Designation: D7033 – 14

Standard Practice for Establishing Design Capacities for Oriented Strand Board (OSB) Wood-Based Structural-Use Panels[1]

INTRODUCTION

Oriented strand board (OSB) wood-based structural-use panels have been used in a variety of applications since the 1970s. OSB panels manufactured for use in North America generally comply with U.S. Department of Commerce Standard PS-2. Panels that comply with PS-2 are subjected to various kinds of qualification performance testing and ongoing quality assurance testing. While many panel applications are specified simply on the basis of meeting a given "span rating" as defined in PS-2, some construction and specialty applications may require a complete set of engineering design values. Based on the structural tests required by PS-2 (flexure), along with data for other properties, a set of baseline capacities has been available since 1988. As is customary for structural-use panels, design values will be discussed in this practice in terms of design capacities rather than design properties, where the difference is that a design property is expressed in units of stress (that is, pounds-per-square inch) and a design capacity is expressed in the engineering units of strength (that is, inch-pounds of bending strength capacity, pounds of tensile capacity, and so forth). The term "design values" will be used generically and can apply to either properties or capacities.

As uses for OSB wood-based structural-use panels extend into new applications, it becomes increasingly important that manufacturers, qualified agencies, and regulatory bodies reference a set of common, consensus-based procedures for establishment of design values. The purpose of this practice is to provide these common procedures.

1. Scope

1.1 This practice covers the basis for code recognition of design capacities for OSB structural-use panels. Procedures are provided to establish or re-evaluate design capacities for OSB structural-use panels. Procedures for sampling and testing are also provided. Design values stated as capacity per unit dimension are to be regarded as standard. Design capacities developed in accordance with this practice are applicable to panels intended for use in dry in-service conditions.

NOTE 1—This practice is based on ICC-ES Acceptance Criteria AC-182. Relative to the scope of AC-182, this practice is limited to OSB panels.

NOTE 2—While this practice makes reference to PS-2, this practice applies similarly to products certified to other standards such as CAN/CSA O325.

NOTE 3—OSB produced under PS-2 is rated with the "Exposure 1" bond classification. Exposure 1 panels covered by PS-2 are intended for dry use applications where the in-service equilibrium moisture content conditions are expected to be less than 16 %. Exposure 1 panels are intended to resist the effects of moisture due to construction delays, or other conditions of similar severity. Guidelines on use of OSB are available from manufacturers and qualified agencies.

NOTE 4—PS-2-10 replaced the use of nominal thicknesses with a classification term known as Performance Category, which is defined in PS-2 as "A panel designation related to the panel thickness range that is linked to the nominal panel thickness designations used in the International Building Code (IBC) and International Residential Code (IRC)." Therefore, the PS-2 Performance Category should be considered equivalent to the term "nominal thickness" used within this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D9 Terminology Relating to Wood and Wood-Based Products

D143 Test Methods for Small Clear Specimens of Timber

D1037 Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials

D1761 Test Methods for Mechanical Fasteners in Wood

[1] This practice is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.03 on Panel Products.

Current edition approved May 1, 2014. Published May 2014. Originally approved in 2005. Last previous edition approved in 2007 as D7033 – 07. DOI: 10.1520/D7033-14.

[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.

D1990 Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens
D2555 Practice for Establishing Clear Wood Strength Values
D2718 Test Methods for Structural Panels in Planar Shear (Rolling Shear)
D2719 Test Methods for Structural Panels in Shear Through-the-Thickness
D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products
D3043 Test Methods for Structural Panels in Flexure
D3500 Test Methods for Structural Panels in Tension
D3501 Test Methods for Wood-Based Structural Panels in Compression
D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials
D4933 Guide for Moisture Conditioning of Wood and Wood-Based Materials
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
D5764 Test Method for Evaluating Dowel-Bearing Strength of Wood and Wood-Based Products
D6815 Specification for Evaluation of Duration of Load and Creep Effects of Wood and Wood-Based Products
E4 Practices for Force Verification of Testing Machines

