



Designing and Building with Mass Timber

First United Bank's Mass Timber Branch
in Moore, OK

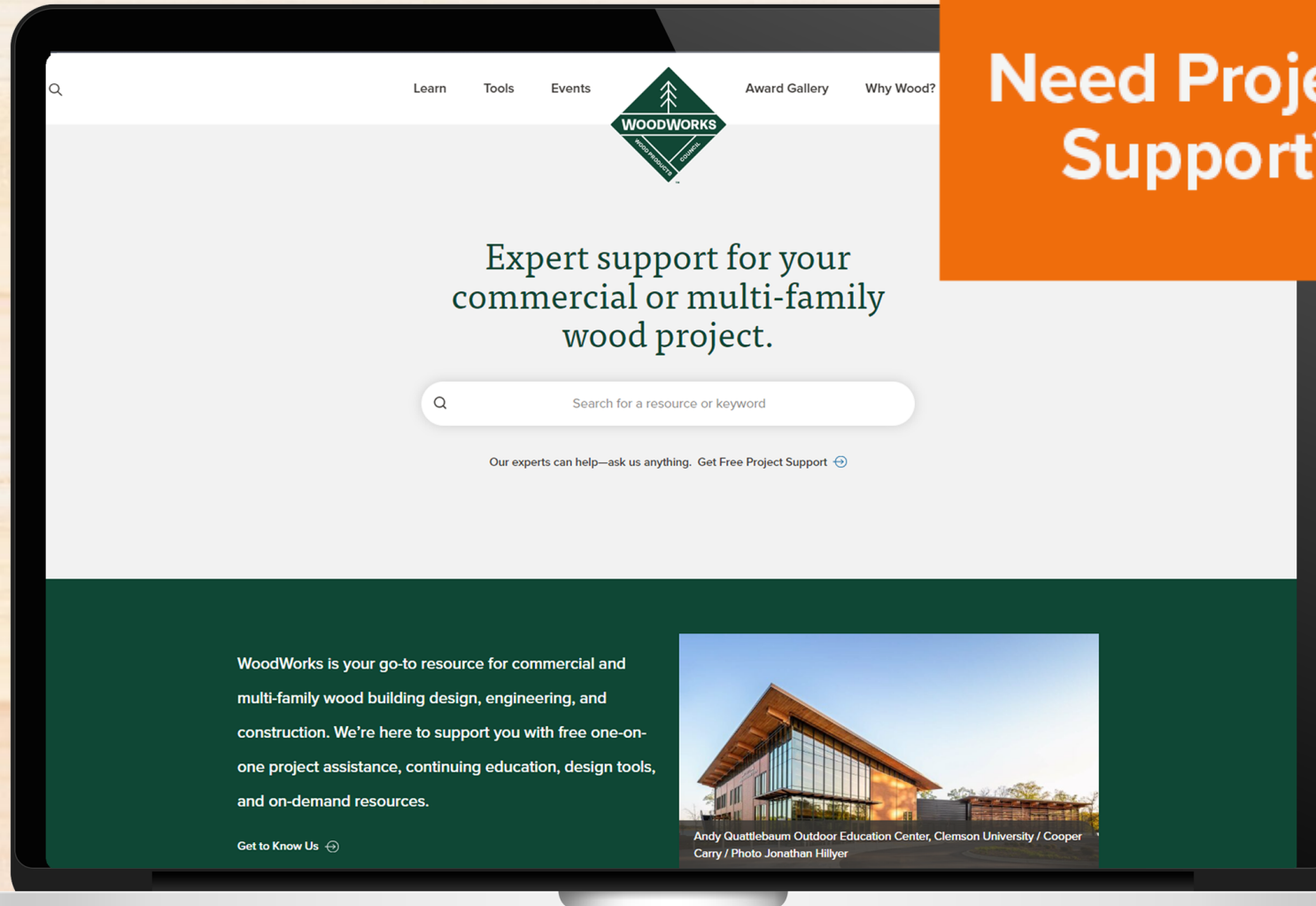
Presented By:
Jason Bahr, PE
October 3, 2023



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Mass Timber / CLT

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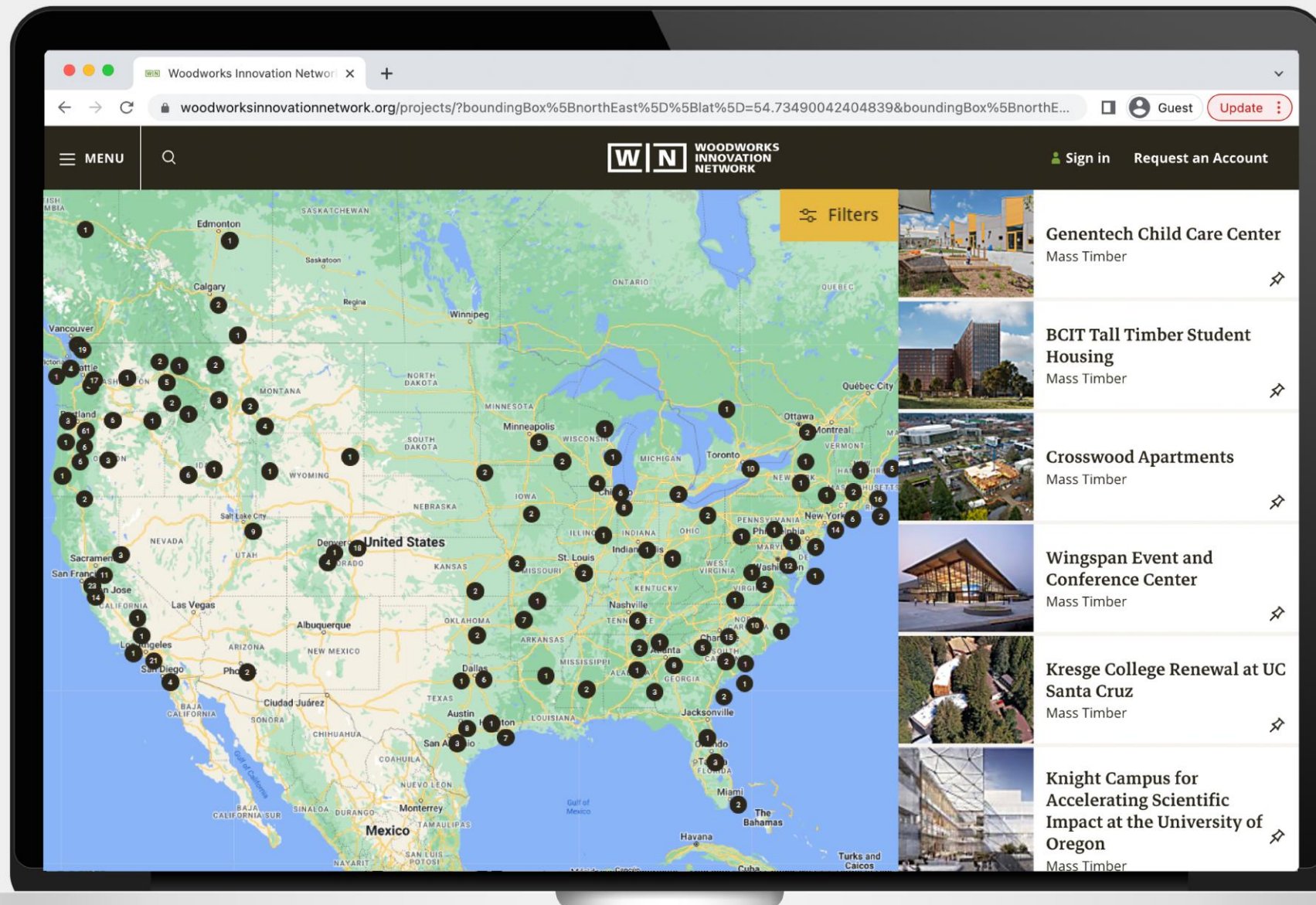
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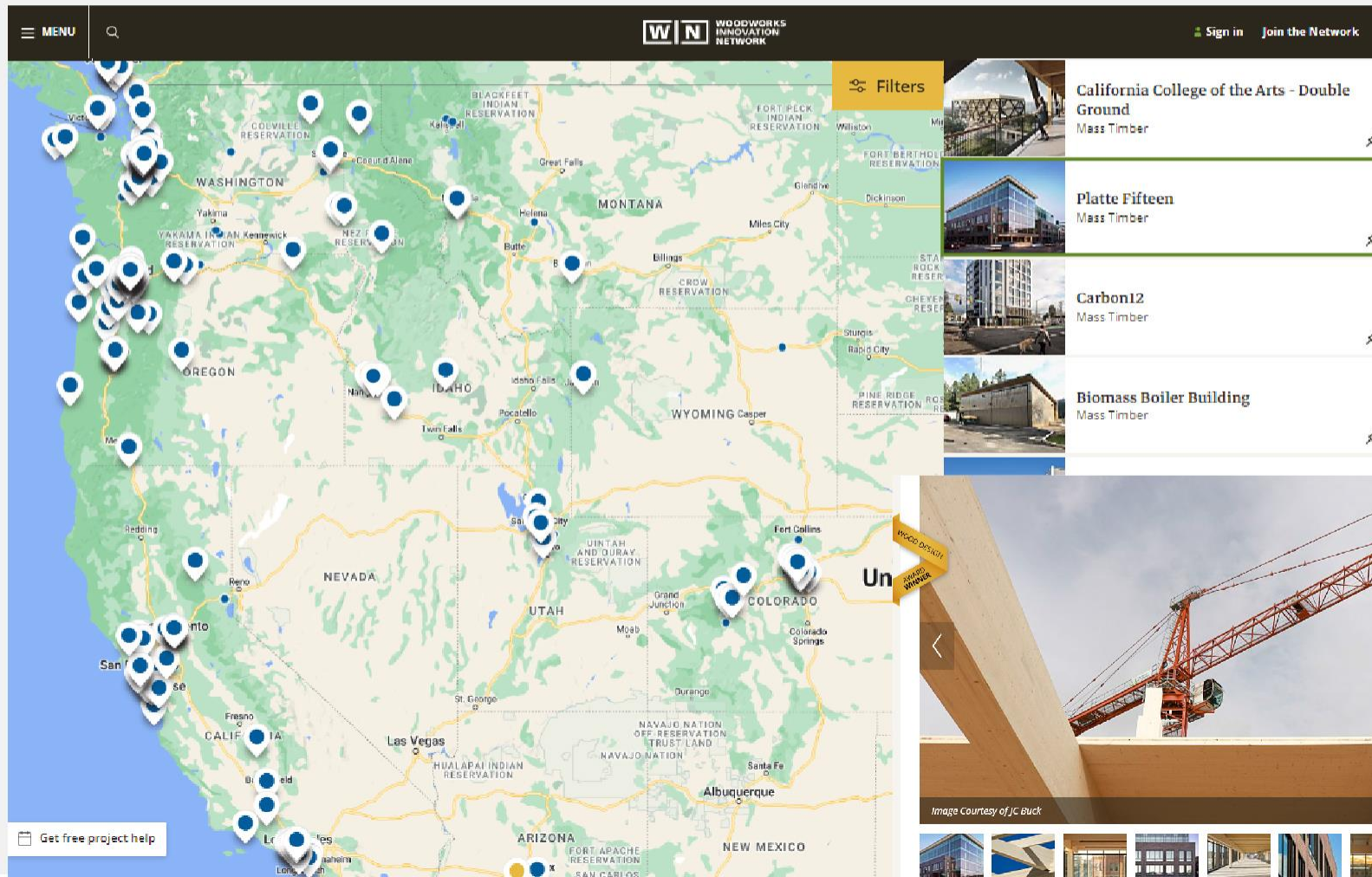
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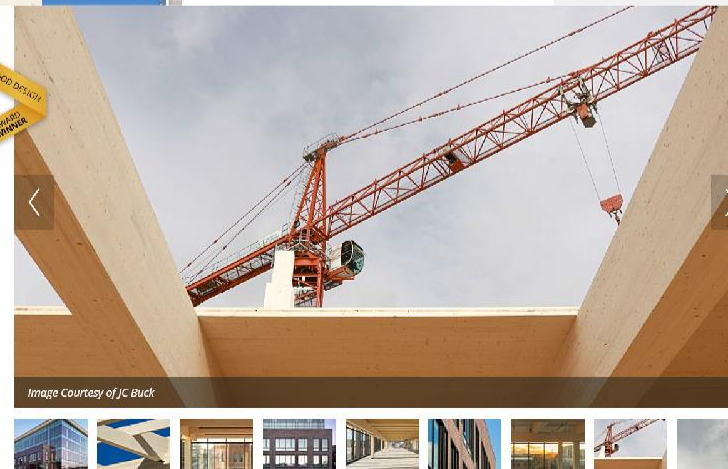
California College of the Arts - Double Ground
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Platte Fifteen

