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Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists[1]

This standard is issued under the fixed designation D5055; 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 *General*—This specification gives procedures for establishing, monitoring, and reevaluating structural capacities of prefabricated wood I-joists. Capacities considered are shear, reaction, moment, and stiffness. Procedures for establishing common details are given and certain design considerations specific to wood I-joists are itemized.

1.2 *Contents of the Standard*—An index and brief description of the main features of this specification are given in X1.1.1.

1.3 *Development of the Standard*—The development and intent of this specification is discussed in Appendix X1.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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.* A specific precautionary statement is given in 6.1.1.5.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D198 Test Methods of Static Tests of Lumber in Structural Sizes
D245 Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber
D1990 Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens
D2559 Specification for Adhesives for Bonded Structural Wood Products for Use Under Exterior Exposure Conditions
D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products
D4761 Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material
D5456 Specification for Evaluation of Structural Composite Lumber Products
D5457 Specification for Computing Reference Resistance of Wood-Based Materials and Structural Connections for Load and Resistance Factor Design
D7247 Test Method for Evaluating the Shear Strength of Adhesive Bonds in Laminated Wood Products at Elevated Temperatures
D7480 Guide for Evaluating the Attributes of a Forest Management Plan
E4 Practices for Force Verification of Testing Machines
E529 Guide for Conducting Flexural Tests on Beams and Girders for Building Construction
E699 Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components
IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System

2.2 *U.S. Product Standards:*[3]

PS-1 Structural Plywood
PS-2 Performance Standard for Wood-Based Structural-Use Panels
PS-20 American Softwood Lumber Standard

2.3 *Other Standards:*

CSA O86 Engineering Design in Wood[4]
CSA Standards for Wood Adhesives O112 Series[4]
CSA O121 Douglas-fir Plywood[4]
CSA O141 Softwood Lumber[4]
CSA O151 Canadian Softwood Plywood[4]

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[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 South 19th Street, Tacoma, WA 98466, http://www.apawood.org; and TECO, 2902 Terra Court, Sun Prairie, WI 53590, http://www.tecotested.com.

[4] Available from Canadian Standards Association (CSA), 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada, http://www.csa.ca.

CSA O325 Construction Sheathing[4]
CSA O437.0 OSB and Waferboard[4]
Lumber Grading Rules Approved by American Lumber Standards Committee (ALSC) or Canadian Lumber Standards Accreditation Board (CLSAB)[5]
SPS-1 Fingerjoined Structural Lumber[6]
SPS-4 Fingerjointed Flange Stock Lumber, 2001[6]
ISO/IEC 17020 General Criteria for the Operation of Various Types of Bodies Performing Inspection[7]

3. Terminology

3.1 *Definitions:*

3.1.1 *prefabricated wood I-joist*—a structural member manufactured using sawn or structural composite lumber flanges and structural panel webs, bonded together with exterior exposure adhesives, forming an "I" cross-sectional shape. These members are primarily used as joists in floor and roof construction.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capacity (or structural capacity)*—the numeric result of certain calculations specified in this specification.

3.2.2 *design value*—the numeric value claimed by the manufacturer as appropriate for use in structural analysis.

NOTE 1—A brief discussion of this issue is found in X1.9.

3.2.3 *structural composite lumber*—a composite of wood elements (for example, wood strands, strips, veneer sheets, or a combination thereof), bonded with an exterior grade adhesive and intended for structural use in dry service conditions.

4. Design Considerations

4.1 *Design Value Adjustments:*

4.1.1 *Duration of Load*—With the exception of reaction design values limited by compression perpendicular to grain, prefabricated wood I-joists shall be designed using the strength adjustment for load duration used in sawn lumber. This adjustment is determined in accordance with the section on Duration of Load Under Modification of Allowable Properties for Design Use in Practice D245.

4.1.2 *Repetitive Members*—The repetitive member factor for prefabricated I-joists shall be taken as 1.0.

NOTE 2—Committee D07 chose to reduce the repetitive member factor to unity primarily for purposes of design simplicity. A discussion of this decision is given in Appendix X1.

4.1.3 *Treatments*—Some pressure treatments affect material strength and the quality of prefabricated wood I-joists. Treated I-joists shall not be used without evaluation of such effects.

4.1.4 *Environment*—The capacities developed in this specification are applicable to joists used under dry conditions such as in most covered structures. Appropriate adjustments for uses in other environments shall be made.

4.2 *Shear Design:*

4.2.1 Neglecting loads within a distance from the support equal to the depth of the member shall not be permitted.

4.2.2 Adjustments to the shear design value near the support or at locations of continuity or where reinforcements are provided must be substantiated by independent testing to the general intended criteria for shear capacity herein.

5. Materials

5.1 *General*—The following I-joist components meet the definition of a biobased product in accordance with 3.3.1 of Guide D7480:

5.1.1 Lumber flange materials complying with USDOC PS-20, CSA O141, NLGA SPS-1, or NLGA SPS-4.

5.1.2 Structural composite lumber flange materials complying with Specification D5456.

5.1.3 Web materials complying with USDOC PS-1, USDOC PS-2, CSA O121, CSA O151, CSA O325, or CSA O437.0.

5.2 *Flange Stock:*

5.2.1 All flange material shall conform to the requirements of 6.4. In addition, when the flange material is structural composite lumber, the following properties shall be determined in accordance with Specification D5456: modulus of elasticity (flat or edge, depending on flange orientation in the I-joist), compression (parallel and perpendicular to grain), and nail design values.

5.2.2 End joints in purchased flange stock are permitted provided such joints conform to the general intent and Section 10 of this specification.

5.3 *Web Material*—Panels shall conform to manufacturing or performance standards recognized by the applicable governing code. Examples are PS-1 (or CSA O151) and PS-2 (or CSA O325). In addition, all panels shall meet the equivalent of Exposure I requirements as specified in PS-1 or PS-2.

5.4 *Adhesives*—Adhesives used to bond together components of the finished product shall conform to the requirements in Specification D2559 (or, in Canada, shall conform to an appropriate standard from the CSA Standards for Wood Adhesives, O112 Series, stipulated in CSA O86). In addition, adhesives used for web-to-web, web-to-flange, and flange-to-flange joints shall be qualified for heat durability performance in accordance with 5.4.3. Appendix X3 gives additional information and standards that shall be considered when qualifying adhesives and adhesive-bonded materials.

NOTE 3—Heat durable performance implies that a bonded joint will exhibit similar material resistance to solid wood in an elevated temperature environment where the wood material surrounding the joint does not provide thermal protection.

5.4.1 Adhesives and binder systems used in the fabrication of Structural Composite Lumber products shall be evaluated in accordance with Specification D5456.

