

Changes to the 2018 National Design Specification (NDS) for Wood Construction and 2018 NDS Supplement: Design Values for Wood Construction

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Introduction

The 2018 Edition of the *National Design Specification*[®] (*NDS*[®]) for Wood Construction was recently published. The updated standard designated *ANSI/AWC NDS-2018* was approved as an ANSI American National Standard on November 30, 2017 (Figure 1). The *2018 NDS* was developed by the American Wood Council's (AWC) Wood Design Standards Committee and is referenced in the *2018 International Building Code (IBC)*.

Primary changes to the *2018 NDS* and the *2018 NDS Supplement: Design Values for Wood Construction* are listed here and major topics are subsequently covered in more detail:

- Allowance for incising factors for specific incising patterns and lumber sizes when obtained from the company providing the incising
- Inclusion of a volume factor for structural composite lumber tension parallel to grain values
- Inclusion of effective shear stiffness for cross-laminated timber
- Added equation for withdrawal design values for smooth shank stainless steel nails
- New provisions for Roof Sheathing Ring Shank nails in accordance with *ASTM F 1667*
- New design provisions for fastener head pull-through of fasteners with round heads
- Revision to method for calculating of lateral design values for threaded nails to be based on use of shank diameter instead of root diameter in accordance with changes in *ASTM F 1575*
- Revised timber rivet design value tables to limit maximum distance perpendicular to grain between outermost rows of fasteners
- Revised terminology for Fire Design of Wood Members to clarify the difference between "char depth" and "effective char depth," used in structural calculations. Provisions for connections is also revised to more precisely describe the requirements for protection of the connection from fire exposure
- Changes to the NDS Supplement include removal of Redwood grades requiring "close grain," Norway Spruce from Norway added to foreign species dimension lumber, and addition of shear-free moduli of elasticity for structural glued laminated softwood timber (glulam)

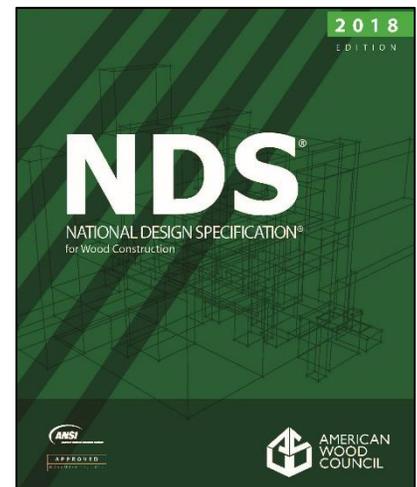


Figure 1. The 2018 NDS is referenced in the 2018 IBC.

Structural Composite Lumber

NDS Chapter 8 on Structural Composite Lumber (SCL) was revised to include a volume factor, C_v , for tension parallel to grain design values, F_t . The change occurs in *NDS* Table 8.3.1 Applicability of Adjustment Factors for Structural Composite Lumber and Section 8.3.6 Volume Factor. A change was also made to clarify that dry service conditions are associated with conditions in which the moisture content of sawn lumber is less than 16%, as in most covered structures. These changes correlate with *ASTM D 5456 Standard Specification for Evaluation of Structural Composite Lumber Products*.

Cross-Laminated Timber (CLT)

Revisions were made to CLT deflection provisions to include the term GA_{eff} (effective shear stiffness of the CLT section). This is a correlating change with *ANSI/APA PRG 320-2017 Standard for Performance-Rated Cross-Laminated Timber* – to facilitate the calculation of apparent bending stiffness $(EI)_{\text{app}}$ consistent with properties as provided in *PRG 320*. The revised equation excerpted from the *2018 NDS* is shown below:

$$(EI)_{\text{app}} = \frac{EI_{\text{eff}}}{1 + \frac{K_s EI_{\text{eff}}}{GA_{\text{eff}} L^2}} \quad (10.4-1)$$

where:

EI_{eff} = Effective bending stiffness of the CLT section, lbs-in.²/ft of panel width

K_s = Shear deformation adjustment factor

GA_{eff} = Effective shear stiffness of the CLT section, lbs/ft of panel width

L = Span of the CLT section, in.

