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

Presented by Laura Cullen, EIT
Regional Director
GA, MS

WoodWorks
December 6, 2022

The seminar will begin at 3:00 PM EST
Exploring Tall Wood: New Code Provisions for Tall Timber Structures
The What, Why and How of Tall Mass Timber
TALL MASS TIMBER
ASSESSING THE WHAT
BROCK COMMONS, BRITISH COLUMBIA

18 STORIES | 174 FT
INTRO, CLEVELAND

9 Stories | 115 ft
8 Timber Over 1 Podium

512,000 SF
297 Apartments, Mixed-Use

Photo: Harbor Bay Real Estate Advisors, Purple Film | Architect: Hartshorne Plunkard Architecture
INTRO, CLEVELAND

Type IV-B
Variance to expose ~50% ceilings

9 Stories | 115 ft
8 Timber Over 1 Podium

Photo: Harbor Bay Real Estate Advisors, Image Fiction | Architect: Hartshorne Plunkard Architecture
ASCENT, MILWAUKEE

493,000 SF
259 APARTMENTS, MIXED-USE

Photo: Korb & Associates Architects | Architect: Korb & Associates Architects
ASCENT, MILWAUKEE

Tallest Mass Timber Building in the World

Photo: CD Smith Construction | Architect: Korb & Associates Architects
ASCENT, MILWAUKEE

25 STORIES

19 TIMBER OVER 6 PODIUM, 284 FT

Photo: Korb & Associates Architects | Architect: Korb & Associates Architects
3 STORY VERTICAL ADDITION
7 STORY EXISTING BUILDING
80 M ST, WASHINGTON, DC

100,000 SF
2 NEW LEVELS OF CLASS A OFFICE SPACE
OCCUPIED PENTHOUSE
17’-0” CEILING HEIGHTS
TALL MASS TIMBER
UNDERSTANDING THE WHY
Global Population Increase

2019 = 7.7 billion people

2050 = 11.2 billion people

Source: https://ourworldindata.org/future-population-growth
### US URBAN POPULATION BOOM

#### Population (millions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Urban</th>
<th>Rural</th>
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<tbody>
<tr>
<td>2019</td>
<td>271.4 M</td>
<td>57.7 M</td>
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<tr>
<td>2030</td>
<td>301 M</td>
<td>53.7 M</td>
</tr>
<tr>
<td>2050</td>
<td>347.3 M</td>
<td>42.2 M</td>
</tr>
</tbody>
</table>
New Buildings & Greenhouse Gasses

Buildings generate nearly 40% of annual global greenhouse gas emissions (*building operations + embodied energy*)

Embodied Energy (11%): Concrete, iron + steel produce approximately 9% of this (Architecture 2030)

Carbon Storage
Wood ≈ 50% Carbon (dry weight)
Biophilic Design, Connection to Forests
Construction Impacts: Labor Availability

Photo: Lendlease
Tall Mass Timber: Structural Warmth is a Value-Add
TALL MASS TIMBER
DEMONSTRATING THE HOW
Glue Laminated Timber (Glulam)
Beams & columns

Cross-Laminated Timber (CLT)
Solid sawn laminations

Cross-Laminated Timber (CLT)
SCL laminations

Photo: StructureCraft

Photo: LendLease

Photo: Freres Lumber

Photo: LEVER Architecture
Glue Laminated Timber (GLT)
Glue Laminated Timber (GLT)
Cross-Laminated Timber (CLT)
Cross-Laminated Timber (CLT)

With solid sawn laminations

General Panel thicknesses*
4 1/8” to 19 1/2”

General Panel dimensions*
4 to 12 ft wide
24 to 64 ft long

*Consult with manufacturers for available panel sizes
Cross-Laminated Timber (CLT)

With SCL laminations

Photos: Freres Lumber
Nail-Laminated Timber (NLT)
Nail-Laminated Timber (NLT)
Dowel-Laminated Timber (DLT)

Photo: StructureCraft
Other Mass Timber Product Options

- Glue Laminated Timber (GLT)
- Laminated Veneer Lumber (LVL)
- Parallel Strand Lumber (PSL)
- Laminated Strand Lumber (LSL)
- Timber-Concrete Composite (TCC)
- Decking

Photos: StructureCraft
STRUCTURAL SOLUTIONS | POST + PLATE
STRUCTURAL SOLUTIONS | HYBRID STEEL + MASS TIMBER
Know The Supply Chain

Efficiency found in understanding supply chain, designing according to its capabilities.
TALL WOOD IN THE CODE
2018 IBC and All Previous Editions:

» Prescriptive Code Limit - 6 stories (B occupancy) or 85 feet

» Over 6 Stories - Alternate Means and Methods Request (AMMR) through performance based design

» Based on the 1910 Heights and Areas Act
3 YEAR CODE CYCLE

Source: ICC
Seen as the catalyst for the mass timber revolution, CLT first recognized in US codes in the 2015 IBC

**[BS] CROSS-LAMINATED TIMBER.** A prefabricated engineered wood product consisting of not less than 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 in accordance with ANSI/APA PRG 320.
Interest in tall wood projects in the US was rapidly increasing. Some building officials were reluctant to approved proposed plans, primarily due to lack of code direction and precedent.
In December 2015, the ICC Board established the ICC Ad Hoc Committee on Tall Wood Buildings. Objectives:
1. Explore the building science of tall wood buildings
2. Investigate the feasibility, and
3. Take action on developing code changes for tall wood buildings.
Tests on exposed mass timber, gypsum-covered mass timber; normal sprinkler protection, delayed sprinkler protection
Majority of flames seen are from contents, not structure
TALL WOOD APPROVED!
Unofficial results posted Dec 19, 2018
Final votes ratified Jan 31, 2019

AWC: Tall Mass Timber code changes get final approval
Dec 19, 2018

LEESBURG, VA. – The International Code Council (ICC) has released the unofficial voting results on code change proposals considered in 2018, including passage of the entire package of 14 tall mass timber code change proposals. The proposals create three new types of construction (Types IV-A, IV-B and IV-C), which set fire safety requirements, and allowable heights, areas and number of stories for tall mass timber buildings. Official results are expected to be announced during the first quarter of 2019. The new provisions will be included in the 2021 International Building Code (IBC).

