Code Compliant Fire Resistance Design for Wood Construction

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Description

Determining the proper code application for wood-frame fire assemblies can be challenging and is often further complicated with increases in a project’s size and scale. In a building environment where the ability to maximize height and area is key to cost effectiveness, designers must understand the gamut of fire protection considerations applicable to mid- and low-rise wood structures. This presentation will include code requirements, compliance options and nuances related to assembly selection for required fire resistance-rated floor/ceiling assemblies, exterior walls, fire barriers, fire partitions, and fire walls. Topics will include distinctions between fire-resistive elements for separation vs. class of construction.

Learning Objectives

1. Apply approved methods and alternatives for establishing the fire-resistance of wood building elements.
2. Discuss the differences in exterior walls, fire walls, fire barriers, and fire partitions considering performance expectations, code requirements, and appropriate application.
3. Understand the paths to achieving code-compliant, fire-rated wood-frame assemblies as outlined by the 2015 IBC.
4. Recognize important nuances in the various methods for demonstrating fire-resistance including: tested assemblies, prescriptive designs, calculations, and engineering analysis.
Outline

• Code Overview
• Background
• Fire-resistance building elements
• Achieving Fire-Resistance

International Building Code

The IBC
• Controls building size
• Regulates types of materials
• Stipulates fire-resistance
Concept Fire and Smoke Protection include:

- Structural fire-resistance
- Limitation of Fire Spread
- Protection of Exitways
- Radiant Heat Exposure
- Restriction of Smoke Movement

International Building Code

Allowable heights & areas determined by

- Tabular values
- Factors allowing increases
  - Frontage
  - Sprinkler Systems
- Special Provisions IBC 510
Allowable Heights & Areas

Allowable area is based upon

• Use of building
• Type of construction
• Frontage
• Existence of sprinkler systems

Tabular areas establish *minimum* allowable building areas that can be increased by added fire safety features - frontage and/or sprinkler.

Classifications

• Group A, Assembly occupancies
• Group B, Business occupancies
• Group E, Educational occupancies
• Group F, Factory/Industrial occupancies
• Group I, Institutional occupancies
• Group M, Mercantile occupancies
• Group R, Residential occupancies
• Group S, Storage occupancies
• More in IBC
Types of Construction

• IBC Chapter 6
  • Defines types of construction
    • Type I & II Non-combustible
    • Type III Non-combustible & Combustible
    • Type IV & V Combustible
  • **Wood frame construction is typical in Types III, IV, and V**

Type of Construction

• IBC Chapter 6
  • Defines types of construction
  • Wood frame construction is typical in Types V, IV and III
  • Specific applications permitting use of wood in Types I and II
Type V Construction

- Permits the use of wood or other approved materials for loadbearing and nonloadbearing structural elements.

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**
  - Minimum of 6” × 8” when supporting roof and ceiling loads
  - Minimum of 8” × 8” when supporting floor loads

- **Beams and girders**
  - Minimum 6” × 10” for floors
  - Minimum 4” × 6” 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

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.
Allowable Heights & Areas

Each occupancy group presents a different level of fire and life safety risk:

- Number of occupants
- Capability of occupants
- Fuel load

Allowable heights and areas are based on a concept of equivalent risk, involving three interdependent considerations

- Level of fire hazard likely to be associated with the occupancy
- Nature of contents associated with the use
- Level of overall fire protection provided by the
  - Type of construction
  - Setbacks of the building from other structures (exposure)
  - Sprinklers and life safety systems
  - Other code trade-offs
Concept Fire and Smoke Protection include:

- Structural fire-resistance
- Limitation of Fire Spread
- Protection of Exitways
- Radiant Heat Exposure
- Restriction of Smoke Movement

2015 Code Conforming Wood Design

- Special occupancies
- Fire-resistance
- Building features
- Wood in noncombustible construction types
- Structural considerations
- Precautions during construction
- Also available for 2009 and 2012 IBC

http://awc.org/codes-standards/buildingcodes/ccwd
## 2015 Code Conforming Wood Design

### TABLE 504.3: Allowable Building Height (Above Grade)

<table>
<thead>
<tr>
<th>Occupancy Classification</th>
<th>Type of Construction</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>HT</td>
<td>A</td>
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<tr>
<td>A, B, E, F, M, S, U</td>
<td>NS</td>
<td>65</td>
<td>55</td>
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<td>S</td>
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<td>I-1 Condition 1, I-3</td>
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### TABLE 504.4: Allowable Number of Stories above Grade