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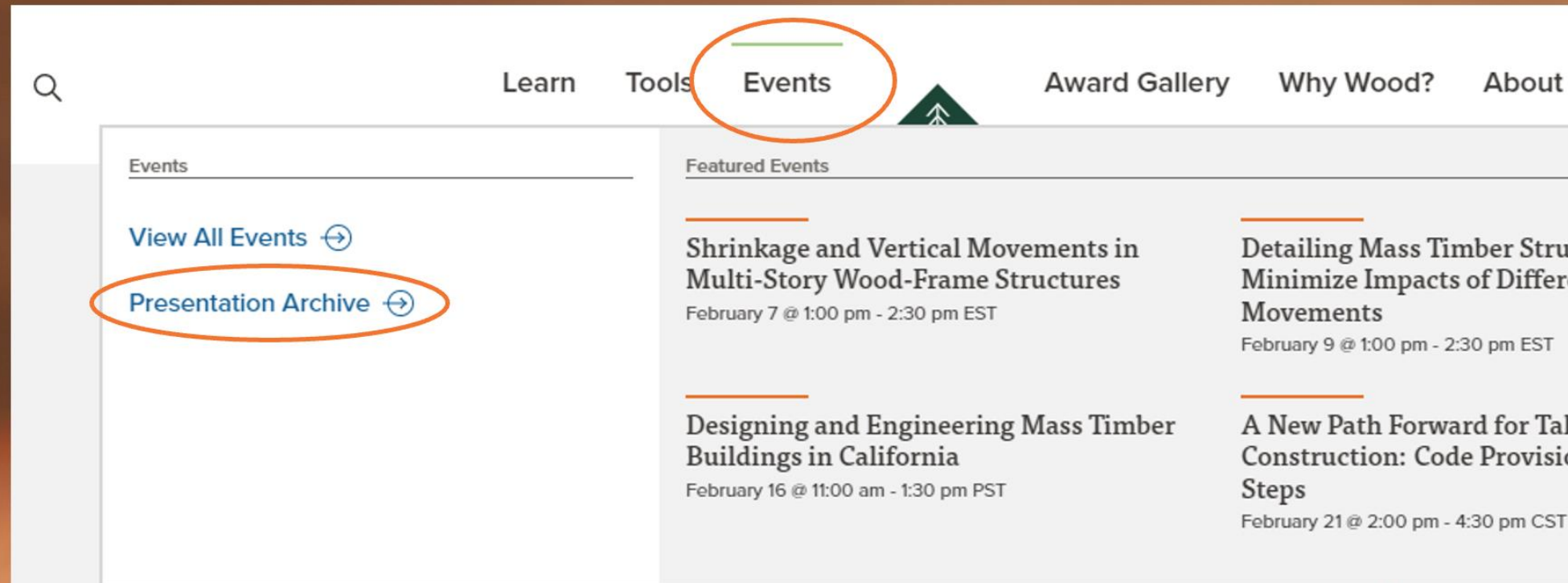


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presentation slides in pdf:

woodworks.org/presentation-archive/



wood project.



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Agenda



Designing and Building with Mass Timber + Tour First United Bank's Mass Timber Branch in Moore, OK

2:00 -2:05 pm	Welcome and Introductions, Jason Bahr
2:05 – 3:05 pm	Designing and Building with Mass Timber: Design, Planning and Performance
3:05 - 3:45 pm	Panel discussion featuring owner, builder, architect
3:45 - 4:30 pm	Tours of First United Bank, Moore branch
4:00 - 5:30 pm	Networking/Taco Tuesday

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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.

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)
Plank orientation



Photo: StructureCraft



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Photo: Ema Peter



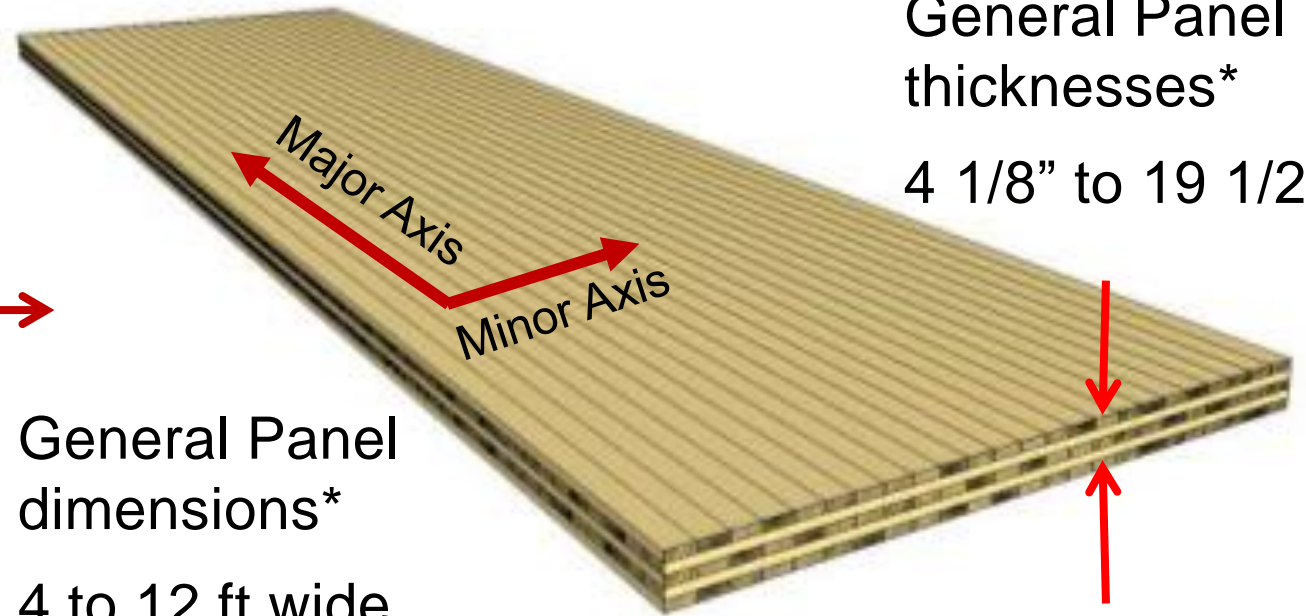
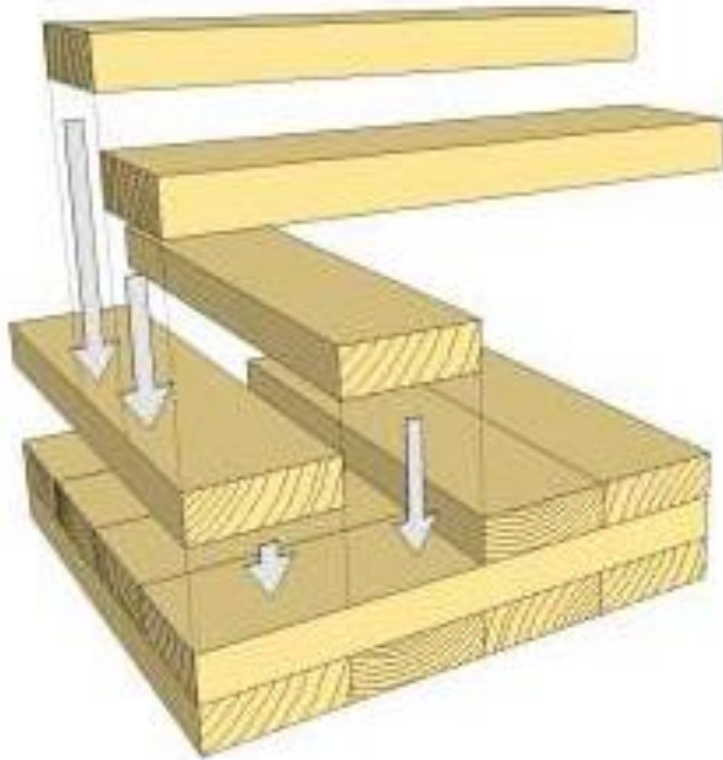
Photo: Manasc Isaac
Architects/Fast + Epp

Cross-Laminated Timber (CLT)



Cross-Laminated Timber (CLT)

With solid sawn laminations



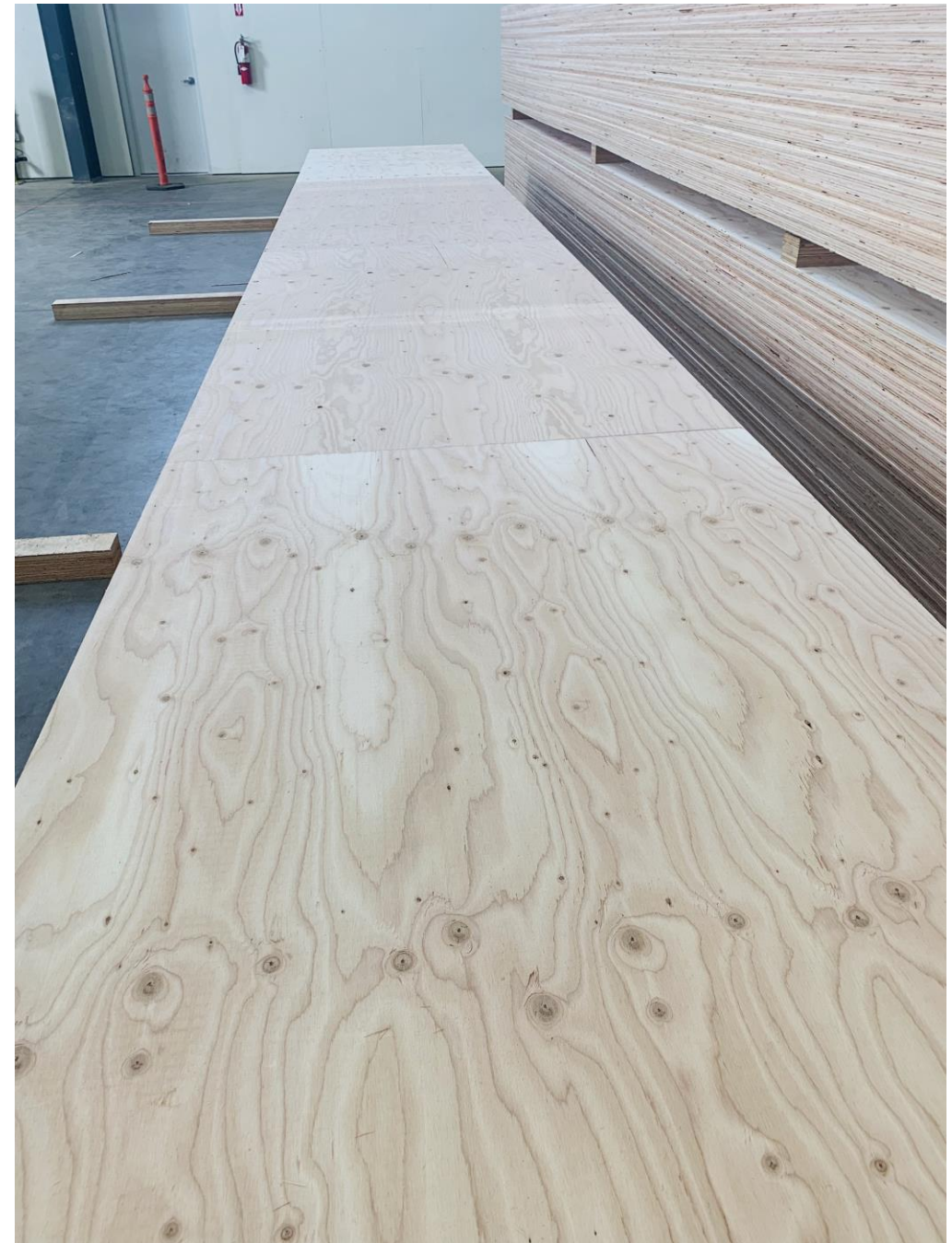
General Panel
thicknesses*
4 1/8" to 19 1/2"

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



Nail-Laminated Timber (NLT)

