.26.3.2.

~~NOTE 8—For 7—~~For stress-graded lumber, data obtained for loads corresponding to maximum stresses in the specimen ranging from 400 to 1000 psi (2.75 to 7 MPa) will usually be adequate for modulus of elasticity calculations.

~~10.56.5.5~~ 5.5 *Maximum Load*—If the purpose of the test is to determine strength properties, record the maximum load attained in the test.

~~NOTE 9—In 8—~~In proof loading, the intended load target may not be reached or may be exceeded slightly. The actual attained load as well as the target load should therefore be recorded.

10.6

6.5.6 *Record of Failure*—Depending on the purpose of the test, a description of the characteristic causing failure, and its location within the test span, may be required.

~~NOTE 10—An 9—~~An example of a coding scheme for recording characteristic type and failure location is given in Appendix X1. This example was derived for application to stress-graded lumber. ~~Report~~

6.6 Report

~~11.1~~ 6.6.1 The report content depends on the purpose of the test program. The report shall include, at the minimum, the following information:

~~11.1.1~~ 6.6.1.1 *Description* of the testing machine, including detailed drawings, the span, and the deflection-measuring apparatus, if applicable.

~~11.1.2~~ 6.6.1.2 *Description* of calibration procedures, frequency, and records.

~~11.1.3~~ 6.6.1.3 *Method* used for the measurement of the moisture content of specimens.

~~11.1.4~~ 6.6.1.4 *Speed* of testing and means of control of the speed of testing.

~~11.1.5~~ 6.6.1.5 *Specimens* lengthwise positioning and selection of the tension edge.

~~11.1.6~~ 6.6.1.6 As applicable, the type of load-deflection data for the calculation of the modulus of elasticity of specimens, including a description of test conditions, extraneous components, and data adjustment procedures in accordance with 8-26.3.2.

~~11.1.7~~ Description of the population sampled, including—

6.6.1.7 Description of the population sampled, in accordance with Practice D2915.

6.6.1.8 Description of the sample, including (1) geographical origin, (2) species or species group, (3) specimen geometry (for example, nominal cross section and length), (4) grade or grades combination, and (5) an indication of specimen treatment at the time of production (for example, drying schedule and preservation), if applicable.

~~11.1.8~~ Description of the sample, including (1) sample size, (2) conditioning, if applicable, (3) temperature of specimens at the time of testing, and (4) number of specimens that failed during the test.

~~11.1.9~~ Data 6.6.1.9 Data on test specimens, including, as applicable, (1) grade, (2) actual cross-sectional dimensions, (3) moisture content, (4) overhang in accordance with 9-2.16.4.2.1, (5) load-deflection data, (6) maximum load, (7) time to maximum load, and (8) failure description and location.

~~11.1.10~~ Details 6.6.1.10 Details of any deviations from the prescribed or recommended procedures as outlined in this test method.

7. BENDING FLAT-WISE—CENTER-POINT LOADING

12.

7.1 *Scope*

~~12.1~~ This 7.1.1 This test method provides procedures for the determination of long-span modulus of elasticity of lumber and other wood-base structural material in flat-wise bending under center-point load. ~~13.~~

7.2 *Definition of Modulus of Elasticity*

~~13.1~~ Long-span 7.2.1 Long-span modulus of elasticity (E) is defined as the modulus of elasticity calculated from deflection measured in a flat-wise test of lumber with center point loading and a span-depth ratio (l/d) of approximately 100 (90 to 110). ~~14.~~

7.3 *Summary of Test Method/Methods*

~~14.1~~ 7.3.1 A known concentrated load is applied at mid-span of a simply supported piece of lumber oriented flatwise. A ~~dial indicator~~ displacement measurement device is used to determine the deflection of the lumber piece under the load. The modulus of elasticity (E) is determined by relating the deflection to the size of lumber and the test span.

15. Apparatus

~~15.1~~

7.4 *Apparatus*

7.4.1 *Support System*—Any may be used that provides unrestrained support at both ends. The support at one end should be constructed so that stability is provided for a piece of twisted lumber, such as a pedestal with a single point bearing support, a support that is designed to tilt to match the twist of the lumber, or special shims that restrain the lumber from rocking on the supports. Each bearing point shall include an in-plane pivot point. Bearing plates, when employed, shall be initially centered about their pivot points.

~~15.2~~ 7.4.2 *Dial Indicator/Displacement Measurement Device*, with the capacity to measure deflections up to at least 1 in. (25 mm) to the nearest 0.001 in. (0.025 mm).

~~15.3~~ 7.4.3 A weight of approximately 5 lbf (22.24 N) to be used for preloading. Compact calibrated accurately (to 0.05 lbf) (0.22 N) weights for loading.