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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&lt;sub&gt;d&lt;/sub&gt;</td>
<td>B</td>
<td>HT</td>
</tr>
<tr>
<td>Primary structural frame&lt;sup&gt;g&lt;/sup&gt; (see Section 202)</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bearing walls, Exterior&lt;sup&gt;d&lt;/sup&gt; &amp; Interior&lt;sup&gt;f&lt;/sup&gt;</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>0</td>
<td>2</td>
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<tr>
<td>Nonbearing walls and partitions, Exterior</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nonbearing walls and partitions, Interior&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Floor construction and associated secondary members (see Section 202)</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Roof construction and associated secondary members (see Section 202)</td>
<td>1-1/2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>1&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> - non-sprinklered
<sup>b</sup> - sprinklered (NFPA 13 System)
<sup>c</sup> - sprinklered NFPA 13R requirements (NFPA 13R System)
<sup>d</sup> - single-story sprinklered building (NFPA 13 System)
<sup>e</sup> - continuous sprinklered building (NFPA 13 System)

Note: 1/2H is equivalent to 1 hour of protection.
Exterior Walls

• A vertical assembly of materials designed to restrict the spread of fire in which openings are protected.

• Not a fire barrier and not a fire wall.

• **Wall assemblies for:**
  
  • Separation walls for Group I-1, R-1, R-2 and R-3 per section 420.2
  
  • Walls separating tenant spaces in covered and open mall buildings per section 402.4.2.1
  
  • Corridor walls per section 1020.1
  
  • Elevator lobby separation per section 3006.2
  
  • Egress balconies per section 1019.2

---

### Fire Partition (708)

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE ( X ) (IN)</th>
<th>TYPE OF CONSTRUCTION</th>
<th>OCCUPANCY GROUP</th>
<th>OCCUPANCY GROUP A, B, E, F-2, L, R, S-29, IUP</th>
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</thead>
<tbody>
<tr>
<td>( X \leq 5 )</td>
<td>All</td>
<td>3</td>
<td>2</td>
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<tr>
<td></td>
<td>JA</td>
<td>3</td>
<td>2</td>
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<tr>
<td></td>
<td>Other</td>
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<td>1</td>
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<tr>
<td></td>
<td>JA, LB</td>
<td>2</td>
<td>1</td>
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<tr>
<td></td>
<td>IB, VB</td>
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<td>0</td>
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<tr>
<td></td>
<td>Other</td>
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<td>1</td>
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<tr>
<td>( 10 \leq X &lt; 30 )</td>
<td>JA, LB, IB, VB</td>
<td>2</td>
<td>1</td>
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<tr>
<td></td>
<td>Other</td>
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<td>0</td>
</tr>
<tr>
<td>( X \geq 30 )</td>
<td>All</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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**Fire Partition (708)**

- A vertical assembly of materials designed to restrict the spread of fire in which openings are protected. cont.
  - Of materials permitted by the building type of construction
  - Fire-resistance rating 708.3 not less than 1 hour.
    - See exceptions for corridor walls, dwelling unit separations, and sleeping unit separations

**Fire Barrier (707)**

- A fire-resistance-rated wall assembly of materials designed to restrict the spread of fire in which continuity is maintained
  - Not a fire wall
  - Of materials permitted by the building type of construction
  - Fire-resistance rating 707.3 - specific ratings as indicated for shaft enclosures, interior exit stairways and ramp, enclosed exit access stairways, exit passageway, horizontal exit, atriums, incidental uses, control areas, separated occupancies, fire areas
Fire Barrier (707)

Fire-resistance rating for separation of fire areas per table 707.3.10

<table>
<thead>
<tr>
<th>OCCLUSION GROUP</th>
<th>FIRE-RESISTANCE RATING (HOURS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-1, H-2</td>
<td>4</td>
</tr>
<tr>
<td>F-1, H-3, S-1</td>
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</tr>
<tr>
<td>A, B, E, F-2, H-4, H-5, I, M, R, S-2</td>
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Separation of Occupancies

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<tr>
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<td>F-2, S-2, U</td>
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</table>

S = Buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1.
NS = Building not equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.
N = No separation required.
NP = Not permitted.
a. See Section 429.
b. The required separation from areas used only for private or pleasure vehicles shall be reduced by 1 hour but not to less than 1 hour.
c. See Section 406.3.4.
d. Separation is not required between occupancies of the same classification.
e. See Section 422.2 for ambulatory care facilities.
Shaft Enclosures (713)

- Constructed as fire barriers (713.2) and continuity provisions are the same (713.5)
- Of materials permitted by the building type of construction (713.3)
- Openings and penetrations are not permitted except those necessary to serve the shaft. (713.7 and 713.8)
- 713.11 and 713.12 for special provision for enclosure at the top and bottom of the shaft.
- Fire resistance rating: Shaft enclosures shall have a fire-resistance rating of not less than 2 hours where connecting four stories or more; not less than 1 hour where connecting less than four stories; and not less than the rating of the floor penetrated. (713.4)

Fire Walls (706)

- Define separate buildings for allowable building size (706)
  - Requires continuity from foundation through the roof and constructed to allow collapse on either side under fire conditions without collapse of the wall.
  - Not smoke barriers, smoke partitions or horizontal assemblies
  - Table 706.4 gives required ratings based on occupancy

<table>
<thead>
<tr>
<th>GROUP</th>
<th>FIRE-RESISTANCE RATING (hours)</th>
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<tbody>
<tr>
<td>A, B, E, H-4, I, R-1, R-2, U</td>
<td>3^a</td>
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<tr>
<td>F-1, H-3, H-5, M, S-1</td>
<td>3</td>
</tr>
<tr>
<td>H-1, H-2</td>
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<tr>
<td>F-2, S-2, R-3, R-4</td>
<td>2</td>
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</tbody>
</table>

^a. In Type II or V construction, walls shall be permitted to have a 2-hour fire-resistance rating.
^b. For Group H-1, H-2 or H-3 buildings, also see Sections 415.7 and 415.8.
Fire Walls (706.3)

- **Type V construction**
  - Fire walls may be wood frame

- **Types I, II, III and IV construction**
  - Fire walls must be of noncombustible materials in accordance with Section 706.3

Smoke Barriers (709)

- A continuous membrane, either vertical or horizontal, such as a wall, floor or ceiling assembly, that is designed and constructed to restrict the movement of smoke.

- **Vertical and horizontal smoke barriers**
  - Of materials permitted by the building type of construction
  - Mostly required in Hospital and Healthcare Facilities
  - **1 hour fire-resistance rating** Exception: Smoke barriers constructed of minimum 0.10-inch-thick (2.5 mm) steel in Group I-3 buildings. (709.3)
Horizontal Assemblies (711)

• A fire-resistance-rated floor or roof assembly of materials designed to restrict the spread of fire in which continuity is maintained.

• Of materials permitted by the building type of construction

• Fire-resistance rating - specific ratings as indicated 711.2.4 but not less than that for building type of construction: separating mixed occupancies, fire areas, dwelling units and sleeping units, smoke compartments, incidental uses, other separations.

Outline

• Code Overview
• Background
• Fire-resistance building elements
• Achieving Fire-Resistance
Methods for Determining Fire-Resistance (703)

(703.2) Tested fire assembly (ASTM E 119 or UL 263)

(703.3)
1. Fire-resistance designs documented in approved sources
2. Prescriptive assemblies using of fire-resistance-rated designs in Section 721
3. Calculation of fire-resistance per Section 722
4. Engineering analysis based on a comparison of building element, component or assembly designs that have been tested
5. Alternative protection methods per Section 104.11
6. Fire-resistance designs certified by an approved agency

Fire Tests

Tested fire assembly (ASTM E 119)

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

Half-lapped – middle of panel

Fire Test

National Frame Building Association
ASTM E119 Fire Endurance Test
• 4-Ply 2x6 (approx. 6” thick)
• 2x4 girts at 16” o.c.
• 4 layers 5/8” Type X GWB each side
• RESULTS: 3 hours 47 minutes

See Frame Building News
January 2014
“NFBA ATTAINS CERTIFICATION FOR 2- AND 1-HOUR FIRE-RATED WALLS”

Figure 1. Full-scale testing of a post-frame fire wall assembly
Documented in Approved Source

- Based on testing to the ASTM E 119 or UL 263 standard
- Choose listed assemblies from fire-resistance publications or directories

Fire-resistance designs - AWC Design for Code Acceptance Pubs -
DCA 3
Fire-Resistive Wood Wall and Floor/Ceiling Assemblies

- ASTM E 119 or UL 263
- NFPA 251

Documented in Approved Source

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

**WS6-2.1 Two-Hour Fire-Resistive Wood-Frame Wall Assembly**

*2x6 Wood Stud Wall – 100% Design Load – ASTM E119/NFPA 251*

[Diagram of a wall assembly with labeled components 1, 2, 3, and 4.]

