Significant Changes to the 2015 IBC, NDS® and SDPWS – BCD120

NAME
TITLE
American Wood Council

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Course Description

What are the latest trends in the world of code development related to wood? How are wood design standards keeping up with technology? This presentation will provide an overview of some of the significant code changes for wood construction per the International Code Council’s 2015 International Building Code (IBC) and American Wood Council’s 2015 National Design Specification® (NDS®) for Wood Construction and 2015 Special Design Provisions for Wind and Seismic (SDPWS).
Objectives

Upon completion, participants will understand:

1. Significant changes between the 2012 and 2015 IBC.
2. Significant changes between the 2012 and 2015 NDS.
3. Significant changes between the 2008 and 2015 SDPWS.
4. The overall format and content within the 2015 NDS and 2015 SDPWS.

Outline

- Overview
- IBC
- NDS
  - Chapter-by-chapter discussion
  - Changes from previous editions
- SDPWS
  - Chapter-by-chapter discussion
  - Changes from previous editions
- Summary
- More Info
NDS History

1944  1977  2001
1962  1982  2005
1968  1986  2012
1971  1991  2015
1973  1997

Governing Codes for Wood Design

2015 IBC references 2015 NDS
ANSI Accreditation

- **AWC – ANSI-accredited standards developer**
- **Consensus Body**
  - Wood Design Standards Committee

Outline

- **Overview**
- **IBC**
- **NDS**
  - Chapter-by-chapter discussion
  - Changes from previous editions
- **SDPWS**
  - Chapter-by-chapter discussion
  - Changes from previous editions
- **Summary**
- **More Info**
Significant Changes to IBC

IBC Ch. 1 Scope and Administration

Section 104 Duties and Powers of Building Officials

**ADDITION**

104.11 Alternative materials, design and methods of construction and equipment.

...Where the alternative material, design or method of construction is not approved, the building official shall respond in writing, stating the reasons why the alternative was not approved.
**IBC Ch. 5 General Building Heights and Areas**

- **Building Height — in feet**
  - Upper building height (feet) is measured from grade plane

- **Building Height — stories**
  - Upper building height (stories) — measured from top of lower building

---

### Section 510 Special Provisions

**510.2 Horizontal building separation allowance.**

2. The building below the horizontal assembly shall be not greater than one story above grade plane.

5. The building below the horizontal assembly shall be protected throughout by an approved automatic sprinkler system in accordance with Section 903.3.1.1, and shall be permitted to be any occupancy allowed by this code except Group H.

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**Modification**

- [Image of a building layout with the specified sections and heights]
IBC Ch. 5 General Building Heights and Areas

- **Building Height – in feet**
  - Upper building height (feet) is measured from grade plane
- **Building Height – stories**
  - Upper building height (stories) – measured from top of lower building

Type I and II Construction

- **Type I and II construction requires most structural loadbearing building elements to be of noncombustible materials.**

(N) Horizontal assembly – NFPA 13 & any occupancy except Group H
Type III Construction

- Requires exterior walls to be noncombustible material or FRTW and have a minimum 2-hour fire-resistance rating (bearing walls).
- Type IIIA requires 1-hour fire-resistance rating for all building elements other than nonbearing walls.
- Type IIIB does not require any fire-resistance rating other than exterior loadbearing wall.

Type IV Construction

- **Heavy Timber (HT)**
  - Exterior walls made of noncombustible materials, fire-retardant-treated wood (FRTW) or protected cross-laminated timber (CLT)
  - Interior building elements made of solid or laminated wood without concealed spaces
- **Columns**
  - Min. 6 × 8 nominal when supporting roof and ceiling loads
  - Min. 8 × 8 nominal when supporting floor loads
- **Beams and girders**
  - Min. 6 × 10 nominal for floors
  - Min. 4 × 6 nominal for roofs
Type IV Construction

- **Flooring**
  - Minimum 3-inch thickness covered with 1-inch nominal dimension tongue and groove flooring or 4-inch thick CLT

- **Roof decking**
  - Minimum 2-inch thickness, 11/8-inch wood structural panels, or 3-inch thick CLT

- **Partitions**
  - 1-hour-fire-resistance-rated; or
  - Minimum two layers of 1-inch nominal board; or
  - Laminated construction 4-inches thick

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**HT Minimum Sizes**

<table>
<thead>
<tr>
<th>Minimum Nominal Sawn Size</th>
<th>Minimum Glued Laminated Timber Net Size</th>
<th>Minimum Structural Composite Lumber Net Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width, inch</td>
<td>Depth, inch</td>
<td>Width, inch</td>
</tr>
<tr>
<td>------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>6-3/4</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>
HT Equivalencies

Table M16.1-2  Minimum Sizes to Qualify as Heavy Timber Construction

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum Size (all sizes nominal unless noted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Decking</td>
<td>• Sawn or glued laminated lumber planks, splined or T&amp;G</td>
</tr>
<tr>
<td></td>
<td>• Structural-use panels</td>
</tr>
<tr>
<td></td>
<td>• Planks set on edge close together</td>
</tr>
<tr>
<td></td>
<td>• Cross-laminated timber</td>
</tr>
<tr>
<td></td>
<td>2 in. thickness</td>
</tr>
<tr>
<td></td>
<td>1 1/8 in. thickness¹</td>
</tr>
<tr>
<td></td>
<td>3 in. width</td>
</tr>
<tr>
<td></td>
<td>3 in. thickness (actual)</td>
</tr>
<tr>
<td>Floor Decking</td>
<td>• Sawn or glued laminated lumber planks, splined or T&amp;G, and topped with</td>
</tr>
<tr>
<td></td>
<td>- Tongue-and-groove flooring, or</td>
</tr>
<tr>
<td></td>
<td>- Wood Structural panel, or</td>
</tr>
<tr>
<td></td>
<td>- Particleboard</td>
</tr>
<tr>
<td></td>
<td>• Planks set on edge close together, and topped with</td>
</tr>
<tr>
<td></td>
<td>- Flooring, or</td>
</tr>
<tr>
<td></td>
<td>- Wood Structural panel, or</td>
</tr>
<tr>
<td></td>
<td>- Particleboard</td>
</tr>
<tr>
<td></td>
<td>• Cross-laminated timber</td>
</tr>
<tr>
<td></td>
<td>3 in. thickness</td>
</tr>
<tr>
<td></td>
<td>1 in. thickness¹</td>
</tr>
<tr>
<td></td>
<td>1 1/2 in. thickness²</td>
</tr>
<tr>
<td></td>
<td>4 in. width</td>
</tr>
<tr>
<td></td>
<td>1 in. thickness¹</td>
</tr>
<tr>
<td></td>
<td>1 1/2 in. thickness</td>
</tr>
</tbody>
</table>

Type V Construction

• Permits the use of wood or other approved materials for loadbearing and nonloadbearing structural elements.
### Table 601

#### Table 601 Fire-Resistance Rating Requirements For Building Elements (hr)

<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^d</td>
<td>B</td>
<td>HT</td>
</tr>
<tr>
<td>Primary structural frame^e (see Section 202)</td>
<td>3^e</td>
<td>2^e</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bearing walls, Exterior^f</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Interior</td>
<td>3^e</td>
<td>2^e</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Exterior Walls

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE X (ft)</th>
<th>TYPE OF CONSTRUCTION</th>
<th>OCCUPANCY GROUP A</th>
<th>OCCUPANCY GROUP B, C, D, E, F</th>
<th>OCCUPANCY GROUP A, B, E, F</th>
<th>OCCUPANCY GROUP A, B, E, F, G, H, I, J, K, L</th>
</tr>
</thead>
<tbody>
<tr>
<td>X &lt; 5</td>
<td>All</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5 ≤ X &lt; 10</td>
<td>IA, IB</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10 ≤ X &lt; 30</td>
<td>IA, IB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>X ≥ 30</td>
<td>All</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Cross-Laminated Timber (CLT)

