A New Path Forward for Tall Wood Construction: Code Provisions and Design Steps

Dallas Wood Design Symposium
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New Building Types – IV-A, IV-B, and IV-C

Type IV-A
- 18 stories
- Building height: 270'
- Allowable building area: 972,000 SF
- Average area per story: 54,000 SF
- IBC 2021

Type IV-B
- 12 stories
- Building height: 180 FT
- Allowable building area: 648,000 SF
- Average area per story: 54,000 SF

Type IV-C
- 9 stories
- Building height: 85'
- Allowable building area: 405,000 SF
- Average area per story: 45,000 SF

Type IV-HT
- 6 stories maximum
- Maximum building height: 85'-0" maximum building height
- Maximum area: 324,000 SF

Business Occupancy [Group B]

*Building floor-to-floor heights are shown at 12'-0" for all examples for clarity in comparison between 2015 to 2021 IBC codes.

Credit: Susan Jones, atelierjones
Minimum sizes for existing Type IV (now IV-HT) apply to the new Type IV-A, IV-B and IV-C

See
IBC 2018 2304.11
IBC 2015 602.4
Type IV Minimum Timber Sizes - Framing

<table>
<thead>
<tr>
<th>Framing</th>
<th>Solid Sawn (nominal)</th>
<th>Glulam (actual)</th>
<th>SCL (actual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Columns</td>
<td>8 x 8</td>
<td>6\textsuperscript{3}/\textsubscript{4} x 8\textsuperscript{1/4}</td>
<td>7 x 7\textsuperscript{1/2}</td>
</tr>
<tr>
<td>Beams</td>
<td>6 x 10</td>
<td>5 x 10\textsuperscript{1/2}</td>
<td>5\textsuperscript{3/4} x 9\textsuperscript{1/2}</td>
</tr>
<tr>
<td>Roof</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Columns</td>
<td>6 x 8</td>
<td>5 x 8\textsuperscript{1/4}</td>
<td>5\textsuperscript{3/4} x 7\textsuperscript{1/2}</td>
</tr>
<tr>
<td>Beams*</td>
<td>4 x 6</td>
<td>3 X 6\textsuperscript{7/8}</td>
<td>3\textsuperscript{1/2} X 5\textsuperscript{1/2}</td>
</tr>
</tbody>
</table>

Minimum Width by Depth in Inches
See IBC 2018 2304.11 or IBC 2015 602.4 for Details

*3” nominal width allowed where sprinklered
Type IV Minimum Timber Sizes – Floor/Roof Decks

Floor Panels/Decking:
• 4” thick CLT (actual thickness)
• 4” NLT/DLT/GLT (nominal thickness)
• 3” thick (nominal) decking covered with: 1” decking or 15/32” WSP or ½” particleboard

Roof Panels/Decking:
• 3” thick CLT (nominal thickness)
• 3” NLT/DLT/GLT (nominal thickness)
• 2” decking (nominal thickness)
• 1-1/8” WSP
## Tall Wood Fire Resistance Ratings (FRR)

### Required Fire Resistance Rating in Hours (per Table 601 only)

<table>
<thead>
<tr>
<th>Roof Construction</th>
<th>Primary Frame @ Roof</th>
<th>Floor Construction</th>
<th>Primary Frame</th>
<th>Exterior Bearing Walls</th>
<th>Interior Bearing Walls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.5</td>
<td></td>
<td>1</td>
<td>1</td>
<td>HT</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>HT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>HT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>HT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1 or HT</td>
<td></td>
</tr>
</tbody>
</table>

- **IV-A**
- **IV-B**
- **IV-C**
- **IV-HT**
Noncombustible Protection (NC)

Noncombustible Protection Required

IV-A
IV-B
IV-C
IV-HT

Credit: LEVER Architecture
Credit: PATH Architecture
Photo: Blaine Brownell
The definition of “Noncombustible Protection (For Mass Timber)” is to address the passive fire protection of mass timber.