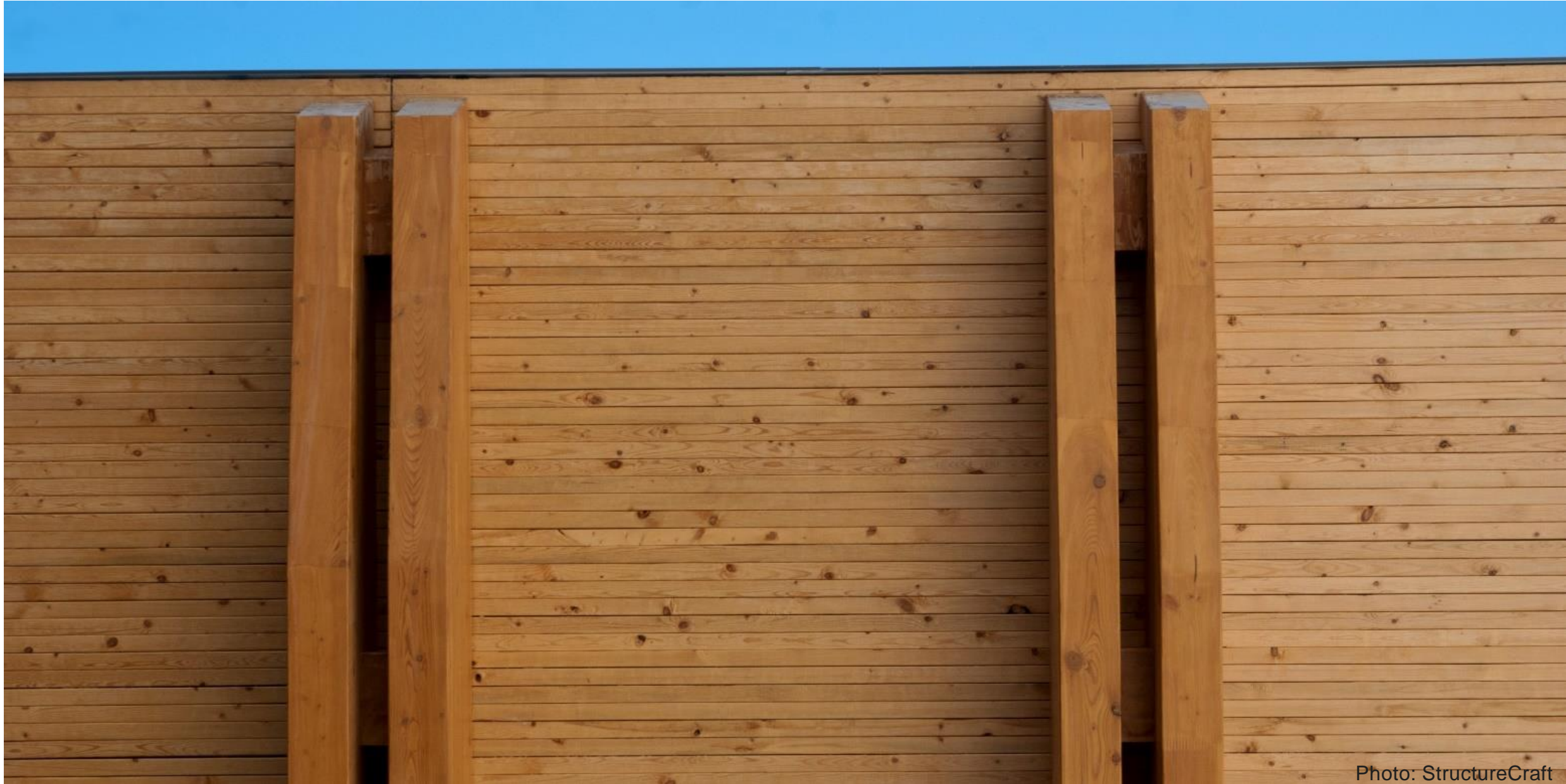


Photo: StructureCraft

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

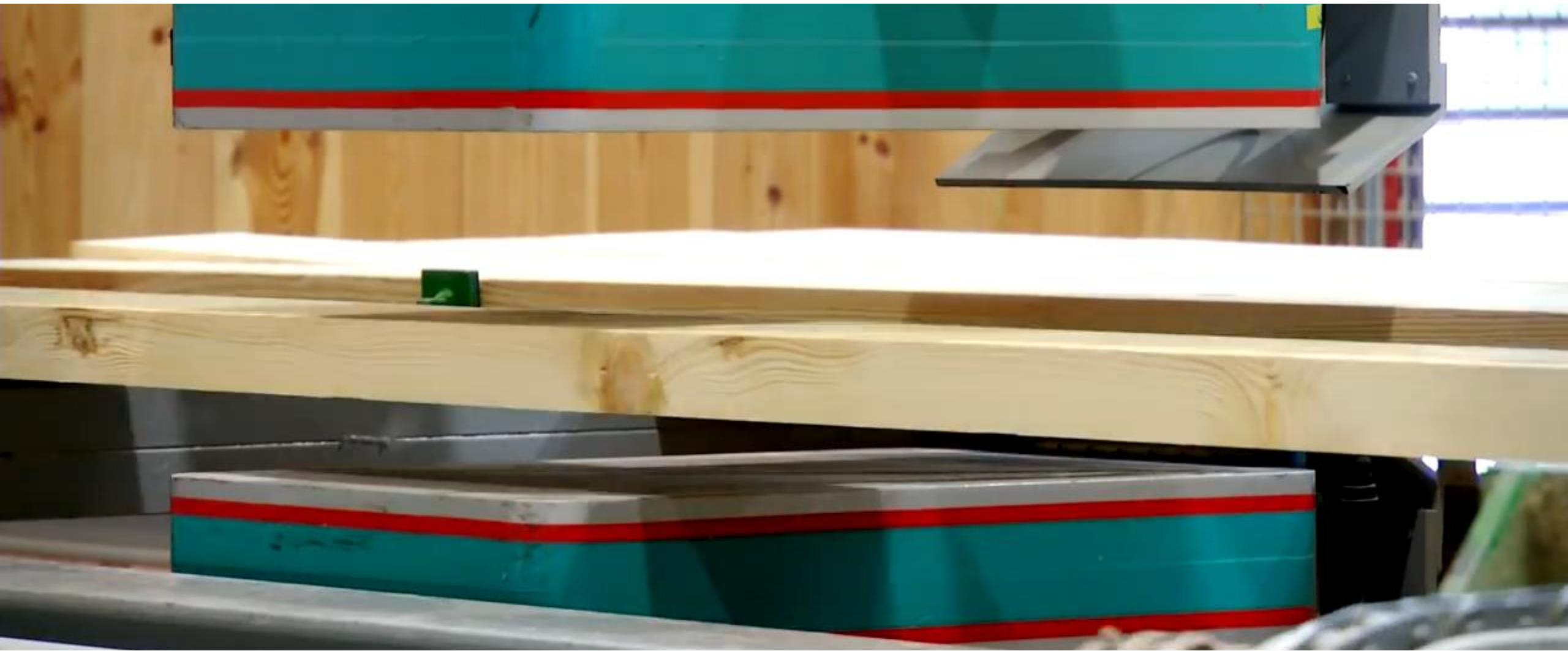




Photo: Ema Peter

STRUCTURAL SOLUTIONS | POST, BEAM + PLATE



Photo: Seagate Structures



Photo: Lendlease



Photo: John Klein

STRUCTURAL SOLUTIONS | HYBRID LIGHT-FRAME + MASS TIMBER



Photo: TimberLab

STRUCTURAL SOLUTIONS | HYBRID STEEL + MASS TIMBER



LEVER Architecture, photo Jeremy Bittermann

STRUCTURAL SOLUTIONS | HYBRID CONCRETE + MASS TIMBER

OVERVIEW | CONNECTIONS



Concealed Connectors

Photo Marcus Kauffman



Self Tapping Screws

Photo Simpson Strong Tie



OVERVIEW | CONNECTIONS



Beam to Column

Photo: StructureCraft



Photo: Structurlam



Column to Foundation

Photo: Alex Schreyer

OVERVIEW | CONNECTIONS



Panel to Panel & Supports

Photo: Charles Judd



Photo: Marcus Kauffman



Photos: Michael Elkan | Naturally Wood | UBC

PRECEDENT PROJECTS | BROCK COMMONS

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



25 STORIES

19 TIMBER OVER 6 PODIUM, 284 FT



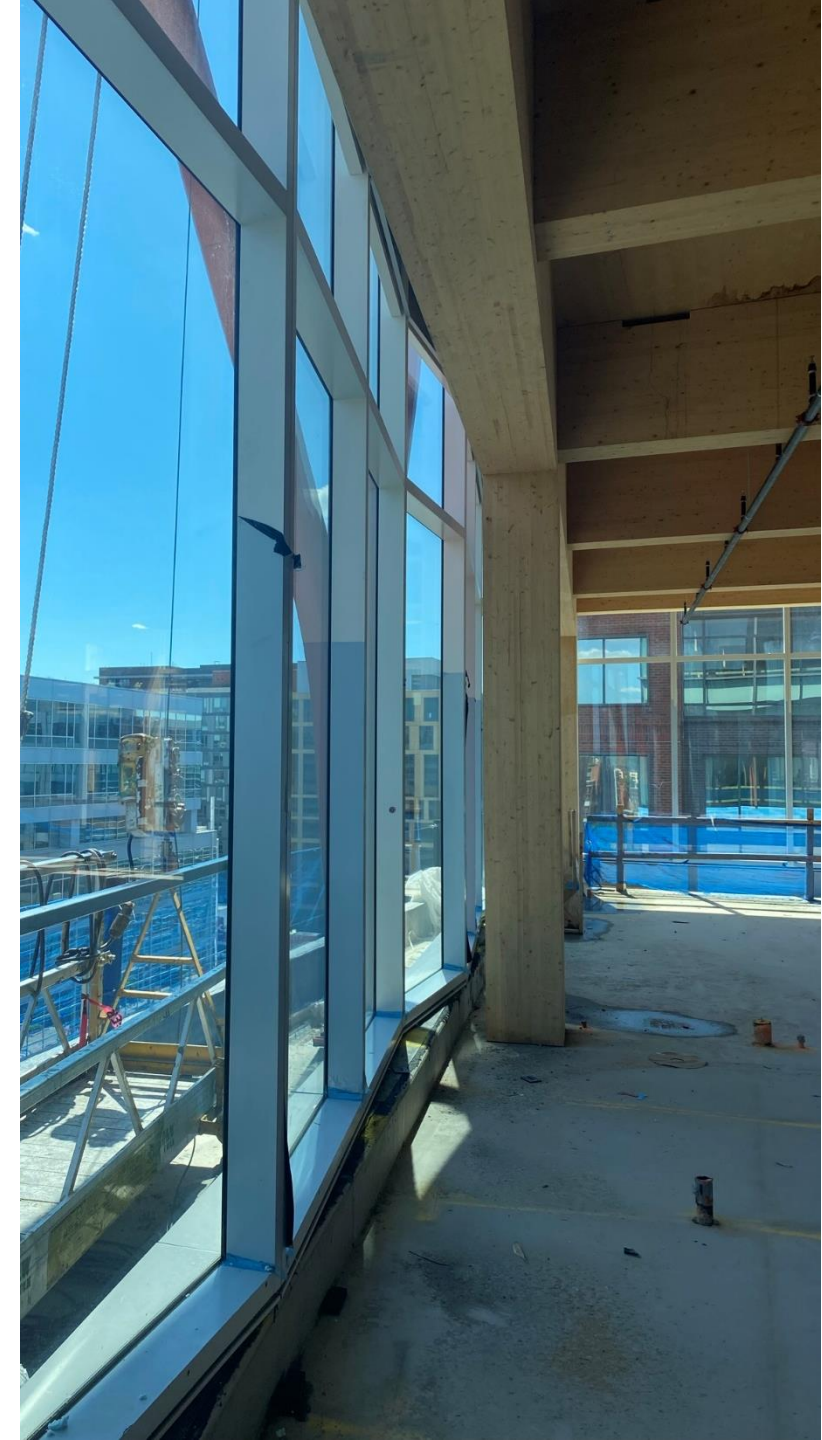
80 M ST, WASHINGTON, DC

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**



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 Architecture

MASS TIMBER PROJECT CONSIDERATIONS



Photo: Hacker Architects

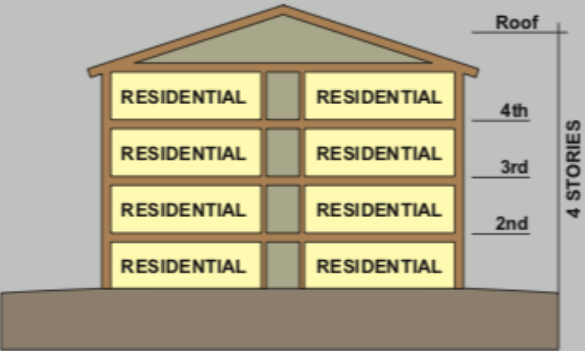
MASS TIMBER IN THE CODE



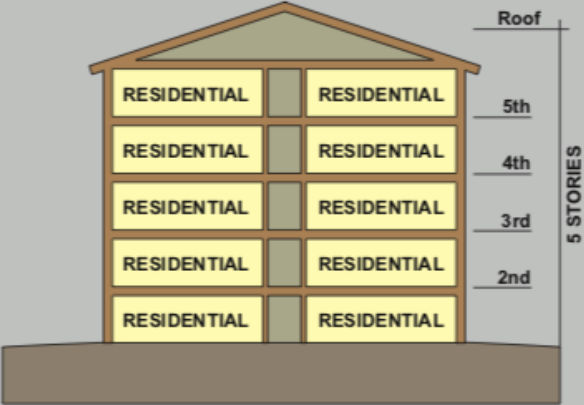
Photo: Freres Lumber

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

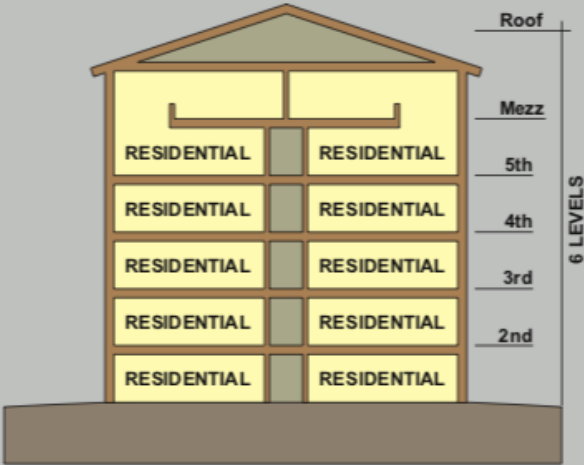
IBC Table 503: Base Height



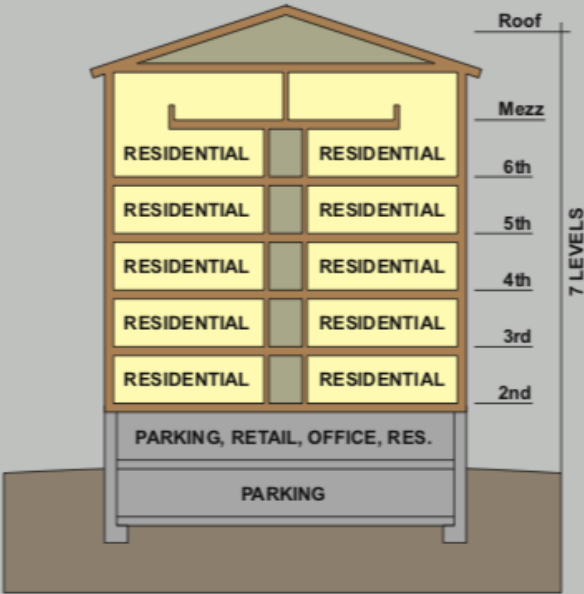
IBC Section 504: NFPA 13-Compliant Sprinkler System