---

**Documented in Approved Source**

**Load-Bearing Fire-Rated Wall Assemblies**

*with OSB and Plywood Sheathing*

[Image of APA Technical Topics with APA TT-063B and website: www.apawood.org]

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WSP over Gypsum

Special Design Provisions for Wind and Seismic 2015

Table 4.3B Nominal Unit Shear Capacities for Wood-Frame Shear Walls^{1,2,6}

<table>
<thead>
<tr>
<th>Sheathing Material</th>
<th>Minimum Required Panel Thickness (in.)</th>
<th>Panel Edge Fastener Spacing (in.)</th>
<th>Panel Edge Fastener Spacing (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Structural Panels - Sheathing**</td>
<td>1/4</td>
<td>5/16</td>
<td>Sheet (centerline or gusseted bond)</td>
</tr>
<tr>
<td>Plywood Siding</td>
<td>1/4</td>
<td>5/16</td>
<td>3/8</td>
</tr>
<tr>
<td>1</td>
<td>Nominal unit shear capacities shall be adjusted in accordance with A5.3.3 to determine ASD allowable shear capacity and LSF (Load and Resistance Factor) design. For general construction requirements, see A5.3.4. For special requirements, see 4.7.3.5.1 for wood structural panel sheathing. See Appendix A for notation and tabular data.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Panel edge fastener spacing for Wood-Frame Shear Walls, wood structural panel sheathing, shall be determined by multiplying the nominal panel edge fastener spacing by the Specific Gravity Adjustment Factor, as determined by the Specific Gravity Adjustment Factor Table 12.3.1A. The Specific Gravity Adjustment Factor shall be greater than or equal to 1.0.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Shear values, G_{shear}, are based on full lap in framing with minimum content less than or equal to 10% of the total framing, and panel stiffness values for the walls constructed with either OSB or 1/2&quot; plywood panels. When a panel of full or half sides is used, the shear values shall be multiplied by 1.0.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Where minimum content of the framing is greater than 10% of the total framing, G_{shear} values shall be multiplied by 0.5.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Where panels are applied with both edges of a shear wall and panel spacing is less than 6&quot; on centers on either side, panel joints shall be offset by 12&quot; on different framing members. Alternatively, the widths of the nailed face of framing members shall be 6&quot; on centers greater than seen in panels and nails at all panel edges shall be staggered.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Documented in Approved Source

WIJ-2.1 Two-Hour Fire-Resistive Ceiling Assembly

Floor/ Ceiling - 100% Design Load - 2 Hour Rating - ASTM E 119 / NFPA 251

48

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### Prescriptive Fire-Resistance Rated Assemblies

Fire-resistance of certain wood assemblies is prescribed in Section 721 based on testing using ASTM E 119 or UL 263

#### TABLE 721.1(3)—continued

<table>
<thead>
<tr>
<th>FLOOR OR ROOF CONSTRUCTION</th>
<th>ITEM NUMBER</th>
<th>CEILING CONSTRUCTION</th>
<th>MINIMUM THICKNESS OF CEILING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28-1</td>
<td>Base layer of 3/4&quot; Type C gypsum wallboard attached directly to I-joints with 1/2&quot; Type S drywall screws spaced 12&quot; o.c. with ends staggered. Minimum 0.0176&quot; thick hat-shaped 1/8-inch furring channel 16&quot; o.c. (channels doubled at wallboard end joints), placed perpendicular to the joint and attached to each joint by 1/4&quot; Type S drywall screws after the base layer of gypsum wallboard has been applied. The middle and face layers of 3/4&quot; Type C gypsum wallboard applied perpendicular to the channel with end joints staggered. The middle layer is fastened with 1&quot; Type S drywall screws spaced 12&quot; o.c. The face layer is applied parallel to the middle layer but with the edge joints offset 24&quot; from those of the middle layer and fastened with 1/2&quot; Type S drywall screws 8&quot; o.c. The joints shall be taped and covered with joint compound.</td>
<td>2 1/4</td>
</tr>
</tbody>
</table>

