Designing with AWC’s 2012 National Design Specification® (NDS®) for Wood Construction

John “Buddy” Showalter, PE  
Vice President, Technology Transfer  
American Wood Council

Michelle Kam-Biron, PE, SE, SECB  
Director of Education  
American Wood Council

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Description

AWC's *National Design Specification (NDS) for Wood Construction 2012* is the dual format *Allowable Stress Design (ASD)* and *Load and Resistance Factor Design (LRFD)* document referenced in US building codes and used to design wood structures worldwide. Participants will learn about changes in the 2012 *NDS* and Supplement relative to previous editions and gain an overview of the standard.

Learning Objectives

**On completion of this course, participants will:**

- Be able to understand Load and Resistance Factor Design (LRFD) and how it applies to wood structural design.
- Be familiar with the significant changes between the 2005 and 2012 *NDS* and supplement.
- Be able to identify the similarities and differences with respect to ASD, design values, and behavioral equations.
- Be able to analyze format and content within the 2012 *NDS*.
Polling Question

1. What is your profession?
   a) Architect
   b) Engineer
   c) Code Official
   d) Building Designer
   e) Other

Outline

• Overview
• LRFD Primer
• NDS
  • Chapter-by-chapter discussion
  • Changes from previous editions
  • Summary
• More Info.
Outline

- Overview
- LRFD Primer
- NDS
  - Chapter-by-chapter discussion
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- More Info.

NDS History

1944 1962 1968 1971


SECTION 2306 ALLOWABLE STRESS DESIGN

2306.1 Allowable stress design. The structural analysis and construction of wood elements in structures using allowable stress design shall be in accordance with the following applicable standards:

- NDS National Design Specification for Wood Construction

2307.1 Load and resistance factor design.

The structural analysis and construction of wood elements and structures using load and resistance factor design shall be in accordance with AF&PA NDS.
NDS and Supplement

- 2005
- 16 Chapters
- 14 Appendices

NDS 2012 Approval

- ANSI approval
- August 15, 2011
- 2012 IBC Reference
Addenda/Errata

- Publications Addenda/Errata
- Comprehensive List
- Free download

Outline

- Overview
- LRFD Primer
- NDS
  - Chapter-by-chapter discussion
  - Changes from previous editions
  - Summary
  - More Info
Design Process

Load
Support Conditions
Geometry
Materials
Performance
Fire
Economics
Aesthetics
...

Demand \leq\ Capacity
Design Concepts

**Two Limit State concerns:**

- Serviceability (performance in-service)
- Safety against failure or collapse

Serviceability

- Unfactored loads
- Mean (avg) material strength values
LRFD - Safety

- Factored loads
- Material strength values - modified

Structural Property Variability

Normal Distribution Curves

\[ \bar{x} = \text{mean} \]
\[ \sigma_x = \text{standard deviation} \]

\[ \text{COV}_x = \frac{\sigma_x}{\bar{x}} \]
Coefficient of variation

SCL
I-Joist
Glulam
MSR Lumber
Visually Graded Lumber
Engineered Wood Design

Statistical Model

- Normal Distribution Curves for Safety Function, $Z$

$$f_Z = f_R - f_S$$

$$m_Z = m_R - m_S$$

$$\sigma_Z = \sqrt{\sigma_R^2 + \sigma_S^2}$$

Safety (or reliability) Index

$$\beta = \frac{m_Z}{\sigma_Z}$$

Probability of failure of structure
Probability of Failure

• \( P_f = \text{one failure expected for } x \text{ number of structures designed and built with a given } \beta \)

• Safety (or reliability index) Ex. \( \beta = 3.2 \) represents 1 failure for every 1,000 structures or members designed.

\[
\begin{array}{|c|c|}
\hline
\beta & P_f \\
\hline
5.2 & \text{1:10,000,000} \\
4.7 & \text{1:1,000,000} \\
4.2 & \text{1:100,000} \\
3.7 & \text{1:10,000} \\
3.2 & \text{1:1,000} \\
2.7 & \text{1:100} \\
2.2 & \text{1:10} \\
\hline
\end{array}
\]

LRFD - Range on \( \beta \)

• Structural Design
• \( \beta \) Range for Strength Various Materials

\[
\begin{array}{|c|c|c|}
\hline
\text{Low} & \text{Typical} & \text{High} \\
\hline
\beta & 2.4 & 2.6 & 2.9 \\
\hline
P_f & \text{1:25} & \text{1:63} & \text{1:251} \\
\hline
\end{array}
\]
LRFD Design Equation

Demand ≤ Capacity

\[ \sum_{i=1}^{n} \alpha Q \leq \lambda \phi R_n \]

\( b \) = Safety or Reliability Index
\( \alpha \) = Load Factor
\( \phi \) = Reliability Index
\( \lambda \) = Time effect factor (replaces LDF)

Allowable Stress Design

- **What stays the same?**
  - Same basic equation format
  - Same adjustment factors
  - Same behavioral equations
LRFD vs. ASD

• Three new notations - $\phi$, $\lambda$, and $K_F$
• Design loads (factored) for safety are bigger
• Design loads (unfactored) for serviceability are the same
• Material resistance values are bigger
• Load Duration Factor changes to Time Effect Factor

LRFD vs. ASD

• ASD
• applied stress $\leq$ allowable stress

Theoretical safety margin applied to material stresses

Estimated Loads $\leq$ Design Load $\leq$ Adjusted Resistance $\leq$ Tested material strength

Design values
LRFD vs. ASD

- LRFD
- factored load ≤ factored resistance

Load factors to account for variations in loads.

Estimated loads ≤ Factored Design Load ≤ Factored Design Resistance ≤ Tested member resistance.

Design values.

2012 NDS

- Factored Load Combinations *ASCE 7-10*

1.4D
1.2D + 1.6L + 0.5(L_t or S or R)

1.2D + 1.6(L_t or S or R) + (L or 0.8W)
1.2D + 1.0W + L + 0.5(L_t or S or R)
1.2D + 1.0E + L + 0.2S
0.9D + 1.0W
0.9D + 1.0E
NDS 2012 LRFD Specification

- Format Conversion Factor $K_F$:

$$ R_N = C_D R_{ASD} $$

$$ R_N = \phi \lambda K_F R_{ASD} $$

2012 NDS

<table>
<thead>
<tr>
<th>Application</th>
<th>Property</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member</td>
<td>$F_b$</td>
<td>$\phi_b$</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>$F_t$</td>
<td>$\phi_t$</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>$F_v$, $F_{rv}$, $F_s$</td>
<td>$\phi_v$</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>$F_c$, $F_c, L$</td>
<td>$\phi_c$</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>$E_{mm}$</td>
<td>$\phi_{mm}$</td>
<td>0.85</td>
</tr>
<tr>
<td>All Connections</td>
<td>(all design values)</td>
<td>$\phi_L$</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Reliability indices or data confidence factors
2012 NDS

• \( \lambda \) tied to ASCE 7 Factored Loads:

Baseline 10 minutes (ASD uses 10 years)

Table N3 Time Effect Factor, \( \lambda \) (LRFD Only)

<table>
<thead>
<tr>
<th>Load Combination ( ^\dagger )</th>
<th>( \lambda )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4D</td>
<td>Permanent 0.6</td>
</tr>
<tr>
<td>1.2D + 1.6L + 0.5(L, or S or R)</td>
<td>0.7 when L is from storage</td>
</tr>
<tr>
<td></td>
<td>0.8 when L is from occupancy</td>
</tr>
<tr>
<td></td>
<td>1.25 when L is from impact(^1)</td>
</tr>
<tr>
<td>1.2D + 1.6(L, or S or R) + (L or 0.8W)</td>
<td>Long term 0.8</td>
</tr>
<tr>
<td>1.2D + 1.0W + L + 0.5(L, or S or R)</td>
<td>Short term 1.0</td>
</tr>
<tr>
<td>1.2D + 1.0E + L + 0.2S</td>
<td>1.0</td>
</tr>
<tr>
<td>0.9D + 1.0W</td>
<td>1.0</td>
</tr>
<tr>
<td>0.9D + 1.0E</td>
<td>1.0</td>
</tr>
</tbody>
</table>

\(^\dagger\) Ref. ASCE 7.1-05

\( K_F \) converts reference design values (ASD normal load duration) to LRFD reference resistance
Why use LRFD?

