Code Compliant Fire Resistance Design for Wood Construction

Paul Coats, PE, CBO
Southeast Regional Manager
American Wood Council
COURSE DESCRIPTION

Determining the proper code application for fire resistant wood frame assemblies and exposed wood structural members 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/ceilings and roof/ceilings, interior and exterior walls, fire barriers, fire partitions, and fire walls. Topics will also include distinctions between fire-resistant elements for separation vs. type of construction.
LEARNING OBJECTIVES

Upon completion, participants will be better able to:

1. Apply approved methods and alternatives for establishing the fire resistance of wood building elements.

2. Discuss the differences in the various requirements for interior and 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 resistance-rated wood frame assemblies and exposed wood members 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.
ABOUT AWC

Codes and Standards
Green Building
Manufacturing Environmental Regulation
Advocacy and Public Policy
CODE ASSISTANCE – AWC FIELD STAFF

Dennis Richardson
West
drichardson@awc.org
707-538-2786

Dave Tyree
South Central
dtyree@awc.org
719-492-3990

Jim Smith
Midwest
jsmith@awc.org; 608-635-6635

Matt Hunter
Northeast
mhunter@awc.org; 484-353-2509

Paul Coats
Southeast
pcoats@awc.org
803-980-7304

Sam Francis
National Director
sfrancis@awc.org; 610-869-4774

Fire-Resistant Design for Wood Construction

6
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• **Outline – principles of fire resistance design**
  1. Establish the minimum construction type
  2. Know the reason for the fire resistance
  3. Know the options for establishing fire resistance
INTRODUCTION

• The IBC:
  • Controls building size
  • Regulates types of materials
  • Stipulates fire resistance
**INTRODUCTION**

- **Building size is determined by:**
  - Tabular values
  - Factors allowing increases
    - Frontage
    - Sprinkler systems
  - Special Provisions (IBC 510)
INTRODUCTION

• Building size is determined by:
  
  • **Tabular values**
  
  • Factors allowing increases
    
    • Frontage
    
    • Sprinkler systems
  
  • **Special Provisions (IBC 510)**
INTRODUCTION

- Tabular values are based on:
  - Use of building (occupancy)
  - Type of construction
  - Existence of NFPA 13 sprinkler system

<table>
<thead>
<tr>
<th>TABLE 506.2: Allowable Area Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2, A-3</td>
</tr>
<tr>
<td>NS 14,000 9,500 15,000 11,500 6,000</td>
</tr>
<tr>
<td>S1 56,000 38,000 60,000 46,000 24,000</td>
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<tr>
<td>SM 42,000 28,500 45,000 34,500 18,000</td>
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<td>NS 28,500 19,000 36,000 18,000 9,000</td>
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<tr>
<td>S1 114,000 76,000 144,000 72,000 36,000</td>
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<tr>
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<td>NS 23,500 14,500 25,500 18,500 9,500</td>
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<td>S1 94,000 58,000 102,000 74,000 38,000</td>
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<tr>
<td>SM 117,000 78,000 115,500 63,000 40,500</td>
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<tr>
<td>NS 24,000 16,000 20,500 12,000 7,000</td>
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<td>S1 96,000 64,000 82,000 48,000 28,000</td>
</tr>
<tr>
<td>SM 72,000 48,000 61,500 36,000 21,000</td>
</tr>
</tbody>
</table>
INTRODUCTION

• Tabular values are based on:
  • Use of building (occupancy)
  • Type of construction
  • Existence of sprinkler system
INTRODUCTION

• Occupancy will determine:
  • Number of occupants
  • Capability of occupants
  • Fuel load
First principle of fire resistance:

Establish the minimum required construction type.
FIRST – MINIMUM CONSTRUCTION TYPE

\[ A_a = [A_t + (NS \times I_f)] \times S_a \quad \text{(Equation 5-2)} \]

\[ I_f = [F / P - 0.25] W / 30 \quad \text{(Equation 5-5)} \]
**FIRST – MINIMUM CONSTRUCTION TYPE**

<table>
<thead>
<tr>
<th>Occupancy Classification</th>
<th>Type of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type III</td>
</tr>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>A, B, E, F, M, S, U</td>
<td></td>
</tr>
<tr>
<td>I-1 Condition 1, I-3</td>
<td>65</td>
</tr>
<tr>
<td>I-1 Condition 2, I-2</td>
<td>NS</td>
</tr>
<tr>
<td>I-4</td>
<td>NS</td>
</tr>
<tr>
<td>R</td>
<td>S</td>
</tr>
</tbody>
</table>

