



Designation: ~~D7147-05~~ Designation: D7147 - 11

## Standard Specification for Testing and Establishing Allowable Loads of Joist Hangers<sup>1</sup>

This standard is issued under the fixed designation D7147; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification covers a procedure for evaluating metal devices used for wood-to-wood, wood-to-concrete, wood-to-concrete masonry, and wood-to-steel connections. This method is intended for use with devices used to connect joists, beams, and girders together. These devices are commonly described as joist hangers.

1.2 This specification describes test methods for evaluating the capacities of joist hangers subject to vertical and torsional loading.

1.3 This specification provides a method of assigning allowable loads to joist hangers based on measured strength and deformation characteristics. Information obtained by the provisions of this specification is applicable to design when using the Allowable Stress Design method.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 *ASTM Standards:*<sup>2</sup>

C31/C31M [Practice for Making and Curing Concrete Test Specimens in the Field](#)

C39/C39M [Test Method for Compressive Strength of Cylindrical Concrete Specimens](#) ~~C90 Specification for Loadbearing Concrete Masonry Units~~

~~C270 Specification for Mortar for Unit Masonry~~

C1314 [Test Method for Compressive Strength of Masonry Prisms](#)

D9 [Terminology Relating to Wood and Wood-Based Products](#) ~~D245 Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber~~

D2395 [Test Methods for Specific Gravity of Wood and Wood-Based Materials](#)

D3737 [Practice for Establishing Allowable Properties for Structural Glued Laminated Timber \(Glulam\)](#)

D4442 [Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials](#) ~~D4444 Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters~~

D5055 [Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists](#)

D5456 [Specification for Evaluation of Structural Composite Lumber Products](#)

D7438 Practice for Field Calibration and Application of Hand-Held Moisture Meters

E4 [Practices for Force Verification of Testing Machines](#)

E8 [Test Methods for Tension Testing of Metallic Materials](#)

E575 [Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections, and Assemblies](#)

F606 [Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets](#)

F1470 [Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection](#)

F1575 [Test Method for Determining Bending Yield Moment of Nails](#)

#### 2.2 *Other Standards:*

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.05 on Wood Assemblies. Current edition approved April 1, 2005. Published April 2005. DOI: 10.1520/D7147-05.

Current edition approved Oct. 1, 2011. Published November 2011. Last previous edition approved in 2005 as D7147-05. DOI: 10.1520/D7147-11.

<sup>2</sup> 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.

ANSI/AF&PA NDS-2001, ANSI/AF&PA NDS-2005 National Design Specification for Wood Construction<sup>3</sup> ANSI/ASME B18.2.1 Square and Hex Bolts and Screws (Inch Series), 1996 Specification and Commentary North American Specification for the Design of Cold-Formed Steel Structural Members, 1996 2007<sup>4</sup> Specification for Structural Steel Buildings, 1989-ANSI/AISC 360-10 Specification for Structural Steel Buildings, 2010<sup>5</sup> ACI 318/318R-08 Building Code Requirements for Structural Concrete and Commentary

**3. Terminology**

3.1 The following section defines terms used in this specification. See Terminology D9 for other terminology.

3.2 *Definitions:*

3.2.1 *header*—a member supporting a joist hanger. A header may also be referred to as a “supporting” member.

3.2.2 *joist*—a bending member supported by a joist hanger. A joist may also be referred to as a “supported” member.

3.2.3 *joist hanger*—a metal device, usually cold-formed from light-gage steel sheet or welded from steel plate, used to transfer loads from a joist to a header member or wall in building construction. Face-mount joist hangers contact the side surface of the header and do not contact the top of the header. Top-mount hangers are joist hangers that contact the side and top surface of the header.

3.2.4 *structural composite lumber*—sawn lumber—see definition for *lumber* in Terminology D9.

3.2.5 *structural composite lumber (SCL)*—see Specification D5456.

3.2.5 *structural glued laminated timber*

3.2.6 *structural glued laminated timber (glulam)*—see Practice D3737.

3.2.6

3.2.7 *wood I-joists*—see Specification D5055.

**4. Significance and Use**

4.1 Joist hangers are used to transfer vertical loads from a joist to a header in building construction. In addition to vertical load transfer, joist hangers may provide torsional resistance for the ends of a joist. The performance of this connection is influenced by a number of variables, such as the properties of the hanger, the joist material, the header material, and the fasteners. The test described in this specification provide for consistency in evaluating the performance of such assembled units.

