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

Presented by David Hanley and
Brandon Brooks, MBA, PMP
WoodWorks
May 22, 2022

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

MULTI-FAMILY/MIXED-USE | EDUCATION | OFFICE | RETAIL | INDUSTRIAL | CIVIC | INSTITUTIONAL

WOODWORKS
WOOD PRODUCTS COUNCIL

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

John W. Olver Design Building at UMass Amherst
Leers Weinzapfel Associates, Equilibrium Consulting
photo © Albert Vecerka / Esto

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

Concealed Spaces in Wood-Frame and Mass Timber Construction | June 8

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

Visit woodworks.org/events

New for GCs and installers:

U.S. Mass Timber Construction Manual

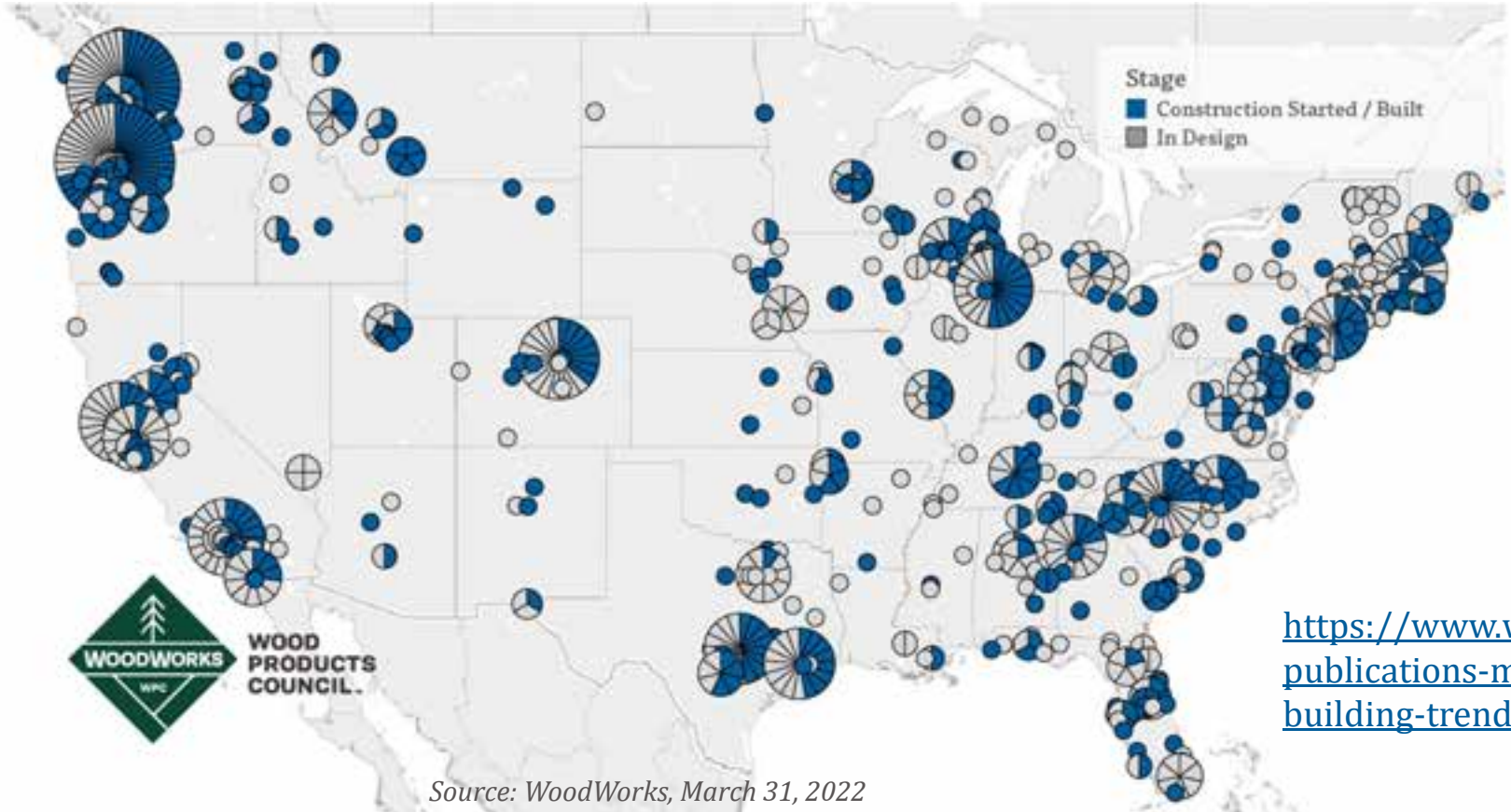
PHOTO: MARCUS KAUFMAN

WOODWORKS
WOOD PRODUCTS COUNCIL

Download free at
woodworks.org

Current State of 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/

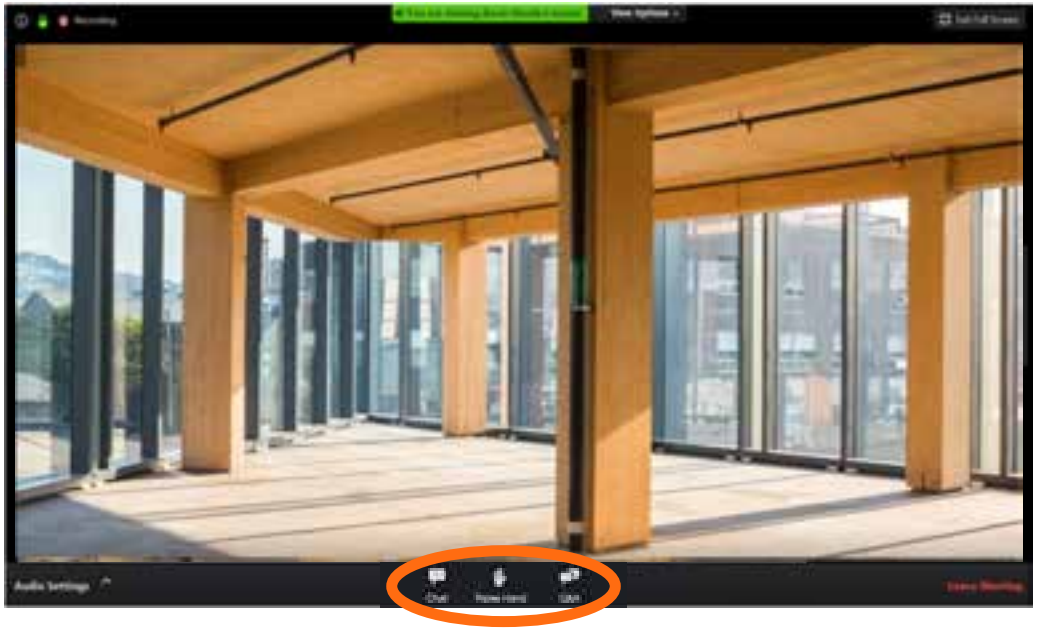
Source: WoodWorks, March 31, 2022

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

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.**



"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.