- Introduced in the 2015 IBC
- Type IV
- Type III (except ext. walls)
- Type V
- The AWC NDS contains new provisions for CLT
- A product standard, ANSI/APA 190.1-12
- ASTM E119 test report available
Forte’, Melbourne

10 stories, 23 apartments
https://youtu.be/pHpthNBiYqE

Fire Tests


### Fire Test

**American Wood Council**  
ASTM E119 Fire Endurance Test

- 5-Ply CLT (approx. 7” thick)
- 5/8” Type X GWB each side
- Sought 2 hour rating
- RESULTS: 3 hours 6 minutes

![Fire Test Image](image)

### IBC Ch. 6 Type of Construction

**Section 602 Construction Classification**

602.4 Type IV. Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. The details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Minimum solid sawn nominal dimensions are required for structures built using Type IV construction (HT). For glued-laminated members and structural composite lumber (SCL) members, the equivalent net finished width and depths corresponding to the minimum nominal width and depths of solid sawn lumber are required as specified in Table 602.4. Cross-laminated timber (CLT) dimensions used in this section are actual dimensions.

602.4.1 Fire-retardant-treated wood in exterior walls. Fire-retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies with a 2-hour rating or less.
Type IV Construction – Exterior Walls

602.4.2 Cross-laminated timber complying with Section 2303.1.4 shall be permitted within exterior wall assemblies with a 2-hour rating or less provided:

- Exterior surface of the cross-laminated timber is protected fire retardant treated wood sheathing complying with 2303.2 and not less than 15/32 inch thick;
  OR
- gypsum board not less than ½ inch thick;
  OR
- a noncombustible material.

Type IV Construction – Floors

602.4.6.2 CLT. Cross laminated timber shall be not less than 4 inches (102 mm) in thickness. It shall be continuous from support to support and mechanically fastened to one another. Cross laminated timber shall be permitted to be connected to walls without a shrinkage gap providing swelling or shrinking is considered in the design…
**Type IV Construction – Roofs**

**602.4.7 Roofs.** Roofs shall be without concealed spaces and wood roof decks shall be sawn or glued laminated...or of cross laminated timber...Cross laminated timber roofs shall be not less than 3 inch nominal in thickness and shall be continuous from support to support and mechanically fastened to one another.

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**Type IV Construction – Walls & Partitions**

**602.4.8.1 Interior walls and partitions.** Interior walls and partitions shall be of solid wood construction formed by not less than two layers of 1-inch (25 mm) matched boards or laminated construction 4 inches (102 mm) thick, or of 1-hour fire-resistance-rated construction.

**602.4.8.2 Exterior walls.** All exterior walls shall be of one of the following:
1. Noncombustible materials; or
2. Not less than 6 inches in thickness and constructed of one of the following:
   2.1 Fire retardant treated wood in accordance with 2303.2 and complying with 602.4.1 or
   2.2 Cross laminated timber complying with 602.4.2.
IBC Ch. 16 Structural Design

Addition

1603.1.8 Special loads. Special loads that are applicable to the design of the building, structure or portions thereof shall be indicated along with the specified section of this code that addresses the special loading condition.

1603.1.8.1 Photovoltaic panel systems. The dead load of rooftop-mounted photovoltaic panel systems, including rack support systems, shall be indicated on the construction documents.

Section 1604 General Design Requirements

<table>
<thead>
<tr>
<th>CONSTRUCTION</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor members</td>
<td>L/500</td>
<td></td>
<td>L/240</td>
</tr>
<tr>
<td>Exterior walls</td>
<td></td>
<td>L/240</td>
<td></td>
</tr>
<tr>
<td>With plaster or stucco finishes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With other brittle finishes</td>
<td></td>
<td>L/240</td>
<td></td>
</tr>
<tr>
<td>With flexible finishes</td>
<td></td>
<td>L/120</td>
<td></td>
</tr>
<tr>
<td>Interior partitions</td>
<td>L/360</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With plaster or stucco finishes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With other brittle finishes</td>
<td>L/240</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With flexible finishes</td>
<td>L/120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For buildings</td>
<td></td>
<td>L/180</td>
<td></td>
</tr>
<tr>
<td>Greenhouses</td>
<td></td>
<td></td>
<td>L/120</td>
</tr>
</tbody>
</table>

- a. 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 AWC NDS, the creep component of the long-term deflection shall be permitted to be estimated as the immediate dead load deflection resulting from 0.50. 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 0.50 shall not be used in combination with AWC NDS provisions for long-term loading.
- b. The above deflections do not ensure against ponding. Roofs that do not have sufficient slope or curbs to ensure adequate drainage shall be investigated for ponding. See Section 1611 for rain and ponding requirements and Section 1503.4 for roof drainage requirements.
- c. The wind load is permitted to be taken as 0.42 times the "component and cladding" load for the purpose of determining deflection limits herein. Where members support glass in accordance with Section 2003 using the deflection limit herein, the wind load shall be no less than 0.4 times the "component and cladding" load for the purpose of determining deflection.
IBC Ch. 2 Definitions

Modification

DIAPHRAGM. A horizontal or sloped system acting to transmit lateral forces to the vertical-resisting elements. When the term "diaphragm" is used, it shall include horizontal bracing systems.

[BS] DIAPHRAGM. A horizontal or sloped system acting to transmit lateral forces to vertical elements of the lateral force resisting system. When the term "diaphragm" is used, it shall include horizontal bracing systems.

Diaphragm, rigid. A diaphragm is rigid for the purpose of distribution of story shear and torsional moment when the lateral deformation of the diaphragm is less than or equal to two times the average story drift.

Diaphragm, unblocked. A diaphragm that has edge nailing at supporting members only. Blocking between supporting structural members at panel edges is not included. Diaphragm panels are field nailed to supporting members.

IBC Ch. 16 Structural Design

Section 1607 Live Loads

1607.12.5 Photovoltaic panel systems. Roof structures that provide support for photovoltaic panel systems shall be designed in accordance with Sections 1607.12.5.1 through 1607.12.5.4, as applicable.

1607.12.5.1 Roof live load. Roof surfaces to be covered by solar photovoltaic panels or modules shall be designed for the roof live load, \( L_r \), assuming that the photovoltaic panels or modules are not present. The roof photovoltaic live load in areas covered by solar photovoltaic panels or modules shall be in addition to the panel loading unless the area covered by each solar photovoltaic panel or module is inaccessible. Areas where the clear space between the panels and the rooftop is not more than 24 inches (610 mm) shall be considered inaccessible. Roof surfaces not covered by photovoltaic panels shall be designed for the roof live load.

1607.12.5.2 Photovoltaic panels or modules. The structure of a roof that supports solar photovoltaic panels or modules shall be designed to accommodate the full solar photovoltaic panels or modules and ballast dead load, including concentrated loads from support frames in combination with the loads from Section 1607.12.5.1 and other applicable loads. Where applicable, snow drift loads created by the photovoltaic panels or modules shall be included.
IBC Ch. 16 Structural Design

1613.5 Amendments to ASCE 7. The provisions of Section 1613.5 shall be permitted as an amendment to the relevant provisions of ASCE 7.

