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

Presented by:
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Brandon Brooks, MBA, PMP
December 9, 2022

San Jacinto College / Kirksey Architecture / photo Joe Aker, Aker Imaging

The Seminar will begin at 2PM PST

Design Professionals:
One-on-One Support & Assistance

PROJECT SUPPORT FIELD DIVISION

Find the Regional Director for your location:

Questions? Ask me anything.

Chelsea Drenick, SE

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901 East Sixth, Thoughtbarn-Delineate Studio, Leap!Structures, photo Casey Dunn

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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

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

WOODWORKS WPC

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.

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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

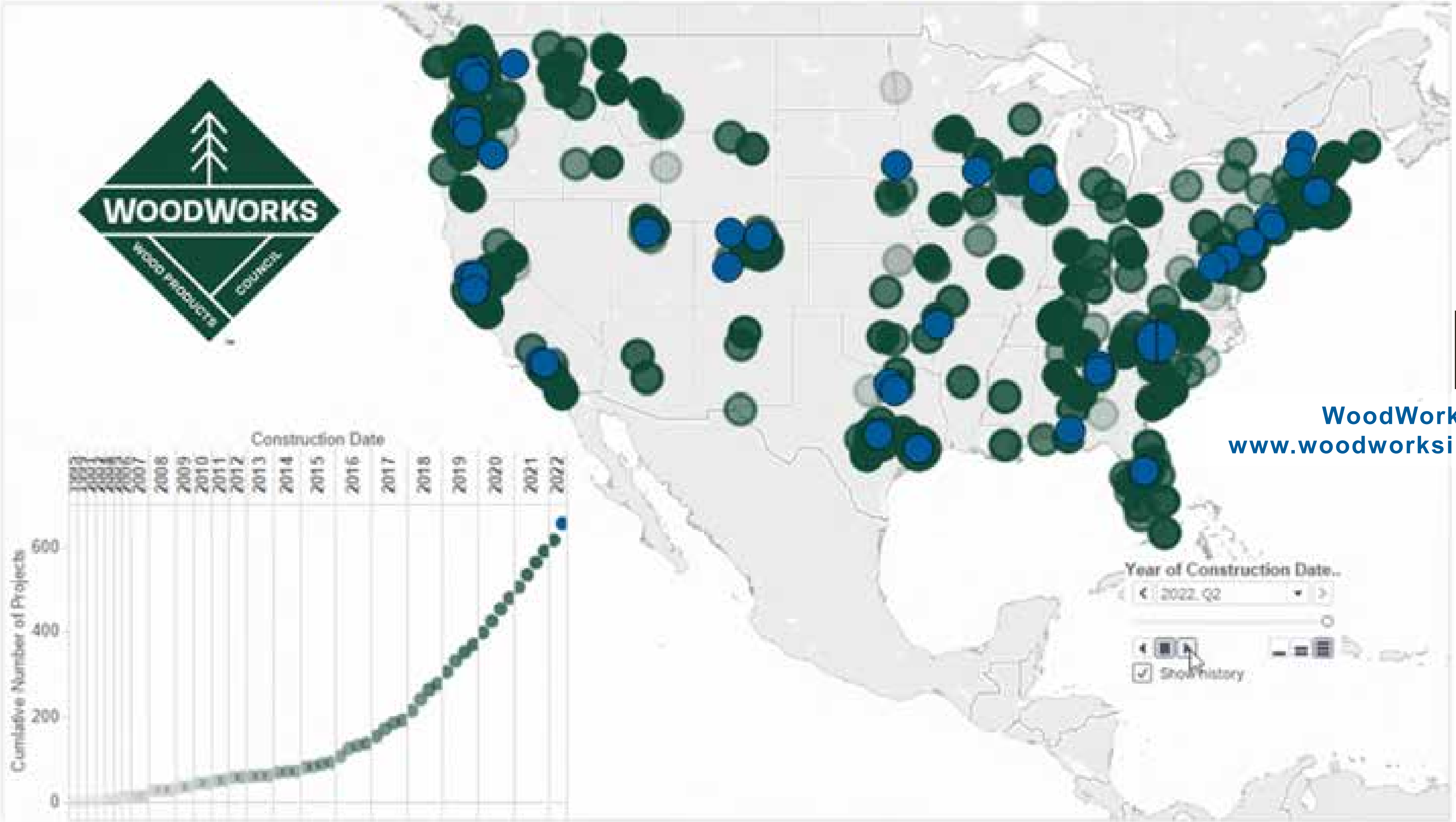
» How to Use Environmental Product Declarations

Scan to view

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.