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

Products
Structural Solution & Connections
Projects and Code Considerations

MASS TIMBER CONSTRUCTION

Planning for Construction
Performing Construction
Workforce Development

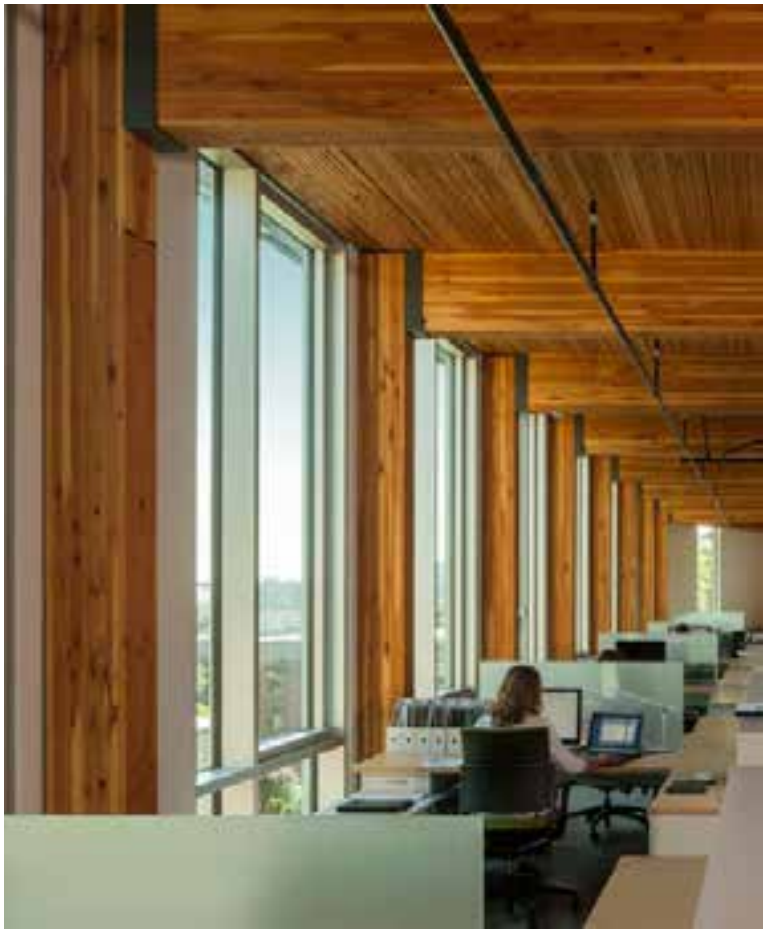
MASS TIMBER OVERVIEW

Photo: PCL Construction

OVERVIEW | TIMBER METHODOLOGIES

Light Wood-Frame
Photo: WoodWorks

Heavy Timber
Photo: Benjamin Benschneider



Mass Timber
Photo: John Stamets

MASS TIMBER PRODUCTS

Glue Laminated Timber (Glulam)
Beams & columns

Cross-Laminated Timber (CLT)
Solid sawn laminations

Cross-Laminated Timber (CLT)
SCL laminations

Photo: Freres Lumber

Photo: StructureCraft

Photo: LendLease

Photo: LEVER Architecture

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Nail-Laminated Timber (NLT)

Photo: Think Wood

Glue-Laminated Timber (GLT)

Photo: StructureCraft

Photo: StructureCraft

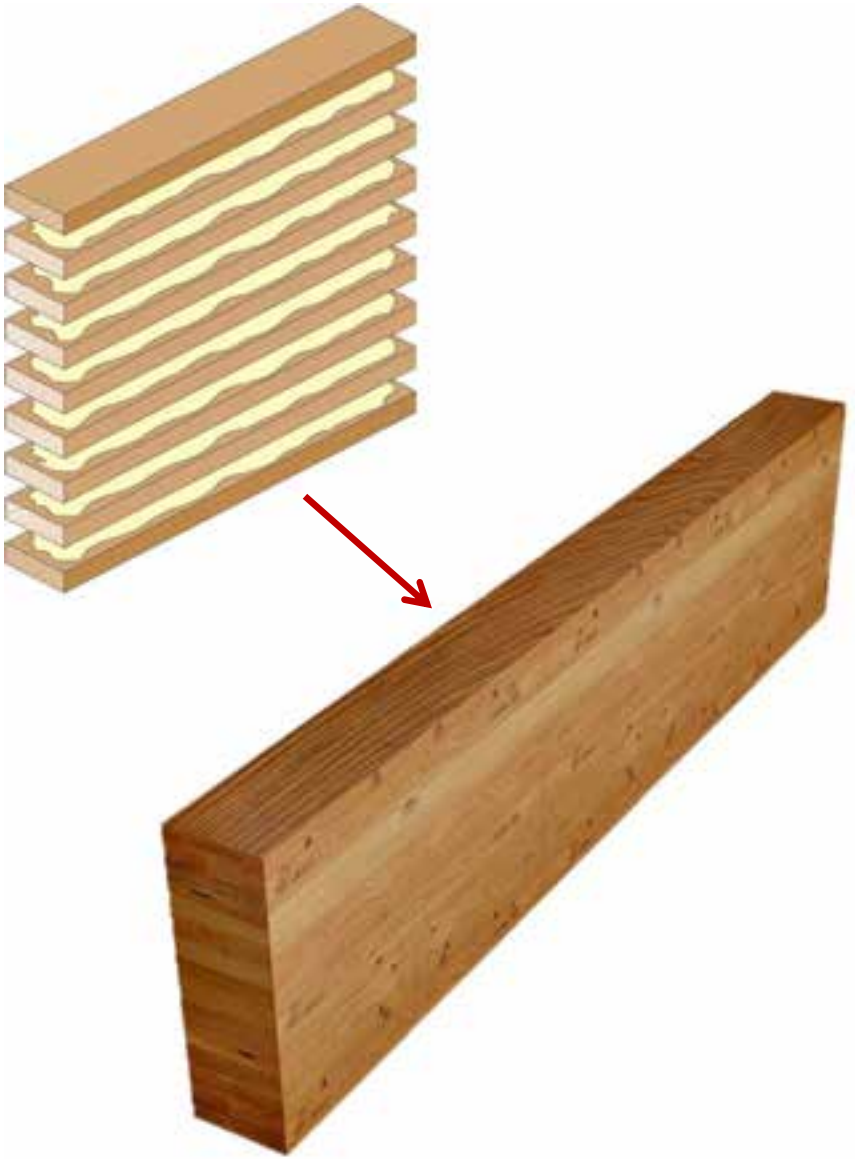
Photo: Ema Peter

Photo: Manasc Isaac Architects/Fast + Epp

Glue Laminated Timber (GLT)

Glue Laminated Timber (GLT)

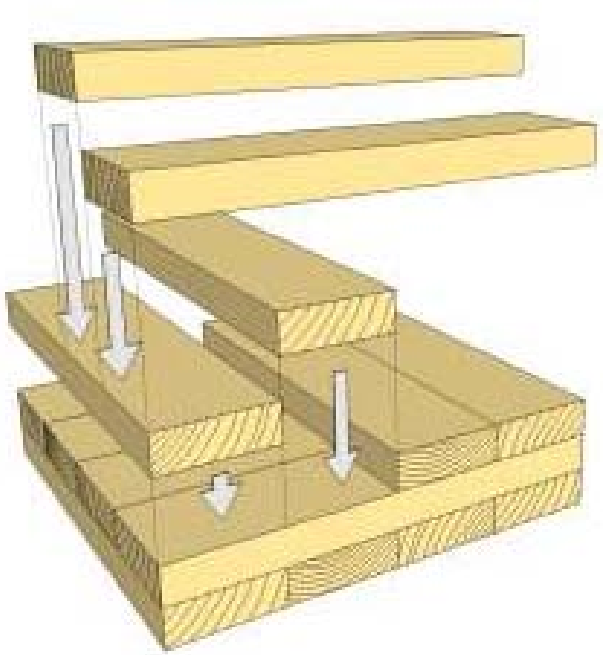
Photo: Manasc Isaac Architects/Fast + Epp

