Significant Wood Design and Construction

Changes to the 2018 IBC and NDS-BCD121

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Course Description

The 2018 International Building Code (IBC) published by the International Code Council and the National Design Specification® (NDS) for Wood Construction published by the American Wood Council are both now available. This presentation will provide an overview of the significant changes to wood design and construction provisions relative to previous editions and include design examples. Most of the changes in the NDS are a result of the adoption of the ASCE/SEI Standard 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures which includes increased wind loads.
Learning Objectives

Upon completion, participants will be better able to identify:

1. **NDS Changes**
   Identify changes in the *2018 IBC and NDS*

2. **ASCE 7-16**
   Identify wind load increases in *ASCE 7-16* that affect wood design and construction

3. **Fasteners**
   Identify new fastener provisions developed to address increased wind loads

4. **Nail Design**
   Design nails for withdrawal and head pull-through to resist new wind loads

Polling Question

1. What is your profession?
   a. Architect
   b. Engineer
   c. Code Official
   d. Fire Service
   e. Builder/Manufacturer/Other
Significant Wood Design and Construction Changes to the 2018 IBC and NDS

**IBC**

2018

- Exterior Balconies
- Fire Retardant Treated Wood
- Heavy Timber & Mass Timber
- Construction Type

**NDS History**

|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

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ANSI ACCREDITATION

AWC – ANSI-accredited standards developer

- Consensus Body
  - Wood Design Standards Committee

NAVIGATING THE IBC

Marginal Markings

Solid vertical lines in the margins within the body of the code indicate a technical change from the requirements of the 2015 edition. Deletion indicators in the form of an arrow (↑) are preceded in the margin where an entire section, paragraph, exception or table has been deleted or an item in a list of items or a table has been deleted.

A single asterisk (*) placed in the margin indicates that text or a table has been relocated within the code. A double asterisk (**) placed in the margin indicates that the text or table immediately following it has been relocated there from elsewhere in the code. The following table indicates such relocations in the 2018 edition of the International Building Code.

<table>
<thead>
<tr>
<th>2018 LOCATION</th>
<th>2015 LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>705.2.3.1</td>
<td>1406.3</td>
</tr>
<tr>
<td>705.2.4</td>
<td>1406.4</td>
</tr>
<tr>
<td>708.4.2</td>
<td>718.3.2</td>
</tr>
<tr>
<td>708.4.2</td>
<td>718.3.3</td>
</tr>
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<td>708.4.2</td>
<td>718.4.2</td>
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<tr>
<td>708.4.2</td>
<td>718.4.3</td>
</tr>
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<td>602.4.3</td>
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<td>602.4.4</td>
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</tr>
<tr>
<td>2304.11.4.1</td>
<td>602.4.8.1</td>
</tr>
</tbody>
</table>
202 DEFINITIONS

Conventional Light-Frame Construction (Modification)
Light-Frame Construction (Modification)

FRT WOOD SHEATHING EXT. WALL ASSEMBLIES

602.3, 602.4.1
• Fire-retardant-treated wood framing and sheathing permitted within exterior walls of Type III and IV construction
  • 2-hour rating or less
  • Type IV - Minimum of 6 inches in thickness
**TYPE IV CONSTRUCTION**

**602.4 TYPE IV**
- Minimum sizes moved to Ch. 23

**COL. PROTECTION IN LIGHT-FRAME CONSTRUCTION**

**704.2, 704.4.1**
- Required fire-resistance rating permitted to be provided with membrane protection
## COL. PROTECTION IN LIGHT-FRAME CONSTRUCTION

### TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Type V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>HT</td>
</tr>
<tr>
<td>Primary structural frame(^e) (see Section 202)</td>
<td>3(^a)</td>
<td>2(^b)</td>
<td>1(^b)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Bearing walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior(^t)</td>
<td>3(^c)</td>
<td>2(^d)</td>
<td>1</td>
<td>0</td>
<td>2(^e)</td>
</tr>
<tr>
<td>Interior</td>
<td>2(^c)</td>
<td>2(^d)</td>
<td>1</td>
<td>0</td>
<td>1(^h)</td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0(^k)</td>
</tr>
<tr>
<td>Floor construction and associated secondary members (see Section 202)</td>
<td>2(^p)</td>
<td>2(^q)</td>
<td>1(^r)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Roof construction and associated secondary members (see Section 202)</td>
<td>1(^t)</td>
<td>1(^u)</td>
<td>1(^v)</td>
<td>0(^w)</td>
<td></td>
</tr>
</tbody>
</table>

**704.4 Protection of secondary members.** Secondary members that are required to have protection to achieve a fire-resistance rating shall be protected by individual encasement protection.

**704.4.1 Light-frame construction.** Studs, columns and boundary elements that are integral elements in walls of light-frame construction and are located entirely between the top and bottom plates or tracks shall be permitted to have required fire-resistance ratings provided by the membrane protection provided for the wall.
COLUMNS WITHIN WALL ASSEMBLY

WS4-1.1 One Hour Fire-Resistive Wood-Frame Wall Assembly
2x4 Wood Stud Wall – 100% Design Load – ASTM E 119/NFPA 251

1. Column
2. Floor sheathing
3. Roof sheathing
4. Stud

IBC 704.2 and 704.3 No additional fireproofing required for the column in the assembly

STRUCTURAL CONTINUITY OF DOUBLE FIRE WALLS

706.2
- Applicable only in SDCs D, E and F
- Allows for continuous diaphragm for floor and/or roof assembly
- Also stabilizes double fire walls to resist impact during seismic event
STRUCTURAL CONTINUITY OF DOUBLE FIRE WALLS

DEFLECTION – TABLE 1604.3

<table>
<thead>
<tr>
<th>CONSTRUCTION</th>
<th>( L ) or ( L_p )</th>
<th>( S ) or ( W )</th>
<th>( D = L^{1.4} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof members:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting plaster or stucco ceiling</td>
<td>( 1/360 )</td>
<td>( 1/260 )</td>
<td>( 1/240 )</td>
</tr>
<tr>
<td>Supporting nonplaster ceiling</td>
<td>( 1/240 )</td>
<td>( 1/240 )</td>
<td>( 1/180 )</td>
</tr>
<tr>
<td>Not supporting ceiling</td>
<td>( 1/180 )</td>
<td>( 1/180 )</td>
<td>( 1/120 )</td>
</tr>
<tr>
<td>Floor members</td>
<td>( 1/360 )</td>
<td>—</td>
<td>( 1/240 )</td>
</tr>
<tr>
<td>Exterior walls:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With plaster or stucco finishes</td>
<td>—</td>
<td>( 1/360 )</td>
<td>—</td>
</tr>
<tr>
<td>With other brittle finishes</td>
<td>—</td>
<td>( 1/240 )</td>
<td>—</td>
</tr>
<tr>
<td>With flexible finishes</td>
<td>—</td>
<td>( 1/120 )</td>
<td>—</td>
</tr>
<tr>
<td>Interior partitions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With plaster or stucco finishes</td>
<td>( 1/360 )</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>With other brittle finishes</td>
<td>( 1/240 )</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>With flexible finishes</td>
<td>( 1/120 )</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Farm buildings</td>
<td>—</td>
<td>—</td>
<td>( 1/180 )</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>—</td>
<td>—</td>
<td>( 1/120 )</td>
</tr>
</tbody>
</table>
**DEFLECTION – TABLE 1604.3**

<table>
<thead>
<tr>
<th>21</th>
</tr>
</thead>
</table>

d. The deflection limit for the \(D+L\) load combination only applies to the deflection due to the creep component of long-term dead load deflection plus the short-term live load deflection. For wood structural members that are dry at time of installation and used under dry conditions in accordance with the ANSI/AWC NDS, the creep component of the long-term deflection shall be permitted to be estimated as the immediate dead load deflection resulting from \(0.5D\). For wood structural members at all other moisture conditions, the creep component of the long-term deflection is permitted to be estimated as the immediate dead load deflection resulting from \(D\). The value of \(0.5D\) shall not be used in combination with ANSI/AWC NDS provisions for long-term loading.

