# Codes and Standards

updates and discussions related to codes and standards

*This article is the first of two that outlines changes for wood design in the 2012 building codes. This article focuses on the 2012 NDS, while Part 2 will outline other updated standards and code modifications.*

## 2012 NDS Changes

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The 2005 Edition of the *National Design Specification® (NDS®) for Wood Construction (ANSI/AF&PA NDS-2005)* was recently updated. The updated standard, designated *ANSI/AWC NDS-2012*, was approved as an ANSI American National Standard on August 15, 2011 (*Figure 1*). The 2012 NDS was developed by the American Wood Council's (AWC) Wood Design Standards Committee and is referenced in the *2012 International Building Code* (IBC).

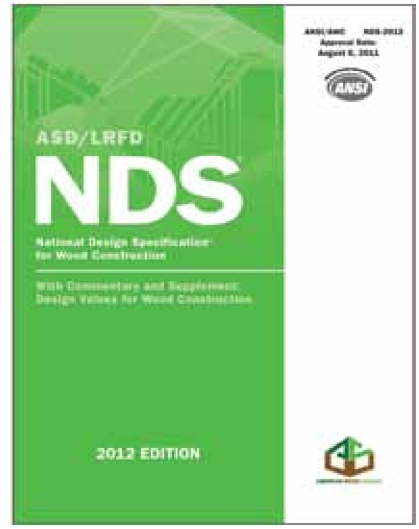


*Figure 1: National Design Specification for Wood Construction, 2012 Edition.*

Primary changes to the *2012 NDS* are listed here. Major issues are subsequently covered in more detail.

- Revised load and resistance factor design (LRFD) Format Conversion Factors ($K_F$) to provide numeric values of $K_F$ rather than equations
- Incorporated LRFD $K_F$ factors and resistance factors (ϕ) into NDS Chapter 2 and all material-specific chapters
- Incorporated a new equation for intermediate calculation of members subjected to bending in combination with axial compression with or without edgewise bending
- Removed sections on specification of glued laminated timber (glulam) and deflection
- Added two glulam adjustment factors: stress interaction factor and shear reduction factor
- Clarified applicability of existing glulam provisions for curved members, double-tapered and tapered straight beam members, and notching
- For poles and piles: updated design values per *ASTM D 2899*, moved design values to the NDS *Design Value Supplement*, and revised several adjustment factors
- Revised I-Joist beam stability factor to be more consistent with NDS Chapter 3
- Removed grade and construction factor for wood structural panels and clarified panel size factor applicability
- Referenced ANSI/TPI standard for design of assemblies utilizing metal connector plates
- Revised connection provisions and table headings and footers for consistency
- Clarified provisions for dowel bearing strength of wood structural panels for fastener diameters less than or equal to ¼ inch
- Added provisions for post-frame ring shank nails
- Clarified how connection tip length is used for lateral load calculations
- Addressed perpendicular to grain outer row distance for fasteners accounting for expected glulam shrinkage
- Clarified provisions for applicability of split ring and shear plate connections in side grain and end grain; relocated provisions for edge distance, end distance, and spacing
- Revised geometry factors for split rings and shear plates for reduced edge distance associated with glulam with faces as narrow as 3 and 5 inches
- Revised timber rivet capacity equations to allow proper application of the load duration factor and LRFD conversion factors
- Directly referenced *Special Design Provisions for Wind and Seismic (SDPWS-08)* and removed all other provisions in Chapter 14

### LRFD

In Section 2.3.5, reference to the Format Conversion Factor, $K_F$, (LRFD only) is changed from Appendix N.3.1 to new Table 2.3.5. Similarly in Section 2.3.6, reference to Resistance Factors, ϕ, (LRFD only) is changed from Appendix N.3.2 to new Table 2.3.6 (*Figure 2*).

The values in Tables 2.3.5 and 2.3.6 are based on Tables N1 and N2, respectively, from Appendix N. Note that Table 2.3.5 (and revised Table N1) shows the numeric values of $K_F$ directly. These numeric values are used to estimate the LRFD reference resistances because use of a constant/ϕ equation format from *ASTM D5457-10 Standard Specification for Computing Reference Resistance of Wood Based Materials and Structural Connections for Load and Resistance Factor Design* has proven to be confusing. Table 2.3.5 includes a revised Format Conversion Factor for $F_{cperp}$ (revised from