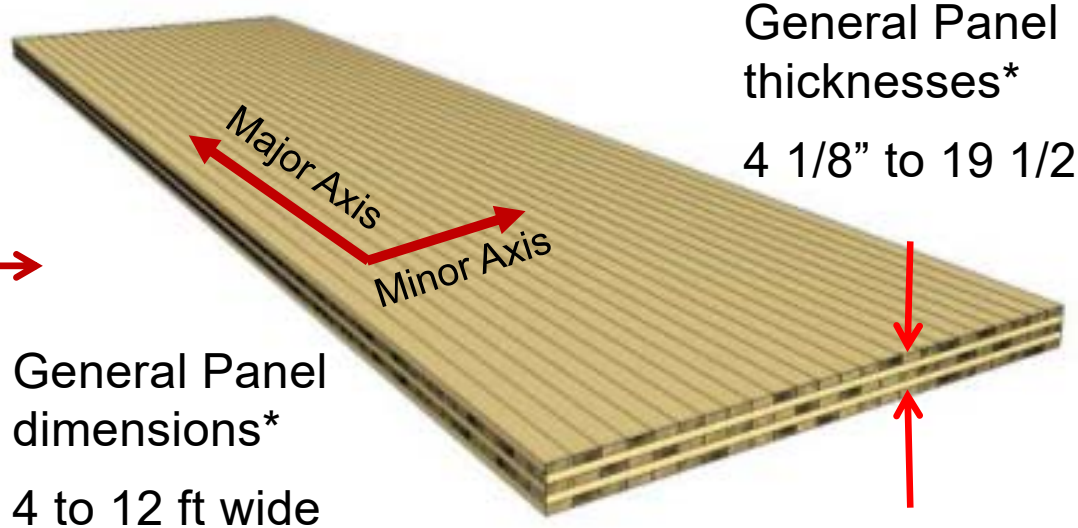


Cross-Laminated Timber (CLT)

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)

Photo: StructureCraft

Nail-Laminated Timber (NLT)

Photo: StructureCraft

Photo: Think Wood

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

Photo: Ema Peter

STRUCTURAL SOLUTIONS | POST, BEAM + PLATE

Photo: Seagate Structures

Photo: Lendlease


Photo: John Klein

STRUCTURAL SOLUTIONS | HYBRID STEEL + MASS TIMBER

Photo: LEVER Architecture

STRUCTURAL SOLUTIONS | HYBRID CONCRETE + MASS TIMBER

Concealed Connectors

Photo Marcus Kauffman

Self Tapping Screws

Photo Simpson Strong Tie

Beam to Column

Photo: StructureCraft

Photo: Structurlam

Column to Foundation

Photo: Alex Schreyer

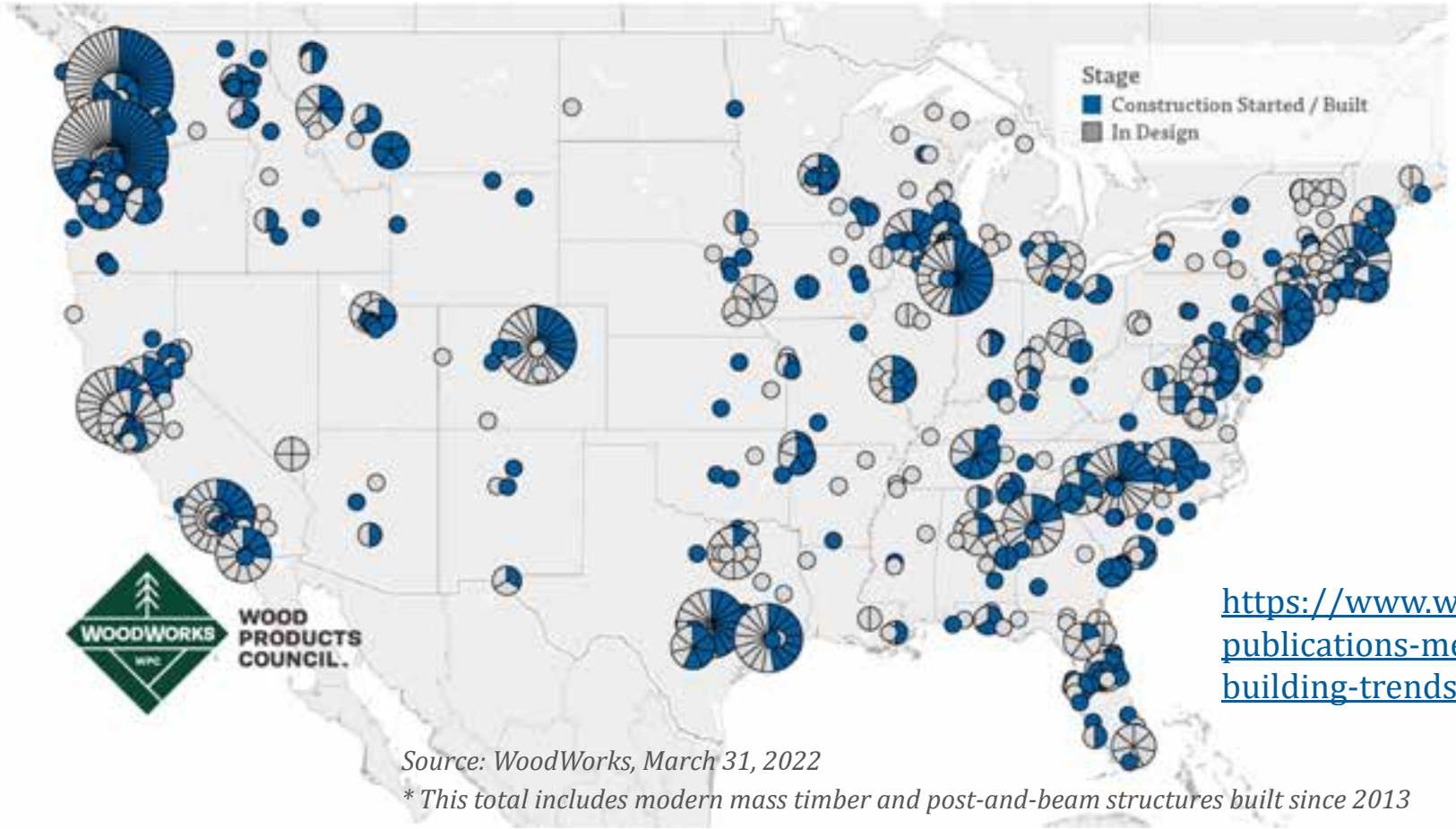
Panel to Panel & Supports

Photo: Charles Judd

Photo: Marcus Kauffman

Current State of 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.