“Mass timber has been capturing the imagination of architects and developers, and the ICC result means they can now turn sketches into reality. ICC’s rigorous study, testing and voting process now opens new opportunities for mass and modular construction. Traditional tall building materials used by the building
SO, WHAT’S CHANGED??

Since its debut, IBC has contained 9 construction type options
5 Main Types (I, II, III, IV, V) with all but IV having sub-types A and B

<table>
<thead>
<tr>
<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>A</td>
<td>A</td>
<td>A</td>
<td>HT</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>
2021 IBC Introduces 3 new tall wood construction types:
IV-A, IV-B, IV-C
Previous type IV renamed type IV-HT
New Building Types

Credit: Susan Jones, atelierjones
Tall Wood Buildings in the 2021 IBC
Up to 18 Stories of Mass Timber

Scott Brennan, PhD, SE, WoodWorks – Wood Products Council
Matt Timmers, SE, John A. Martin & Associates
Dennis Richardson, PE, CBDS, CAGC, 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-HTI) 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 (Brennan 2013, Timmers 2015). Around the world there

WoodWorks Tall Wood Design Resource
TALL TIMBER CODE ADOPTION
2019-2020 Regular Session - HB 777
Community Affairs, Department of; consider amending the state minimum standard codes to allow tall mass timber construction types; direct

Sponsored By
(1) Corbett, John 174th
(2) Burns, Jon 159th
(3) McCall, Tom 33rd
(4) England, Terry 116th
(5) Smith, Lynn 70th
(6) LaRiccia, Dominic 169th

Sponsored In Senate By
Wilkinson, John 50th

Committees
HC: Agriculture & Consumer Affairs
SC: Agriculture and Consumer Affairs

First Reader Summary
A BILL to be entitled an Act to amend Chapter 2 of Title 8 of the Official Code of Georgia Annotated, relating to standards and requirements for construction, alteration, etc., of buildings and other structures, so as to direct the Department of Community Affairs to undertake a review of the 2021 edition of the International Building Code so as to consider amending the state minimum standard codes to allow tall mass timber construction types; to provide a date by which said review is to be completed; to provide for related matters; to repeal conflicting laws; and for other purposes.

Status History
Jul/01/2020 - Effective Date

Approved November 9, 2021;
effective date of January 1, 2022
North Carolina

- Statewide code is 2018 North Carolina Building Code (based upon 2015 IBC)
- Existing code cycle is 6 years – next NCSBC is 2024 (based upon 2021 IBC)
- Various appointed committees are now reviewing 2021 IBC language for submittal and impact assessment by the NC State Building Code Council
- Released for public comment and feedback
- Final revisions in place for statewide implementation by 1/1/24
South Carolina

• Statewide code is 2018 South Carolina Building Code (based upon 2018 IBC)

• It is anticipated that the Building Code Council will consider the 2021 International Codes for adoption beginning the fall of 2020 or spring of 2021

• Adoption of 2021 IBC codes expected in late 2022

• Changes proposed would be effective January 1st, 2023

Note- all dates are subject to change

Lynch Associates Architects
Tall Timber Construction Types

Credit: Susan Jones, atelierjones
Type IV-C

Credit: Susan Jones, atelierjones

Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman
## 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 add’l 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

Credit: Kaiser+Path, Ema Peter
All timber surfaces may be exposed
Type IV-B

12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000 SF

Credit: Susan Jones, atelierjones

Credit: LEVER Architecture
# 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 Protection vs. Exposed

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

~20% of Ceiling or ~40% of Wall can be exposed
Some timber surfaces may 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, calculated as follows:
Mixed unprotected areas, exposing both ceilings and walls:

- In each dwelling unit or fire area, max. unprotected area = 
  \[(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1.0\]

- \(U_{tc}\) = Total unprotected MT ceiling areas
- \(U_{ac}\) = Allowable unprotected MT ceiling areas
- \(U_{tw}\) = Total unprotected MT wall areas
- \(U_{aw}\) = Allowable unprotected MT wall areas
Design Example: Mixing unprotected MT walls & ceilings

800 SF dwelling unit

- $U_{ac} = (800 \text{ SF}) \times (0.20) = 160 \text{ SF}$
- $U_{aw} = (800 \text{ SF}) \times (0.40) = 320 \text{ SF}$
- Could expose 160 SF of MT ceiling, OR 320 SF of MT Wall, OR
- If desire to expose 100 SF of MT ceiling in Living Room, determine max. area of MT walls that can be exposed
Type IV-B Protection vs. Exposed

Design Example: Mixing unprotected MT walls & ceilings

\[
\frac{(U_{tc}/U_{ac})}{(100/160)} + \frac{(U_{tw}/U_{aw})}{(U_{tw}/320)} \leq 1.0
\]

\[U_{tw} = 120 \text{ SF}\]

- Can expose 120 SF of MT walls in dwelling unit in combination with exposing 100 SF of MT ceiling

Credit: AWC
Type IV-B Protection vs. Exposed

Credit: AWC

IV-B

Ceiling Exposed (20% max)
Type IV-B Protection vs. Exposed

Credit: AWC
Type IV-B Protection vs. Exposed

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.