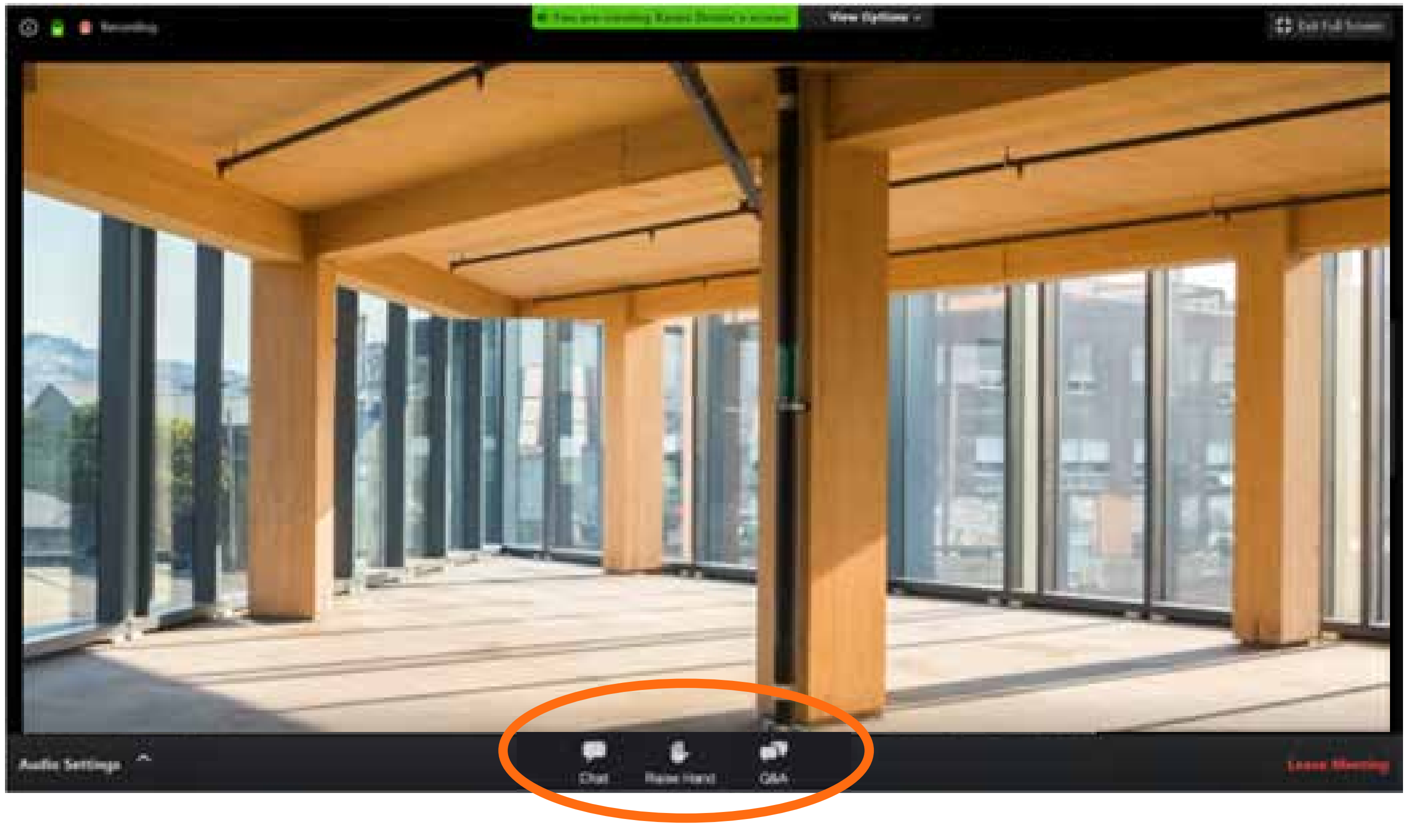


WOODWORKS INNOVATION NETWORK

WoodWorks Innovation Network
www.woodworksinnovationnetwork.org

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.



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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 Approved Continuing Education

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

PRESENTATION OUTLINE

MASS TIMBER DESIGN

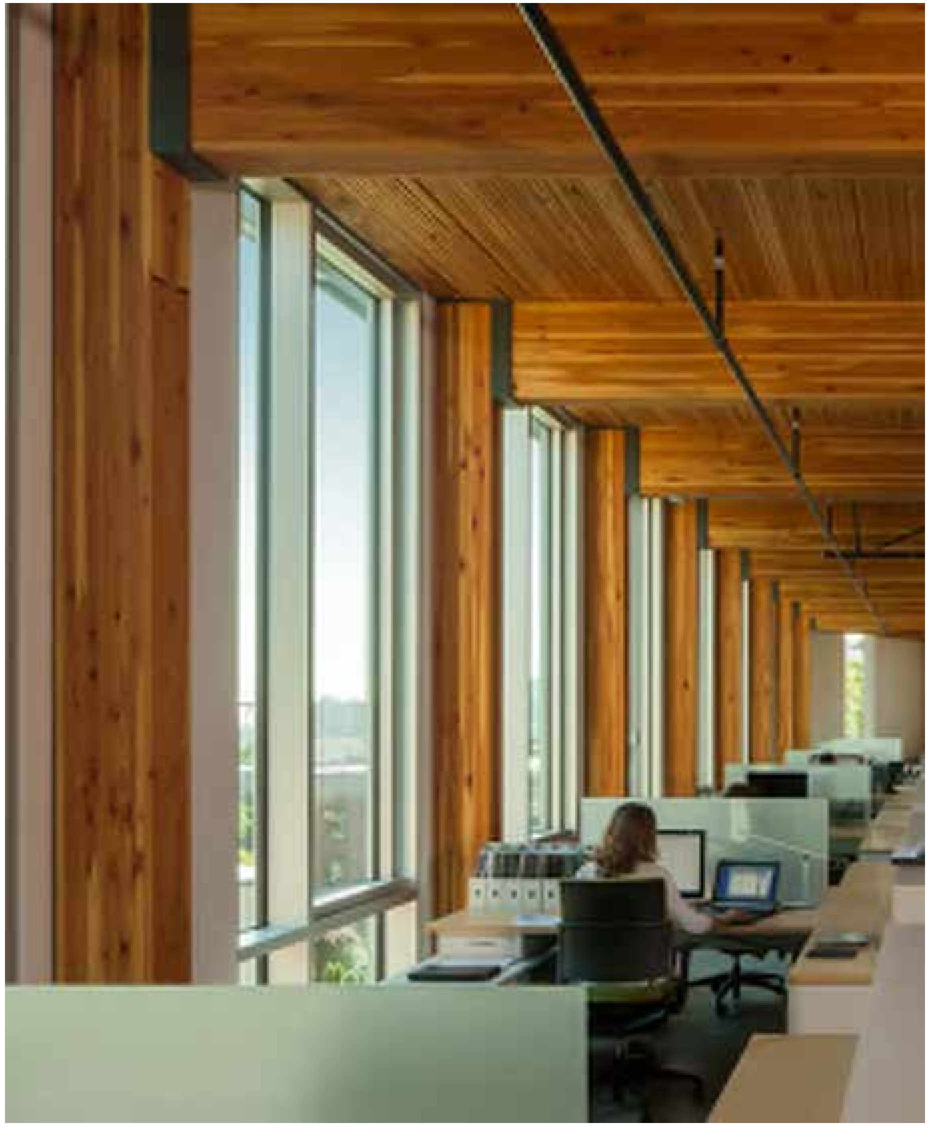
Products, Framing Solutions & Project Examples
Code Considerations
Cost Implications of Design Decisions
MEP Layout & Integration
Insurance Considerations