5.4.2 Adhesives and binder systems used in the fabrication of panel products used as a web shall be evaluated in

[5] Available from American Lumber Standard Committee (ALSC), P.O. Box 210, Germantown, MD 20874, http://www.alsc.org; and Canadian Lumber Standards Accreditation Board (CLSAB), 960 Quayside Drive, Suite 406, New Westminster, BC V3M 6G2, Canada, http://www.clsab.ca.

[6] Available from National Lumber Grades Authority (NLGA), 302–960 Quayside Drive, New Westminster, BC V3M 6G2, Canada, http://www.nlga.org.

[7] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

accordance with PS-2 (or, in Canada, CSA O325) with the Exposure 1 classification.

5.4.3 *Adhesives*—Heat durability:

5.4.3.1 Adhesives used for web-to-web, web-to-flange, and flange-to-flange joints shall be qualified for heat durability performance through testing in accordance with Test Method D7247. The test temperature and heat exposure duration for specimens tested at elevated temperature (7.2 of Test Method D7247) shall meet the requirements of Items 1, 2, and 3 below.

(1) For the bonded specimens, the minimum target bondline temperature shall be 428°F (220°C). For the matched solid wood control specimens, the minimum target temperature at the shear plane shall be 428°F (220°C).

(2) The minimum target temperatures of Item 1 shall be maintained for a minimum of 10 min or until achieving a residual strength ratio for the solid wood control specimens of 30 ± 10 %, whichever is longer.

(3) Block shear testing shall be conducted immediately after removal from the oven such that the specimen bondline or shear plane temperature does not drop more than 9°F (5°C) after leaving the oven and prior to failure. This provision is satisfied when the time interval from the removal of the specimen from the oven to the failure of the block shear specimen does not exceed 60 s for each specimen tested and the room temperature of the test laboratory at the time of testing is not less than 60°F (15.5°C).

5.4.3.2 For adhesives tested in accordance with 5.4.3.1, the residual shear strength ratio for the bonded specimens, as calculated in accordance with Test Method D7247, shall be equal to or higher than the lower 95 % confidence interval on the mean residual shear strength ratio for the solid wood control specimens.

6. Qualification

6.1 *General*—This section describes procedures, both empirical and analytic, for initial qualification of the structural capacities of prefabricated wood I-joists. Qualification is required for certain common details of I-joist application since they often influence structural capacities. All capacities are to be reported with three significant digits. Any time significant changes in joist or application details, manufacturing processes or material specifications occur, qualification is required, as for a new manufacturer or product line.

6.1.1 *Testing*—Qualification tests shall be conducted or witnessed by a qualified agency as defined in 8.1. All test results are to be certified by the qualified agency.

6.1.1.1 *Sample Size*—The number of specimens specified in 6.2, 6.3, 6.4, 6.5, and 6.6 are minimums. The producer wishing to evaluate the validity of the sample size will find a procedure in 4.7 of Practice D2915.

6.1.1.2 *Test Specimens*—Materials and fabrication procedures of test specimens shall be as typical of intended production as can be obtained at the time of manufacturing qualification specimens. Minimum specimen temperature at the time of test shall be 40°F (4°C). Specimens shall be tested at the as-received moisture content.

NOTE 4—It is desirable to conduct preliminary tests to aid the selection of representative specimens.

6.1.1.3 *Test Accuracy*—Tests in accordance with this specification are to be conducted in a machine or apparatus calibrated in accordance with Practices E4 except that the percentage error shall not exceed ±2.0.

6.1.1.4 *Test Methods*—Methods generally applicable to the full-section joist tests required herein are in Guide E529, with the following exceptions: (*1*) the methods are applicable to both qualification and quality control, (*2*) load rate shall be as specified in the following sections, and (*3*) delays between load increments are not required. Required tension and compression tests shall be substantially in accordance with Test Methods D198 or Test Methods D4761 with load rates as specified in the following sections. All test report formats and content shall be in keeping with the intended use of the results and be agreed upon by all involved parties prior to the test.

6.1.1.5 *Test Safety*—All full-scale structural tests are potentially hazardous and appropriate safety precautions must be observed at all times. One particular concern is the potential for lateral buckling during full-section I-joist tests and appropriate lateral restraint must be maintained at all times.

6.2 *Shear Capacity Qualification:*

6.2.1 Initial capacity shall be established from either test results or calculations. The equations used for the calculation method shall be confirmed by a test program; the details of which are beyond the scope of this specification. Explanations of the statistics used in the analysis of test results, with an example, are given in Appendix X4.

6.2.2 Factors which influence shear capacity include web type, thickness, and grade; web to flange joint; joint type in web (machined, butted, glued or not, reinforced, etc.). Each combination of these web factors must be tested separately in accordance with 6.2.3, unless the critical combination in a proposed grouping is first established by test. Flange stiffness influences shear strength: if a range of flange sizes is to be used with a given combination of web factors, all sizes must be tested unless all values are to be based on tests with the smallest flange. When a range of species or grades of either sawn or composite lumber is to be grouped, preliminary tests shall be conducted to determine which is critical. Joists with structural composite lumber flanges, such as laminated veneer lumber (LVL), must be tested separately from joists with sawn lumber flanges.

6.2.3 For each web factor combination, a minimum of ten specimens shall be tested for each critical joist depth. Critical joist depths are minimum and maximum product depths with approximate 4-in. (102-mm) depth increments between. If the installation of specific reinforcement as defined in the manufacturer's literature is required at a certain depth to maintain product performance in the progression of a series of depths within a combination, the product must be tested at this depth plus the adjacent depth which does not require specific reinforcement.

6.2.4 Specimen length shall be that which usually produces failures in shear and shall not extend past each bearing support more than ¼ in. (6.4 mm). The bearing length shall be adequate to usually produce shear failure instead of a bearing failure but shall not exceed 4 in. (102 mm), unless justified.

There shall be a minimum horizontal distance of 1½ times the joist depth between the face of the support and the edge of the load pad.

6.2.5 On one end of the specimen, a vertical web joint, if used, shall be located approximately 12 in. (305 mm) from the face of the support or ½ the distance between the support and the load pad.

6.2.6 The load shall be applied to the top flange either as a single point load at center span or as two point loads of equal distance from the center span. Load pads shall be of sufficient length to prevent local failure.

6.2.7 The load shall be applied at a uniform rate so that anticipated failure will occur in not less than 1 min.

6.2.8 Any required web reinforcements developed in 6.7.1 shall be installed at supports. When required to prevent failure at a load point, additional reinforcement shall be installed, provided such reinforcement is not wider than the load pad.