Changes to Fastener Design

Revision of *NDS* connection design provisions were primarily in response to significant increases in Components and Cladding (C&C) roof wind pressures in *ASCE 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Wind uplift related changes include new fastener withdrawal and new fastener head pull-through design provisions.

Added Equation for Stainless Steel Nail Withdrawal Strength

An equation for the withdrawal strength of smooth shank stainless steel nails was added. Stainless steel nails have lower withdrawal strength when compared to carbon steel wire nails of the same diameter, due to the reduced surface friction of stainless steel. The differences in withdrawal strength vary with the specific gravity of wood (Figure 2). When stainless steel nails are specified as an alternative to reference smooth shank carbon steel wire (bright or galvanized) nails in wood construction including shear walls and diaphragms, these differences in nail withdrawal strengths must be considered. For example, where smooth shank stainless steel nails are used for roof sheathing attachment, more nails, or nails of greater length or diameter, may be required to provide equivalent withdrawal strength performance for wind uplift.

Roof Sheathing Ring Shank Nails

Roof Sheathing Ring Shank (RSRS) nails were recently added to *ASTM F 1667 Standard Specification for Driven Fasteners: Nails, Spikes, and Staples*. Design provisions for RSRS nails have been added to the *2018 NDS*. RSRS nails, which have higher withdrawal design values than smooth shank nails, provide additional options for efficient attachment of wood structural panel roof sheathing. In many cases, specification of RSRS nails will produce a reduced roof sheathing attachment schedule than permissible by use of smooth shank nails and enable use of a single minimum fastener schedule for

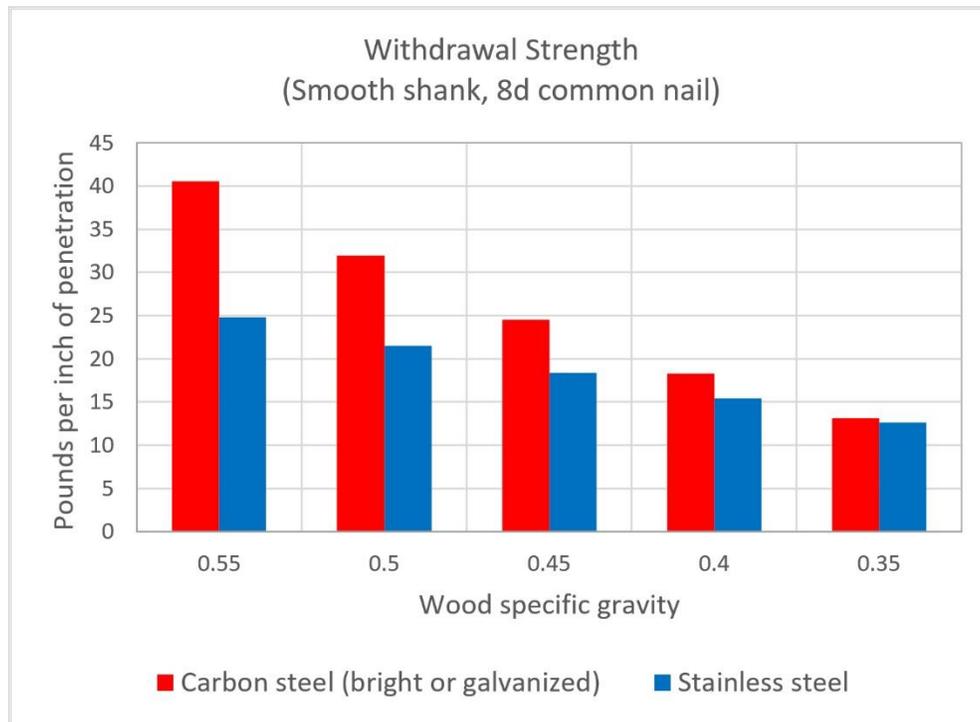


Figure 2. Smooth shank nail withdrawal strength (allowable stress design) from wood in accordance with 2018 NDS.

roof perimeter edge zones and interior zones. Recognition of higher withdrawal strength in the *NDS* is based on presences of standardized ring deformations including minimum 1-1/2" length of deformations on the nail. In a related change, tabular values for generic threaded-hardened nails, which had no standardized deformation pattern, were deleted to remove an approximate 10% increase in withdrawal values for such nails relative to smooth shank nails of equivalent diameter. The revised NDS provisions allow these generic deformed shank nails in accordance with *ASTM F 1667* to use withdrawal design value equations for smooth shank nails.

