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

Presented by:
Mike Romanowski, SE, Regional Director | CA-South, AZ, NM
Brandon Brooks, MBA, PMP, Construction Management Program Manager
June 17, 2022

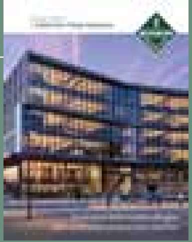
RESOURCES & UPCOMING EVENTS

New WOOD SOLUTION PAPER

CLT Diaphragm Design for Wind and Seismic Resistance

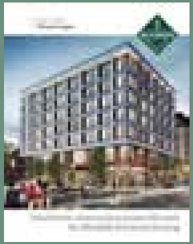
Using SDPWS 2021 and ASCE 7-22

New CASE STUDIES



Adidas East Village Expansion

Innovative mass timber designs meet ambitious construction timeline



Thomas Logan

Wood-frame urban podium project fills need for affordable downtown housing

Visit woodworks.org/publications-media

Offsite Construction in Wood: Reinventing the Role of the Design Professional

July 13

1.0 AIA/CES HSW LUs, 1.0 PDH credits, 0.10 ICC credits

General Contractor's Guide to Mass Timber Project Estimation

August 12

Visit woodworks.org/events

Meet the **Help Desk**

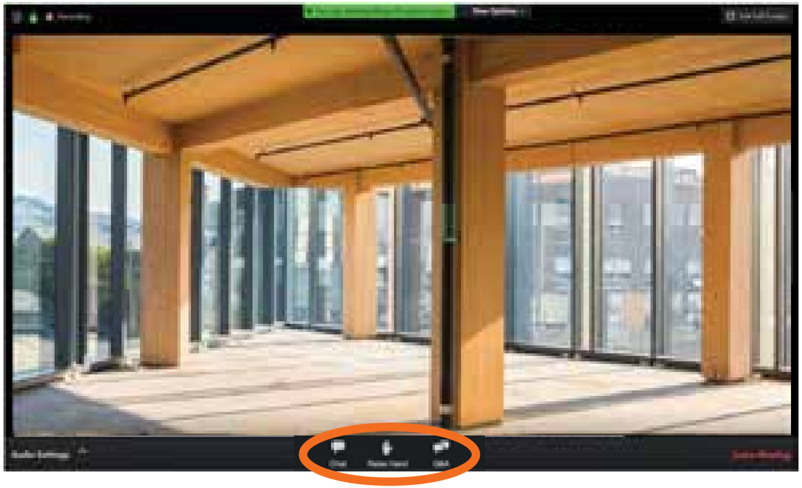
Need technical assistance on a project?

Email: **help@woodworks.org**

Watch the Chat Window, Ask Questions through the Q&A Box

» During today's event will be sending links, files and other pertinent information through the Chat window, located at the bottom of your screen.

» Submit questions in the Q&A box at the bottom of your screen as they come up in the presentations. We will get to as many questions as possible.



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

AIA Continuing Education Provider

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.

PRESENTATION OUTLINE

MASS TIMBER DESIGN

- Overview
- Products
- Structural Framing Systems
- Connections
- Existing U.S. Projects
- Code Considerations
- Cost Implications Due to Early Design Decisions
- MEP Layout & Integration
- Insurance Issues

MASS TIMBER CONSTRUCTION MANAGEMENT

- Planning
- Performance
- Workforce Training

OVERVIEW

Photo: PCL Construction

Light-Frame Wood
Photo: WoodWorks

Heavy Timber
Photo: Benjamin Benschneider

Mass Timber
Photo: John Stamets

PRODUCTS

Glued Laminated Timber (Glulam)

Beams & columns

Photo: StructureCraft

Cross-Laminated Timber (CLT)

Solid sawn laminations

Photo: LendLease

Cross-Laminated Timber (CLT)

SCL laminations

Photo: Freres Lumber

Photo: LEVER Architecture

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Nail-Laminated Timber (NLT)

