Designation: D 5652 – 95 (Reapproved 2000)

Standard Test Methods for Bolted Connections in Wood and Wood-Based Products[1]

This standard is issued under the fixed designation D 5652; 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 These test methods cover procedures for evaluating the strength and stiffness of single-bolted connections in wood or wood-based products when subjected to static loading. These test methods serve as a basis for determining the effects of various factors on the strength and stiffness of the connection.

1.2 The values stated in inch-pound units are to be regarded as the standard. The SI units in parentheses are for information only.

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:*

D 2395 Test Methods for Specific Gravity of Wood and Wood-Base Materials[2]

D 2915 Method for Evaluating Allowable Properties for Grades of Structural Lumber[2]

D 4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials[2]

E 4 Practice for Force Verification of Testing Machines[3]

F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets[4]

2.2 *Federal Specification:*

Fed. Spec. FF-W-92 for Washers, Metal, Flat (Plain)[5]

3. Summary of Test Methods

3.1 Specimens consisting of at least one wood or wood-based member fastened with one bolt to at least one other member of any material are evaluated for capacity to resist compressive or tensile forces applied at a constant rate of deformation with a suitable testing machine. The deformation of the connection at various intervals of loading is measured. Supplementary physical properties of the wood or wood-based members are also determined.

4. Significance and Use

4.1 Connections are one of the weakest links in wood construction. While the strength of metal bolts and of wood or wood-based products are ascertainable, a full evaluation of the performance of the combination is only possible through the testing of a complete connection. Such variables as member thickness, member width, end and edge distances, type of bolt, fabrication tolerances, moisture content of the wood or wood-based product, preservative or fire-retardant treatment of the wood or wood-based product, and species of wood may affect connection behavior. In order to develop design criteria for established bolt types as well as those under development, the effect of these variables on connection strength and stiffness must be known. The tests described herein permit the observation of data on the strength and stiffness of wood or wood-based connections, or both, under the influence of any or all of these factors.

5. Apparatus

5.1 *Testing Machine*—Any suitable testing machine capable of operation at a constant rate of motion of its movable head and having an accuracy of ±1 % when calibrated in accordance with Practices E 4.

5.2 *Spherical Bearing Block*, for compressive loading of specimens.

5.3 *Grips*—Gripping devices capable of attaching the specimen to the stationary and moving heads of the testing machine in such a way as to ensure true axial tensile loads.

5.4 *Deformation Gages*—At least two dial gages with a least reading of 0.001 in. (0.025 mm) or other suitable devices for measuring the slip between connection members during load application.

6. Sampling

6.1 Sampling shall provide for selection of representative test specimens that are appropriate to the objectives of the testing program.

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[1] These test methods are under the jurisdiction of ASTM Committee D07 on Wood and are the direct responsibility of Subcommittee D07.05 on Wood Assemblies.

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[2] *Annual Book of ASTM Standards*, Vol 04.10.

[3] *Annual Book of ASTM Standards*, Vol 03.01.

[4] *Annual Book of ASTM Standards*, Vol 15.08.

[5] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

6.2 Estimate sample size in accordance with the procedures of Method D 2915.

NOTE 1—The precision required, and thus, the manner of sampling and the number of tests, depend upon the specific test objectives. No specific criteria can therefore be established. General experience indicates that the coefficients of variation from tests on connections range from approximately 15 to 30 %.

7. Sampling: Test Specimens and Test Units

7.1 Select wood members, and position the bolt in them in such a way that the results are not affected by knots, cross grain, or other natural or manufacturing characteristics unless the purpose of the test methods is to evaluate the effects of such growth characteristics. When the affects of growth characteristics are not being evaluated, wood members shall be essentially clear and straight-grained. For wood-based products, select specimens with regard to manufactured characteristics.

7.2 *Connections Containing One Bolt*:

7.2.1 Make tests on three-member connections as shown in Figs. 1-3 except where specific data on two- or multiple-member connections are being sought. Select the width, length, and thickness of the members with consideration of required edge and end distances. Member dimensions shall be representative of the intended use of the connection.

7.2.2 For connections involving metal or other side members (such as panel materials), the side member thickness shall be that anticipated in service. For all-wood joints, the thickness of each side member shall be at least one half of the thickness of the center member and width and length of all members shall be selected with consideration of required edge and end distances for a specific application. Minimum end distance shall be four bolt diameters for compression loading and seven bolt diameters for tension loading, unless the effect of various end distances is to be studied.