**Table 2.3.5 Format Conversion Factor, $K_F$ (LRFD Only)**

| Application | Property | $K_F$ |
|---|---|---|
| Member | $F_b$ | 2.54 |
| | $F_t$ | 2.70 |
| | $F_v$, $F_{rt}$ $F_s$ | 2.88 |
| | $F_c$, | 2.40 |
| | $F_{c\perp}$ | 1.67 |
| | $E_{min}$ | 1.76 |
| All Connections | (all design values) | 3.32 |

**Table 2.3.6 Resistance Factor, $\phi$ (LRFD Only)**

| Application | Property | Symbol | Value |
|---|---|---|---|
| Member | $F_b$ | $\phi_b$ | 0.85 |
| | $F_t$ | $\phi_t$ | 0.80 |
| | $F_v$, $F_{rt}$, $F_s$ | $\phi_v$ | 0.75 |
| | $F_c$, $F_{c\perp}$ | $\phi_c$ | 0.90 |
| | $E_{min}$ | $\phi_s$ | 0.85 |
| All Connections | (all design values) | $\phi_z$ | 0.65 |

*Figure 2: LRFD format conversion factors and resistance factors.*

**Table 5.3.1 Applicability of Adjustment Factors for Structural Glued Laminated Timber**

| | ASD only | ASD and LRFD | | | | | | | | | | LRFD only | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Load Duration Factor | Wet Service Factor | Temperature Factor | Beam Stability Factor [1] | Volume Factor [1] | Flat Use Factor | Curvature Factor | Stress Interaction Factor | Shear Reduction Factor | Column Stability Factor | Bearing Area Factor | Format Conversion Factor | Resistance Factor | Time Effect Factor |
| | | | | | | | | | | | | $K_F$ | $\phi$ | |
| $F_b' = F_b$ x | $C_D$ | $C_M$ | $C_t$ | $C_L$ | $C_V$ | $C_{fu}$ | $C_c$ | $C_I$ | - | - | - | 2.54 | 0.85 | $\lambda$ |
| $F_t' = F_t$ x | $C_D$ | $C_M$ | $C_t$ | - | - | - | - | - | - | - | - | 2.70 | 0.80 | $\lambda$ |
| $F_v' = F_v$ x | $C_D$ | $C_M$ | $C_t$ | - | - | - | - | - | $C_{vr}$ | - | - | 2.88 | 0.75 | $\lambda$ |
| $F_{rt}' = F_{rt}$ x | $C_D$ | $C_M$ | $C_t$ | - | - | - | - | - | - | - | - | 2.88 | 0.75 | $\lambda$ |
| $F_c' = F_c$ x | $C_D$ | $C_M$ | $C_t$ | - | - | - | - | - | - | $C_P$ | - | 2.40 | 0.90 | $\lambda$ |
| $F_{c\perp}' = F_{c\perp}$ x | - | $C_M$ | $C_t$ | - | - | - | - | - | - | - | $C_b$ | 1.67 | 0.90 | - |
| $E' = E$ x | - | $C_M$ | $C_t$ | - | - | - | - | - | - | - | - | - | - | - |
| $E_{min}' = E_{min}$ x | - | $C_M$ | $C_t$ | - | - | - | - | - | - | - | - | 1.76 | 0.85 | - |

1. The beam stability factor, $C_L$, shall not apply simultaneously with the volume factor, $C_V$, for structural glued laminated timber bending members (see 5.3.6). Therefore, the lesser of these adjustment factors shall apply.

*Figure 3: Adjustment factors for structural glued laminated timber.*

$K_F$=2.08 to $K_F$=1.67). This revision is necessary in order to be consistent with ASTM D5457-10.

Variables for the Format Conversion Factor, $K_F$, and the Resistance Factor, $\phi$, in the applicability tables of NDS chapters 4, 5, 6, 7, 8, 9 and 10 have been replaced with specific values from Table 2.3.5 and Table 2.3.6, respectively (*Figure 3* for an example). Specifying language in NDS sections 2.3.5 and 2.3.6 has been revised, as has the specifying language in each of the material chapters to reflect this change.

## Intermediate Calculation for Combined Bending and Compression

A new equation 3.9-4 was added for intermediate calculation of members subjected to flatwise bending in combination with axial compression with or without edgewise bending. When a flatwise bending load is checked with the third term of the stress interaction equation, axial and edgewise bending interactions in the denominator can become negative. Occurrence of a negative value indicates an overstress. However, use of this negative term in the stress interaction equation overlooks overstress in flatwise bending and incorrectly reduces the overall interaction. While a check for overstress due to bending is a limiting condition of member design for bending per 3.3.1 of the NDS, an explicit check needs to be provided to clarify limitations on flatwise bending in NDS stress interaction equations. Similar modifications were made for built-up columns in Chapter 15 (equations 15.4-2 and 15.4-4).