2.2 *Other Documents:*

PS-2 Performance Standard for Wood-Based Structural-Use Panels, U.S. Department of Commerce Voluntary Product Standard [3]
NDS ANSI/AF&PA National Design Specification for Wood Construction[4]
AF&PA ASD/LRFD Manual for Engineered Wood Construction[4]
CAN/CSA O325 Construction Sheathing[5]
CSA O86 Engineering Design in Wood[5]
ASD/LRFD Manual for Engineered Wood Construction[6]
ICC Evaluation Service Acceptance Criteria AC-182 Acceptance Criteria for Wood-Based Structural-Use Panels[7]

3. Terminology

3.1 *Definitions*—For definitions of terms related to wood, refer to Terminology D9.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *baseline capacities*—capacities developed for OSB panels intended for use in applications that are not governed by building codes. As distinct from PS-2 and proprietary panels, documentation of baseline capacities is on the basis of test reports rather than evaluation reports or code reference. Example applications include, but are not limited to, concrete form and industrial panels.

3.2.2 *characteristic value*—a population mean, confidence interval, or tolerance limit estimated from the test data. The characteristic value is an intermediate value in the development of design values.

3.2.3 *design capacity*—a value that is a function of material design property and design section property.

3.2.4 *design property*—the stress-based design value derived by dividing design capacity by the design section property.

3.2.5 *oriented strand board (OSB)*—a mat-formed panel product with oriented layers resulting in directional properties. Oriented strand board is comprised primarily of wood strands bonded with exterior adhesive formulations under heat and pressure. Design capacities are referenced to the primary and secondary structural axes, which typically correspond to the manufacturing machine and cross-machine directions, respectively. The primary direction is often referred to as the strength direction.

3.2.6 *primary axis*—the primary axis typically corresponds to the manufacturing machine direction and exhibits higher mechanical properties relative to the secondary axis. The primary axis typically corresponds to the eight-foot dimension of four-foot by eight-foot OSB.

3.2.7 *proprietary panels*—refers to OSB structural-use panels having proprietary design capacities as provided in an evaluation report issued by a code evaluation service.

3.2.8 *PS-2 panels*—refers to panels manufactured in accordance with PS-2.

NOTE 5—Design values for OSB certified to CAN/CSA O325 are published in CSA O86 Engineering Design in Wood. See CSA 086 for specific applications of OSB design values.

3.2.9 *secondary axis*—the secondary axis typically corresponds to the manufacturing cross-machine direction and exhibits lower mechanical properties relative to the primary axis. The secondary axis typically corresponds to the four-foot dimension of four-foot by eight-foot OSB.

3.2.10 *test cell*—the combined test data for a single span rating/property that is intended to characterize that sampling unit.

3.2.11 *tolerance limit*—in this standard, a one-sided tolerance limit is a value about which it may be stated with 75% confidence that a proportion (that is, 90%, 50%, and so forth) of the population has values greater than this tolerance limit.

4. Significance and Use

4.1 The procedures described in this practice are intended to be used to establish design capacity (both strength and stiffness) values based on testing of OSB that, at a minimum, satisfies the relevant performance requirements of PS-2.

4.2 Review and reassessment of values derived from this practice shall be conducted on a periodic basis. If a change is

[3] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.
[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.
[5] Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON Canada M9W1R3.
[6] Available from American Forest and Paper Association (AF&PA), 1111 19th St., NW, Suite 800, Washington, DC 20036.
[7] Available from ICC Evaluation Service, 5360 Workman Mill Rd, Whittier, California 90601

found to be significant, retesting or reevaluation, or both, in accordance with the procedures of this practice shall be considered.

5. Minimum Sampling Matrix and Frequency

5.1 Development of design capacities under this practice may be for either a single span rating or a full matrix of span ratings as defined in PS-2.

5.2 Panels sampled for testing shall be representative of the population for which design capacities are desired. Panel sampling and grouping procedures shall comply with Section 4 of Specification D5457.

5.3 Each product (span rating, grade, nominal thickness) represents a unique product designation. Grouping within product designations shall comply with Section 4 of Specification D5457.