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<table>
<thead>
<tr>
<th>22</th>
</tr>
</thead>
</table>

f. The wind load is permitted to be taken as 0.42 times the “component and cladding” loads for the purpose of determining deflection limits herein. Where members support glass in accordance with Section 2403 using the deflection limit therein, the wind load shall be no less than 0.6 times the “component and cladding” loads for the purpose of determining deflection.

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f. The wind load shall be permitted to be taken as 0.42 times the “component and cladding” loads or directly calculated using the 10-year mean return interval wind speed for the purpose of determining deflection limits in Table 1604.3. Where framing members support glass, the deflection limit therein shall not exceed that specified in Section 1604.3.7.
**DECK LIVE LOADS**

**TABLE 1607.1**

Balcony & Deck live load

\[ = 1.5 \times \text{room live load} \leq 100 \text{ psf} \]

Same as occupancy served

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**TSUNAMI LOADS**

**1615**

- New section and definitions address tsunami-resistant design of critical infrastructure and essential facilities
- Applicable to Risk Category III and IV structures located in Tsunami Design Zones
**STRUCTURAL OBSERVATION**

1704.6.1 1704.6.2 & 1704.6.3

- Clarifies and consolidates requirements for structural observation for both seismic and wind into 1704.6.1
- Modifies the wind trigger from structural observation from 110 mph to 130 mph for Risk Categories III or IV

**SPECIAL INSPECTION**

1705.11.1 Structural wood

- Clarifies the main wind force-resisting system fastening exception to special inspection in wood frame construction (based on nail spacing for sheathing exceeding 4 inches on center) at the panel edges.
POLLING QUESTION

2. Which of the following is NOT true for floor sheathing at light-frame double fire walls? It may be:
   a) 1” thick.
   b) Continuous thru fire walls in SDC E-F
   c) Continuous thru fire walls in high wind zones & SDC D.
   d) Answers b) and c)
REFERENCED STANDARDS

- **2018 National Design Specification (NDS)** for Wood Construction
- **2015 Special Design Provisions for Wind and Seismic (SDPWS)**
- **2018 Wood Frame Construction Manual for One-and-Two Family Dwellings (WFCM)**

REFERENCED STANDARDS

- **ANSI A190.1-2017 Structural Glued Laminated Timber**
- **ANSI/APA PRP 210-2014 Standard for Performance-Rated Engineered Wood Siding**
- **ANSI/APA PRR 410-2016 Standard for Performance-Rated Engineered Wood Rim Boards**

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FIRE-RETARDANT-TREATED WOOD

2303.2.2

- Lumber of FRT wood to be impregnated with chemicals
- Paints, coating, stains and other surface treatments not an approved method

2303.2 Fire-retardant-treated wood. Fire-retardant-treated wood is any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested....

2303.2.2 Other means during manufacture. For wood products impregnated with chemicals by other means during manufacture, the treatment shall be an integral part of the manufacturing process of the wood product. The treatment shall provide permanent protection to all surfaces of the wood product. The use of paints, coatings, stains or other surface treatment are not an approved method of protection as required in this section.
MECHANICALLY LAMINATED DECKING

TABLE 2304.9.3.2

- New alternative fastener schedule for construction of mechanically laminated decking [also called Nail Laminated Timber (NLT)]
- Provides for equivalency where power-driven fasteners are used instead of 2.5x laminate (equivalent 20d nails)

Architect: Profeta Royalty Architecture
Structural Engineer: Structural Focus
Completed: 2011
MECHANICALLY LAMINATED DECKING

TABLE 2304.8.2
FASTENING SCHEDULE FOR MECHANICALLY LAMINATED DECKING USING LAMINATIONS OF 2-INCH NOMINAL THICKNESS

<table>
<thead>
<tr>
<th>MINIMUM NAIL SIZE (Length x Diameter) (inches)</th>
<th>MAXIMUM SPACING BETWEEN FACE NAILS **(inches)</th>
<th>NUMBER OF TOE-NAILS INTO SUPPORTS**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decking Supports ≤ 48 inches O.C.</td>
<td>Decking Supports &gt; 48 inches O.C.</td>
</tr>
<tr>
<td>4 x 0.192</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>4 x 0.162</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>4 x 0.148</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>3/4 x 0.162</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>3/4 x 0.148</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>3/4 x 0.135</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>3 x 0.148</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>3 x 0.128</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>2 x 0.148</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>2 x 0.131</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>2 x 0.120</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm
a. Nails shall be driven perpendicular to the lamination face, alternating between top and bottom edges.
b. Where nails penetrate through two laminations and into the third, they shall be staggered one-third of the spacing in adjacent laminations. Otherwise, nails shall be staggered one-half of the spacing in adjacent laminations.
c. Where supports are 48 inches or less, alternate laminations shall be toenailed to alternate supports; where supports are spaced more than 48 inches on center, alternate laminations shall be toenailed to every support.

**FASTENERS SCHEDULE ROOF REQUIREMENTS NAILS**

TABLE 2304.10.1

- 8d common and ring shank nails now addressed for fastening of roof sheathing when nailing 6 inches or 12 inches on center
- Provides for alignment of 2018 IBC and IRC

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RING SHANK NAILS

### TABLE 2304.10.1 Fastening Schedule, roof requirements

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Number and Type of Fastener</th>
<th>Spacing and Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>34-30.</td>
<td>8d heavy common or deformed (2⅜&quot; × (i+1+[0.131&quot;) (roof), or RSRS-01 (2⅜&quot; × 0.113&quot;) nail (roof))</td>
<td>Edges (inches)</td>
</tr>
<tr>
<td>⅜&quot; - ½&quot;</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2⅜&quot; × 0.113&quot; nail (roof)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1-⅛&quot; 16 gage staple, ⅛&quot; crown (roof)</td>
<td>3</td>
</tr>
<tr>
<td>32-31.</td>
<td>8d common or deformed (2⅜&quot; × 0.121&quot;) (roof), or RSRS-01 (2⅜&quot; × 0.113&quot;) nail (roof))</td>
<td>6</td>
</tr>
<tr>
<td>⅜¾&quot; - ⅝&quot;</td>
<td>2⅜&quot; × 0.113&quot; nail, or 2&quot; 16 gage staple, ⅛&quot; crown</td>
<td>4</td>
</tr>
<tr>
<td>32-32.</td>
<td>10d common (3&quot; × 0.148&quot;) or 8d deformed (2⅜&quot; × 0.131&quot;)</td>
<td>6</td>
</tr>
<tr>
<td>⅜&quot; - ⅝&quot;</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.
- RSRS-01 is a Roof Sheathing Ring Shank nail meeting the specifications in ASTM F 1967.
  (No changes to footnotes a-e.)