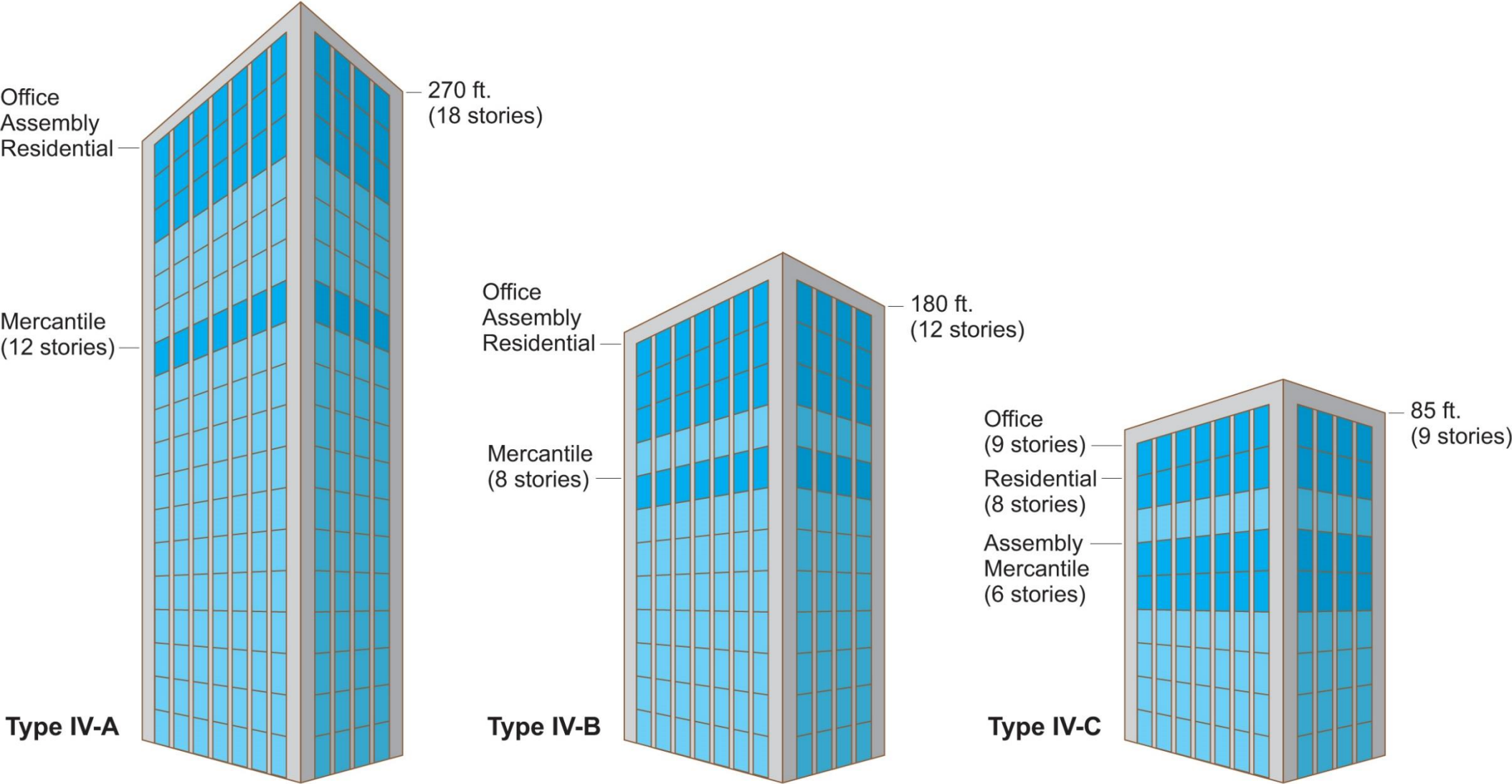
IBC Section 505: Mezzanine



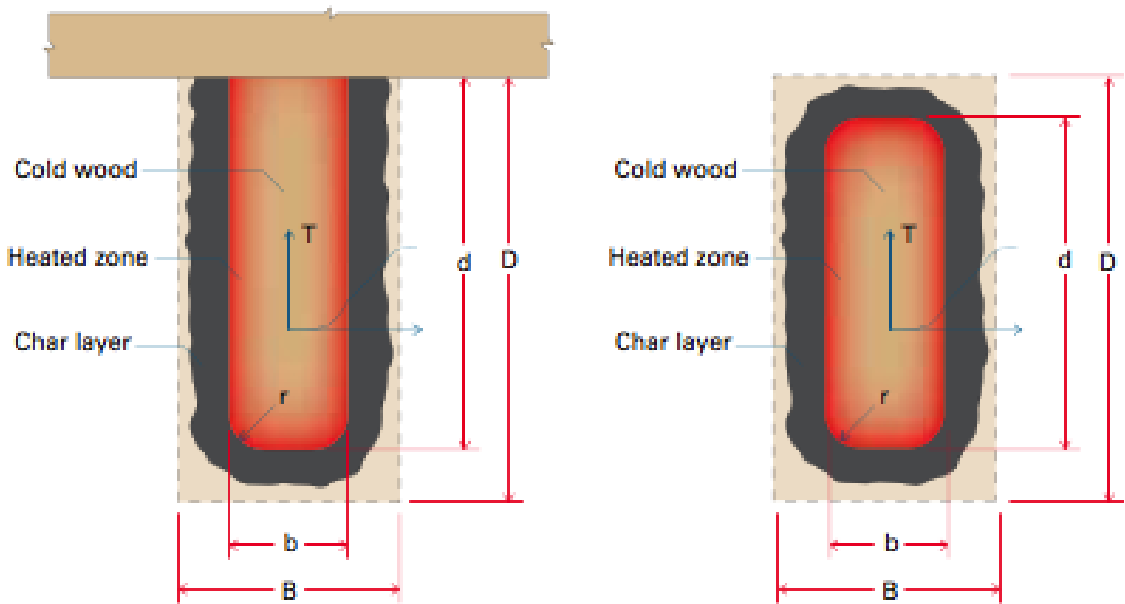
IBC Section 510.2: Podium



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 $\beta_n = 1.5 \text{ in./hr.}$)

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



Credit: David Barber, ARUP



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

Changes to the 2021 International Building Code (IBC) have created opportunities for wood buildings that are much larger and taller than prescriptively allowed in past versions of the code. Occupant safety, and the need to ensure fire performance in particular, was a fundamental consideration as the changes were developed and approved. The result is three new construction types—Type IV-A, IV-B and IV-C—which are based on the previous Heavy Timber construction type (renamed Type IV-HT), but with additional fire protection requirements.

One of the main ways to demonstrate that a building will meet the required level of passive fire protection, regardless of structural materials, is through hourly fire-resistance ratings (FRRs) of its elements and assemblies. The IBC defines an FRR as the period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703.

FRRs for the new construction types are similar to those required for Type I construction, which is primarily steel and concrete.¹ (See Table 1.) They are found in IBC Table 601, which includes FRR requirements for all construction types and building elements; however, other code



- ## Mass Timber Fire Design Resource
- Code compliance options for demonstrating FRR
 - Updated as new tests are completed
 - Free download at woodworks.org

TABLE 1: FRR Requirements (Hours) for Tall Mass Timber Construction Types and Existing Type I

Building Element	I-A Unlimited stories, heights and areas*	IV-A Max. 19 stories, 270 ft, 324,000 sf**	I-B Max. 12 stories, 180 ft, unlimited areas*	IV-B Max. 12 stories, 180 ft, 216,000 sf**	IV-C Max. 9 stories, 85 ft, 135,000 sf**
Primary Frame	3	3	2	2	2
Exterior Bearing Walls	3	3	2	2	2
Interior Bearing Walls	3	3	2	2	2
Roof Construction	1.5	1.5	1	1	1
Primary Frame at Roof	2	2	1	1	1
Floor Construction	2	2	2	2	2

Assumes an NFPA 13 automatic sprinkler system throughout building

Source: 2021 IBC Tables 504.3, 504.4, 506.2 and 601

*Unlimited building size permitted for most occupancies

**Area limits indicated are per level, assuming no frontage increase; see IBC Tables 504.3, 504.4 and 506.2 for additional details

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

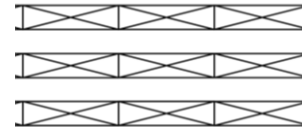
Exposed Mass Timber
Elements

None 20-40% Most All

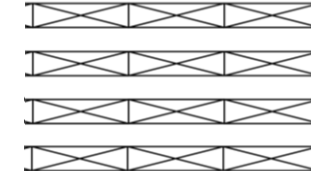
Baseline
0hr & HT



+\$10/SF
1hr & maybe 2hr



+\$12-15/SF
2hr FRR

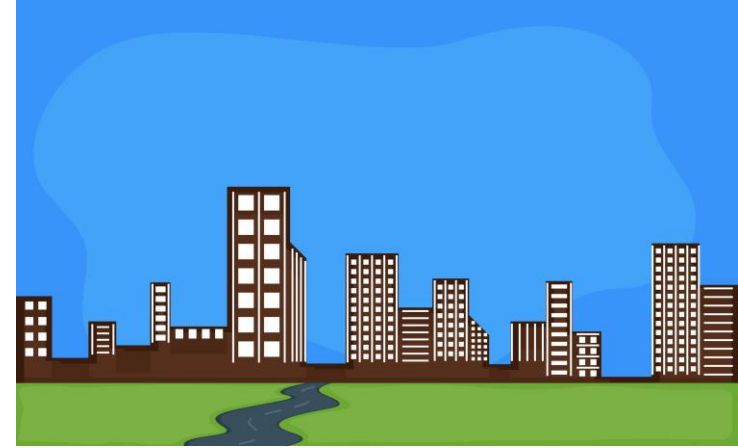


Cost Source: Swinerton

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

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	3 rd Floor	1 st 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
<u>Superstructure Cost/SF</u>	<u>\$65/SF</u>	<u>\$53/SF</u>



Source: PCL Construction

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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

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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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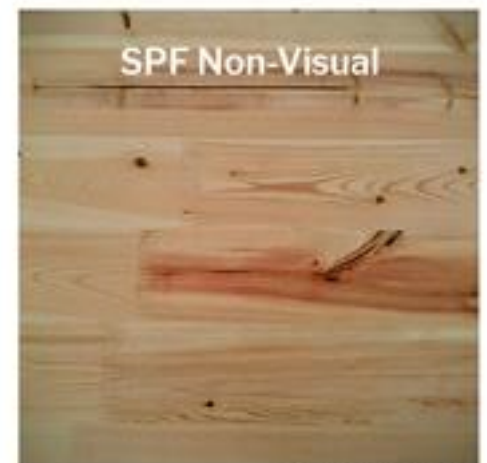
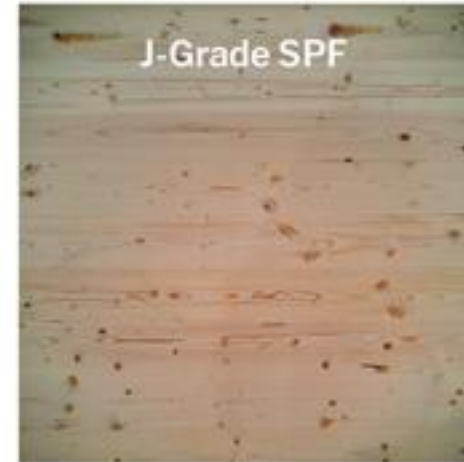
Mass timber products such as cross-laminated timber (CLT), nail-laminated timber (NLT) and glue-laminated timber (glulam) are at the core of a revolution that is shifting how designers think about construction. At no time has materials selection been such an integral aspect of the building designer's 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

Cost Impacts of Finish/ Appearance Grade

Appearance vs. Industrial Grades

Aesthetic Expectations

- Appearance grade more \$
- Industrial grade can save \$
- Specification of appearance grade varies by product
- CLT, DLT, NLT: aesthetic expectations are agreed upon by building designer and manufacturer/ fabricator (ask for samples & outline in specs)
- Glulam: grades are standardized



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Expert Tips

Specifying Appearance Grades for CLT, NLT and Glulam

Information for designers seeking to specify appearance grade for cross-laminated timber (CLT), nail-laminated timber (NLT), or glue-laminated timber (glulam).