### Prescriptive Fire-Resistance-Rated Assemblies

Fire-resistance of certain wood assemblies is prescribed in Section 721 based on testing using ASTM E 119 or UL 263

#### TABLE 721.1(2)—continued

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>ITEM NUMBER</th>
<th>CONSTRUCTION</th>
<th>MINIMUM FINISHED THICKNESS FACE-TO-FACE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14-1.2</td>
<td>2&quot; x 4&quot; wood studs 10' on center with two layers of 7/8&quot; regular gypsum wallboard on each side. 5d Variety or #2 common nails at 8&quot; on center face layer. 5d Variety or #2 common nails at 8&quot; on center.</td>
<td>5</td>
</tr>
<tr>
<td>14-1.3</td>
<td>2&quot; x 4&quot; wood studs 10' on center with two layers of 7/8&quot; regular gypsum wallboard applied vertically or horizontally each side. Joints staggered. Nail base layer with 5d Variety or #2 common nails at 8&quot; on center face layer with 5d Variety or #2 common nails at 8&quot; on center.</td>
<td>9 1/2</td>
<td></td>
</tr>
<tr>
<td>14-1.4</td>
<td>2&quot; x 4&quot; fire retardant treated wood studs spaced 24&quot; on center with one layer of 7/8&quot; Type X gypsum wallboard applied with face paper joints long direction parallel to studs. Wallboard attached with 5d Variety or #2 common nails at 7&quot; on center</td>
<td>4 1/4</td>
<td></td>
</tr>
</tbody>
</table>

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Calculated Resistance (703.3)

- Fire-resistance of wood frame assemblies also may be calculated based on the known fire-resistance of the components, using the provisions of Section 722.6
- 1.0 hour maximum

722.6 Wood assemblies. The provisions of this section contain procedures by which the fire-resistance ratings of wood assemblies are established by calculations.

Calculated Fire Resistance (722.6)

DCA 4
Component Additive Method (CAM) for Calculating and Demonstrating Assembly Fire Endurance

722.6 Wood assemblies. The provisions of this section contain procedures by which the fire-resistance ratings of wood assemblies are established by calculations.
Calculated Fire Resistance (722.6)

**CAM Membrane Table**

Time Assigned to Protective Membranes

- IBC Table 722.6.2(1)

<table>
<thead>
<tr>
<th>DESCRIPTION OF FINISH</th>
<th>TIME (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/32-inch wood structural panel bonded with exterior glue</td>
<td>5</td>
</tr>
<tr>
<td>7/32-inch wood structural panel bonded with exterior glue</td>
<td>10</td>
</tr>
<tr>
<td>7/32-inch wood structural panel bonded with exterior glue</td>
<td>15</td>
</tr>
<tr>
<td>1/4-inch gypsum wallboard</td>
<td>10</td>
</tr>
<tr>
<td>1/4-inch gypsum wallboard</td>
<td>15</td>
</tr>
<tr>
<td>1/4-inch gypsum wallboard</td>
<td>30</td>
</tr>
<tr>
<td>1/4-inch Type X gypsum wallboard</td>
<td>25</td>
</tr>
<tr>
<td>1/4-inch Type X gypsum wallboard</td>
<td>40</td>
</tr>
<tr>
<td>Double 1/4-inch gypsum wallboard</td>
<td>25</td>
</tr>
<tr>
<td>1/2-inch + 1/4-inch gypsum wallboard</td>
<td>35</td>
</tr>
<tr>
<td>Double 1/2-inch gypsum wallboard</td>
<td>40</td>
</tr>
</tbody>
</table>

Calculated Fire Resistance (722.6)

**CAM Wood Component Table**

Assigned Times for Wood Components

IBC Table 722.6.2(2)

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>TIME ASSIGNED TO FRAME (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood studs 16 inches o.c.</td>
<td>20</td>
</tr>
<tr>
<td>Wood floor and roof joints 16 inches o.c.</td>
<td>10</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm.