**TABLE 504.3: Allowable Building Height (Ft above Grade)**

<table>
<thead>
<tr>
<th>Occupancy Classification</th>
<th>Type of Construction</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Type III</td>
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<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>A-1, A-2, A-3, A-4</td>
<td>NS</td>
</tr>
<tr>
<td>B</td>
<td>S</td>
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<tr>
<td>E</td>
<td>NS</td>
</tr>
<tr>
<td>M</td>
<td>S</td>
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<td>NS</td>
</tr>
<tr>
<td>R-1</td>
<td>S</td>
</tr>
<tr>
<td>R-2</td>
<td>NS</td>
</tr>
</tbody>
</table>

**TABLE 504.4: Allowable Number of Stories above Grade**

<table>
<thead>
<tr>
<th>Occupancy Classification</th>
<th>Type of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>S13R</td>
<td>60</td>
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</tbody>
</table>
## FIRST – MINIMUM CONSTRUCTION TYPE

### 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>Primary structural frame (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  0</td>
<td>1  0</td>
<td>HT  1  0</td>
</tr>
<tr>
<td>Bearing walls, Exterior (g)</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1  0</td>
<td>2  2</td>
<td>2  1/HT 1 0</td>
</tr>
<tr>
<td>Bearing walls, Interior (g)</td>
<td>3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1  0</td>
<td>1  0</td>
<td>1  0</td>
</tr>
<tr>
<td>Nonbearing walls and partitions, Exterior</td>
<td></td>
<td></td>
<td>See Table 602</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonbearing walls and partitions, Interior</td>
<td>0  0</td>
<td>0  0</td>
<td>0  0</td>
<td>0  0</td>
<td>See Section 602.4.6 0  0</td>
</tr>
<tr>
<td>Floor construction and associated secondary members (see Section 202)</td>
<td>2  2</td>
<td>1  0</td>
<td>1  0</td>
<td>HT  1  0</td>
<td></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; 0 HT 1&lt;sup&gt;b,c&lt;/sup&gt; 0</td>
</tr>
</tbody>
</table>

<sup>a</sup> Additional protection clauses apply.
<sup>b</sup> Fire-resistance rating required for types I, II, and III construction.
<sup>c</sup> Fire-resistance rating required for types I, II, and III construction.
FIRST – MINIMUM CONSTRUCTION TYPE

2015 Code Conforming Wood Design

Fire-Resistant Design for Wood Construction
**FIRST – MINIMUM CONSTRUCTION TYPE**

<table>
<thead>
<tr>
<th># of stories</th>
<th>% frontage</th>
<th>IIIA</th>
<th>IIIB</th>
<th>IV</th>
<th>VA</th>
<th>VB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-25</td>
<td>23,500</td>
<td>14,500</td>
<td>25,500</td>
<td>12,120</td>
<td>9,500</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>29,370</td>
<td>25,370</td>
<td>31,870</td>
<td>22,500</td>
<td>11,870</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>41,120</td>
<td>33,250</td>
<td>44,620</td>
<td>32,370</td>
<td>16,620</td>
</tr>
<tr>
<td>2</td>
<td>0-25</td>
<td>23,500</td>
<td>14,500</td>
<td>25,500</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>29,370</td>
<td>18,120</td>
<td>31,870</td>
<td>NP</td>
<td>NP</td>
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<td>100</td>
<td>41,120</td>
<td>25,370</td>
<td>44,620</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>3</td>
<td>0-25</td>
<td>23,500</td>
<td>NP</td>
<td>25,500</td>
<td>NP</td>
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<td>50</td>
<td>29,370</td>
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<td>31,870</td>
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<td>100</td>
<td>41,120</td>
<td>NP</td>
<td>44,620</td>
<td>NP</td>
<td>NP</td>
</tr>
</tbody>
</table>
## FIRST – MINIMUM CONSTRUCTION TYPE

### Group E Nonsprinklered Buildings

<table>
<thead>
<tr>
<th># of stories</th>
<th>% frontage</th>
<th>Maximum floor area per story (sq. ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IIIA</td>
<td>IIIB</td>
</tr>
<tr>
<td>1</td>
<td>0-25</td>
<td>23,500</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>29,370</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>41,120</td>
</tr>
<tr>
<td>2</td>
<td>0-25</td>
<td>23,500</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>29,370</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>41,120</td>
</tr>
<tr>
<td>3</td>
<td>0-25</td>
<td>23,500</td>
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<td>29,370</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>41,120</td>
</tr>
</tbody>
</table>