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

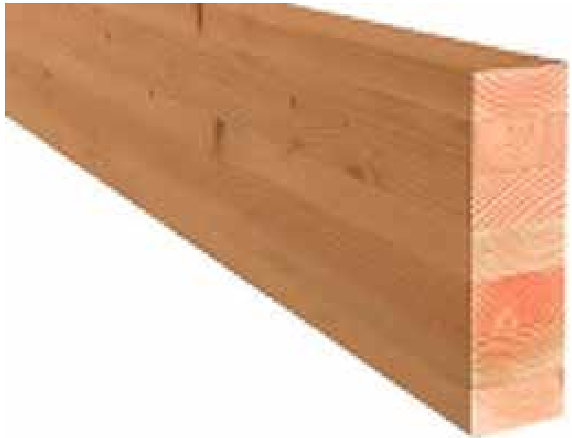


Photo: StructureCraft

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

Glue-Laminated Timber (GLT)

Plank orientation

Photo: StructureCraft

Photo: StructureCraft

Photo: Ema Peter

Photo: Manasc Isaac Architects/Fast + Epp

Mass Timber Building Options


Photo: Blaine Brownell


Photo: acton ostry architects


Photo: : LendLease

Post and Beam **Flat Plate** **Honeycomb**

Mass Timber Building Options

Hybrid: Light-frame

Hybrid: Steel framing

Nail-Laminated Timber (NLT)