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HEAVY-TIMBER CONSTRUCTION

### 2304.11

- Heavy timber provisions of Chapter 23 have been reorganized
- Wood member size equivalencies relocated from Section 602.4
HEAVY-TIMBER CONSTRUCTION

Relocated from Ch. 6

<table>
<thead>
<tr>
<th>Supporting Members for Permeable Floors and Roofs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2304.12.2.5, 2304.12.2.6</strong></td>
</tr>
</tbody>
</table>

TABLE 2304.11

<table>
<thead>
<tr>
<th>Minimum Dimensions of Heavy Timber Structural Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting Elements</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Floor loads only or combined floor and roof loads</td>
</tr>
<tr>
<td>Columns; Framed sawn or glued-laminated timber arches that spring from the floor line; framed timber trusses</td>
</tr>
<tr>
<td>Wood beams and girders</td>
</tr>
<tr>
<td>Roof loads only</td>
</tr>
<tr>
<td>Columns (roof and ceiling loads); lower half of wood-frame or glued-laminated arches that spring from the floor line or from grade</td>
</tr>
<tr>
<td>Upper half of wood-frame or glued-laminated arches that spring from the floor line or from grade</td>
</tr>
<tr>
<td>Framed timber trusses and other roof framing;* Framed or glued-laminated arches that spring from the top of walls or wall abutments</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

a. Spaced members shall be permitted to be composed of two or more pieces not less than 3 inches nominal in thickness where blocked solidly throughout their intervening spaces or where spaces are tightly closed by a continuous wood cover plate of not less than 2 inches nominal in thickness secured to the underside of the members. Splice plates shall be not less than 3 inches nominal in thickness.

b. Where protected by approved automatic sprinklers under the roof deck, framing members shall be not less than 3 inches nominal in width.
SUPPORTING MEMBERS FOR PERMEABLE FLOORS AND ROOFS

IBC & IEBC CH. 1

- Details in construction documents and inspections for impervious moisture barriers used in exterior balconies.

SUPPORTING MEMBERS FOR PERMEABLE FLOORS AND ROOFS

2304.12.2.5, 2304.12.2.6

- Where an impervious moisture barrier system is used to protect the wood structure supporting moisture-permeable floors, positive drainage shall be provided for water that infiltrates the moisture-permeable floor topping.
Significant Wood Design and Construction Changes to the 2018 IBC and NDS

TABLE 2308.4.1.1(1)  Header and Girder Spans* for Exterior Bearing Walls

<table>
<thead>
<tr>
<th>Ground Snow Load (psf)</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Widths (feet)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2308.4.1.1(1)

**Table 2308.4.1.1 (1)**

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa.

a. Spans are given in feet and inches.

b. Spans are based on minimum design properties for No. 2 grade lumber of Douglas fir-larch, hem-fir, Southern pine and spruce-pine-fir. No. 1 or better grade lumber shall be used for Southern Pine.

c. Building width is measured perpendicular to the ridge. For widths between those shown, spans are permitted to be interpolated.

d. NJ - Number of jack studs required to support each end. Where the number of required jack studs equals one, the header is permitted to be supported by an approved framing anchor attached to the full-height wall stud and to the header.

e. Use 30 psf ground snow load for cases in which ground snow load is less than 30 psf and the roof live load is equal to or less than 20 psf.

f. Spans are calculated assuming the top of the header or girder is laterally braced by perpendicular framing. Where the top of the header or girder is not laterally braced (for example, cripple studs bearing on the header), tabulated spans for headers consisting of 2x8, 2x10, or 2x12 sizes shall be multiplied by 0.70 or the header or girder shall be designed.

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**HEADER AND GIRDER SPANS – INTERIOR WALLS**

**2308.4.1.1(2)** Table: Header and Girder Span^b^ for Interior Bearing Walls

<table>
<thead>
<tr>
<th>Headers and Girders Supporting</th>
<th>12' Spans</th>
<th>24' Spans</th>
<th>26' Spans</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Story Only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 x 8</td>
<td>6.3</td>
<td>6.3</td>
<td>6.3</td>
</tr>
<tr>
<td>2 x 10</td>
<td>6.3</td>
<td>6.3</td>
<td>6.3</td>
</tr>
<tr>
<td>3 x 12</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>4 x 10</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td>4 x 12</td>
<td>12.5</td>
<td>12.5</td>
<td>12.5</td>
</tr>
</tbody>
</table>

| Two Floors                    |           |           |           |
| 2 x 8                          | 6.3       | 6.3       | 6.3       |
| 2 x 10                         | 6.3       | 6.3       | 6.3       |
| 3 x 12                         | 10.0      | 10.0      | 10.0      |
| 4 x 10                         | 12.5      | 12.5      | 12.5      |

Notes:
- Spans are given in feet and inches.
- Spans per Table 2308.4.1.1(1)(2) for one- and two-story buildings when the top of the header or girder is limited to a structural bearing. Where the top of the header or girder is limited to bearing at an upper story, the header or girder shall be extended to the bearing, if any, at the upper story.

**OPENINGS IN EXTERIOR BEARING WALLS**

**2308.5.5.1**

- Single member headers now permitted in Section 2308.
- Typically limited to spans of 2-4 ft, Table 2308.4.1.1(1).
- Increases energy efficiency by allowing for a greater thickness of cavity insulation.
ASCE 7-16

Changes

ASCE 7-16 CHANGES

- General reference to ASCE 7 references 2015 edition in Chapter 35
- IBC wind and seismic load provisions agree with updated criteria in ASCE 7-16
- References in Chapter 18 seismic provisions to coordinate with ASCE 7-16
**ASCE 7-16 CHANGES**

IBC allows three paths to determine snow load:

1. Use the IBC to determine snow loads (Figure 1608.2 or Table 1608.2 for Alaska)
2. Use new ASCE 7 tables for the western US and New Hampshire.
3. Reference state produced maps which have greater detail for the western US and New Hampshire.

**ASCE 7-16 CHANGES**

- Requirements for secondary drains – rain loads
  - ASCE 7-16 bases minimum requirements on a 15 min/100-yr event.
  - IBC still uses the 1 hr/100-yr event for both primary and secondary minimum drain flow.
ASCE 7-16 WIND LOAD CHANGES

Figure 26.5-1B Basic Wind Speeds for Risk Category II Buildings and Other Structures

ASCE 7-10 WIND LOAD

Figure 26.5-1A Basic Wind Speeds for Risk Category II Buildings and Other Structures
ASCE 7-16 WIND LOAD CHANGES

ASCE 7-16 Wind Load Provisions
By Donald R. Scott
Structure Magazine
https://www.structuremag.org/?p=13360

Significant Wood Design and Construction Changes to the 2018 IBC and NDS

ASCE 7 WIND LOAD CHANGES

C&C Loads

- Increase in hurricane regions
- Larger roof zones
- Interior roof zones increase most

Gable Roof (7° < Θ ≤ 45°)
**ASCE 7 WIND LOAD CHANGES**

**C&C Roof Coefficients**

<table>
<thead>
<tr>
<th>Roof Slope</th>
<th>Ratio of ASCE 16/ASCE 10</th>
<th>Roof Overhang GCp - GCpi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3r</td>
<td>3e</td>
</tr>
<tr>
<td>7 &lt; Θ ≤ 20</td>
<td>1.36</td>
<td>1.14</td>
</tr>
<tr>
<td>20 &lt; Θ ≤ 27</td>
<td>1.36</td>
<td>0.96</td>
</tr>
<tr>
<td>27 &lt; Θ ≤ 45</td>
<td>1.58</td>
<td>2.45</td>
</tr>
</tbody>
</table>

---

**ASCE/SEI 7-16 WIND LOAD CHANGES**

**C&C Wind Pressure Calculations**

\[
q_z = 0.00256 \times K_z \times K_{zt} \times K_d \times K_e \times V^2
\]

\[q = 0.6 \times q_z\text{ (conversion to ASD)}\]

\[p_{max} = q[(GC_{pf}) - (GC_{pi})]\]