**5. Summary of Test Method**

5.1 *Vertical Load Test*—Test specimens consisting of a length of joist supported by joist hangers attached to two headers are subjected to a vertical load by a suitable testing machine (see Figs. 1-3), while the vertical load and corresponding deflection of the joist are measured and recorded to provide load-slip data.

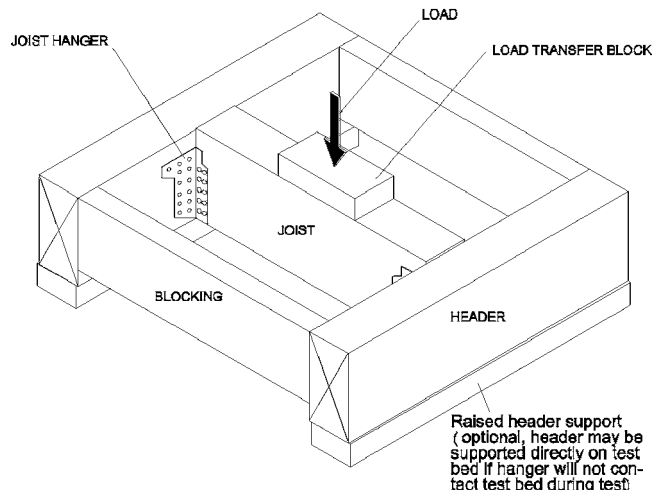


FIG. 1 Typical Vertical Downward Test Setup

<sup>3</sup> Available from American Forest and Paper Association (AF&PA), 1111 19th St., NW, Suite 800, Washington, DC 20036.

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

<sup>4</sup> Available from American Iron and Steel Institute (AISI), 1101 17th St., NW, Suite 1300, Washington, DC 20036.

<sup>5</sup> Available from American Iron and Steel Institute (AISI), 1101 17th St., NW, Suite 1300, Washington, DC 20036.

<sup>5</sup> Available from American Institute of Steel Construction (AISC), One E. Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