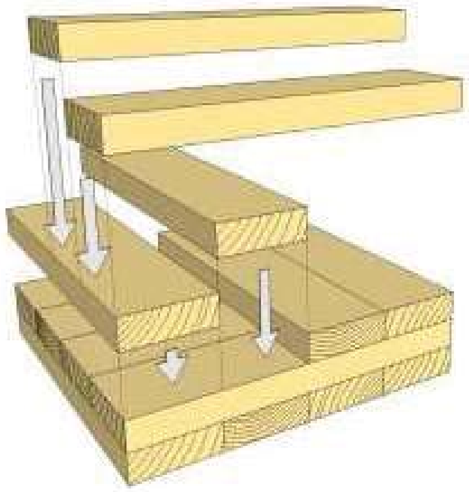
Photo: Think Wood

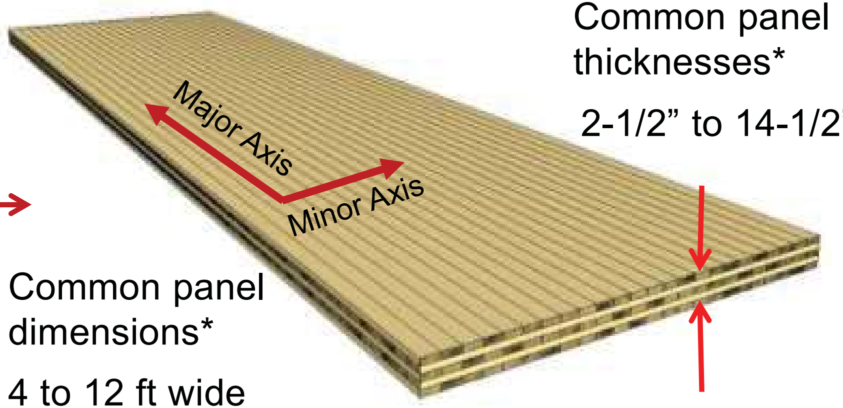
Photo: StructureCraft

Photo: Ema Peter

Glulam Beams & Columns w/ CLT (solid sawn lamina) Deck

CLT (solid sawn lamina)





Common panel thicknesses*

2-1/2” to 14-1/2”

Common panel dimensions*

4 to 12 ft wide

24 to 64 ft long

*Consult with manufacturers for available panel sizes

CLT (solid sawn lamina)

CLT (SCL lamina)

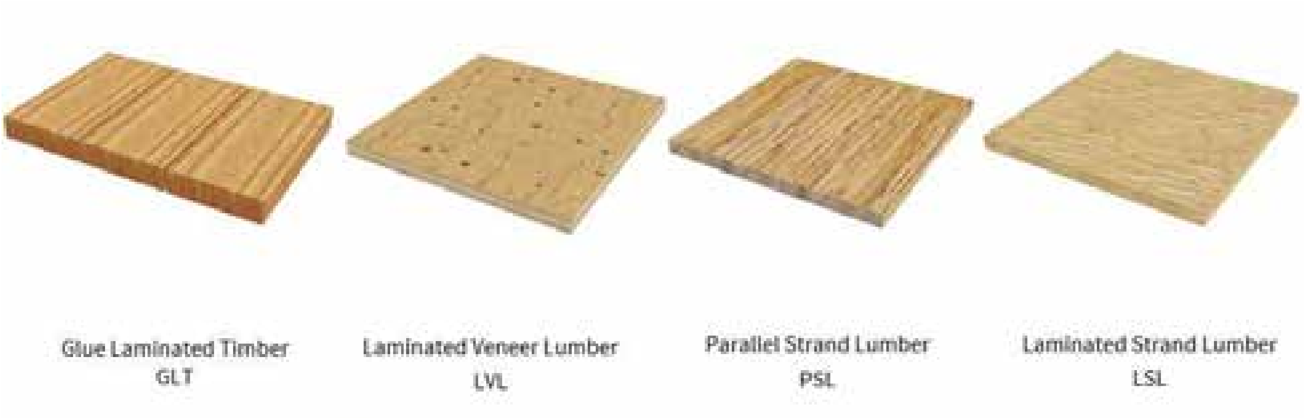
Photos: Freres Lumber

Glulam Beams & Columns w/ NLT Deck

DLT

Photo: StructureCraft

Other Mass Timber Product Options



T&G Decking

Photos: StructureCraft

STRUCTURAL FRAMING SYSTEMS

The Canyons, photo Marcus Kauffman, Oregon Department of Forestry


Photo: Ema Peter

STRUCTURAL FRAMING SYSTEMS | POST, BEAM + PLATE


Photo: Seagate Structures

STRUCTURAL FRAMING SYSTEMS | POST + PLATE


Photo: Lendlease

STRUCTURAL FRAMING SYSTEMS | HONEYCOMB

STRUCTURAL FRAMING SYSTEMS | HYBRID LIGHT-FRAME + MASS TIMBER

STRUCTURAL FRAMING SYSTEMS | HYBRID STEEL + MASS TIMBER

STRUCTURAL FRAMING SYSTEMS | HYBRID CONCRETE + MASS TIMBER

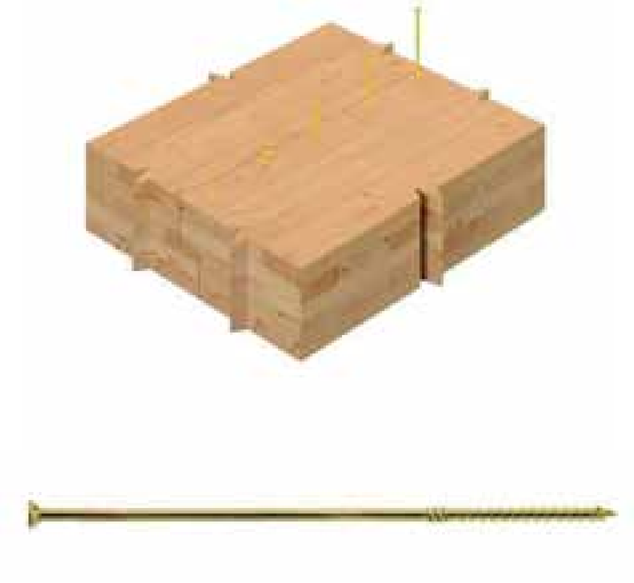
CONNECTIONS

John W. Olver Design Building at UMass Amherst, Leers Weinzapfel Associates, Equilibrium Consulting, photo Alexander Schreyer

