Designing and Building with Mass Timber: Design, Planning and Performance

Presented by:
Chelsea Drenick, SE
Brandon Brooks, MBA, PMP
December 9, 2022

The Seminar will begin at 2PM PST
Designing a wood building?  
Ask us anything.

FREe PROJECT SUPPORT / EDUCATION / RESOURCES

Nationwide support for the code-compliant design, engineering and construction of non-residential and multi-family wood buildings.

- Allowable Heights/Areas
- Construction Types
- Structural Detailing
- Wood-Framed & Hybrid Systems
- Fire/Acoustic Assemblies
- Lateral System Design
- Alternate Means of Compliance
- Energy-Efficient Detailing
- Building Systems & Technologies

woodworks.org/project-assistance | help@woodworks.org
Design Professionals: One-on-One Support & Assistance

Find the Regional Director for your location:
Questions? Ask me anything.

Chelsea Drenick, SE
Regional Director | CA-North, NV, UT
303.588.1300
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Resources

WOOD SOLUTION PAPERS

Acoustics and Mass Timber: Room-to-Room Noise Control
Covers key aspects of mass timber acoustical design. Companion to WoodWorks’ Inventory of Acoustically-Tested Mass Timber Assemblies

Mass Timber Cost and Design Optimization Checklists
Guides coordination between designers and builders (GCs, construction managers, estimators, fabricators, installers, etc.) as they estimate and make cost-related decisions on mass timber projects

Visit woodworks.org/tools-guides/ for many more resources.

Upcoming Events

NATIONAL ONLINE

Light Wood-Frame Shaft Wall Detailing for Code Compliance and Constructability | December 13
1.5 AIA/CES HSW LUs, 1.5 PDH credits, 0.15 ICC credits

Mass Timber Shafts and Shaft Wall Solutions for Mass Timber Buildings | December 15
1.5 AIA/CES HSW LUs, 1.5 PDH credits, 0.15 ICC credits

Visit woodworks.org/events/
Mass Timber Business Case Studies

Real financial information on real deals

- Prepared by WoodWorks and Conrad Investment Management
- Include qualitative influences + quantitative data to examine investment success

PROPERTY SUB-TYPES:
- For-Rent Institutional Housing
- Institutional Offices
- Industrial Buildings
- Redevelopment/Additions
- Purpose-Built Owner/Occupied (Student Housing)

Scan the code to download the current package.
New for GCs and installers:

Download free at woodworks.org
Resources from WoodWorks

**Whole Building Life Cycle Assessment (WBLCA)**
- Introduction to Whole Building Life Cycle Assessment: The Basics

**Biogenic Carbon and Carbon Storage**
- When to Include Biogenic Carbon in an LCA
- How to Include Biogenic Carbon in an LCA
- Biogenic Carbon Accounting in WBLCA Tools
- Long-Term Biogenic Carbon Storage
- Calculating the Carbon Stored in Wood Products

**Environmental Product Declarations (EPDs)**
- Current EPDs for Wood Products
- How to Use Environmental Product Declarations

Photo: DPR Office, SmithGroup, photo Chad Davies
Current State of Mass Timber Projects

As of September 2022, in the US, 1,571 multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.
Ask Questions through the Q&A Box

Submit online questions in the Q&A box at the bottom of your screen as they come up in the presentation. We will get to as many questions as possible.
“The Wood Products Council” is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES), Provider #G516.

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.
Course Description

How can architects, engineers and contractors collaborate to meet the growing demand for mass timber buildings? While developers across the country are pursuing mass timber projects, knowledge among AEC professionals is not yet widespread. Firms have varying degrees of familiarity with both the products and practicalities of designing, sourcing, and building a modern mass timber structure, and early adopters continue to play a significant role in educating the rest of the community. This presentation seeks to build on this openness and environment of shared learning, providing an overview of mass timber products, planning, design and implementation to maximize the benefits these buildings can deliver. We’ll also discuss why some mass timber projects face resistance, and how to overcome misconceptions to achieve success. Topics will also include preconstruction coordination and interactions between the manufacturer and design/construction teams, case-based approaches to costing and scheduling, project delivery methods, how to achieve the highest level of efficiency for costs, schedule, and performance, and additional education and training opportunities.
Learning Objectives

1. Identify project planning, coordination and design topics that translate into successful buildings for both the design and construction team.