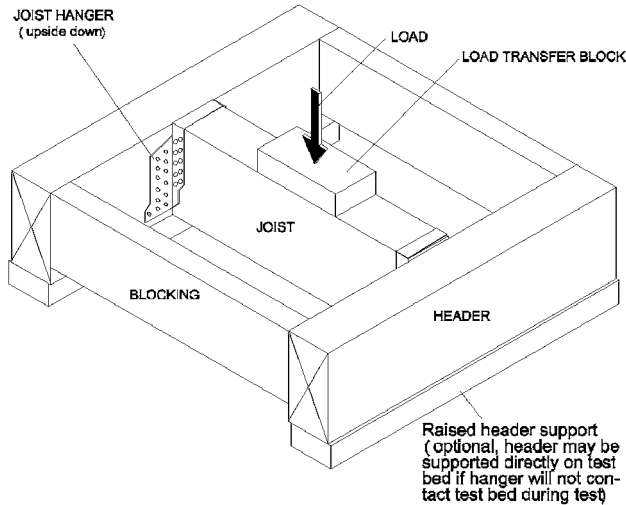


FIG. 2 Typical Uplift Test Setup

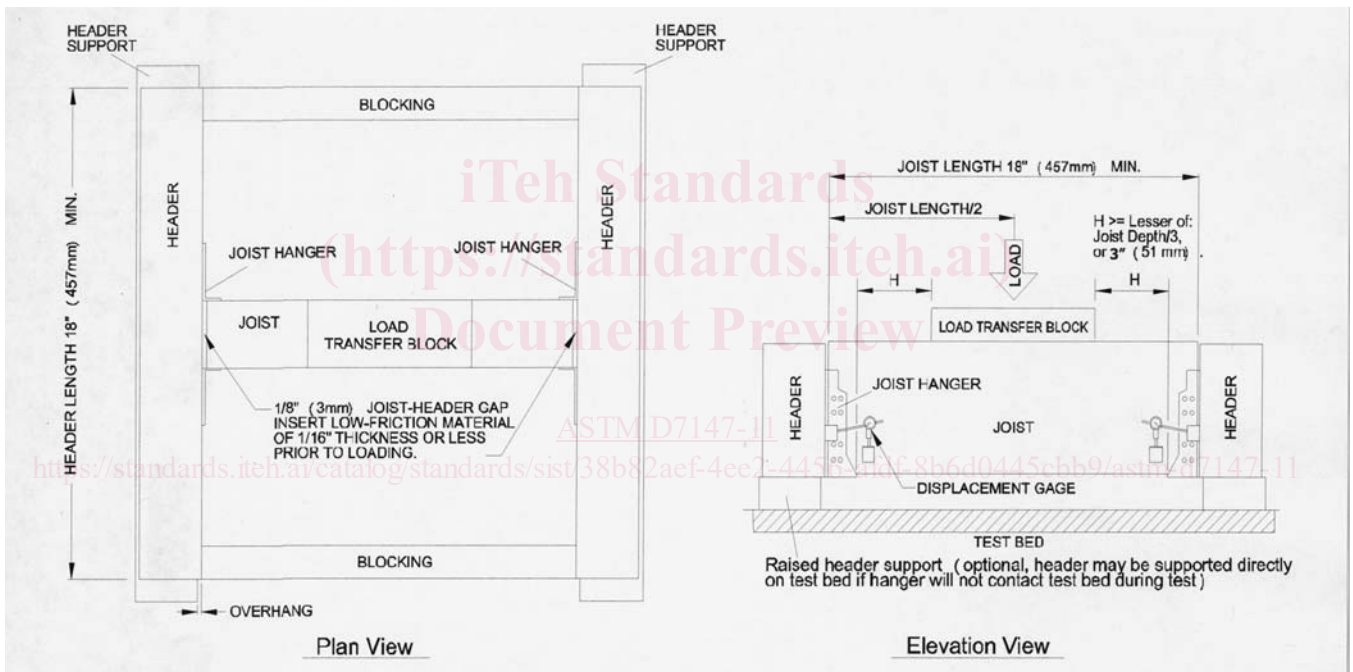


FIG. 3 Vertical Downward Test Setup

5.1.1 Loads applied vertically downward with reference to the intended application of the joist hanger, shall be classified as downward (see Fig. 1).

5.1.2 Loads applied vertically upward with reference to the intended application of the joist hanger, shall be classified as uplift (see Fig. 2).

5.2 *Torsional Moment Test (optional)*—A test method is provided in Appendix X1 for torsional moment capacity evaluation of hangers. This test consists of a joist supported by two joist hangers attached to headers (see Figs. X1.1 and X1.2). The movement of the joist with respect to the headers is measured and recorded to provide data for calculating angular rotation and load-deflection relationships.

**6. Apparatus**

6.1 *Testing Machine*—A testing machine that is capable of operation at a constant rate of motion of the movable crosshead or a constant rate of loading and a force-measuring device that is calibrated in accordance with Practices E4.

6.2 *Displacement Gage*—All tests shall use a dial gage(s), or equivalent, to measure the relative movement between the joist and header. Devices used for this purpose shall have a least reading of 0.001 in. (0.02 mm).

## 7. Test Materials

7.1 *Wood*—All wood materials shall be of structural quality with allowable values substantiated by accepted procedures, such as those found in Section 2. The specific gravity and moisture content of the joists and headers shall be determined in accordance with Test Methods D2395 and D4442 or ~~D4444~~ or D7438, respectively. All specific gravities shall be reported on an oven-dry basis in accordance with Test Methods D2395. Specific gravity measurements taken at moisture contents other than oven-dry shall be adjusted to the oven-dry moisture content in accordance with Appendix X1 of Test Methods D2395.

### 7.2 *Concrete or Masonry:*

7.2.1 If concrete is used, a minimum of two concrete test cylinders shall be prepared, stored, and cured in accordance with Practice C31/C31M from the same batch of concrete used in the joist hanger test specimen. Cylinders shall be tested in accordance with Test Method C39/C39M within 24 h of the test of the joist hanger.

7.2.2 If masonry is used, the compressive strength of the masonry shall be determined by the prism test method in accordance with Test Method C1314.

7.3 *Steel*—Standard tensile tests of the steel from which the joist hanger was produced shall be conducted in accordance with Test Methods E8.

7.4 *Fasteners*—Fasteners from the same ~~manufacturer's lot~~ manufacturer's lot as were used in the joist hanger test specimen shall be sampled in accordance with Guide F1470 to determine the fastener bending yield strength. Nails and wood screws shall be tested for bending yield strength in accordance with Test Method F1575. Bolts shall be tested in accordance with Test Methods F606 for the properties relevant to the application.