Credit: Kaiser+Path
Type IV-B Protection vs. Exposed

Credit: AWC
2024 IBC Changes
Type IV-A

18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

Credit: Susan Jones, atelierjones

Photos: Structurlam, naturally:wood, Fast + Epp
## 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 Protection vs. Exposed

100% NC protection on all surfaces of Mass Timber

Credit: Susan Jones, atelierjones
No timber surfaces may be exposed
# Tall Wood Building Size Limits

## Construction Type (All Sprinklered Values)

<table>
<thead>
<tr>
<th>Occupancies</th>
<th>Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)</th>
<th>Allowable Number of Stories above Grade Plane (IBC Table 505.4)</th>
<th>Allowable Area Factor (At) for SM, Feet$^2$ (IBC Table 506.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, R</td>
<td>Unlimited</td>
<td>180</td>
<td><strong>270</strong></td>
</tr>
</tbody>
</table>
## Tall Wood Building Size Limits

<table>
<thead>
<tr>
<th>Construction Type (Unsprinklered Values)</th>
<th>I-A</th>
<th>I-B</th>
<th>IV-A</th>
<th>IV-B</th>
<th>IV-C</th>
<th>IV-HT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Occupancies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A, B, R</td>
<td>Unlimited</td>
<td>160</td>
<td>65</td>
<td>65</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>A-2, A-3, A-4</td>
<td>Unlimited</td>
<td>11</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>Unlimited</td>
<td>11</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>R-2</td>
<td>Unlimited</td>
<td>11</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-2, A-3, A-4</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>45,000</td>
<td>30,000</td>
<td>18,750</td>
<td>15,000</td>
</tr>
<tr>
<td>B</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>108,000</td>
<td>72,000</td>
<td>45,000</td>
<td>36,000</td>
</tr>
<tr>
<td>R-2</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>61,500</td>
<td>41,000</td>
<td>25,625</td>
<td>20,500</td>
</tr>
</tbody>
</table>

Even so, Sprinklers may be required by 903.2 (all occupancies) and definitely for residential (420.4)
## Tall Wood Building Size Limits

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>A, B, R</td>
<td>Unlimited</td>
<td>160</td>
<td>11</td>
</tr>
<tr>
<td>A-2, A-3, A-4</td>
<td>65</td>
<td>65</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>65</td>
<td>65</td>
<td>3</td>
</tr>
<tr>
<td>R-2</td>
<td>65</td>
<td>65</td>
<td>3</td>
</tr>
</tbody>
</table>

Even so, Sprinklers may be required by 903.2 (all occupancies) and definitely for residential (420.4)

In almost all cases, sprinklers will be required.
# Non-Tall Opportunities – Large Area

<table>
<thead>
<tr>
<th>Occupancies</th>
<th>Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)</th>
<th>Allowable Number of Stories above Grade Plane (IBC Table 505.4)</th>
<th>Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, R</td>
<td>180, 270, 180, 85</td>
<td>12, 18, 12, 6, 4, 4</td>
<td>135,000, 90,000, 56,250, 45,000</td>
</tr>
<tr>
<td>A-2, A-3, A-4</td>
<td>12, 18, 12</td>
<td>12, 18, 8, 5, 5</td>
<td>324,000, 216,000, 135,000, 108,000</td>
</tr>
<tr>
<td>B</td>
<td>12, 18, 12</td>
<td>12, 8, 5, 5</td>
<td>184,500, 123,000, 76,875, 61,500</td>
</tr>
<tr>
<td>R-2</td>
<td>12, 18, 12</td>
<td>12, 8, 5, 5</td>
<td></td>
</tr>
</tbody>
</table>
What’s the ‘Sweet Spot’ for Tall Mass Timber?

Depends on many factors:

• Project Use
• Site Constraints
• Local Zoning & FAR Limitations
• Budget
• Client Objectives for Sustainability, Exposed Timber
• And More...

But Some General Trends Could Be:
**Type IV-C Tall Mass Timber**

**Example R-2, Type IV-C Building**

<table>
<thead>
<tr>
<th>8 Stories</th>
<th>85 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>76,875 SF</td>
<td>max per floor</td>
</tr>
<tr>
<td>230,625 SF bldg.</td>
<td></td>
</tr>
</tbody>
</table>

- Not Likely to Utilize Podium Due to Overall Building Height Limit (85 ft) Relative to # of Timber Stories (8)
- Same Overall Building Height Limit as IV-HT (85 ft) but higher Fire-Resistance Ratings Req’d
- 3 Additional Stories Permitted Compared to IV-HT
- All Timber Exposed
Type IV-B Tall Mass Timber

- Timber, R-2: 12 Stories
- 123,000 SF max per floor
- 369,000 SF bldg.
  (areas noted assume no frontage increase)

Example Mixed-Use, Type IV-B Building

Likely to Utilize Podium Due to Overall Building Height Limit (180 ft) Relative to # of Timber Stories (12)

Same Fire-Resistance Ratings Req’d as IV-C But Limitations on Timber Exposed

4 Additional Stories Permitted Compared to IV-C

Limited Timber Exposed
Type IV-A Tall Mass Timber

Example Mixed-Use, Type IV-A Building

- Likely to Utilize Podium Due to Overall Building Height Limit (270 ft) Relative to # of Timber Stories (18)
- Higher Fire-Resistance Ratings Req’d than IV-B For Primary Frame
- 6 Additional Stories Permitted Compared to IV-B
- No Exposed Timber Permitted

Timber, R-2:
18 Stories
184,500 SF max per floor
553,500 SF bldg.
(areas noted assume no frontage increase)

Multi-Story Type IA Podium

270 ft Grade to Roof
Materials Permitted

**602.4 Type IV.** Type IV construction is that type of construction in which the building elements are mass timber or noncombustible materials and have fire resistance ratings in accordance with Table 601. Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both and shall be determined in accordance with Section 703.2 or 703.3. The minimum dimensions and permitted materials for building elements shall comply with the provisions of this section and Section 2304.11. Mass timber exterior load-bearing walls and nonload-bearing walls shall be mass timber construction, or shall be of noncombustible construction.