CONNECTIONS

Concealed Connectors

Photo Marcus Kauffman



Self Tapping Screws

Photo Simpson Strong Tie

CONNECTIONS

Partially Concealed Connectors

Photo: StructureCraft

Photo: Structurlam

Concealed Connectors

Base of Column

Photo: Alex Schreyer

CONNECTIONS

Panel to Panel Spline w/ Screws

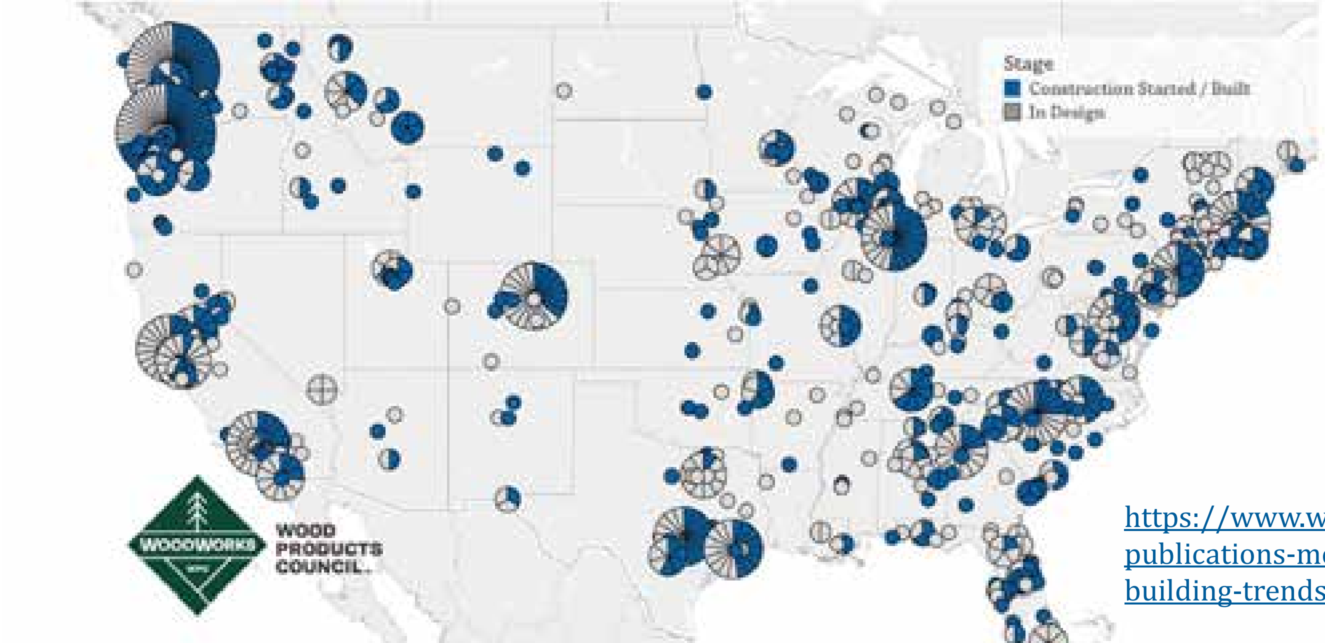
Photo: Charles Judd

Panel to Support w/ Screws

Photo: Marcus Kauffman

Current State of U.S. Mass Timber Projects

As of March 2022, in the US, **1,384** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.



https://www.woodworks.org/publications-media/building-trends-mass-timber/

Source: WoodWorks, March 31, 2022

** This total includes modern mass timber and post-and-beam structures built since 2013*

Current State of U.S. Mass Timber Projects

As of March 2022, in the US, **1,384** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.