- This table does not apply to studs or joints spaced more than 16 inches o.c.
- All studs shall be nominal 2 x 4 and all joints shall have a nominal thickness of not less than 2 inches.
- Allowable spans for joints shall be determined in accordance with Sections 2008.4.2.1, 2008.7.1 and 2008.7.2.
Calculated Fire Resistance (722.6)

**CAM Wall Membranes**
Membranes on Exterior Face of Walls
**IBC Table 722.6.2(3)**

<table>
<thead>
<tr>
<th>SHEATHING</th>
<th>PAPER</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4-inch T &amp; G lumber</td>
<td>Sheathing paper</td>
</tr>
<tr>
<td>3/8-inch exterior glue wood structural panel</td>
<td></td>
</tr>
<tr>
<td>1/2-inch gypsum wallboard</td>
<td></td>
</tr>
<tr>
<td>1/2-inch gypsum wallboard</td>
<td></td>
</tr>
<tr>
<td>1/2-inch fiberboard</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1/2-inch exterior-grade wood structural panels</td>
</tr>
</tbody>
</table>

*For SI: 1 inch = 25.4 mm.

a. Any combination of sheathing, paper and exterior finish is permitted.

---

Calculated Fire Resistance (722.6)

**CAM Cavity Insulation Table**
Assigned Times for Insulation of Cavity
• **IBC Table 722.6.2(5)**

<table>
<thead>
<tr>
<th>DESCRIPTION OF ADDITIONAL PROTECTION</th>
<th>FIRE RESISTANCE (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add to the fire-resistance rating of wood stud walls if the spaces between the studs are completely filled with glass fiber mineral wool batts weighing not less than 2 pounds per cubic foot (0.6 pound per square foot of wall surface) or rockwool or slag material wool batts weighing not less than 3.3 pounds per cubic foot (1 pound per square foot of wall surface), or cellulose insulation having a nominal density not less than 2.6 pounds per cubic foot.</td>
<td>15</td>
</tr>
</tbody>
</table>

*For SI: 1 pound/cubic foot = 16.0145 kg/m³.
CAM Example 1

**Interior Wall**

![Diagram of interior wall with wood stud (2x4 minimum), 5/8" Type X gypsum board, and 16" maximum separation.]

- 5/8 inch Type X gypsum wallboard = 40 minutes
- Wood studs = 20 minutes
- Combined Assembly Fire Resistance Rating = 60 minutes

**Figure 1** Interior Wall

---

CAM Example 2

**Floor/Ceiling with Wood Joists**

![Diagram of floor/ceiling assembly with subfloor, 1/2" plywood, wood joist, 1/2" Type X gypsum wallboard (2 layers), and 16" fire exposed side.]

- 1/2 inch Type X Gypsum wallboard = 25 minutes
- Wood joists = 10 minutes
- Combined Assembly Fire Resistance Rating = 60 minutes

**Figure 2** Floor/Ceiling Assembly
CAM Example 3

Floor/Ceiling with I-joists

Columns within Wall Assembly

IBC 704.2 and 704.3 No additional fireproofing required for the column in the assembly
Columns within Wall Assembly

- **704.2 Column protection (IBC 2018 text)**
  - “Exception: Columns that meet the limitations of Section 704.4.1”

- **704.4.1 Light-frame construction (IBC 2018 text)**
  - “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.”

Structural Stability 705.6

- 2 hour wall
- 1 hour floor
- 2 hour wall
Calculated Fire-Resistance

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

Products
- Lumber
- Glulam
- SCL
- Decking
- CLT

SECTION 722
CALCULATED FIRE RESISTANCE

722.1 General. The provisions of this section contain procedures by which the fire resistance of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated fire resistance of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with ACI 216.1/ASTM 0218. The calculated fire resistance of steel assemblies shall be permitted in accordance with Chapter 9 of ASCE 20. 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).