## 8. Sampling

8.1 Sampling shall provide for selection of representative test materials except where the tests are designed to specifically address use with particular grades, dimensions, wood species, or other condition. Properties of tested materials shall be permitted to exceed the minimum or nominal values of those properties reported in relevant specifications for that material provided the adjustments to tested results that are addressed in Section 13 ~~are made.~~ are made. Structural composite lumber and I-joist materials shall be chosen to represent the grade and species of each product type that conservatively represent the range of similar products to be addressed by each test set.

NOTE 1—It is not uncommon for SCL manufacturers to conservatively assign a design value for fastener performance for a product type (that is, parallel strand lumber, laminated veneer lumber, laminated strand lumber, etc.) that covers multiple species, process variables, and grades. Sampling SCL materials and components made thereof (that is, I-joist flange materials) from the species and grade mix that conservatively addresses the range for a given product type is one way to satisfy this requirement.

8.2 A minimum of three identical tests shall be performed for each selected hanger condition.

## 9. Test Setup

9.1 A joist hanger test setup shall consist of a joist supported between two headers by the hanger devices to be evaluated.

9.2 Headers shall have a length sufficient to provide the intended hanger-to-header contact for the hanger, for example, space for nailing and bearing as applicable. The minimum header length shall be 18 in. (457 mm). See Fig. 3.

9.3 Joist length shall be in accordance with Fig. 3.

9.3.1 Joist lengths shall be sufficient to prevent contact between joist hangers and any material other than the attached headers and joist. A minimum horizontal clear distance of 3 in. (76 mm) or  $\frac{1}{3}$  the joist depth, whichever is smaller, shall be provided between the load transfer block and the hanger seat. A minimum clearance of 0.125 in. (3.18 mm) shall be provided between each end of the joist and abutting material, such as the adjacent header or any hanger section between the header and the joist (see Fig. 4). Prior to loading, the 0.125 in. (3.18 mm) gap shall be maintained between joist and header by providing blocking, or equivalent, between the ends of the headers.

9.3.2 To minimize header-joist load transfer due to friction, a low friction material ~~such as teflon or polyethylene~~ with a thickness no greater than 0.063 in. (1.6 mm) shall be inserted into the 0.125 in. (3.18 mm) gap prior to loading.

9.3.3 The seat of the hanger shall be prevented from direct contact with the header during the test unless provisions are made to prevent the hanger seat from gouging into the header or the hanger seat shall be at or below the bottom of the header.

### 9.4 *Header Supports:*

9.4.1 Header supports shall provide sufficient bearing to prevent excessive crushing.

9.4.2 No portion of the joist hanger shall bear on any support other than the header during the test. This shall be accomplished by:

9.4.2.1 Using raised supports with a minimum header overhang of  $\frac{1}{8}$  in. (3.18 mm) at the inside edges (see Figs. 1-3), or

9.4.2.2 Using headers that are deeper than the joist by an amount sufficient to ensure that neither the joist nor the hanger contact the test bed.

9.4.3 The test bed or any header supports shall not contact the joist or joist hanger at any time during the test.

NOTE 1—A  $\frac{1}{8}$  2—A  $\frac{1}{8}$ -in. overhang of the header beyond the inside edge of the support has historically been provided to ensure contact does not occur between the joist hanger and the header support.

9.5 Reinforcement of joist members at the area of load application shall be permitted to prevent member failure in bending,