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

9 Stories | 115 ft

8 Timber Over 1 Podium

Type IV-B

Variance to expose ~50% ceilings

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

ASCENT, MILWAUKEE

Photo: Korb & Associates Architects |
Architect: Korb & Associates Architects

493,000 SF

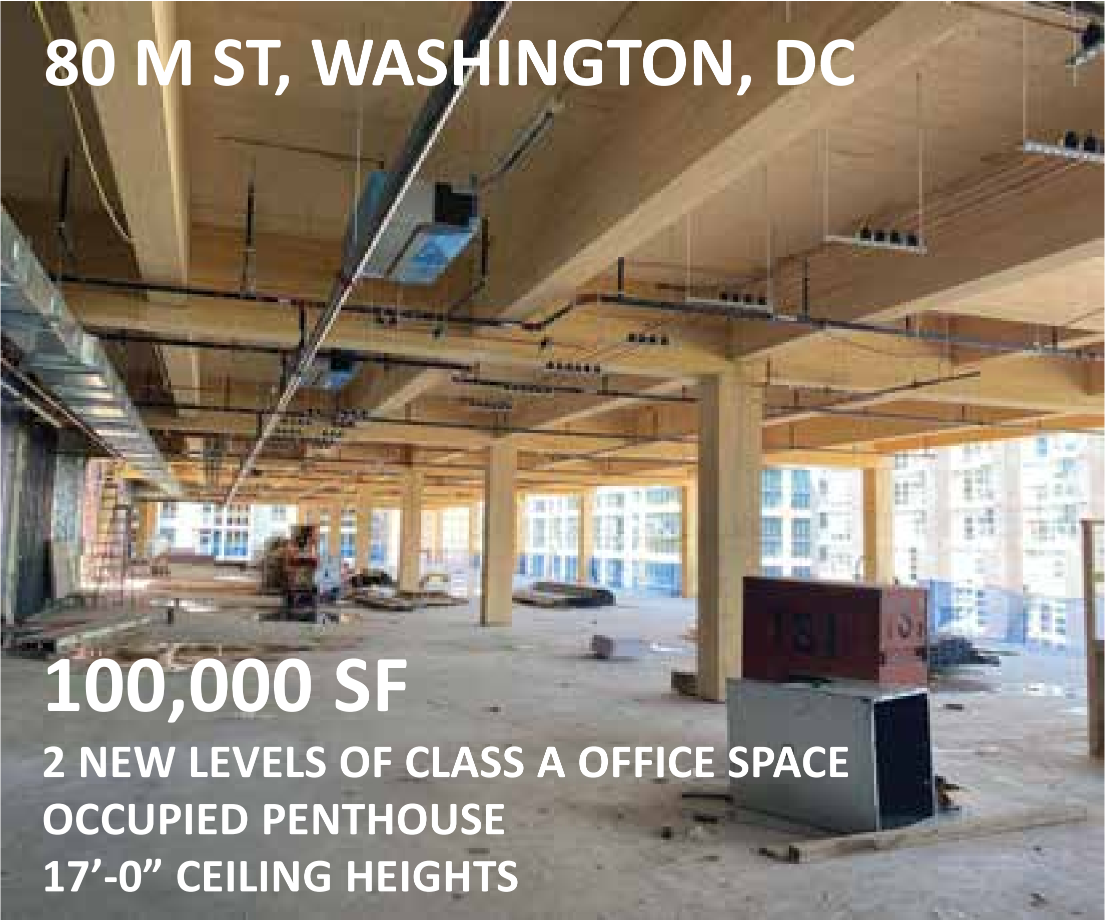
259 APARTMENTS, MIXED-USE

ASCENT, MILWAUKEE

Tallest Mass Timber Building in the World

Photo: CD Smith Construction |
Architect: Korb & Associates Architects


80 M ST, WASHINGTON, DC
3 STORY VERTICAL ADDITION
7 STORY EXISTING BUILDING
Photo: WoodWorks | Architect: Hickok Cole


80 M ST, WASHINGTON, DC
100,000 SF
2 NEW LEVELS OF CLASS A OFFICE SPACE
OCCUPIED PENTHOUSE
17’-0” CEILING HEIGHTS

APEX PLAZA
CHARLOTTESVILLE, VA

8 STORIES
6 TIMBER OVER 2 PODIUM, 100 FT

PRIMARILY OFFICE SPACE

Photo: William McDonough + Partners | Architect: William McDonough + Partners


11 E LENOX, BOSTON, MA
7 STORIES
70 FT
Passive House
Multi-Family
Credit: H + O Structural Engineering
Credit: Monte French Design Studio