NONCOMBUSTIBLE PROTECTION (FOR MASS TIMBER)
Noncombustible material, in accordance with Section 703.5, designed to increase the fire-resistance rating and delay the combustion of mass timber.
Noncombustible Protection (NC)

Other Noncombustible materials can qualify by comparative testing per new IBC 703.8

Protection from NC = Tested FRR with NC – Tested FRR without NC

<table>
<thead>
<tr>
<th>Noncombustible Protection</th>
<th>Protection Contribution (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch Type X Gypsum Board</td>
<td>25</td>
</tr>
<tr>
<td>5/8 inch Type X Gypsum Board</td>
<td>40</td>
</tr>
</tbody>
</table>
## Table 722.7.1(a)

**Protection Required from Noncombustible Covering Material**

<table>
<thead>
<tr>
<th>Required Fire Resistance Rating of Building Element per Tables 601 and 602 (hours)</th>
<th>Minimum Protection Required from Noncombustible Protection (minutes)</th>
<th>Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>1 layer 5/8 Type X</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>2 layers 5/8 Type X</td>
</tr>
<tr>
<td>3 or more</td>
<td>120</td>
<td>3 layers 5/8 Type X</td>
</tr>
</tbody>
</table>
Noncombustible Protection

(Non-combustible Protection (NC))

Requirements Per new 602.4. * Some MT permitted to be exposed.

<table>
<thead>
<tr>
<th>Location</th>
<th>60 min</th>
<th>40 min*</th>
<th>Not Req.</th>
<th>Not Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof below Mass Timber</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Frame @ Roof</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Frame</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below Mass Timber Floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above Mass Timber Floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1” Min NC Material</td>
<td>80 min</td>
<td>80 min*</td>
<td>Not Req.</td>
<td>Not Req.</td>
</tr>
<tr>
<td>1” Min NC Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Noncombustible Protection Required**
MT Fire Resistance Ratings (FRR)

IBC 722.7
The fire resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element (MT) added to the protection time of the noncombustible (NC) protection.
# Type IV-C Height and Area Limits

<table>
<thead>
<tr>
<th>Occupancy</th>
<th># of Stories</th>
<th>Height</th>
<th>Area per Story</th>
<th>Building Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2</td>
<td>6</td>
<td>85 ft</td>
<td>56,250 SF</td>
<td>168,750 SF</td>
</tr>
<tr>
<td>B</td>
<td>9</td>
<td>85 ft</td>
<td>135,000 SF</td>
<td>405,000 SF</td>
</tr>
<tr>
<td>M</td>
<td>6</td>
<td>85 ft</td>
<td>76,875 SF</td>
<td>230,625 SF</td>
</tr>
<tr>
<td>R-2</td>
<td>8</td>
<td>85 ft</td>
<td>76,875 SF</td>
<td>230,625 SF</td>
</tr>
</tbody>
</table>

*Areas exclude potential frontage increase*

In most cases, Type IV-C height allowances = Type IV-HT height allowances, but additional stories permitted due to enhanced FRR

Type IV-C area = 1.25 * Type IV-HT area
Type IV-C Protection vs. Exposed

All Mass Timber surfaces may be exposed

Exceptions: Shafts, concealed spaces, outside face of exterior walls

Credit: Susan Jones, atelierjones
### Type IV-A Height and Area Limits

<table>
<thead>
<tr>
<th>Occupancy</th>
<th># of Stories</th>
<th>Height</th>
<th>Area per Story</th>
<th>Building Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2</td>
<td>18</td>
<td>270 ft</td>
<td>135,000 SF</td>
<td>405,000 SF</td>
</tr>
<tr>
<td>B</td>
<td>18</td>
<td>270 ft</td>
<td>324,000 SF</td>
<td>972,000 SF</td>
</tr>
<tr>
<td>M</td>
<td>12</td>
<td>270 ft</td>
<td>184,500 SF</td>
<td>553,500 SF</td>
</tr>
<tr>
<td>R-2</td>
<td>18</td>
<td>270 ft</td>
<td>184,500 SF</td>
<td>553,500 SF</td>
</tr>
</tbody>
</table>

Areas exclude potential frontage increase

**In most cases,** Type IV-A height & story allowances = 1.5 * Type I-B height & story allowances

Type IV-A area = 3 * Type IV-HT area
Type IV-A Protected vs. Exposed

100% NC protection on all surfaces of Mass Timber

Credit: Susan Jones, atelierjones
## Type IV-B Height and Area Limits

<table>
<thead>
<tr>
<th>Occupancy</th>
<th># of Stories</th>
<th>Height</th>
<th>Area per Story</th>
<th>Building Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2</td>
<td>12</td>
<td>180 ft</td>
<td>90,000 SF</td>
<td>270,000 SF</td>
</tr>
<tr>
<td>B</td>
<td>12</td>
<td>180 ft</td>
<td>216,000 SF</td>
<td>648,000 SF</td>
</tr>
<tr>
<td>M</td>
<td>8</td>
<td>180 ft</td>
<td>123,000 SF</td>
<td>369,000 SF</td>
</tr>
<tr>
<td>R-2</td>
<td>12</td>
<td>180 ft</td>
<td>123,000 SF</td>
<td>369,000 SF</td>
</tr>
</tbody>
</table>

