The primary change in the 2005 NDS is the introduction of load and resistance factor design (LRFD). Learn more about the format changes that were necessary to accommodate the addition of LRFD.

The 2005 Edition of the National Design Specification for Wood Construction has been approved as an American National Standard, with a designation ANSI/AF&PA NDS-2005. The 2005 NDS was developed as a dual format specification incorporating design provisions for both allowable stress design (ASD) and load and resistance factor design (LRFD). AF&PA’s Wood Design Standards Committee (WDSC) guided it through the consensus process over the course of 2-1/2 years. The primary change in the 2005 NDS is the introduction of LRFD methods to the Specification.

Several format changes to the NDS to accommodate addition of LRFD are summarized in this article and include:

• Revised terminology,
• Expanded applicability of adjustment factor tables,
• Re-format of radial tension design values,
• Revised format of beam and column stability provisions (addition of $E_{\text{min}}$ property), and
• Addition of NDS Appendix N – Load and Resistance Factor Design.

A number of other changes introduced in the 2005 Edition include:

• Removal of form factor,
• Revision of repetitive member factor for I-joists,
• Revision of full-design value terminology, and
• Clarification of built-up column provisions.

The NDS Supplement, Design Values for Wood Construction has also been updated to provide the latest design values for sawn lumber and glued laminated timber. What follows are the updates most likely to affect those undertaking wood member design in the wood truss industry.

Introducing LRFD to NDS – An Overview

Over the years, the WDSC identified benefits of developing a dual format specification which would include: addressing user needs for consistent design information regardless of design format (ASD or LRFD); better utilizing standards committee resources; and providing current design information for the academic community. The 2005 NDS maintains the current 2001 NDS format, familiar to most wood designers. As a result, NDS 2005 is very similar to the 2001 NDS for ASD design, with few exceptions.

Users familiar with the NDS ASD provisions will also find transition to LRFD straightforward. Behavioral equations, such as those for member and connection design, are the same for both ASD and LRFD. Adjustment factor tables now include applicable factors for determining an adjusted ASD design value or an adjusted LRFD design value. A new Appendix N - Mandatory Appendix for Load and Resistance Factor Design (LRFD) outlines requirements that are unique to LRFD and adjustment factors for LRFD.
Terminology:
Basic requirements for checking strength are revised to use terminology applicable to both ASD and LRFD. For example, the basic requirement for strength in bending is revised as follows:

“3.3.1 The actual bending stress or moment shall not exceed the adjusted allowable bending design value.”

In equation format, this takes the standard form $f_b \leq F_b'$. The term “allowable,” typically associated with ASD, is replaced by “adjusted” to be more generally applicable to either ASD or LRFD and to better describe the approach of applying adjustment factors to reference design values. Reference design values ($F_b, F_t, F_v, F_c, F_{cL}, E, E_{min}$) are multiplied by adjustment factors to determine adjusted design values ($F_b', F_t', F_v', F_c', F_{cL}', E', E_{min}'$).

Applicability of Adjustment Factor Tables:
For member design, the adjusted bending design value, $F_b'$, of a sawn lumber bending member is determined using Table 4.3.1 (see page 52) as follows:

For ASD:
$$F_b' = F_b \cdot C_D \cdot C_M \cdot C_t \cdot C_L \cdot C_F \cdot C_{fu} \cdot C_i \cdot C_t$$

For LRFD:
$$F_b' = F_b \cdot K_F \cdot \phi \cdot \lambda \cdot C_M \cdot C_t \cdot C_L \cdot C_F \cdot C_{fu} \cdot C_i \cdot C_t$$

where:
$$F_b = \text{the reference bending design value based on normal load duration.}$$

For connection design, the adjusted lateral design value, $Z'$, of a dowel connection (i.e., nail, bolt, etc.) is determined using Table 10.3.1 Applicability of Adjustment Factors for Connections as follows:

For ASD:
$$Z' = Z \cdot C_D \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn}$$

For LRFD:
$$Z' = Z \cdot K_F \cdot \phi \cdot \lambda \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn}$$

where:
$$Z = \text{the reference design value based on normal load duration.} Z \text{ may be taken from connection tables directly or calculated using yield mode equations.}$$

For ASD member and connection design, this approach is identical to that used in prior editions of the NDS. For LRFD member and connection design, adjustment factors applicable to reference design values, make conversion between ASD and LRFD-based design values transparent.

In the 2005 NDS, “reference design value” designates the allowable stress design value based on normal load duration and replaces terms such as tabulated, nominal, base, and published, which were also based on normal load duration. The variety of terms was considered potentially confusing. For example, tabulated and published values outside of the Specification may already include adjustment factors.

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Nominal may be interpreted as nominal strength (especially with the addition of LRFD) rather than in current NDS use where it means unadjusted. To avoid confusion, the descriptor “reference” is used and serves as a reminder that design value adjustment factors are applicable for design values in accordance with referenced conditions specified in the NDS—such as normal load duration.

Revised Format of NDS Beam and Column Stability Provisions:

The 2005 NDS includes a revised format for column and beam behavioral equations to address both ASD and LRFD:

**NDS 2005 3.3.3.8:**

3.3.3.8 The beam stability factor shall be calculated as follows:

\[
C_b = \frac{1 + \left(\frac{F_{bE}}{F_{b}}\right)}{1.9} - \sqrt{\left(1 + \left(\frac{F_{bE}}{F_{b}}\right)\right)^2 - \frac{F_{bE}}{0.95}} - \frac{F_{bE}}{F_{b}}
\]

where:

- \(F_{bE}^{*}\) = reference bending design value multiplied by all applicable adjustment factors except \(C_{fu}\), \(C_V\), and \(C_L\) (see 2.3) and \(F_{bE} = 1.20E_{\text{min}} / R_b^2\).