## Structural Glued Laminated Timber

Sections on specification of glued laminated timber (Section 5.1.4) and deflection (Section 5.4.3) were removed. Dry-use adhesives are not permitted in *ANSI/AITC A190.1 Structural Glued Laminated Timber*, removing the need to specify whether the glulam can be used in dry or wet service conditions. The specification of stress requirements and design values were removed for consistency with other NDS product chapters which do not contain similar requirements. Deflection information was redundant to provisions elsewhere in the standard, including Section 3.5.

Provisions were added for two stress adjustment factors (*Figure 3*). The stress interaction factor (Section 5.3.9) was added consistent with provisions of the *Timber Construction Manual* (TCM) used to adjust bending stress in tapered bending members. The shear reduction factor (Section 5.3.10), previously appearing in footnotes to glulam design values in the *NDS Design Value Supplement*, has been specifically defined as an adjustment factor applicable for shear design of other than prismatic beams (e.g. notched members, curved members, tapered members, design for radial tension, and shear design at connections).

Applicability of existing provisions was clarified for curved members (Section 5.4.1) and provisions for double-tapered and tapered straight beam members (Section 5.4.2 and Section 5.4.4) were added in lieu of referencing the TCM (Section 5.4.1).

Finally, notching provisions were clarified for glulam. Notches are not permitted on the top and bottom of the beam at the same location (Section 5.4.5).

## Timber Poles and Piles

NDS Chapter 6 has been updated to address changes to ASTM standards for developing and adjusting round timber pile and round construction pole design values. Changes are summarized as follows:

- New design values for Table 6A "Untreated Round Timber Piles" and Table 6B "Untreated Round Construction Poles" were relocated from NDS Chapter 6 to the *NDS Design Value Supplement* (*Figure 4*).
- Section 6.3.5 "Untreated Factor" adjustment was changed to "Condition Treatment Factor" in recognition that new reference

**Table 6A Reference Design Values for Treated Round Timber Piles Graded per ASTM D25**

(Tabulated design values are for normal load duration and wet service conditions. See NDS 6.3 for a comprehensive description of design value adjustment factors.)

| | Design values in pounds per square inch (psi) | | | | | |
|---|---|---|---|---|---|---|
| | Bending | Shear parallel to grain | Compression perpendicular to grain | Compression parallel to grain | Modulus of elasticity | |
| Species | $F_b$ | $F_v$ | $F_{c\perp}$ | $F_c$ | E | $E_{min}$ |
| Pacific Coast Douglas Fir[1] | 2,050 | 160 | 490 | 1,300 | 1,700,000 | 690,000 |
| Red Pine[2] | 1,350 | 125 | 270 | 850 | 1,300,000 | 520,000 |
| Southern Pine (Grouped)[3] | 1,950 | 160 | 440 | 1,250 | 1,500,000 | 600,000 |

1. Pacific Coast Douglas Fir reference design values apply to this species as defined in ASTM Standard D 1760. For connection design use Douglas Fir-Larch reference design values.
2. Red Pine reference design values apply to Red Pine grown in the United States. For connection design use Northern Pine reference design values.
3. Southern Pine reference design values apply to Loblolly, Longleaf, Shortleaf, and Slash Pines.

**Table 6B Reference Design Values for Construction Poles Graded per ASTM D3200**

(Tabulated design values are for normal load duration and wet service conditions. See NDS 6.3 for a comprehensive description of design value adjustment factors.)

| | Design values in pounds per square inch (psi) | | | | | |
|---|---|---|---|---|---|---|
| | Bending | Shear parallel to grain | Compression perpendicular to grain | Compression parallel to grain | Modulus of elasticity | |
| Species | $F_b$ | $F_v$ | $F_{c\perp}$ | $F_c$ | E | $E_{min}$ |
| Pacific Coast Douglas Fir[1] | 2,050 | 160 | 490 | 1,300 | 1,700,000 | 690,000 |
| Lodgepole Pine | 1,275 | 125 | 265 | 825 | 1,100,000 | 430,000 |
| Ponderosa Pine | 1,200 | 175 | 295 | 775 | 1,000,000 | 400,000 |
| Red Pine[2] | 1,350 | 125 | 270 | 850 | 1,300,000 | 520,000 |
| Southern Pine (Grouped)[3] | 1,950 | 160 | 440 | 1,250 | 1,500,000 | 600,000 |
| Western Hemlock | 1,550 | 165 | 275 | 1,050 | 1,300,000 | 560,000 |
| Western Larch | 1,900 | 170 | 405 | 1,250 | 1,500,000 | 660,000 |
| Western Red Cedar | 1,250 | 140 | 260 | 875 | 1,000,000 | 360,000 |

1. Pacific Coast Douglas Fir reference design values apply to this species as defined in ASTM Standard D 1760. For connection design use Douglas Fir-Larch reference design values.
2. Red Pine reference design values apply to Red Pine grown in the United States. For connection design use Northern Pine reference design values.
3. Southern Pine reference design values apply to Loblolly, Longleaf, Shortleaf, and Slash Pines.