Areas exclude potential frontage increase

In most cases, Type IV-B height & story allowances = Type I-B height & story allowances

Type IV-B area = 2 * Type IV-HT area
Type IV-B Protected vs. Exposed

NC protection on all surfaces of Mass Timber except limited exposed areas

~20% of Ceiling or ~40% of Wall can be exposed
Limited Exposed MT allowed in Type IV-B for:

- MT beams and columns which are not integral part of walls or ceilings, no area limitation applies
- MT ceilings and beams up to 20% of floor area in dwelling unit or fire area, or
- MT walls and columns up to 40% of floor area in dwelling unit or fire area, or
- Combination of ceilings/beams and walls/columns

Credit: Kaiser+Path
Horizontal separation of unprotected areas:

• Unprotected portions of mass timber walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.
2021 IBC Section 602.4 added: Cross-laminated timber shall be labeled as conforming to PRG 320 - 18 as referenced in Section 2303.1.4.

**ANNEX B. PRACTICE FOR EVALUATING ELEVATED TEMPERATURE PERFORMANCE OF ADHESIVES USED IN CROSS-LAMINATED TIMBER (MANDATORY)**

Note 7. The intent of the elevated temperature performance evaluation is to identify and exclude use of adhesives that permit CLT char layer fall-off resulting in fire regrowth during the cooling phase of a fully developed fire.
### Noncombustible Protection (NC)

<table>
<thead>
<tr>
<th>Location</th>
<th>IV-A</th>
<th>IV-B</th>
<th>IV-C</th>
<th>IV-HT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof below Mass Timber</td>
<td>60 min</td>
<td>40 min*</td>
<td>Not Req.</td>
<td>Not Req.</td>
</tr>
<tr>
<td>Primary Frame @ Roof</td>
<td>80 min</td>
<td>40 min*</td>
<td>Not Req.</td>
<td>Not Req.</td>
</tr>
<tr>
<td>Primary Frame</td>
<td>120 min</td>
<td>80 min*</td>
<td>Not Req.</td>
<td>Not Req.</td>
</tr>
<tr>
<td>Below Mass Timber Floor</td>
<td>80 min</td>
<td>80 min*</td>
<td>Not Req.</td>
<td>Not Req.</td>
</tr>
<tr>
<td>Above Mass Timber Floor</td>
<td>1” Min NC Material</td>
<td>1” Min NC Material</td>
<td>Not Req.</td>
<td>Not Req.</td>
</tr>
</tbody>
</table>

Requirements Per new 602.4. *Some MT permitted to be exposed.*
In Type IV-A and IV-B, the floor assembly shall contain a noncombustible material not less than one inch in thickness above the mass timber.
Type IV-A and IV-B Example Floor

2 Hour Floor with Required NC Protection

Min. 1” NC

Mass Timber Floor Panel

40 minutes of MT FRR + 2 layers 5/8” type X gypsum

OR

3 layers 5/8” type X gypsum
### Exterior Wall

- **Fire Rating (bearing wall)**
- **Mass Timber**
- **Exterior NC Protection**
- **Interior NC Protection**
- **Light Frame FRTW**

#### Fire Rating

<table>
<thead>
<tr>
<th></th>
<th>IBC 2021</th>
<th>IBC 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Hr</td>
<td>2 Hr</td>
<td>2 Hr</td>
</tr>
<tr>
<td>2 Hr</td>
<td>2 Hr</td>
<td>2 Hr</td>
</tr>
</tbody>
</table>

#### Materials

<table>
<thead>
<tr>
<th></th>
<th>IBC 2021</th>
<th>IBC 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Timber/CLT</td>
<td>4” min thick CLT*</td>
<td>6” Wall*</td>
</tr>
<tr>
<td>40 Min NC &amp; No Exterior Combustible Coverings</td>
<td>FRT Sheathing, Gyp or other NC</td>
<td></td>
</tr>
<tr>
<td>Per Interior Requirements</td>
<td>Not Required</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Yes*</td>
<td>6” Wall*</td>
</tr>
</tbody>
</table>

*Changes in IBC 2015, 2018, and 2021 editions*
**Interior Wall Construction**

### Fire Rating (bearing wall)

- **IV-A**: 3 Hr
- **IV-B**: 2 Hr
- **IV-C**: 2 Hr
- **IV-HT**: 1 Hr or HT*

**Laminated construction 4” thick (CLT, NLT, etc)**
**Solid wood construction min. 2 layers of 1” matched boards**

**NC Protection**

- Per Interior Requirements: No

**Noncombustible non-bearing wall**

- 0 Hr: 1 Hr
- No: 1 Hr

**Wood Stud Wall**

*IBC 2021 requires at least 1 Hr FRR for HT walls supporting 2 levels*
Tall Wood Exit and Hoistway Shaft Enclosures