**Exception:** Type IV-HT Construction in accordance with Section 602.4.4.

The interior building elements, including nonload-bearing walls and partitions, shall be of mass timber construction or of noncombustible construction.

**Exception:** Type IV-HT Construction in accordance with Section 602.4.4.
MT Type IV Minimum Sizes

In addition to meeting FRR, all MT elements must also meet minimum sizes.

These minimum sizes have been in place for old type IV (current type IV-HT) construction and the same minimums sizes also apply to MT used in new types IV-A, IV-B and IV-C.

Contained in IBC 2304.11
### Type IV Minimum 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(\frac{3}{4}) x 8(\frac{3}{4})</td>
<td>7 x 7(\frac{1}{2})</td>
</tr>
<tr>
<td>Beams</td>
<td>6 x 10</td>
<td>5 x 10(\frac{1}{2})</td>
<td>5(\frac{1}{4}) x 9(\frac{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(\frac{1}{4})</td>
<td>5(\frac{1}{4}) x 7(\frac{1}{2})</td>
</tr>
<tr>
<td>Beams*</td>
<td>4 x 6</td>
<td>3 X 6(\frac{7}{8})</td>
<td>3(\frac{1}{2}) X 5(\frac{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 Sizes – Floor/Roof Panels

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
MT Type IV Minimum Sizes – Walls

Exterior Walls for Type IV-A B C
• CLT or Non-combustible

Exterior Walls for Type IV-HT
• CLT or FRTW or Non-combustible
• IBC 2018 - 6” Thick Wall (FRTW or CLT)
• IBC 2021 - 4” Thick CLT
MT Type IV Minimum Sizes – Walls

MT Interior Walls in all Type IV:
• Laminated construction 4” thick
• Solid wood construction min. 2 layers of 1” matched boards

Other Interior Walls in Type IV A,B,C
• Non-combustible (0 hr for nonbearing)

Other Interior Walls in Type IV HT
• Non-combustible (1 hr min)
• Wood stud wall (1 hr min)

Verify other code requirements for FRR (eg. interior bearing wall; occupancy separation)
**Interior Wall Construction Recap**

<table>
<thead>
<tr>
<th>Fire Rating (bearing wall)</th>
<th>3 Hr</th>
<th>2 Hr</th>
<th>2 Hr</th>
<th>1 Hr or HT*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction – MT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC Protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noncombustible non-bearing wall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Stud Wall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Per Interior Requirements

<table>
<thead>
<tr>
<th>0 Hr</th>
<th>1 Hr</th>
</tr>
</thead>
</table>

*IBC 2021 requires at least 1 Hr FRR for HT walls supporting 2 levels*
### Exterior Wall Construction Recap

#### Fire Rating (bearing wall)

<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>Mass Timber</td>
<td>Mass Timber/CLT</td>
<td>4” min thick CLT*</td>
</tr>
<tr>
<td>Exterior NC Protection</td>
<td>6” Wall*</td>
<td></td>
</tr>
<tr>
<td>Interior NC Protection</td>
<td>FRT Sheathing, Gyp or other NC</td>
<td></td>
</tr>
<tr>
<td>Light Frame FRTW</td>
<td>Per Interior Requirements</td>
<td>Not Required</td>
</tr>
</tbody>
</table>

*Changes in IBC 2015, 2018, and 2021 editions*
### Tall Wood Fire Resistance Ratings (FRR)

#### FRR Requirements for Tall Mass Timber Structures (hours)

<table>
<thead>
<tr>
<th>Building Element</th>
<th>IV-A</th>
<th>IV-B</th>
<th>IV-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Frame</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Exterior Bearing Walls</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Interior Bearing Walls</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Roof Construction</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Primary Frame at Roof</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Floor Construction</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

*Source: 2021 IBC Table 601*
Noncombustible Protection (NC)

Where timber is required to be protected, NC must contribute at least 2/3 FRR

Required Noncombustible Contribution to FRR

<table>
<thead>
<tr>
<th>FRR of Building Element (hours)</th>
<th>Minimum from Noncombustible Protection (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
</tr>
<tr>
<td>3 or more</td>
<td>120</td>
</tr>
</tbody>
</table>

Source: 2021 IBC Section 722.7
Noncombustible Protection (NC)

The definition of “Noncombustible Protection (For Mass Timber)” is created to address the passive fire protection of mass timber.