2. Explore best practices for interaction between manufacturer, design team and preconstruction manager that can lead to cost efficiency and safety on site.

3. Discuss potential construction schedule savings and construction fire safety practices realized through the use of prefabricated mass timber elements.

4. Discuss benefits of using mass timber products, including structural versatility, prefabrication, lighter carbon footprint, and reduced labor costs.
Continuing Education Credits

• Participants will receive a certificate of completion via email
• AIA credits will be processed by WoodWorks

• To receive credit and a certificate, attendees must stay on for the duration of the seminar.
• Group attendee form can be found at [www.woodworks.org/webinar](http://www.woodworks.org/webinar)
PRESENTATION OUTLINE

MASS TIMBER DESIGN
Products, Framing Solutions & Project Examples
Code Considerations
Cost Implications of Design Decisions
MEP Layout & Integration
Insurance Considerations

MASS TIMBER CONSTRUCTION
Planning for Construction
Performing Construction
Workforce Development
Light-Frame Wood
Photo: WoodWorks

Heavy Timber
Photo: Benjamin Benschneider

Mass Timber
Photo: John Stamets
Glue Laminated Timber (Glulam)
Beams & columns

Cross-Laminated Timber (CLT)
Solid sawn laminations

Cross-Laminated Timber (CLT)
SCL laminations

Photo: StructureCraft
Photo: LendLease
Photo: LEVER Architecture

Photo: Freres Lumber
Dowel-Laminated Timber (DLT)

Nail-Laminated Timber (NLT)

Glue-Laminated Timber (GLT)

Photo: StructureCraft

Plank orientation

Photo: Think Wood

Photo: StructureCraft

Photo: Ema Peter

Photo: Manasc Isaac Architects/Fast + Epp
Mass Timber Building Options

Post and Beam  Flat Plate  Honeycomb

Photo: Blaine Brownell  Photo: acton ostry architects  Photo: Lend Lease
Mass Timber Building Options

Hybrid: Light-frame

Hybrid: Steel framing
Nail-Laminated Timber (NLT)

Photo: StructureCraft

Photo: Think Wood
Dowel-Laminated Timber (DLT)
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
ONE DE HARO
SAN FRANCISCO, CA

4 STORIES
130,000

SIGNIFICANT SAVINGS ON FOUNDATION COSTS WITH MASS TIMBER
PROJECT TEAM:
KAISER+PATH
R&H CONSTRUCTION

THE CANYONS
PORTLAND, OR
ASCENT, MILWAUKEE

493,000 SF
259 APARTMENTS, MIXED-USE
ASCENT, MILWAUKEE

Tallest Mass Timber Building in the World

25 STORIES

19 TIMBER OVER 6 PODIUM, 284 FT

Photo: CD Smith Construction | Architect: Korb & Associates Architects
ALBINA YARD
PORTLAND, OR

4 STORIES
16,000 SF
GREEN ROOF

ARCHITECT: LEVER ARCHITECTURE
IMAGE CREDIT: LEVER ARCHITECTURE
80 M ST, WASHINGTON, DC

3 STORY VERTICAL ADDITION
7 STORY EXISTING BUILDING
Cross-Laminated Timber (CLT)

With SCL laminations

Photos: Freres Lumber
MASS TIMBER IN THE CODE

Photo: Freres Lumber
Mass timber products

Cross-laminated timber (CLT)

In 2018 IBC, CLT is now defined in Chapter 2 Definitions:

[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.

And is referenced in Chapter 23:

2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.
Mass Timber in Low- to Mid-Rise: 1-6 Stories in Construction Types III, IV or V
Tall Mass Timber: Up to 18 Stories in Construction Types IV-A, IV-B or IV-C
How do you design a mass timber building?