6.2.9 Ultimate load and mode of failure shall be recorded in addition to product and test setup descriptions. If any specimen fail in bending, the data shall be excluded. However, for purposes of evaluating shear capacity, bearing failure is considered a mode of shear failure. Appendix X5 discusses some of the modes of shear failure and offers a possible coding scheme.

6.2.10 The dead load of the specimen is to be included in the ultimate load calculation when specified by the producer.

6.2.11 The mean ultimate shear values shall show logical progression of strength as a function of depth. A linear regression analysis of the mean values shall have a coefficient of determination (r^2) of at least 0.9, or the specified tests of 6.2.3 must be repeated. If the second test set fails to meet the criteria, all depths which have been skipped must also be tested. (A check of the regression criteria is given in X4.4.5.)

6.2.11.1 Data from joist depths where failure is web buckling shall be excluded from the regression analysis, if: (*1*) including the results causes failure to meet the criteria of 6.2.11; or (*2*) the producer determines the reduction in regression line slope is unacceptable. In either case, all depths greater than the shallowest excluded, shall be tested.

NOTE 5—Depending on joist details and material, there will be some depth where web buckling appears as a mode of failure. Further increases in depth will result in consistent web buckling, and at some point ultimate strength will reduce compared to shallower joists.

6.2.11.2 When no more than three depths are to be qualified, the correlation is not necessary, but each depth must be tested.

6.2.12 The shear capacity of the product shall be limited to that calculated by taking into account sample size, test result variability, and reduction factors. Data from tests at different joist depths included in regression analysis are permitted to be combined to obtain a pooled estimate of variability.

6.2.12.1 *Combining Data*—The regression equation from 6.2.11 provides the expected mean shear strength (P_e) for depth (d_i):

$$P_e = A + Bd_i \tag{1}$$

where A and B are intercept and slope of the equation.

6.2.12.2 Where too few depths are involved for correlation in 6.2.11, when the tests fail the regression criteria, or where depths are excluded from the correlation, no combining is allowed and each such depth shall be evaluated separately.

6.2.12.3 The mean and standard deviation of the data from each depth tested are ($\bar{P}_i$) and (S_i). The coefficient of variation is:

$$v_i = S_i / \bar{P}_i \tag{2}$$

Let n_i be the number of tests for each depth (d_i) tested and included in the regression analysis. Then the coefficient of variation in the combined data sets is:

$$v = \sqrt{\frac{\sum[(n_i - 1)\, v_i{}^2]}{\sum n_i - J}} \tag{3}$$

Where J is the number of depths included in the regression analysis and the summation is from $i = 1$ to J.

6.2.12.4 *Shear Capacity*—The shear capacity is calculated as follows:

$$P_s = C\,(P_e - KvP_e)/2.37 \tag{4}$$

where:

K = factor for one-sided 95 % tolerance limit with 75 % confidence for a normal distribution. Values for this factor are given in Appendix X4, Eq X4.20, and Table X4.3;
P_e = ultimate mean shear strength from Eq 1 or the mean of any depth in accordance with 6.2.12.2;
v = coefficient of variation of combined data from Eq 3 or, in accordance with 6.2.12.2, from Eq 2 when any depth is evaluated alone;
C = product of any appropriate special use reduction factors from Appendix X6; and
P_s = shear capacity.

6.2.12.5 When data are combined, the factor K is based on a sample size $N = \sum n_i - J$. When the criteria of 6.2.11 are not met and for depths excluded from the regression analysis, then the allowable shear capacity is computed separately for each such depth and is:

$$P_s = C\left(\bar{P}_i - Kv_i\bar{P}_i\right)/2.37 \tag{5}$$

and the factor K is for a sample size of n_i. A discussion of the reduction factor (2.37) is given in Appendix X6.

6.3 *Reaction Capacity Qualification*—Reaction capacity shall be determined in accordance with Annex A1.

6.4 *Moment Capacity Qualification*—Moment capacity shall be determined either analytically from the characteristics of flange material (6.4.1) or empirically from the results of I-joist bending tests (6.4.3).

6.4.1 *Analytical Method:*

6.4.1.1 In this method, the I-joist moment capacity is determined as follows:

$$M_a = K_L F_a A_{net} y \quad (6)$$

where:

K_L = length adjustment factor, computed in accordance with 6.4.1.5. The factor adjusts flange material F_a as a function of joist span and stress. Joist depth, tension test gage length, finger joint spacing, and material or joint variability are utilized in determining K_L;
A_{net} = net area of one flange (excluding areas of all web material and rout);
y = distance between flange centroids (with the rout removed); and
F_a = design flange axial stress, taken as the lower of flange tensile stress adjusted to the reference gage length or end joint tensile stress computed in accordance with 6.4.1.4, or flange compressive stress computed in accordance with 6.4.1.6.

NOTE 6—The assessment of axial stress on the basis of average stress at a given cross section matches committee judgment and experimental evidence based on joists in which the thickness of an individual flange is less than approximately one sixth of the overall joist depth. For joists not meeting this criterion, additional consideration of extreme fiber stresses may be needed.

NOTE 7—The information in this specification is not intended to be limited to the allowable stress design (ASD) format. Provided that appropriate scaling of design values is completed (from ASD to the limit states design (LSD) or load and resistance factor design (LRFD) format) in accordance with applicable standards.

6.4.1.2 *Flange Material Types*—Flange materials fall into one of the following three categories:

(1) Standard Lumber Grades; Standard Lengths—Flanges utilizing nominal 8-ft (2.44-m) and longer sawn lumber of a standard grade permitted by the governing code and graded under standards recognized by American Lumber Standards Committee (ALSC) or Canadian Lumber Standards Accreditation Board (CLSAB). The tabulated allowable tension value, F_t, is assumed to be based on a 12-ft (3.66-m) gage length. End joints, when used, shall be qualified in accordance with 6.5.

(2) Nonstandard Grades; Standard Lengths—Flanges utilizing nominal 8-ft (2.44-m) and longer structural composite or sawn lumber, but not meeting the standard grade criteria of 6.4.1.2 (*1*). Qualification testing and analysis shall be in accordance with 6.4.1.3 and 6.4.1.4. End joints, when used, shall be qualified in accordance with 6.5. Alternatively, a single end joint, when used, shall be permitted to be included within the gauge length of each flange specimen when tested in accordance with 6.4.1.3. To use this alternative method, the minimum end-joint spacing permitted in application and used to determine L_1 in 6.4.1.5 shall be the tested gauge length.