Photo: StructureCraft


Photo: Think Wood

Image Credit: Ema Peter

PRECEDENT PROJECTS | T3 MINNEAPOLIS

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Photos: StructureCraft

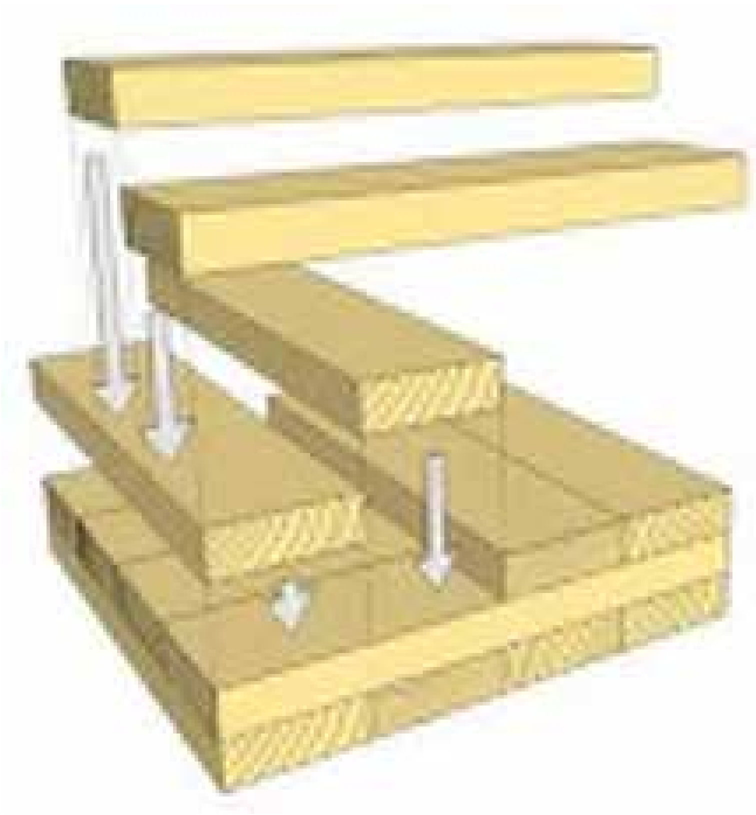
Photo: Hartshorne Plunkard Architecture

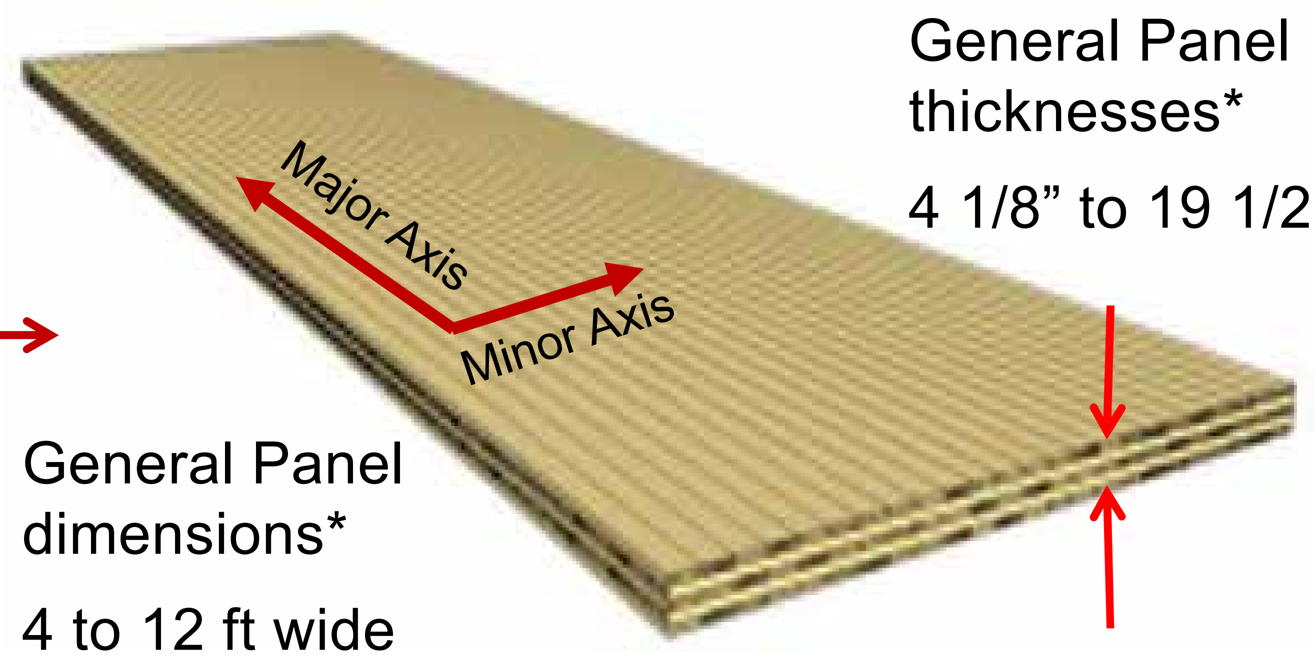
PRECEDENT PROJECTS | T3 ATLANTA

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


IMAGE CREDIT: NORDIC STRUCTURES

ONE DE HARO

SAN FRANCISCO, CA

4 STORIES

130,000

SIGNIFICANT SAVINGS ON FOUNDATION COSTS WITH MASS TIMBER

IMAGE CREDIT: ALEX NYE

PROJECT TEAM:
KAISER+PATH
R&H CONSTRUCTION

THE CANYONS

PORTLAND, OR


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

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

Photo: WoodWorks | Architect: Hickok Cole

Cross-Laminated Timber (CLT)

With SCL laminations

Photos: Freres Lumber

PROJECT ONE

OAKLAND, CA

IMAGE CREDIT: GURNET POINT LLC

OVERVIEW | MANUFACTURING

PHOTO CREDIT: DR JOHNSON

MASS TIMBER IN THE CODE

Photo: Freres Lumber

MASS TIMBER PRODUCTS

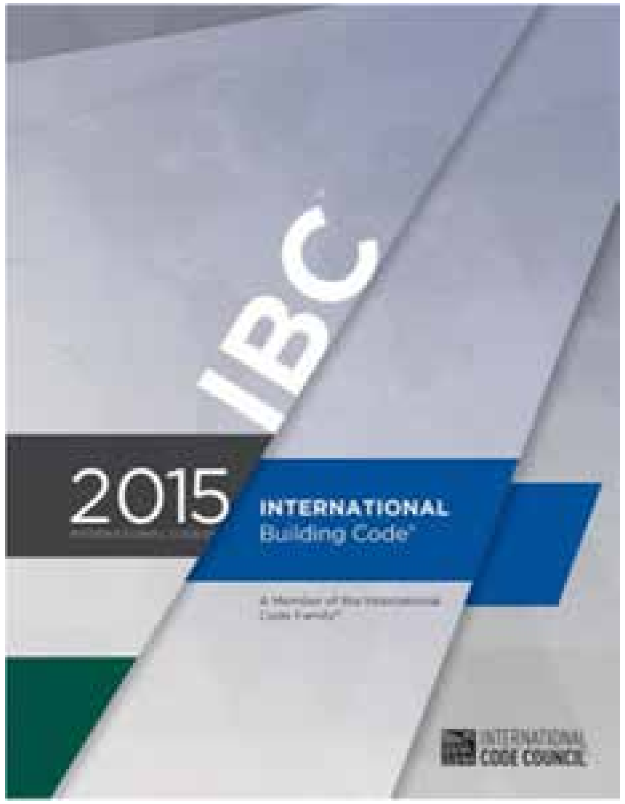
CROSS-LAMINATED TIMBER (CLT)

IN 2018 IBC, CLT IS NOW DEFINED IN CHAPTER 2 DEFINITIONS:

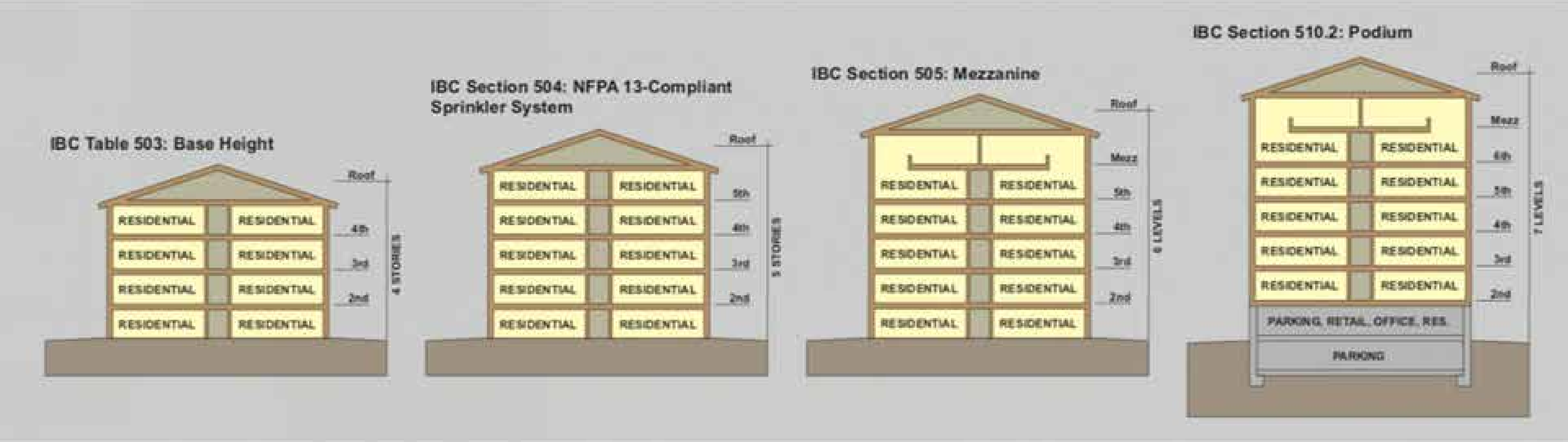
[BS] CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than three layers of solid-sawn lumber or *structural composite lumber* where the adjacent layers are cross oriented and bonded with structural adhesive to form a solid wood element.