*Figure 4: Reference design values for timber poles and piles.*

design values are now based on air dried condition.

- Section 6.3.9 "Critical Section" is changed to be consistent with changes to reference design values in *ASTM D2899 Standard Practice for Establishing Allowable Stresses for Round Timber Piles*.
- Section 6.3.11 "Single Pile Factor" adjustment was changed to "Load Sharing Factor" in recognition that new reference design values are now based on a single pile condition.

## Prefabricated Wood I-Joists

NDS 7.3.5 regarding I-Joist Beam Stability Factor, $C_L$, was revised to be more consistent with provisions in Section 3.3.3 and to address confusion that currently exists with these provisions. A new section 7.3.5.1 was created that permits $C_L$=1.0 when the compression flange of an I-joist is supported throughout its length to prevent lateral displacement, consistent with the general requirements in 3.3.3.3. Additionally, a new section 7.3.5.2 was added that provides a method for designing the compression flange as an unbraced or partially braced column when the compression flange is not braced throughout its length. These provisions are consistent with 3.3.3.4.

## Wood Structural Panels

The Grade and Construction Factor, $C_G$, was removed from Section 9.3.4 and Table 9.3.1 as this factor is no longer used by the wood structural panel industry. The *NDS Commentary* will also be updated to remove reference to $C_G$.

Additional wording is provided in NDS 9.3.4 to better clarify under what conditions the panel size factor, $C_s$, is required. *NDS Commentary* Table C9.3.4 "Panel Size Factor" is relocated and designated as NDS Table 9.3.4.

## Dowel-type Fasteners

Provisions throughout NDS Chapter 11 have been revised to clarify intent and to add charging text utilizing a consistent format. Design value tables were also revised to use consistent and more descriptive table headings and table footnotes.

For lateral design value tables where penetration is an issue, footnotes clarify penetration basis of tabulated values and applicability of penetration adjustment to the table values only. The addition of penetration assumptions in the table titles are intentionally redundant with similar information in table footnotes to more clearly identify the reference penetration used for tabulated values.

Provisions for dowel bearing strength for wood structural panels were clarified as being applicable to fastener diameters of less than or equal to ¼ inch (see 11.3.2.2) for consistency with supporting data. Commentary will be developed to address available guidance for larger diameter fasteners.

Provisions were added for post-frame ring shank nails manufactured in accordance with *ASTM F1667 Standard Specification for Driven Fasteners: Nails, Spikes, and Staples*. A withdrawal design (Section 11.2.3.3) equation for post-frame ring shank nails, based on research conducted at the Forest Products Laboratory including a 20% adjustment to account for effects of galvanized coatings, was added. Lateral design value tables (Table 11S and 11T), based on application of yield limit equations to standard properties for post-frame ring shank nails as noted in table footnotes, were also added.

Provisions were added to clarify how tip length is addressed in determination of bearing length used for lateral load calculations (Section 11.3.4). New provisions to specifically address length of tapered tip are based on analysis of reduced bearing present as the fastener diameter tapers to a point at the tip, and the effect of tip length on lateral design values for small penetrations. Commentary will be developed to provide background for determination of new bearing length provisions for driven fasteners and the effect of tip length.

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Provisions were also added to address the maximum perpendicular to grain distance for outermost fasteners in glulam based on moisture content and fastener type (Section 11.5.1.3), taking into account the expected shrinkage of glulam.

## Split Ring and Shear Plate Connectors

NDS Section 12.3.2 was revised to clarify applicability of provisions to connections in side grain. Provisions for edge distance, end distance, and spacing (Section 12.3.3, 12.3.4, and 12.3.5) were relocated in the following sections:

- Section 12.3.2.1 combines requirements for geometry factors for parallel or perpendicular to grain loading (i.e. Section 12.3.3.1, 12.3.4.1, and 12.3.4.5).
- Section 12.3.2.2 clarifies requirements for connectors loaded at an angle to grain. Separate geometry factors for end and edge distance are to be calculated for the parallel and perpendicular components of the resistance. An equation and table for determining spacing requirements were added (Eq. 12.3-1 and Table 12.3.2.1).