- Ease of designing with multiple materials
- Does not penalize material strength for unknowns on loads
- Realize efficiencies with
  - Multiple transient live loads
  - Extreme event loads
- ASD load combinations have not been maintained in deference to LRFD load combinations

Polling Question

2. Format Conversion Factor, $K_F$
   a) is only used with ASD
   b) is not necessary when calculating shear strength using LRFD
   c) converts ASD material reference design values from the 2012 NDS Supplement for use with LRFD
   d) converts LRFD material reference design values from the 2012 NDS Supplement for use with ASD
Outline

- Overview
- LRFD Primer
- NDS
  - Chapter-by-chapter discussion
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  - Summary

More Info.

NDS 2012 Chapters

1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. Mechanical Connections
11. Dowel-Type Fasteners
12. Split Ring and Shear Plate Connectors
13. Timber Rivets
14. Shear Walls and Diaphragms
15. Special Loading Conditions
16. Fire Design of Wood Members
   Commentary!!!
1. Sawn Lumber Grading Agencies
2. Species Combinations
3. Section Properties
4. Reference Design Values
   - Lumber and Timber
   - Non-North American Sawn Lumber
   - Structural Glued Laminated Timber
   - MSR and MEL
   - Timber Poles and Piles

A. Construction and Design Practices
B. Load Duration (ASD Only)
C. Temperature Effects
D. Lateral Stability of Beams
E. Local Stresses in Fastener Groups
F. Design for Creep and Critical Deflection Applications
G. Effective Column Length
H. Lateral Stability of Columns
I. Yield Limit Equations for Connections
J. Solution of Hankinson Equation
K. Typical Dimensions for Split Ring and Shear Plate Connectors
L. Typical Dimensions for Standard Hex Bolts, Hex Lag Screws, Wood Screws, Common, Box, and Sinker Nails
M. Manufacturing Tolerances for Rivets and Steel Side Plates for Timber Rivet Connections
N. Appendix for Load and Resistance Factor Design (LRFD) – Mandatory
Chapter 1 - Terminology

\[ f_b \leq F'_b \]

**Reference** design values \((F_b, F_t, F_v, F_c, F_{cL}, E, E_{min})\)

**Adjusted** design values \((F'_b, F'_t, F'_v, F'_c, F'_{cL}, E', E_{min}')\)

*Allowable* (changed in the 2005)
Chapter 1 – Design Loads

• Reference loads
• Minimum load standards
• ASCE 7 – 10

NDS – Chapter 2
Chapter 2 – Adjustment Factors

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

<table>
<thead>
<tr>
<th>Application</th>
<th>Property</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member</td>
<td>$F_b$</td>
<td>$\phi_b$</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>$F_t$</td>
<td>$\phi_t$</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>$F_v, F_{re}, F_i$</td>
<td>$\phi_v$</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>$F_{c}, F_{cl}$</td>
<td>$\phi_c$</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>$F_{mn}$</td>
<td>$\phi_m$</td>
<td>0.85</td>
</tr>
<tr>
<td>All Connections</td>
<td>(all design values)</td>
<td>$\phi_e$</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Reliability indices or data confidence factors

Appendix N – Adjustment Factors

$\lambda$ tied to ASCE 7 Factored Loads: Baseline 10 minutes (ASD uses 10 years)

Table N3 Time Effect Factor, $\lambda$ (LRFD Only)

<table>
<thead>
<tr>
<th>Load Combination $^2$</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4D</td>
<td>Permanent $\rightarrow$ 0.6</td>
</tr>
<tr>
<td>$1.2D + 1.6(L_t \text{ or } S \text{ or } R)$</td>
<td>0.7 when $L$ is from storage</td>
</tr>
<tr>
<td>$1.2D + 1.0W + L + 0.5(L_t \text{ or } S \text{ or } R)$</td>
<td>0.8 when $L$ is from occupancy</td>
</tr>
<tr>
<td>$1.2D + 1.0E + L + 0.2S$</td>
<td>1.25 when $L$ is from impact $^3$</td>
</tr>
<tr>
<td>0.9D + 1.0W</td>
<td>Long term $\rightarrow$ 0.8</td>
</tr>
<tr>
<td>0.9D + 1.0E</td>
<td>$\rightarrow$ 1.0</td>
</tr>
</tbody>
</table>

Short term $\rightarrow$ 1.0

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Chapter 2 – Adjustment Factors

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

<table>
<thead>
<tr>
<th>Application</th>
<th>Property</th>
<th>$K_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member</td>
<td>$F_b$</td>
<td>2.54</td>
</tr>
<tr>
<td></td>
<td>$F_t$</td>
<td>2.70</td>
</tr>
<tr>
<td></td>
<td>$F_c$, $F_n$, $F_s$</td>
<td>2.88</td>
</tr>
<tr>
<td></td>
<td>$F_e$</td>
<td>2.40</td>
</tr>
<tr>
<td></td>
<td>$E_{min}$</td>
<td>1.67</td>
</tr>
<tr>
<td>All Connections</td>
<td>(all design values)</td>
<td>1.76</td>
</tr>
</tbody>
</table>

$R_N = \phi \lambda K_F R_{ASD}$

$K_F$ converts reference design values (ASD normal load duration) to LRFD reference resistance

Chapter 2 – Adjustment Factors

- Adjusts from reference to site conditions
- $C_D$ time-dependent

Baseline 10 years

Table 2.3.2 Frequently Used Load Duration Factors, $C_D$

<table>
<thead>
<tr>
<th>Load Duration</th>
<th>$C_D$</th>
<th>Typical Design Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent</td>
<td>0.9</td>
<td>Dead Load</td>
</tr>
<tr>
<td>Ten years</td>
<td>1.0</td>
<td>Occupancy Live Load</td>
</tr>
<tr>
<td>Two months</td>
<td>1.15</td>
<td>Snow Load</td>
</tr>
<tr>
<td>Seven days</td>
<td>1.25</td>
<td>Construction Load</td>
</tr>
<tr>
<td>Ten minutes</td>
<td>1.6</td>
<td>Wind/Earthquake Load</td>
</tr>
<tr>
<td>Impact</td>
<td>2.0</td>
<td>Impact Load</td>
</tr>
</tbody>
</table>
Chapter 2 – Adjustment Factors

- Adjusts from reference to site conditions
  - $C_t$ temperature factor

<table>
<thead>
<tr>
<th>Reference Design Values</th>
<th>In-Service Moisture Conditions$^1$</th>
<th>$C_t$ ≤100°F</th>
<th>100°F&lt;T≤125°F</th>
<th>125°F&lt;T≤150°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_o$, $E$, $F_{min}$</td>
<td>Wet or Dry</td>
<td>1.0</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>$F_o$, $F_c$, and $F_{cl}$</td>
<td>Dry</td>
<td>1.0</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Wet</td>
<td>1.0</td>
<td>0.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Exposed for “sustained” period