- \(q_z\): velocity pressure at height \(z\), psf (section 26.10-1)
- \(K_z\): velocity pressure exposure coefficient = 0.72 (section 26.10.1)
- \(K_{zt}\): topographic factor = 1.0 (section 26.8.2)
- \(K_d\): wind directionality factor = 0.85 (section 26.6)
- \(K_e\): ground elevation factor = 1.0 (section 26.9)
- \(V\): basic wind speed, mph (section 26.5)
- \(GC_{pf}\): external pressure coefficients (section 30.4)
- \(GC_{pi}\): internal pressure coefficients = 0.18 (section 26.13)
- \(p_{max}\): maximum pressure, psf

---

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Polling Question

3. Exterior balconies w/ an impervious moisture barrier system over wood structure supporting moisture-permeable floors shall have:
   a) Positive draining of water
   b) Ventilation below the floor system
   c) Details in construction documents
   d) Inspections for impervious moisture barriers
   e) All of the above.
Significant Wood Design and Construction Changes to the 2018 IBC and NDS

2018 NDS® CHANGES
National Design Specification® for Wood Construction

GOVERNING CODES FOR WOOD DESIGN

2018 NDS referenced in 2018 IBC and IRC
GOVERNING CODES FOR WOOD DESIGN

2015 SDPWS referenced in 2018 IBC and IRC

2018 NDS – PRIMARY CHANGES

- References ASCE 7-16
- 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
- Revision to method for calculating lateral design values for threaded nails
- Revised timber rivet design value tables
- Revised terminology for Fire Design of Wood Members
- NDS Supplement design values updated
NDS 2018 CHAPTERS

1. General Requirements for Structural 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. Cross-Laminated Timber *
11. Mechanical Connections *
12. Dowel-Type Fasteners *
13. Split Ring and Shear Plate Connectors
14. Timber Rivets *
15. Special Loading Conditions
16. Fire Design of Wood Members *

* Changes

NDS 2018 APPENDICES

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 Dowel-Type Fasteners and Washers
M. Manufacturing Tolerances for Rivets and Steel Side Plates for Timber Rivet Connections
N. Appendix for Load and Resistance Factor Design (LRFD) – Mandatory
Significant Wood Design and Construction Changes to the 2018 IBC and NDS

CHAPTER 1

GENERAL REQUIREMENTS FOR STRUCTURAL DESIGN

1. Sawn Lumber Grading Agencies
2. Species Combinations
3. Section Properties
4. Reference Design Values
   - Sawn Lumber and Timber*
   - MSR and MEL *
   - Decking*
   - Non-North American Sawn Lumber *
   - Structural Glued Laminated Timber *
   - Timber Poles and Piles

* Changes
MINIMUM DESIGN LOADS

- Reference Loads
- Minimum Load Standards
- ASCE 7-16

NOTATION

1.6 Notation

**CLT**
- \( E_{\text{I}_{\text{eff}}} \) = effective bending stiffness of the CLT section, lbs-in.\(^2\)/ft of panel width
- \( G_{\text{A}_{\text{eff}}} \) = effective shear stiffness of the CLT section, lbs/ft of panel width
- \( D_{\text{H}} \) = fastener head diameter, in.

**Fasteners**
- \( W_{\text{hr}}, W_{\text{H}'}, \) = reference and adjusted pull-through design value, lbs
- \( t_{\text{ns}} \) = net side member thickness, in.

**Fire**
- \( a_{\text{char}} \) = effective char depth, in.
- \( a_{\text{eff}} \) = effective char depth, in.
- \( \beta_{\frac{1}{2}} \beta_{\text{eff}} \) = non-linear effective char rate (in./hr.\(^{0.813}\)) adjusted for exposure time, t
## LOAD DURATION FACTOR

### 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$^2$</td>
<td>2.0</td>
<td>Impact Load</td>
</tr>
</tbody>
</table>

1. Load duration factors shall not apply to reference modulus of elasticity, $E$, reference modulus of elasticity for beam and column stability, $E_{wut}$, nor to reference compression perpendicular to grain design values, $F_{ct}$, based on a deformation limit.

2. Load duration factors greater than 1.6 shall not be used in the design of structural members pressure-treated with water-borne preservatives (see Reference 50), or fire retardant chemicals. Load duration factors greater than 1.6 shall not be used in the design of connections or wood structural paneling.
POLLING QUESTION

4. Load Duration Factor, C_D for Impact Loads is limited to 1.6 wood structural panels
   a) True
   b) False
BEAM STABILITY FACTOR

3.3.3 Beam Stability Factor, \( C_L \)

3.3.3.6 The slenderness ratio, \( R_b \), for bending members shall be calculated as follows:

\[
R_b = \frac{P_d}{b t^2} \quad (3.3-5)
\]

3.3.3.7 The slenderness ratio for bending members, \( R_b \), shall not exceed 50.

3.3.3.8 The beam stability factor shall be calculated as follows:

\[
C_L = \frac{1 + \left( \frac{F_{u,b}}{F_{u,m}} \right)}{1.9} - \sqrt{\left[ \frac{1 + \left( \frac{F_{u,b}}{F_{u,m}} \right)^2}{1.9} \right] - \frac{F_{u,b}}{0.95}} \quad (3.3-6)
\]

where:

\( F_{u,b} \) = reference bending design value multiplied by all applicable adjustment factors except \( C_L \)

\( C_v \) when \( C_L \leq 1.0 \), and \( C_L \) (see 2.3), psi

\[
F_{u,m} = \frac{1.20 F_{u,m}}{R_b^2}
\]

Source: APA

CHAPTER 4

SAWN LUMBER

4.1 General 26
4.2 Reference Design Values 27
4.3 Adjustment of Reference Design Values 28
4.4 Special Design Considerations 31

Table 4.3.1: Applicability of Adjustment Factors for Sawn Lumber 30
Table 4.3.2: Induction Factors, \( C_L \) 39
**FLAT USE FACTOR**

4.3.7 Flat Use Factor, $C_{fu}$

4.3.7.1 When sawn lumber 2" to 4" thick is loaded on the wide face, multiplying the reference bending design value, $F_b$, by the flat use factors, $C_{fu}$, specified in Tables 4A, 4B, 4C, and 4F, shall be permitted.

4.3.7.2 When members classified as Beams and Stringers are loaded on the wide face, the reference bending design value, $F_b$, and the reference modulus of elasticity, (E or $E_{min}$), shall be multiplied by the flat use factors, $C_{fu}$, specified in Table 4D.

**INCISING FACTOR**

4.3.8 Incising Factor, $C_i$

Dimensional lumber - Allowance for incising factors from company providing incising

<table>
<thead>
<tr>
<th>Table 4.3.8 Incising Factors, $C_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Value</td>
</tr>
<tr>
<td>$E$, $E_{min}$</td>
</tr>
<tr>
<td>$F_b$, $F_t$, $F_c$, $F_v$</td>
</tr>
<tr>
<td>$F_{cl}$</td>
</tr>
</tbody>
</table>
CHAPTER 8

STRUCTURAL COMPOSITE LUMBER

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8.2 Reference Design Values 52
8.3 Adjustment of Reference Design Values 52
8.4 Special Design Considerations 54

Table 8.1.1 Applicability of Allowable Stress for Structural Composite Lumber 53

Source: APA

DRY SERVICE CONDITIONS

8.1.4 Service Conditions

Reference design values reflect dry service conditions, where the moisture content of sawn lumber in service is less than 16%, as in most covered structures. Structural composite lumber shall not be used in higher moisture service conditions unless specifically permitted by the structural composite lumber manufacturer.