NOTE 6—Data should be reviewed periodically. Inclusion of data beyond the review period should be supplemented by proof that it represents more recent production.

5.4 *Sampling Matrix for Design Capacities*—For the purpose of developing design capacities, the minimum sampling matrix shall include every thickness and span rating for which a design value will be claimed. Alternatively, when supported by a documented model, characteristic values for untested cells are permitted to be established by analytical methods. For each manufacturing facility and product for which design capacities are desired, the minimum number of test replications shall be 30, with the exception of bending stiffness and bending strength capacity, for which the minimum number of test replications shall be 60. A quality assurance program monitored by a qualified agency shall provide verification of continuing compliance with claimed design values.

6. Testing Requirements

6.1 *Bending Stiffness (EI, lbf-in.^{2}/ft)* —Bending stiffness shall be determined in accordance with Test Methods D3043, Method C—Pure Moment Test. Test panel thickness shall be recorded. Flexural stiffness shall be determined in the primary and secondary panel directions and shall be reported on a per foot of width basis. The applicable moment arm shall be the load bar spacing between points of contact with the test panel.

6.2 *Bending Strength Capacity (F_bS, lbf-in./ft)*—Bending strength capacity shall be determined in accordance with Test Methods D3043, Method C—Pure Moment Test. Bending strength capacity shall be determined for the same panel specimens evaluated under 6.1. Bending strength capacity shall be determined in the primary and secondary panel directions and shall be reported on a per foot of panel width basis. Test panel thickness shall be recorded. The applicable moment arm shall be the load bar spacing between points of contact with the test panel.

6.3 *Strength Capacity in Planar Shear ($F_s(Ib/Q)$, lbf/ft)*—Planar shear strength capacity shall be determined in accordance with Test Methods D2718. Test specimen thickness shall be recorded. Planar shear strength capacities along the primary and secondary axes shall be determined and shall be reported on a per foot of panel width basis.

NOTE 7—Test Methods D2718 includes the use of a five-point bending test as an approved method.

6.4 *Strength Capacity in Shear Through-the-Thickness (F_vt_v, lbf/in.)*—Shear through-the-thickness shall be determined in accordance with Test Methods D2719, Method B or Method C. Test panel thickness shall be recorded. Shear through-the-thickness shall be determined along the primary and secondary axes and shall be reported on the basis of pound-force per inch of shear-resisting panel length.

6.5 *Shear Rigidity Through-the-Thickness (G_vt_v, lbf/in.)*—Shear rigidity through-the-thickness shall be determined in accordance with Test Methods D2719, Method B or Method C. Test panel thickness shall be recorded. Shear rigidity through-the-thickness shall be determined along the primary and secondary axes and shall be reported in units of pound-force per inch of panel depth.

6.6 *Axial Stiffness (in tension and compression, EA, lbf/ft)*—Axial tension and compression stiffness shall be determined in accordance with Test Methods D3500, Method B—Tensile Strength of Large Specimens, and Test Methods D3501, Method B—Compression Test for Large Specimens, respectively. Test panel thickness shall be recorded. Axial stiffness shall be determined along the primary and secondary axes and shall be reported on a per foot of panel width basis. Specimen dimensions shall be recorded.

6.7 *Axial Strength (in tension and compression, F_cA, F_tA, lbf/ft)*—Axial tension and compression strength shall be determined in accordance with Test Methods D3500, Method B—Tensile Strength of Large Specimens, and Test Methods D3501, Method B—Compression Test for Large Specimens, respectively. Test panel thickness shall be recorded. Axial strength shall be determined along the primary and secondary axes and shall be reported on a per foot of panel width basis. Specimen dimensions shall be recorded.

6.8 *Fastener Withdrawal Resistance*—Fastener withdrawal resistance tests shall be conducted in accordance with Test Methods D1761, except that 8d common wire (bright, plain-shank medium diamond-point steel nail with a nominal shank diameter of 0.131 in., a nominal length of 2.5 in., and a head diameter of 0.281 in.) nails shall be used. Specimen thickness and density shall be recorded. Results shall be reported as tested and as normalized to a per inch of thickness basis for determination or equivalent specific gravity in accordance with A1.5 of Annex A1. Fastener specifications shall be recorded and shall include actual diameter.