Chapter 2 – Adjustment Factors

- Wet Service Factor, $C_M$
Wet Service Factor, $C_M$

- **Sawn lumber MC $\leq 19\%$ considered dry**
- **Otherwise, NDS Supplement for lumber**

### Wet Service Factors, $C_M$

<table>
<thead>
<tr>
<th>$F_b$</th>
<th>$F_t$</th>
<th>$F_v$</th>
<th>$F_{c,\perp}$</th>
<th>$F_c$</th>
<th>$E$ and $E_{\text{min}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.85*</td>
<td>1.0</td>
<td>0.97</td>
<td>0.67</td>
<td>0.8**</td>
<td>0.9</td>
</tr>
</tbody>
</table>

* when $(F_b)(C_f) \leq 1,150$ psi, $C_M = 1.0$

** when $(F_v)(C_f) \leq 750$ psi, $C_M = 1.0$

### Polling Question

3. **Temperature Factor $C_t$ applies to conditions where the wood temperatures exceed:**
   - a) 100 degrees F for sustained periods of time
   - b) 100 degrees F for short period of time
   - c) 100 degrees F at any time
   - d) 100 degrees C at any time
Chapter 3 – Behavioral Equations

ASD vs LRFD – adjusted stresses from reference

- ASD \( F'_n = F_n C_D \times \text{adjustment factors} \)

- LRFD \( F'_n = F_n K_F \phi_n \lambda \times \text{adjustment factors} \)
Chapter 3 – Behavioral Equations

• **Beams**
  • CL beam stability
    \[
    C_L = \frac{1 + \left( \frac{F_{bE}}{F_b^*} \right)}{1.9} - \sqrt{\left( \frac{1 + \left( \frac{F_{bE}}{F_b^*} \right)}{1.9} \right)^2 - \frac{F_{bE}}{0.95}} \quad (3.3-6)
    \]
    
    \( F_{bE} = \text{reference bending design value multiplied by all applicable adjustment factors except } C_{pl}, C_p, \text{ and } C_L \text{ (see 2.3)} \)

  \[
  \frac{F_{bE}}{F_b^*} = \frac{1.20 E_{min}'}{R_b^2} \quad \text{Critical Buckling Design Value for bending members}
  \]

Chapter 3 – Behavioral Equations

• **Beams**
  • **F_{bE} Equivalence**
    \[
    F_{bE} = \frac{1.20 E_{min}'}{R_b^2} = \frac{K_{bE} E'}{R_b^2}
    \]
    
    \[
    \begin{align*}
    2012/2005 & \quad 2001 \\
    \text{NDS} & \quad \text{NDS}
    \end{align*}
    \]
    
    • \( E_{min} \text{ adjusted for safety for both ASD and LRFD processes} \)
    • \( RB = \text{Slenderness Ratio} \)

    \[
    K_{rb} = 0.745 - 1.225(COV_e)
    \]
    
    = 0.439 for visually graded lumber
    = 0.561 for machine evaluated lumber (MEL)
    = 0.610 for products with \( COV_e \leq 0.11 \)
Chapter 3 – Behavioral Equations

• Columns
  • $C_p$ column stability

$$C_p = \frac{1 + (F_{cE}/F_c^*)}{2c} - \sqrt{\left[1 + \left(\frac{F_{cE}}{F_c^*}ight)^2\right] - \frac{F_{cE}}{F_c^*}} \quad (3.7-1)$$

$F_c^*$ = reference compression design value parallel to grain multiplied by all applicable adjustment factors except $C_p$ (see 2.3)

$$F_{cE} = \frac{0.822E_{\min}^{'}}{\left(\frac{\varepsilon_s}{d}\right)^2}$$  Critical Buckling Design Value for compression members

Chapter 3 – Behavioral Equations

• Columns
  • $F_{cE}$ equivalence

$$F_{cE} = \frac{0.822E_{\min}^{'}}{\left(\frac{l_e}{d}\right)^2} = \frac{K_{cE}E'}{\left(\frac{l_e}{d}\right)^2}$$

2012/2005 NDS 2001 NDS

$K_{cE} = 0.510 - 0.839(COV_e)$
  = 0.3 for visually graded lumber
  = 0.384 for machine evaluated lumber (MEL)
  = 0.418 for products with $COV_e \leq 0.11$ (see Appendix F.2)
Chapter 3 – Behavioral Equations

\[ E_{\text{min}} = 1.03 E \left( 1 - 1.645(COV_E) \right)/1.66 \]

- \( E \) = reference MOE
- 1.03 = adjustment factor to convert \( E \) to a pure bending basis (shear-free) (use 1.05 for glulam)
- 1.66 = factor of safety
- \( COV_E \) = coefficient of variation in MOE (NDS Appendix F)

**OR**

\( E_{\text{min}} \) values published in NDS Supplement

Chapter 3 – Behavioral Equations

Tension members (tension parallel to grain)

- ASD \[ F'_t = F_t C_D \times \text{adjustment factors} \]
- LRFD \[ F'_t = F_t K_F \phi_t \lambda \times \text{adjustment factors} \]
Chapter 3 – Behavioral Equations

• Wood and tension perpendicular to grain
  • Not recommended per NDS 3.8.2

  *Initiators:*
  • notches
  • moment connections
  • hanging loads

Chapter 3 – Behavioral Equations

• Combined bi-axial bending and axial compression

\[
\frac{f_c}{F'_c} + \frac{f_{b1}}{F_{b1}' \left[1 - \left(f_c/F_{c1}\right)\right]} + \frac{f_{b2}}{F_{b2}' \left[1 - \left(f_c/F_{c2}\right) - (f_{b1}/F_{b1})^2\right]} \leq 1.0 \quad (3.9-3)
\]
Chapter 3 – Behavioral Equations

• Combined bi-axial bending and axial compression

\[ \frac{f_c}{F_{ce2}} + \left( \frac{f_{bl}}{F_{bc}} \right)^2 < 1.0 \]  
(3.9-4)

New
Added to account for possible negative value in denominator of third term of equation 3.9-3

Chapter 3 – Behavioral Equations

• Bearing perpendicular to grain
  - \( F'_{c\perp} = F_{c\perp} C_M C_t C_i C_b \) (ASD)
  - \( F'_{c\perp} = F_{c\perp} C_M C_t C_i C_b K_f \phi_c \lambda \) (LRFD)

<table>
<thead>
<tr>
<th>( t_b )</th>
<th>0.5&quot;</th>
<th>1&quot;</th>
<th>1.5&quot;</th>
<th>2&quot;</th>
<th>3&quot;</th>
<th>4&quot;</th>
<th>6&quot; or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_b )</td>
<td>1.75</td>
<td>1.38</td>
<td>1.25</td>
<td>1.19</td>
<td>1.13</td>
<td>1.10</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 3.10.4 Bearing Area Factors, \( C_b \)
Chapter 4 – Lumber

• Design values
  • Visually graded lumber
  • MSR / MEL
  • Timber
  • Decking
Chapter 4 – Lumber

• Lumber adjustment factors
  • \( K_F \) and \( \phi \)