Source: APA
### VOLUME FACTOR

Volume Factor $C_v$ –

**Tension parallel to grain**

#### 8.3.6 Volume Factor, $C_v$

8.3.6.1 Reference bending design values, $F_k$, for structural composite lumber shall be multiplied by the volume factor, $C_v$, which shall be obtained from the structural composite lumber manufacturer’s literature or code evaluation reports. When $C_v \leq 1.0$, the volume factor, $C_v$, shall not apply simultaneously with the beam stability factor, $C_b$ (see 3.3.3) and therefore, the lesser value of these adjustment factors shall apply. When $C_v > 1.0$, the volume factor, $C_v$, shall apply simultaneously with the beam stability factor, $C_b$ (see 3.3.3).

8.3.6.2 Reference tension design values, $F_k$, for structural composite lumber shall be multiplied by the volume factor, $C_v$, which shall be obtained from the structural composite lumber manufacturer’s literature or code evaluation reports.

#### Table 8.3.1: Applicability of Adjustment Factors for Structural Composite Lumber

<table>
<thead>
<tr>
<th>Source</th>
<th>ASD only</th>
<th>ASD and LRFD</th>
<th>LRFD only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Domain Factor</td>
<td>Wet Service Factor</td>
<td>Degradation Factor</td>
<td>Volume Factor</td>
</tr>
<tr>
<td>$C_g$</td>
<td>$C_M$</td>
<td>$C_V$</td>
<td>$C_b$</td>
</tr>
</tbody>
</table>

1. See 8.3.1 for definitions on simultaneous application of the factor, $C_v$, and the beam stability factor, $C_b$, to the reference bending design value, $F_k$. 

---

### CHAPTER 5

**STRUCTURAL GLUED LAMINATED TIMBER**

5.1 General 34
5.2 Reference Design Values 35
5.3 Adjustment of Reference Design Values 36
5.4 Special Design Considerations 39

Table 5.3.1 | Not tabulated values of Structural Glued Laminate Timber 34
Table 5.5.1 | Adjustments of Design Values for Cured Glued Laminated Timber 36
Table 5.5.2 | Applicability of Adjustment Factors for Structural Glued Laminated Timber 37

Source: APA
### ADJUSTMENT FACTORS

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

<table>
<thead>
<tr>
<th>ASD only</th>
<th>ASD and LRFD</th>
<th>LRFD only</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_{ai} )</td>
<td>( F_{ai} )</td>
<td>( F_{ai} )</td>
</tr>
<tr>
<td>( C_D )</td>
<td>( C_D )</td>
<td>( K_F )</td>
</tr>
<tr>
<td>( C_{V} )</td>
<td>( C_{V} )</td>
<td>0.75</td>
</tr>
<tr>
<td>( F_{ax} )</td>
<td>( F_{ax} )</td>
<td>( 2.88 )</td>
</tr>
</tbody>
</table>

1. The beam stability factor, \( C_{V} \), shall not apply simultaneously with the volume factor, \( C_D \), for structural glued laminated timber bending members (see 5.3.6). Therefore, the lower of these adjustment factors shall apply.
2. For radial tension, \( F_{ax} \), the same adjustment factors, \( C_{V} \) and \( C_D \), for shear parallel to grain, \( F_{ax} \), shall be used.

---

### CHAPTER 10

#### CROSS-LAMINATED TIMBER

- 10.1 General
- 10.2 Reference Design Values
- 10.3 Adjustment of Reference Design Values
- 10.4 Special Design Considerations
- Table 10.1.1 Applicability of Adjustment Factors for Cross-Laminated Timber
- Table 10.1.2 Shear Deformation Adjustment Factors, \( K_F \)

---

Source: APA

Source: Seagate
<table>
<thead>
<tr>
<th>Format Conversion Factor</th>
<th></th>
</tr>
</thead>
</table>

### Table 10.3.1 Applicability of Adjustment Factors for Cross-Laminated Timber

<table>
<thead>
<tr>
<th></th>
<th>ASD only</th>
<th>ASD and LRFD</th>
<th>LRFD only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASD</td>
<td>ASDFactor</td>
<td>LRFD</td>
</tr>
<tr>
<td>Load Division Factor</td>
<td>C_D</td>
<td>C_M</td>
<td>2.54</td>
</tr>
<tr>
<td>Wet Service Factor</td>
<td>C_M</td>
<td>C_I</td>
<td>0.85</td>
</tr>
<tr>
<td>Temperature Factor</td>
<td>C_I</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Beam Stability Factor</td>
<td>C_L</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Column Stability Factor</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bearing Area Factor</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fire Resistance Factor</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fire Load Factor</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\[
F_v(S_{eff})' = F_v(S_{eff})
\]

\[
F_v(A_{parallel})' = F_v(A_{parallel})
\]

\[
F_v(t_v) = F_v(t_v)
\]

\[
F_v(t_b Q)_{eff} = F_v(t_b Q)_{eff}
\]

### DEFLECTION – EFFECTIVE SHEAR STIFFNESS

Per ANSI/APA PRG 320-2017

\[
(EI)_{app} = \frac{E_{I_{eff}}}{1 + \frac{K_d E_{I_{eff}}}{K_{eff} G_{eff} L^2}}
\]

(10.4-1)

where:

- \(E_{I_{eff}}\) = Effective bending stiffness of the CLT section, lbs-in.^2/ft of panel width
- \(K_d\) = Shear deformation adjustment factor
- \(G_{eff}\) = Effective shear stiffness of the CLT section, lbs/ft of panel width
- \(L\) = Span of the CLT section, in.

Source: APA

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CHAPTER 11

MECHANICAL CONNECTIONS

11.1 General
11.2 Reference Design Values
11.3 Adjustment of Reference Design Values

Table 11.3.1 Applicability of Adjustment Factors for Connections

Significant Wood Design and Construction Changes to the 2018 IB C and NDS

ADJUSTMENT FACTORS – HEAD PULL-THROUGH

Table 11.3.1 Applicability of Adjustment Factors for Connections

Lateral Loads

| Dowel-type Fasteners | \( Z = Z \times x \) | \( C_D \) | \( C_{M} \) | \( C_t \) | \( C_y \) | \( C_{B} \) | \( C_{R} \) | \( C_{w} \) | \( C_{n} \) | \( 3.32 \times 0.65 \) |
| Split Ring and Sheer Plate Connectors | \( P = P \times x \) | \( C_D \) | \( C_{M} \) | \( C_t \) | \( C_y \) | \( C_{B} \) | \( C_{R} \) | \( C_{w} \) | \( C_{n} \) | \( 3.32 \times 0.65 \) |
| Timber Rivets | \( Q = Q \times x \) | \( C_D \) | \( C_{M} \) | \( C_t \) | \( C_y \) | \( C_{B} \) | \( C_{R} \) | \( C_{w} \) | \( C_{n} \) | \( 3.32 \times 0.65 \) |
| Spike Grids | \( Z = Z \times x \) | \( C_D \) | \( C_{M} \) | \( C_t \) | \( C_y \) | \( C_{B} \) | \( C_{R} \) | \( C_{w} \) | \( C_{n} \) | \( 3.32 \times 0.65 \) |

Withdrawal Loads

| Nails, spikes, lag screws, wood screws, & drift pins | \( W = W \times x \) | \( C_D \) | \( C_{M} \) | \( C_t \) | \( C_y \) | \( C_{B} \) | \( C_{R} \) | \( C_{w} \) | \( C_{n} \) | \( 3.32 \times 0.65 \) |

Pull-Through

| Fasteners with Round Heads | \( W_p = W_n \times x \) | \( C_D \) | \( C_{M} \) | \( C_t \) | \( C_y \) | \( C_{B} \) | \( C_{R} \) | \( C_{w} \) | \( C_{n} \) | \( 3.32 \times 0.65 \) |
WET SERVICE FACTORS – HEAD PULL-THROUGH