Photos: StructureCraft

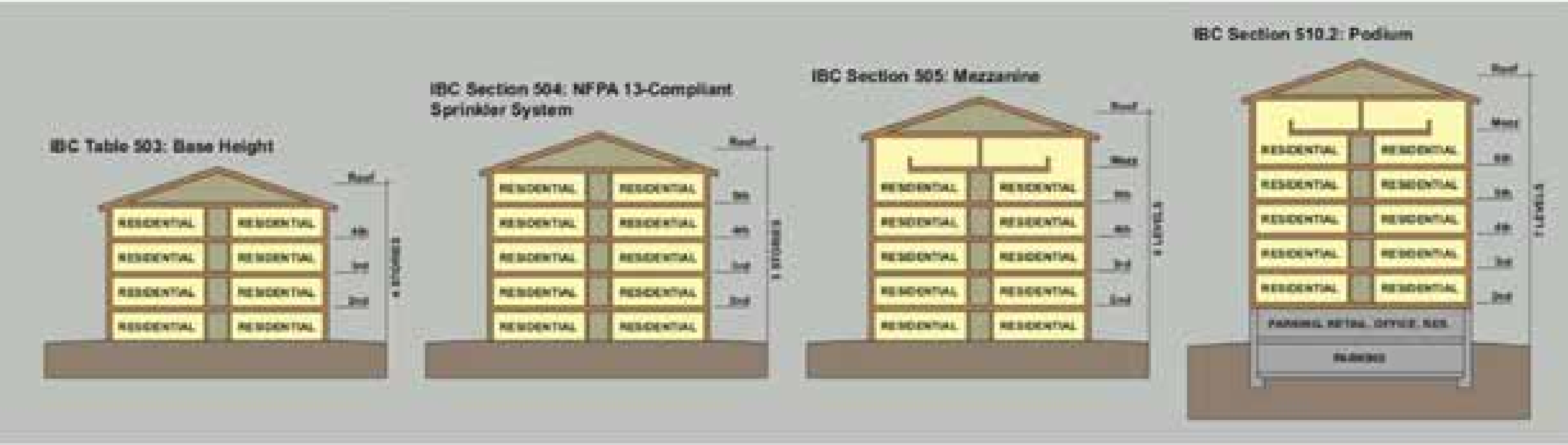
Photo: Hartshorne Plunkard Architecture

EXISTING U.S.PROJECTS | T3 ATLANTA

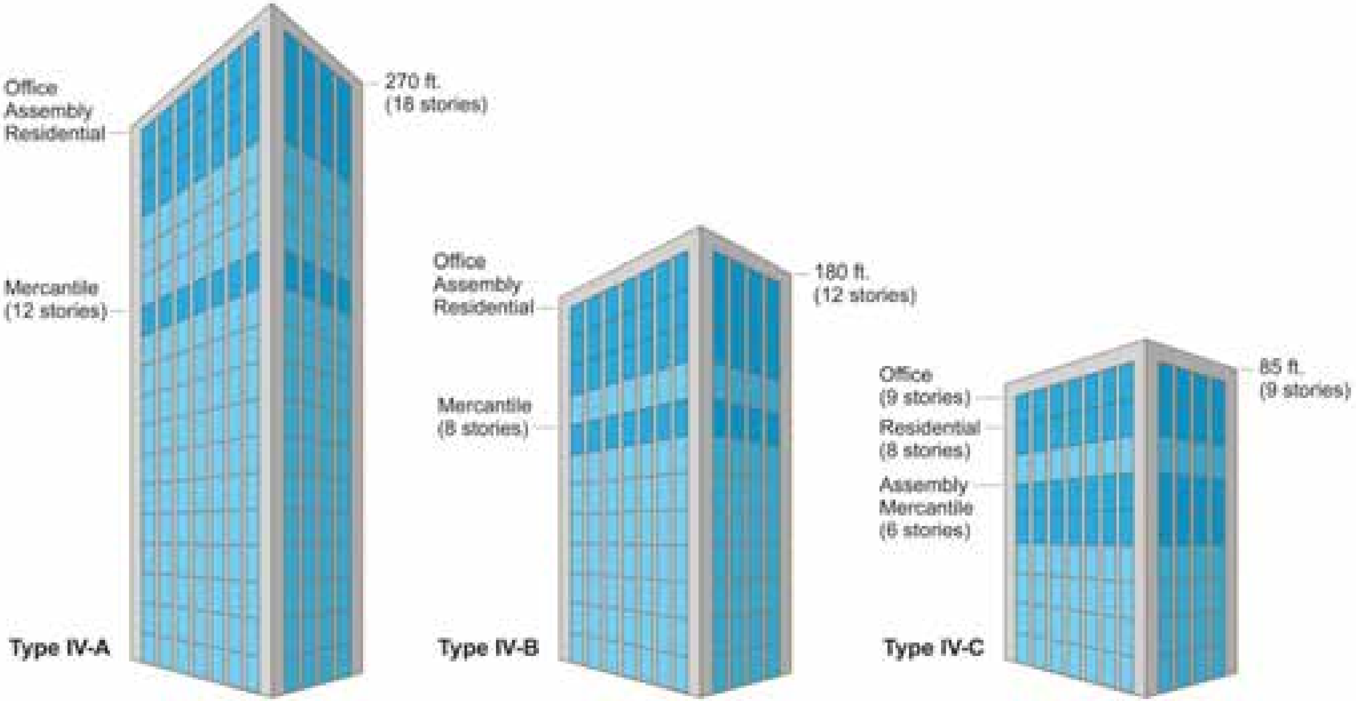
CODE CONSIDERATIONS

Photo: Freres Lumber

Mass Timber in Low- to Mid-Rise: 1-6 Stories in Construction Types III, IV or V



Mass Timber in Taller Buildings: Up to 18 Stories in Construction Types IV-A, IV-B or IV-C