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For mass timber, specification of appearance grade varies by product. Aesthetic expectations for cross-laminated timber (CLT) and nail-laminated timber (NLT) are agreed upon between the building designer and manufacturer/fabricator and described in the product specifications, whereas grades for glued-laminated timber (glulam) are standardized.

CLT Appearance Grades

Starting with the 2015 version of the International Building Code (IBC), CLT has been prescriptively



MASS TIMBER CONSTRUCTION MANAGEMENT

ANDY QUATTLEBAUM
OUTDOOR EDUCATION CENTER

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



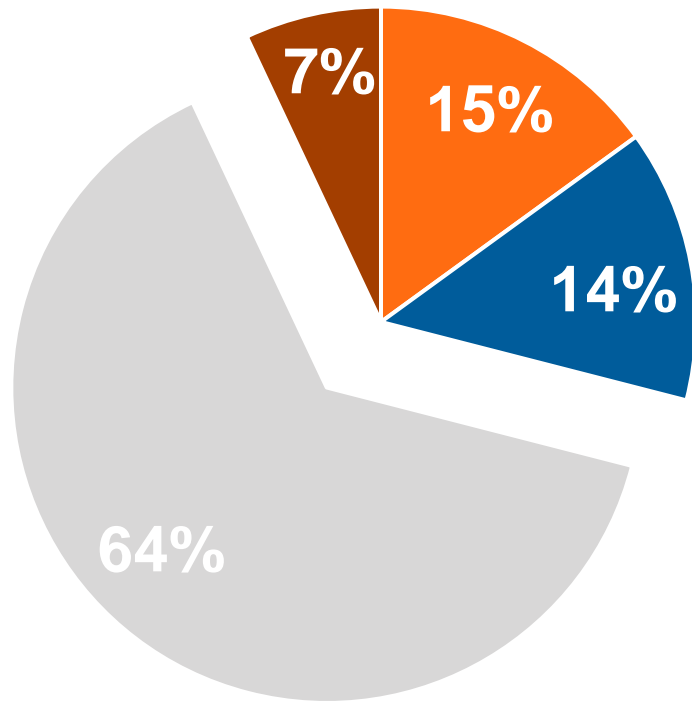
$\$/\text{SF}$



$\$/\text{SF}$

Image: GBD Architects

Material (Direct Cost)



Turnkey Mass Timber Package



or



Total Project Cost Analysis

CONSIDERATIONS:

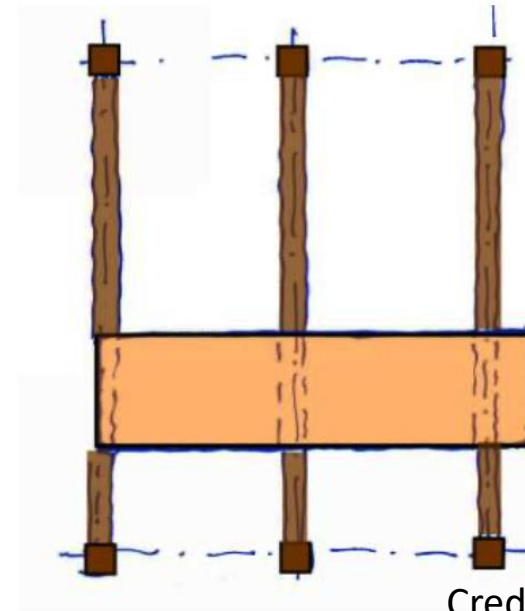
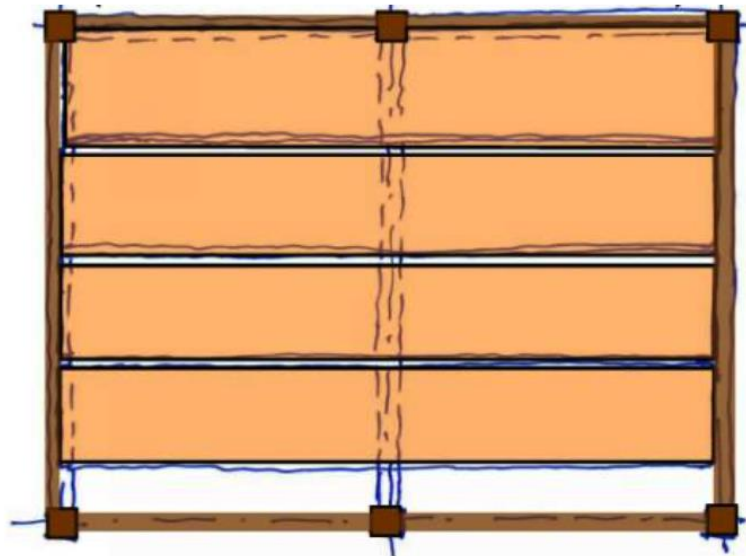
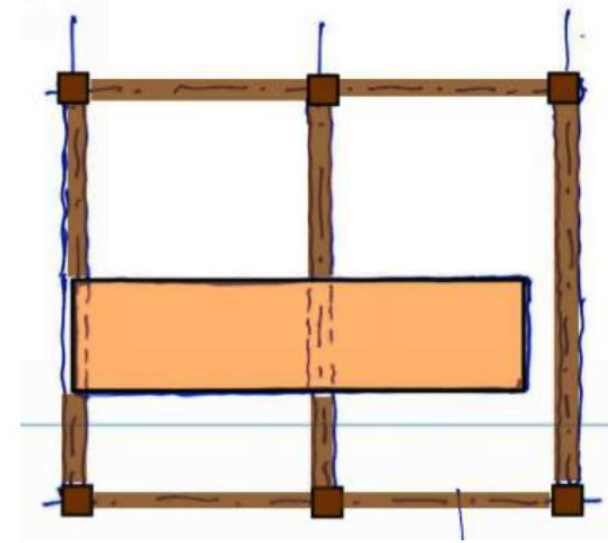
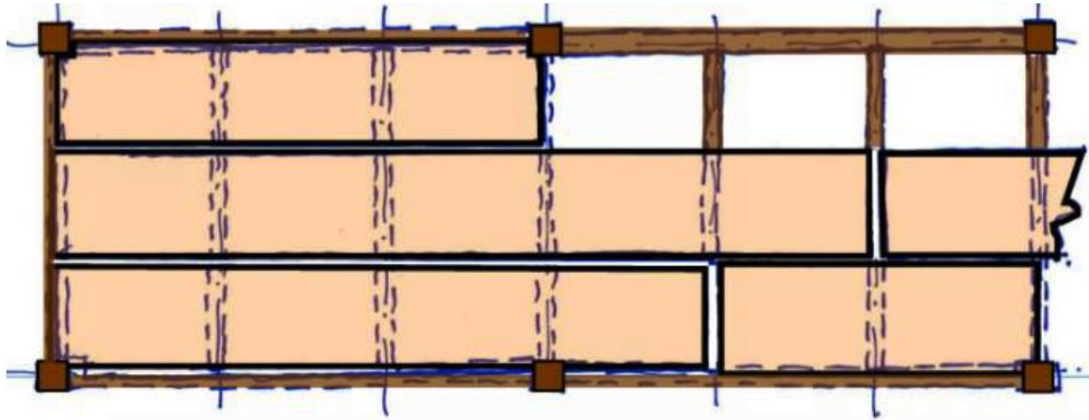
- Ceiling Treatment
- Floor Topping
- HVAC System & Route
- Foundation Size
- Material Savings
- Perimeter glazing
- Value of Time
- Completion Bonds/Insurance