Table 11.3.3  Wet Service Factors, Dw, for Connections

<table>
<thead>
<tr>
<th>Fastener Type</th>
<th>Moisture Content</th>
<th>Cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Time of Fabrication</td>
<td>In-Service</td>
</tr>
<tr>
<td>Lag Screws &amp; Wood</td>
<td>any</td>
<td>≤ 19%</td>
</tr>
<tr>
<td>Screws</td>
<td>any</td>
<td>&gt; 19%</td>
</tr>
<tr>
<td>Nails &amp; Spikes³</td>
<td>≤ 19%</td>
<td>≤ 19%</td>
</tr>
<tr>
<td></td>
<td>&gt; 19%</td>
<td>&gt; 19%</td>
</tr>
<tr>
<td></td>
<td>&gt; 19%</td>
<td>&gt; 19%</td>
</tr>
</tbody>
</table>

Pull-Through Loads

| Fasteners with Round Heads | any | ≤ 19% | 1.0 |
|                           | any | > 19% | 0.7 |

1. For application of wet service connections, moisture content limiters apply to a depth of 0.25” below the surface of the wood.
2. Cw = 0.25 for dowel-type fasteners with diameters 0.25” less than 0.625”.
3. Cm = 1.0 for dowel-type fasteners with:
   a) one fastener only,
   b) two or more fasteners placed in a single row parallel to grain, or
   c) drywood placed in two or more parallel rows with a minimum space greater than equal to 1.5 times the diameter of the nail.
4. For Roof Sheathing Ring Shank (RSH) and Post-Frame Ring Shank (PF) nails, Cw=1.0.

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CHAPTER 12

DOVETAIL-TYPE FASTENERS

Table 16  Roof Sheathing Ring Shank Nails

| H | L | T1 | TL | P |
TYPICAL NAIL HEADS

- Full Round
- Offset Round
- D-Head
- Notched Head

Photos courtesy of Hitachi – Hitachi

TYPICAL NAIL SHANKS

- Smooth
- Ring
- Screw
- Barbed

Photos courtesy of Falcon Fasteners

Sketches courtesy ISANTA
**TYPICAL NAIL POINTS**

Diamond  
Needle  
Blunt or No

Photos courtesy of Falcon Fasteners

---

**ROOF SHEATHING RING SHANK NAILS**

---

12.1.6 Nails and Spikes

12.1.6.1 Installation requirements apply to common steel wire nails and spikes, box nails, sinker nails, Roof Sheathing Ring Shank nails, and Post-Frame Ring Shank nails meeting requirements in ASTM F1667. Nails and spikes used in engineered construction shall meet the Supplementary Requirements of ASTM F1667.

Nail specifications for engineered construction shall include the minimum lengths, head diameters, and shank diameters for the nails and spikes to be used. See Appendix Table L4 for standard common, box, and sinker nail dimensions, Appendix Table L5 for standard Post-Frame Ring Shank nail dimensions, and Appendix Table L6 for Roof Sheathing Ring Shank nail dimensions.
SMOoth Shank Nails or Spikes

12.2.3 Nails and Spikes

12.2.3.1 Smooth shank nails or spikes

(a) The nail or spike reference withdrawal design value, W, in lbs/in. of penetration, for a smooth shank (bright or galvanized) carbon steel nail or spike driven into the side grain of a wood member, with the nail or spike axis perpendicular to the wood fibers, shall be determined from Table 12.2C or Equation 12.2-3, within the range of specific gravities, G, and nail or spike diameters, D, given in Table 12.2C. Reference withdrawal design values, W, shall be multiplied by all applicable adjustment factors (see Table 11.3.1) to obtain adjusted withdrawal design values, W*.

\[ W = 1380 \frac{G^{3/2}}{D} \quad (12.2-3) \]

(b) The nail or spike reference withdrawal design value, W, in lbs/in. of penetration, for a smooth shank stainless steel nail or spike driven into the side grain of a wood member, with the nail or spike axis perpendicular to the wood fibers, shall be determined from Table 12.2D or Equation 12.2-4, within the range of specific gravities, G, and nail or spike diameters, D, given in Table 12.2C. Reference withdrawal design values, W, shall be multiplied by all applicable adjustment factors (see Table 11.3.1) to obtain adjusted withdrawal design values, W*.

\[ W = 465 \frac{G^{3/2}}{D} \quad (12.2-4) \]

CARbon Steel Nail Withdrawal

Table 12.2C (Bright or Galvanized) Carbon Steel Nail and Spike Reference Withdrawal Design Values, W^{1/3}

<table>
<thead>
<tr>
<th>Specific Gravity, G</th>
<th>0.092”</th>
<th>0.099”</th>
<th>0.113”</th>
<th>0.120”</th>
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</table>

1. Tabulated withdrawal design values, W, for nail or spike connections shall be multiplied by all applicable adjustment factors (see Table 11.3.1).
2. Specific gravity shall be determined in accordance with Table 12.3.3A.
3. Tabulated withdrawal design values for smooth shank nails are permitted to be used for deformed shank nails of equivalent diameter, D.

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STAINLESS STEEL NAIL WITHDRAWAL

NEW

Table 12.2D  Stainless Steel Nail and Spike Reference Withdrawal Design Values, W₁,₂

Tabulated withdrawal design values, W, are in pounds per inch of fastener penetration into side grain of wood member (see 12.2.3.1)

Specific Gravity, G

<table>
<thead>
<tr>
<th>Smooth Shank Stainless Steel Nail and Spike Diameter, D</th>
<th>0.062&quot;</th>
<th>0.069&quot;</th>
<th>0.113&quot;</th>
<th>0.120&quot;</th>
<th>0.125&quot;</th>
<th>0.133&quot;</th>
<th>0.135&quot;</th>
<th>0.148&quot;</th>
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<tr>
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</table>

1. Tabulated withdrawal design values, W, for nail or spike connections shall be multiplied by all applicable adjustment factors (see Table 12.3.1).
2. Specific gravity shall be determined in accordance with Table 12.3.2.
3. Tabulated withdrawal design values for smooth Shank nails are permitted to be used for deformed Shank nails of equivalent diameter, D.

SMOOTH SHANK NAIL WITHDRAWAL STRENGTH

ASD Withdrawal Strength
(Smooth shank, 8d common nail)

Pounds per inch of penetration

Carbon steel (bright or galvanized)  Stainless steel
DEFORMED SHANK NAILS

12.2.3.2 Deformed shank nails
(a) The reference withdrawal design value, in lbs/in. of ring shank penetration, for a Roof Sheathing Ring Shank nail or Post-Frame Ring Shank nail driven in the side grain of the main member, with the nail axis perpendicular to the wood fibers, shall be determined from Table 12.2E or Equation 12.2-5, within the range of specific gravities and nail diameters given in Table 12.2E. Reference withdrawal design values, W, shall be multiplied by all applicable adjustment factors (see Table 11.3.1) to obtain adjusted withdrawal design values, \( W' \).

\[
W = 1800 G^2 D \quad \text{(12.2-5)}
\]

(b) For Roof Sheathing Ring Shank nails (Appendix Table L6) or Post-Frame Ring Shank nails (Appendix Table L5) that are uncoated carbon steel, reference withdrawal design values determined from Table 12.2E or Equation 12.2-5 shall be permitted to be multiplied by 1.25.