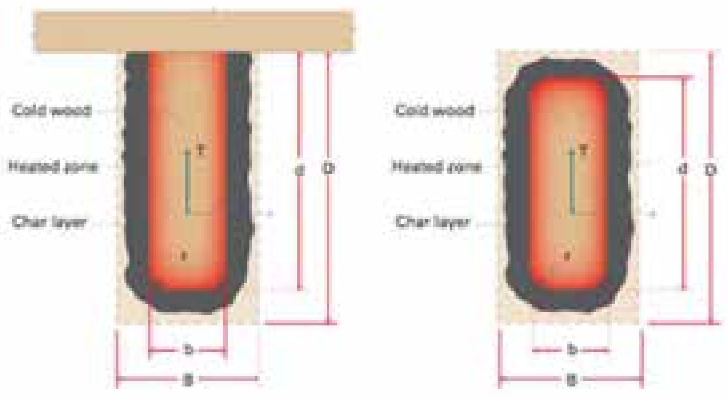


Mass Timber's Fire-Resistive Performance is Well-Tested, Documented and Recognized via Code Acceptance

Table 16.2.1A Char Depth and Effective Char Depth (for β_n = 1.5 in./hr.)

Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

Source: AWC's NDS



Source: AWC's TR 10

Demonstrating Fire-Resistance Ratings for Mass Timber Elements in Tall Wood Structures

Mass Timber Fire Design Resource

- Code compliance options for demonstrating FRR
- Updated as new tests are completed
- Free download at woodworks.org

COST IMPLICATIONS DUE TO EARLY DESIGN DECISIONS

Photo: Hacker Architects

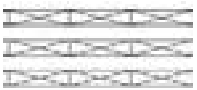
TABLE 601

Fire Resistance Rating Requirements for Building Elements (Hours)

Building Element	I-A	I-B	III-A	III-B	IV-A	IV-B	IV-C	IV-HT	V-A	V-B
Primary Structural Frame	3*	2*	1	0	3	2	2	HT	1	0
Ext. Bearing Walls	3*	2*	2	2	3	2	2	2	1	0
Int. Bearing Walls	3*	2*	1	0	3	2	2	1/HT	1	0
Floor Construction	2	2*	1	0	2	2	2	HT	1	0
Roof Construction	1.5*	1*	1	0	1.5	1	1	HT	1	0
Exposed Mass Timber Elements					None	20-40%	Most	All		

Baseline
0hr & HT

+$10/SF
1hr & maybe 2hr



+$12-15/SF
2hr FRR

Cost Source: Swinerton

*These values can be reduced based on certain conditions in IBC 403.2.1.

Early Design Decision Example: Construction Type

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

Assembly occupancy placement impact on construction type:

Owner initially desires events space on top (3rd) floor

- Requires Construction Type IIIA

If owner permits moving events space to 1st or 2nd floor

- Could use Construction Type IIIB

Early Design Decision Example: Construction Type

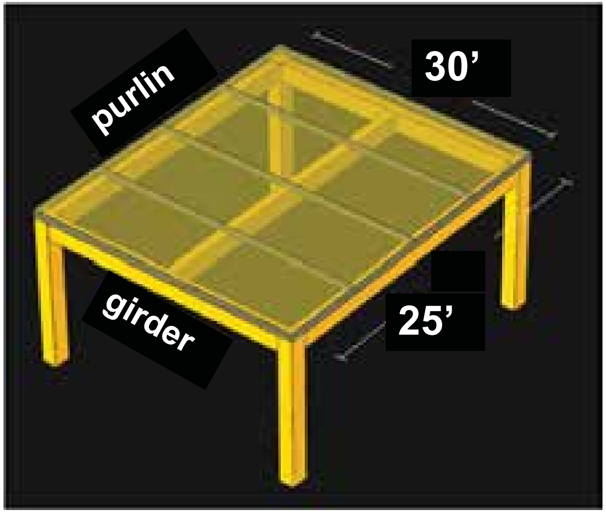
3-story building on college campus

Construction type impact on cost:

Location of Event Space	3rd Floor	1st Floor
Construction Type	III-A	III-B
Assembly Group	A-3	A-3
Fire Resistive Rating	1-Hr	0-Hr
Connections	Concealed	Exposed
CLT Panel Thickness	5-Ply	3-Ply
Superstructure Cost/SF	**$65/SF**	**$53/SF**