1613.5.1 Transfer of anchorage forces into diaphragm. Modify ASCE 7 Section 12.11.2.2.1 as follows:

12.11.2.2.1 Transfer of anchorage forces into diaphragm. Diaphragms shall be provided with continuous ties or struts between diaphragm chords to distribute these anchorage forces into the diaphragms. Diaphragm connections shall be positive, mechanical or welded. Added chords are permitted to be used to form subdiaphragms to transmit the anchorage forces to the main continuous cross-ties. The maximum length-to-width ratio of a wood, wood structural panel or untopped steel deck sheathed structural subdiaphragm that serves as part of the continuous tie system shall be 2.5 to 1. Connections and anchorages capable of resisting the prescribed forces shall be provided between the diaphragm and the attached components. Connections shall extend into the diaphragm a sufficient distance to develop the force transferred into the diaphragm.

IBC Ch. 17 Special Inspections and Tests

Section 1705 Required Special Inspections and Tests

1705.5 Wood construction. Special inspections of prefabricated wood structural elements and assemblies shall be in accordance with Section 1704.2.5. Special inspections of site-built assemblies shall be in accordance with this section.

1705.5.1 High-load diaphragms. High-load diaphragms designed in accordance with Section 2306.2 shall be installed with special inspections as indicated in Section 1704.2. The special inspector shall inspect the wood structural panel sheathing to ascertain whether it is of the grade and thickness shown on the approved construction documents. Additionally, the special inspector must verify the nominal size of framing members at adjoining panel edges, the nail or staple diameter and length, the number of fastener lines and that the spacing between fasteners in each line and at edge margins agrees with the approved construction documents.
**CROSS-LAMINATED TIMBER.** A prefabricated engineered wood product consisting of at least three layers of solid-sawn lumber or *structural composite lumber* where the adjacent layers are cross-oriented and bonded with structural adhesive to form a solid wood element.

**2303.1.4 Structural glued cross laminated timber.** Cross-laminated timbers shall be manufactured and identified as required in ANSI/APA PRG 320-2011.

**Ch. 35 Reference Standards**

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**Section 2301 General**

**2301.2 General design requirements.** The design of structural elements or systems, constructed partially or wholly of wood or wood-based products, shall be in accordance with one of the following methods:

1., 2.....

3. *Conventional light-frame construction* in accordance with Sections 2304 and 2308.

**Exception:** Buildings designed in accordance with the provisions of the AF&PA WFCM shall be deemed to meet the requirements of the provisions of Section 2308.

4. AWC WFCM in accordance with Section 2309.
SECTION 2309
WOOD FRAME CONSTRUCTION MANUAL
2309.1 Wood Frame Construction Manual. Structural design in accordance with the AWC WFCM shall be permitted for buildings assigned to Risk Category I or II subject to the limitations of Section 1.1.3 of the AWC WFCM and the load assumptions contained therein. Structural elements beyond these limitations shall be designed in accordance with accepted engineering practice.

IBC Ch. 2 Definitions & Ch. 23 Wood

[BS] ENGINEERED WOOD RIM BOARD. A full-depth structural composite lumber, wood structural panel, structural glued laminated timber or prefabricated wood I-joint member designed to transfer horizontal (shear) and vertical (compression) loads, provide attachment for diaphragm sheathing, siding and exterior deck ledgers, and provide lateral support at the ends of floor or roof joists or rafters.

Section 2303 Minimum Standards and Quality
2303.1.13 Engineered wood rim board. Engineered wood rim boards shall conform to ANSI/APA PRR 410 or shall be evaluated in accordance with ASTM D 7672. Structural capacities shall be in accordance with ANSI/APA PRR 410 or established in accordance with ASTM D 7672. Rim boards conforming to ANSI/APA PRR 410 shall be marked in accordance with that standard.

Chapter 35 References
ASTM. ASTM D 7672-2011e1 Standard Specifications for Evaluating Structural Capacities of Rim Board Products and Assemblies.
GABLE. The triangular portion of a wall beneath the end of a dual-slope, pitched, or mono-slope roof or portion thereof and above the top plates of the story or level of the ceiling below.

Section 2304 General Construction Requirements

2304.6 Exterior wall sheathing. Wall sheathing on the outside of exterior walls, including gables, and the connection of the sheathing to framing shall be designed in accordance with the general provisions of this code and shall be capable of resisting wind pressures in accordance with Section 1609.

2304.6.1 Wood structural panel sheathing. Where wood structural panel sheathing is used as the exposed finish on the outside of exterior walls, it shall have an exterior exposure durability classification. Where wood structural panel sheathing is used elsewhere, but not as the exposed finish, it shall be of a type manufactured with exterior glue (Exposure 1 or Exterior). Wood structural panel sheathing, connections and framing spacing shall be in accordance with Table 2304.6.1 for the applicable wind speed and exposure category where used in enclosed buildings with a mean roof height not greater than 30 feet (9144 mm) and a topographic factor ($K_t$) of 1.0.

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2304.10.6 Load path. Where wall framing members are not continuous from the foundation sill to the roof, the members shall be secured to ensure a continuous load path. Where required, sheet metal clamps, ties or clips shall be formed of galvanized steel or other approved corrosion-resistant material not less than 0.0329-inch (0.836 mm) base metal thickness.
Outline

• Overview
• IBC
• **NDS**
  • Chapter-by-chapter discussion
  • Changes from previous editions
• SDPWS
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  • Changes from previous editions
• Summary
• More Info

2015 NDS – Primary Change

New Provisions to Address CLT

• Charging Language
• Design Values
• Design Equations
• Product Chapter
• Connection Design
• Fire Design
### 2015 NDS Chapter Reorganization

<table>
<thead>
<tr>
<th>2012 NDS</th>
<th>2015 NDS</th>
<th>2015 NDS</th>
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<tbody>
<tr>
<td>• 1-3 General</td>
<td>• 1-3 General</td>
<td>• 4-10 Products +CLT</td>
</tr>
<tr>
<td>• 4-9 Products</td>
<td>• 4-9 Products</td>
<td>• 11-14 Connections</td>
</tr>
<tr>
<td>• 10-13 Connections</td>
<td>• 10-13 Connections</td>
<td>• Shear Walls &amp; Diaphragms</td>
</tr>
<tr>
<td>• 14 Shear Walls &amp; Diaphragms</td>
<td>• 14 Shear Walls &amp; Diaphragms</td>
<td>• 15 Special Loading</td>
</tr>
<tr>
<td>• 15 Special Loading</td>
<td>• 15 Special Loading</td>
<td>• 16 Fire</td>
</tr>
<tr>
<td>• 16 Fire</td>
<td>• 16 Fire</td>
<td></td>
</tr>
</tbody>
</table>

### NDS 2015 Supplement

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
NDS 2015 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 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

NDS – Chapter 1

GENERAL REQUIREMENTS FOR STRUCTURAL DESIGN

1. Scope
2. General Requirements
3. Structural Analysis
4. Design Procedures
5. Specifications and Data
6. References

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Chapter 1 – Design Loads

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

Chapter 1 – CLT Charging Language

1.1 Scope

1.1.1 Practice Defined

1.1.1.1 This Specification defines the methods to be followed in structural design with the following wood products:
- visually graded lumber
- mechanically graded lumber
- structural glued laminated timber
- timber poles
- timber piles
- prefabricated wood I-joists
- structural composite lumber
- wood structural panels
- cross-laminated timber

This defines the practices to be followed in the design and fabrication of single and multiple fastener connections using the fasteners described herein.

1.1.1.2 Structural assemblies utilizing panel products shall be designed in accordance with the specified design values, design strengths, and structural member sizes listed in the NDS.

1.1.1.3 Structural assemblies utilizing metal connector plates shall be designed in accordance with accepted engineering practice (see Reference 9).

1.1.1.4 Shear walls and diaphragms shall be designed in accordance with the Special Design Provision for Wind and Seismic (see Reference 56).