Mass timber is permitted to have its own fire-resistance rating (e.g., Mass Timber only) or have a fire resistance rating based on the fire resistance through a combination of the mass timber fire-resistance plus protection by non-combustible materials as defined in Section 703.5 (e.g., additional materials that delay the combustion of mass timber, such as gypsum board).
# Noncombustible Protection (NC)

## Prescriptive Noncombustible Contributions to FRR

<table>
<thead>
<tr>
<th>Type of Protection</th>
<th>Contribution per Layer (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; Type X gypsum board</td>
<td>25</td>
</tr>
<tr>
<td>5/8&quot; Type X gypsum board</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: 2021 IBC Section 722.7.1

## Required Noncombustible Contribution to FRR

<table>
<thead>
<tr>
<th>FRR of Building Element (hours)</th>
<th>Minimum from Noncombustible Protection (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
</tr>
<tr>
<td>3 or more</td>
<td>120</td>
</tr>
</tbody>
</table>

1 layer 5/8 Type X
2 layers 5/8 Type X
3 layers 5/8 Type X

Source: 2021 IBC Section 722.7
Min. 1” thick NC protection required on mass timber floors in IV-A and IV-B. Not required in IV-C
## Noncombustible Protection

### Requirements Per new 602.4.

<table>
<thead>
<tr>
<th>Category</th>
<th>Time 1</th>
<th>Time 2</th>
<th>Requirement</th>
<th>Requirement</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>

* Some MT permitted to be exposed.
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.
MT Fire Resistance Ratings (FRR)

However, FRR Doesn’t always need to be from a combination of MT + NC. In some cases, just NC can be used, in other cases, just MT can be used:

IBC 602.4
Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both.
Type IV-A Fire Resistance Ratings (FRR)

Primary Frame (3-hr) + Floor Panel Example (2-hr):

- Minimum 1" noncombustible material
- Mass timber floor panel
- 40 minutes of MT FRR
- Two layers 5/8" Type X gypsum
- Glulam beam (primary structural frame)
- 60 minutes of MT FRR
- Three layers 5/8" Type X gypsum
Type IV-B Fire Resistance Ratings (FRR)

Primary Frame (2-hr) + Floor Panel (2-hr)

Minimum 1" noncombustible material
Mass timber floor panel
40 minutes of MT FRR
2 layers 5/8" Type X gypsum
Glulam beam (primary structural frame)
40 minutes of MT FRR
Two layers 5/8" Type X gypsum
Primary Frame (2-hr) + Floor Panel Example (2-hr)

- Minimum 1" noncombustible material
- Mass timber floor panel
- 2-hr of MT FRR; noncombustible material not required
- Glulam beam (primary structural frame)
- 2-hr of MT FRR; Noncombustible material not required
Type IV-C Fire Resistance Ratings (FRR)

Primary Frame (2-hr) + Floor Panel Example (2-hr)

Noncombustible material not required

Mass timber floor panel

2-hr of MT FRR; noncombustible material not required

Glulam beam (primary structural frame)

2-hr of MT FRR; Noncombustible material not required
How do you determine FRR of MT?

2 Options:
1. Calculations in Accordance with IBC 722 → NDS Chapter 16
2. Tests in Accordance with ASTM E119
MT FRR Calculations Method:
• IBC 703.3 allows several methods of determining FRR. One is calculations per 722.
• 722.1 refers to NDS Chpt 16 for exposed wood FRR

703.3 Methods for determining fire resistance. The application of any of the methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E119 or UL 263. The required fire resistance of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures:

3. Calculations in accordance with Section 722.
MT Fire Resistance Ratings (FRR)

NDS Chapter 16 includes calculation of fire resistance of NLT, CLT, Glulam, Solid Sawn and SCL wood products

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

<table>
<thead>
<tr>
<th>Required Fire Endurance (hr.)</th>
<th>Effective Char Depths, $a_{\text{char}}$ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lamination thicknesses, $h_{\text{lam}}$ (in.)</td>
</tr>
<tr>
<td></td>
<td>5/8  3/4  7/8  1  1-1/4  1-3/8  1-1/2  1-3/4  2</td>
</tr>
<tr>
<td>1-Hour</td>
<td>2.2  2.2  2.1  2.0  2.0  1.9  1.8  1.8  1.8</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>3.4  3.2  3.1  3.0  2.9  2.8  2.8  2.8  2.6</td>
</tr>
<tr>
<td>2-Hour</td>
<td>4.4  4.3  4.1  4.0  3.9  3.8  3.6  3.6  3.6</td>
</tr>
</tbody>
</table>

Credit: FPInnovations
Nominal char rate of 1.5”/HR is recognized in NDS. Effective char depth calculated to account for duration, structural reduction in heat-affected zone.
MT Fire Resistance Ratings (FRR)

Structural capacity check performed on remaining section, with stress increases

Solid Sawn, Glulam, SCL

CLT

Effective Char Depth

\[ a_{\text{char}} = \beta_I t^{0.813} \]