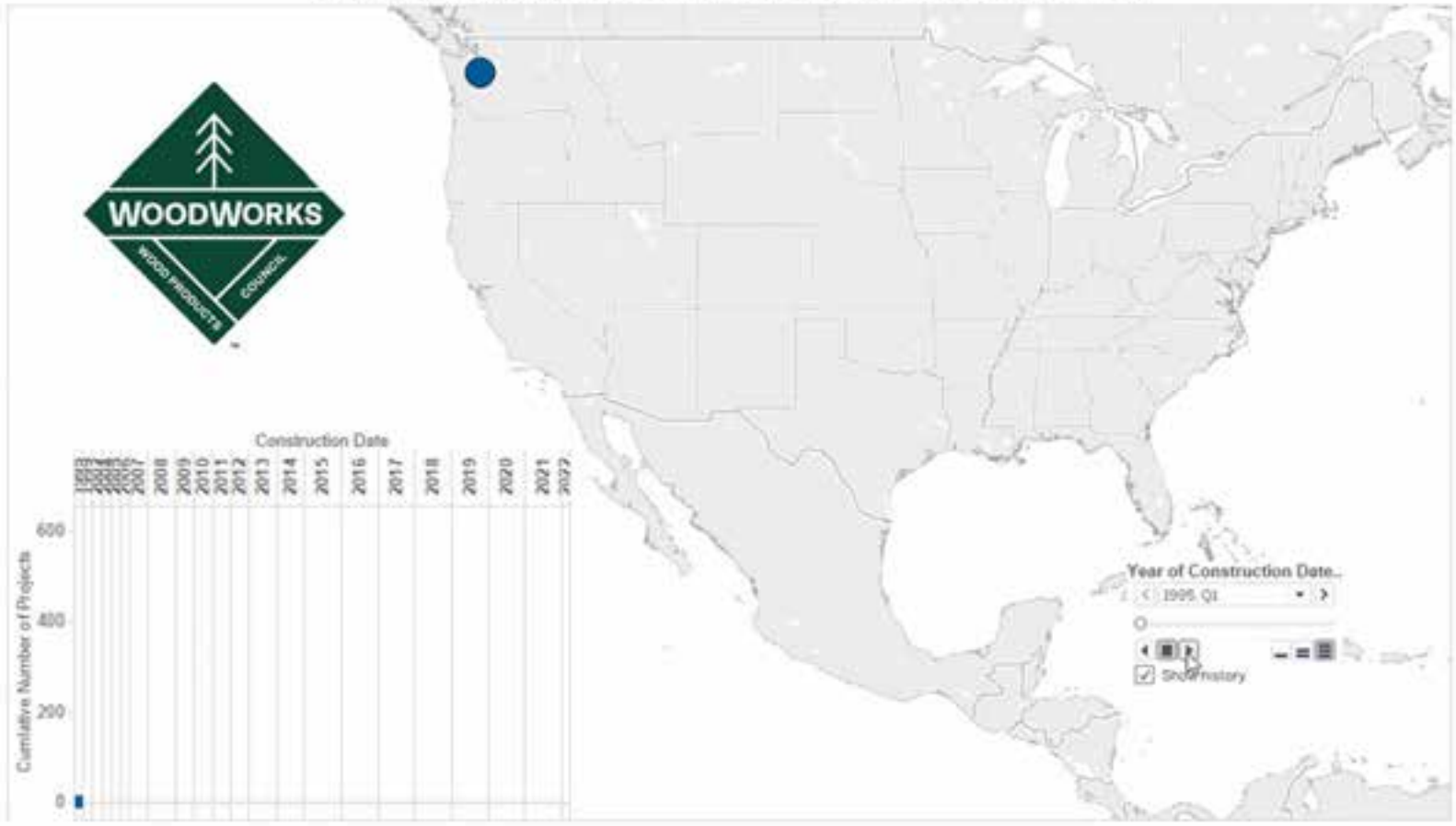
https://www.woodworks.org/publications-media/building-trends-mass-timber/

Source: WoodWorks, March 31, 2022

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

Current State of 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.