Fire Design of Exposed Wood Members

Beam Fire Test
ASTM E 119
Calculated Fire-Resistance (722)

Chapter 16 of the National Design Specification® (NDS®)

Fire Design of Exposed Wood Members

**Effective char rate**

solid sawn, structural glued laminated softwood, laminated veneer lumber, parallel strand lumber, and laminated strand lumber

\[
\beta_{\text{eff}} = \frac{1.2\beta_n}{t^{0.187}}
\]  

(16.2-1)

where:

- \(\beta_{\text{eff}}\) = effective char rate (in./hr.), adjusted for exposure time, \(t\)
- \(\beta_n\) = nominal char rate (in./hr.), linear char rate based on 1-hour exposure
- \(t\) = exposure time (hr.)
Effective char depth

C16.2.1.2 Using Equation 16.2-1 and assuming nominal char rate, $\beta_n$ or 1.5 inches/hr:

$$a_{char} = 1.8t^{0.813}$$

<table>
<thead>
<tr>
<th>Required Fire Endurance (hr.)</th>
<th>Effective Char Rate, $\beta_{eff}$ (in./hr.)</th>
<th>Effective Char Depth, $a_{char}$ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Hour</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>1.67</td>
<td>2.5</td>
</tr>
<tr>
<td>2-Hour</td>
<td>1.58</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Fire Design of Exposed Wood Members

Allowable Stress Design

Table 16.2.2 Adjustment Factors for Fire Design

<table>
<thead>
<tr>
<th>Property</th>
<th>ASD Factor</th>
<th>CF</th>
<th>CV</th>
<th>CB</th>
<th>CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Strength</td>
<td>2.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beam Buckling Strength</td>
<td>2.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>2.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>2.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Column Buckling Strength</td>
<td>2.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. See 4.3, 5.3, 8.3, and 10.3 for applicability of adjustment factors for specific products.
2. Factor shall be based on initial cross-section dimensions.
3. Factor shall be based on reduced cross-section dimensions.

Special Provisions NDS 16.2.4

Glued-laminated Timber
Tension Lam Provisions – unbalanced layup

Figure 3-1 Typical glulam unbalanced beam layups
Special Provisions NDS 16.2.4

Glued-laminated Timber
Tension Lam Provisions – balanced

Fire Design of Exposed Wood Members

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

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

\[ t_{gl} = \text{time for char front to reach glued interface (hr.)} \]

\[ h_{lam} = \text{lamination thickness (in.)} \]

\[ n_{lam} = \frac{t}{t_{gl}} \]

\[ n_{lam} = \text{number of laminations charred (rounded to lowest integer)} \]

\[ t = \text{exposure time (hr.)} \]
Fire Design of Exposed Wood Members

CLT manufactured with laminations of equal thickness

Table 16.2.1B  Effective Char Depths (for CLT with $\beta_n=1.5$ in./hr.)

<table>
<thead>
<tr>
<th>Required Fire Endurance (hr.)</th>
<th>5/8</th>
<th>3/4</th>
<th>7/8</th>
<th>1</th>
<th>1-1/4</th>
<th>1-3/8</th>
<th>1-1/2</th>
<th>1-3/4</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Hour</td>
<td>2.2</td>
<td>2.2</td>
<td>2.1</td>
<td>2.0</td>
<td>2.0</td>
<td>1.9</td>
<td>1.8</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>3.4</td>
<td>3.2</td>
<td>3.1</td>
<td>3.0</td>
<td>2.9</td>
<td>2.8</td>
<td>2.8</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>2-Hour</td>
<td>4.4</td>
<td>4.3</td>
<td>4.1</td>
<td>4.0</td>
<td>3.9</td>
<td>3.8</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</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

Calculated Resistance (722)

Technical Report No. 10 (TR10)
• contains background and examples for the method

Figure 1-1 Reduction in member breadth and depth over time, t
TR-10 Design Example

TR10 contains
• decking
• beam
• column
• CLT
• etc

Fire-Resistance of Exposed Wood

16.3 Wood Connections
• Where fire endurance is required, connectors and fasteners shall be protected from fire exposure
  • Wood
  • Fire-rated gypsum board
Nail-Laminated Timber

Engineering Analysis

NFBA UL V304 2- and 1-Hour Walls
- UL engineering evaluation

<table>
<thead>
<tr>
<th>Gypsum Layers and Fastener Length and Spacing</th>
<th>Length of screw @ horizontal spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hourly wall</td>
<td>3-hour</td>
</tr>
<tr>
<td>Layers per side</td>
<td>4</td>
</tr>
<tr>
<td>1st layer</td>
<td>2&quot; @ 24&quot;</td>
</tr>
<tr>
<td>2nd layer</td>
<td>2-1/2&quot; @ 24&quot;</td>
</tr>
<tr>
<td>3rd layer</td>
<td>3&quot; @ 24&quot;</td>
</tr>
<tr>
<td>4th layer</td>
<td>4&quot; @ 12&quot;</td>
</tr>
<tr>
<td></td>
<td>2-hour</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2-1/2&quot; @ 24&quot;</td>
</tr>
<tr>
<td></td>
<td>3&quot; @ 24&quot;</td>
</tr>
<tr>
<td></td>
<td>N/R</td>
</tr>
<tr>
<td></td>
<td>1-hour</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2-1/2&quot; @ 12&quot;</td>
</tr>
<tr>
<td></td>
<td>N/R</td>
</tr>
<tr>
<td></td>
<td>N/R</td>
</tr>
</tbody>
</table>

