This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

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Standard Specification for Computing Reference Resistance of Wood-Based Materials and Structural Connections for Load and Resistance Factor Design[1]

This standard is issued under the fixed designation D5457; 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.

INTRODUCTION

Load and resistance factor design (LRFD) is a structural design method that uses concepts from reliability theory and incorporates them into a procedure usable by the design community. The basic design equation requires establishing a reference resistance based on several material property parameters. A standard method for calculating the required material property input data is critical so that all wood-based structural materials can be treated equitably. This specification provides the format conversion procedure that is required for the generation of reference resistance for LRFD. A non-mandatory appendix of this specification provides broad guidance for users who wish to pursue the test-based approach for the generation of reference resistance for LRFD.

1. Scope

1.1 This specification covers the format conversion procedure for computing the reference resistance of wood-based materials and structural connections for use in load and resistance factor design (LRFD). The format conversion procedure is outlined in Section 4. The reference resistance derived from this specification applies to the design of structures addressed by the load combinations in ASCE 7-16.

1.2 A commentary to this specification is provided in Appendix X1.

1.3 Guidance for users considering test-based derivation of reference resistance is provided in Appendix X2.

1.4 The values stated in inch-pound units are to be regarded as the 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 international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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

D198 Test Methods of Static Tests of Lumber in Structural Sizes

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

D1761 Test Methods for Mechanical Fasteners in Wood and Wood-Based Materials

D1990 Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens

D2718 Test Methods for Structural Panels in Planar Shear (Rolling Shear)

D2719 Test Methods for Wood 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 Wood Structural Panels in Tension

D3501 Test Methods for Wood-Based Structural Panels in Compression

D3737 Practice for Establishing Allowable Properties for

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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.

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Structural Glued Laminated Timber (Glulam)
D4761 Test Methods for Mechanical Properties of Lumber and Wood-Based Structural Materials
D5055 Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists
D5456 Specification for Evaluation of Structural Composite Lumber Products
E105 Guide for Probability Sampling of Materials
2.2 *ASCE Standard:*[3]
ASCE 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures

3. Terminology

3.1 *Definitions:*

3.1.1 For general definitions of terms related to wood, refer to Terminology D9.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *ASD reference design value, F_x*—the design value at reference conditions used in allowable stress design (ASD) prior to application of the load duration factor (C_D).

3.2.2 *coefficient of variation, CV_w*—the standard deviation divided by the mean of a 2-parameter Weibull distribution.

3.2.2.1 *Discussion*—Coefficient of variation, CV_w, can be calculated three ways: the traditional method of moments; method of maximum likelihood; and method of least squares. The method of moments calculates the mean and standard deviation directly from the data of a complete data set. The methods of maximum likelihood and least squares calculate the Weibull parameters from complete or incomplete data sets. An incomplete data set includes suspended data (for example, data from proof loading.) Mean and standard deviation (and CV_w) are then calculated from the Weibull parameters.

3.2.3 *factored resistance*—the product of the resistance factor (ϕ) and the reference or nominal resistance (R_n).

3.2.4 *format conversion factor, K_F*—a factor applied to convert resistance from the allowable stress design (ASD) format to the LRFD format, equal to the ratio R_n/F_x.

3.2.5 *lower tail*—a portion of an ordered data set consisting of all test specimens with the lowest property values (for example, lowest strengths).

3.2.6 *nominal resistance*—a term equivalent to the reference resistance used in reliability analysis and LRFD standards.

3.2.7 *reference conditions*—the design basis for which all applicable adjustment factors are equal to unity, except for the load duration factor in ASD or the time effect factor in LRFD.

3.2.8 *reference resistance, R_n*—the design value at reference conditions used in LRFD to represent member resistance prior to application of the resistance factor (ϕ) and the time effect factor (λ).

3.2.8.1 *Discussion*—The reference value represents member resistance at 10-minute load duration.

3.2.9 *reliability normalization factor, K_R*—a factor used to establish the reference resistance (R_n) to achieve a target reliability index for a specific set of conditions.

3.2.10 *resistance factor, ϕ*—a factor applied to the resistance side of the LRFD equation.

4. Reference Resistance for LRFD

4.1 Reference resistance for LRFD shall be determined using the format conversion procedure per 4.2.

NOTE 1—Appendix X2 discusses considerations that should be addressed by users considering test-based approaches for the generation of reference resistance for LRFD. Appendix X5 provides discussion of alternative methods to determine reference resistance for LRFD.

4.2 *Format Conversion Procedure:*

4.2.1 Resistance values for LRFD shall be based on format conversion from code-recognized allowable stress design (ASD). It shall not be claimed that reference resistance values generated in this manner achieve a stated reliability index. Resistance factors for determining LRFD factored resistance, ϕR_n, are given in Table 1.

NOTE 2—Examples of standards that are used to generate code-recognized ASD values include Test Methods D143, D198, D1037, D1761, D2718, D2719, D3043, D3500, D3501, and D4761; Practices D1990 and D3737; and Specifications D5055 and D5456.

4.2.2 For standardization purposes, format conversion reference resistance values shall be based on the arithmetic conversion for a specific design case that results from the calibration of basic ASD and LRFD equations. Here, the calibration means providing an identical required section modulus, cross-sectional area, allowable load capacity, and so forth. The specific design case was chosen such that changes in design capacity over the range of expected load cases and load ratios were minimized.

4.2.3 Values of the format conversion factor, K_F, are given in Table 2.

4.2.4 The format conversion reference resistance is computed by multiplying the ASD resistance by K_F. For members and connections, the ASD resistance is based on a normal (10-year) load duration. For shear walls and diaphragms, the ASD resistance is based on a 10-min load duration.

4.2.5 For lateral buckling (stability), compression perpendicular to grain, and rolling shear that is not subject to load duration or time effect adjustments, the value of K_F is based on the assumption that neither the ASD nor LRFD resistance values are modified by duration of load or time effect adjustments.

4.2.6 *Format Conversion Example*—An ASD bolt design value for a single shear connection, F_x, is 800 lbf (3.56 kN) (based on normal 10-year load duration). From Table 2, the

TABLE 1 Specified LRFD Resistance Factors, ϕ_s

Application	Property	ϕ_s
Members	compression[A]	0.90
	bending, lateral buckling (stability)	0.85
	tension parallel	0.80
	shear, radial tension	0.75
Connections	all	0.65
Shear Walls, diaphragms	shear (wind)	0.80
	shear (seismic)	0.50

[A] Compression parallel-to-grain, compression perpendicular-to-grain, and bearing.

[3] Available from The American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191.