### Footnotes

- **a.** Frontage based on open space widths of 30 feet or more.
- **b.** Interpolation permitted.
- **c.** Sprinklers must be provided for Group E occupancies when the fire area exceeds 12,000 square feet in accordance with Section 903.2.3, or by reason of other specific conditions in that section. In lieu of sprinklers, compartmentalization of the floor area into fire areas not more than 12,000 square feet can be provided with fire-resistance-rated construction in accordance with Chapter 7.
FIRST – MINIMUM CONSTRUCTION TYPE

- The minimum construction type:
- Can be independent of materials chosen
- Allows greatest flexibility for materials use
FIRST – MINIMUM CONSTRUCTION TYPE

• The minimum construction type:

• Should take into account the final size of building with all future expansions in mind
Second principle of fire resistance:

Know the reason for the fire resistance.
SECOND – REASON FOR THE FIRE RESISTANCE

• Building elements (walls, floors, roofs) rated per construction type (704):
  • Have general protection requirements in 704
  • Do not require opening/penetration protection
  • Have ratings based on Table 601
## SECOND – REASON FOR THE FIRE RESISTANCE

### 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;sup&gt;d&lt;/sup&gt;</td>
<td>B</td>
<td>A&lt;sup&gt;d&lt;/sup&gt;</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;l, g&lt;/sup&gt; Interior</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>
</tr>
<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;e&lt;/sup&gt;</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Floor construction and associated secondary members (see Section 202)</td>
<td>1-1&lt;sup&gt;b&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>
<td>0&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
SECOND – REASON FOR THE FIRE RESISTANCE

• Exterior walls (705):
  • Have unique structural, continuity, and opening/penetration protection requirements
  • Have material requirements based on construction type
  • Have ratings based on proximity to lot lines
  • Required to be rated for exposure to both sides of the wall only when FSD ≤10 ft. (otherwise interior side of wall is the exposed side for testing)
### Table 602

<table>
<thead>
<tr>
<th>FIRE SEPARATION DISTANCE = X (feet)</th>
<th>TYPE OF CONSTRUCTION</th>
<th>OCCUPANCY GROUP H</th>
<th>OCCUPANCY GROUP F-1, M, S-1&lt;sup&gt;g&lt;/sup&gt;</th>
<th>OCCUPANCY GROUP A, B, E, F-2, I, R, S-2&lt;sup&gt;g&lt;/sup&gt;, U&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>X &lt; 5&lt;sup&gt;e&lt;/sup&gt;</td>
<td>All</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td>5 ≤ X &lt; 10</td>
<td>IA</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10 ≤ X &lt; 30</td>
<td>IA, IB</td>
<td>2</td>
<td>1</td>
<td>1&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
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<td>0</td>
</tr>
<tr>
<td></td>
<td>Others</td>
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<td>1</td>
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<tr>
<td>X ≥ 30</td>
<td>All</td>
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</tbody>
</table>

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**SECOND – REASON FOR THE FIRE RESISTANCE**

[Bldg. 2] LOT LINE
SECOND – REASON FOR THE FIRE RESISTANCE

If ≤ 10 feet wall must be rated for exposure from both sides
SECOND – REASON FOR THE FIRE RESISTANCE

Fire-Resistant Design for Wood Construction

[Diagram of fire-resistant wood construction with labels for different components, such as FRTW wall framing, untreated wood floor sheathing, untreated sawn lumber, SCL or prefabricated wood I-joist, one-hour fire-resistance-rated assembly with two-layer gypsum ceiling membrane, 2-hour fire-resistance-rated wall assembly, rated for exposure from interior side (and from exterior side as required by IBC 705.5).]
SECOND – REASON FOR THE FIRE RESISTANCE

• Fire walls (706):
  • Define separate buildings
  • Have unique structural, continuity, and opening/penetration protection requirements
  • Have materials requirements based on type of construction (Type V may be wood)
  • Have ratings based on occupancy
SECOND – REASON FOR THE FIRE RESISTANCE

- **Fire barriers (707):**
  - Create fire resistant separations
  - Have unique continuity and opening/penetration protection requirements
  - May have any materials permitted by the construction type
  - Have ratings based on function
    - shaft enclosures, exit enclosures, occupancy separations, hazardous material control areas, fire areas, atrium protection, and others
SECOND – REASON FOR THE FIRE RESISTANCE

#### TABLE 508.4
REQUIRED SEPARATION OF OCCUPANCIES (HOURS)

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>F-2, S-2°, U</td>
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<tr>
<td>B*, F-1, M, S-1</td>
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<td>H-1</td>
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<tr>
<td>H-2</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>H-3, H-4</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>H-5</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.
NS = Buildings not equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.
N = No separation requirement.
NP = Not permitted.
a. See Section 420.
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.
SECOND – REASON FOR THE FIRE RESISTANCE