One *potential* design route:

1. Building size & occupancy informs construction type & grid

2. Construction type informs fire resistance ratings

3. Grid & fire resistance ratings inform timber member sizes & MEP layout
Construction Type – Primarily based on building size & occupancy

<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>270 180 85 85 85 85 70 60</td>
<td>18 12 6 4 4 3 3 2</td>
<td>135,000 90,000 56,250 45,000 42,000 28,500 34,500 18,000</td>
</tr>
<tr>
<td>A-2, A-3, A-4</td>
<td>18 12 6 4 4 3 3 2</td>
<td>18 12 9 6 6 4 4 3</td>
<td>324,000 216,000 135,000 108,000 85,500 57,000 54,000 27,000</td>
</tr>
<tr>
<td>B</td>
<td>18 12 8 5 5 4 3 3</td>
<td>18 12 8 5 5 4 3</td>
<td>184,500 123,000 76,875 61,500 72,000 48,000 36,000 21,000</td>
</tr>
<tr>
<td>R-2</td>
<td>18 12 8 5 5 4 3</td>
<td>18 12 8 5 5 4</td>
<td>184,500 123,000 76,875 61,500 72,000 48,000 36,000 21,000</td>
</tr>
</tbody>
</table>
### Key Early Design Decisions

#### Construction Type – Primarily based on building size & occupancy

<table>
<thead>
<tr>
<th>Occupancies</th>
<th>Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, R</td>
<td>270 180 85 85 85 85 70 60</td>
</tr>
<tr>
<td>B</td>
<td>18 12 9 6 6 4 4 3</td>
</tr>
<tr>
<td>R-2</td>
<td>18 12 8 5 5 5 4 3</td>
</tr>
</tbody>
</table>

For low- to mid-rise mass timber buildings, there may be multiple options for construction type. There are pros and cons of each, don’t assume that one type is always best.

<table>
<thead>
<tr>
<th>Occupancies</th>
<th>Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2, A-3, A-4</td>
<td>135,000 90,000 56,250 45,000 42,000 28,500 34,500 18,000</td>
</tr>
<tr>
<td>B</td>
<td>324,000 216,000 135,000 108,000 85,500 57,000 54,000 27,000</td>
</tr>
<tr>
<td>R-2</td>
<td>184,500 123,000 76,875 61,500 72,000 48,000 36,000 21,000</td>
</tr>
</tbody>
</table>
Fire-Resistance Ratings

- Driven primarily by construction type
- Rating achieved through timber alone or non-combustible protection required?

<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</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Primary structural frame (see Section 202)</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Bearing walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Interior</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor construction and associated secondary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>structural members (see Section 202)</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Roof construction and associated secondary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>structural members (see Section 202)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See Table 705.5
MASS TIMBER DESIGN

FIRE RESISTANCE

Mass Timber’s Fire-Resistive Performance is Well-Tested, Documented and Recognized via Code Acceptance

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Char Depth, $a_{\text{char}}$ (in.)</th>
<th>Effective Char Depth, $a_{\text{eff}}$ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Hour</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>2-Hour</td>
<td>2.6</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Source: AWC’s NDS

Credit: David Barber, ARUP

Source: AWC’s TR 10
FRR Design of MT

Calculated FRR of Exposed MT: IBC to NDS code compliance path
Key Early Design Decisions

Fire-Resistance Ratings (FRR)

- Thinner panels (i.e. 3-ply) generally difficult to achieve a 1+ hour FRR
- 5-ply CLT / 2x6 NLT & DLT panels can usually achieve a 1- or 2-hour FRR
- Construction Type | FRR | Member Size | Grid (or re-arrange that process but follow how one impacts the others)

<table>
<thead>
<tr>
<th>Panel</th>
<th>Example Floor Span Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-ply CLT (4-1/8&quot; thick)</td>
<td>Up to 12 ft</td>
</tr>
<tr>
<td>5-ply CLT (6-7/8&quot; thick)</td>
<td>14 to 17 ft</td>
</tr>
<tr>
<td>7-ply CLT (9-5/8&quot;)</td>
<td>17 to 21 ft</td>
</tr>
<tr>
<td>2x4 NLT</td>
<td>Up to 12 ft</td>
</tr>
<tr>
<td>2x6 NLT</td>
<td>10 to 17 ft</td>
</tr>
<tr>
<td>2x8 NLT</td>
<td>14 to 21 ft</td>
</tr>
</tbody>
</table>
| 5" MPP                 | 10 to 15 ft
### FRR Design of MT