Fastener Head Pull-through Provisions

Fastener head pull-through data, used to set industry recommendations for wood structural panels, combined with historical data from tests of lumber and plywood was analyzed to develop new fastener head pull-through provisions. Within the range of head diameters, thicknesses and specific gravities in the NDS, the analysis found that head pull-through is related to the perimeter of the fastener head. New equations based on fastener head diameter, specific gravity, and net side member thickness are as follows:

$$W_H = 690 \pi D_H G^2 t_{ns} \quad \text{for } t_{ns} \leq 2.5 D_H$$

$$W_H = 1725 \pi D_H^2 G^2 \quad \text{for } t_{ns} > 2.5 D_H$$

where:

- πD_H = perimeter for fasteners with round heads
- D_H = fastener head diameter, in.
- G = specific gravity of side member
- t_{ns} = net side member thickness

An excerpt of tabulated head pull-through values from *2018 NDS* Table 12.2F is shown below:

Table 12.2F Head Pull-Through, W_H ¹

Tabulated pull-through design values, W_H , are in pounds.										
Side Member Specific Gravity ² , G	Head Diameter, D_H (in.)	Net Side Member Thickness, t_{NS} (in.)								
		5/16	3/8	7/16	15/32	1/2	19/32	5/8	23/32	3/4
0.50	0.234	40	48	55	59	63	74	74	74	74
	0.250	42	51	59	64	68	80	85	85	85
	0.266	45	54	63	68	72	86	90	96	96
	0.281	48	57	67	71	76	90	95	107	107
	0.297	50	60	70	75	80	96	101	116	120
	0.312	53	63	74	79	85	100	106	122	127
	0.344	58	70	82	87	93	111	117	134	140

For design of roof sheathing fastening to resist wind uplift, the addition of head pull-through allows the controlling roof sheathing fastener spacing to be calculated from the lesser of the head pull-through design value or the fastener withdrawal design value from wood in accordance with the *NDS*. Previously, such design required use of a combination of design documents including minimum prescribed spacing criteria for wood panels.

Although not specifically addressed by the added head pull-through equations in the *NDS* which assume fasteners with round heads, analysis of underlying data is considered to support use of the fastener head perimeter model for fasteners with other than round heads such as proprietary nails with clipped or oval heads.

Diameter for Threaded Nails

A change in *ASTM F 1575 Standard Test Method for Determining Bending Yield Moment of Nails* clarifies that nail bending yield strength, F_{yb} , is based on the nominal diameter, D , not on the root diameter, D_r . This change allowed simplification of the calculation of nail moment resistance in the *NDS* yield equations for nails specified in *F 1667* because D is provided for all nail types, but D_r is not always provided for deformed shank nails. As a result, revised *NDS* provisions allow the use of D for deformed shank nails per *F 1667* when calculating lateral design values in accordance with the yield limit equations.

Fire Design of Wood Members

NDS Chapter 16 on Fire Design of Wood Members was revised to provide separate calculations of char depth based on nominal char rates for wood, a_{char} , and effective char depth for use in structural calculations, a_{eff} . Increased use of wood as a fire protective covering has made it important to provide provisions for calculation of the expected a_{char} separate from a_{eff} . Previous versions of the *NDS* have only provided a_{eff} which is increased 20% over a_{char} to account for loss of strength and stiffness due to elevated temperatures in uncharred wood near the char front.

Design of connections for fire were also clarified as follows:

Wood connections, including connectors, fasteners, and portions of wood members included in the connection design, shall be protected from fire exposure for the required fire resistance time. Protection shall be provided by wood, fire-rated gypsum board, other approved materials, or a combination thereof.