Shaft wall/floor intersections and connections – additional protection may be required
SECOND – REASON FOR THE FIRE RESISTANCE

• Fire partitions (708):
  • Create fire resistant separations
  • Have unique continuity and opening/penetration protection requirements
  • May have any materials permitted by the construction type
  • Have ratings based on function and sprinkler protection
  • Dwelling unit separation, tenant space separation, corridor walls, elevator lobby separation
SECOND – REASON FOR THE FIRE RESISTANCE

• **Horizontal assemblies (711):**
  
  • Have unique continuity and opening/penetration protection requirements
  
  • Have requirements for supporting construction
  
  • Have ratings based on function
SECOND – REASON FOR THE FIRE RESISTANCE

• Penetrations protection (714)

• Openings protection (716)

• Fire resistant joint systems (715)

  • “Joint: The opening in or between adjacent assemblies that is created due to building tolerances, or is designed to allow independent movement of the building in any plane caused by thermal, seismic, wind or any other loading.”
SECOND – REASON FOR THE FIRE RESISTANCE

• Structural connections and building element intersections not always regulated by the code

• Supporting construction fire resistance requirements may apply
SECOND – REASON FOR THE FIRE RESISTANCE

• 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.”
SECOND – REASON FOR THE FIRE RESISTANCE

Rated wall

Column needs no separate protection
Third principle of fire resistance:

Know your options for establishing fire resistance.
THIRD – OPTIONS FOR FIRE RESISTANCE

- Methods for establishing fire resistance (703):
  1. Tested fire assembly (ASTM E119 or UL 263)
  2. Fire-resistance designs documented in approved sources
  3. Prescriptive assemblies using fire-resistance rated designs in Section 721
  4. Calculation of fire-resistance per Section 722
  5. Engineering analysis based on a comparison of building element, component or assembly designs that have been tested
  6. Alternative protection methods per Section 104.11
  7. Fire-resistance designs certified by an approved agency
THIRD – OPTIONS FOR FIRE RESISTANCE

• Tested assembly:
  • ASTM E119/UL 263 test
  • May be listed in fire resistance directories
  • Approval may be based on listing or the test report
THIRD – OPTIONS FOR FIRE RESISTANCE

• Documentation in approved source:
  • AWC DCA 3 is one example
  • Fire-Resistive Wood Wall and Floor/Ceiling Assemblies
  • ASTM E119 or UL 263
  • NFPA 251
THIRD – OPTIONS FOR FIRE RESISTANCE

WIJ-2.1 Two-Hour Fire-Resistive Ceiling Assembly
Floor²/Ceiling - 100% Design Load - 2 Hour Rating - ASTM E 119 / NFPA 251
THIRD – OPTIONS FOR FIRE RESISTANCE

- Prescriptive assemblies from the code (721):
  - Based on ASTM E119 or UL 263 testing
THIRD – OPTIONS FOR FIRE RESISTANCE

• **Calculated fire resistance (722.6):**
  - Component Additive Method (CAM)
  - Calculated fire resistance of exposed wood members per Chapter 16 of the NDS
## THIRD – OPTIONS FOR FIRE RESISTANCE

<table>
<thead>
<tr>
<th>DESCRIPTION OF FINISH</th>
<th>TIME (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8-inch wood structural panel bonded with exterior glue</td>
<td>5</td>
</tr>
<tr>
<td>15/32-inch wood structural panel bonded with exterior glue</td>
<td>10</td>
</tr>
<tr>
<td>19/32-inch wood structural panel bonded with exterior glue</td>
<td>15</td>
</tr>
<tr>
<td>3/8-inch gypsum wallboard</td>
<td>10</td>
</tr>
<tr>
<td>1/2-inch gypsum wallboard</td>
<td>15</td>
</tr>
<tr>
<td>5/8-inch gypsum wallboard</td>
<td>30</td>
</tr>
<tr>
<td>1/2-inch Type X gypsum wallboard</td>
<td>25</td>
</tr>
<tr>
<td>5/8-inch Type X gypsum wallboard</td>
<td>40</td>
</tr>
<tr>
<td>Double 3/8-inch gypsum wallboard</td>
<td>25</td>
</tr>
<tr>
<td>1/2-inch + 3/8-inch gypsum wallboard</td>
<td>35</td>
</tr>
<tr>
<td>Double 1/2-inch gypsum wallboard</td>
<td>40</td>
</tr>
</tbody>
</table>
THIRD – OPTIONS FOR FIRE RESISTANCE