Understand the Supply Chain



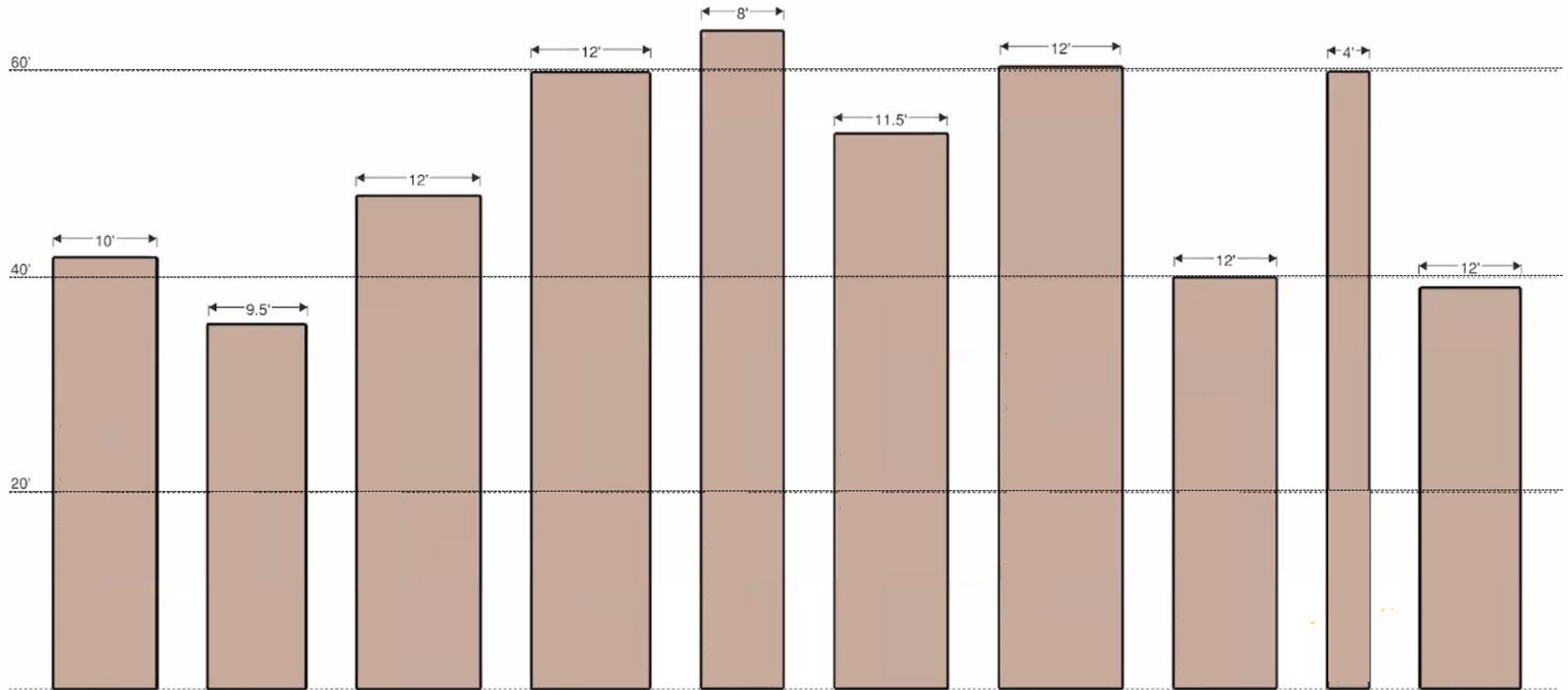
Photo: Swinerton



Credit: Tanya Luthi, Entuitive

Understand Manufacturer's Capabilities

Understand Manufacturer's Capabilities

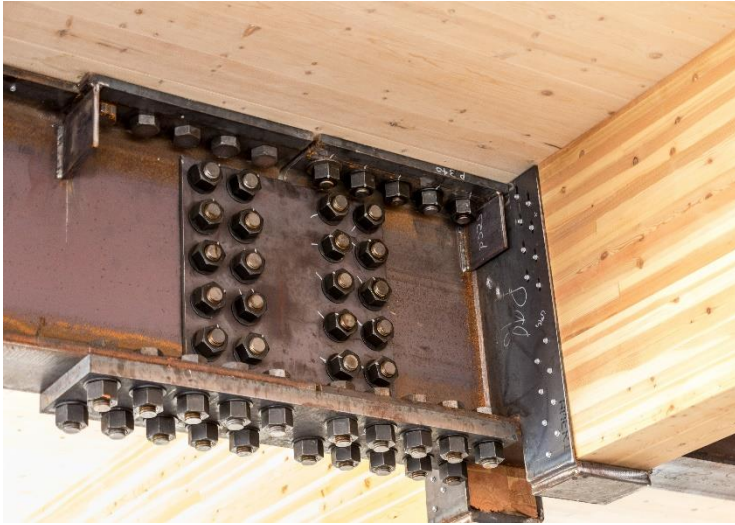


Credit: TimberLab



Embrace the
Prefab Advantage

Tolerances: Interface with Other Structural Materials



Photos: Swinerton

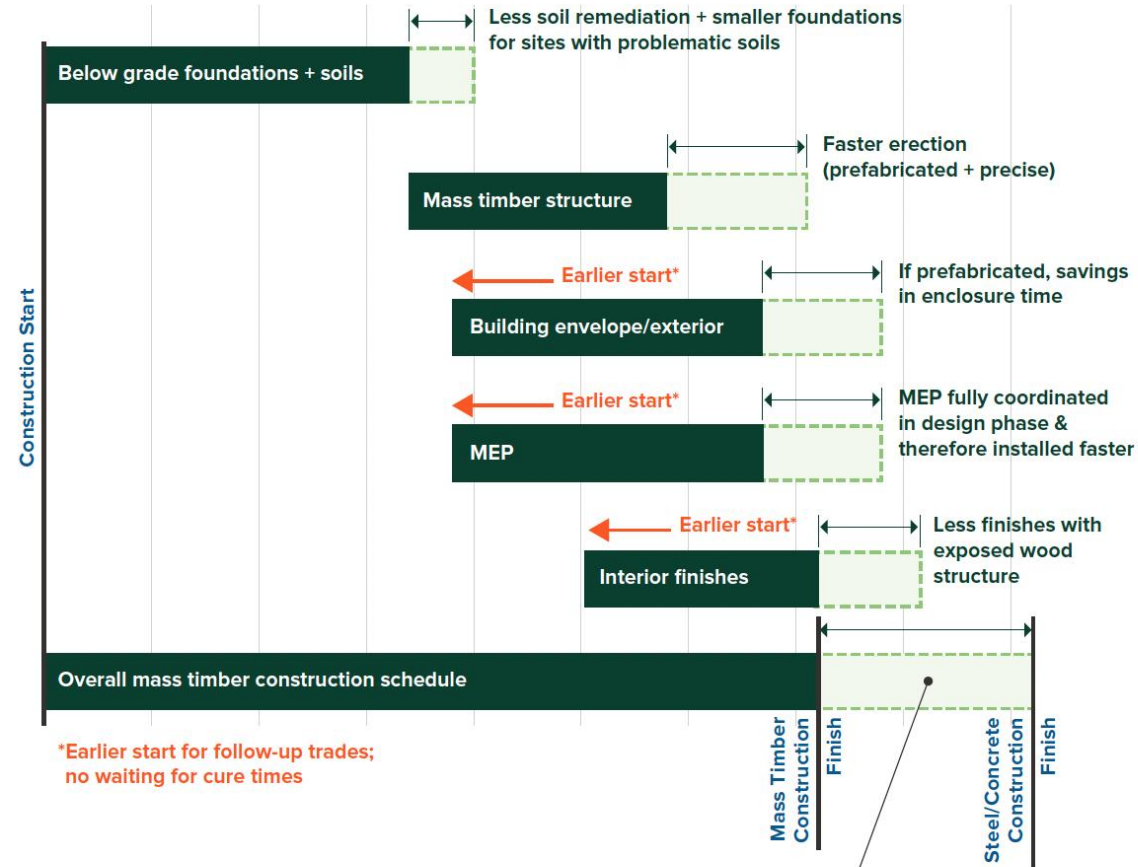
Schedule Drivers



Procurement Approach Determines Schedule

Compressing the Typical Construction Schedule with Mass Timber^{13, 15, 16}

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



Up to 25% schedule savings

- = Less carrying costs
- + Less GC overhead
- + Ability to lease/occupy sooner

Procurement Approach Determines Schedule



Photo: Alex Schreyer

Procurement Logic for Scheduling

Shop drawings, Planning, Fabrication, Delivery

**Mass Timber
Installation**

Nov

Dec

Jan

Feb

Mar

Apr

May

Jun

Jul

Aug

Sep

Source: Swinerton

Example 6 Story Type IIIA Project

Schedule Comparison

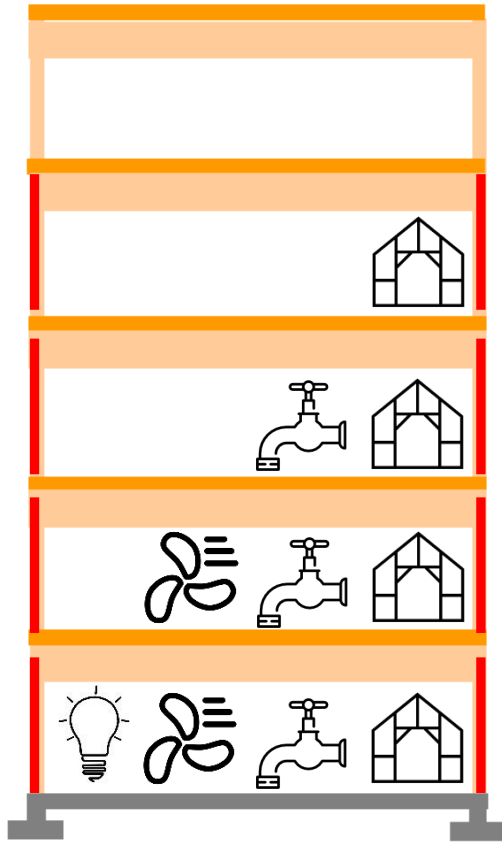


Image: Swinerton

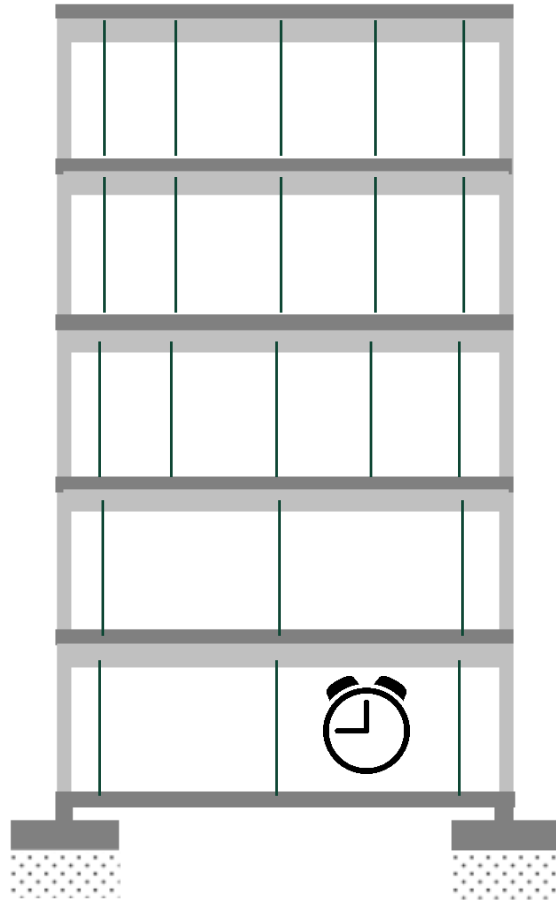



Photo: WoodWorks

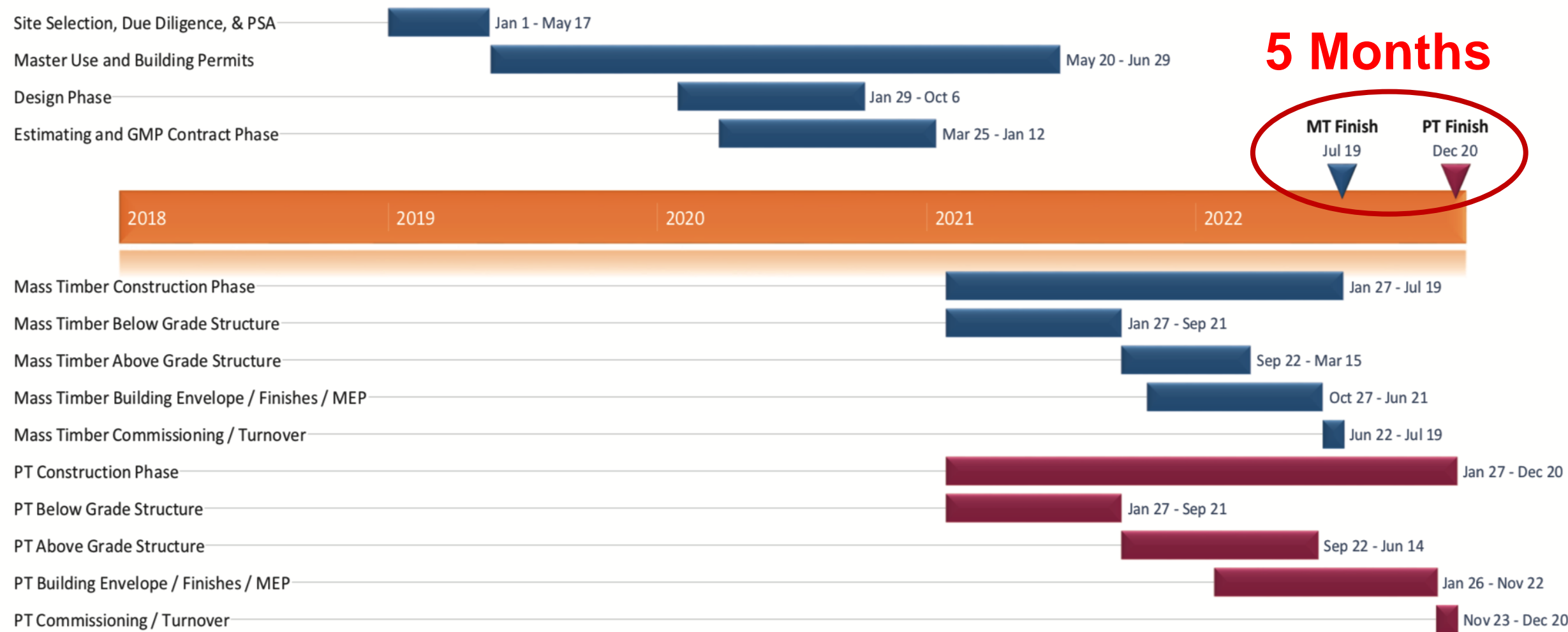
Schedule Impacts: Hybrid Structures





Look At Schedule Holistically

Overall Project Schedule Analysis: 12 Story Type IV-B



Schedule Impact on Cost | Value of Time

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.



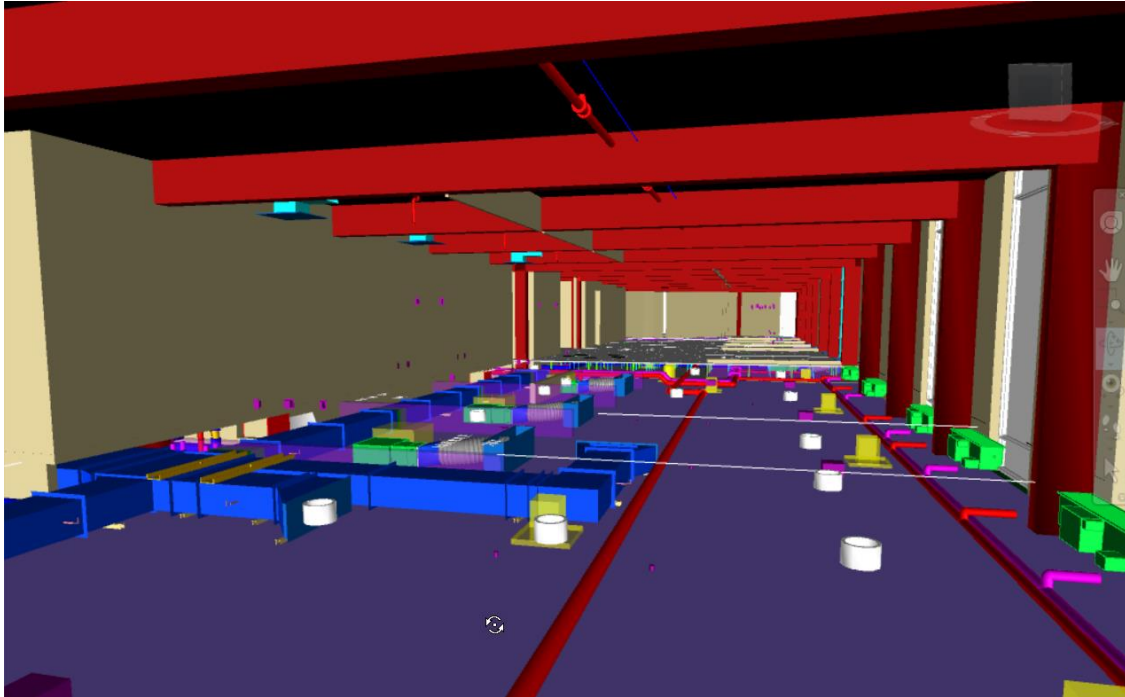
Early Move-In for Rough-In Trades.