AND IS REFERENCED IN CHAPTER 23:

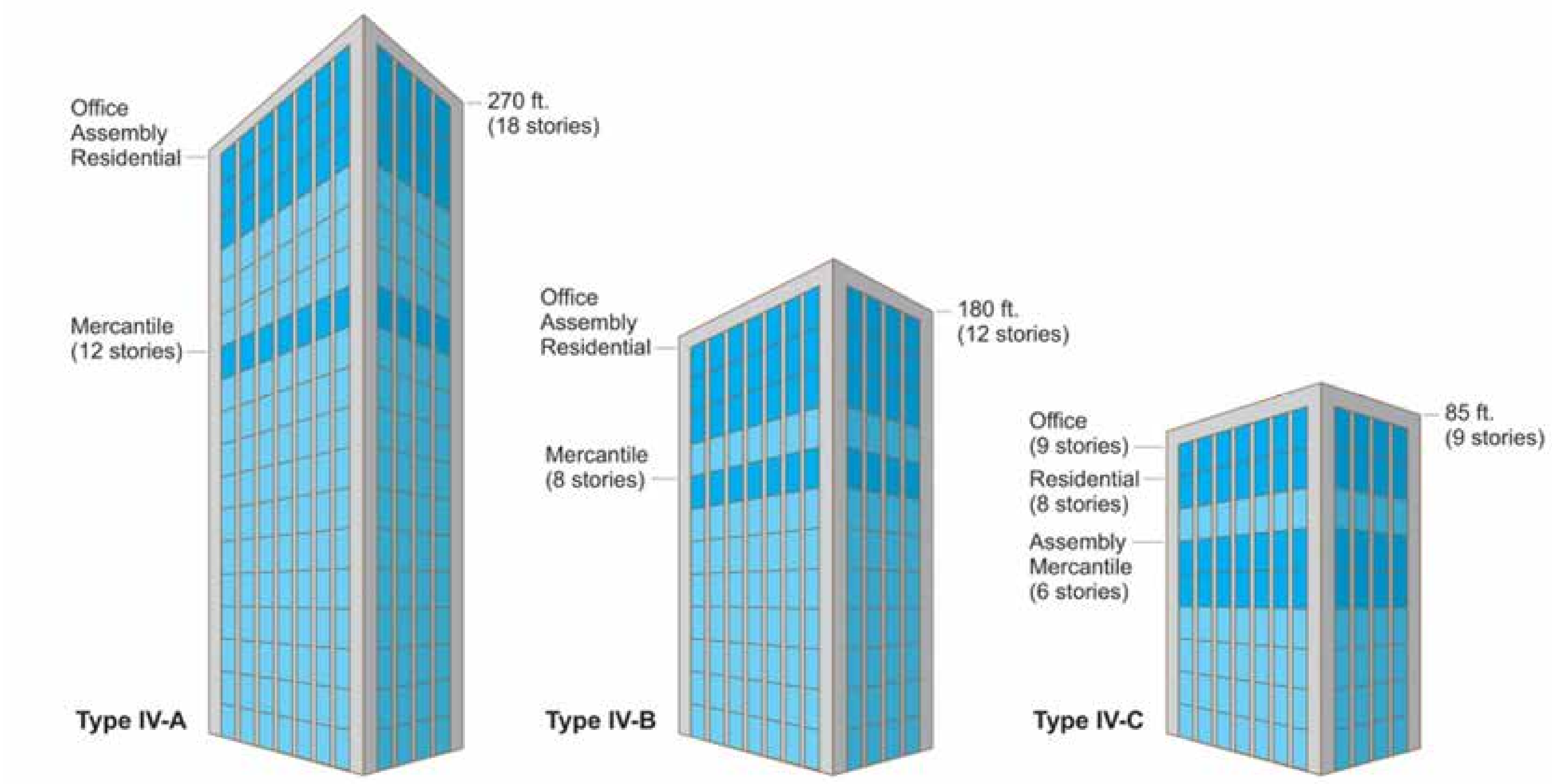
2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.



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

	Construction Type (All Sprinklered Values)							
	IV-A	IV-B	IV-C	IV-HT	III-A	III-B	V-A	V-B
Occupancies	Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)							
A, B, R	270	180	85	85	85	85	70	60
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)							
A-2, A-3, A-4	18	12	6	4	4	3	3	2
B	18	12	9	6	6	4	4	3
R-2	18	12	8	5	5	5	4	3
	Allowable Area Factor (At) for SM, Feet^2 (IBC Table 506.2)							
A-2, A-3, A-4	135,000	90,000	56,250	45,000	42,000	28,500	34,500	18,000
B	324,000	216,000	135,000	108,000	85,500	57,000	54,000	27,000
R-2	184,500	123,000	76,875	61,500	72,000	48,000	36,000	21,000

Key Early Design Decisions

Construction Type – Primarily based on building size & occupancy

	Construction Type (All Sprinklered Values)							
	IV-A	IV-B	IV-C	IV-HT	III-A	III-B	V-A	V-B
Occupancies	Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)							
A, B, R	270	180	85	85	85	85	70	60
	[illegible]							
[illegible]	18	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	18	12	9	[illegible]	6	[illegible]	4	3
R-2	18	12	8	5	5	5	4	3
	Allowable Area Factor (At) for SM, Feet^2 (IBC Table 506.2)							
A-2, A-3, A-4	135,000	90,000	56,250	45,000	42,000	28,500	34,500	18,000
B	324,000	216,000	135,000	108,000	85,500	57,000	54,000	27,000
R-2	184,500	123,000	76,875	61,500	72,000	48,000	36,000	21,000

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.