The value \(F_{bE} = 1.20E_{\text{min}} / R_b^2\) is algebraically equivalent to and replaces \(F_{bE} = K_{bE} E' / R_b^2\) used in the 2001 NDS. Because the design equation for \(K_{bE}\) includes a reduction for safety, two different formats of the 2001 NDS equation would be needed to address both ASD and LRFD.

Instead, the 2005 NDS utilizes \(E_{\text{min}}\), which is adjusted for safety, so the safety factor is not part of the basic design equation. Applicable adjustments to \(E_{\text{min}}\), based on applicability of adjustment factor tables are used to establish the appropriate adjusted modulus of elasticity for beam and column stability, \(E_{\text{min}}'\) for either ASD or LRFD.

**NDS 2005 3.7.1.5:**

3.7.1.5 The column stability factor shall be calculated as follows:

\[
C_c = \frac{1 + \left(\frac{F_{cE}}{F_{c}}\right)}{2c} - \sqrt{\left(1 + \left(\frac{F_{cE}}{F_{c}}\right)\right)^2 - \frac{F_{cE}}{c}}
\]

where:

- \(F_{cE}^{*}\) = reference compression design value parallel to grain multiplied by all applicable adjustment factors except \(C_p\) (see 2.3) and \(F_{cE} = 0.822E_{\text{min}}' / (f_{e}/d)^2\).

The value \(F_{cE} = 0.822E_{\text{min}}' / (f_{e}/d)^2\) is algebraically equivalent to and replaces \(F_{cE} = K_{cE} E' / (f_{e}/d)^2\) used in the 2001 NDS. The background justification for this change is identical to that for the beam equation in 3.3.3.8.

Modulus of Elasticity for Beam and Column Stability, \(E_{\text{min}}'\):

For sawn lumber and glulam, reference modulus of elasticity for beam and column stability, \(E_{\text{min}}\) (which represents an approximate 5 percent lower exclusion value on pure bending modulus of elasticity, divided by a 1.66 factor of safety),
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is tabulated in the NDS Supplement. However, it can also be calculated as follows:

$$E_{\text{min}} = 1.03E \times (1-1.645(\text{COV}_E)) / 1.66$$

where:

- $E =$ reference modulus of elasticity,
- $1.03 =$ adjustment factor to convert $E$ to a pure bending basis except that the factor is 1.05 for glued laminated timber,
- $1.66 =$ factor of safety, and
- $\text{COV}_E =$ coefficient of variation in modulus of elasticity (see NDS Appendix F).

**Repetitive Member Factor for I-joists:**

Revision to the NDS 2005 repetitive member factor, $C_r$, for I-joists corresponds to revisions in ASTM D5055-02 setting the factor equal to 1.0:

**7.3.6 Repetitive Member Factor, $C_r$**

For prefabricated wood I-joists with structural composite lumber flanges or sawn lumber flanges, adjusted moment design resistances shall be multiplied by the repetitive member factor, $C_r = 1.0$.

In lieu of complete removal of the $C_r$ factor for I-joists in the 2005 NDS, the repetitive member factor was set to 1.0 for clarity since past practice has permitted other $C_r$ factors. For example, in the 2001 NDS, $C_r = 1.04$, for I-joists with structural composite lumber flanges and $C_r = 1.07$, for I-joists with sawn lumber flanges.

**Revised “Full-Design Value” Terminology and Added Reference to Provisions for Checking Wood Stresses:**

Phrases such as “minimum spacing for full design value” and “minimum end distance for full design value” are replaced with alternate descriptions since other provisions for evaluating wood strength must also be checked to ensure that the “full-design value” can be developed. Multiple references to section 10.1.2 are added as a reminder to check wood strength at connections. Example revisions follow:

**10.2.2 Multiple Fastener Connections**

When a connection contains two or more fasteners of the same type and similar size, each of which exhibits the same yield mode (see Appendix I), the total adjusted design value for the connection shall be the sum of the adjusted design values for each individual fastener. Local stresses in connections using multiple fasteners shall be checked in accordance with principles of engineering mechanics (see 10.1.2).

**11.1.2.4 Edge distance, end distance, and fastener spacing required to develop full design values shall not be less than the requirements in accordance with Table 11.5.1A-D.**
These revisions do not change methods for calculating strength of connections, but remove language that is potentially confusing. For example, there are additional requirements for checking wood strength at connections based on principles of engineering mechanics and procedures outlined in Appendix E for evaluating member strength around fastener groups.

**Clarify 15.3.2.2 Built-Up Column Design:**

Built-up column provisions were revised to correct an obvious but unintended limitation on short built-up columns.

15.3.2.2.... $F'_{c}$ for built-up columns need not be less than $F'_{c}$ for the individual laminations designed as individual solid columns per section 3.7.

This change permits individual laminations in a built-up column to be designed using provisions of section 3.7 for solid columns. With this change, built-up columns are not unnecessarily limited to design capacities less than the sum of individual member capacities.

**Additional Design Tools**

The revised NDS will be packaged with additional publications as follows:

- ANSI/AF&PA NDS-2005 with Commentary,
- ANSI/AF&PA SDPWS-05 Supplement – Special Design Provisions for Wind and Seismic (SDPWS) with Commentary, and

The 2005 Wood Design Package will be available later this year through WTCA Publications. Visit www.woodtruss.com/pubs to place your order online.

**Conclusion**

The primary change in the 2005 NDS is the introduction of LRFD methods to the Specification. Several format changes to the NDS to accommodate the addition of LRFD have been summarized. Users will find very minimal impact on the ASD process as a result, with the added benefit of having a transparent approach to learn and use LRFD. An integrated commentary and other design tools will be available for the new standard. **SBC**

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