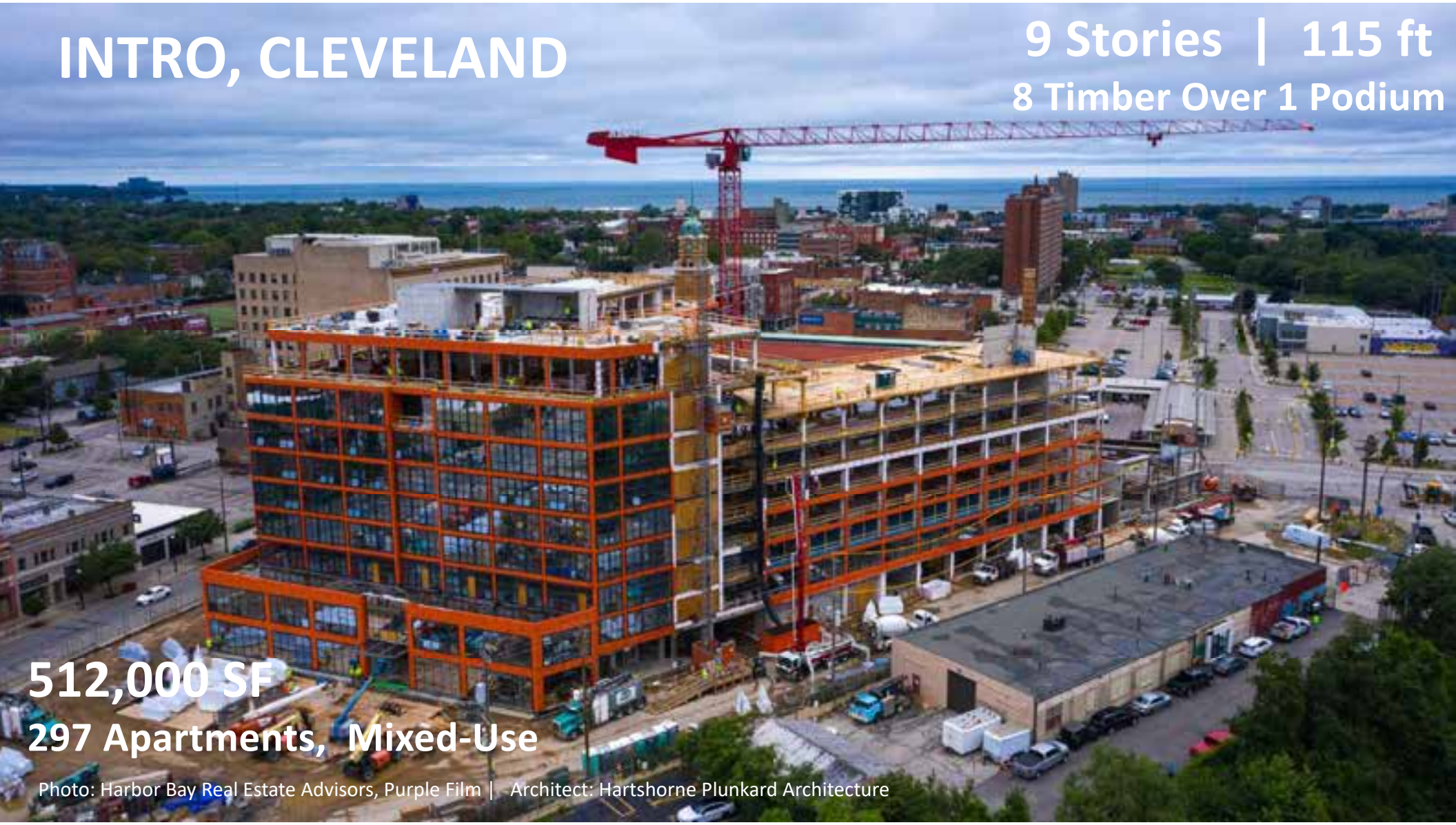


Photos: Michael Elkan | Naturally Wood | UBC

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

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

9 Stories | 115 ft
8 Timber Over 1 Podium

ASCENT, MILWAUKEE

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

493,000 SF

259 APARTMENTS, MIXED-USE

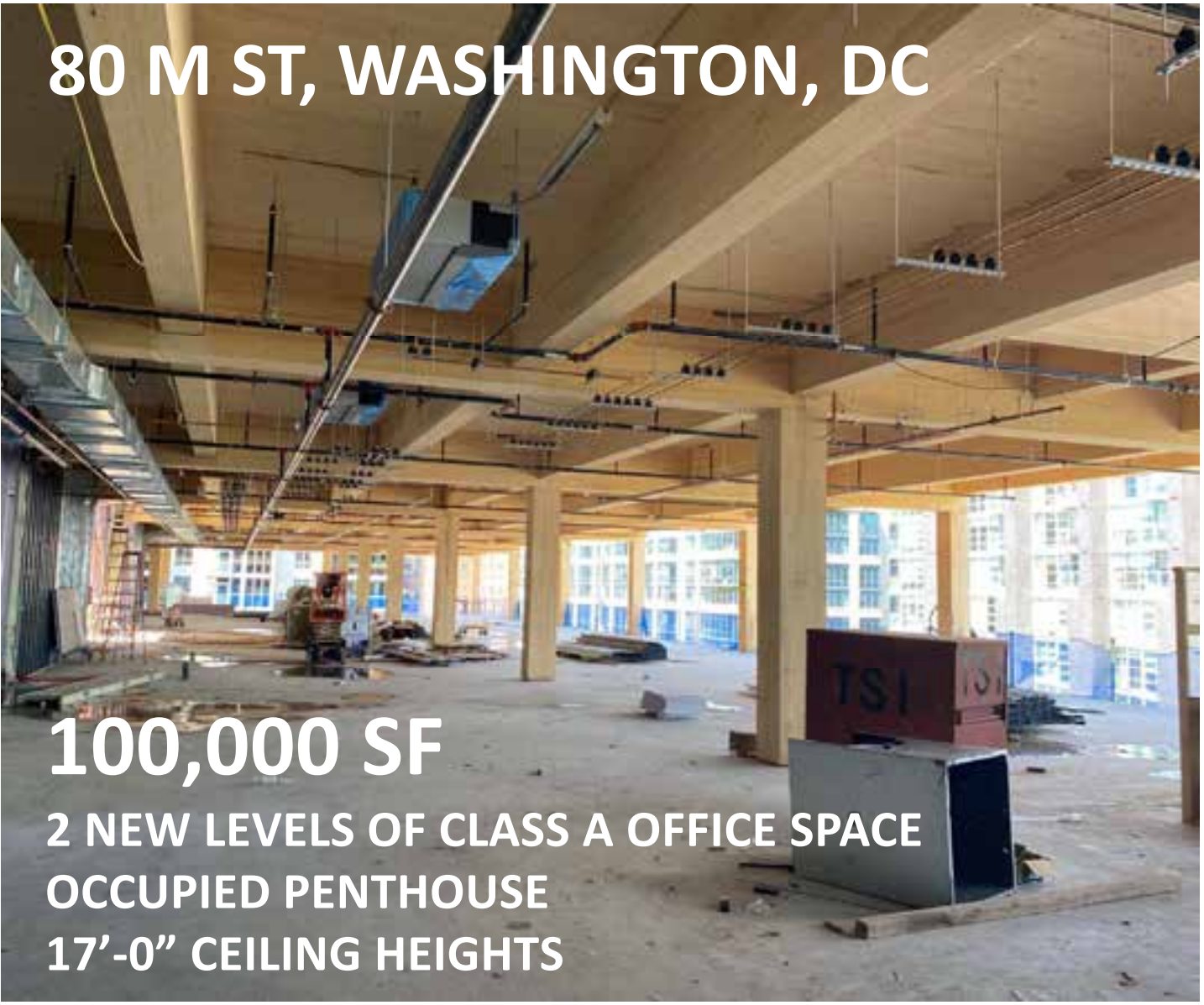
ASCENT, MILWAUKEE

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

187,000 SF

Photo: WoodWorks | Architect: William McDonough + Partners


APEX PLAZA
CHARLOTTESVILLE, VA
8 STORIES
6 TIMBER OVER 2 PODIUM, 100 FT
Monticello Av
Gleason St
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