IV-A  IV-B  IV-C  IV-HT

Fire Resistance
Mass Timber Option

<table>
<thead>
<tr>
<th></th>
<th>2 Hr</th>
<th>2 Hr</th>
<th>2 Hr</th>
<th>1 or 2 Hr FRR per IBC 713.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-A</td>
<td>80 Min NC Protection, inside &amp; outside</td>
<td>80 Min NC Protection, inside &amp; outside</td>
<td>40 Min NC Protection, inside &amp; outside</td>
<td>No NC Protection</td>
</tr>
</tbody>
</table>

Credit: Alex Schreyer
Tall Wood Exit and Hoistway Shaft Enclosures

Fire Resistance

Mass Timber Option

<table>
<thead>
<tr>
<th>IV-A</th>
<th>IV-B</th>
<th>IV-C</th>
<th>IV-HT</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;12 Stories or &gt;180 ft</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2 Hr</th>
<th>2 Hr</th>
<th>2 Hr</th>
<th>2 Hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-A</td>
<td>Not Allowed Noncombustible only</td>
<td>80 Min NC Protection, inside &amp; outside</td>
<td>80 Min NC Protection, inside &amp; outside</td>
<td>40 Min NC Protection, inside &amp; outside</td>
</tr>
<tr>
<td>IV-B</td>
<td>80 Min NC Protection, inside &amp; outside</td>
<td>80 Min NC Protection, inside &amp; outside</td>
<td>40 Min NC Protection, inside &amp; outside</td>
<td>1 or 2 Hr FRR per IBC 713.4</td>
</tr>
<tr>
<td>IV-C</td>
<td>40 Min NC Protection, inside &amp; outside</td>
<td>40 Min NC Protection, inside &amp; outside</td>
<td>40 Min NC Protection, inside &amp; outside</td>
<td>No NC Protection</td>
</tr>
<tr>
<td>IV-HT</td>
<td>1 or 2 Hr FRR per IBC 713.4</td>
<td>1 or 2 Hr FRR per IBC 713.4</td>
<td>1 or 2 Hr FRR per IBC 713.4</td>
<td>No NC Protection</td>
</tr>
</tbody>
</table>

Credit: Alex Schreyer
What is one code requirement of Type IV today that project teams really do not like?

Restrictions on Concealed Spaces
Concealed Spaces in Type IV-A, IV-B

Min. 1” NC

Mass Timber Floor Panel

2 layers 5/8” type X gypsum*

w/o dropped ceiling

2 layers 5/8” type X gypsum

w/ dropped ceiling

*Applicable to most locations. Limited exposed MT permitted in IV-B
Concealed Spaces in Type IV-C

- Mass Timber Floor Panel

**Without Dropped Ceiling**
- No NC req’d

**With Dropped Ceiling**
- 1 layer 5/8” type X gypsum
- No NC req’d
Concealed Spaces in Type IV-HT

Option 1
Sprinklers in concealed spaces

Option 2
Noncombustible insulation

Option 3
5/8” Type X gypsum on all MT surfaces
Many More Items not Covered

- Sealants at panel edges
- Fire safety during construction
- NC protection at occupancy separations
- Reliability of water supply for sprinklers
Tall Wood Buildings in the 2021 IBC
Up to 18 Stories of Mass Timber

Scott Breneman, PhD, SE, WoodWorks – Wood Products Council • Matt Timmers, SE, John A. Martin & Associates
• Dennis Richardson, PE, CBO, Calip, American Wood Council

In January 2019, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (IBC). Based on these proposals, the 2021 IBC will include three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber or noncombustible materials. These new types are based on the previous Heavy Timber construction type (renamed Type IV-HT) but with additional fire-resistance ratings and levels of required noncombustible protection. The code will include provisions for up to 18 stories of Type IV-A construction for Business and Residential Occupancies.

Based on information first published in the Structural Engineers Association of California (SEAOC) 2018 Conference Proceedings, this paper summarizes the background to these proposals, technical research that supported their adoption, and resulting changes to the IBC and product-specific standards.

Background: ICC Tall Wood Building Ad Hoc Committee
Over the past 10 years, there has been a growing interest in tall buildings constructed from mass timber materials (Breneman 2013, Timmers 2015). Around the world there...
This concludes The American Institute of Architects Continuing Education Systems Course

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