Fire-Resistance Ratings

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

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[b,c]	0
Bearing walls												
Exterior[a,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior					See Table 705.5							
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	$1^1/_2$[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	$1^1/_2$	1	1	HT	1[b,c]	0

MASS TIMBER DESIGN

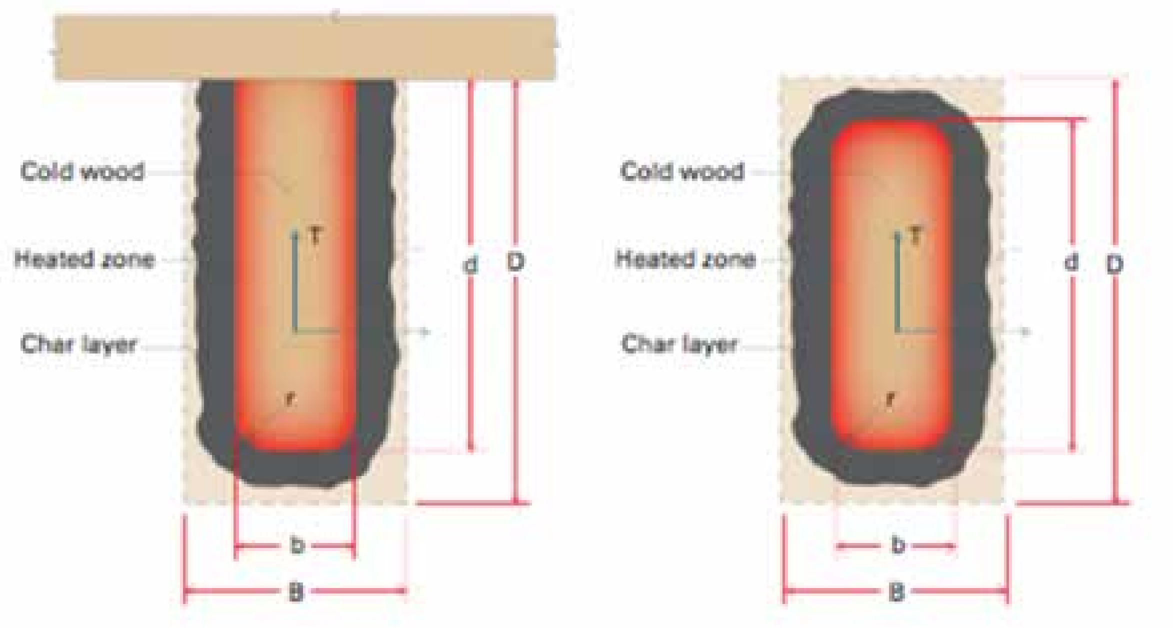
FIRE RESISTANCE

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

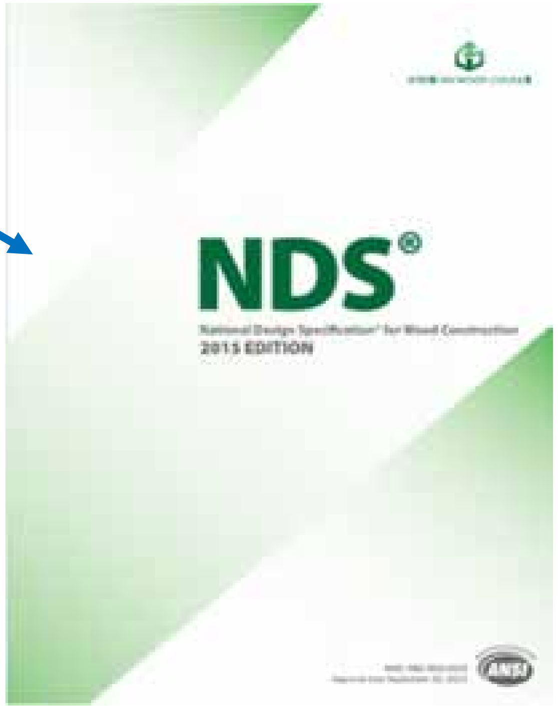
Source: AWC's NDS



Source: AWC's TR 10

FRR Design of MT

Calculated FRR of Exposed MT:
IBC to NDS code compliance path



Code Path for Exposed Wood Fire-Resistance Calculations

IBC 703.3
Methods for determining fire resistance
- Prescriptive designs per IBC 721.1
- ***Calculations in accordance with IBC 722***
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Alternate protection methods as allowed by 104.11

IBC 722
Calculated Fire Resistance
"The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with **Chapter 16 of ANSI/AWC National Design Specification for Wood Construction (NDS)**

NDS Chapter 16
Fire Design of Wood Members
- Limited to calculating fire resistance up to 2 hours
- Char depth varies based on exposure time (i.e., fire-resistance rating), product type and lamination thickness. Equations and tables are provided.
- TR 10 and NDS commentary are helpful in implementing permitted calculations.