(3) Any Grades; Short Lengths—Flanges utilizing structural composite lumber or sawn lumber in lengths shorter than 8 ft (2.44 m) before end jointing. Qualification testing and analysis shall be in accordance with 6.4.1.3 and 6.4.1.4. Qualification specimens shall be used to establish a characteristic (that is, average) joint spacing as noted in Eq 7. Average joint spacing in individual flanges in the qualification sample shall not be less than 75 % of the established characteristic joint spacing. The characteristic joint spacing established during qualification shall be maintained in subsequent production.

$$L_J = L/N \quad (7)$$

where:

L_J = characteristic joint spacing,
L = total length of flange in the gage length for the qualification sample, and
N = total number of joints in the gage length for the qualification sample.

6.4.1.3 *Tension Tests*—For flange material conforming to 6.4.1.2 (*2*) or (*3*), tension tests parallel to grain shall be conducted on a gage length (distance between grips) of not less than 8 ft (2.44 m) for sawn lumber and 3 ft (0.91 m) for structural composite lumber. When flanges utilize sawn lumber or structural composite lumber less than 8 ft long, the characteristic end joint spacing for the qualification sample shall comply with the provisions of 6.4.1.2 (*3*). Testing speed shall be in accordance with 28.3 of Test Methods D4761. The minimum sample size shall be 53. The flange material variability (coefficient of variation) and tension gage length shall be reported.

NOTE 8—SPS-4 provides alternative methods which comply with the intent of characteristic joint spacing and minimum gage length provisions of 6.4.

6.4.1.4 *Capacity*—The tensile capacity shall be the lower 5 % tolerance limit with 75 % confidence, divided by 2.1. The lower 5 % tolerance limit shall be established with 75 % confidence using either parametric or nonparametric procedures; however, if parametric procedures are adopted, an appropriate analysis used to confirm the type of distribution must be presented. Minimal evidence that a distribution fits the data shall consist of a cumulative plot of the data with the chosen distribution superimposed on the data. The latter shall be either a curve as shown in Fig. X4.1 or a linearized plot as shown in Fig. X4.5.

6.4.1.5 The length adjustment factor K_L is the lesser of 1.0 or the value computed as follows:

$$K_L = K_S \left(L_1/L\right)^Z \leq 1.0 \quad (8)$$

where:

K_L = length adjustment factor;
K_S = stress distribution adjustment factor (adjusts design flange axial stress (F_a) from full-length constant stress (such as a tension test) to the reference stress condition = 1.15;
L_1 = gage length, (in.). For 6.4.1.2 (*1*) utilizing flange stress, L_1 = 144 in. (3658 mm). For 6.4.1.2 (*2*) utilizing flange stress, L_1 = distance between tension tester grips. For 6.4.1.2 (*3*) utilizing flange stress, L_1 = distance between tension tester grips. For 6.4.1.2 (*1*) and (*2*) utilizing end joint stress, L_1 = minimum end joint spacing allowed in the I-joist;
L = joist span = 18 times the joist depth (in.); and

Z = exponent for Eq 8 in accordance with Table 1.

NOTE 9—K_L is not intended for use as an adjustment factor for specific application lengths. It is a modifier for assigning design I-Joist moment capacity by depth. (See Eq 6.)

6.4.1.6 Values for compression shall be established by testing the material in tension and assigning a value in compression such that:

$$F_{ci} = F_{ti}(F_c/F_t) \quad (9)$$

where:

F_t = closest assigned code value in tension for same species and size as tested pieces;
F_c = code assigned value in compression for same grade, species, and size as F_t visual grades;
F_{ti} = tensile value as determined in 6.4.1.3; and
F_{ci} = allowable stress in compression.

If F_{ti} is larger than the highest value given in tables of visual grade lumber for the species, then the ratio of tension to compression shall be from tables for the nearest machine stress rated (MSR) lumber grade.

6.4.2 *Analytical Method Confirming Tests:*

6.4.2.1 It is required that a minimum of ten I-joist specimens be tested at each of the extremes of flange size, allowable stress, and joist depth. This testing is not intended to substantiate the moment capacity determined in 6.4.1, but is considered necessary for any new product to generally confirm the overall performance of the assembled components. This testing is also necessary to satisfy the requirements of 6.6.

6.4.2.2 Test setup and procedures shall conform to the requirements of 6.4.3, except that loading may simulate uniform load with load points spaced no greater than 24 in. (610 mm) on center. In addition, the maximum permitted web hole specified in 6.4.3.2 is optional.

6.4.2.3 Any specimen failing at a calculated maximum moment of less than 2.1 times the calculated capacity indicates the possibility of errors in manufacturing, material selection, or calculation. The reason for such failures shall be carefully evaluated and probable cause determined. Further testing shall be conducted as indicated in 6.4.2.4 and 6.4.2.5.

6.4.2.4 If the determined probable cause identified in 6.4.2.3 results in manufacturing or design changes of the product, retesting shall be conducted in accordance with 6.4.2.1.

6.4.2.5 If a probable cause is not found and the low result cannot be attributed to errors that can be corrected, further testing shall be conducted. A minimum of 10 additional samples for parametric analysis or 43 additional samples for nonparametric statistics shall be tested. The tested moment capacity shall be the lower 5 % tolerance limit with 75 % confidence divided by 2.1. To confirm the analytical method, the tested moment capacity shall be greater than or equal to the calculated moment capacity determined in 6.4.1.1.

NOTE 10—Although it is unlikely that in a ten-specimen confirming test of a controlled manufacturing process, a result below 2.1 times the calculated capacity will be encountered, it is statistically possible that such a specimen could appear. Increasing the sample size and applying parametric or nonparametric procedures to analyze the data will determine if changes to the analytical moment capacity are needed. (See commentary in X1.5.3.)

6.4.3 *Empirical Method:*

6.4.3.1 *Test Procedure*—Bending tests are to be conducted on a span of 17 to 21 times the joist depth. Two point loads are to be placed symmetrically about the center and the spacing between such load points shall be a minimum of one third of the span. Joists shall be reinforced under the load points when necessary to prevent local failure. Load rate shall be adjusted to produce failure in not less than 1 min. Maximum moment in the specimen and the location of failure shall be recorded.

NOTE 11—A span to depth ratio of 18 is a frequent international practice.

6.4.3.2 *Specimens Tested*—Specimens shall be typical of intended production. Each flange material, grade, dimension, species and supplier, combined with each web type, thickness and grade, shall be tested. Procedures for evaluating materials from each supplier shall be addressed in the manufacturing standard. One method of evaluation is shown in X1.1.1.8. When flanges contain end joints, such joints shall have been qualified in accordance with 6.5.1, and all bending test specimens shall include at least one joint in the tension flange located between the load points. When holes are allowed in the web in accordance with 6.7, the maximum permitted hole shall be located approximately at the center of the span. Sufficient bearing length or reinforcement, or both, shall be provided at supports to prevent bearing failures.