11 E LENOX, BOSTON, MA

Credit: H + O Structural Engineering

Photos: StructureCraft

Photo: Hartshorne Plunkard Architectur

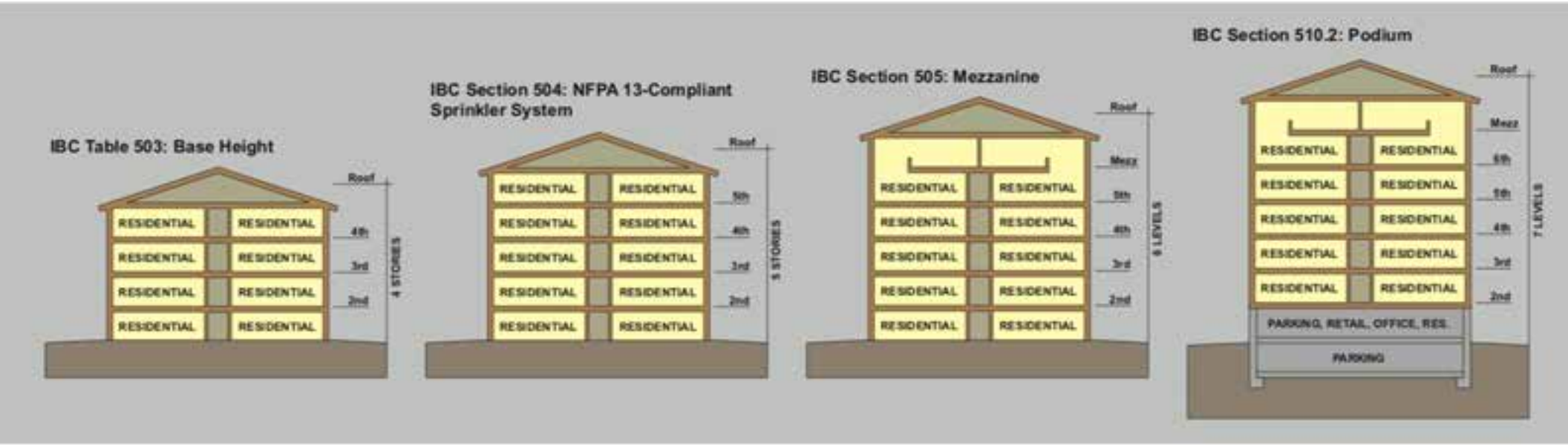
MASS TIMBER PROJECT CONSIDERATIONS

Photo: Hacker Architects

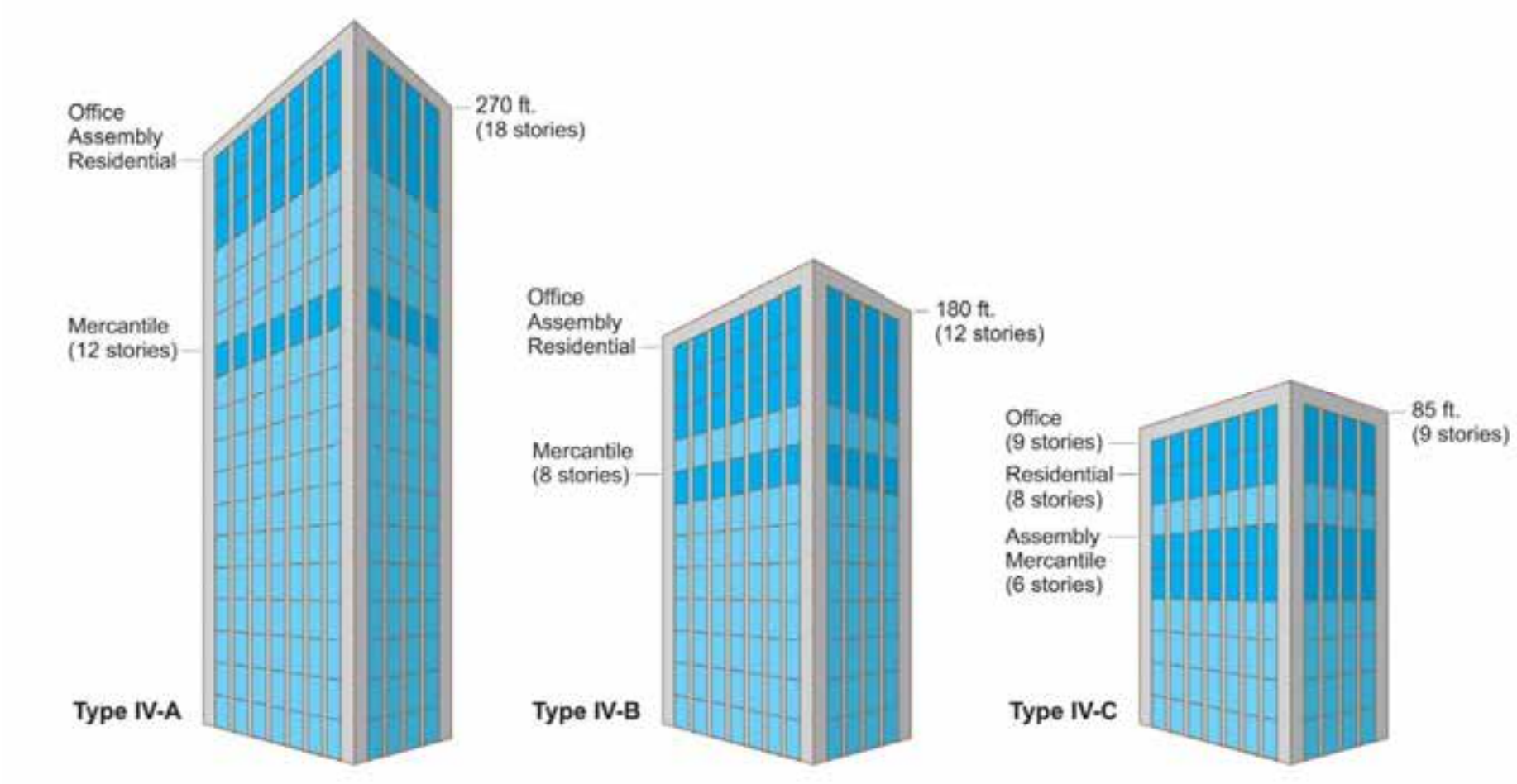
MASS TIMBER IN THE CODE

Photo: Freres Lumber

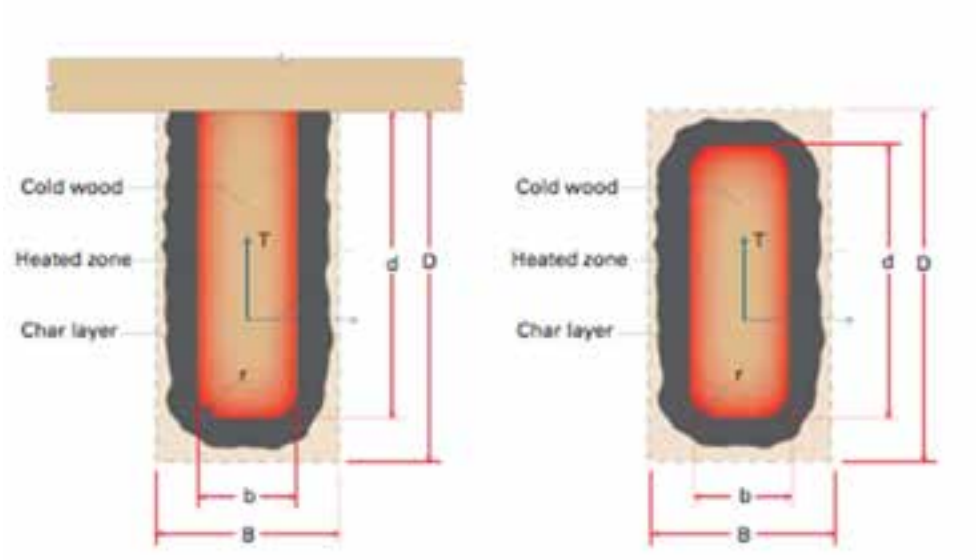
Mass Timber in Low- to Mid-Rise: 1-6 Stories in Construction Types III, IV or V



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



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



Source: AWC's TR 10

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

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

Value: Program

Level 1

Level 2

Concept Plan

Hillsboro Community Center at 53rd Ave.

opsis

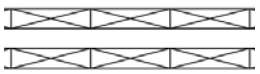
Cost: Construction Type

TABLE 601

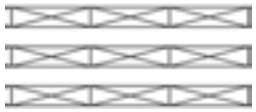
Fire Resistance Rating Requirements for Building Elements (Hours)