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)

Panel	Example Floor Span Ranges
3-ply CLT (4-1/8" thick)	Up to 12 ft
5-ply CLT (6-7/8" thick)	14 to 17 ft
7-ply CLT (9-5/8")	17 to 21 ft
2x4 NLT	Up to 12 ft
2x6 NLT	10 to 17 ft
2x8 NLT	14 to 21 ft
5" MPP	10 to 15 ft

FRR Design of MT

WoodWorks Inventory of Fire Tested MT Assemblies

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

WoodWorks WOOD PRODUCTS COUNCIL

CLT Panel	Manufacturer	CLT Grade or Major x Minor Grade	Ceiling Protection	Panel Connection in Test	Floor Topping	Load Rating	Fire Resistance Achieved (Hours)	Source	Testing Lab
3-ply CLT (114mm 4.488 in)	Nordic	SPF 1650 Fb 1.5 E MSR x SPF #3	2 layers 1/2" Type X gypsum	Half-Lap	None	Reduced 34% Moment Capacity	1	1 (Test 1)	NRC Fire Laboratory
3-ply CLT (105mm 4.133 in)	Structurlam	SPF #1/#2 x SPF #1/#2	1 layer 5/8" Type X gypsum	Half-Lap	None	Reduced 75% Moment Capacity	1	1 (Test 5)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	Nordic	E1	None	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	2	NRC Fire Laboratory March 2016
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer of 5/8" Type X gypsum under Z-channels and furring strips with 3 5/8" fiberglass batts	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	5	NRC Fire Laboratory Nov 2014
5-ply CLT (175mm 6.875")	Nordic	E1	None	Topside Spline	3/4 in. proprietary gypcrete over Maxxon acoustical mat	Reduced 50% Moment Capactiy	1.5	3	UL
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer 5/8" normal gypsum	Topside Spline	3/4 in. proprietary gypcrete over Maxxon acoustical mat or proprietary sound board	Reduced 50% Moment Capactiy	2	4	UL
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer 5/8" Type X Gyp under Resilient Channel under 7 7/8" I-Joists with 3 1/2" Mineral Wool between Joists	Half-Lap	None	Loaded, See Manufacturer	2	21	Intertek 8/24/2012
5-ply CLT (175mm 6.875")	Structurlam	E1 M5 MSR 2100 x SPF #2	None	Topside Spline	1-1/2" Maxxon Cyp-Crete 2000 over Maxxon Reinforcing Mesh	Loaded, See Manufacturer	2.5	6	Intertek, 2/22/2016
5-ply CLT (175mm 6.875")	DR Johnson	V1	None	Half-Lap & Topside Spline	2" gypsum topping	Loaded, See Manufacturer	2	7	SwRI (May 2016)
5-ply CLT (175mm 6.875")	Nordic	SPF 1950 Fb MSR x SPF #3	None	Half-Lap	None	Reduced 59% Moment Capacity	1.5	1 (Test 3)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	Structurlam	SPF #1/#2 x SPF #1/#2	1 layer 5/8" Type X gypsum	Half-Lap	None	Unreduced 101% Moment Capacity	2	1 (Test 6)	NRC Fire Laboratory
7-ply CLT (245mm 9.65")	Structurlam	SPF #1/#2 x SPF #1/#2	None	Half-Lap	None	Unreduced 101% Moment Capacity	2.5	1 (Test 7)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	SmartLam	SL-V4	None	Half-Lap	nominal 1/2" plywood with 8d nails	Loaded, See Manufacturer	2	12 (Test 4)	Western Fire Center 10/26/2016
5-ply CLT (175mm 6.875")	SmartLam	V1	None	Half-Lap	nominal 1/2" plywood with 8d nails	Loaded, See Manufacturer	2	12 (Test 5)	Western Fire Center 10/28/2016
5-ply CLT (175mm 6.875")	DR Johnson	V1	None	Half-Lap	nominal 1/2" plywood with 8d nails	Loaded, See Manufacturer	2	12 (Test 6)	Western Fire Center 11/01/2016
3-ply CLT [illegible]	KLH	CV3M1	None	Half-Lap & Topside spline	None	Loaded, See Manufacturer	1	16	SwRI [illegible]

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 (3^{rd}) floor

- Requires Construction Type IIIA

If owner permits moving events space to 1^{st} or 2^{nd} 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

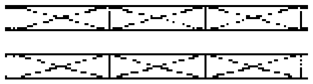
Cost: Construction Type

TABLE 601

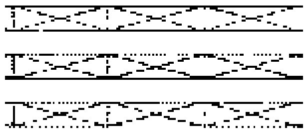
Fire Resistance Rating Requirements for Building Elements (Hours)

Building Element	III-A	III-B	IV-A	IV-B	IV-C	IV-HT	V-A	V-B
Primary Structural Frame	1	0	3	2	2	HT	1	0
Ext. Bearing Walls	2	2	3	2	2	2	1	0
Int. Bearing Walls	1	0	3	2	2	1/HT	1	0
Floor Construction	1	0	2	2	2	HT	1	0
Roof Construction	1	0	1.5	1	1	HT	1	0