WoodWorks Inventory of Fire Tested MT 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 (118mm x 8.88 in)</td>
<td>Nordic</td>
<td>SPF 14.50 ft. 1.5 E/MSR x SPF 3</td>
<td>2 layers 1/2” Type X Gypsum</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 70% Moment Capacity</td>
<td>1</td>
<td>1 (Test 1)</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>3-ply CLT (150mm x 4.13 in)</td>
<td>Structurall</td>
<td>SPF #1/2 x SPF #1/2</td>
<td>1 layer 5/8” Type X Gypsum</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 70% Moment Capacity</td>
<td>1</td>
<td>1 (Test 3)</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>Nordic</td>
<td>EI</td>
<td>None</td>
<td>Topside Spline</td>
<td>2 staggered layers of 1/2” cement boards</td>
<td>Loaded, See Manufacturer</td>
<td>2</td>
<td>2</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>Nordic</td>
<td>EI</td>
<td>1 layer of 3/8” Type X Gypsum under Z-channels and lathing strips with 3 3/8” dimensions</td>
<td>Topside Spline</td>
<td>2 staggered layers of 1/2” cement boards</td>
<td>Loaded, See Manufacturer</td>
<td>2</td>
<td>5</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>Nordic</td>
<td>EI</td>
<td>None</td>
<td>Topside Spline</td>
<td>3/4 in. proprietary gypscape over Maxxon acoustical mat</td>
<td>Reduced 50% Moment Capacity</td>
<td>1.5</td>
<td>3</td>
<td>UL</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>Nordic</td>
<td>EI</td>
<td>1 layer 5/8” normal gypsum</td>
<td>Topside Spline</td>
<td>3/4 in. proprietary gypscape over Maxxon acoustical mat or proprietary sound board</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>4</td>
<td>UL</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>Nordic</td>
<td>EI</td>
<td>1 layer 5/8” Type X Gypsum under Z-channels under 7 5/8” Joists with 3 3/8” Msnl/3/8” Wood</td>
<td>Half-Lap</td>
<td>None</td>
<td>Loaded, See Manufacturer</td>
<td>2</td>
<td>21</td>
<td>Intertek 8/24/2012</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>Structurall</td>
<td>EI M5</td>
<td>None</td>
<td>Topside Spline</td>
<td>1-1/2” Maxxon CypGrtz 2000 over Maxxon Reinforcing Mesh</td>
<td>Loaded, See Manufacturer</td>
<td>2.5</td>
<td>6</td>
<td>Intertek, 2/22/2016</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>DR Johnson</td>
<td>V1</td>
<td>None</td>
<td>Half-Lap &amp; Topside Spline</td>
<td>2” gypscape topping</td>
<td>Loaded, See Manufacturer</td>
<td>2</td>
<td>7</td>
<td>SWRI (May 2016)</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>Nordic</td>
<td>SPF 195 ft. 1.5 E/MSR x SPF #3</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 50% Moment Capacity</td>
<td>1.5</td>
<td>1 (Test 3)</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>5-ply CLT (175mm x .875”)</td>
<td>Structurall</td>
<td>SPF #1/2 x SPF #1/2</td>
<td>1 layer 5/8” Type X Gypsum</td>
<td>Half-Lap</td>
<td>None</td>
<td>Unreduced 100% Moment Capacity</td>
<td>2</td>
<td>1 (Test 6)</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>5-ply CLT (245mm x 3.93”)</td>
<td>Smartlam</td>
<td>SL-V4</td>
<td>None</td>
<td>Half-Lap</td>
<td>nominal 1/2” plywood with 4d nails</td>
<td>Unreduced 100% Moment Capacity</td>
<td>2.5</td>
<td>1 (Test 7)</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>5-ply CLT (245mm x 3.93”)</td>
<td>Smartlam</td>
<td>V1</td>
<td>None</td>
<td>Half-Lap</td>
<td>nominal 1/2” plywood with 8d nails</td>
<td>Unreduced 100% Moment Capacity</td>
<td>2</td>
<td>12 (Test 4)</td>
<td>Western Fire Center 10/26/2016</td>
</tr>
<tr>
<td>5-ply CLT (245mm x 3.93”)</td>
<td>Smartlam</td>
<td>V1</td>
<td>None</td>
<td>Half-Lap</td>
<td>nominal 1/2” plywood with 4d nails</td>
<td>Unreduced 100% Moment Capacity</td>
<td>2</td>
<td>12 (Test 5)</td>
<td>Western Fire Center 10/28/2016</td>
</tr>
<tr>
<td>5-ply CLT (245mm x 3.93”)</td>
<td>Smartlam</td>
<td>V1</td>
<td>None</td>
<td>Half-Lap</td>
<td>nominal 1/2” plywood with 8d nails</td>
<td>Unreduced 100% Moment Capacity</td>
<td>2</td>
<td>12 (Test 6)</td>
<td>Western Fire Center 1/1/2016</td>
</tr>
<tr>
<td>5-ply CLT (245mm x 3.93”)</td>
<td>KLH</td>
<td>CVM3</td>
<td>None</td>
<td>Half-Lap &amp; Topside Spline</td>
<td>None</td>
<td>Unreduced 100% Moment Capacity</td>
<td>1</td>
<td>18</td>
<td>SWRI</td>
</tr>
</tbody>
</table>
Cost Impacts of Construction Type