~~NOTE 1—Three~~ 10—Three 5-lbf (22.24 N) weights and one 10-lbf (44.5 N) weight have been found to provide an adequate combination of weights for 2 by 4 through 2 by 12 surfaced dimension lumber sizes. ~~16.~~

7.5 *Procedure*

7.5.1 *Specimen Measurements*—The procedures of 6.5.1 shall be followed.

7.5.2 Space the supports to provide a span-to-depth ratio for the test specimen of approximately 100 (90 to 110). This spacing shall be determined to plus or minus 1/8 in. (3 mm) for use in the calculation of the modulus of elasticity.

~~16.2~~ Place 7.5.3 Place the ~~dial indicator~~ displacement measurement device midway between the supports and adjust it so the downward deflection of the lumber can be measured when loaded. Construct or arrange the apparatus such that the relative position of the ~~dial indicator~~ displacement measurement device to the supports is not changed more than 0.001 in. (0.025 mm) when the load weight is placed on the test specimen.

~~16.3~~ Place 7.5.4 Place the test specimen flatwise on the supports and in firm contact with both end supports.

~~16.4~~ Apply 7.5.5 Apply the preload weight to the test specimen at or near the center of the span.

~~16.5~~ Then 7.5.6 Then apply the load weight(s) to the test specimen at the center of the span. This load shall be such that it will induce 0.2 in. (5 mm) or more deflection in a specimen with 2.0×10^6 psi (13 790 MPa) long-span modulus of elasticity.

~~16.6~~ Observe 7.5.7 Monitor the ~~dial indicator~~ displacement measurement device to determine the deflection of the test specimen due to the load weight(s).

~~16.7~~ Long-span 7.5.8 Long-span modulus of elasticity is determined using the following equation:

$$E = PL^3/(48dl)$$

where:

E = modulus of elasticity, $\text{psi} \times 10^6$,

P = load, lbf,

L = span, in.,

d = deflection, and

I = moment of inertia, in.^4

17.

7.6 Report

7.6.1 The content of the report depends on the purpose of the test program. The report shall include, at the minimum, all applicable information as presented in Section 6.6.

8. BENDING FLAT-WISE—THIRD-POINT LOADING

18.

8.1 Scope

8.1.1 This test method provides procedures for the determination of bending strength and modulus of elasticity of stress-graded lumber and other wood base structural material in flat-wise bending on short spans under third-point load.

8.2 Summary of Test Method

8.2.1 The test specimen is simply supported and loaded on the wide face by two equal, concentrated forces spaced equidistant between the supports. The specimen is loaded at a prescribed rate and, as applicable, observation of load or deflection, or both, is made until failure occurs or a preselected load or deflection is reached.

8.2.2 For modulus of elasticity calculation, a step-wise load may be used, for example, pre-loading and then adding a known weight for deflection measurement.

20. Apparatus

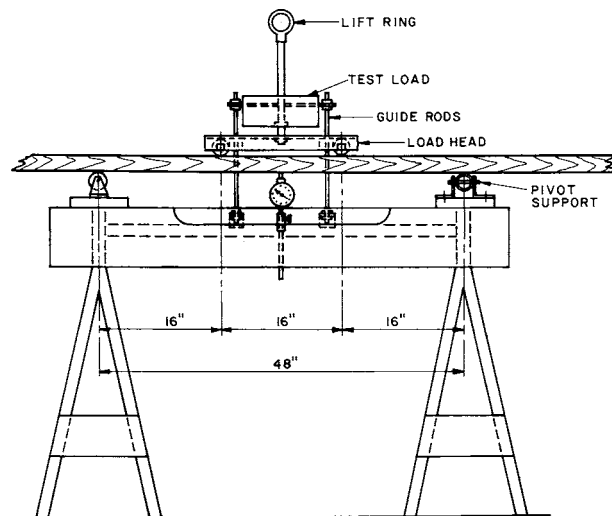
20.1

8.3 Apparatus

8.3.1 Testing Machine—A device that combines (1) a reaction frame to support the test specimen; (2) a loading mechanism for applying load at a specified rate or prescribed load interval; and (3) a force-measuring apparatus that can be calibrated to the accuracy requirements of 8.3.3.2, following the procedures outlined in Practices E4. If the test is for modulus of elasticity only, no force-measuring device is required. Fig. 1 illustrates the traditional device meeting the requirements of these test methods for modulus of elasticity measurement.

20.1.1

8.3.1.1 Load and Support Apparatus, including bearing plates at least as wide as the specimen is broad. It is recommended that the bearing plate length be no less than one half the specimen depth. If only the modulus of elasticity is to be determined in



16 in. = 410 mm
48 in. = 1220 mm

NOTE 1—This device is used for assessment of E in third-point, flat-wise bending on a span-to-depth ratio of 32 for 1½-in. (38-mm) thick lumber.

FIG. 1 Schematic of Static Bending Testing Device