6.9 *Lateral Fastener Resistance*—The equivalent specific gravity of the OSB shall be determined on the basis of dowel-bearing performance in accordance with A1.6 of Annex A1 except that the test fasteners shall include 8d and 10d common wire nails as defined in Specification D5456, Annex A2. Lateral fastener capacity shall be determined along the primary and secondary axes. Specimen thickness and density shall be recorded.

6.10 *Nail-Head Pull-Through Resistance*—To measure the resistance of a panel to having the head of a nail or other fastener pulled through the board, nail-head pull-through tests shall be conducted in accordance with Test Methods D1037, except that 8d common wire nails with a nominal head diameter of 0.281 in. shall be used. Specimen thickness and density shall be recorded. Fastener specifications shall be recorded and shall include actual shank diameter and actual nail head diameter. Results shall be reported as-tested.

6.11 *Compression Perpendicular (Bearing) Capacity (F_{cp}, psi)*—Compression perpendicular tests shall be conducted in accordance with principles of Test Methods D143, except that references to placement of growth rings are not applicable. Specimen dimensions shall be 1.5 in. (minimum) by 6 in. by panel thickness. The compressive load shall be applied perpendicular to the surface of the specimen through a 2-in. wide bearing plate aligned across the width of the specimen. Stress at 0.04-in. deformation shall be recorded. Specimen dimensions and density shall be recorded.

7. Determination of Design Capacities

7.1 *Allowable Stress Design (ASD)*—Design capacities for allowable stress design shall be determined in accordance with ASD/LFRD procedures established in this practice or through soft conversion from reliability-based design capacities developed in accordance with Specification D5457 (7.2 of this practice and 6.7 of Specification D5457) except that the lower-tail fit per 4.2.2 of Specification D5457 shall not be permitted.

7.1.1 *Characteristic Values*—Characteristic values shall be determined by parametric or non-parametric procedures, or both, as specified in Practice D2915. Characteristic values for strength capacities shall be the parametric and non-parametric values, except that the characteristic value for fastener withdrawal, lateral fastener resistance, and head pull-through shall be the average of the test results determined by 6.8, 6.9, and 6.10, respectively.

7.1.2 *Parametric Characteristic Values*—The procedures of Sections 3 and 4 of Practice D2915 shall be followed except that provisions of this practice govern where differences occur.

7.1.2.1 The lower 5 % tolerance limit with 75 % confidence shall be the characteristic value for strength capacities. When grouping results from multiple producing units, the characteristic value shall be determined for the grouped data as well as for each unit represented in the grouped dataset. The characteristic value of the group shall be the lesser of the characteristic value of the grouped data and 1.05 times the characteristic value of the lowest unit in the group.

7.1.2.2 The characteristic value for stiffness properties (such as EI, EA, G_vT_v), bearing (Fcp), and fastener properties shall be the average of the test results determined in accordance with this practice. When grouping results from multiple producing units, the characteristic value shall be the lesser of the grouped mean and 1.1 times the mean of the lowest unit in the group.

7.1.3 *Non-Parametric Characteristic Values*—The nonparametric characteristic value for strength capacities shall be the fifth percentile tolerance limit with 75 % confidence.

7.2 *Load and Resistance Factor Design (LRFD)*—Design capacities for LRFD shall be determined in accordance with reliability-based provisions of Specification D5457. Reliability indices established for each strength limit state shall be presented with corresponding design capacities. Design capacities for ASD can be developed through soft conversion of reliability-based LRFD design strength capacities. See 7.1.

7.3 *Design Capacities*—Design capacities shall be determined by dividing the characteristic values from 7.1 or 7.2 by the corresponding adjustment factors provided in Table 1. The applicable moisture content from which the design values are derived shall be reported. If ASD design capacities are derived through soft conversion from LRFD design capacities in accordance with 7.2, the adjustment factors provided in Table 1 shall be used in the soft conversion process. Appendix X1 provides examples of design capacity derivation.