Construction Type Early Decision Example

3-story building on college campus
- Mostly Group B occupancy, some assembly (events) space
- NFPA 13 sprinklers throughout
- Floor plate = 7,700 SF
- Total Building Area = 23,100 SF

Impact of Assembly Occupancy Placement:

Owner originally desires events space on top (3rd) floor
- Requires Construction Type IIIA
If owner permits moving events space to 1st or 2nd floor
- Could use Type IIIB
Cost Impacts of Construction Type

Construction Type Early Decision Example

3-story building on college campus

Cost Impact of Assembly Occupancy Placement:

<table>
<thead>
<tr>
<th>Location of Event Space</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; Floor</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Type</td>
<td>III-A</td>
<td>III-B</td>
</tr>
<tr>
<td>Assembly Group</td>
<td>A-3</td>
<td>A-3</td>
</tr>
<tr>
<td>Fire Resistive Rating</td>
<td>1-Hr</td>
<td>0-Hr</td>
</tr>
<tr>
<td>Connections</td>
<td>Concealed</td>
<td>Exposed</td>
</tr>
<tr>
<td>CLT Panel Thickness</td>
<td>5-Ply</td>
<td>3-Ply</td>
</tr>
<tr>
<td><strong>Superstructure Cost/SF</strong></td>
<td><strong>$65/SF</strong></td>
<td><strong>$53/SF</strong></td>
</tr>
</tbody>
</table>

Source: PCL Construction
# Cost: Construction Type

### TABLE 601
Fire Resistance Rating Requirements for Building Elements (Hours)

<table>
<thead>
<tr>
<th>Building Element</th>
<th>III-A</th>
<th>III-B</th>
<th>IV-A</th>
<th>IV-B</th>
<th>IV-C</th>
<th>IV-HT</th>
<th>V-A</th>
<th>V-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Structural Frame</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>HT</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Ext. Bearing Walls</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Int. Bearing Walls</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1/HT</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Floor Construction</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>HT</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Roof Construction</td>
<td>1</td>
<td>0</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
<td>HT</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Baseline 0hr & HT

+$10/SF 1hr & maybe 2hr

+$12-15/SF 2hr FRR

Cost Source: Swinerton
Cost Implication of Design Choices

Which is the most efficient option?

<table>
<thead>
<tr>
<th>Timber Volume Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIIA – Option 1</td>
</tr>
<tr>
<td>IIIA – Option 2</td>
</tr>
<tr>
<td>IV-HT / IIIB</td>
</tr>
</tbody>
</table>

A general rule of thumb for efficient mass timber fiber volume is no higher than 0.75 CF per SF for up to a 1 hour rated structure (higher if 2 hour exposed timber in tall mass timber).

Ratios in the 0.85 to 1.0 CF / SF range tend to become cost prohibitive.
There are three main ways to improve an assembly’s acoustical performance:

1. Add mass
2. Add noise barriers
3. Add decouplers
Mass Timber Acoustics

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 & Sound Control

## Inventory of Tested Assemblies

**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>STC¹</th>
<th>IIC²</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2&quot; Gyp-Crete*</td>
<td>Maxxon Acousti-Mat® 3/4</td>
<td>None</td>
<td>LVT</td>
<td>47² ASTC</td>
<td>49⁴ AIC</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LVT + Pad</td>
<td>75⁵ AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maxxon Acousti-Mat® ¾ Premium</td>
<td></td>
<td>LVT on Acousti-Top*</td>
<td>52⁴ AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-1/2&quot; Gyp-Crete*</td>
<td></td>
<td></td>
<td>Eng Wood on Acousti-Top*</td>
<td>51⁴ AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLT 5-ply (6.875&quot;)</td>
<td>USG SAM N25 Ultra</td>
<td>None</td>
<td>LVT</td>
<td>49⁴ AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LVT Plus</td>
<td>49⁴ AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Eng Wood</td>
<td>47⁴ AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Carpet + Pad</td>
<td>45⁴ AIC</td>
<td>67⁶ AIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ceramic Tile</td>
<td>50⁶ AIC</td>
<td>46⁶ AIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>45⁴ AIC</td>
<td>42⁴ AIC</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LVT</td>
<td>48⁴ AIC</td>
<td>44⁶ AIC</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LVT Plus</td>
<td>49⁴ AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Eng Wood</td>
<td>47⁴ AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Carpet + Pad</td>
<td>45⁴ AIC</td>
<td>67⁶ AIC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ceramic Tile</td>
<td>50⁶ AIC</td>
<td>46⁶ AIC</td>
<td></td>
</tr>
</tbody>
</table>

¹ STC: Sound Transmission Class
² IIC: Impact Insulation Class

*Note: Values may vary depending on specific installation and testing conditions.
MASS TIMBER DESIGN
LATERAL FRAMING SYSTEMS

STEEL OR CONCRETE SEISMIC SYSTEM:
• Commonly used with glazing/curtain walls
• May use rigid or semi-rigid (if used with frames at exterior) analysis

LIGHT FRAME SHEARWALLS:
• Typical for 1-5 stories
• Typically assume flexible diaphragm
• Need ample wall at perimeter
OVERVIEW | CONNECTIONS

Panel to Panel & Supports

Photo: Charles Judd

Photo: Marcus Kauffman
Connections

Connection design considerations:
- Fire rating
- Structural capacity
- Shrinkage
- Constructability
- Aesthetics
- Cost

Credit: Alex Schreyer
NEW MASS TIMBER CONNECTIONS INDEX

A library of commonly used mass timber connections with designer notes and information on fire resistance, relative cost and load-carrying capacity.
Insurance Perspective on Mass Timber

• Lack of historic loss data = Unknowns
• Unknowns = Risk
• Risk = Higher Premiums
• Some take a ‘wood is wood’ approach

• Important to understand the significant differences in how mass timber performs in the event of a fire, etc. when compared to light wood-frame and all other building materials
MEP Layout & Integration

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

Key considerations:
• Level of exposure desired
• Floor to floor, structure depth & desired head height
• Building occupancy and configuration (i.e. central core vs. double loaded corridor)
• Grid layout and beam orientations
• Need for future tenant reconfiguration
• Impact on fire & structural design: concealed spaces, penetrations
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

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
MEP Layout & Integration

In gaps between MT panels
- Fewer penetrations, can allow for easier modifications later
MEP Layout & Integration

In raised access floor (RAF) above MT
• Impact on head height
• Concealed space code provisions
MEP Layout & Integration

In topping slab above MT
- Greater need for coordination prior to slab pour
- Limitations on what can be placed (thickness of topping slab)
- No opportunity for renovations later
INTEGRATED SYSTEMS

Credit: John Klein, Generate Architecture
INFORMATION

1. In accordance with Lease and Option Agreement, the tenant is responsible for maintaining the premises in good condition.
INSURANCE PERSPECTIVE ON MASS TIMBER

• Lack of historic loss data = Unknowns
• Unknowns = Risk
• Risk = Higher Premiums
• Some take a ‘wood is wood’ approach

• Important to understand the significant differences in how mass timber performs in the event of a fire, etc. when compared to light wood-frame and all other building materials
Insurance Perspective on Mass Timber

• Mass timber insurance resource for insurers, developers, contractors & designers
• Free download at woodworks.org
Insurance vs. Building Codes

• It is important to note the distinct difference between the primary concerns of insurers vs. primary concerns of building codes
  • **Insurance** primarily concerned with **property loss**
  • **Building codes** primarily concerned with **occupant safety**

• As such, code acceptance and associated testing may be helpful to insurers in evaluating a new product like mass timber, but it will not address all concerns
**Planning**
- Anatomy of a Mass Timber Package
- Procurement, Supply Chain, Schedule Drivers