1.1.1.5 This Specification is not intended to preclude the use of materials, assemblies, structures or designs not meeting the criteria herein, where it is demonstrated through analysis based on recognized theory, full-scale or prototype loading tests, studies of load systems or extensive experience in use that the assembly, structure or design will perform in its intended end use.

1.1.2 Competent Supervision

The reference design values, design strengths, and structural member sizes listed in the NDS shall be used only as a guide when the designer is competent and able to provide for the safety and soundness of the final design.
Chapter 2 – CLT Design Values

2.2 Reference Design Values

Reference design values and design value adjustments for wood products in 1.1.1.1 are based on methods specified in each of the wood product chapters. Chapters 4 through 16 contain design provisions for sawn lumber, glued laminated timber, poles and piles, prefabricated wood I-beams, structural composite lumber, wood structural panels, and cross-laminated timber, respectively. Chapters 11 through 14 contain design provisions for connections. Reference design values are for normal load duration under the moisture service conditions specified.

2.3 Adjustment of Reference Design Values

2.3.1 Applicability of Adjustment Factors

Reference design values shall be multiplied by all applicable adjustment factors to determine adjusted design values. The applicability of adjustment factors to sawn lumber, structural glued laminated timber, poles and piles, prefabricated wood I-beams, structural composite lumber, wood structural panels, cross-laminated timber, and connection design values is defined in 4.1, 5.3, 6.3, 7.3, 8.3, 9.3, 10.3, and 11.3, respectively. The load duration factor, based on a deformation limit (see 4.2.6) shall be multiplied by the appropriate load duration factor, C, from Table 2.3.2 or Figure B1 (see Appendix B) to account for the change in strength of wood with load duration.

2.3.2 The load duration factor, C, for a load duration load in a combination of loads is the minimum of all load duration factors for each load combination. All applicable load duration factors shall be multiplied to determine the load duration factor.
3.5 Bending Members – Deflection

3.5.1 Deflection Calculations

If deflection is a factor in design, it shall be calculated by standard methods of engineering mechanics considering bending deflections and, when applicable, shear deflections. Consideration for shear deflection is required when the reference modulus of elasticity has not been adjusted to include the effects of shear deflection (see Appendix F).

3.5.2 Long-Term Loading

Where total deflection under long-term loading, stressing member size is one way to provide extra stiffness to allow for this time dependent deformation (see Appendix F). Total deflection, \( \Delta_t \), shall be calculated as follows:

\[
\Delta_t = K_e \Delta_t + \Delta_t^{*}
\]

where:

- \( K_e \) = time dependent deformation (creep) factor
  - 1.5 for seasoned lumber, structural glued laminated timber, prefabricated wood I-joists, or structural composite lumber used in dry service conditions as defined in 4.1.4, 5.1.4, 7.1.4, and 8.1.4, respectively
  - 2.0 for cross-laminated timber used in dry service conditions as defined in 10.1.5
Chapter 3 – CLT Design Equations

3.7.1.5 The column stability factor shall be calculated as follows:

\[ C_p = \frac{1 + \left( \frac{F_{u,c}}{F_{c}} \right)}{2c} \sqrt{1 + \left( \frac{F_{u,c}}{F_{c}} \right)^2} - \frac{F_{d,c}}{F_{c,c}} \]  

(3.7-1)

where:

- \( F_{u,c} \) = reference compression design value parallel to grain multiplied by all applicable adjustment factors except \( C_0 \) (see 2.3), psi
- \( F_{d,c} = 0.8222 \frac{E_{mod}}{C_0} \) (psi)
- \( C_0 = 0.8 \) for sawn lumber
- \( C_0 = 0.9 \) for structural glued laminated timber, structural composite lumber, and cross-laminated timber

New

NDS Commentary – guidance on \( C_p \)

---

NDS – Chapter 8

---

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Chapter 8 – Structural Composite Lumber

• Design Values
• Evaluation Reports
  • Contain proprietary design

Material Property Values

Chapter 8 – Structural Composite Lumber

• New products
  • Laminated Strand Lumber (LSL)
  • Oriented Strand Lumber (OSL)
  • ASTM D5456
What is Cross Laminated Timber (CLT)?

Photos provided by FPInnovations
Chapter 10 – Cross-Laminated Timber

10.1 General

10.1.1 Application

Chapter 10 applies to engineering design with performance-rated cross-laminated timber.

10.1.2 Definition

Cross-Laminated Timber (CLT) – a prefabricated engineered wood product consisting of at least three layers of solid-sawn lumber or structural composite lumber where the adjacent layers are cross-oriented and bonded with structural adhesive to form a solid wood element.

10.1.3 Standard Dimensions

10.1.3.1 The net thickness of a lamination for all layers at the time of gluing shall not be less than 5/8 inch or more than 2 inches.

10.1.3.2 The thickness of cross-laminated timber shall not exceed 20 inches.

10.1.4 Specification

All required reference design values shall be obtained from the cross-laminated timber manufacturer’s literature or code evaluation report.

10.1.5 Service

Refer to servicing information, where applicable.

10.2 Reference Design Values

10.2.1 Reference Design Values

Reference design values for cross-laminated timber shall be obtained from the cross-laminated timber manufacturer’s literature or code evaluation report.

10.2.2 Design Section Properties

Reference design values shall be used with design section properties provided by the cross-laminated timber manufacturer based on the actual layout used in the manufacturing process.

10.3 Adjustment of Reference Design Values

10.3.1 General

Reference design values: $F_{d}(S_{d})$, $F_{d}(A_{w})$, $F_{d}(A)$, $F_{d}(W_{d})$, $F_{d}(I_{w})$, $F_{d}(I_{d})$, $F_{d}(Q_{d})$, $F_{d}(A_{w})$, $F_{d}(A)$, $F_{d}(W_{d})$, $F_{d}(I_{w})$, $F_{d}(I_{d})$, $F_{d}(Q_{d})$ provided in 10.2 shall be multiplied by the adjustment factors specified in Table 10.3.1 to determine adjusted design values: $F_{d}(S_{d})$, $F_{d}(A_{w})$, $F_{d}(A)$, $F_{d}(W_{d})$, $F_{d}(I_{w})$, $F_{d}(I_{d})$, $F_{d}(Q_{d})$, $F_{d}(A_{w})$, $F_{d}(A)$, $F_{d}(W_{d})$, $F_{d}(I_{w})$, $F_{d}(I_{d})$, $F_{d}(Q_{d})$.

10.3.2 Load Duration Factor, $C_{L}$(ASD only)

All reference design values except stiffness, $E_{w}I_{w}$, $E_{d}I_{d}$, rolling shear, $F_{d}(I_{w})$, and compression perpendicular to grain, $F_{d}(A)$, shall be multiplied by load duration factors, $C_{L}$, as specified in 2.3.2.
### Chapter 10 – Cross-Laminated Timber

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

<table>
<thead>
<tr>
<th>Factor</th>
<th>ASD only</th>
<th>ASD and LRFD</th>
<th>LRFD only</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLT</td>
<td>Load Demand Factor</td>
<td>Wind Load Factor</td>
<td>Temperature Factor</td>
</tr>
<tr>
<td>$F_d(S_{aw}) = F_d(S_{aw})$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_t$</td>
</tr>
<tr>
<td>$F_d(A_{wau}) = F_d(A_{wau})$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_t$</td>
</tr>
<tr>
<td>$F_d(T) = F_d(T)$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_t$</td>
</tr>
<tr>
<td>$F_d(B+Q_{ref}) = F_d(B+Q_{ref})$</td>
<td>$-$</td>
<td>$C_M$</td>
<td>$C_t$</td>
</tr>
<tr>
<td>$F_d(A_{wau}) = F_d(A_{wau})$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_t$</td>
</tr>
<tr>
<td>$F_d(A) = F_d(A)$</td>
<td>$-$</td>
<td>$C_M$</td>
<td>$C_t$</td>
</tr>
<tr>
<td>$(EI)<em>{wau}/(EI)</em>{wau}$</td>
<td>$-$</td>
<td>$C_M$</td>
<td>$C_t$</td>
</tr>
<tr>
<td>$(EI)<em>{wau}/(EI)</em>{wau}$</td>
<td>$-$</td>
<td>$C_M$</td>
<td>$C_t$</td>
</tr>
</tbody>
</table>