7.4 *Design Section Properties*—Design capacities determined in 7.3 shall be normalized as necessary to compensate for adjustment of section properties of test material to published design section properties. Normalization of design capacities shall be conservative and normalization shall be applied within specific product designations. If the average thickness of the sample (average thickness of all test specimens in the sample) is 98 % of the design thickness or greater, design capacities shall be normalized on the basis of the design thickness. If the average thickness of the sample is less than 98 % of the design thickness, design capacities shall be used as tested without normalization. When grouping results from multiple producing units (see 7.1.2.1 and 7.1.2.2), normalization of design capacities is not required when the lower 90 % confidence bound on the mean thickness is less than or equal to the design thickness. Appendix X2 provides examples of normalization of design capacities.

7.5 *Test Conditions:*

7.5.1 OSB specimens shall be tested at the mill or in an outside laboratory. For specimens tested at the mill, a minimum cure time of 24 h is required prior to qualification testing. If quality assurance testing conducted with a shorter cure time is to be correlated to qualification testing, correlation factors shall be generated and reported.

NOTE 8—If a standardization moisture condition is desired, the test specimens may be equilibrated to constant mass at 65% (±5%) relative humidity and 68 ± 11°F.

7.5.2 Report ambient temperature at time of test. Report moisture content of specimens at time of test.

TABLE 1 Design Capacity Adjustment Factors

Capacity	Adjustment Factor
Bending stiffness	1.00
Bending strength	2.10
Planar shear strength	2.10
Shear strength through-the-thickness	2.10
Shear rigidity through-the-thickness	1.00
Axial stiffness (compression and tension)	1.00
Axial strength (compression and tension)	2.10
Fastener withdrawal resistance	5.00
Lateral fastener resistance	1.00
Nail-head pull-through resistance	5.00
Compression perpendicular (bearing) resistance	1.67

NOTE 9—The reference range of moisture contents for OSB structural-use panels at time of test is typically 2% to 7%. For quality assurance testing at the mill, approximate moisture content may be estimated based on prior experience. For specimens tested at an outside laboratory, approximate moisture content shall be estimated based on testing representative specimens in accordance with Test Methods D4442.

7.5.3 Test data from panels tested at the mill prior to exposure to the weather need no adjustment.

7.6 The design capacities determined in accordance with this practice are applicable to dry service conditions as traditionally used for wood structural products.

NOTE 10—Test programs to develop adjustments to design capacities for moisture conditions in which the equilibrium moisture content is 16% or higher are available in publications cited in the References. (1-5)

NOTE 11—Adjustments to strength and stiffness capacities for higher in-service moisture conditions do not account for any potential biological degradation at high moisture conditions. The user is advised to follow code requirements and industry recommendations or to use only preservatively treated or naturally durable wood products in applications potentially subject to biological degradation.

7.7 The design capacities determined in accordance with this practice are applicable to "normal duration of load" as traditionally used for wood structural products. Adjustments to other durations are permitted in accordance with the duration of load factors in the National Design Specification for Wood Construction (NDS).

NOTE 12—Duration of load factors traditionally used for wood structural products have been evaluated for use with wood-based structural-use panel products as reported in Laufenberg, et al.(6) Specification D6815 provides methodology to be used to evaluate duration of load performance of OSB.

8. Quality Assurance

8.1 *Quality Control*—The wood-based structural-use panel products shall be produced under a quality assurance program administered by a qualified agency. An approved quality assurance manual shall be developed in collaboration with the qualified agency and complying with applicable criteria of model building code evaluation services. The quality assurance manual shall specify quality assurance testing and process control requirements in accordance with 8.2 and 8.3 of this practice.

8.2 *Quality Assurance Testing:*

8.2.1 Test equipment shall be properly maintained, calibrated, and evaluated for accuracy and adequacy at a frequency satisfactory to the qualified agency.