**Environmental Exposure**
- Site Planning
- Moisture Planning and Mitigation
- UV Planning and Mitigation

**Workforce Training**
- Strategic Partnerships
- Training/Education
- Resources
Holistic Costing

$/SF  $/SF
Anatomy of a Turnkey Mass Timber Package

- Project Overhead: 7%
- Labor: 14%
- Material: 15%
- Equipment: 64%

Source: Swinerton
Material (Direct Cost)

Turnkey Mass Timber Package

Source: Swinerton
Mass Timber Package Costs

Panels are the biggest part of the biggest piece of the cost pie

Source: Swinerton
Labor (Direct Cost)

Turnkey Mass Timber Package

Photo: Swinerton

Source: Swinerton
Equipment (Direct Cost)

Turnkey Mass Timber Package

Source: Swinerton
Project Overhead

Turnkey Mass Timber Package

Cost Analysis  Design Refinement  System Integration
VD&C  Detail Optimization  Logistics Planning

Source: Swinerton
Photos: Swinerton
CONSIDERATIONS:
• Ceiling Treatment
• Floor Topping
• HVAC System & Route
• Foundation Size
• Material Savings
• Perimeter glazing
• Value of Time
• Completion Bonds/Insurance
### Sample Procurement Strategies

<table>
<thead>
<tr>
<th>GC/CM Hires Turnkey Mass Timber Subcontractor</th>
<th>GC/CM Buys Material, Self-Performs Installation and Coordinates</th>
<th>GC/CM Buys Material, Subcontracts Labor and Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Hiring experience</td>
<td>+ Hiring experience</td>
<td>+ Potential added mark-up</td>
</tr>
<tr>
<td>+ Single point of responsibility</td>
<td>+ Single point of responsibility</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ Financial security of strong GC/CM</td>
<td></td>
</tr>
<tr>
<td>-- Prequalify capacity of subs</td>
<td>-- Lack of familiarity with supply chain</td>
<td>-- Multiple layers of coordination</td>
</tr>
<tr>
<td>-- Potential added mark-up</td>
<td>-- Steep learning curve for coordination</td>
<td></td>
</tr>
</tbody>
</table>

**Risk Spectrum**

*Source: Timberlab*
This slide has always been a bit of mystery to me. 1 and 3 make sense. I don't fully understand the discussion for option 2

Potential Cost Impacts: Design-Bid-Build Procurement
Alternate Procurement Option: Trade Partner/Master Builder Approach
Procurement Strategy is Key to Success

5% Savings  Neutrality  10% Premium
Material Fabrication Planning
Understand the Supply Chain

Photo: Swinerton
Understand Manufacturer’s Capabilities

Credit: Tanya Luthi, Entuitive
Understand Manufacturer’s Capabilities
Poached this from a TL presentation, put colored bpxes over names to avoid europeans, Nordic and Element 5.

Brandon Brooks, 2022-05-06T23:31:34.791
Embrace the Prefab Advantage

Photo: Swinerton
Tolerances: Interface with Other Structural Materials

Photos: Swinerton
Schedule Drivers

Photo: Swinerton
Procurement Approach Determines Schedule

Compressing the Typical Construction Schedule with Mass Timber

Look for these potential schedule savings in comparison to steel and concrete:

- Less soil remediation + smaller foundations for sites with problematic soils
- Faster erection (prefabricated + precise)
- If prefabricated, savings in enclosure time
- MEP fully coordinated in design phase & therefore installed faster
- Less finishes with exposed wood structure
- Earlier start for follow-up trades; no waiting for cure times

Overall mass timber construction schedule

Up to 25% schedule savings
- Less carrying costs
- Less GC overhead
- Ability to lease/occupy sooner

Source: WoodWorks
We need to reconcile the 25% claim

We have a few sources in the cost checklist which is where this graphic is taken from. Should we reference the cost checklist here or were you thinking more specifics?
Procurement Approach Determines Schedule

Example 6 Story Type IIIA Project

Source: Swinerton

Design-Bid-Build Procurement
Procurement Approach Determines Schedule
Example 6 Story Type IIIA Project