6.4.3.3 *Remanufactured Solid Sawn Flanges*—When flanges utilize remanufactured lumber, the specimens tested shall be typical of the specifications in the manufacturing standard in accordance with 9.1.1.1.

NOTE 12—It is strongly recommended that plant personnel performing regrading activities be trained by an agency under an accreditation program such as the ALSC.

6.4.3.4 *Sample Size and Analysis*—For qualification, a minimum of 28 specimens are required in each tested depth. Testing shall be at joist depth intervals no greater than 3 in. (76 mm), with a minimum of four depths tested, including the minimum and maximum joist depths. The mean ultimate moment capacities shall show logical progression as a function of the depth squared. A linear regression analysis of the mean values shall have a coefficient of determination (r^2) of at least 0.9. If the manufacturer produces less than 4 depths, 53 specimens of each depth shall be tested, but the requirement for a coefficient of determination shall not apply. Moment capacity shall be based on the lower 5 % tolerance limit with 75 % confidence, divided by 2.1. Nonparametric statistics shall be used to determine the tolerance limit and confidence unless justification is presented for using parametric procedures. Joist depths not tested shall be assigned capacities based on a logical progression of the depth squared between values assigned at the nearest depths tested to either side.

6.5 *End Joint Qualification:*

6.5.1 *Standards*—Adhesives used in joints shall conform to the requirements of 5.4.

6.5.2 *Testing*—Tension tests parallel to grain, on full-section joints, shall be conducted on a gage length (distance between grips) of not less than 2 ft (0.61 m). Testing speed shall be in accordance with 28.3 of Test Methods D4761. The minimum sample size shall be 53. The design stress shall be determined from 6.4.1.4. End joint variability (coefficient of variation) shall be reported.

6.5.3 *Requirements*—Joints in any flange material shall conform to this specification, with particular reference to Section 10 when applicable.

6.6 *Stiffness Capacity and Creep:*

6.6.1 *Tests*—The tests of 6.4.2 or the first ten tests at the extremes of depth in accordance with 6.4.3 shall be used to confirm stiffness capacity and evaluate creep characteristics. Center span deflection measurements shall be recorded at a minimum of four increments to 1½ times expected moment capacity at time of qualification.

6.6.2 *Stiffness Capacity*—Any formula which accurately predicts the effects of both bending and shear deformation is permitted to be used. The equation must be adjusted when the mean of the ratios of test deflections at moment capacity load (determined from a least square line fitted through the data points), to predicted deflection is more than $1.0+S/\sqrt{N}$, where S is the standard deviation of the ratios of test to predicted deflections and N is the total number of deflection tests conducted.

NOTE 13—Usually, a required adjustment will be applied only to the flange modulus of elasticity (MOE) used in the equation. For stiffness-limited applications of I-joists, the largest percentage of deflection is typically attributed to bending, and because of the section geometry, the principle elastic modulus is that of the flange material. Therefore, here and in Sections 9 and 11, emphasis is placed on the flange MOE.

6.6.2.1 *Elastic Properties*—Mean values are to be used in the deflection equation (*1*) when flange modulus of elasticity cannot be obtained from tables of recognized values, it shall be obtained from tests of the flange material used to establish moment capacity in accordance with 6.4.1; or (*2*) when moment capacity is determined in accordance with 6.4.3, the flange MOE shall be obtained from tables of recognized values or tests of the flange material. (*3*) Elastic properties of the web material shall be obtained from the appropriate standard.

6.6.3 *Creep*—Two of the I-joist specimens shall be loaded to 20 % of their moment capacity and center-span deflection readings taken. For purposes of this test, 20 % is assumed to be typical basic dead load (BDL). The specimen shall then be loaded to 1½ times the moment capacity for 1 h and deflection readings taken. The specimen shall be unloaded to BDL and deflection readings shall be taken after 15 min. The specimens must recover an average of 90 % of the total deflection from BDL to the end of the 1-h load period.

6.7 *Details of End Use:*

6.7.1 The intent of this section is to define common application details. In addition to the following minimum considerations, other details which affect application performance shall be investigated (for example, minimum nail spacing to avoid splitting).

6.7.2 *Web Openings:*

6.7.2.1 Holes which remove a significant portion of the web will reduce shear strength at that section of the I-joist. Tests are to define such reductions for varying size and shape openings so that in application, openings can be located at sections subjected to appropriate shear levels. A minimum of five specimens of at least three depths encompassing the product range shall be tested for each depth/opening combination. Test specimens and setup are permitted to be the same as specified in 6.2 with an opening located between support and load points and centered on a web joint, when web joints exist in the product.

6.7.2.2 Maximum size hole which can be located anywhere in the web, shall be specified by the manufacturer and supported by data.

6.7.2.3 Spacing of allowed multiple holes must be verified by test.

6.7.3 *Special Details*—Depending on joist configuration, concentrated loads require local reinforcement. Loads supported by connection to the web or applied to the bottom flange require special consideration and appropriate details. These and other special conditions of application require appropriate evaluation and testing to ensure the safety provisions of this specification are maintained.

7. Design Values

7.1 *Design Value Limited*—Design values are determined from the analysis and capacities as specified in this specification. In no case shall a design value exceed the capacity determined in Sections 6 or 11. (See definitions of capacity and design value in 3.1.1.)

7.2 *Design Value*—It is the responsibility of the I-joist producer to determine design values. Judgment is required particularly when assessing design values from qualification tests. Design values shall consider potential low-line lot capacities to avoid marginal application performance or uneconomical reject rates in the quality assurance program.

8. Independent Inspection

8.1 A qualified agency shall be employed by the manufacturer to audit the quality assurance program and inspect the production process of the plant without prior notification or with minimal prior notification. The audit and inspection shall include review and approval of the plant's quality assurance program and inspection of randomly selected products and QC data. When production is sporadic, the qualified agency shall communicate with the manufacturer to schedule inspections to coincide with production.