Photos: Swinerton



Embracing BIM for Fabrication



Photos: Swinerton

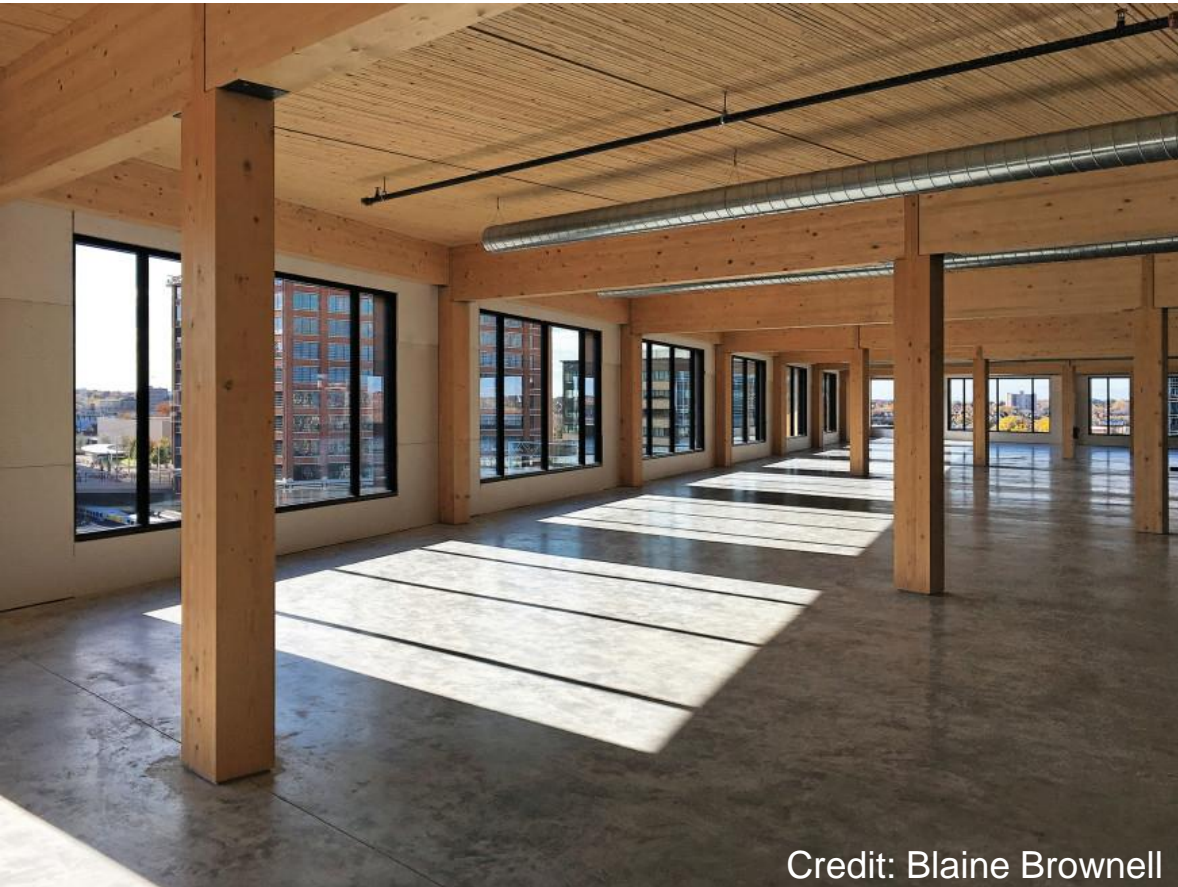
MEP Layout & Integration



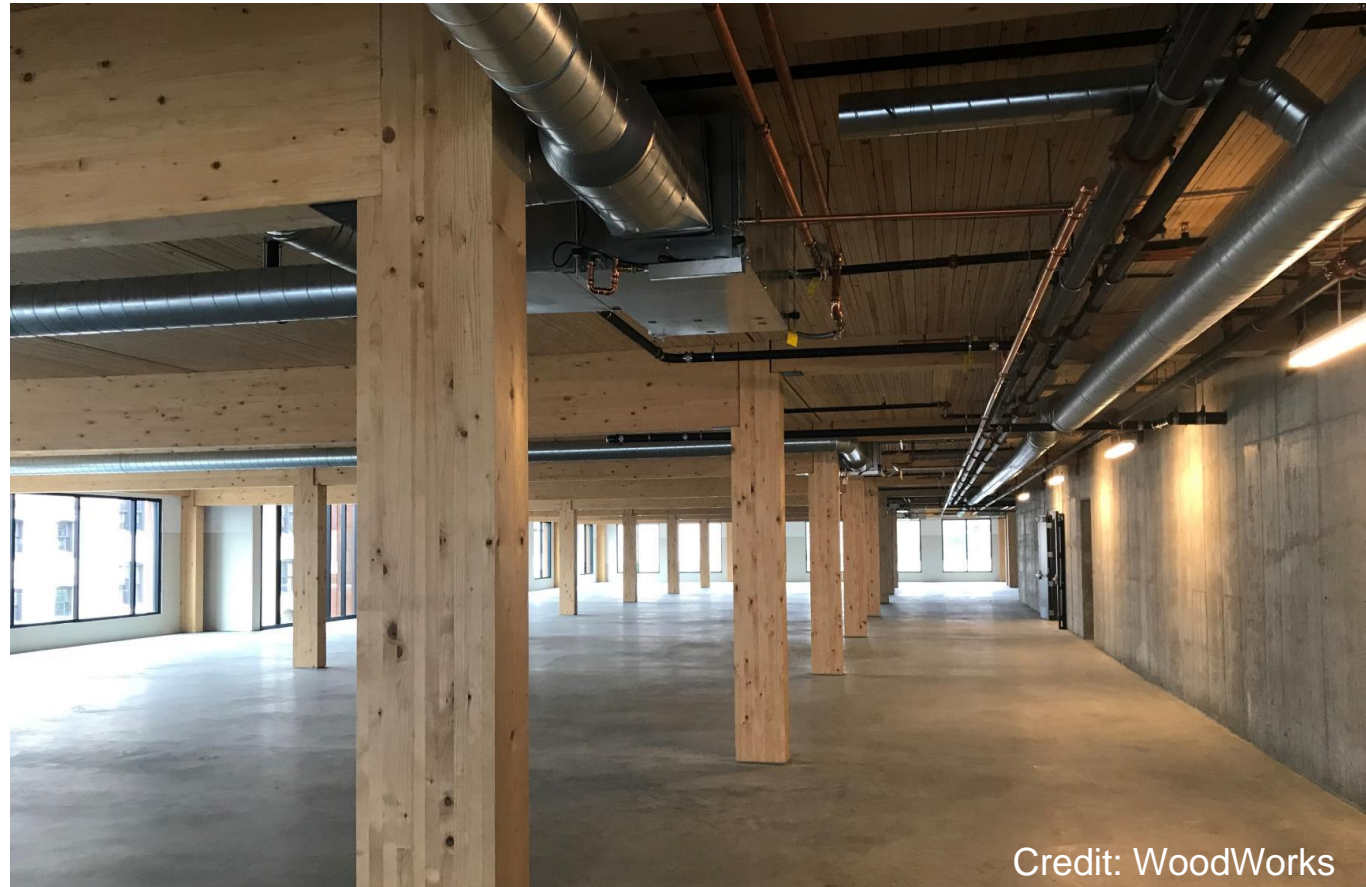
MEP Layout & Integration

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

MEP Layout & Integration

Dropped below MT framing

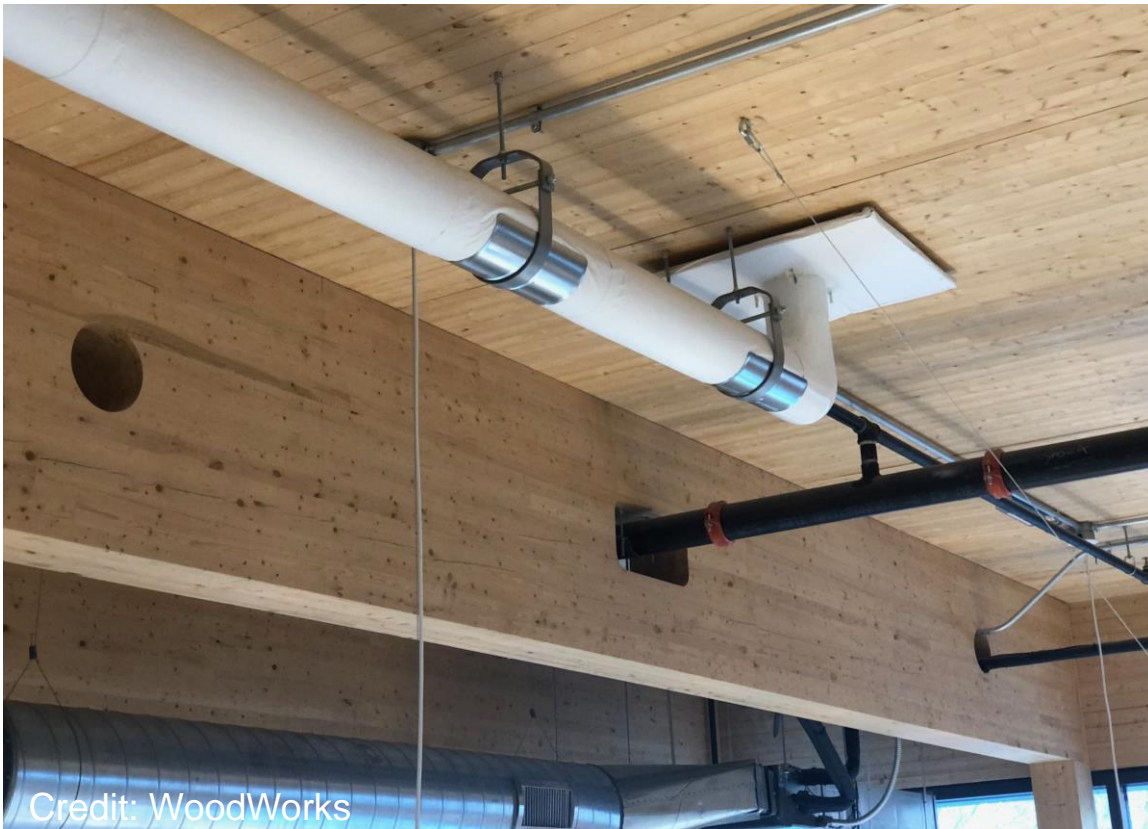
- Can simplify coordination (fewer penetrations)
- Bigger impact on head height