These provisions, while not intended to be technically different from current *NDS* provisions, clarify that protection of all components of the connection (connectors, fasteners, and wood) must be protected from fire exposure for the required time.

NDS Supplement

NDS Supplement design values are unchanged from prior *NDS Supplements* with only a few exceptions. New and revised grades of machine stress-rated lumber and machine evaluated lumber are added. Redwood grades requiring “close grain,” were removed due to general lack of availability for commercial use. Other revisions include addition of Norway Spruce from Norway to foreign species dimension lumber, and addition of shear-free moduli of elasticity for structural glued laminated softwood timber (glulam). As a compendium of product types, species, grades and sizes, a note has been added to the *NDS Supplement* to alert designers and product specifiers to check for availability of sizes and grades of products prior to specifying.

More Details

A section by section list of changes to the *NDS* is available in the appendix to this paper.

Availability

The *2018 NDS* with *2018 NDS Supplement* is currently available in electronic format (PDF) only. Once the *NDS Commentary* and other support documents to be included in the *2018 Wood Design Package* (WDP) are updated, printed copies will be available for purchase. Check the AWC website (www.awc.org) for status updates on the *2018 WDP*.

Conclusion

The *2018 NDS* represents the state-of-the-art for design of wood members and connections. Added head-pull through design values and withdrawal provisions for RSRS nails provide design options to address increased design wind uplift pressures resulting from *ASCE 7-16* and added withdrawal equation for stainless steel smooth shank nails are among the major changes in this edition. The *2018 NDS* is referenced in the *2018 IBC*.

Authors

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Appendix: Summary of Changes – 2018 National Design Specification (NDS) for Wood Construction and 2018 NDS Supplement: Design Values for Wood Construction

Section	Description of Change
<p>Chapter 1 General Requirements for Structural Design</p>	<p>Add/revise notation to address effective bending stiffness and effective shear stiffness in the calculation of $(EI)_{app}$ for cross-laminated timber (CLT) (per Chapter 10), addition of fastener head pull-through (per Chapter 12), and changes in Chapter 16 (Fire Design of Wood Members) regarding Section 16.2.1 Char Rate.</p>
<p>Chapter 2 Design Values for Structural Members</p>	<ol style="list-style-type: none"> 1. Revise Section 2.1.2 Responsibility of Designer to Adjust for Conditions of Use, to clarify that the designer is responsible for determining the appropriate design value adjustments to use for end use conditions that are addressed in the NDS. 2. Revise Footnote 2 in Table 2.3.2 Frequently Used Load Duration Factors, C_D, to clarify that the impact load duration factor does not apply to wood structural panels. This change reflects current wood structural panel industry recommendations.
<p>Chapter 3 Design Provisions and Equations</p>	<p>Revise F_b^* in Section 3.3.3.8 Beam Stability Factor, to clarify that the volume factor, C_V, shall be included in the calculation of F_b^* when C_V is greater than 1.0 – which can be the case for SCL per Section 8.3.6.</p>
<p>Chapter 4 Sawn Lumber</p>	<ol style="list-style-type: none"> 1. In Section 4.3.7 Flat Use Factor, C_{fu}, add a new Section 4.3.7.2 to clarify that the application of the flat use factor, C_{fu}, in Adjustment Table 4.3.1 is required for beams and stringers. 2. Revise Section 4.3.8 Incising Factor, C_i, to permit incising factors, C_i, for specific incising patterns and lumber sizes, when obtained from the company providing the incising. This is added as an alternative to using the C_i values per Table 4.3.8. 3. Revise Section 4.4.2 Wood Trusses, to clarify that the buckling stiffness factor, C_T, for wood trusses, applies not only when the truss is sheathed with “plywood” but also when sheathed with Oriented Strand Board (OSB) panels. Plywood panels and OSB panels are both “wood structural panel (WSP) sheathing.”
<p>Chapter 5 Structural Glued Laminated Timber</p>	<p>In Table 5.3.1 Applicability of Adjustment Factors for Structural Glued Laminated Timber, add a footnote to clarify that wet service and temperature adjustment factors, C_M and C_t, for shear parallel to grain, shall be used to adjust reference radial tension, F_{rt}.</p>
<p>Chapter 7 Prefabricated Wood I-joists</p>	<p>Revise Section 7.1.4 Service Conditions, to clarify that dry service conditions are associated with conditions where the moisture content of sawn lumber is less than 16%.</p>