8.2 A qualified agency is defined as one that:

8.2.1 Has been accredited by an International Accreditation Forum (IAF) accreditor as meeting ISO/IEC 17020 requirements;

8.2.2 Has trained technical personnel to verify that the grading, measurement, species, construction, shaping, bonding, workmanship, and other characteristics of the products as determined by inspection, sampling, and testing comply with all applicable requirements specified herein;

8.2.3 Has procedures to be followed by its personnel in performance of the inspection and testing; and

8.2.4 Has no financial interest in, or is not financially dependent upon, any single company manufacturing the product being inspected or tested;

8.2.5 Is not owned, operated, or controlled by any such company.

9. In-House Quality Assurance

9.1 *Manufacturing Standard:*

9.1.1 A manufacturing standard shall be written and maintained for each product and each production facility and shall be the basis for the qualified agency's specific inspection at that location. As a minimum, it shall include the following:

9.1.1.1 Material specifications, including incoming inspection and acceptance requirements, and specifications for regrading flange stock when applicable,

9.1.1.2 Process controls for each operation in production of the product,

9.1.1.3 Quality control, inspection and testing procedures, and frequencies, and

9.1.1.4 Finished product identification, handling, protection, and shipping requirements.

9.1.1.5 When applicable, the minimum permitted flange joint spacing shall be specified.

9.2 *Inspection Personnel*—All in-house persons responsible for quality control shall demonstrate to the satisfaction of the qualified agency that they have adequate knowledge of the manufacturing process, of the inspection and test procedures used to control the process, of the operation and calibration of the recording and test equipment used, and of the maintenance and interpretation of quality control records.

9.3 *Record Keeping*—All pertinent records shall be maintained on a current basis and be available for review by both in-house and qualified agency inspection personnel. As a minimum, such records shall include:

9.3.1 All inspection reports and records of test equipment calibration whether accomplished by in-house or qualified agency personnel,

9.3.2 All test data, including retests and data associated with rejected production, and

9.3.3 Details of any corrective actions taken and the disposition of any rejected production, resulting from tests or inspections.

9.4 *Testing Equipment*—Testing equipment is to be properly maintained, calibrated, and evaluated for accuracy and adequacy in accordance with 6.1.1.3, at a frequency satisfactory to the qualified agency.

9.5 *I-Joist Quality Control Testing:*

9.5.1 *Objectives*—The following objectives are to be met simultaneously with the quality-control testing program:

9.5.1.1 Provide test data for use in maintaining and updating design values, and

9.5.1.2 Verify production process and material quality on a daily basis.

9.5.2 *Initial Quality Control*—When qualification is based on no more than the minimum testing required in this specification, the producer shall initiate higher test frequencies and retest levels. All new producers are advised to intensify quality control in early production.

9.5.3 *Required Tests*—The following shall be the scope of a minimum testing program:

9.5.3.1 Test methods shall be identical to those of Section 6.

9.5.3.2 The shear strength test described in 6.2 shall be used for quality control of shear strength. This test is required even if qualification is by calculation.

9.5.3.3 If flanges contain end joints qualified in accordance with 6.5, daily tension tests of full-section joints shall be conducted and failure loads recorded. The manufacturing standard must include the characteristic joint spacing that will be maintained in production. Durability tests of such joints are required only at such frequency as required to verify adhesive performance in accordance with 5.4.

9.5.3.4 When flange material is qualified by test in accordance with 6.4.1.2 (*2*) or 6.4.1.2 (*3*), the testing of that section shall be included in daily quality control tests. In all cases, QA provisions shall be established to maintain qualification strength.

9.5.3.5 When moment capacity is determined empirically, the test detailed in 6.4.3 shall be conducted as part of the daily quality-control program. All depths produced shall be tested in this program, and the tests shall include deflection measurement.

9.5.3.6 When the flange material does not have a modulus of elasticity assigned by the code, stiffness measurement of the material shall be part of the quality-control program.

9.5.4 *Data Collection and Analysis*—Test frequency, minimum test values, and rejection criteria for all tests of 9.5.3 shall be chosen to yield quality-control performance which is consistent with design values assigned to the product and its intended use.

10. Qualification and Quality Assurance of I-Joist Components Manufactured by Others

10.1 *Producer's Responsibility*—When the I-joist producer purchases material which would require qualification and quality control under the provision of this specification, the I-joist producer shall be responsible for assuring that, as a minimum, such material conforms to the requirements of Sections 6, 8, 9, and 11 of this specification.

10.2 *Record Keeping*—The I-joist producer shall obtain and maintain records of certification from the outside producer's qualified agency that the components supplied conform to the requirements of this specification.

10.3 *Identification*—All such components shall be appropriately marked as agreed upon between the component and I-joist producers.

11. Periodic Reevaluation of Structural Capacities

11.1 *Reevaluation Required*—Each capacity monitored by the required tests of 9.5.3 shall be reevaluated on a periodic basis. As a minimum, reevaluation shall be accomplished at the end of the first six months of production by any new manufacturer and for any new product line, and thereafter each such capacity shall be reevaluated and audited by the qualified agency at the end of each successive year of production.

11.1.1 *Reaction Capacity Reevaluation*—A one-time reevaluation of reaction capacity shall be accomplished at the end of the first six months of production by any new manufacturer and for any new product line. The reevaluation is to be based on data from specimens selected randomly throughout the six-month period and tested when convenient. Tests are to be conducted in accordance with 6.3.

11.1.2 *Regraded Solid Sawn Lumber Flanges*—As a minimum, reevaluation shall be conducted every six months for regraded solid sawn lumber flanges as described in 6.4.1.2. The testing shall be that specified in 9.5.3.4 and the test data shall be evaluated in accordance with 6.4.1.4.

11.2 *Minimum Data Base in Periodic Evaluation:*

11.2.1 *Shear and Flange Material Tests*—The minimum number of tests to be included in the analysis is that required for qualification in accordance with Section 6. When it becomes apparent that this requirement will not be met by the initial test frequency established, the frequency of testing shall be increased. Evaluation of test frequency shall be accomplished early in the evaluation period to ensure that test data is representative of production in the period and will be randomly accumulated at time intervals spaced throughout the period.

11.2.2 *Empirical Moment Capacity Tests*—Reevaluation shall be conducted every three months and the minimum number of tests required is that used for qualifying in 6.4.3. Test frequency in the period must be adjusted as necessary to ensure the minimum number of tests are met. If data on the full range of depths is not available, additional depths shall be selected and tested so that the data available is at least equal to that required in 6.4.3, except that if the coefficient of determination (r^2) is at least 0.9 as described in 6.4.3.4, the data for joists where the only change is depth may be combined provided a minimum of 112 tests are conducted every 60 production days, but in a period not to exceed 6 calendar months. Details of how suppliers are reevaluated shall be a part of the manufacturing standard.

11.3 *Data Analysis*—Data to be included in the analysis is that developed in the latest evaluation period from the testing specified in 9.5.3. Test data which was cause for rejection of a production lot shall be excluded, unless a reduced design value and associated reject level is to be established by the reevaluation. Also, with the agreement of the qualified agency, low test values related to any assignable and correctable cause which has been corrected, shall be excluded from consideration. Analysis of the data shall be identical to that of the applicable qualification section of this specification.