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



Credit: WoodWorks



Credit: WoodWorks

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



Credit: JC Buck



Credit: KL&A Engineers & Builders

MEP Layout & Integration

In gaps between MT panels

- Fewer penetrations, can allow for easier modifications later



Credit: Ema Peter/MGA



Credit: Hacker Architects

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



SITE PLANNING



QA/QC



Photo: Swinerton

SITE INSPECTIONS



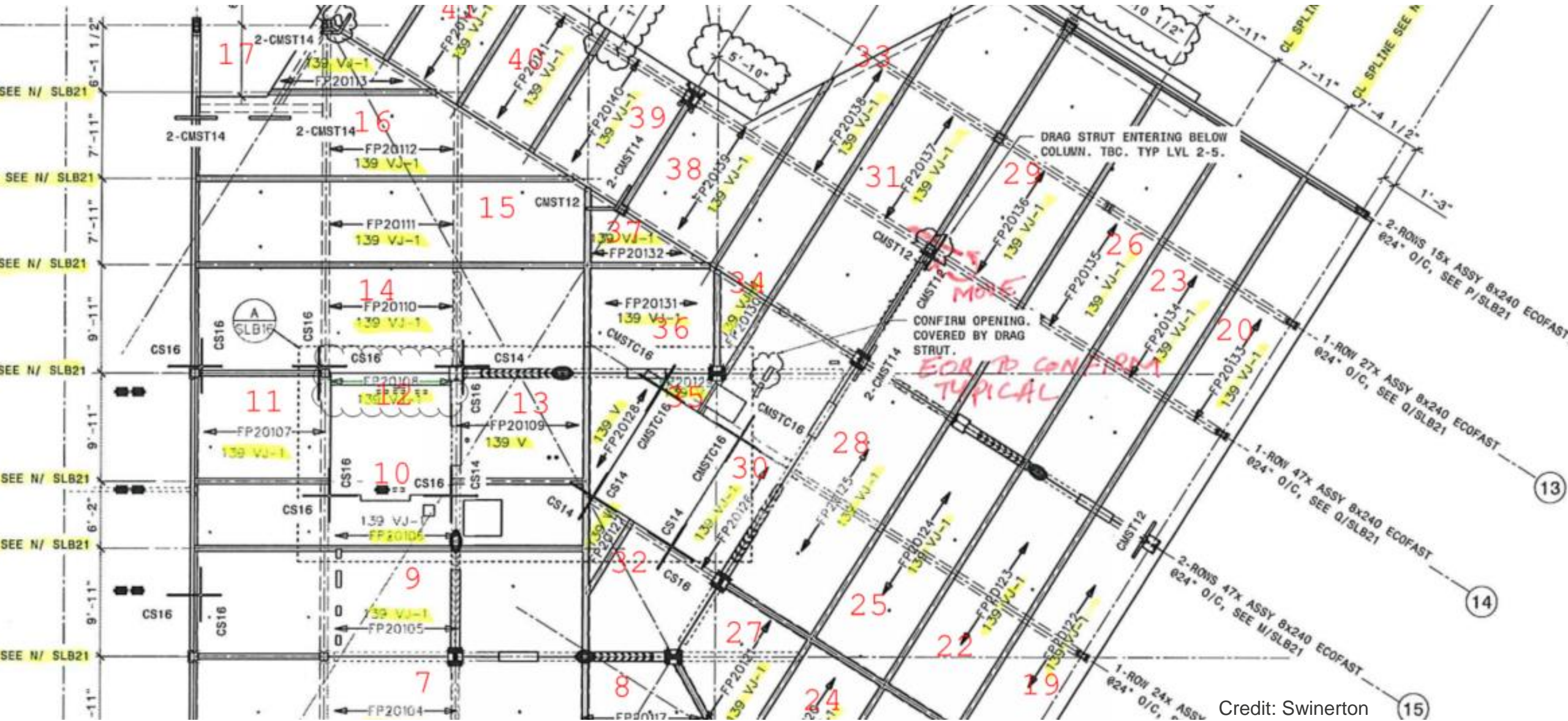
Photo: H+O Structural Engineering,,Kure Creative

Tall Mass Timber Special Inspections

TABLE 1705.5.3
REQUIRED SPECIAL INSPECTIONS OF MASS TIMBER CONSTRUCTION

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

Sequencing



PICK PLAN



Photo: Swinerton

MATERIAL DELIVERY



Photo: Swinerton



Photo: Swinerton

STAGING

Planning for Environmental Exposures

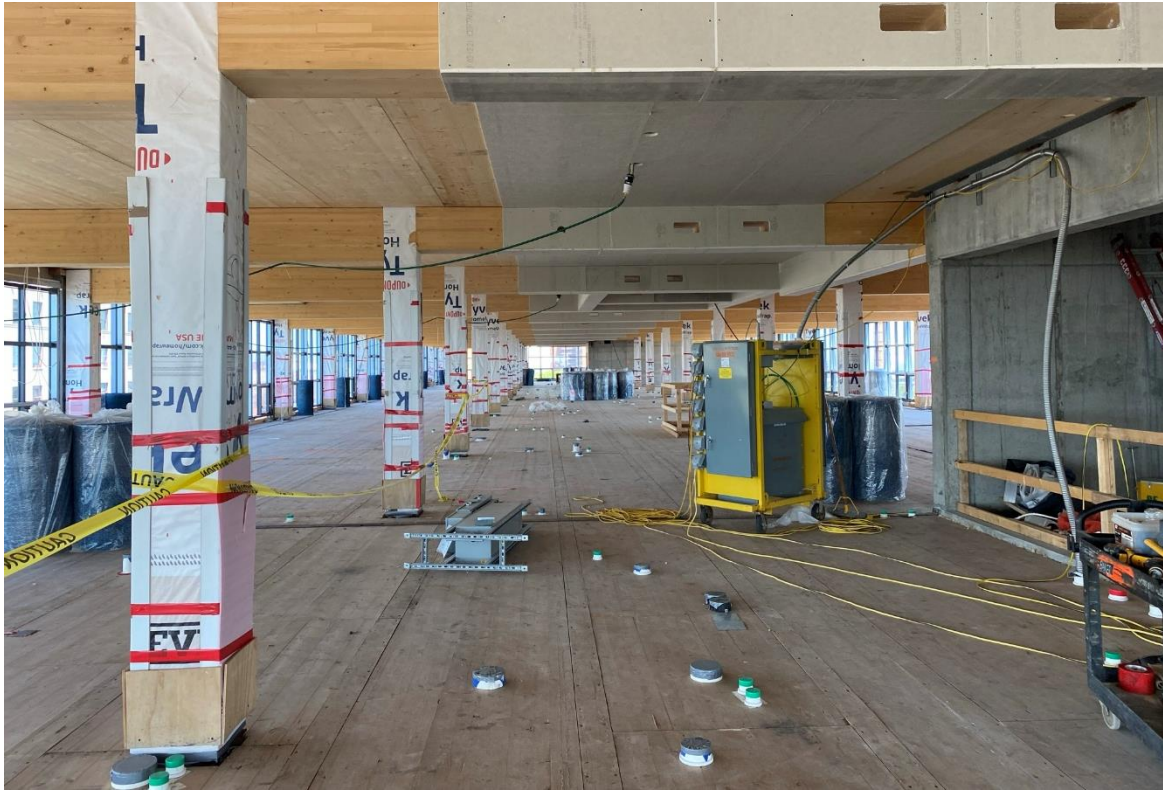


- Plan Early
- Risk Evaluation
- Develop Construction Phase Plan
- Execute the Design and Moisture Management Plan
- Monitor

RDH Moisture
Management Guide 1st Ed



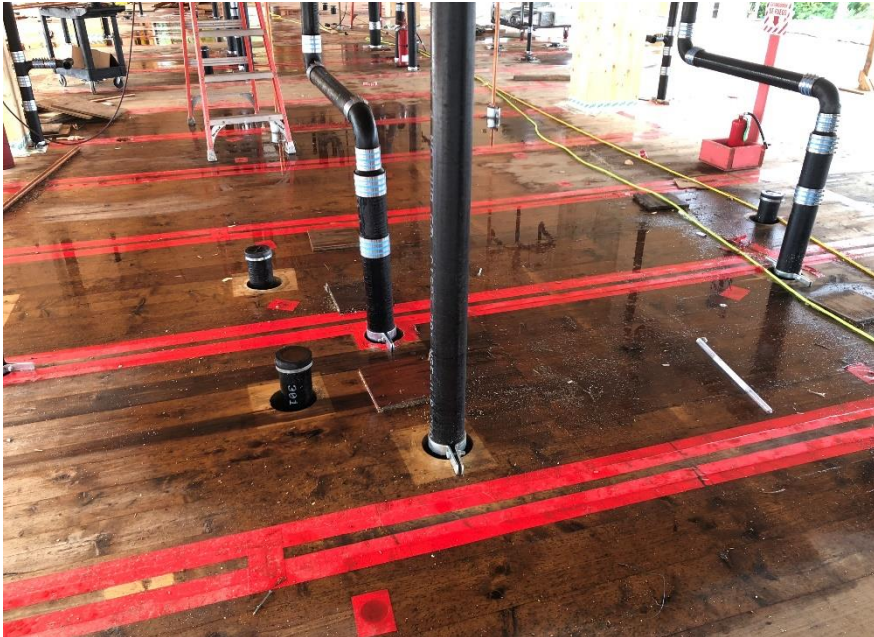
Enroute Exposure



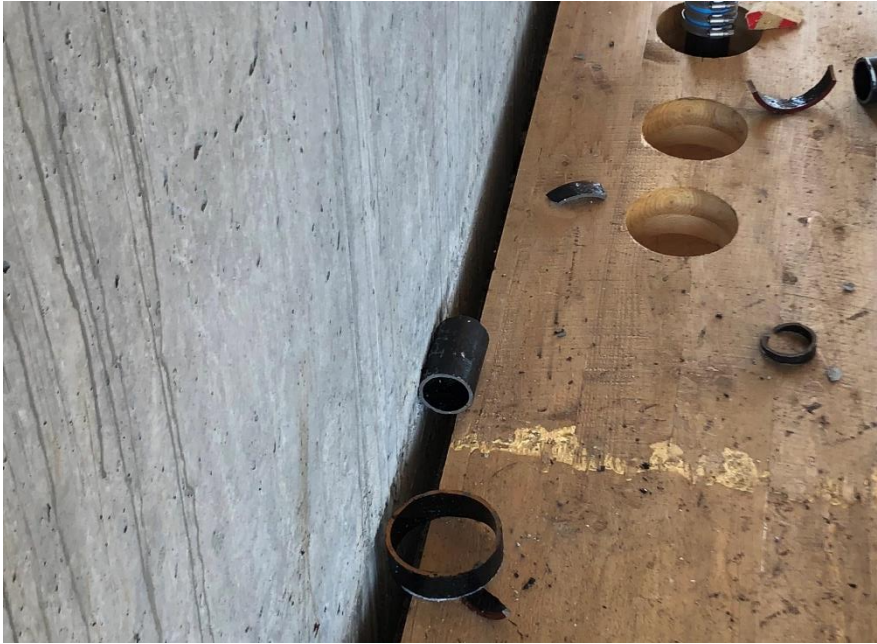
On Site Considerations



On Site Considerations



Onsite Considerations



Other Materials



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

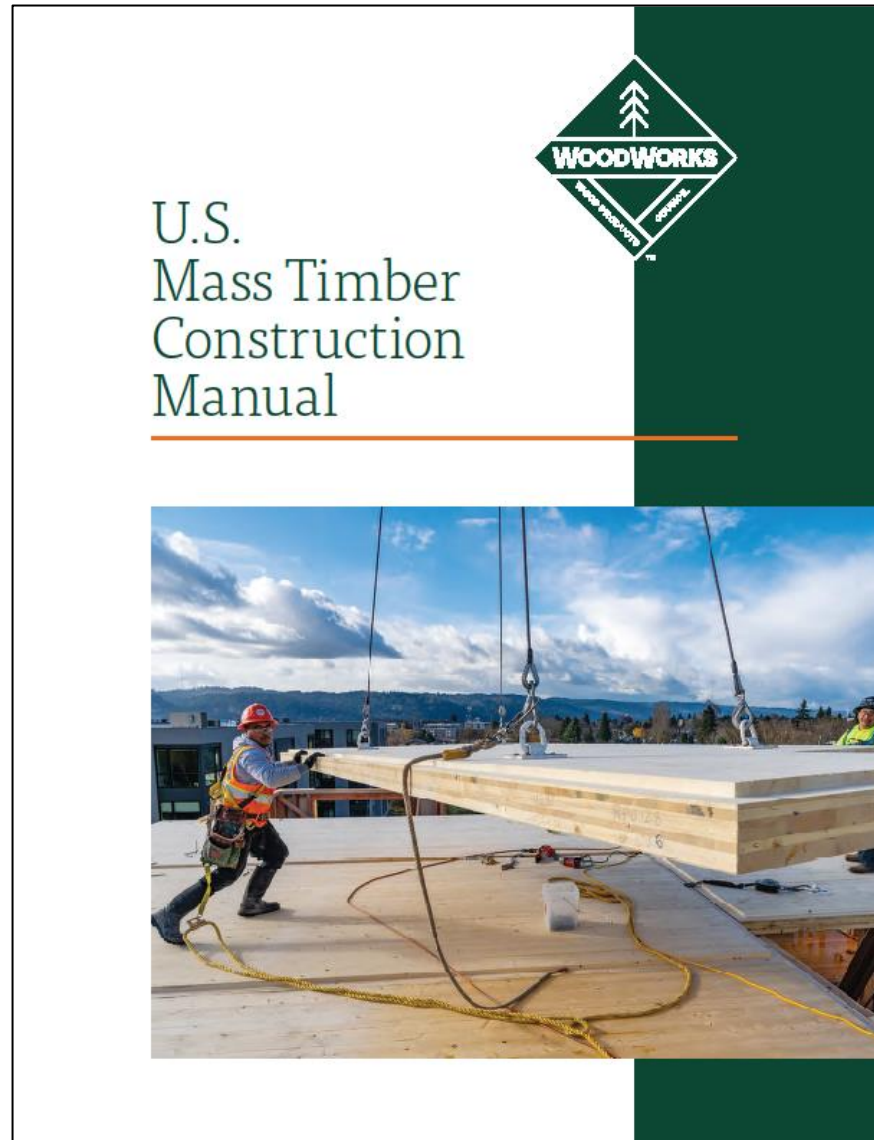


ENGAGE WITH GENERAL
CONTRACTORS ACROSS THE US



Released on 20 October 2021

<https://www.woodworks.org/mass-timber-construction-management-program/>





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

Questions? Ask us anything.



Jason Bahr, PE
Regional Director | KS, AR, MO, OK
(913) 732-0075
jason.bahr@woodworks.org



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