### Table 4.3.1: Applicability of Adjustment Factors for Sawd Lumber

<table>
<thead>
<tr>
<th>Factor</th>
<th>ASD only</th>
<th>ASD and LRFD</th>
<th>LRFD only</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_A ) = ( F_S )</td>
<td>( C_1 )</td>
<td>( C_2 )</td>
<td>( C_3 )</td>
</tr>
<tr>
<td>( F_A ) = ( F_{S1} )</td>
<td>( C_1 )</td>
<td>( C_2 )</td>
<td>( C_3 )</td>
</tr>
<tr>
<td>( F_A ) = ( F_{S2} )</td>
<td>( C_1 )</td>
<td>( C_2 )</td>
<td>( C_3 )</td>
</tr>
<tr>
<td>( F_A ) = ( F_{S3} )</td>
<td>( C_1 )</td>
<td>( C_2 )</td>
<td>( C_3 )</td>
</tr>
<tr>
<td>( E_o ) = ( E_{o1} )</td>
<td>( C_1 )</td>
<td>( C_2 )</td>
<td>( C_3 )</td>
</tr>
</tbody>
</table>

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Chapter 4 – Lumber

• Lumber adjustment factors

• \( C_F \) - size factor

<table>
<thead>
<tr>
<th>Grades</th>
<th>Width (depth)</th>
<th>Thickness (breath)</th>
<th>( F_3 )</th>
<th>( F_i )</th>
<th>( F_c )</th>
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<tr>
<td>Select</td>
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<td>1.5</td>
<td>1.5</td>
<td>1.15</td>
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<tr>
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<td>5&quot;</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
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<td>1.1</td>
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<tr>
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<td>1.2</td>
<td>1.2</td>
<td>1.05</td>
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<tr>
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<tr>
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<td>12&quot;</td>
<td>1.0</td>
<td>1.1</td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td></td>
<td>14&quot; &amp; wider</td>
<td>0.9</td>
<td>1.0</td>
<td>0.9</td>
<td>0.9</td>
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**Table 4.3.8 Incising Factors, \( C_i \)**

<table>
<thead>
<tr>
<th>Design Value</th>
<th>( C_i )</th>
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<tbody>
<tr>
<td>( E, E_{min} )</td>
<td>0.95</td>
</tr>
<tr>
<td>( F_{bb}, F_b, F_e, F_v )</td>
<td>0.80</td>
</tr>
<tr>
<td>( F_{dl} )</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Chapter 4 – Lumber

• **Lumber adjustment factors**
  • repetitive member
  • \( C_r = 1.15 \)
  • 2” – 4” lumber
  • < 24” o.c.
  • 3 or more
  • Load distributing element

---

NDS – Chapter 5

---
Chapter 5 – Glulam

• Significant changes
  • New adjustment factors
    • Stress interaction
    • Shear reduction
• Clarified or added
  • Curved members
  • Double-tapered
  • Tapered straight

Chapter 5 – Glulam

• New adjustment factors
  • Stress interaction
    • Tapered
    • Timber Construction manual
  • Shear reduction
    • NDS footnote
    • Non-prismatic
Chapter 5 – Glulam

- Clarified or added
  - Curved members
  - Double-tapered
  - Tapered straight

\[
C_v = \left( \frac{2L}{b} \right)^{1/4} \left( \frac{12}{d} \right)^{1/4} \left( \frac{5.125}{b} \right)^{1/4} \leq 1.0
\]

<table>
<thead>
<tr>
<th>Table 5.3.1 Applicability of Adjustment Factors for Structural Glued Laminated Timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD only</td>
</tr>
<tr>
<td>Load/Dead Force</td>
</tr>
<tr>
<td>( F_S = F_{\text{LR}} \times C_D \times C_M \times C_L \times C_V \times C_0 \times K_F \times \phi_\lambda )</td>
</tr>
</tbody>
</table>

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Polling Question

4. The two new adjustment factors were added to glued laminated timber design are stress interaction and shear reduction factors. T/F
Chapter 6 – Poles & Piles

- **Poles - post-frame**
- **Piles - foundations**

Chapter 6 – Timber Piles

- **Design values**
  - Significant changes from 2005 NDS
  - Design values moved to NDS Supplement

<table>
<thead>
<tr>
<th>Species</th>
<th>$F_r$</th>
<th>$F_w$</th>
<th>$F_t$</th>
<th>$F_{vl}$</th>
<th>$E$</th>
<th>$E_{am}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2005 NDS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific Coast Douglas Fir$^a$</td>
<td>1250</td>
<td>2450</td>
<td>115</td>
<td>230</td>
<td>1,500,000</td>
<td>790,000</td>
</tr>
<tr>
<td>Red Oak$^a$</td>
<td>1300</td>
<td>2450</td>
<td>135</td>
<td>350</td>
<td>1,250,000</td>
<td>660,000</td>
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<tr>
<td>Red Pine$^a$</td>
<td>900</td>
<td>1900</td>
<td>85</td>
<td>155</td>
<td>1,280,000</td>
<td>680,000</td>
</tr>
<tr>
<td>Southern Pine$^a$</td>
<td>1200</td>
<td>2400</td>
<td>110</td>
<td>250</td>
<td>1,500,000</td>
<td>790,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species</th>
<th>$F_r$</th>
<th>$F_w$</th>
<th>$F_t$</th>
<th>$F_{vl}$</th>
<th>$E$</th>
<th>$E_{am}$</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific Coast Douglas Fir$^a$</td>
<td>2,080</td>
<td>160</td>
<td>490</td>
<td>1,310</td>
<td>1,700,000</td>
<td>890,000</td>
</tr>
<tr>
<td>Red Pine$^a$</td>
<td>1,340</td>
<td>126</td>
<td>270</td>
<td>860</td>
<td>1,500,000</td>
<td>620,000</td>
</tr>
<tr>
<td>Southern Pine (Grouped)$^a$</td>
<td>1,950</td>
<td>160</td>
<td>440</td>
<td>1,250</td>
<td>1,600,000</td>
<td>690,000</td>
</tr>
</tbody>
</table>
Chapter 6 – Timber Poles

Table 6B Reference Design Values for Poles Graded in Accordance with ASTM D 3200

<table>
<thead>
<tr>
<th>Species</th>
<th>F&lt;sub&gt;x&lt;/sub&gt;</th>
<th>F&lt;sub&gt;r&lt;/sub&gt;</th>
<th>F&lt;sub&gt;yy&lt;/sub&gt;</th>
<th>F&lt;sub&gt;r&lt;/sub&gt;</th>
<th>F&lt;sub&gt;y&lt;/sub&gt;</th>
<th>F&lt;sub&gt;yy&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific Coast Douglas Fir</td>
<td>1,850</td>
<td>115</td>
<td>175</td>
<td>1,000</td>
<td>1,500,000</td>
<td>750,000</td>
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<tr>
<td>Lodgepole Pine</td>
<td>1,550</td>
<td>95</td>
<td>260</td>
<td>600</td>
<td>1,070,000</td>
<td>370,000</td>
</tr>
<tr>
<td>Northern White Cedar</td>
<td>1,550</td>
<td>85</td>
<td>260</td>
<td>700</td>
<td>1,500,000</td>
<td>570,000</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>1,350</td>
<td>65</td>
<td>300</td>
<td>650</td>
<td>1,050,000</td>
<td>380,000</td>
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<tr>
<td>Red Pine</td>
<td>1,400</td>
<td>85</td>
<td>265</td>
<td>750</td>
<td>1,070,000</td>
<td>440,000</td>
</tr>
<tr>
<td>Southern Pine</td>
<td>1,400</td>
<td>85</td>
<td>265</td>
<td>800</td>
<td>1,300,000</td>
<td>490,000</td>
</tr>
<tr>
<td>Western Hemlock</td>
<td>1,400</td>
<td>115</td>
<td>245</td>
<td>900</td>
<td>1,400,000</td>
<td>740,000</td>
</tr>
<tr>
<td>Western Larch</td>
<td>1,650</td>
<td>115</td>
<td>245</td>
<td>900</td>
<td>1,600,000</td>
<td>690,000</td>
</tr>
<tr>
<td>Western Red Cedar</td>
<td>1,350</td>
<td>95</td>
<td>255</td>
<td>750</td>
<td>1,300,000</td>
<td>500,000</td>
</tr>
</tbody>
</table>