Table 1. UL V304: Gypsum Layers and Fastener Specifications

See Frame Building News January 2014
“NFBA ATTAINS CERTIFICATION FOR 2- AND 1-HOUR FIRE-RATED WALLS”

© American Wood Council 2017
May be used in almost all occupancies.

803.1.1 Interior wall and ceiling finish materials. Interior wall and ceiling finish materials shall be classified in accordance with ASTM E 84 or UL 723. Such interior finish materials shall be grouped in the following classes in accordance with their flame spread and smoke-developed indexes:

- **Class A**: Flame spread index 0-25; smoke-developed index 0-450.
- **Class B**: Flame spread index 26-75; smoke-developed index 0-450.
- **Class C**: Flame spread index 76-200; smoke-developed index 0-450.

Exception: Materials tested in accordance with Section 803.1.2.

### Wood Interior Finish Classification System

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum Interior Finish Classification by Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Exit enclosures and exit passageways&lt;sup&gt;c&lt;/sup&gt;</td>
<td>A, B, E, I, M, R-1, R-4</td>
</tr>
<tr>
<td>Corridors</td>
<td>A&lt;sup&gt;d&lt;/sup&gt;, I-2, I-3, I-4</td>
</tr>
</tbody>
</table>

(Table 803.11)
Wood Interior Finish Classification System

Sprinklered Buildings: Minimum Interior Finish Classification by Occupancy

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum Interior Finish Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Exit enclosures and exit passageways</td>
<td>I-3</td>
</tr>
<tr>
<td>Corridors</td>
<td>I-3</td>
</tr>
<tr>
<td>Enclosed spaces and rooms</td>
<td>I-2, I-4</td>
</tr>
</tbody>
</table>

(Table 803.11)

Wood Interior Finish (803)

- Most wood species qualify as Class C or Class B
- Wood boards and panels may meet Class A criteria when pressure treated with a fire-retardant chemical
- AWC’s DCA-1 documents the performance
### Flame Spread

<table>
<thead>
<tr>
<th>Class</th>
<th>Flame Spread</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I or A</td>
<td>0 - 25</td>
<td>Fire retardant treated wood</td>
</tr>
<tr>
<td>Class II or B</td>
<td>26 - 75</td>
<td>Redwood, cedar, douglas-fir, hem-fir, pine (other than lodge pole, ponderosa &amp; red)</td>
</tr>
<tr>
<td>Class III or C</td>
<td>76 - 200</td>
<td>Most other wood species</td>
</tr>
</tbody>
</table>

### Smoke Developed Index

A smoke-developed index was also measured for some of the wood products listed in DCA 1. None of the products tested exceeded the limiting value of 450 commonly used in building code regulations.
Wood Interior Finish – Exceptions

• Traditional wood floor covering is exempt from interior floor finish requirements (804.1)
• Exposed portions of Type IV structural members also exempt (803.3)

Design for Code Acceptance Pubs.

Free download www.awc.org
2015 Code Conforming Wood Design

- Special occupancies
- Fire-resistance
- Building features
- Wood in noncombustible construction types
- Structural considerations
- Precautions during construction
- Also available for 2009 and 2012 IBC
- [http://awc.org/codes-standards/buildingcodes/ccwd](http://awc.org/codes-standards/buildingcodes/ccwd)

Finger Jointed Sawn Lumber

- Also known as end-jointed & edge-glued
- 2303.1.1 Sawn lumber - Approved end-jointed lumber is permitted to be used interchangeably with solid-sawn members of the same species and grade.
- Note HRA for fire-resistance rating
Finger Jointed Sawn Lumber

- WWPA - http://www2.wwpa.org/Portals/9/docs/PDF/FF-HRA.pdf

Questions?

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

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