Source: PCL Construction

Panel volume is usually 65-80% of MT package volume



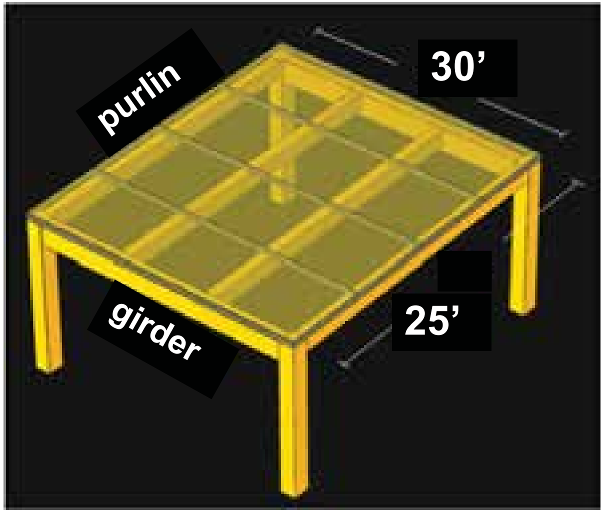
Source: Fast + Epp, Timber Bay Design Tool

Type IIIA option 1

1-hr FRR
Purlins: 5.5”x28.5”
Girders: 8.75”x33”
Columns: 10.5”x10.75”
Floor panels: 5-ply, 6-7/8” thk.

Glulam volume = 118 CF (22% of MT)
CLT volume = 430 CF (78% of MT)
Total MT volume = 0.73 CF/SF

Panel volume is usually 65-80% of MT package volume



Source: Fast + Epp, Timber Bay Design Tool

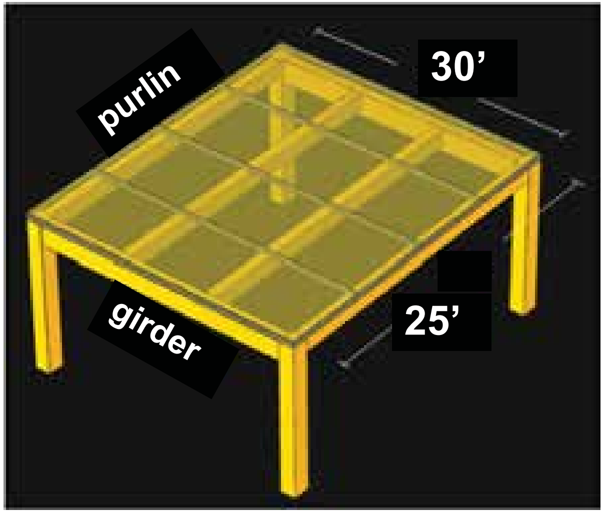
Type IIIA option 2

1-hr FRR
Purlins: 5.5”x24”
Girders: 8.75”x33”
Columns: 10.5”x10.75”
Floor panels: 5-ply, 6-7/8” thk.

Glulam volume = 123 CF (22% of MT)
CLT volume = 430 CF (78% of MT)
Total MT volume = 0.74 CF / SF

Cost considerations: One additional beam (one additional erection pick), 2 more connections

Panel volume is usually 65-80% of MT package volume



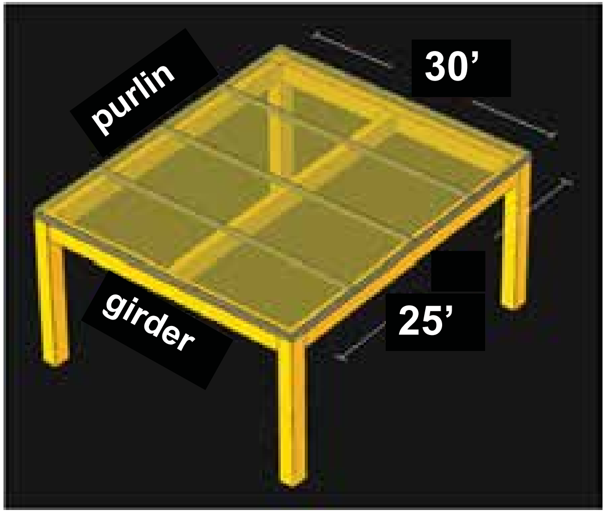
Source: Fast + Epp, Timber Bay Design Tool

Type IV-HT

0-hr FRR (min sizes per IBC)
Purlins: 5.5”x24” (IBC min = 5”x10.5”)
Girders: 8.75”x33” (IBC min = 5”x10.5”)
Columns: 10.5”x10.75” (IBC min = 6.75”x8.25”)
Floor panels: 3-ply, 4-1/8” thk. (IBC min = 4”)

Glulam volume = 120 CF (32% of MT)
CLT volume = 258 CF (68% of MT)
Total volume = 0.51 CF/SF

Which is the most efficient option?



Source: Fast + Epp, Timber Bay Design Tool

	Timber Volume Ratio
IIIA – Option 1	0.73 CF / SF
IIIA – Option 2	0.74 CF / SF
IV-HT	0.51 CF / SF

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

Expert Tips

Key Design Considerations for Mass Timber Projects

Important considerations related to construction type, fire ratings, panel thickness, member size and occupancy.