2005 NDS

2012 NDS

Chapter 6 – Poles & Piles

- **Adjustment factors**
  - C<sub>ct</sub> – condition treatment
  - C<sub>ls</sub> – load sharing
  - C<sub>cs</sub> – critical section

### 6.3.9 Critical Section Factor

\[ C_{cs} = 1.0 + 0.004L_c \]

---

---
Chapter 7 – I-joists

- Design values
  - M, V, EI, K – no changes
- Evaluation Reports
  - Contain proprietary design
Chapter 7 – I-Joists

• Beam stability factor
  • Braced compression flange
    • $C_L = 1.0$
  • Unbraced compression flange
    • Design as unbraced column

NDS – Chapter 8
Chapter 8 – Structural Composite Lumber

• No changes from 2005 NDS
• Evaluation Reports
  • Contain proprietary design

![NDS Logo]

Chapter 8 – Structural Composite Lumber

• Adjustment factors
  • CV – volume
    
    \( C_V \leq 1.0 \) Not cumulative with beam stability factor, \( C_L \) - then min. \( (C_V, C_L) \)
    
    \( C_V > 1.0 \) Cumulative with beam stability factor, \( C_L \)

<table>
<thead>
<tr>
<th>Table 8.3.1</th>
<th>Applicability of Adjustment Factors for Structural Composite Lumber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASD only</td>
</tr>
<tr>
<td></td>
<td>Strength Factor</td>
</tr>
<tr>
<td>F_s - F_k</td>
<td>C_D</td>
</tr>
</tbody>
</table>

![Graph showing material property values]
Chapter 8 – Structural Composite Lumber

• Adjustment factors
  • $C_r$ Repetitive Member Factor = 1.04
  • $C_r$ is different than lumber ($C_{r \text{ lumber}} = 1.15$)
  • Applies to $F_b$ only

NDS – Chapter 9
Chapter 9 – Wood Structural Panels

- **Design values** – obtain from an approved source
  - $F_b$, $S$
  - $F_t$, $A$
  - $F_v$, $t_v$
  - $F_s$
  - $F_c$, $A$
  - $E_I$
  - $E_A$
  - $G_v$, $t_v$
  - $F_{cL}$

- **Adjustment factors** apply $F_b$ & $F_t$
  - $C_G$ - grade & construction
  - Removed (no longer used by WSP industry)
  - $C_s$ - panel size
  - Clarified
  - Moved from commentary

<table>
<thead>
<tr>
<th>Panel Strip Width, w</th>
<th>$C_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w \leq 8$&quot;</td>
<td>0.5</td>
</tr>
<tr>
<td>$8&quot; &lt; w &lt; 24&quot;$</td>
<td>$(8 + w) / 32$</td>
</tr>
<tr>
<td>$w \geq 24$&quot;</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Chapter 9 – Wood Structural Panels

- Adjustment factors
  - $C_M$ - wet service

- $C_t$ - temperature

\[ C_I = 1.0 - 0.005 (T - 100) \]  
(C9.3-1)

where:

\[ T = \text{temperature (°F)} \]

Table C9.3.3 Wet Service Factor, $C_M$

<table>
<thead>
<tr>
<th>Reference Design Capacity</th>
<th>$C_M$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength ($F_S$, $F_p$, $F_A$, $F_t$, $F_{THA}$), $F_t$</td>
<td>0.75</td>
</tr>
<tr>
<td>Stiffness ($EI$, $EA$, $G_t$)</td>
<td>0.85</td>
</tr>
</tbody>
</table>

NDS – Chapter 10
Chapter 10 – Mechanical Connections

• Design issues
• Reference design values
  • Chapter 11 – dowel-type connectors (nails, bolts, lag/wood screws)
  • Chapter 12 – split rings and shear plates
  • Chapter 13 – timber rivets
• Adjustment factors
• No significant changes
• Connections session

NDS – Chapter 11

NDS – Chapter 11
Chapter 11 - Tabulated Values

- Consistent titles and footnotes
- Penetration assumptions in titles

### Table 11.2A Lag Screw Reference Withdrawal Design Values (W)\(^1\)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>0.75</td>
<td>517</td>
<td>441</td>
<td>331</td>
<td>694</td>
<td>648</td>
<td>609</td>
<td>568</td>
<td>528</td>
<td>512</td>
<td>492</td>
<td>474</td>
<td>458</td>
<td>441</td>
<td>425</td>
<td>411</td>
<td>397</td>
<td>383</td>
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<td>358</td>
</tr>
<tr>
<td>0.71</td>
<td>507</td>
<td>434</td>
<td>324</td>
<td>673</td>
<td>627</td>
<td>587</td>
<td>547</td>
<td>507</td>
<td>491</td>
<td>472</td>
<td>454</td>
<td>438</td>
<td>420</td>
<td>402</td>
<td>387</td>
<td>372</td>
<td>358</td>
<td>345</td>
<td>332</td>
</tr>
<tr>
<td>0.69</td>
<td>496</td>
<td>423</td>
<td>316</td>
<td>654</td>
<td>608</td>
<td>568</td>
<td>528</td>
<td>491</td>
<td>475</td>
<td>456</td>
<td>438</td>
<td>421</td>
<td>403</td>
<td>385</td>
<td>371</td>
<td>357</td>
<td>343</td>
<td>330</td>
<td>317</td>
</tr>
<tr>
<td>0.67</td>
<td>485</td>
<td>411</td>
<td>303</td>
<td>635</td>
<td>590</td>
<td>550</td>
<td>510</td>
<td>475</td>
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<td>423</td>
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<td>357</td>
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</table>

### Table 11.2B Lag Screw Reference Withdrawal Design Values, W\(^1\)

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</thead>
<tbody>
<tr>
<td>0.75</td>
<td>517</td>
<td>441</td>
<td>331</td>
<td>694</td>
<td>648</td>
<td>609</td>
<td>568</td>
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<tr>
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<td>357</td>
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<td>318</td>
<td>305</td>
</tr>
</tbody>
</table>

---

Chapter 11-Dowels

### 11.3.6 Dowel Diameter

11.3.6.1 When used in Tables 11.3-1A and 11.3-1B, the fastener diameter shall be taken as D for unthreaded full-body diameter fasteners and D\(_f\) for reduced body diameter fasteners or threaded fasteners except as provided in 11.3.6.2.