---

#### CLT Manufacturing Standard

### TABLE 1

<table>
<thead>
<tr>
<th>CLT Grades</th>
<th>$f_{cm}$ (psi)</th>
<th>$E_i$ (10^6 psi)</th>
<th>$f_{cm}$ (psi)</th>
<th>$f_{cm}$ (psi)</th>
<th>$f_{cm}$ (psi)</th>
<th>$f_{cm}$ (psi)</th>
<th>$f_{cm}$ (psi)</th>
<th>$f_{cm}$ (psi)</th>
<th>$f_{cm}$ (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>4,095</td>
<td>1.7</td>
<td>2,885</td>
<td>3,420</td>
<td>425</td>
<td>140</td>
<td>1,050</td>
<td>1.2</td>
<td>425</td>
</tr>
<tr>
<td>E2</td>
<td>3,465</td>
<td>1.5</td>
<td>2,140</td>
<td>3,220</td>
<td>565</td>
<td>190</td>
<td>1,100</td>
<td>1.4</td>
<td>565</td>
</tr>
<tr>
<td>E3</td>
<td>2,520</td>
<td>1.2</td>
<td>1,260</td>
<td>2,660</td>
<td>345</td>
<td>115</td>
<td>735</td>
<td>0.9</td>
<td>345</td>
</tr>
<tr>
<td>E4</td>
<td>4,095</td>
<td>1.7</td>
<td>2,885</td>
<td>3,420</td>
<td>550</td>
<td>180</td>
<td>1,205</td>
<td>1.4</td>
<td>550</td>
</tr>
<tr>
<td>V1</td>
<td>1,890</td>
<td>1.6</td>
<td>1,250</td>
<td>2,555</td>
<td>565</td>
<td>190</td>
<td>1,100</td>
<td>1.4</td>
<td>565</td>
</tr>
<tr>
<td>V2</td>
<td>1,825</td>
<td>1.4</td>
<td>945</td>
<td>2,185</td>
<td>425</td>
<td>140</td>
<td>1,050</td>
<td>1.2</td>
<td>425</td>
</tr>
<tr>
<td>V3</td>
<td>2,045</td>
<td>1.6</td>
<td>1,155</td>
<td>2,755</td>
<td>550</td>
<td>180</td>
<td>1,205</td>
<td>1.4</td>
<td>550</td>
</tr>
</tbody>
</table>
TABLE A1
ALLOWABLE DESIGN PROPERTIES\footnote{a,b,c,d} FOR PRG 320 CLT (FOR USE IN THE U.S.)

<table>
<thead>
<tr>
<th>CLT Grade</th>
<th>$F_{ult}$ (psi)</th>
<th>$F_{u}$ (ksi)</th>
<th>$F_{cr}$ (ksi)</th>
<th>$F_{ct}$ (ksi)</th>
<th>$F_{as}$ (ksi)</th>
<th>$F_{at}$ (ksi)</th>
<th>$F_{ast}$ (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>1,950</td>
<td>1.7</td>
<td>1,375</td>
<td>1,800</td>
<td>135</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>E2</td>
<td>1,650</td>
<td>1.5</td>
<td>1,020</td>
<td>1,700</td>
<td>180</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>E3</td>
<td>1,200</td>
<td>1.2</td>
<td>600</td>
<td>1,400</td>
<td>110</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>E4</td>
<td>1,950</td>
<td>1.7</td>
<td>1,375</td>
<td>1,800</td>
<td>175</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Y1</td>
<td>900</td>
<td>1.6</td>
<td>575</td>
<td>1,250</td>
<td>180</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Y2</td>
<td>875</td>
<td>1.4</td>
<td>450</td>
<td>1,150</td>
<td>135</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>V2</td>
<td>975</td>
<td>1.6</td>
<td>550</td>
<td>1,450</td>
<td>175</td>
<td>55</td>
<td></td>
</tr>
</tbody>
</table>

For $b$: 1 psi = 0.006895 MPa

(a) See Section 4 for symbols.
(b) Tabelized values are allowable design values and not permitted to be increased by the lumber size adjustment factor in accordance with the NDS. The design values shall be used in conjunction with the section properties provided by the CLT manufacturer
(c) Custom CLT grades that are not listed in this table shall be permitted in accordance with Section 7.7.1

CLT Manufacturing Standard

CLT layups:

- E1: 1900F-1.7E Spruce-pine-fir MSR lumber in all parallel layers and No. 3 Spruce-pine-fir lumber in all perpendicular layers
- E2: 1650F-1.5E Douglas fir-Larch MSR lumber in all parallel layers and No. 3 Douglas fir-Larch lumber in all perpendicular layers
- E3: 1200F-1.2E Eastern Softwoods, Northern Species, or Western Woods MSR lumber in all parallel layers and No. 3 Eastern Softwoods, Northern Species, or Western Woods lumber in all perpendicular layers
- E4: 1900F-1.7E Southern pine MSR lumber in all parallel layers and No. 3 Southern pine lumber in all perpendicular layers
- V1: No. 2 Douglas fir-Larch lumber in all parallel layers and No. 3 Douglas fir-Larch lumber in all perpendicular layers
- V2: No. 1 No. 2 Spruce-pine-fir lumber in all parallel layers and No. 3 Spruce-pine-fir lumber in all perpendicular layers
- V3: No. 2 Southern pine lumber in all parallel layers and No. 3 Southern pine lumber in all perpendicular layers
Bending Members

No standardized design properties for in-plane loading
- contact the manufacturer
Chapter 12 – Dowel-type Fasteners

12.3.5 Dowel Bearing Length

12.3.5.1 Dowel bearing length in the side member(s) and main member, $l_1$ and $l_m$, shall be determined based on the length of dowel bearing perpendicular to the application of load.

12.3.5.2 For cross-laminated timber where the direction of loading relative to the grain orientation at the shear plane is parallel to grain, the dowel bearing length in the perpendicular plies shall be reduced by multiplying the bearing length of those plies by the ratio of dowel bearing strength perpendicular to grain to dowel bearing strength parallel to grain ($F_{li} / F_{l1}$).
Chapter 12 – Dowel-type Fasteners

- Adjust \( \ell_m \) or \( \ell_s \) to compensate for orthogonal grain orientations in adjacent layers
- Parallel to grain: \( F_{e\|}/F_{e\perp} \)
  
  Example: \( \frac{1}{2}" \) bolt in southern pine 3-ply CLT with 1-\( \frac{1}{2}" \) laminations

\[
\ell_m = t_{1\|} + t_{2\perp} + t_{3\|} = 3(1.5) = 4.5"
\]

\[
\ell_{m\text{-adj}} = t_{1\|} + t_{2\perp}(F_{e\perp}/F_{e\|}) + t_{3\|} \\
= 1.5 + 1.5(3650/6150) + 1.5 = 3.9"
\]