7.2.3 The excess of bolt-hole diameter over bolt diameter shall be 1/32 in. (0.8 mm) for bolts 1/2 in. (13 mm) or less in diameter, and 1/16 in. (1.6 mm) for bolts of larger diameter, unless other bolt-hole diameters are specified.

7.2.3.1 Bolt-holes shall be precisely bored perpendicular to the surface, so that the surface of the hole is smooth and uniform to ensure good bearing of the bolt. Holes shall be drilled after members are conditioned unless the purpose of the test is to study the effect of shrinkage on the performance of bolted connections.

7.2.4 Bolts shall be of sufficient length to penetrate all members without having any member bear on the bolt threads.

7.2.5 Place heavy round washers conforming to Fed. Spec. FF-W-92 for washers, metal, flat (plain), and hereafter referred to as a standard washer, between wood or wood-based side members and bolt head and nut. Bring abutting faces of connection members into normally installed contact; then back off the nut and retighten to "finger tightness".

7.2.6 Primary tests shall be made on connections loaded parallel to the grain of wood members and perpendicular to the grain of wood members. Perpendicular to the grain tests shall be conducted with the grain of the center member parallel and the side members perpendicular to the direction of the load or with the grain of the center member perpendicular and the side members parallel to the direction of the load. These tests shall be made by applying compressive or tensile loads as required; however, application of tensile load is preferred.