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

\[ a_{\text{eff}} = 1.2 a_{\text{char}} \]
## FRR Design of MT

WoodWorks Inventory of Fire Tested MT Assemblies

### Table 1: North American Fire Resistance Tests of Mass Timber Floor / Roof Assemblies

<table>
<thead>
<tr>
<th>CLT Panel</th>
<th>Manufacturer</th>
<th>CLT Grade or Major x Minor Grade</th>
<th>Ceiling Protection</th>
<th>Panel Connection in Test</th>
<th>Floor Topping</th>
<th>Load Rating</th>
<th>Fire Resistance Achieved (Hours)</th>
<th>Source</th>
<th>Testing Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-ply CLT</td>
<td>Nordic</td>
<td>SPF 16/50 ft 3.5EMR x SPF #3</td>
<td>2 layers 1/2&quot; Type X gypsum</td>
<td>Half-Lap &amp; Topside Splice</td>
<td>None</td>
<td>Reduced 160 Min. Capacity</td>
<td>1</td>
<td>1 (Test 1) NRC Fire Laboratory</td>
<td></td>
</tr>
<tr>
<td>3-ply CLT</td>
<td>Strochem</td>
<td>SPF #3/2 x SPF #1/2</td>
<td>1 layer 3/8&quot; Type X gypsum under E-channel and barring strips with 5/8&quot; fiberglass</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 75 Min. Capacity</td>
<td>1</td>
<td>1 (Test 2) NRC Fire Laboratory</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Nordic</td>
<td>EI</td>
<td>None</td>
<td>Topside Splice</td>
<td>2 staggered layers of 1/2&quot; cement board</td>
<td>Loaded, See Manufacturer</td>
<td>2</td>
<td>2</td>
<td>NRC Fire Laboratory March 2016</td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Nordic</td>
<td>EI</td>
<td>None</td>
<td>Topside Splice</td>
<td>2 staggered layers of 1/2&quot; cement board</td>
<td>Loaded, See Manufacturer</td>
<td>2</td>
<td>3</td>
<td>NRC Fire Laboratory Nov 2014</td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Nordic</td>
<td>EI</td>
<td>None</td>
<td>Topside Splice</td>
<td>3/4&quot; ins proprietary gypsum over Mass or acoustical mat</td>
<td>Reduced 50 Min. Capacity</td>
<td>1.5</td>
<td>3</td>
<td>UL</td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Nordic</td>
<td>EI</td>
<td>None</td>
<td>Topside Splice</td>
<td>3/4&quot; ins proprietary gypsum over Mass or acoustical mat or proprietary wood board</td>
<td>Reduced 50 Min. Capacity</td>
<td>2</td>
<td>4</td>
<td>UL</td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Nordic</td>
<td>EI</td>
<td>1 layer 3/8&quot; ins. &amp; 1 layer 3/8&quot; normal gypsum</td>
<td>Half-Lap &amp; Topside Splice</td>
<td>None</td>
<td>Reduced 50 Min. Capacity</td>
<td>2</td>
<td>21</td>
<td>InterTek 8/24/2012</td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Nordic</td>
<td>EI</td>
<td>None</td>
<td>Topside Splice</td>
<td>1-1/2&quot; Meets on Type-IV over Meets on Reinforcing Mesh</td>
<td>Loaded, See Manufacturer</td>
<td>2.5</td>
<td>6</td>
<td>InterTek, 2/2/2016</td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Nordic</td>
<td>EI</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 50 Min. Capacity</td>
<td>2</td>
<td>1 (Test 5) NRC Fire Laboratory</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Strochem</td>
<td>EI</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Unreduced 100% Min. Capacity</td>
<td>2</td>
<td>1 (Test 6) NRC Fire Laboratory</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Strochem</td>
<td>EI</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Unreduced 100% Min. Capacity</td>
<td>2.5</td>
<td>1 (Test 7) NRC Fire Laboratory</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Smartlam</td>
<td>SI-V8</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 1/2&quot; plywood with 6d nails</td>
<td>2</td>
<td>12 (Test 8) Western Fire Center 10/26/2016</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Smartlam</td>
<td>VI</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 1/2&quot; plywood with 6d nails</td>
<td>2</td>
<td>12 (Test 8) Western Fire Center 10/28/2016</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>Smartlam</td>
<td>VI</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 1/2&quot; plywood with 6d nails</td>
<td>2</td>
<td>12 (Test 8) Western Fire Center 11/01/2016</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>KLI</td>
<td>CV301</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 1/2&quot; plywood with 6d nails</td>
<td>1</td>
<td>18</td>
<td>SwRI</td>
</tr>
</tbody>
</table>
Mass Timber Fire Design Resource

- Code compliance options for demonstrating FRR
- Free download at woodworks.org
What if I have a dropped ceiling? Can I have a dropped ceiling?
• Impact on FRR, NC placement, sprinkler requirements
Concealed Spaces in Type IV-A, IV-B

Without Dropped Ceiling

Minimum 1" noncombustible material
Mass timber floor panel
Two layers 5/8" Type X gypsum*

*Applicable to most locations; limited exposed mass timber permitted in IV-B

With Dropped Ceiling

Minimum 1" noncombustible material
Mass timber floor panel
Two layers 5/8" Type X gypsum
Dropped ceiling
Concealed Spaces in Type IV-C

**Without Dropped Ceiling**
- Noncombustible material not required
- Mass timber floor panel
- Noncombustible material not required

**With Dropped Ceiling**
- Noncombustible material not required
- Mass timber floor panel
- One layer 5/8" Type X gypsum covering all mass timber surfaces within concealed space
- Dropped ceiling
Concealed Spaces in Mass Timber and Heavy Timber Structures

Concealed spaces, such as those created by a dropped ceiling in a floor-ceiling assembly or by a stud wall assembly, have unique requirements in the International Building Code (IBC) to address the potential of fire spread in non-visible areas of a building. Section 718 of the 2018 IBC includes prescriptive requirements for protection and/or compartmentalization of concealed spaces through the use of drip or drip spacing, fire blocking, sprinkler, and other means. For information on these requirements, see the WoodWorks Q&A: Are appliances required in concealed spaces such as floor and roof cavities in multi-family wood-frame buildings?

For mass timber building elements, the choice of construction type can have a significant impact on concealed space requirements. Because mass timber products such as cross-laminated timber (CLT) are prescriptive recognized for Type IV construction, there is a common misconception that exposed mass timber building elements cannot be used or exposed in other construction types. This is not the case. In addition to Type IV buildings, structural mass timber elements—including CLT, glued-laminated timber (glulam), nail-laminated timber (NLT), structural composite lumber (SCL), and tongue-and-groove (T&G) siding—can be utilized and exposed in the following construction types, whether or not a fire resistance rating is required:

- **Type III** - Floors, roofs and interior walls may be any material permitted by code, including mass timber; exterior walls are required to be noncombustible or fire-retardant-treated wood.
- **Type V** - Floors, roofs, interior walls, and exterior walls (i.e., entire structural may be constructed of mass timber).
- **Types I and II** - Mass timber may be used in selected circumstances such as roof construction—including the primary frame in the 2021 IBC—by Types I, II-A, or II-B; exterior columns and arches when 20 feet or more of horizontal separation is provided, and balconies, canopies and similar projections.
Structural Grid
Structural Grid