### 11.3.7 Dowel Diameter

11.3.7.1 Where used in Tables 11.3.1A or 11.3.1B, the fastener diameter shall be taken as D for unthreaded full-body diameter fasteners and D\(_f\) for reduced body diameter fasteners or threaded fasteners except as provided in 11.3.7.2.
Chapter 11-Dowels

11.3.7 Dowel Diameter

11.3.7.1 Where used in Tables 11.3.1A or 11.3.1B, the fastener diameter shall be taken as $D$ for unthreaded full-body diameter fasteners and $D_r$ for reduced body diameter fasteners or threaded fasteners except as provided in 11.3.7.2.

11.3.7.2 For threaded full-body fasteners (see Appendix L), $D$ shall be permitted to be used in lieu of $D_r$ where the bearing length of the threads does not exceed $\frac{1}{2}$ of the full bearing length in the member holding the threads. Alternatively, a more detailed analysis accounting for the moment and bearing resistance of the threaded portion of the fastener shall be permitted (see Appendix L).

Chapter 11-Dowels

Appendix L (Non-mandatory) Typical Dimensions for Dowel-Type Fasteners and Washers

<table>
<thead>
<tr>
<th>Table L1</th>
<th>Standard Hex Bolts $^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D$ = diameter</td>
<td></td>
</tr>
<tr>
<td>$D_o$ = root diameter</td>
<td></td>
</tr>
<tr>
<td>$T$ = thread length</td>
<td></td>
</tr>
<tr>
<td>$L$ = bolt length</td>
<td></td>
</tr>
<tr>
<td>$F$ = width of head across flats</td>
<td></td>
</tr>
<tr>
<td>$H$ = height of head</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table L2</th>
<th>Standard Hex Lag Screws $^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D$ = diameter</td>
<td></td>
</tr>
<tr>
<td>$D_o$ = root diameter</td>
<td></td>
</tr>
<tr>
<td>$S$ = unthreaded body length</td>
<td></td>
</tr>
<tr>
<td>$T$ = minimum thread length $^2$</td>
<td></td>
</tr>
<tr>
<td>$F$ = length of tapered tip</td>
<td></td>
</tr>
<tr>
<td>$L$ = lag screw length</td>
<td></td>
</tr>
<tr>
<td>$N$ = number of threads/inch</td>
<td></td>
</tr>
<tr>
<td>$F'$ = width of head across flats</td>
<td></td>
</tr>
<tr>
<td>$H$ = height of head</td>
<td></td>
</tr>
</tbody>
</table>

Reduced Body Diameter

Full Body Diameter

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Chapter 11-Dowels

Threaded length \( \leq \frac{1}{4}l_m \)

Dia. Fastener = D

Threaded length \( \leq \frac{1}{4}l_m \)

Dia. Fastener = D

Dia. Fastener = D

\( l_m \)
Chapter 11 - Dowels

Provide tools for the analysis
• gaps between members
• various fastener moment resistance configurations
• fasteners through hollow members
• fasteners with tapered tips


Chapter 11 - Tabulated Values

• New post frame ring shank tables
  • Based on ASTM F1667

Table 11S POST FRAME RING SHANK NAILS: Reference Lateral Design Values, Z, for Single Shear (two member) Connections\(^1,2,3\)

<table>
<thead>
<tr>
<th>Nail Diameter</th>
<th>Nail Length</th>
<th>1/2</th>
<th>3/8</th>
<th>1/4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>lbs</td>
<td>lbs</td>
<td>lbs</td>
</tr>
<tr>
<td>1 1/2</td>
<td>114</td>
<td>89</td>
<td>60</td>
<td>47</td>
</tr>
<tr>
<td>1 3/8</td>
<td>127</td>
<td>100</td>
<td>89</td>
<td>67</td>
</tr>
<tr>
<td>3/8</td>
<td>139</td>
<td>125</td>
<td>107</td>
<td>83</td>
</tr>
<tr>
<td>3/4</td>
<td>151</td>
<td>137</td>
<td>115</td>
<td>90</td>
</tr>
<tr>
<td>7/8</td>
<td>163</td>
<td>142</td>
<td>122</td>
<td>106</td>
</tr>
</tbody>
</table>

\(^1\) For sawn lumber or SCL with both members of identical specific gravity
\(^2\) Tabulated lateral design values are calculated based on an assumed length of nail penetration, p, into the main member equal to 1.00
Chapter 11 - Dowel Bearing Length

<table>
<thead>
<tr>
<th>Fastener Type</th>
<th>Tip Length, E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag Screws</td>
<td>Appendix L</td>
</tr>
<tr>
<td>Wood Screws</td>
<td>2D</td>
</tr>
<tr>
<td>Nails &amp; Spikes</td>
<td>2D</td>
</tr>
</tbody>
</table>

\[ E, \ell_s, \ell_m \leq p - E / 2 \]

Chapter 11 - Dowel Bearing Strength

- Wood Structural Panels
  - \( D \leq \frac{1}{4}'' \)

**Table 11.3.3B Dowel Bearing Strengths for Wood Structural Panels**

<table>
<thead>
<tr>
<th>Wood Structural Panel</th>
<th>Specific Gravity, ( C )</th>
<th>Dowel Bearing Strength, ( F_e ) in pounds per square inch (psi) for ( D\leq1/4'' )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plywood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural 1, Marine</td>
<td>0.50</td>
<td>4650</td>
</tr>
<tr>
<td>Other Grades</td>
<td>0.42</td>
<td>3350</td>
</tr>
<tr>
<td>Oriented Strand Board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Grades</td>
<td>0.50</td>
<td>4650</td>
</tr>
</tbody>
</table>
Polling Question

5. TR 12 includes general dowel equations and provides tools for the analysis of:
   a) gaps between members
   b) fasteners through hollow members
   c) fasteners with tapered tips
   d) All of the above
   e) None of the above
Chapter 12 – Split Rings and Shear Plates

- Geometry factor, CD
- Side Grain

Table 12.3.2.2 Factors for Determining Minimum Spacing Along Connector Axis for $C_i = 1.0$

<table>
<thead>
<tr>
<th>Connector</th>
<th>Angle of Load to Grain (degrees)</th>
<th>$s_A$</th>
<th>$s_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2&quot; split ring</td>
<td>0</td>
<td>6.75</td>
<td>3.50</td>
</tr>
<tr>
<td>or 2-5/8&quot; shear plate</td>
<td>15</td>
<td>6.00</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>5.13</td>
<td>3.88</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>4.25</td>
<td>4.13</td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>3.5</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>9.00</td>
<td>5.00</td>
</tr>
<tr>
<td>4&quot; split ring</td>
<td>15</td>
<td>8.00</td>
<td>5.25</td>
</tr>
<tr>
<td>or 4&quot; shear plate</td>
<td>30</td>
<td>7.00</td>
<td>5.50</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>6.00</td>
<td>5.75</td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>5.00</td>
<td>6.00</td>
</tr>
</tbody>
</table>

1. Interpolation shall be permitted for intermediate angles of load to grain.
Chapter 12 – Split Rings and Shear Plates

- Geometry factor, CD
- End Grain

<table>
<thead>
<tr>
<th>Connector</th>
<th>Geometry Factor</th>
<th>E_d in.</th>
<th>E_s in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2&quot; split ring</td>
<td>C_d = 1.0</td>
<td>5.5</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>C_s = 0.70</td>
<td>3.3</td>
<td>1.5</td>
</tr>
<tr>
<td>2-5/8&quot; shear plate</td>
<td>C_d = 1.0</td>
<td>5.5</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>C_s = 0.83</td>
<td>4.25</td>
<td>1.5</td>
</tr>
<tr>
<td>4&quot; split ring</td>
<td>C_d = 1.0</td>
<td>7.0</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td>C_s = 0.70</td>
<td>4.2</td>
<td>2.5</td>
</tr>
<tr>
<td>4&quot; shear plate</td>
<td>C_d = 1.0</td>
<td>7.0</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td>C_s = 0.83</td>
<td>5.4</td>
<td>2.5</td>
</tr>
</tbody>
</table>