11.3.1 *Flange Strength Distributions*—Flange strength data from the period, including joint strength when applicable, shall be evaluated. If the coefficient of variation of production has increased by more than 1½ % since the last evaluation, the evaluation of 6.4.1.5 shall be repeated and design moment shall be adjusted or corrective action taken that is acceptable to the qualified agency.

11.4 *Adjustment of Design Value*—If the capacity determined in the analysis of 11.3 is less than the current design value, the design values must be reduced or corrective action taken that is acceptable to the qualified agency. When stiffness capacity is determined from flange material stiffness tests or joist bending tests, the comparison shall be between the mean of the tests in the period and the design value; the flange modulus of elasticity in the design equation shall be reduced proportionately when the current test mean is less than the design value.

12. Installation Instructions

12.1 Proper installation instructions or drawings shall accompany the product to the final job site. They shall include any special instructions required for the product, and weather protection and handling requirements. In cases where web reinforcement and attachment requirements, lateral support details, bearing or connection requirements, and web hole cutting limits are not covered by adequate general notes, standard sketches and charts shall be included with the installation instructions, or specific job drawings shall properly cover these requirements.

13. Identification

13.1 The product shall be clearly and properly identified by product name, company name or logo, plant location or number, qualified agency name or logo, and a means for establishing the date of manufacture.

ANNEX

(Mandatory Information)

A1. ESTABLISHING REACTION CAPACITIES FOR PREFABRICATED WOOD I-JOISTS

A1.1 Scope

A1.1.1 Annex A1 provides empirical procedures for establishing the reaction capacity of prefabricated wood I-joists. Derivation by an analytical model is beyond the scope of Annex A1.

A1.1.2 Explanations of the statistics used in the empirical analysis of test results, with examples, are given in Appendix X7 and Appendix X8.

A1.1.3 Annex A1 does not preclude the development of alternative reaction qualification procedures meeting the intent of Annex A1. Documentation showing equivalency to each of the qualification requirements in Annex A1 shall be provided and agreed upon with the manufacturer's qualified agency.

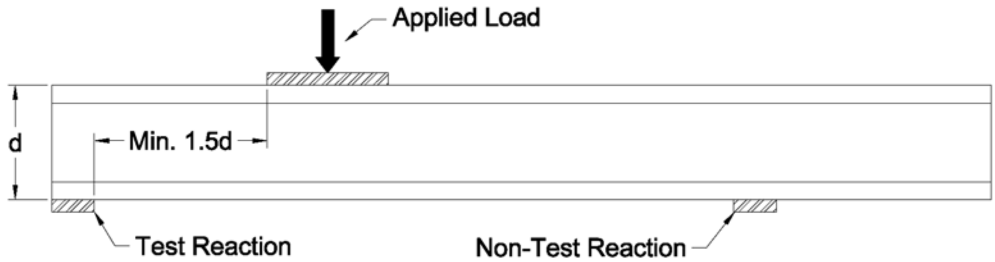

FIG. A1.1 End Reaction Test Set-up (non-symmetric set-up allows for two end-bearing tests per specimen)

A1.1.4 Annex A1 was developed in light of currently manufactured products, produced from materials defined in Section 5. New materials may require new or revised procedures to provide comparable levels of safety and performance.

A1.2 Wood I-Joist Reaction Capacity Qualification

A1.2.1 Factors that influence reaction capacity include bearing length, web (type, orientation, thickness, and grade), rout geometry, adhesive type, joist depth, and flange (type, size, species, and grade). Each combination of these factors should be tested separately according to A1.2.4, unless the critical combination is first established by test. Joists with structural composite lumber flanges must be tested and analyzed separately from joists with sawn lumber flanges.

A1.2.2 Qualification testing for both end and intermediate reaction capacity shall be undertaken and analyzed as independent test programs.

A1.2.3 The minimum sample size for either an end or intermediate reaction capacity qualification program shall be 40 for a series of I-joists with the same materials except for the joist depth. The test specimens shall be evenly divided into groups that represent the extremes of bearing length and joist depth to be qualified. Extrapolation beyond the tested extremes of bearing length and joist depth shall not be permitted.

NOTE A1.1—Bearing lengths less than 1.5 in. are not recommended due to concerns regarding construction tolerances and building code requirements.

A1.2.4 End and intermediate reaction capacity qualifications shall follow either the "Default" or "Regression-Based" procedures. Any data set that does not support the minimum coefficient of determination (r^2) requirement for a Regression-Based qualification shall be re-analyzed as a Default qualification.

A1.2.4.1 *Default Qualification*—A Default qualification shall be conducted by testing independent groups at the extremes of bearing length and joist depth to be qualified. Additional test groups are permitted to be added to the program provided that the minimum sample size in each additional group is 10 and the minimum sample size for the entire I-joist series is 40. Each group shall be analyzed independently to determine a design value using the procedures of A1.4.5.

NOTE A1.2—The following represent typical Default test programs that would meet the minimum sampling criteria to qualify a joist series for end or intermediate reaction capacity: four test groups with $n = 10$ at the extremes of bearing length and depth to qualify a range for both variables, two test groups with $n = 20$ when one bearing length will be qualified for a range of depths, and one test group with $n = 40$ when only a single bearing length and depth are qualified.

A1.2.4.2 *Regression-Based Qualification*—In a Regression-Based qualification, a manufacturer shall establish that reaction capacity is a linear function of bearing length. At a minimum, the test program shall include the shallowest and deepest joist depths to be qualified. At least three evenly spaced increments of bearing length (±10 %) shall be evaluated for each joist depth tested. Provided that the resulting regressions maintain a minimum r^2 of 0.9 for each joist depth, they may be reduced to a design equation using the procedures of A1.4.6.

NOTE A1.3—A typical Regression-Based test program to establish end or intermediate reaction capacity shall consist of six groups with $n = 7$ for each group. A minimum of three bearing lengths shall be tested at the maximum and minimum joist depths to be qualified. The data for each depth shall be combined using a linear regression to define reaction capacity as a function of bearing length at the extreme depths.