### Table 12.3.3 Dowel Bearing Strengths, \( F_d \), for Dowel-Type Fasteners in Wood Members

<table>
<thead>
<tr>
<th>Specific Gravity, ( G )</th>
<th>Dowel bearing strength in pounds per square inch (psf)</th>
<th>( F_d )</th>
<th>D=1/4&quot;</th>
<th>D=3/8&quot;</th>
<th>D=1/2&quot;</th>
<th>D=5/8&quot;</th>
<th>D=7/16&quot;</th>
<th>D=11/32&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.55</td>
<td>5550 6150</td>
<td>5100 4600</td>
<td>4200</td>
<td>3900</td>
<td>3500</td>
<td>3250</td>
<td>2950</td>
<td>2750</td>
</tr>
<tr>
<td>0.54</td>
<td>6350 6950</td>
<td>5900 5400</td>
<td>4900</td>
<td>4600</td>
<td>4200</td>
<td>3850</td>
<td>3550</td>
<td>3350</td>
</tr>
<tr>
<td>0.53</td>
<td>6150 6750</td>
<td>5700 5200</td>
<td>4700</td>
<td>4400</td>
<td>4000</td>
<td>3650</td>
<td>3350</td>
<td>3150</td>
</tr>
</tbody>
</table>

**NDS – Chapter 16**
Chapter 16 – Fire (ASD)

- Fire resistance up to **two hours**
  - Columns
  - Beams
  - Tension Members
  - ASD only

- Products
  - Lumber
  - Glulam
  - SCL
  - Decking
  - CLT - NEW

---

**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 calculation. 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 ACI 216.1/DMS 6216. The calculated fire resistance of steel assemblies shall be permitted in accordance with Chapter 9 of ASCE 10. The calculated fire resistance of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AF&PA National Design Specification for Wood Construction (NDS).

---

Chapter 16 – Calculated Resistance

- Fire resistance of exposed wood members may be calculated using the provisions of NDS Chapter 16

---
Fire Design of Exposed Wood Members

Cross-laminated Timber-Effective Char Depth

\[
a_{char} = 1.2 \left[ n_{lam} h_{lam} + \beta_n \left( t - \left( n_{lam} t_{gi} \right) \right)^{0.813} \right]
\]

\[
t_{gi} = \left( \frac{h_{lam}}{\beta_n} \right)^{1.23}
\]

- \( t_{gi} \) = time for char front to reach glued interface (hr.)
- \( h_{lam} \) = lamination thickness (in.)
- \( n_{lam} \) = \( \frac{t}{t_{gi}} \)
- \( n_{lam} \) = number of laminations charred (rounded to lowest integer)
- \( t \) = exposure time (hr.)

Fire Design of Exposed Wood Members

CLT manufactured with laminations of equal thickness

<table>
<thead>
<tr>
<th>Required Fire Endurance (hr.)</th>
<th>Effective Char Depths, ( a_{char} ) (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lamination thicknesses, ( h_{lam} ) (in.)</td>
</tr>
<tr>
<td>5/8</td>
<td>3/4</td>
</tr>
<tr>
<td>1-Hour</td>
<td>2.2</td>
</tr>
<tr>
<td>1-1/2-Hour</td>
<td>3.4</td>
</tr>
<tr>
<td>2-Hour</td>
<td>4.4</td>
</tr>
</tbody>
</table>
GLT and CLT Adhesives

CLT- ANSI/APA PRG 320-2011 references ANSI/AITC 405-2008
GLT- ANSI/AITC 405-2008 – references D7247

GLT and CLT Adhesives

CLT-ANSI/APA PRG 320-2012 references ANSI/APA 405-2008
GLT - ANSI/APA 405-2008 – references D7247
Chapter 16 – Fire (ASD)

Technical Report No. 10
- Background on NDS provisions
- Design examples
- New CLT background/examples

Code Updates -
Design of Fire-Resistive Exposed Wood Members

http://www.awc.org/publications/download.php
2015 NDS Supplement

- New Southern Pine Design Values
  - ALSC approves design values
    - June 1, 2013
    - AWC compiles them
    - NDS Supplement
  - More information
    - www.spib.org
    - www.southernpine.com

Outline

- Overview
- IBC
- NDS
  - Chapter-by-chapter discussion
  - Changes from previous editions
- SDPWS
  - Chapter-by-chapter discussion
  - Changes from previous editions SDPWS
- Summary
- More Info
Code Acceptance of Standard

- 2012 IBC
  - References 2008 SDPWS in Section 2305 for lateral design and construction
- 2015 IBC
  - References 2015 SDPWS in Section 2305 for lateral design and construction

General Overview

Outline

- Chapter 1: Flowchart
- Chapter 2: General Design Requirements
- Chapter 3: Members and Connections
- Chapter 4: Lateral Force Resisting Systems
Chapter 2 – General Requirements

- General
- Terminology
- Notation

2.1 General

2.1.1 Scope

The provisions of this document cover materials, design and construction of wood members, Notation

2.1.2 Design Methods

Engineered design of wood structures to resist wind and seismic forces shall be by one of the methods described in 3.1.21.01 and 3.1.22.

Example: Wood structures shall be permitted to be constructed in accordance with prescriptive provisions permitted by the authority having jurisdiction.

2.1.3 Allowable Stress Design: Allowable-stress design (ASD) shall be in accordance with the National Design Specification (NDS) for Wood Con-

structure (AMERICAN NDS) and provisions of this document.

2.2.2 Load and Resistance Factor Design (LRFD) of wood structures shall be in accordance with the National Design Specification (NDS) for Wood Con-

struction (AMERICAN NDS) and provisions of this document.

2.2.3 Bipes

Wood products shall be ranked in terms of standard quality, evaluated using or special grades. For wood preser-

ted products referred to elsewhere with PS 1 or PS 2, use of the term “preserved wood product” includes insulated siding to the “Performance Category” value for these products.
Chapter 2 – General Requirements

• Terminology

Definitions

OPEN FRONT STRUCTURE. A structure in which any diaphragm edge cantilevers beyond vertical elements of the lateral force-resisting system.

NEW

SUBDIAPHRAGM. A portion of a diaphragm used to transfer wall anchorage forces to diaphragm cross ties.

• Flexible and Rigid Diaphragm removed

Chapter 3 - Members and Connections

MEMBERS AND CONNECTIONS

3.1 Framing 8
3.2 Sheathing 8
3.3 Connections 10
Chapter 3 - Members and Connections

- Framing
- Sheathing
- Connections

- Covers out-of-plane wind load resistance of shear walls and diaphragms

Chapter 3 - Members and Connections

- Framing – walls
  - Accounts for composite action
  - Strength and Stiffness
  - Applies now to EI
  - Up to 24” oc

<table>
<thead>
<tr>
<th>Table 3.1.1.1</th>
<th>Wall Stud Repetitive Member Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stud Size</td>
<td>System Factor</td>
</tr>
<tr>
<td>2x4</td>
<td>1.50</td>
</tr>
<tr>
<td>2x6</td>
<td>1.35</td>
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<tr>
<td>2x8</td>
<td>1.25</td>
</tr>
<tr>
<td>2x10</td>
<td>1.20</td>
</tr>
<tr>
<td>2x12</td>
<td>1.15</td>
</tr>
</tbody>
</table>

Extension of 1.15 repetitive member factor, $C_r$
# Chapter 3 - Members and Connections