<p>Chapter 8 Structural Composite Lumber</p>	<ol style="list-style-type: none"> 1. Revise Section 8.1.4 Service Conditions, to clarify that dry service conditions are associated with conditions where the moisture content of sawn lumber is less than 16% for consistency with ASTM D5456, <i>Standard Specification for Evaluation of Structural Composite Lumber Products</i>. 2. In Table 8.3.1 Applicability of Adjustment Factors for Structural Composite Lumber, and Section 8.3.6 Volume Factor, C_v, a volume adjustment factor, C_v, applicable to tension, F_t, is added. This is a correlating change with ASTM D5456, which requires development of a volume factor for tension. Footnotes for C_L and C_v are removed from the column headings in Table 8.3.1 and repositioned next to these adjustment factors within the table for greater clarity.
<p>Chapter 10 Cross-Laminated Timber</p>	<ol style="list-style-type: none"> 1. Revise the Format Conversion Factor, K_F, for rolling shear in CLT in Table 10.3.1 Applicability of Adjustment Factors for CLT, from 2.88 to 2.00. This is a correlating change with ASTM D5457, <i>Standard Specification for Computing Reference Resistance of Wood-Based Materials and Structural Connections for Loads and Resistance Factor Design</i>. The format conversion factor of 2.00 is consistent with format conversion assumptions implemented for modulus of elasticity and compression perpendicular to grain design properties which are not adjusted for either load duration or time effect factors. 2. Revise Equation 10.4-1 to include the term GA_{eff} (effective shear stiffness of the CLT section). This is a correlating change with ANSI/APA PRG 320 <i>Standard for Performance-Rated Cross-Laminated Timber</i> – to facilitate the calculation of $(EI)_{app}$ per Equation 10.4-1 consistent with properties as provided in PRG 320.
<p>Chapter 11 Mechanical Connections</p>	<ol style="list-style-type: none"> 1. Revise Table 11.3.1 Applicability of Adjustment Factors for Connections, to add Head Pull-Through. 2. Revise Table 11.3.3 Wet Service Factors, C_M, for Connections, as follows: <ol style="list-style-type: none"> a. Add wet service factors for Round Head Fasteners subjected to Pull-Through Loads. b. Delete reference to Threaded Hardened Nails. c. Add a new footnote for Nails & Spikes subjected to Withdrawal Loads - to indicate the appropriate C_M factor for Roof Sheathing Ring Shank nails and Post-Frame Ring Shank nails.
<p>Chapter 12 Dowel-Type Fasteners</p>	<ol style="list-style-type: none"> 1. Revise Section 12.1.6 General: Nails and Spikes: <ol style="list-style-type: none"> a. Add language for Roof Sheathing Ring Shank (RSRS) Nails, including reference to new Appendix Table L6. b. Clarify that nails and spikes used in engineered construction shall meet the Supplementary Requirements of ASTM F1667 S1 Nail Bending Yield Strength. c. Add "head diameters," required for new head pull-through design provisions.