A1.3 Test Methods

A1.3.1 *End Reaction*—Specimens shall be tested according to either Fig. A1.1 or Fig. A1.2 . The test span shall be that which usually produces end reaction failures. Fig. A1.1 allows for one overhang no longer than ½ the test span. A single concentrated load shall be placed off-center toward the test reaction. This set up allows the joist to be turned end-for-end to perform a second test, with the failed end as the overhang for the second test. In Fig. A1.2, the load shall be applied at the center of the test span as either a single concentrated load as shown, or as two concentrated loads placed symmetrically about the center of the test span. Fig. A1.2 allows for only one test per specimen. For both Figs. A1.1 and A1.2, the applied load shall have a clear distance of at least 1.5 times the joist depth, *d* , between the inside face of the test reaction and the edge of the load pad. The load shall be applied at a uniform rate so that anticipated failure will not occur in less than 1 min. The I-joist specimens shall have bearing lengths and web stiffeners installed at the test reactions that are consistent with the end reaction condition to be evaluated. The reaction fixtures of the test frame shall be smooth, hard, and flat surfaces that are wide enough to provide full vertical support for the flange as it fractures without creating out-of-plane lateral interference that impacts the failure. The load pad shall be of sufficient length to prevent local failure under the load point. Additional web reinforcement is permitted at the load point and non-test reaction to prevent local failure provided the reinforcement is not wider than the length of the load pad or reaction surface. Out-of-plane lateral restraints may be provided for the flanges at the reactions and as necessary within the span to prevent a

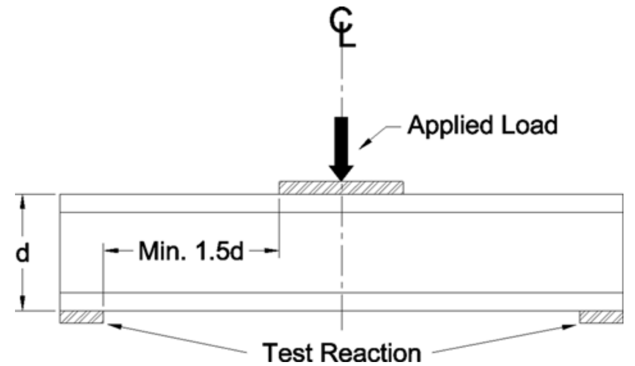

FIG. A1.2 End Reaction Test Set-up (symmetric set-up allows for one end-bearing test per specimen)

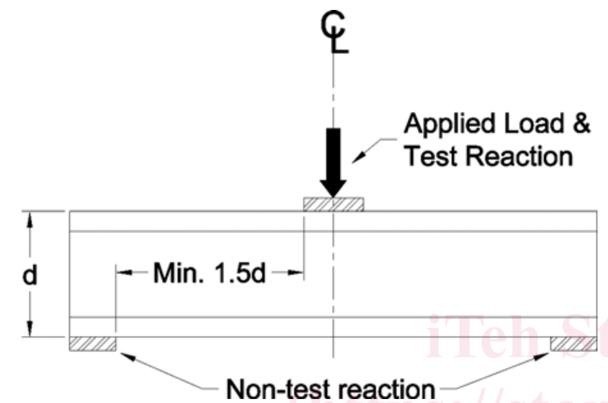

FIG. A1.3 Three-Point Intermediate Reaction Test Set-up

flange buckling failure. Lateral restraints shall not restrict the in-plane movement of the joist. Load cells shall record the test reaction (half the total applied load is appropriate for set-up shown in Fig. A1.2). Perforated knockouts (1½ in. maximum diameter) shall be randomly located within the joist specimen, as they would occur in application. Web-to-web joints are permitted to be randomly located when shear capacity is qualified using an independent test program. Otherwise, a web joint shall be positioned at the mid-point between the edge of the load and reaction plates.

A1.3.2 *Intermediate Reaction*—Specimens shall be tested according to either Fig. A1.3 or Fig. A1.4. The test span(s) shall be that which usually produces intermediate reaction failures. In Fig. A1.3, the load shall be applied at the center of the test span through a surface that represents the intermediate reaction condition to be evaluated. In Fig. A1.4, the loads shall be applied symmetrically about the test reaction through load pads of sufficient length to prevent local failure under load points. With both test setups, the I-joist specimens shall have bearing lengths and web stiffeners installed at the test reactions that are consistent with the intermediate reaction condition to be evaluated. The fixtures of the test frame at the test reactions shall be smooth, hard, and flat surfaces that are wide enough to provide full vertical support for the flange as it fractures without creating out-of-plane lateral interference that impacts the failure. For both Figs. A1.3 and A1.4, the applied load(s) shall have a clear distance of at least 1.5 times the joist depth, *d*, between the inside face of the reaction and the edge of the load surface. The load shall be applied at a uniform rate so that anticipated failure will not occur in less than 1 min. Additional web reinforcement is permitted at the non-test reactions and load points to prevent local failure provided the reinforcement is not wider than the length of the load or reaction surfaces. Out-of-plane lateral restraints may be provided for the flanges at the reactions and as necessary within the span to prevent a flange buckling failure. Lateral restraints shall not restrict the in-plane movement of the joist. Load cells shall record the test reaction (the sum of both reactions is appropriate for setup shown in Fig. A1.3). Perforated knockouts (1½ in. maximum diameter) shall be randomly located within the joist specimen, as they would occur in application. Web-to-web joints are permitted to be randomly located when shear capacity is qualified using an independent test program. Otherwise, a web joint shall be positioned at the mid-point between the edge of the load and reaction plates.

A1.3.3 Ultimate loads and modes of failure shall be recorded.

A1.4 Data Analysis

A1.4.1 Each end and intermediate reaction qualification data set shall be independently analyzed.

A1.4.2 Bending failures are permitted to be excluded from the data set. However, the minimum sample size provisions of A1.2.3 shall be maintained after any exclusion.

A1.4.3 The mean (P_i) and standard deviation (S_i) shall be calculated for each individual test group. The coefficient of variation (COV) for each group is defined as:

$$\nu_i = \frac{S_i}{P_i} \quad \text{(A1.1)}$$

A1.4.4 The analysis of data from either a Default or Regression-Based qualification require the COV from individual test groups be combined into a single COV as part of the design value derivation process as outlined in A1.4.5 and A1.4.6, respectively. No combined COV shall be less than the minimum permitted COV, ν_{min}. ν_{min} shall be equal to 0.10 for an end bearing qualification and 0.08 for an intermediate bearing qualification.

NOTE A1.4—Due to the limited qualification samples and lack of ongoing quality assurance requirements, the specified minimum coefficients of variation (ν_{min}) are intended to provide a rational coefficient of variation for I-joist reaction capacities and were established based on committee judgments.

A1.4.5 *Specific Analysis Provisions For a Default Qualification:*

A1.4.5.1 The combined COV for an end or intermediate reaction qualification data set shall be computed as:

$$\nu_d = \sqrt{\frac{\sum[(n_i - 1)\nu_i^2]}{\sum n_i - J_d}} \geq \nu_{min} \quad \text{(A1.2)}$$

where:

ν_d = combined COV for the end or intermediate reaction data set in a Default qualification,
n_i = sample size within an individual test group,
ν_i = COV for an individual test group,