## Sheathing capacities - walls

### Table 3.2.1 Nominal Uniform Load Capacities (psf) for Wall Sheathing Resisting Out-of-Plane Wind Loads

<table>
<thead>
<tr>
<th>Sheathing Type</th>
<th>Span Rating or Grade</th>
<th>Minimum Thickness (in)</th>
<th>Strength Avg² Applied</th>
<th>Perpendicular to Supports</th>
<th>Parallel to Supports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Minimum Actual Spacing (in)</td>
<td>Maximum Actual Spacing (in)</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td>12 16 24 32 40</td>
<td>12 16 24 32 40</td>
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<td></td>
<td></td>
<td>Nominal Uniform Loads (psf)</td>
<td>Actual Uniform Loads (psf)</td>
</tr>
<tr>
<td>Wood Structural Panel</td>
<td>Sheathing Grades, C-C, C-D, C-C Plugged, C-C Plugged</td>
<td>24/16</td>
<td>3/16</td>
<td>24</td>
<td>0.16</td>
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<tr>
<td>Wood Structural Panel</td>
<td>Sheathing Grades, C-C, C-D, C-C Plugged, C-C Plugged</td>
<td>32/16</td>
<td>1/8</td>
<td>24</td>
<td>0.19</td>
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<td>48/20</td>
<td>1/8</td>
<td>24</td>
<td>0.24</td>
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<td>Revised</td>
<td></td>
</tr>
<tr>
<td>Plywood Spanning Sheathing</td>
<td>(with/without glue)</td>
<td>5/8</td>
<td>1/8</td>
<td>16</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Revised</td>
<td></td>
</tr>
<tr>
<td>Hardboard Sheathing</td>
<td>(directly glued)</td>
<td>5/8</td>
<td>1/8</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Revised</td>
<td></td>
</tr>
<tr>
<td>Cellulose Fiberboard</td>
<td>Sheathing</td>
<td>5/8</td>
<td>1/8</td>
<td>16</td>
<td>-</td>
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## Sheathing capacities – roof

### Table 3.2.2 Nominal Uniform Load Capacities (psf) for Roof Sheathing Resisting Out-of-Plane Wind Loads

<table>
<thead>
<tr>
<th>Sheathing Type</th>
<th>Span Rating or Grade</th>
<th>Minimum Thickness (in)</th>
<th>Strength Avg² Applied</th>
<th>Perpendicular to Supports</th>
<th>Parallel to Supports</th>
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<td>Maximum Actual Spacing (in)</td>
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<td>12 16 24 32 40</td>
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<td>Sheathing Grades, C-C, C-D, C-C Plugged, C-C Plugged</td>
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<td>3/16</td>
<td>24</td>
<td>0.16</td>
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<td></td>
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<td>Revised</td>
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<td>1/8</td>
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<td>Revised</td>
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<tr>
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<td>0.24</td>
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<td>Revised</td>
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</tr>
<tr>
<td>Plywood Spanning Sheathing</td>
<td>(with/without glue)</td>
<td>5/8</td>
<td>1/8</td>
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<td></td>
<td></td>
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<td></td>
<td>Revised</td>
<td></td>
</tr>
<tr>
<td>Hardboard Sheathing</td>
<td>(directly glued)</td>
<td>5/8</td>
<td>1/8</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cellulose Fiberboard</td>
<td>Sheathing</td>
<td>5/8</td>
<td>1/8</td>
<td>16</td>
<td>-</td>
</tr>
</tbody>
</table>

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Chapter 3 - Members and Connections

3.4 Uplift Force Resisting Systems

3.4.1. General

The proportioning, design, and detailing of engineered wood systems, members, and connections resisting wind uplift shall be in accordance with the reference documents in 2.3.2 and all provisions of 3.4.2. The uplift load path, or paths, shall be provided to transfer all forces from the point of application to the final point of resistance.

3.4.2 Design Requirements

Uplift force resisting systems shall comply with the following:

1. Metal connectors, continuous tie rods, or other similar connection devices used in the uplift load path shall be of adequate strength and stiffness to transfer induced forces to supporting elements.
2. The design strength and stiffness of wood members and connections used in combination with metal connectors, continuous tie rods, or other similar connection devices shall be determined in accordance with 3.3.
3. Where wind uplift load path connections are not aligned from point of load application to point of resistance, additional forces and deflections resulting from such eccentricities shall be accounted for in the design of supporting load path elements.

Exception: Walls sheathed with wood structural panel sheathing or siding that are designed to resist uplift from wind, or combined shear and uplift from wind shall be in accordance with 4.4.

Chapter 3 - Members and Connections

3.4 Uplift Force Resisting Systems
Chapter 4 - Lateral Force-Resisting Systems

- General
- Wood Diaphragms
- Wood Shear Walls

Covers \textit{in-plane} wind and seismic load resistance of shear walls and diaphragms
Chapter 4 - Lateral Force-Resisting Systems

Chapter 4 – Anchorage of Concrete or Masonry Walls

4.1.5.1 Anchorage of Concrete or Masonry Structural Walls to Diaphragm

- SDC C, D, E, or F

New

4.1.5.1 Anchorage of Concrete or Masonry Structural Walls to Diaphragm: In Seismic Design Categories C, D, E, or F, diaphragms shall be provided with continuous ties or struts between diaphragm chords to distribute concrete or masonry structural wall anchorage forces in accordance with Section 12.11.2 of ASCE 7 into the diaphragm. Subdiaphragms shall be permitted to be used to transmit the anchorage forces to the main continuous cross-ties. The maximum length-to-width ratio of the structural subdiaphragm shall be 2.5:1. Connections and anchorages capable of resisting the prescriptive forces shall be provided between the diaphragm and the attached components.

4.1.5.1.1 Anchorage shall not be accomplished by use of nails subject to withdrawal or toe-nails nor shall wood ledgers or framing be used in cross-grain bending or cross-grain tension.

4.1.5.1.2 The diaphragm sheathing shall not be considered effective as providing the ties or struts required by this section.
Chapter 4 – Anchorage of Concrete or Masonry Walls

Irregularity

Reentrant Corner

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12.3.3.4 Increase in Forces Due to Irregularities for Seismic Design Categories D through F

For structures assigned to Seismic Design Category D, E, or F and having a horizontal structural irregularity of Type 1a, 1b, 2, 3, or 4 in Table 12.3-1 or a vertical structural irregularity of Type 4 in Table 12.3-2, the design forces determined from Section 12.10.1.1 shall be increased 25 percent for the following elements of the seismic force-resisting system:

1. Connections of diaphragms to vertical elements and to collectors.
2. Collectors and their connections, including connections to vertical elements, of the seismic force-resisting system.

**EXCEPTION:**
Forces calculated using the seismic load effects including overstrength factor of Section 12.4.3 need not be increased.

\[ E_{mh} = \Omega_o Q_E \]

Collector forces likely comply with exception per A SCE Sec. 12.10.2.1
Chapter 4 - Lateral Force-Resisting Systems

• Wood Diaphragms

Anchor bolting of ledger: Design for 25% more shear

Chapter 4 - Lateral Force-Resisting Systems

• Wood Diaphragms

Collector beam

Boundary nail (B.N.) diaphragm NOT subject to 25% increase
Irregularity

Chapter 4 – Horizontal Distribution

4.2.5 Horizontal Distribution of Shear

- Idealized as Flexible
  - ASCE 12.3.1.1, or
  - $\Delta_{\text{DIAPHRAGM}} > 2 \times \Delta_{\text{SHEARWALLS}}$
  - tributary area
- Idealized as Rigid
  - ASCE 12.3.1.2, or
  - $\Delta_{\text{DIAPHRAGM}} \leq 2 \times \Delta_{\text{SHEARWALLS}}$
  - relative lateral stiffness of vertical LFRS
- Semi-rigid – complex analysis or “envelope” (NEW)
Chapter 4 - Lateral Force-Resisting Systems

4.2.5.1 Torsional Irregularity

• Torsional Irregular
  • Story Drift $\Delta_{A_{\text{max}}} > 1.2 \Delta_{A \& B \text{ Average}}$

\[ \Delta_{A_{\text{max}}} = \frac{\Delta_{A} + \Delta_{B}}{2} \]

\[ \alpha = \frac{\Delta_{A_{\text{max}}}}{1.2 \Delta_{A \& B}} \]