8.2.2 Test frequency shall be chosen to yield quality assurance performance that is consistent with design capacities and design section properties assigned to the product and its intended use.

8.3 *Process Control:*

8.3.1 Data from tests outlined in 8.2 shall be evaluated prior to shipment of the material represented by the sample. Analytical procedures shall determine if product capacities are in statistical control. The control levels selected shall be consistent with current design capacities and design section properties.

8.3.2 When the analysis described in 8.3.1 indicates that the product is below the control level, the associated portion of production shall be subject to re-examination in accordance with the acceptance procedures provided in the approved quality assurance manual.

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

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

8.3.3.2 All test data, including retests and data associated with rejected production.

8.3.3.3 Details of any corrective actions taken and the disposition of any rejected production resulting from tests or inspection.

ANNEX

(Mandatory Information)

A1. ESTABLISHING EQUIVALENT SPECIFIC GRAVITY CONNECTION PROPERTIES FOR OSB

A1.1 Scope

A1.1.1 This annex presents one method for establishing equivalent specific gravity for connection properties of oriented strand board (OSB). The specific gravity values determined by this method are equivalent to values determined for species and species combinations of solid sawn lumber. The equivalency is limited to withdrawal capacities of nails and bearing capacities of dowel type fasteners (bolts, lag screws, wood screws, and nails).

NOTE A1.1—The method presented in this annex does not preclude the use of alternate methods of establishing equivalency of design values, such as direct comparative testing of joints.

A1.1.2 Equivalency is established by determining an equivalent specific gravity for an OSB product. The OSB equivalent specific gravity is established by determining the specific gravity value of a solid sawn species or species combination in the NDS that shows equivalent nail withdrawal or dowel bearing performance. This OSB equivalent specific gravity permits the design of connections using established design procedures and specific gravity values for species combinations of sawn lumber found in the NDS.

A1.1.3 A different equivalent specific gravity is permitted for nail withdrawal from the surface and the edge of the OSB panel. A different equivalent specific gravity is permitted for lateral capacity (dowel bearing) along the primary and secondary axes.

A1.1.4 Fasteners shall be specified in accordance with the dimensions provided in Appendix L of the NDS.

NOTE A1.2—For example, an 8d common nail would be specified as a nail with a length of 2.5 inches, a shank diameter of 0.131 inches, and a head diameter of 0.281 inches.

A1.2 Sample Size

A1.2.1 Minimum sample size for each test group shall provide 5 % precision of estimation of the mean value, with 75 % confidence, in accordance with 3.4.2 of Practice D2915 and not be less than that specified in 5.4 of this Practice.

A1.3 Withdrawal Tests

A1.3.1 Fastener withdrawal testing shall be performed in accordance with 6.8 of this Practice. Withdrawal testing shall be performed for nails driven normal (perpendicular) to the panel surface. When design values are required for nails driven into the edge of the panel, testing shall also be performed for edge nailing.

A1.4 Lateral Capacity Tests

A1.4.1 Testing for lateral capacity shall be conducted in accordance with 6.9 of this Practice and the dowel bearing provisions of Test Method D5764. Testing for nails along the primary and secondary axes is required. Testing for bolts and lag screws along the primary and secondary axes is permitted.

A1.4.2 Rate of testing is in accordance with Test Method D5764.

A1.4.3 When lateral capacities of bolts and lag screws are required, the dowel bearing strength of ½-in. (12.7-mm) and ¾-in. (19-mm) bolts shall be determined. Bolt fastener length shall be sufficient to prevent bearing of the threads on the specimen.

A1.4.4 Panel materials used for dowel bearing qualification tests shall be brought to moisture equilibrium in a conditioned environment of 20 ± 6° C (68 ± 11°F) and 65 % (±5%) relative humidity. Methods for determination of completion of conditioning are given in Guide D4933.