RSRS NAIL WITHDRAWAL

Table 12.2E Roof Sheathing Ring Shank Nail and Post-Frame Ring Shank Nail Reference Withdrawal Design Values, \( W' \)

<table>
<thead>
<tr>
<th>Specific Gravity, ( G )</th>
<th>Roof Sheathing Ring Shank Nail Diameter, ( D ) (in.)</th>
<th>Post-Frame Ring Shank Nail Diameter, ( D ) (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.113</td>
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<td>0.73</td>
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<tr>
<td>0.50</td>
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<td>54</td>
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</tbody>
</table>

1. Tabulated withdrawal design values, \( W \), for Roof Sheathing Ring Shank (RSRS) nails and Post-Frame Ring Shank (PF) nails shall be multiplied by all applicable adjustment factors (see Table 11.3.1).
2. Tabulated reference withdrawal design values, \( W' \), are only applicable to Roof Sheathing Ring Shank (RSRS) nails or Post-Frame Ring Shank (PF) nails meeting requirements of ASTM F1667.
3. Specific gravity shall be determined in accordance with Table 12.3.3A.
FASTENER HEAD PULL-THROUGH

12.2.5 Fastener Head Pull-Through

12.2.5.1 For fasteners with round heads, the reference pull-through design value, \( W_{fL} \), in pounds for wood side members shall be determined from Table 12.2F or Equation 12.2-6, within the range of fastener head diameters, \( D_h \), and net side member thicknesses, \( t_{ns} \), given in Table 12.2F. Reference pull-through design values, \( W_{fL} \), shall be multiplied by all applicable adjustment factors (see Table 11.1.1.3) to obtain adjusted pull-through design values, \( W_{fH} \).

\[
W_{fH} = \begin{cases} 
690 \pi D_h t_{ns} & \text{for } t_{ns} \leq 2.5 D_h \\
1725 \pi D_h^2 t_{ns} & \text{for } t_{ns} > 2.5 D_h
\end{cases} \quad (12.2.6a)
\]

Where:

- \( \pi D_h \) = perimeter for fasteners with round heads
- \( D_h = \) fastener head diameter, in.
- \( G = \) specific gravity of side member

Pull-through for other materials shall be determined in accordance with 11.1.1.3.

---

FASTENER HEAD PULL-THROUGH

NEW

<table>
<thead>
<tr>
<th>Table 12.2F</th>
<th>Head Pull-Through, ( W_{fH} )</th>
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</thead>
<tbody>
<tr>
<td>Tabulated pull-through design values, ( W_{fH} ), are in pounds.</td>
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<table>
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<tr>
<th>Side Member Specific Gravity*, ( G )</th>
<th>Head Diameter, ( D_h ) (in.)</th>
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<th>3/8</th>
<th>1/2</th>
<th>3/16</th>
<th>1/4</th>
<th>1/8</th>
<th>3/32</th>
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</table>

1. Tabulated pull-through design values, \( W_{fH} \), shall be multiplied by all adjustment factors as applicable per Table 11.1.3.
2. Specific gravity, \( G \), shall be determined in accordance with Table 12.3.3A for lumber and Table 12.3.3B for panels.

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**FASTENER UPLIFT CAPACITY**

Fastener Uplift Capacity = lesser of $W'$ and $W_H'$

---

**FASTENER UPLIFT DESIGN EXAMPLE**

Fastener Uplift Capacity - Roof Sheathing Ring Shank Nail

Using 2018 NDS section 12.2, calculate the Allowable Stress Design (ASD) reference withdrawal capacity and head pull-through capacity of a 0.131" diameter, 3" long roof sheathing ring shank (RSRS) nail in the narrow face of a Douglas Fir-Larch 2x6 with a 7/16 in. thick OSB side member.

- **Main member:**
  - Douglas Fir-Larch (DF-L) 2x6 ($G = 0.5$)
- **Side member:**
  - 7/16 in. thick Oriented Strand Board (OSB) ($G = 0.5$)

- **Fastener Dimensions:**
  - Dash No. 05 (NDS Table L6)
  - Length = 3 in.
  - Diameter = 0.131 in.
  - Head diameter = 0.281 in.
  - $TL = 1.5$ in.

---
FASTENER UPLIFT DESIGN EXAMPLE

Fastener Uplift Capacity - Roof Sheathing Ring Shank Nail (cont.)

- Fastener diameter (in.): 0.131
- Fastener head diameter (in.): 0.281
- Deformed Shank Length (in.): 1.5
- Net Side Member thickness (in.): 0.4375
- Specific gravity, main and side members (NDS Table 12.3.3A): 0.5

Table 16: Roof Sheathing Ring Shank Nails

Checking Fastener Withdrawal

- \( W = 1800 \cdot G^2 \cdot D \) (NDS Equation 12.2.5)
- Reference withdrawal design value. Compare to NDS Table 12.2E, \( W = 59 \text{ lbs/in} \)
- Resistance = TL \( \cdot \) W
- Resistance = 88

Resistance based on main member deformed shank penetration (lbs)
FASTENER UPLIFT DESIGN EXAMPLE

Fastener Uplift Capacity - Roof Sheathing Ring Shank Nail (cont.)

Checking Fastener Head Pull-Through

\[ t_{ns} = 0.438 \]

\[ 2.5D_H = 0.703 \]

\[ 2.5D_H \text{ greater than } t_{ns}, \text{ so NDS Equation 12.2-6a applies} \]

\[ W_H = 690 \pi D_H G^2 t_{ns} \]

\[ W_H = 67 \text{ Head pull-through capacity (lbs). Compare to NDS Table 12.2F, } W_H = 67 \text{ lbs} \]

Fastener head pull-through of 67 lbs is less than withdrawal capacity of 88 lbs and controls design capacity. See NDS Table 11.3.1 for application of additional adjustment factors for connections based on end use conditions.

FASTENER UPLIFT CAPACITY

2018 WFCM Table 3.10

<table>
<thead>
<tr>
<th>Sheathing Thickness (in.)</th>
<th>3/8</th>
<th>7/16</th>
<th>15/32</th>
<th>19/32</th>
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<tr>
<td>RSRS-03</td>
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<td>99</td>
<td>99</td>
<td>99</td>
</tr>
</tbody>
</table>

2 Minimum capacity of withdrawal and fastener head pull-through is tabulated.
3 Tabulated values include a load duration factor adjustment, \( C_D = 1.6 \).
4 Tabulated values for 8d common nails and 10d box nails are applicable to carbon steel nails (bright or galvanized).
5 Tabulated values for RSRS-03 nails are applicable to carbon steel (bright or galvanized) or stainless steel nails.
FASTENER UPLIFT CAPACITY COMPARISONS

110mph Exposure B, 7/16" WSP, Framing G = 0.42, Rafter spacing = 24"
- For lower wind speed zones and lower G framing, RSRS gives simpler nailing schedule option

<table>
<thead>
<tr>
<th>Nail Type</th>
<th>Perimeter Nailing (Zones 2 &amp; 3)</th>
<th>Interior Nailing (Zone 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSRS</td>
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<td>6/12</td>
</tr>
<tr>
<td>8d Common</td>
<td>6/6</td>
<td>6/12</td>
</tr>
</tbody>
</table>

180mph Exposure B, 19/32" WSP, Framing G = 0.55, Rafter spacing = 24"
- Assume complex roof where separating perimeter and interior zones is difficult
- RSRS nails with 19/32" WSP allow 6/6 nailing everywhere – simple
- For higher wind speeds and higher G framing, RSRS provides beneficial options

<table>
<thead>
<tr>
<th>Nail Type</th>
<th>Perimeter Nailing</th>
<th>Interior Nailing</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSRS</td>
<td>6/6</td>
<td>6/12</td>
</tr>
<tr>
<td>8d Common</td>
<td>4/4</td>
<td>6/6</td>
</tr>
</tbody>
</table>

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Significant Wood Design and Construction Changes to the 2018 IBC and NDS

**Dowel Diameter**

12.3.7 Dowel Diameter

12.3.7.1 Where used in Tables 12.3.1A and 12.3.1B, the fastener diameter shall be taken as:

(a) \( D \) for smooth Shank nails and deformed Shank nails in accordance with ASTM F1667.