FIGURE 4.2.5-1 Torsional Amplification Factor, $\alpha$

Chapter 4 - Lateral Force-Resisting Systems

Revised

4.2.5.1 Torsional Irregularity

• SDC A - Exempt
• Rigid or Semi-rigid
• Conform to Diaphragm Assemblies 4.2.7.1, 4.2.7.2 or 4.2.7.3
• WSP diaphragms L/W < 1.5:1
• Diagonal Lumber (single or double layer) L/W < 1:1
• $\Delta_{A_{\text{max}}} < ASCE 7$ allowable story drift
4.2.5.2 Open Front Structures

- Conform to Diaphragm Assemblies 4.2.7.1, 4.2.7.2 or 4.2.7.3
- Not Torsionally Irregular
  - WSP diaphragms $L'/W' < 1.5:1$
  - Diagonal Lumber (single or double layer) $L'/W' < 1:1$
- Torsionally Irregular
  - $> 1$-story $L'/W' < 0.67:1$
  - $1$-story $L'/W' < 1:1$
Chapter 4 – Open Front Structures

Revised

4.2.5.2 Open Front Structures

• Load parallel to opening - model as semi-rigid or rigid
  \[ \Delta_{A,\text{max}} < \text{ASCE 7 allowable story drift} \]

• \( L' < 35' \)

Exception: Cantilever \(< 6'\) beyond nearest vertical LFRS need not comply to 4.2.5.2.

Chapter 4 – Open Front Structures

Revised

4.2.5.2.1 Open Front Structures – 1 story

• \( L' < 25' \)
• \( L'/W' < 1:1 \)
• Idealized as rigid - distribution of torsional shear
High Load Diaphragms

• 4.2.7.1.2 rules for construction
• Need 3" or greater nominal members
• Requires Special Inspection

Chapter 4 – High Load Diaphragms

4.2.7.1.2 High Load Blocked Diaphragms

4. The depth of framing members and blocking into which the nail penetrates shall be 3" nominal or greater.

4.-5. The width of the nailed face of framing members and blocking at boundaries and adjoining panel edges shall be 3” nominal or greater. The width of the nailed face not located at boundaries or adjoining panel edges shall be 2” nominal or greater.
Chapter 4 - Lateral Force-Resisting Systems

Structural Fiberboard Shear Walls

NEW

4.3.2.3 Deflection of Structural Fiberboard Shear Walls: For a structural fiberboard shear wall with an aspect ratio \( h/b_1 \) greater than 1.0, the deflection obtained from equation 4.3-1 shall be multiplied by \( (h/b_1)^{1/2} \).
4.3.3.4 Shears Walls in a Line: same materials and construction

4.3.3.4.1 - Individual full height shear walls provide all same deflection, $\delta_{sw}$

Exception:
- WSP $h/b_s > 2:1 \quad v_s \times 2b_s/h$
- Fiberboard $h/b_s > 1:1 \quad v_s \times (0.1 + 0.9b_s/h)$
- Shear distribution proportional to capacities
- Shear capacity reduction not combined with aspect ratio adjustment (4.3.4.2)

### Table

<table>
<thead>
<tr>
<th>Aspect Ratio</th>
<th>2:1</th>
<th>3:1</th>
<th>3½:1</th>
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<td>Factor</td>
<td>1.00</td>
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<td>0.57</td>
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Chapter 4 - Lateral Force-Resisting Systems

Wood Shear Walls

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<tr>
<th>Shear Wall Sheathing Type</th>
<th>Maximum h/b_s Ratio</th>
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<tbody>
<tr>
<td>Wood structural panels, unblocked</td>
<td>2:1</td>
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<tr>
<td>Wood structural panels, blocked</td>
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<tr>
<td>Particleboard, blocked</td>
<td>2:1</td>
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<tr>
<td>Diagonal sheathing, conventional</td>
<td>2:1</td>
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<td>Gypsum wallboard</td>
<td>2:1</td>
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<tr>
<td>Portland cement plaster</td>
<td>2:1</td>
</tr>
<tr>
<td>Structural Fiberboard</td>
<td>3:5:1</td>
</tr>
</tbody>
</table>

- **WSP**

• \( v_s \times (1.25 - 0.125h/b_s) \)

- **Struct. Fiberboard**

• \( v_s \times (1.09 - 0.09h/b_s) \)

### Chapter 4 – Aspect Ratios & Capacity Adjustments

#### Revised

4.3.4.2 – Shear Wall Aspect Ratio Factors

- \( h/b_s > 2:1 \) WSP
  - \( v_s \times (1.25 - 0.125h/b_s) \)
  - \( h/b_s > 1:1 \) Struct. Fiberboard
  - \( v_s \times (1.09 - 0.09h/b_s) \)

<table>
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<tr>
<th>2:1 unless ( v_s = (1.25 - 0.125(h/b_s)) )</th>
<th>2:1</th>
<th>3:1</th>
<th>3½:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.875</td>
<td>0.813</td>
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</tbody>
</table>
Chapter 4 – Aspect Ratios & Capacity Adjustments

4.3.4.3 – Perforated Shear Walls
- \( h/b_s > 3.5:1 \) Not considered
- \( h/b_s > 2:1 \) \( L_i = L (2b_s/h) \)
- Aspect Ratio Factors (4.3.4.2) do not apply
- Shear distribution exceptions (4.3.3.4.1) do not apply

Note: \( b_s \) is the minimum shear wall segment length, \( b_s \) in the perforated shear wall.

Chapter 4 – Construction Requirements

NEW

4.3.6.1.1 Common Framing Members
- 2-2x permitted to replace 3x
  - Fastened together per NDS
  - Spacing <4” o.c. shall be staggered
- Applies broadly to all framing

4.3.7 Shear Wall Systems
- 2-2x permitted to replace 3x
  - Wood Structural Panels (4.3.7.1(5))
  - Particleboard (4.3.7.3(5))
What’s Missing for CLT?

Seismic Design!

- *ASCE 7 Minimum Design Loads for Buildings and Other Structures*
- *Response Modification Coefficient, R*
- CLT not recognized system in ASCE 7 Table 12.2-1
- Options
  - Performance-based design procedure per ASCE 7
  - Demonstrating equivalence to an existing ASCE 7 system
  - ASCE 7-10, FEMA P695, and FEMA P795 Quantification of Building Seismic Performance Factors; Component Equivalency Methodology

Outline

- Overview
- IBC
- NDS
  - Chapter-by-chapter discussion
  - Changes from previous editions
- SDPWS
  - Chapter-by-chapter discussion
  - Changes from previous editions SDPWS
- More Info
Availability

- [www.awc.org](http://www.awc.org)
  - PDF versions
    - Free view-only
    - No commentaries
    - Buy a printable PDF
    - With Commentaries
  - Printed versions
    - With Commentaries

Other Resources

- [www.awc.org](http://www.awc.org)
  - Manual for Engineered Wood Construction
    - Free printable PDF
    - New CLT product chapter
    - New heavy timber minimum sizes for CLT and SCL
Technical Articles

- **Structure Magazine**
  - 2015 NDS
    - January 2015
  - 2015 SDPWS
    - July 2015

- [www.awc.org](http://www.awc.org)

Wind & Seismic Standards

- More details on changes
- Wood Design Focus papers
  - 2008 Special Design Provisions for Wind and Seismic
  - Use of Wood Structural Panels to Resist Combined Shear and Uplift from Wind
- Download free at [www.awc.org](http://www.awc.org)
Questions?

• This concludes The American Institute of Architects Continuing Education Systems Course

American Wood Council
info@awc.org
www.awc.org