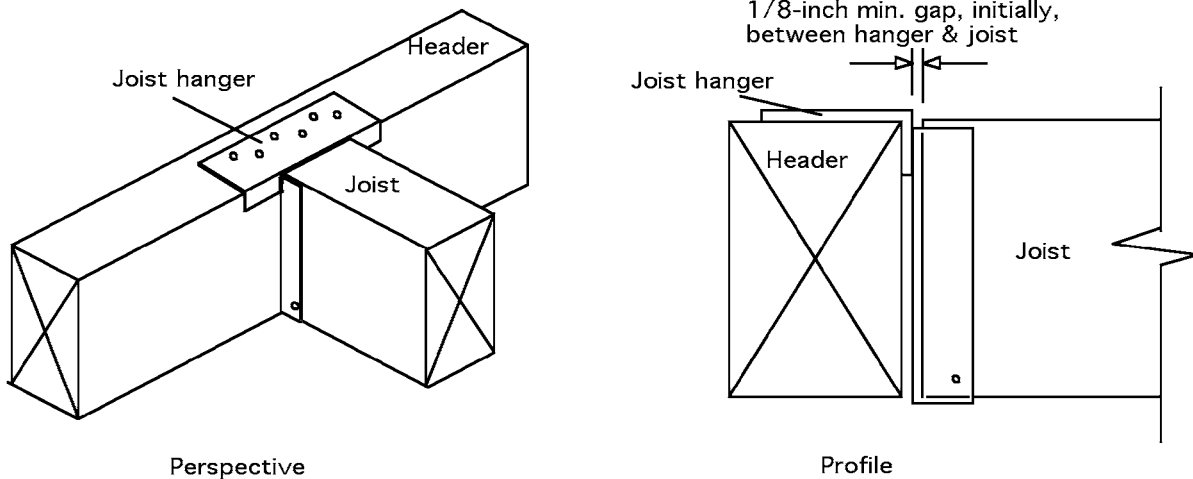


FIG. 4 Required Gap When Portion of Joist Hanger Exists Between Header and Joist

shear, or compression perpendicular-to-grain at the applied load, so as to produce a failure in the joist hanger, or of the fasteners between the joist hanger and the joist or header member(s) or a joist bearing failure at the hanger. The length of joist reinforcement shall be no closer than 2 in. (51 mm) from the end of each hanger.

9.6 Blocking between the headers or alternate methods shall be provided to prevent rotation of the headers inward towards the joist. Tensile reinforcement between the headers shall be permitted to prevent rotation of the headers outward away from the joist. Such reinforcement shall not contact the joist hangers or otherwise interfere with their performance.

9.7 Where a hanger device is of a design that is not adaptable to the test setup described above, necessary departures shall be permitted, provided the altered setup will perform the essential function of testing the joist hanger device, and provided that such departures are reported in the test report in detail.

## 10. Conditioning

10.1 Test specimens fabricated and tested with dimension lumber shall have a moisture content of not less than 11 % unless adjustments are made to test results in accordance with 13.2.

10.2 For structural composite lumber, structural glued-laminated wood and wood I-joist products, tests shall be made at a moisture content of no less than 7 %. When the member consists of different elements, such as an I-joist flange, a web, or other wood elements, or a combination thereof, moisture content shall be measured of all parts in contact with the joist hanger or its fasteners.

10.2.1 *Exception*—The moisture content of plywood and oriented strand board elements need not be measured.

## 11. Procedure

11.1 The following properties must be determined for materials used in the test:

- (1) tensile strength of hanger steel,
- (2) specific gravity of wood materials as outlined in 13.5.2-13.5.4, and
- (3) bending yield strength of the fasteners.

11.2 Vertical movement of the joist with respect to each header shall be measured with a minimum of two dial gages or other suitable device as depicted in Fig. 3. The dial gage shall measure movement of any point along the depth of the joist (top, bottom, or side) located within 1.5 in. (38 mm) from the end of the joist. Dial gage bases shall be attached to the bottom half of the header to the center of the gage base or attached to the test machine bed.

11.2.1 *Exception*—When the joist setup is inverted for uplift testing, the dial gage or other suitable device shall be located on the joist within 1 in. (25 mm) from the end of the hanger seat.

11.3 The load shall be centered over the joist and be transferred from the crosshead to the test specimen in a manner that will assure equal distribution of the load to both ends of the joist. The load shall be applied over a sufficient joist length to prevent excessive crushing under the loading head and shall conform to the requirements of Section 9.

11.4 For downward load capacity tests, an initial load, or preload, shall be applied to the joist to seat the test assembly. This preload shall not exceed 20 % of the ultimate load. This load shall then be removed and the dial gages shall be set to zero. The preload shall be recorded and reported for each test specimen.

11.5 An initial load, or preload, shall not be applied for uplift load capacity tests.

11.6 The load shall be applied at a uniform crosshead rate between 0.03 and 0.20 in. (0.8 to 5.1 mm) per minute. For all tests, the ultimate load shall not be reached in less than 5 min.

11.6.1 The loads shall be recorded to a precision of 1 % for loads exceeding 1000 lb and 10 lb for loads up to and including 1000 lb. The deflections shall be recorded to the nearest 0.001 in. (0.02 mm). A sufficient number of readings shall be taken to

permit determining the load at a deflection of 0.125 in. (3.18 mm).