A1.5 Withdrawal Equivalence

A1.5.1 The equivalent specific gravity is determined from Table 11.2C of the NDS such that the table value for the tested nail does not exceed the average ultimate withdrawal resistance in lbf/in (N/mm) from A1.3 divided by 5.0. Straight line interpolation between the nearest withdrawal design values in Table 11.2C of the NDS is permitted to obtain a closer approximation of OSB equivalent specific gravity. It is also permissible to determine equivalent specific gravity on the basis of the following equation:

$$G_{eq} = \left(\frac{\frac{W}{5}}{1380d} \right)^{0.4} \quad \text{(A1.1)}$$

where:

G_{eq} = equivalent specific gravity
W = withdrawal capacity per inch of penetration, lbf/in.
d = nail diameter, in.

A1.5.2 The specified testing establishes the equivalent specific gravity for the full range of nail types and sizes in Table 11.2C of the NDS. A different equivalent specific gravity is permitted for withdrawal from the surface and withdrawal from the edge of the panel. If one equivalent specific gravity is to be specified for surface and edge withdrawal, it shall be the lower of the two individual values. If one equivalent specific gravity is to be specified over the range of panel thickness' or span ratings, it shall be the minimum of the values determined over the range. It is permissible to establish an equivalent specific gravity for each nominal thickness or span rating.

A1.6 Lateral Capacity Equivalence

A1.6.1 *Nails*—The nail dowel bearing strength is determined by dividing the 5 % offset load from A1.4 by the bearing area, the product of nail diameter, and specimen dimension parallel to the nail.

NOTE A1.3—The 5% offset load is the load at which a line parallel to the initial slope of the load-deformation curve, and offset by an amount equal to 5 % of the dowel diameter, intersects either the load-deformation curve, or the maximum load, whichever occurs first.

A1.6.2 The equivalent specific gravity value for laterally loaded nails shall be determined from Table 11.3.2 of the NDS such that the table value of dowel bearing strength does not exceed the average dowel bearing strength from A1.6.1. It is also permissable to use the equations provided in the footnotes of NDS Table 11.3.2 to determine the OSB equivalent specific gravity.

A1.6.3 Equivalent specific gravity shall be established for 8d and 10d common nails along the primary and secondary axes as specified in 6.9 of this Practice. The dowel bearing strength shall combine the average of 8d and 10d test results along the primary and secondary axes in accordance with the provisions of Section A2.7.1, Annex A2, of Specification D5456. It is permissible to establish an equivalent specific gravity for each nominal thickness or span rating.

NOTE A1.4—An example of dowel bearing strength combination procedures for nail connections is provided in Section X2.3 of Appendix X2 in Specification D5456.

A1.6.4 results from the nail tests can also be applied to wood screws.

A1.6.5 *Bolts*—The equivalent specific gravity value for laterally loaded bolts shall be determined from Table 11.3.2 of the NDS such that the table value of dowel bearing strength does not exceed the 5% offset load from A1.6.1 divided by the bearing area – the product of bolt diameter and specimen dimension parallel to the bolt length. The equations provided in the footnotes of Table 11.3.2 can be used to determine the OSB equivalent specific gravity.

A1.6.6 Equivalent specific gravity for laterally loaded bolts shall be determined along the primary and secondary axes. The equivalent specific gravity shall combine the average of test results for all tested bolt diameters along the primary and secondary axes in accordance with the provisions of Section A2.7.5, Annex A2, of Specification D5456. It is permissible to establish an equivalent specific gravity for each nominal thickness or span rating.

NOTE A1.5—An example of dowel bearing strength combination procedures for bolted connections is provided in Section X2.4 of Appendix X2 of Specification D5456.

A1.6.7 The results from bolt tests can also be applied to lag screws.

A1.6.8 The specified testing establishes the equivalent specific gravity values for the full range of dowel-type (nails, wood screws, bolts, lag screws) fasteners within the scope of the NDS.