Provisions were added to clarify applicability of requirements to connectors installed in end grain:

- Section 12.3.3 was revised to clarify that a single geometry factor is determined and applied to parallel and perpendicular components of the resistance.
- Section 12.3.3.1(a) clarifies that end distance provisions do not apply to connectors installed in end grain.
- For connectors in sloping surface of end grain, loaded parallel or perpendicular to axis of cut (Section 12.3.3.1b and 12.3.3.1c), an equation approach was added for determination of the geometry factor for greater consistency with the method used for side grain connections when transitioning from 0 degrees to 90 degrees and to remove a step function.
- Provisions were added to clarify requirements for connectors in sloping surfaces of end grain, loaded other than parallel or perpendicular to the axis of cut (Section 12.3.3.1d).

Geometry factors were revised to account for reduced edge distance associated with glulam with faces as narrow as 3 and 5 inches rather than 3.5 and 5.5 inches assumed previously (e.g. edge distances of 1.5 and 2.5 inches rather than 1.75 and 2.75 inches). Reduced values of the geometry factor were based on a re-evaluation of the original research and will be provided as background in *NDS Commentary*.

## Timber Rivets

The constant in Equation 13.2-1 for parallel to grain reference timber rivet capacity, $P_r$, was changed from 280 to 188, and the constant in Equation 13.2-2 for perpendicular to grain reference timber rivet capacity, $Q_r$, was changed from 160 to 108. To allow proper application of the load duration factor and LRFD conversion factors to timber rivet connections, including those conditions limited by rivet strength rather than wood strength, these constants have been reduced to be consistent with other NDS connection values. Average ultimate values of $P_r$ and $Q_r$ have previously been divided by 3.36. Similarly, a correlating change was made in Chapter 10, Table 10.3.1 to remove footnote 4 which will permit application of the load duration factor when rivet capacity controls as well as when wood capacity controls.

The following sentence was added to Section 13.3.1: "The maximum distance perpendicular to grain between outermost rows of rivets shall be 12." This change parallels requirements in the new Table 11.5.1F specifying maximum spacing between outer rows of dowel-type fasteners in glulam connections.

## NDS Supplement

The *NDS Supplement* incorporates several new species combinations and revisions to existing design values. Changes include:

- Revision of Table 1A "Nominal and Minimum Dressed Sizes of Sawn Lumber" to reflect new sizes for Timbers per Voluntary Product Standard *PS 20-10 American Softwood Lumber Standard*
- Reorganization of Table 1B "Section Properties of Standard Dressed Sawn Lumber" to better distinguish between dimension lumber, Posts and Timbers, and Beams and Stringers
- Incorporation of new Coast Sitka Spruce and Yellow Cedar design values in Table 4A for dimension lumber
- Revision of Northern Species bending and tension design values in Table 4A
- Clarification of size factor adjustments for visually graded timbers in Table 4D
- Revision of Ponderosa Pine decking repetitive member design values in Table 4E
- Table 4F for non-North American species was revised to incorporate new design values for Douglas-fir from France and Germany, and revised values for Norway Spruce and Scots Pine from the countries of Estonia, Latvia, and Lithuania
- Revision of glulam design values in Tables 5A, 5A Expanded, and 5B. Primary changes are to shear parallel to grain design values
- Addition of Tables 6A and 6B for Timber Poles and Piles

## More Details

A comprehensive table listing section by section changes to the NDS, including modifications to Appendix material, is available to download from the AWC website (**www.awc.org**). Navigate to the NDS page to locate the document.

## Availability

The 2012 NDS and 2012 *NDS Supplement* is currently available for purchase in electronic format (PDF) only. Once the *NDS Commentary* and other support documents to be included in the 2012 *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 2012 WDP. Once the *NDS Commentary* and other support documents are complete, those who purchased electronic versions of the 2012 NDS and 2012 *NDS Supplement* will receive those documents in electronic format at no additional charge.

## Conclusion

The 2012 NDS represents the state-of-the-art for design of wood members and connections. Its reference in the 2012 IBC will make it a required design methodology in those jurisdictions adopting the latest building code. However, building officials are also apt to accept designs prepared in accordance with newer reference standards even if the latest building code has not been adopted in their jurisdiction. IBC 104.11 for alternate materials and design provides the authority having jurisdiction with that leeway.▪