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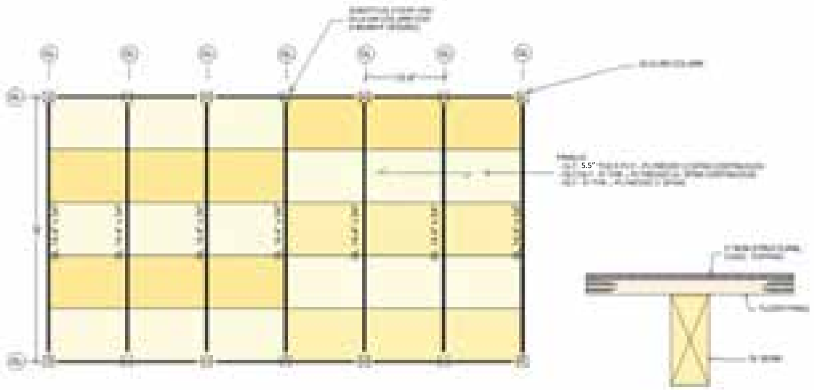
Selecting a Construction Type

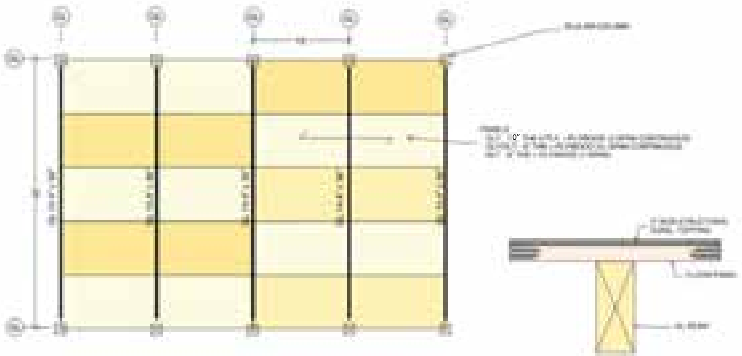
For mass timber projects, selection of construction type is one of the more significant design decisions. While it's common to choose construction type based on structural material—i.e., to assume that steel and concrete structures should be Type II, light-frame wood should be Type V, and exposed heavy/mass timber should be Type IV—this approach can lead to additional costs. While Type IV construction can be used for exposed



Baseline

12’-6” Glulam Spacing

5.5” CLT



$ +5%

15’ Glulam Spacing

7” CLT

Source: Seattle Mass Timber Tower Book

Expert Tips

Creating Efficient Structural Grids in Mass Timber Buildings

Although a mass timber solution may work economically on grids created for other materials, a few modifications can increase efficiencies related to member sizing and manufacturer capabilities.

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Mass timber products such as cross-laminated timber (CLT), nail-laminated timber (NLT) and glue-laminated timber (glulam) are at the core of a revolution that is shifting how designers think about construction. At no time has materials selection been such an integral aspect of the building designer's daily responsibilities. In addition to its sustainability and light carbon footprint, mass timber has benefits that include enhanced aesthetics, speed of construction and light weight, all of which can positively impact costs. However, to convince building owners and developers that a mass timber solution is viable, the structural design must also be cost competitive. This requires a full understanding of both material properties and

$$Value\ Analysis = \frac{\uparrow Function + \uparrow Aesthetics}{\downarrow Cost}$$

Photo: RMW Architecture & Interiors

$$Value\ Engineering = \frac{\downarrow Function + \downarrow Aesthetics}{\downarrow Cost}$$

MEP LAYOUT & INTEGRATION

Smaller grid bays at central core (more head height)

- Main MEP trunk lines around core, smaller branches in exterior bays


Credit: Blaine Brownell


Credit: WoodWorks

Dropped below framing

- Can simplify coordination (fewer penetrations)
- Bigger impact on head height


Credit: Alex Schreyer


Credit: WoodWorks

Penetrations through framing

- Requires more coordination (penetrations)
- Bigger impact on structural capacity of penetrated members
- Minimal impact on head height

Over top of dropped beams and below panels

- Fewer penetrations
- Bigger impact on head height (overall structure depth is greater)
- FRR impacts: top of beam exposure

Gaps between MT panels

- Fewer penetrations, can allow for easier modifications later

Credit: Ema Peter/MGA

Credit: Hacker Architects

Raised access floors (RAF)

- Impact on head height
- Concealed space code provisions

Credit: Global IFS

Buried in topping slab

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

Credit: Alex Schreyer

INSURANCE ISSUES

ICE Block 1, RMW Architecture & Interiors, Buehler Engineering, photo © TG Photography

- 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

Photo Credit: StructureCraft

Photo Credit: GLI Partners

INSURANCE ISSUES | INSURANCE CONCERNS VS. BUILDING CODE CONCERNS

- 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