A1.7 Presentation of Connection Properties

A1.7.1 Presentation of connection properties shall state the equivalent specific gravity for each fastener type, product orientation, and panel thickness evaluated.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLE DERIVATIONS OF DESIGN CAPACITIES

X1.1 Parametric Design Capacity Derivation Examples

NOTE X1.1—While the Kolmogorov-Smirnov statistic was applied to assess goodness-of-fit for the strength distributions in the following examples, the Anderson-Darling statistic or other appropriate measures may be applied in practice.X1.1

X1.2 Non-Parametric Design Capacity Derivation Examples X1.2

TABLE X1.1 Bending Strength Capacity (F_bS), Primary Axis, lbf-in./ft

Distribution	K-S	Characteristic Value	Design Adjustment Factor	Design Capacity[A]
Normal	0.075	2744		
Log-Normal	0.052	2684	2.1	1278
2-p Weibull	0.124	2565		

[A] Log-normal distribution provides the best fit for this sample (lowest Kolmogorov-Smirnov statistic).

TABLE X1.2 Planar Shear Capacity (F_sIb/Q), Primary Axis, lbf/ft

Distribution	K-S	Characteristic Value	Design Adjustment Factor	Design Capacity[A]
Normal	0.042	911	2.1	434
Log-Normal	0.058	935		
2-p Weibull	0.065	895		

[A] Normal distribution provides the best fit for this sample (lowest Kolmogorov-Smirnov statistic).

TABLE X1.3 Bending Stiffness (EI), Primary Axis, lbf-in.^{2}/ft

Mean	Characteristic Value	Design Adjustment Factor	Design Capacity
311 788	311 788	1.0	311 788

TABLE X1.4 Bending Strength Capacity (F_bS), Primary Axis, lbf-in./ft

Distribution	Characteristic Value	Design Adjustment Factor	Design Capacity
Non-parametric	2731	2.1	1300

TABLE X1.5 Planar Shear Capacity (F_sIb/Q), Primary Axis, lbf/ft

Distribution	Characteristic Value	Design Adjustment Factor	Design Capacity
Non-parametric	877	2.1	417

TABLE X1.6 Bending Stiffness (EI), Primary Axis, lbf-in.^{2}/ft

Mean	Characteristic Value	Design Adjustment Factor	Design Capacity
311 788	311 788	1.0	311 788

X2. DESIGN SECTION PROPERTIES AND DESIGN CAPACITY NORMALIZATION

X2.1 Section properties of test specimens will typically differ from design section properties. Design section properties must be consistent with section properties of the finished product. Design capacities must be normalized to reflect the adjustment from test section properties to design section properties.

X2.2 Tables X2.1-X2.3 provide examples of capacity normalization for a sample (set of test specimens) with an average thickness within 2 % of the design thickness. See 7.4 for normalization procedures. For each design capacity (bending strength, planar shear, and bending stiffness) an example is provided for a test specimen thickness less than the design thickness and an example is provided for a test specimen thickness greater than the design thickness.

TABLE X2.1 Adjustment of Test Capacity to Normalized Capacity—Bending Strength Capacity

F_bS (lbf-in./ft)	Test Thickness (in.)	Apparent Property, F_b (psi)	Design Thickness (in.)	Normalized Capacity[A] (lbf-in./ft)
2684	0.688	2835	0.685	2661
2684	0.682	2885	0.685	2708

[A] Normalized capacities determined on the basis of apparent properties.

TABLE X2.2 Adjustment of Test Capacity to Normalized Capacity—Planar Shear Capacity

$F_s(IB/Q)$ (lbf/ft)	Test Thickness (in.)	Apparent Property, F_s (psi)	Design Thickness (in.)	Normalized Capacity[A] (lbf/ft)
877	0.688	159	0.685	873
877	0.682	161	0.685	881

[A] Normalized capacities determined on the basis of apparent properties.

TABLE X2.3 Adjustment of Test Capacity to Normalized Capacity—Bending Stiffness

EI (lbf-in.^{2}/ft)	Test Thickness (in.)	Apparent Property, MOE (psi)	Design Thickness (in.)	Normalized Capacity[A] (lbf-in.^{2}/ft)
311 730	0.688	957 223	0.685	307 670
311 730	0.682	982 710	0.685	315 862

[A] Normalized capacities determined on the basis of apparent properties.

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