Grids & Spans

- Consider Efficient Layouts
- Repetition & Scale
- Manufacturer Panel Sizing
- Transportation
Structural Grid

Grids & Spans

• Consider Efficient Layouts
• Repetition & Scale
• Manufacturer Panel Sizing
• Transportation

24’-6” 26’-2” 24’-6” 40’-0”

14’-0”

26’-0”

26’-0”

26’-0”
Structural Grid

Member Sizes

- Impact of FRR on Sizing
- Impact of Sizing on Efficient Spans
- Consider connections – can drive member sizing

0 HR FRR: Consider 3-ply Panel

- Efficient Spans of 10-12 ft
- Grids of 20x20 (1 purlin) to 30x30 (2 purlins) may be efficient

Platte Fifteen, Denver, CO
30x30 Grid, 2 purlins per bay
3-ply CLT
Image: JC Buck
Structural Grid

Member Sizes
• Impact of FRR on Sizing
• Impact of Sizing on Efficient Spans
• Consider connections – can drive member sizing

1 or 2 HR FRR: Likely 5-ply Panel
• Efficient spans of 14-17 ft
• Grids of 15x30 (no purlins) to 30x30 (1 purlin) may be efficient
MEP Layout & Integration
MEP Layout & Integration

Set Realistic Owner Expectations About Aesthetics
• MEP fully exposed with MT structure, or limited exposure?
MEP Layout & Integration

Smaller grid bays at central core (more head height)
• Main MEP trunk lines around core, smaller branches in exterior bays
MEP Layout & Integration

Smaller grid bays at central core

Main MEP trunk lines around core

Smaller branches in exterior bays
MEP Layout & Integration

In chases above beams and below panels at Catalyst
- 30x30 grid, 5-ply CLT ribbed beam system

Credit: Hans-Erik Blomgren
MEP Layout & Integration

Dropped below MT framing
• Can simplify coordination (fewer penetrations)
• Bigger impact on head height
MEP Layout & Integration

In penetrations through MT framing
- Requires more coordination (penetrations)
- Bigger impact on structural capacity of penetrated members
- Minimal impact on head height
MEP Layout & Integration

In chases above beams and below panels
- Fewer penetrations
- Bigger impact on head height (overall structure depth is greater)
- FRR impacts: top of beam exposure
LATERAL SYSTEMS IN TALL WOOD
INTRO, CLEVELAND
Concrete Core Shearwalls

Photo: Panzica Construction
ASCENT, MILWAUKEE
Concrete Core Shearwalls

Photos: Korb + Associates, Thornton Tomasetti
FUTURE POTENTIAL LATERAL SYSTEM FOR TALL WOOD

Mass Timber Rocking Shearwalls

Image: KPFF

Photo: WoodWorks
CONSIDERATIONS FOR LATERAL SYSTEMS

Prescriptive Code Compliance

Concrete Shearwalls ✓
Steel Braced Frames ✓
CLT Shearwalls (65 ft max) ✓
CLT Rocking Walls ✗

Photo: WoodWorks

ASCE 7-22
CONSIDERATIONS FOR LATERAL SYSTEMS

Connections to concrete core
- Tolerances & adjustability
- Drag/collector forces
CONSIDERATIONS FOR LATERAL SYSTEMS

Connections to steel frame
- Tolerances & adjustability
- Ease of installation

Photos: Marcus Kauffmann, ODF
CONNECTIONS IN TALL WOOD

Photo: Structurlam
Connection Fire Protection

In Construction Types IV-A, IV-B & IV-C, building elements are required to be FRR as specified in IBC Tables 601 and 602. Connections between these building elements must be able to maintain FRR no less than that required of the connected members.

16.3 Wood Connections

Wood connections, including connectors, fasteners, and portions of wood members included in the connection design, shall be protected from fire exposure for the required fire resistance time. Protection shall be provided by wood, fire-rated gypsum board, other approved materials, or a combination thereof.

Source: NDS
Steel hangers/hardware fully concealed within a timber to timber connection is a common method of fire protection.
Connection Fire Protection

Many ways to demonstrate connection fire protection: calculations, prescriptive NC, test results, others as approved by AHJ
Air-Borne Sound:
Sound Transmission Class (STC)
• Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other
• Applies to walls and floor/ceiling assemblies
Structure-borne sound:
Impact Insulation Class (IIC)
• Evaluates how effectively an assembly blocks impact sound from passing through it
• Only applies to floor/ceiling assemblies
Code requirements only address residential occupancies:

For unit to unit or unit to public or service areas:

**Min. STC of 50 (45 if field tested):**
- Walls, Partitions, and Floor/Ceiling Assemblies

**Min. IIC of 50 (45 if field tested) for:**
- Floor/Ceiling Assemblies
Tall Timber: Structure Often is Finish

Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman | Architect: Kaiser + PATH
# Mass Timber Acoustics