Jan 1 - Feb 1  Concept Design
Feb 1 - Apr 1  Schematic Design
Apr 1 - Jul 1  Design Development
Jul 1 - Sep 1  85% Construction Documents - Permit Set
Sep 1 - Dec 1  100% Construction Documents
Sep 1 - Sep 27  General Contractor Bidding
Sep 27 - Oct 10  General Contractor Award
Jul 1 - Jul 26  Mass Timber Subcontractor Negotiation/Buyout
Jul 26  Release Mass Timber Subcontractor
Jul 26 - Oct 17  Mass Timber Shop Drawings
Oct 17 - Oct 30  Shop Drawing Approval
Oct 30 - Jan 22  Single Piece Shop Drawings, Coding, Fabrication & Delivery
Jan 22 - Apr 14  Mass Timber Installation
Dec 1 - Jan 31  Construction Duration

Source: Swinerton

Design-Build/Design-Assist Procurement

14 weeks early
Procurement Logic for Scheduling

Shop drawings, Planning, Fabrication, Delivery

Mass Timber Installation

Source: Swinerton

Example 6 Story Type IIIA Project
Procurement Approach Determines Schedule
Schedule Comparison

Image: Swinerton

Photo: WoodWorks
Schedule Drivers
BIM/Digital Twins

Photos: Swinerton
Schedule Impacts: Hybrid Structures
Look At Schedule Holistically
Overall Project Schedule Analysis: 12 Story Type IV-B

Source: Swinerton
A large-scale MT project can be up to 2% higher in direct costs, but a minimum of 20% lower in project overhead costs. The net result is cost-neutrality and higher value.

Source: Swinerton
Photo: Alex Schreyer
Early Move-In for Rough-In Trades.

Photos: Swinerton
Embracing BIM for Fabrication

Photos: Swinerton
## Tall Mass Timber Special Inspections

### Table 1705.5.3
REQUARED SPECIAL INSPECTIONS OF MASS TIMBER CONSTRUCTION

<table>
<thead>
<tr>
<th>Type</th>
<th>Continuous Special Inspection</th>
<th>Periodic Special Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Inspection of anchorage and connections of mass timber construction to timber deep foundation systems.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>2. Inspect erection of mass timber construction</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3. Inspection of connections where installation methods are required to meet design loads.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1. Threaded fasteners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1.1. Verify use of proper installation equipment</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3.1.2. Verify use of pre-drilled holes where required</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3.1.3. Inspect screws, including diameter, length, head type, spacing, installation angle, and depth.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3.2. Adhesive anchors installed in horizontal or upwardly inclined orientation to resist sustained tension loads</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3.3. Adhesive anchors not defined in 3.2.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3.4. Bolted connections</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3.5. Concealed connections</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Table is only required for **Type IV-A, IV-B, and IV-C**

Source: International Building Code
Planning for Environmental Exposures

- Plan Early
- Risk Evaluation
- Develop Construction
- Phase Plan
- Execute the Design and Moisture Management Plan
- Monitor

RDH Moisture Management Guide 1st Ed
Material Environmental Exposure and Moisture Management

Enroute
Onsite
Post-Install
Other Material
Plenty of great tips from Dave Beck and Jeff Chan to expand this section

I agree we should build this out more, maybe also rely on the RDH doc and what we have in the construction manual
Ricky McLain, 2022-04-21T18:39:36.926
Enroute Exposure
On Site Considerations
On Site Considerations
Onsite Considerations
All photos on left from Adohi Hall folder in Sharefile. No particular credit is listed.

Right: Ascent, J. Reynolds WoodWorks & C.D. Smith Construction

Brandon Brooks, 2022-04-29T01:07:52.548
Photos: Apex Clean Energy (Terry Patillo – Credit is WoodWorks)
Brandon Brooks, 2022-04-29T01:07:37.924
Workforce Development
Training is the key to efficiency
Training takes time and money

Training versus Education

Resources available to all
MT Construction Manual
Installer Curriculum
Other WW Resources
CM Workshops
Previous recorded versions
Learning Management System
Mass Timber Construction Management Program

- **Mass Timber Construction Manual**
- **8- & 16-Hour Installer Training Package and Training Centers**
- **Community College and University CM Programs**
- **Virtual and/or In-Person Workshops**
- **Partner with Construction Associations**
- **Project Tours**
- **Engage with General Contractors Across the US**
Released on 20 October 2021

https://www.woodworks.org/mass-timber-construction-management-program/
Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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