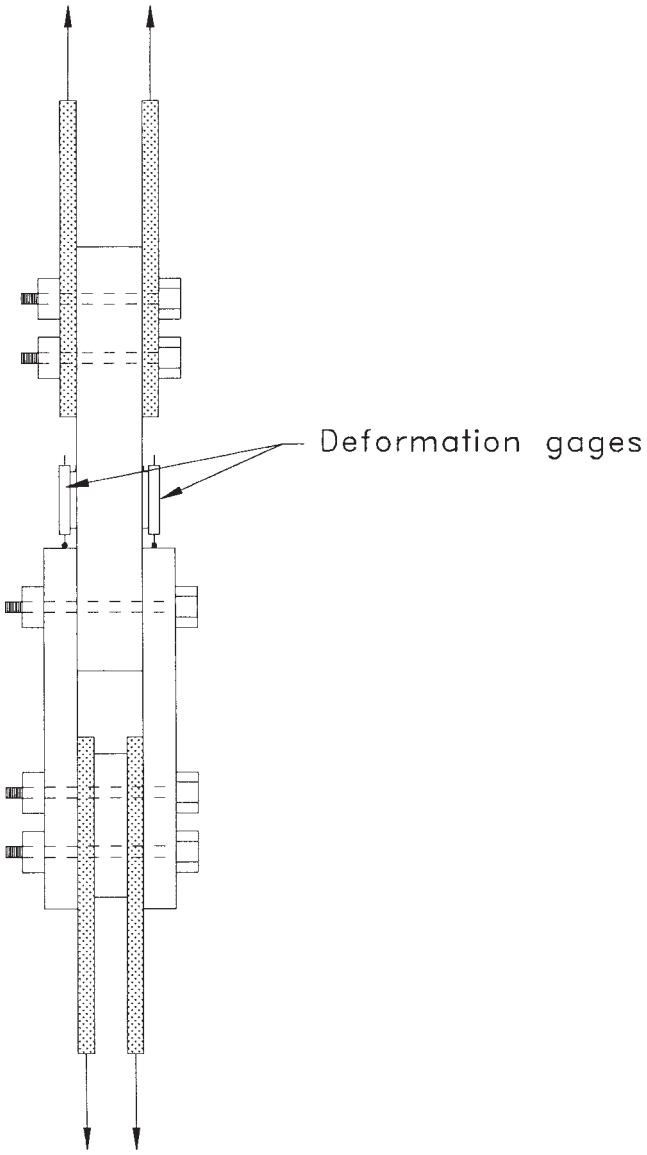

FIG. 1 Assembly for Testing Bolted Connections Parallel to Grain in Tension

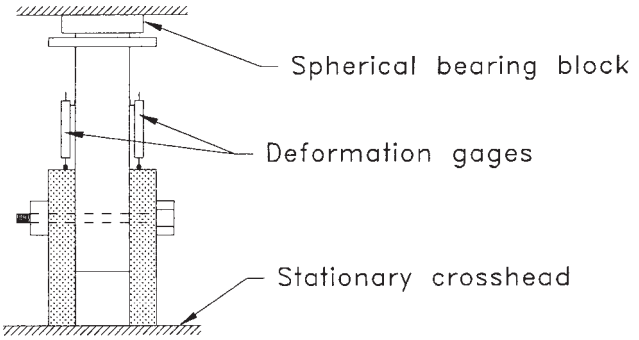

FIG. 2 Assembly for Testing Bolted Connections Parallel to Grain in Compression

7.2.7 When required, conduct additional primary tests to provide information on the items stated in 7.2.7.1-7.2.7.7. In

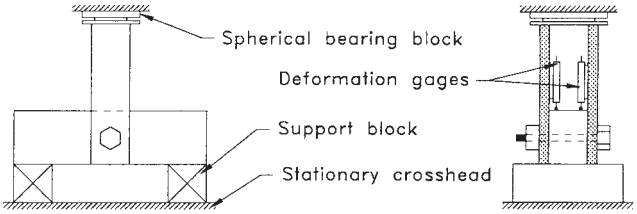

FIG. 3 Assembly for Testing Bolted Connections Perpendicular to Grain in Compression

such tests, use a method of matching the material in corresponding members as follows to prevent masking of differences in specific gravity, rate of growth, or other factors:

7.2.7.1 To establish the effect of bearing area and length to diameter (L/d) relationship,

7.2.7.2 To determine the effect of variations in member thickness.

7.2.7.3 To determine the effect of angle of load to grain of the wood,

7.2.7.4 To establish minimum end distances required for each size of bolt and the effect of variations in end distances,

7.2.7.5 To establish minimum edge distance and the effect of variations in edge distance,

7.2.7.6 To determine the effect of moisture content of the wood or wood-based product, and

7.2.7.7 To evaluate any other factor that may affect the performance of the connection.

NOTE 2—The properties of the metal of the bolts and metal side plates are also factors affecting the connection strength and behavior. All available data on their properties shall be included in the report. Method F 606 provides a method of obtaining mechanical properties of bolts.

7.2.8 Make a minimum of ten tests for evaluating each of the variables to be studied. See Note 1 for guidance in this respect.

8. Conditioning

8.1 Make the tests with material conditioned to the appropriate conditions for the objectives of the testing program. Maintain the condition of the material prior to and during testing, unless specified otherwise.

9. Procedure

9.1 *General*—Test the connections within 1 h after assembly unless the performance of delayed tests is required.

9.2 *Test Setup*:

9.2.1 Connections tested in tension are more representative of behavior in service than those tested in compression. The method of testing a connection parallel to the grain during tensile loading is shown in Fig. 1. Design of the ends of the members where tensile loads are applied is required to ensure failure away from the gripping devices. Use an alignment support when the applied load is eccentric in a two-member specimen. Dial gages with a least reading of 0.001 in. (0.025 mm) or other equivalent devices are required for measuring the slip between the members. Attach gages in such a way that the amount of member strain not associated with connection slip is minimized.

9.2.2 The method of testing a connection parallel to the grain during compressive loading is shown in Fig. 2. Use a spherical bearing block in applying the load. Measure the deformation, that is the slip between members, at successive increments using dial gages accurate to 0.001 in. (0.025 mm) or other suitable devices.

9.2.3 The method of conducting a connection test perpendicular to the grain with compressive loading is shown in Fig. 3. Maintain a clear distance between the supports of at least three times the depth of the transverse member. Measure the deformation, that is the slip between members, at successive increments using dial gages accurate to 0.001 in. (0.025 mm) or other suitable devices.

9.3 *Loading*—The procedures described herein are for static loading. When required, evaluate the connection under impact or cyclic loading.

9.4 *Slip Measurement*—Measure the slip between members of the connection from the initiation of load application and take readings of the slip at sufficiently frequent load intervals to permit establishment of a satisfactory load-deformation curve. Observe the general behavior of the connection under load and record the observations. Record the first relaxation of the load, the mode of failure, and other significant details. Continue the test until the ultimate load is reached. With compressive loading, the test may be stopped at a total deformation of 0.60 in. (15 mm). Record the maximum load.