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		

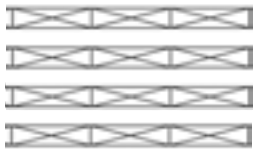
Baseline
0hr & HT



+$10/SF
1hr & maybe 2hr



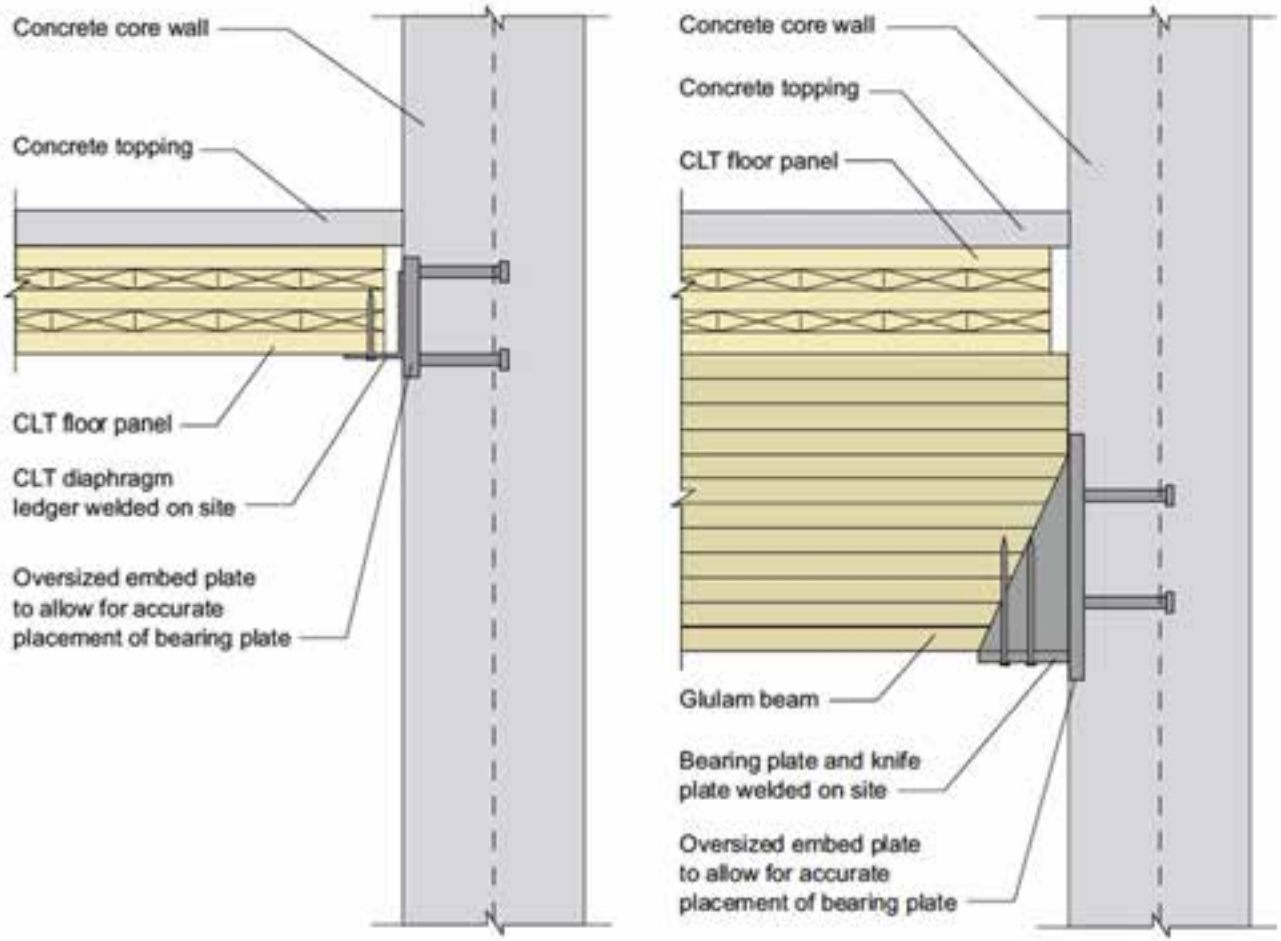
+$12-15/SF
2hr FRR



Cost Source: Swinerton

*These values can be reduced based on certain conditions in IBC 403.2.1, which do not apply to Type IV buildings.

Options for accommodating differential movement



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

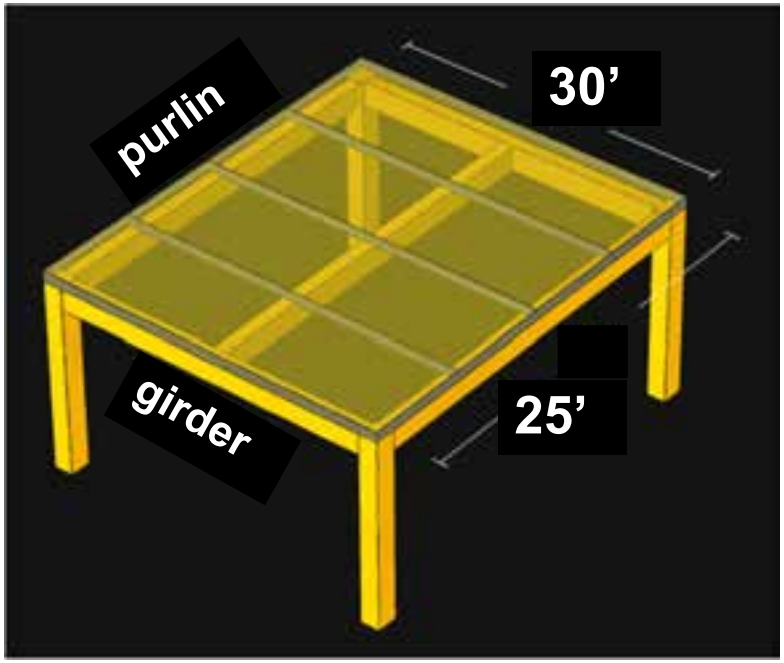
Cost Impact of Assembly Occupancy Placement:

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

Cost Implication of Design Choices

Panel volume usually 65-80% of MT package volume



Source: Fast + Epp, Timber Bay Design Tool

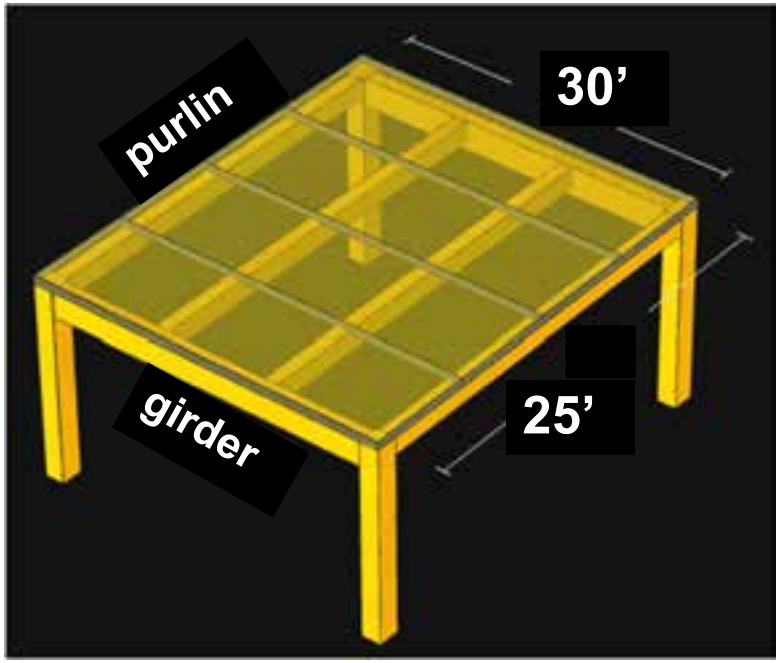
Type IIIA option 1

1-hr FRR
Purlin: 5.5”x28.5”
Girder: 8.75”x33”
Column: 10.5”x10.75”
Floor panel: 5-ply