NDS – Chapter 13

TIMBER RIVETS

13.1 General
13.2 Reference Design Values
13.3 Placement of Timber Rivets

Table 13.1.1-2 Factors for Determining Minimum Loaded Edge Distance for Connectors in End Grain

<table>
<thead>
<tr>
<th>Connector</th>
<th>Geometry Factor</th>
<th>E_d in.</th>
<th>E_s in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2&quot; split ring</td>
<td>C_d = 1.0</td>
<td>5.5</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>C_s = 0.70</td>
<td>3.3</td>
<td>1.5</td>
</tr>
<tr>
<td>2-5/8&quot; shear plate</td>
<td>C_d = 1.0</td>
<td>5.5</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>C_s = 0.83</td>
<td>4.25</td>
<td>1.5</td>
</tr>
<tr>
<td>4&quot; split ring</td>
<td>C_d = 1.0</td>
<td>7.0</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td>C_s = 0.70</td>
<td>4.2</td>
<td>2.5</td>
</tr>
<tr>
<td>4&quot; shear plate</td>
<td>C_d = 1.0</td>
<td>7.0</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td>C_s = 0.83</td>
<td>5.4</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Chapter 13 – Timber Rivets

- Many applications
Chapter 13 – Timber Rivets

- Parallel to grain
- Timber rivet capacity
  - Proper application of CD

\[ P_r = 188 \, p^{0.32} \, n_1 \, n_c \]
\[ Q_r = 108 \, p^{0.32} \, n_1 \, n_c \]
Chapter 13 – Timber Rivets

- **Timber rivet capacity**
  - **Proper application of** $C_D$
  - **Parallel to grain timber rivet capacity**
    - $P_r = 280 \times p^{0.32} n_R n_C$ (13.2-1)
    - [188] 2012 NDS
  - **Perpendicular to grain timber rivet capacity**
    - $Q_r = 160 \times p^{0.32} n_R n_C$
    - [108] 2012 NDS
Chapter 13 – Timber Rivets

• Maximum distance perpendicular to grain between outermost rows of rivets shall be 12"
  • Consistent with glulam

NDS – Chapter 14
Chapter 14 – Shear Walls and Diaphragms

- **ANSI / AWC SDPWS**
  - 2008 standard
- **Recorded Webinar**
  - Online course 2005/2008 SDPWS
  - Diaphragm Deflection
  - www.awc.org
Chapter 15 – Special Loading

• Built-up columns
  • Flatwise bending check
  • Consistent with Chapter 3

\[
\frac{f_{b1}}{F_{te2}} + \left( \frac{f_{b1} + f_e (6e / d)}{F_{te}} \right)^2 < 1.0 \\
\frac{f_{b2}}{F_{te2}} + \left( \frac{f_e (6e / d)}{F_{te}} \right)^2 < 1.0
\]
Chapter 16 – Fire (ASD)

- Fire resistance up to **two hours**
  - Columns
  - Beams
  - Tension Members
  - ASD only
- Products
  - Lumber
  - Glulam
  - SCL
  - Decking

SECTION 722
CALCULATED FIRE RESISTANCE

722.1 General. The provisions of this section contain procedures by which the fire resistance of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated fire resistance of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with AIC 218.1/TMS 69216. The calculated fire resistance of steel assemblies shall be permitted in accordance with Chapter 5 of ASCE 19. The calculated fire resistance of exposed wood members and wood decking shall be permitted in accordance with Chapter 10 of ANSI/NAFPA National Design Specifications for Wood Construction (NDS).
Chapter 16 – Calculated Resistance

- Fire resistance of exposed wood members may be calculated using the provisions of NDS Chapter 16
Performance of Wood vs. Steel

![Comparative Strength Loss of Wood Versus Steel](chart.png)

Chapter 16 – Fire (ASD)

Technical Report No. 10

**Calculating the Fire Resistance of Exposed Wood Members**
Chapter 16 – Fire (ASD)

Polling Question

6. The IBC includes provisions for calculating fire resistance of exposed wood members and wood decking for up to two hours. True/False
NDS – Appendices

APPENDIX

A Construction and Design Practices B
B Load Duration C
C Temperature Effects D
D Lateral Stability of Beams E
E Local Stresses in Fastener Groups F
F Design for Creep and Critical Deflection Applications

G Effective Column Length H
H Lateral Stability of Columns I
I Yield Limit Equations for Connections J
J Solution of Hankinson Equation K
K Typical Dimensions for Split Ring and Shear Plate Connectors L
L Typical Dimensions for Standard Hex Bolts, Hex Lag Screws, Wood Screws, Common, Box, and Sinker Nails M Manufacturing Tolerances for Rivets and Steel Side Plates for Timber Rivet Connections N Appendix for Load and Resistance Factor Design (LRFD)

NDS 2012 Appendices

2012

A Construction and Design Practices
B Load Duration
C Temperature Effects
D Lateral Stability of Beams
E Local Stresses in Fastener Groups
F Design for Creep and Critical Deflection Applications
G Effective Column Length
H Lateral Stability of Columns
I Yield Limit Equations for Connections
J Solution of Hankinson Equation
K Typical Dimensions for Split Ring and Shear Plate Connectors
L Typical Dimensions for Standard Hex Bolts, Hex Lag Screws, Wood Screws, Common, Box, and Sinker Nails
M Manufacturing Tolerances for Rivets and Steel Side Plates for Timber Rivet Connections
N Appendix for Load and Resistance Factor Design (LRFD)
Appendix E

- Example E.8
- \( A_{\text{critical}} \) check

![Diagram of split ring connection](image)

Figure E5  \( A_{\text{critical}} \) for Split Ring Connection (based on distance between first and second split ring)

Hole diameter = 0.10"  
2.87"  
6.75"

Appendix L

<p>| Table L5  Post-Frame Ring Shank Nails(^1) |
|---------|---------|---------|---------|</p>
<table>
<thead>
<tr>
<th>D</th>
<th>L</th>
<th>TL</th>
<th>Root Diameter ( R )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.149</td>
<td>3.0&quot;</td>
<td>2.05&quot;</td>
<td>3.05&quot;</td>
</tr>
<tr>
<td>0.177</td>
<td>3.5&quot;</td>
<td>2.75&quot;</td>
<td>3.05&quot;</td>
</tr>
<tr>
<td>0.199</td>
<td>3.5&quot;</td>
<td>2.75&quot;</td>
<td>3.05&quot;</td>
</tr>
<tr>
<td>0.237</td>
<td>3.5&quot;</td>
<td>2.75&quot;</td>
<td>3.05&quot;</td>
</tr>
</tbody>
</table>

\(^{1}\) Dimensions are specified in ANSI F15.-

| Table L6  Standard Cut Washers\(^1\) |
|---------|---------|---------|---------|
| A = inside diameter |
| B = outside diameter |
| C = thickness |