9.5 *Rate of Testing*—Conduct the tests to reach the maximum load in approximately 10 min, however reach the maximum load in not less than 5 and not more than 20 min. Record the rate of testing used.

NOTE 3—A constant rate of motion of the movable crosshead of the testing machine of 0.040 in. (1.0 mm)/min ±50 % usually permits reaching the maximum load in the prescribed time.

NOTE 4—The crosshead speed shall mean the free-running, or no-load, crosshead speed for testing machines of the mechanical-drive type, and the loaded crosshead speed for testing machines of the hydraulic-loading type.

9.6 *Minor Tests*:

9.6.1 Determine the oven-dry specific gravity and moisture content of each unmatched wood or wood-based member of all connections tested. Procedures for determining these properties are given in Test Methods D 2395 and D 4442.

9.6.2 Determine the properties of the bolts by certification or testing. In the latter case, use Method F 606 on representative bolt samples.

10. Interpretation of Results

10.1 *Yield Load*—The connection yield load, Fig. 4, is determined by fitting a straight line to the initial linear portion of the load-deformation curve, offset this line by a deformation equal to 5 % of the bolt diameter, and select the load at which the offset line intersects the load-deformation curve. In those cases where the offset line does not intersect the load-deformation curve, the maximum load shall be used as the yield load.

10.2 *Proportional Limit Load*—The proportional limit load, Fig. 4, is the load at which the load-deformation curve deviates from a straight line fitted to the initial linear portion of the load-deformation curve.

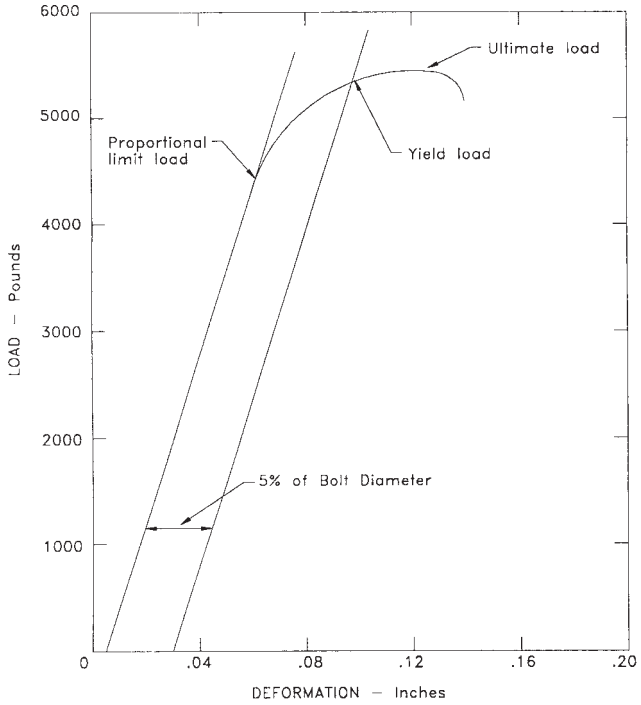

FIG. 4 Definition of Loads to Be Obtained from the Load-Deformation Curve

11. Report

11.1 Report the following information:

11.1.1 Tabulated and plotted data on load-deformation relationships,

11.1.2 Description of the general behavior of the connection under load, such as the proportional limit, yield, and maximum loads, and mode of failure,

11.1.3 Description of the connection, including the materials used,

11.1.4 Member thickness, bolt-hole diameter, and end and edge distances,

11.1.5 Details of loading procedure,

11.1.6 Number of replicate tests.

11.1.7 Oven-dry specific gravity and moisture content of wood or wood-based members of all connections at time of test, along with species identification,

11.1.8 Compression parallel or perpendicular to grain strength of the wood members if determined,

11.1.9 Fastener embedding resistance if determined,

11.1.10 Properties and dimensions of the bolts used and metal side plates when used, and

11.1.11 Details of any deviations from the prescribed methods as outlined in these test methods.

12. Precision and Bias

12.1 The precision and bias of these test methods have not yet been determined.

13. Keywords

13.1 bolted connections; stiffness; wood base