![Diagram of Fire Resistant Design for Wood Construction]

**Figure 2**  Floor/Ceiling Assembly

- 1/2 inch Type X Gypsum wallboard = 25 minutes
- 1/2 inch Type X Gypsum wallboard = 25 minutes
- Wood joists = 10 minutes

**Combined Assembly Fire Resistance Rating** = 60 minutes
THIRD – OPTIONS FOR FIRE RESISTANCE
### Table 16.2.1A

<table>
<thead>
<tr>
<th>Required Fire Endurance (hr.)</th>
<th>Effective Char Rate, $\beta_{\text{eff}}$ (in./hr.)</th>
<th>Effective Char Depth, $a_{\text{char}}$ (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>
THIRD – OPTIONS FOR FIRE RESISTANCE

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

(16.2-1)

where:

\[ \beta_{\text{eff}} = \text{effective char rate (in./hr.), adjusted for exposure time, } t \]

\[ \beta_n = \text{nominal char rate (in./hr.), linear char rate based on 1-hour exposure} \]

\[ t = \text{exposure time (hr.)} \]
THIRD – OPTIONS FOR FIRE RESISTANCE

Technical Report No. 10 (TR10)

- contains background and examples for the method

Figure 1-1 Reduction in member breadth and depth over time, t
### THIRD – OPTIONS FOR FIRE RESISTANCE

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

<table>
<thead>
<tr>
<th>Required Fire Endurance (hr.)</th>
<th>Effective Char Depths, $a_{\text{char}}$ (in.)</th>
<th>Lamination thicknesses, $h_{\text{lamin}}$ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$5/8$</td>
<td>$3/4$</td>
</tr>
<tr>
<td>1-Hour</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>2-Hour</td>
<td>4.4</td>
<td>4.3</td>
</tr>
</tbody>
</table>
THIRD – OPTIONS FOR FIRE RESISTANCE

Fire-Resistant Design for Wood Construction
THIRD – OPTIONS FOR FIRE RESISTANCE

• **ASTM E119 test:**
  • 5-ply CLT (6-7/8”)
  • Single layer 5/8” Type X wallboard each side
  • Achieved 3 hrs. 6 min.
THIRD – OPTIONS FOR FIRE RESISTANCE
Design for Code Acceptance

Design of Fire-Resistive Exposed Wood Members

Designers, engineers, and fire officials throughout the country recognize the superior fire resistance demonstrated by structural wood beams and columns in actual fires. This document provides a simplified description of a code-approved fire design procedure for exposed wood members. These general fire design provisions are given in Chapter 16 of the 2012 National Design Specifications® for Wood Construction (NDS®), which is referenced in Section 722.1 of the 2012 International Building Code (IBC) as a method of calculating fire resistance of exposed wood members. A more comprehensive discussion of the mechanics-based design procedure can be found in a separate document entitled Designing the Fire Resistance of Exposed Wood Members, Technical Report No. 16 available from the American Wood Council.

Char Rate and Char Depth

Prior to the development of the mechanics-based design procedure presented in this document, the code-accepted method for calculating fire resistance of exposed wood members was based on empirical solutions fit to beam and column test data. The current mechanics-based design procedure presented herein permits the calculation of fire resistance for a greater range of loading conditions, fire exposure, and member sizes. Member design is based on reduced section properties of the residual (uncharred) section, which is determined by subtracting a dimension equal to the effective char depth normal to each exposed surface. Char depth is calculated using an assumed effective char rate that varies non-linearly with respect to time. The effective...
THIRD – OPTIONS FOR FIRE RESISTANCE

- **Methods for establishing fire resistance (703):**
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THIRD – OPTIONS FOR FIRE RESISTANCE

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THIRD – OPTIONS FOR FIRE RESISTANCE

• Protections of connections in the NDS:
  • Section 16.3
  • Protection can be provided by wood or fire-rated gypsum board
THIRD – OPTIONS FOR FIRE RESISTANCE

Figure 3-8 Beam to girder – concealed connection
PRECAUTIONS DURING CONSTRUCTION

• **IBC/IFC Chapters 33:**
  - Fire-fighting vehicle access and water supply (3310 and 3312)
  - Requirements for a fire watch, a fire protection superintendent, and prevention program (3304 and 3308)
  - Extensive hot work and roofing requirements (3304, Chapter 35, and 3317)
  - Fire extinguishers (3309)
  - Standpipes (3311)
  - Temporary heating equipment (3303)
  - Emergency phones (3309)
PRECAUTIONS DURING CONSTRUCTION

www.constructionfiresafety.org
This concludes the American Institute of Architects Continuing Education Systems Course