<table>
<thead>
<tr>
<th>Nominal Washer Size</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/32&quot;</td>
<td>0.156&quot;</td>
<td>0.312&quot;</td>
<td>0.087&quot;</td>
</tr>
<tr>
<td>3/32&quot;</td>
<td>0.188&quot;</td>
<td>0.375&quot;</td>
<td>0.134&quot;</td>
</tr>
<tr>
<td>1/8&quot;</td>
<td>0.312&quot;</td>
<td>0.625&quot;</td>
<td>0.142&quot;</td>
</tr>
<tr>
<td>5/32&quot;</td>
<td>0.188&quot;</td>
<td>0.375&quot;</td>
<td>0.134&quot;</td>
</tr>
</tbody>
</table>

\(^{1}\) Dimensions are provided in ANSI A575.30. For other materials, see ANSI A575.30.
Appendix N

Table N1 Format Conversion Factor, Kf (LRFD Only)

<table>
<thead>
<tr>
<th>Application</th>
<th>Property</th>
<th>Kf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Member</td>
<td>Fy</td>
<td>2.54</td>
</tr>
<tr>
<td></td>
<td>Fy</td>
<td>2.70</td>
</tr>
<tr>
<td></td>
<td>Fy, Fx, Fy</td>
<td>2.88</td>
</tr>
<tr>
<td></td>
<td>Fx</td>
<td>2.40</td>
</tr>
<tr>
<td></td>
<td>Fu</td>
<td>1.67</td>
</tr>
<tr>
<td></td>
<td>Fu</td>
<td>1.76</td>
</tr>
</tbody>
</table>

All Connections (all design values) 3.32

Table N3 Time Effect Factor, λ (LRFD Only)

<table>
<thead>
<tr>
<th>Load Combination</th>
<th>λ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0D</td>
<td>1.0</td>
</tr>
<tr>
<td>1.2D</td>
<td>0.8</td>
</tr>
<tr>
<td>1.2D + 1.0L + 0.5L or S or R</td>
<td>0.7 when L is from storage 0.6 when L is from occupancy</td>
</tr>
<tr>
<td>1.2D + 0.8L + L + 0.4L or S or R</td>
<td>0.8</td>
</tr>
<tr>
<td>1.2D + 1.0L + 0.4L or S or R</td>
<td>1.0</td>
</tr>
<tr>
<td>1.2D + 1.0L + 0.25</td>
<td>1.0</td>
</tr>
<tr>
<td>0.9D + 1.0W</td>
<td>1.0</td>
</tr>
<tr>
<td>0.9D + 1.0E</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1. Time effect factor, λ, greater than 1.0 that do not apply to connections or to structural members carrying live load or horizontal wind forces.
2. Load combinations and load factors consistent with ASCE 7-10 are listed for ease of reference. Nominal loads shall be in accordance with N1.1.2.

NDS – Commentary

C1 GENERAL REQUIREMENTS FOR STRUCTURAL DESIGN

C1.1 Scope

C1.1.1 The scope of this section covers all residential, commercial, institutional, and industrial structures, including buildings, bridges, and other structures. The purpose of this section is to provide guidance on the application of residential RDI and the LRFD for residential and light-frame construction. Residential RDI shall be used in accordance with the latest edition of the American Wood Council's Residential Design Specifications (RDS). The LRFD shall be used in accordance with the latest edition of the American Wood Council's Residential Design Specifications (RDS). The LRFD shall be used in accordance with the latest edition of the American Wood Council's Residential Design Specifications (RDS).
Outline

- Overview
- LRFD Primer
- NDS
  - Chapter-by-chapter discussion
  - Changes from previous editions
  - Summary
- More Info.

2012 NDS – Notable Changes

- Chapter 5 – Glulam
- Chapter 6 – Poles and Piles
- Chapter 12 – Split Rings & Shear Plates
NDS 2012 Supplement

- New nominal and minimum Timber sizes per PS 20-10
- Section properties distinguish lumber, P&T, B&S
- New Coast Sitka Spruce & Yellow Cedar values
- Revised Northern Species bending and tension values
- Clarify Timber size factor adjustments
- New and revised values for several foreign species
- Revised glulam values - primary changes to shear
- New Tables 6A & 6B for Timber Poles and Piles

Southern Pine Design Values

- ALSC approves design values
  - June 1, 2013
- AWC compiles them
  - NDS Supplement
- More information
  - www.spib.org
  - www.southernpine.com
Wood Design Package

- Wood Design Package
  - NDS + Commentary
  - NDS Supplement
  - ASD/LRFD Manual
  - Example Problems
    - Almost complete

Future

2015
Coming in 2015 NDS/SDPWS

- **NDS**
- **CLT Provisions**

Franklin Elementary School

Franklin, West Virginia
Architect: MSES Architects, Fairmont, WV

Source: LignaTerra
Franklin Elementary School

Franklin, West Virginia
46,200 sq. ft.
8 week assembly

Source: LignaTerra
Franklin Elementary School

Scheduled completion date: Winter 2015

Coming in 2015 NDS/SDPWS

- **NDS**
  - CLT Provisions

- **SDPWS**
  - Design Flexible and Open Front/Cantilever Diaphragms
2015 Special Design Provisions for Wind and Seismic

Overview

- Ch. 2
  - Removes definition of flexible and rigid diaphragms
  - Defines “Open-Front Structure” & “Subdiaphragm”

- Ch. 4
  - Clarification of concrete and masonry wall anchorage
  - Revised Horizontal Distribution of Shear
  - Clarification of shear wall Aspect ratio adjustments
Figure 4A  Examples of Open Front Structures

(a) Plan Views
- Shear Wall
- Cantilevered Diaphragm
- Open Front

(b) Shear Wall
- Cantilevered Diaphragm
- Open Front

(c) Shear Wall
- Cantilevered Diaphragm
- Open Front

(d) Cantilevered Diaphragm
- Shear Wall
- Open Front
More Details

- White paper - www.awc.org
- Comprehensive table
- Section-by-section changes
- Structure Magazine
- January 2012

What's Changed?
2017 NDS Changes
John "Buddy" Sheehan, P.E., Bradford K. Douglas, P.E.,

Introduction
The 2005 Edition of the National Design Specification® (NDS®) for Wood Construction
(2005 NDS) was recently updated. The updated standard, designated
AWI/AWC NDS-2012, was approved as an ANSI American National Standard on August 11,
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.

Primary changes to the 2012 NDS are listed here and major
resources are referenced in separate sections:

- Revised load and resistance factor design (LRFD)
  Formulas and Equations to provide numeric
  values for Fu, rather than equations.
- Incorporation of LRFD Vol. factors and resistance factors (a)
  into NDS Chapter 2 and all material-specific chapters.
- Incorporation of a new equation for intermediate calculation
  of members subjected to bending in combination with
  axial compression with or without edge-wedge
  bending.
- Removed deflection specification of glued laminated
  timber (glulam) and deflection.
- Added two glulam adjustment factors: stress interaction

Resources

Accreditation
The Structure Magazine is available online and in print. For more information, please visit

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Professional Education Programs

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Resources

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Live Webinars

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Why Wood?

Wood is a versatile building material that offers a range of benefits.

Benefits:
- **Economic Benefits:** Wood is a cost-effective building material. It is durable, long-lasting, and easy to maintain.
- **Environmental Benefits:** Wood is a renewable resource. It reduces the demand for non-renewable energy sources.
- **Sustainability Benefits:** Wood is a sustainable building material. It is harvested and processed in a responsible manner.
- **Aesthetic Benefits:** Wood is a beautiful material. It can be used to enhance the appearance of any building.
- **Energy Efficiency Benefits:** Wood is an excellent insulator. It helps to keep buildings cool in the summer and warm in the winter.

Resources:

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