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

Cost Implication of Design Choices

Panel volume usually 65-80% of MT package volume



Source: Fast + Epp, Timber Bay Design Tool

Type IIIA option 2

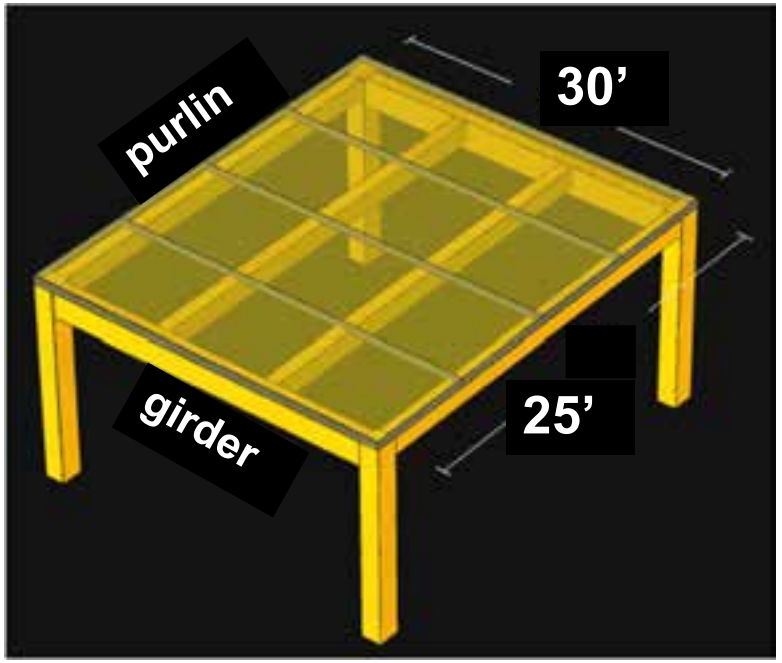
1-hr FRR
Purlin: 5.5”x24”
Girder: 8.75”x33”
Column: 10.5”x10.75”
Floor panel: 5-ply

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

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

Cost Implication of Design Choices

Panel volume usually 65-80% of MT package volume



Source: Fast + Epp, Timber Bay Design Tool

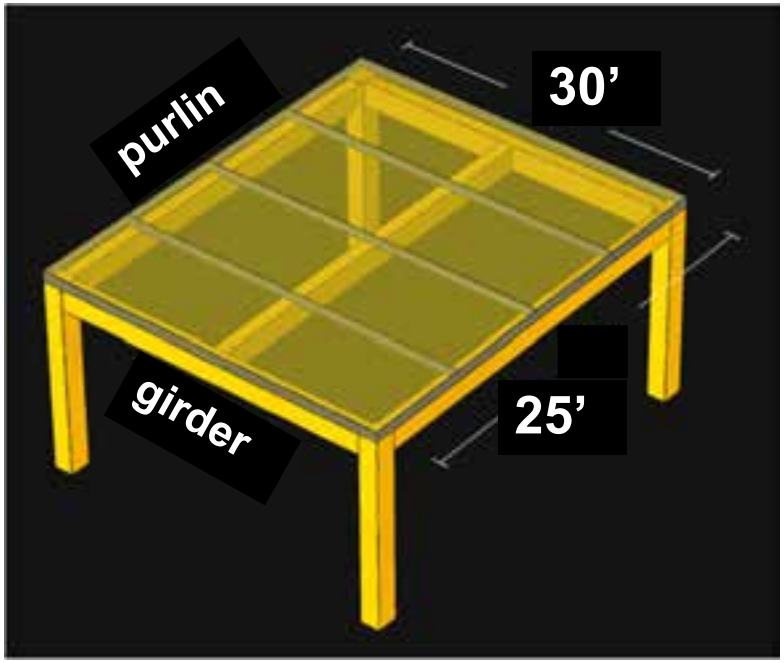
Type IV-HT

0-hr FRR (min sizes per IBC)
Purlin: 5.5”x24” (IBC min = 5”x10.5”)
Girder: 8.75”x33” (IBC min = 5”x10.5”)
Column: 10.5”x10.75” (IBC min = 6.75”x8.25”)
Floor panel: 3-ply (IBC min = 4” CLT)

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

Cost Implication of Design Choices

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.

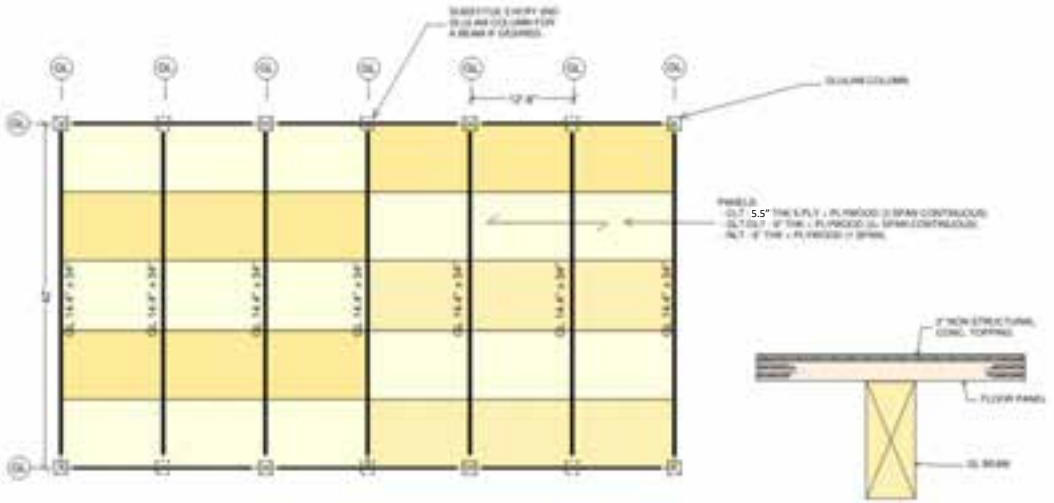
Share

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

Photo: Swinerton

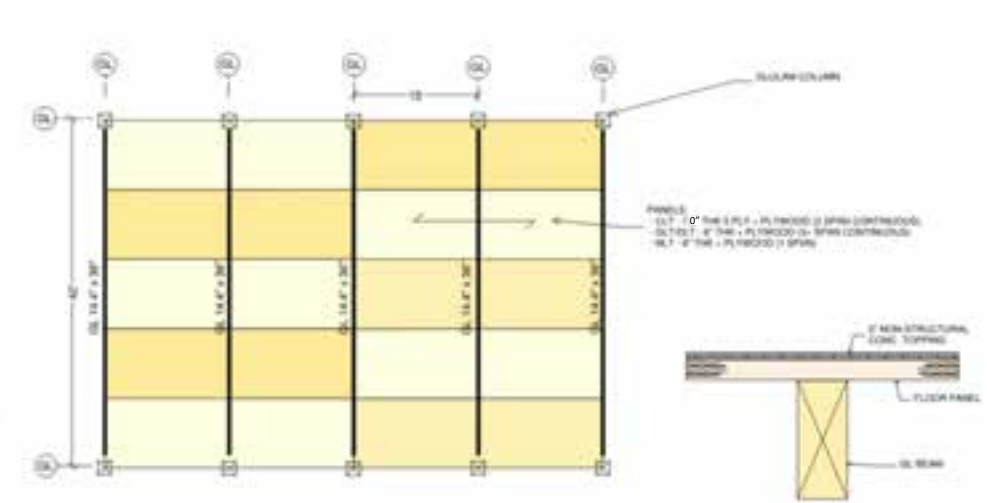
Cost: Structural System & Grid



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.

Share

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

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


Photo: RMW Architecture & Interiors

Value Analysis

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

Perimeter Glazing

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

Photo Credit: StructureCraft

Photo Credit: GLI Partners

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