	<p>d. Remove "Threaded Hardened Nails" in Section 12.1.6.2 and replace with new provision for "other deformed shank nails" per new Section 12.2.3.2d.</p> <p>2. Revise Section 12.2.3 Reference Withdrawal Design Values: Nails and Spikes, as follows:</p> <p>a. Add new Section 12.2.3.1 to address smooth shank nails or spikes as follows:</p> <p>i. Utilize terminology "smooth shank" instead of "plain shank" for consistency with ASTM F1667 terminology.</p> <p>ii. Clarify that withdrawal design provisions for steel wire nails are applicable for carbon steel nails and spikes including bright or galvanized nails.</p> <p>iii. Add provisions in 12.2.3.1b, new Table 12.2D and new equation 12.2-4 for withdrawal design provisions of smooth shank stainless steel nails.</p> <p>b. Add new Section 12.2.3.2 to address deformed shank nails as follows:</p> <p>i. Add language in 12.3.2a to address withdrawal design provisions for Roof Sheathing Ring Shank (RSRS) nails. Table 12.2E includes withdrawal design values for RSRS nails.</p> <p>ii. Add language to permit reference withdrawal design values for uncoated Roof Sheathing Ring Shank or Post-Frame Ring Shank nails to be multiplied by 1.25.</p> <p>iii. Add 12.2.3.2d to address other deformed shank nails (e.g. threaded hardened nails) to permit use of withdrawal design provisions for smooth shank nails or spikes in 12.2.3.1.</p> <p>3. Add new Section 12.2.5 and Table 12.2F to address fastener head pull-through for fasteners with round heads based on pull-through tests results.</p> <p>4. Revise Section 12.3.7.1 Reference Lateral Design Values: Dowel Diameter, to clarify the fastener diameter to be used in Tables 12.3.1A and 12.3.1B (Yield Limit Equations) for different fastener types. This change specifies use of diameter D for both smooth shank and deformed shank nails in accordance with ASTM F1667 for calculation of lateral design values. It accounts for standard method of determining F_{yb} for nails which is based on diameter D.</p> <p>5. Revise Tables 12Q and 12R (Reference Lateral Design Values for Single-Shear Connections using WSP side members), to add Roof Sheathing Ring Shank Nails.</p> <p>6. Revise Table 12S and 12T (Reference Lateral Design Values for Single-Shear Connections) for Post-Frame Ring Shank nails. Updated lateral design values are based on a lower F_{yb} for low-medium carbon steel considered to be more widely used than high-carbon steel, and an increase in the diameter from D_r (root diameter) to D.</p>
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<p>Chapter 14 Timber Rivets</p>	<p>Revise Tables 14.2.1A through 14.2.1F, and Table 14.2.2A to limit the tabulated maximum number of timber rivet rows per side and maximum number of timber rivet rows, respectively – to be consistent with the provisions in Section 14.3.1 (Spacing between Rivets) which limits the maximum distance perpendicular to grain between outermost rows of rivets to 12”.</p>
<p>Chapter 16 Fire Design of Wood Members</p>	<p>Revise terminology in Chapter 16 (Fire Design of Wood Members) to clarify the difference between “char depth,” (a_{char}) and “effective char depth,” (a_{eff}) used in structural calculations. Section 16.3 (Wood Connections) is also revised to more precisely describe the requirements for protection of the connection from fire exposure.</p>
<p>Appendix L Typical Dimensions for Dowel-Type Fasteners and Washers</p>	<ol style="list-style-type: none"> 1. Addition of Head Diameter in Table L3 (Standard Wood Screws) to facilitate calculation of head pull-through. 2. Addition of new Table L6 (Roof Sheathing Ring Shank Nails).
<p>References</p>	<p>References are updated to most recent applicable editions.</p>
<p>NDS Supplement</p>	<ol style="list-style-type: none"> 1. Introduction revised to advise users that it is good practice to “check for sources of availability of sizes, species and grades of products specified in this Supplement.” 2. Northern Softwood Lumber Bureau (NSLB) references replaced with Northeastern Lumber Manufacturers Association (NELMA). 3. Norway Spruce species added to the Spruce-Pine-Fir (South) species combination for lumber. 4. Redwood grades requiring “Close Grain” removed. 5. Modified Table 4C footnote 2 applicable to mechanically graded dimension lumber to show specific modulus of elasticity ranges (e.g. “1.0 to 1.9” for DFL instead of “1.0 and higher”). 6. Modified Table 4D adjustment factors for visually graded timbers for consistency with flat use factor definition per NDS changes. 7. Norway Spruce from Norway added to Table 4F for Non-North American Visually Graded Dimension Lumber. 8. Revised Tables 5A, 5A Expanded, and 5B for structural glued laminated timber to address new format for design values for modulus of elasticity.