(b) \( D \) for unthreaded full-body diameter fasteners, and

(c) \( D_{r} \) for reduced body diameter fasteners or threaded fasteners except as provided in 12.3.7.2.

12.3.7.2 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 \( \frac{1}{4} \) 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).

---

**RSRS Nail Lateral Values**

Table 12Q: Common, Box, Sinker, or Roof Sheathing Ring Shank (RSRS) Steel Wire Nails: Reference Lateral Design Values, \( Z \), for Single Shear (two member) Connections for sawn lumber or SCL with wood structural panel side members with an effective \( p \geq 0.50 \)

(tabulated lateral design values are calculated based on an assumed length of nail penetration, \( p \), into the main member equal to 1.00)

<table>
<thead>
<tr>
<th>Nail Diameter</th>
<th>Lateral Design Value, ( Z )</th>
<th>Lateral Design Value, ( Z )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Tabulated lateral design values, \( Z \), are unadjusted by all applicable adjustment factors (see Table 11.3.3).

2. Tabulated lateral design values, \( Z \), are for common, box, or sinker steel wire nails (see Appendix Table 11.4) and for roof sheathing ring shank nails (see Appendix Table 11.6) inserted in side grain with nail axis perpendicular to wood fibers, and penetration, \( p \), into the main member equal to \( D_{r} \) and nail breaking yield strengths, \( F_{y} \), of 100,000 psi for \( 0.009'' \leq D_{r} \leq 0.147'' \) and 60,000 psi for \( 0.177'' \leq D_{r} \leq 0.216'' \), and 50,000 psi for \( 0.238'' \leq D_{r} \leq 0.273'' \).
POLLING QUESTION

5. The new equations for fastener head pull-through are based on which of the following:
   a) Fastener head diameter
   b) Specific gravity of side member
   c) Net side member thickness
   d) All of the above

CHAPTER 16

FIRE DESIGN OF WOOD MEMBERS

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Table 16.2.1A  Effective Char Rates and Char Depths
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Table 16.2.1B  Effective Char Depths for CLT with
T  1.5 in (38 mm) .................................. 155
Table 16.2.2  Adjustment Factors for Fire Design........... 150
## CHAR RATE

### 16.2.1 Char Rate

16.2.1.1 The non-linear char rate to be used in this procedure can be estimated from published nominal 1-hour char rate data using the following equation:

\[ \beta_t = \beta_n \text{ at one hour} \tag{16.2-1} \]

where:

- \( \beta_n \) = non-linear char rate (in./hr.\(^{0.015}\)), adjusted for exposure time, \( t \)
- \( \beta_n \) = nominal char rate (in./hr.), linear char rate based on 1-hour exposure
- \( t \) = exposure time (hr.)

A nominal char rate, \( \beta_n \), of 1.5 in./hr. is commonly assumed for sawn lumber, structural glued laminated softwood timber, laminated veneer lumber, parallel strand lumber, laminated strand lumber, and cross-laminated timber.

16.2.1.2 For sawn lumber, structural glued laminated softwood timber, laminated veneer lumber, parallel strand lumber, and laminated strand lumber, the char depth, \( a_{\text{char}} \), for each exposed surface shall be calculated as:

\[ a_{\text{char}} = \beta_n t^{0.813} \tag{16.2-2} \]

### CHAR DEPTH

#### Table 16.2.1A Char Depth and Effective Char Depth (for \( \beta_n = 1.5 \text{ in./hr.} \))

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Char Depth, ( a_{\text{char}} ) (in.)</th>
<th>Effective Char Depth, ( a_{\text{eff}} ) (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Hour</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>2-Hour</td>
<td>2.6</td>
<td>3.2</td>
</tr>
</tbody>
</table>

For sawn lumber, structural glued laminated softwood timber, laminated veneer lumber, parallel strand lumber, and laminated strand lumber, assuming a nominal char rate, \( \beta_n = 1.5 \text{ in./hr.} \), the char depth, \( a_{\text{char}} \), and effective char depth, \( a_{\text{eff}} \), are shown in Table 16.2.1A.

For cross-laminated timber manufactured with laminations of equal thickness and assuming a nominal char rate, \( \beta_n \), of 1.5 in./hr., the effective char depth, \( a_{\text{eff}} \), for each exposed surface is shown in Table 16.2.1B.
16.3 Wood Connections

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.

Photo courtesy of Softwood Lumber Board

APPENDIX L

Table L3 Standard Wood Screws\(^L6\)

<table>
<thead>
<tr>
<th>Cut Thread(^6)</th>
<th>Rolled Thread(^6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D = diameter, in.</td>
<td>D(_h) = head diameter(^7), in.</td>
</tr>
<tr>
<td>D(_r) = root diameter, in.</td>
<td>L = screw length, in.</td>
</tr>
<tr>
<td>T = thread length, in.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wood Screw Number</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.138</td>
<td>0.151</td>
<td>0.164</td>
<td>0.177</td>
<td>0.19</td>
<td>0.216</td>
<td>0.242</td>
<td>0.268</td>
<td>0.294</td>
<td>0.32</td>
<td>0.372</td>
</tr>
<tr>
<td>D(_h)</td>
<td>0.113</td>
<td>0.122</td>
<td>0.131</td>
<td>0.142</td>
<td>0.152</td>
<td>0.171</td>
<td>0.196</td>
<td>0.209</td>
<td>0.233</td>
<td>0.255</td>
<td>0.288</td>
</tr>
<tr>
<td>D(_r)</td>
<td>0.262</td>
<td>0.287</td>
<td>0.312</td>
<td>0.337</td>
<td>0.363</td>
<td>0.414</td>
<td>0.480</td>
<td>0.515</td>
<td>0.602</td>
<td>0.616</td>
<td>0.724</td>
</tr>
</tbody>
</table>

2. Thread length on cut threaded wood screws is approximately 2/3 of the wood screw length, L.
3. Single lead thread shown. Thread length is at least four times the screw diameter or 2/3 of the wood screw length, whichever is greater. Wood screws which are too short to accommodate the minimum thread length, have threads extending as close to the underside of the head as practicable.
4. Taken as the average of the specified maximum and minimum limits for body diameter of rolled thread wood screws.
5. Taken as the average of the specified maximum and minimum limits for head diameter.
6. It is permitted to advance the length of the tapered tip is 2D.
## APPENDIX L

### NEW

Table L6  Roof Sheathing Ring Shank Nails

<table>
<thead>
<tr>
<th>Dash No.</th>
<th>D</th>
<th>L</th>
<th>TL</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>0.113</td>
<td>2-3/8</td>
<td>1-1/2</td>
<td>0.281</td>
</tr>
<tr>
<td>02</td>
<td>0.120</td>
<td>2-1/2</td>
<td>1-1/2</td>
<td>0.281</td>
</tr>
<tr>
<td>03</td>
<td>0.131</td>
<td>2-1/2</td>
<td>1-1/2</td>
<td>0.281</td>
</tr>
<tr>
<td>04</td>
<td>0.120</td>
<td>3</td>
<td>1-1/2</td>
<td>0.281</td>
</tr>
<tr>
<td>05</td>
<td>0.131</td>
<td>3</td>
<td>1-1/2</td>
<td>0.281</td>
</tr>
</tbody>
</table>

**D** = diameter, in.  
**L** = length, in.  
**H** = head diameter, in.  
**TL** = minimum length of threaded shank, in.  
**T1** = crest diameter, in.  
**P** = pitch or spacing of threads, in.  

D = 0.005 in. ≤ TL ≤ D = 0.012 in.  
0.05 in. ≤ P ≤ 0.077 in.

---

**RESOURCES**

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