11.7 Wood failure modes, such as joist bending failure and joist top surface crushing at the load transfer block, are unrelated to the performance of the joist hanger. When such failure modes occur, it shall be permitted to replace the tests that resulted in these failure modes with additional tests with appropriate reinforcement to prevent the reoccurrence of these failure modes.

## 12. Report

12.1 The test report shall follow the format of Practice E575, shall include a detailed drawing of the test setup, and shall include the following:

12.1.1 A description of the joist hangers tested including a drawing of the joist hangers showing all pertinent dimensions and material specifications, and a description of the required fasteners,

12.1.2 A description of the joist, headers, and any backer or filler blocking or stiffeners,

12.1.2.1 Actual dimensions, species, grades, specific gravities, moisture contents for each header, and joist of each assembly, including name of the manufacturer for proprietary products,

12.1.2.2 A description of any modifications made to the joist or headers used in the test assembly,

12.1.3 The measured hanger steel properties including yield strength, ultimate strength, and base metal thickness. The base metal thickness shall be permitted to be determined by subtracting the average measured coating thickness from the average measured overall thickness,

12.1.4 A description of the fasteners including the finish, head configuration, head diameter, and markings; the measured length, diameter; and strength properties required in 7.4,

12.1.5 A description of the concrete or masonry properties, including measured properties as required in 7.2, if concrete or masonry was used,

12.1.6 A description of the load transfer block, other blocking, low-friction materials, reinforcement, and any deviations from the standard test setup shown in Figs. 3 and 4,

12.1.7 Data on load-deflection, including the load at the 0.125 in. (3.18 mm) deflection limit, and the maximum test load observed,

12.1.8 Type and location of failure of the specimen,

12.1.9 Number of replications including a description of replications not used as allowed in 11.7,

12.1.10 Loading procedure details, including preload, load rate, and time to maximum load, and

12.1.11 Details of any deviations from the prescribed test setup and test procedures as outlined in this specification.

## 13. Allowable Joist Hanger Loads Limited by Test

13.1 Joist hanger design values limited by test shall be limited to the materials tested, except as otherwise provided in Section 13. For application to materials used in construction, the construction materials shall satisfy 13.1.1-13.1.4.

13.1.1 *Wood*—All wood materials shall be of structural quality with allowable values substantiated by accepted procedures, such as those found in Section 2.

13.1.2 *Steel*—All production steel material shall meet or exceed a specified minimum yield strength, a specified minimum ultimate strength, and a specified minimum thickness.

13.1.3 *Fasteners*—Fasteners used for field installation shall meet or exceed minimum specified cross-sectional dimensions (for example, diameter or width and thickness), length, other relevant dimensions, and relevant material properties.

13.1.4 *Concrete and Masonry*—All concrete and masonry materials shall have structural properties that meet or exceed a minimum specified compression strength.

13.2 Allowable loads for joist hangers based upon test shall be the lesser of the values determined in 13.3 and 13.4. Adjustments to test results shall be made in accordance with 13.5.

13.2.1 The results of all load tests except those tests excluded per 11.7 shall be used to determine the allowable load capacity of the joist hanger.

13.3 *Test Strength Limit:*

13.3.1 The ultimate load rating shall be the lowest ultimate load per joist hanger divided by 3.0 if less than six replicates are tested. The ultimate load rating shall be the average ultimate load per joist hanger divided by 3.0 when six or more replicates are tested. See 13.5 for adjustments to test results.

13.4 *Test Deflection Limit:*

13.4.1 For all vertical load tests, the load at 0.125-in. deflection shall be recorded for each hanger. The test deflection limit load shall be the average of all of these loads. The load at the specified deflection limit shall be permitted to be interpolated from the test data.

13.5 *Adjustments to Test Strength Limit:*

13.5.1 When the specific gravity of any member is greater than the average specific gravity for that species as listed in the “National Design Specification for Wood Construction” (NDS), or other approved source, the resulting test values shall be multiplied by the lowest of the adjustment factors determined in

13.5.1 The resulting test values shall be multiplied by the lowest of the adjustment factors determined in 13.5.2-13.5.4.

NOTE2—Many evaluation reports for SCL list an “equivalent” specific gravity for connections as a convenience for design. This should not be