## Table 1: Examples of Acoustically-Tested Mass Timber Panels

<table>
<thead>
<tr>
<th>Mass Timber Panel</th>
<th>Thickness</th>
<th>STC Rating</th>
<th>IIC Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-ply CLT wall</td>
<td>3.07&quot;</td>
<td>33</td>
<td>N/A</td>
</tr>
<tr>
<td>5-ply CLT wall</td>
<td>6.875&quot;</td>
<td>38</td>
<td>N/A</td>
</tr>
<tr>
<td>5-ply CLT floor</td>
<td>5.1875&quot;</td>
<td>39</td>
<td>22</td>
</tr>
<tr>
<td>5-ply CLT floor</td>
<td>6.875&quot;</td>
<td>41</td>
<td>25</td>
</tr>
<tr>
<td>7-ply CLT floor</td>
<td>9.65&quot;</td>
<td>44</td>
<td>30</td>
</tr>
<tr>
<td>2x4 NLT wall</td>
<td>3-1/2&quot; bare NLT 4-1/4&quot; with 3/4&quot; plywood</td>
<td>24 bare NLT 29 with 3/4&quot; plywood</td>
<td>N/A</td>
</tr>
<tr>
<td>2x6 NLT wall</td>
<td>5-1/2&quot; bare NLT 6-1/4&quot; with 3/4&quot; plywood</td>
<td>22 bare NLT 31 with 3/4&quot; plywood</td>
<td>N/A</td>
</tr>
<tr>
<td>2x6 NLT floor + 1/2&quot; plywood</td>
<td>6&quot; with 1/2&quot; plywood</td>
<td>34</td>
<td>33</td>
</tr>
</tbody>
</table>

*Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks*
Regardless of the structural materials used in a wall or floor ceiling assembly, there are 3 effective methods of improving acoustical performance:

1. Add Mass
2. Add noise barriers
3. Add decouplers
Acoustical Detailing

What does this look like in typical wood-frame construction:

1. Add Mass
2. Add noise barriers
3. Add decouplers

STC 62
Mass Timber Acoustics

Mass timber has relatively low “mass”
Recall the three ways to increase acoustical performance:

1. Add Mass
2. Add noise barriers
3. Add decouplers

Image credit: Christian Columbres
Mass Timber Acoustics

Concrete Slab:
6” Thick
80 PSF
STC 53

CLT Slab:
6-7/8” Thick
18 PSF
STC 41
There are three main ways to improve an assembly’s acoustical performance:

1. Add mass
2. Add noise barriers
3. Add decouplers
There are three main ways to improve an assembly’s acoustical performance:

1. Add mass
2. Add noise barriers
3. Add decouplers

**Acoustical Mat:**
- Typically roll out or board products
- Thicknesses vary: Usually $\frac{1}{4}''$ to $1''+$
Common mass timber floor assembly:

- Finish floor (if applicable)
- Underlayment (if finish floor)
- 1.5” to 4” thick concrete/gypcrete topping
- Acoustical mat
- WSP (if applicable)
- Mass timber floor panels
Acoustics and Mass Timber: Room-to-Room Noise Control

Richard Morris, PE, SE, A Senior Technical Advisor (Acoustics)

The growing availability and code acceptance of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction has given designers a low-carbon alternative to steel, concrete, and masonry for many applications. However, the use of mass timber in multi-family and commercial buildings presents unique acoustic challenges.

While laboratory measurements of the impact and airborne sound isolation of traditional building assemblies such as light wood-frame, steel and concrete are widely available, fewer resources exist that quantify the acoustic performance of mass timber assemblies. Additionally, one of the most desired aspects of mass timber construction is the ability to leave a building’s structure exposed as finish, which creates the need for resistant assemblies. With careful design and detailing, mass timber buildings can meet the acoustic performance expectations of most building types.

Mass Timber Acoustics

Inventory of Tested Assemblies

Acoustically-Tested Mass Timber Assemblies

Following is a list of mass timber assemblies that have been acoustically tested as of January 23, 2019. Sources are noted at the end of this document. For free technical assistance on any questions related to the acoustical design of mass timber assemblies, or free technical assistance related to any aspect of the design, engineering or construction of a commercial or multi-family wood building in the U.S., email help@woodworks.org or contact the WoodWorks Regional Director nearest you: http://www.woodworks.org/project-assistance

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## Table 1: CLT Floor Assemblies with Concrete/Gypsum Topping, Ceiling Side Exposed

<table>
<thead>
<tr>
<th>CLT Panel</th>
<th>Concrete/Gypsum Topping</th>
<th>Acoustical Mat Product Between CLT and Topping</th>
<th>Finish Floor</th>
<th>STC</th>
<th>IIC</th>
<th>Source</th>
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</thead>
<tbody>
<tr>
<td>CLT 5-ply (6.875&quot;)</td>
<td>1-1/2&quot; Gyp-Crete®</td>
<td>Maxxon Acousti-Mat® 3/4</td>
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<td></td>
<td>LVT</td>
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<tr>
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<td></td>
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<td>Carpet + Pad</td>
<td>73&quot; IIC</td>
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<td></td>
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<td></td>
<td>LVT on Acousti-Top*</td>
<td>52&quot; IIC</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Eng Wood on Acousti-Top*</td>
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<td></td>
<td>Maxxon Acousti-Mat® ¾ Premium</td>
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<td>49&quot; STC</td>
<td>45&quot; IIC</td>
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<td></td>
<td></td>
<td></td>
<td>Carpet + Pad</td>
<td>73&quot; IIC</td>
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<td></td>
<td>LVT on Acousti-Top*</td>
<td>52&quot; IIC</td>
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<tr>
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<th>STC</th>
<th>IIC</th>
<th>Source</th>
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<tr>
<td>CLT 5-ply (6.875&quot;)</td>
<td>1-1/2&quot; Lavalock® Brand 2500</td>
<td>USG SAM N25 Ultra</td>
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<td>46&quot;</td>
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<td></td>
<td>Eng Wood</td>
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<td>47&quot;</td>
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<td></td>
<td>Carpet + Pad</td>
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<td>USG SAM N75 Ultra</td>
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Questions? Ask me anything.

Laura Cullen, EIT
Regional Director | GA, MS

(404) 488-7495
laura.cullen@woodworks.org