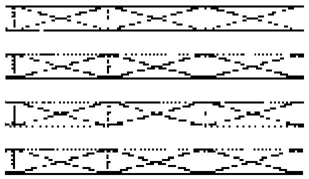
Baseline
0hr & HT



+$10/SF
1hr & maybe 2hr



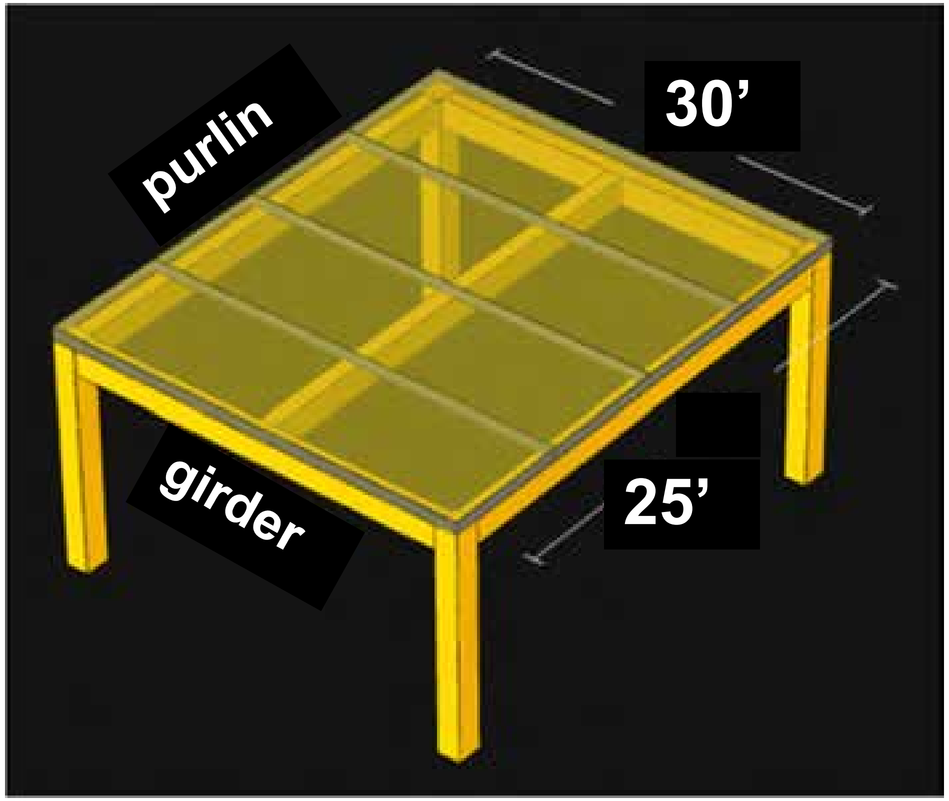
+$12-15/SF
2hr FRR



Cost Source: Swinerton

Cost Implication of Design Choices

Which is the most efficient option?



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 / IIIB	0.51 CF / SF

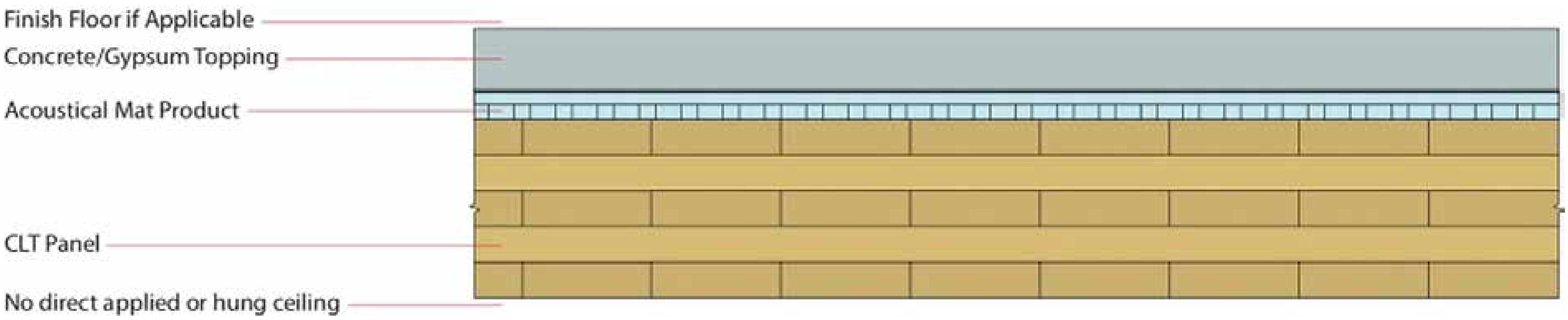
A general rule of thumb for efficient mass timber fiber volume is no higher than 0.75 CF per SF for up to a 1 hour rated structure (higher if 2 hour exposed timber in tall mass timber).

Ratios in the 0.85 to 1.0 CF / SF range tend to become cost prohibitive

Mass Timber Acoustics

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

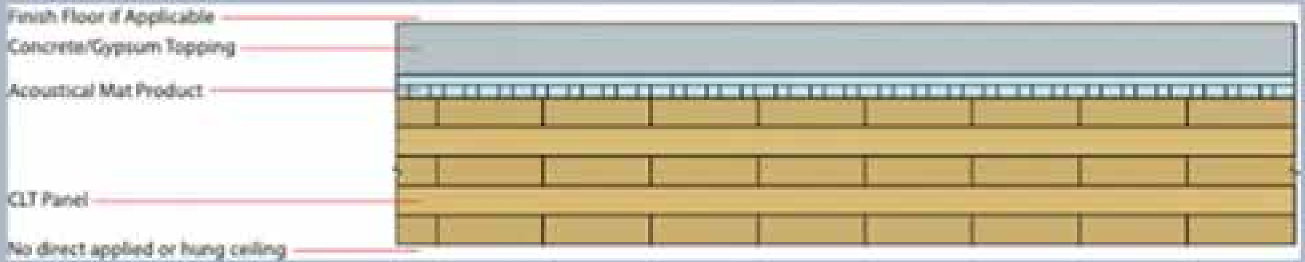
Image credit: AcoustiTECH

Acoustics & Sound Control

Inventory of Tested Assemblies

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

WoodWorks
WOOD PRODUCTS COUNCIL



CLT Panel	Concrete/Gypsum Topping	Acoustical Mat Product Between CLT and Topping	Finish Floor	STC[1]	IIC[1]	Source
CLT 5-ply (6.875")	1-1/2" Gyp-Crete®	Maxxon Acousti-Mat® 3/4	None	47[2] ASTC	47[2] AIIC	1
			LVT	-	49[2] AIIC	
			Carpet + Pad	-	75[2] AIIC	
			LVT on Acousti-Top®	-	52[2] AIIC	
			Eng Wood on Acousti-Top®	-	51[2] AIIC	
		Maxxon Acousti-Mat® ¾ Premium	None	49[2] ASTC	45[2] AIIC	
			LVT	-	47[2] AIIC	
			LVT on Acousti-Top®	-	49[2] AIIC	
	1-1/2" Levelrock®	USG SAM N25 Ultra	None	45[6]	39[6]	15
			LVT	48[6]	47[6]	16
			LVT Plus	48[6]	49[6]	58
			Eng Wood	47[6]	47[6]	59
			Carpet + Pad	45[6]	67[6]	60
			Ceramic Tile	50[6]	46[6]	61
			None	45[6]	42[6]	15
			LVT	48[6]	44[6]	16

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS

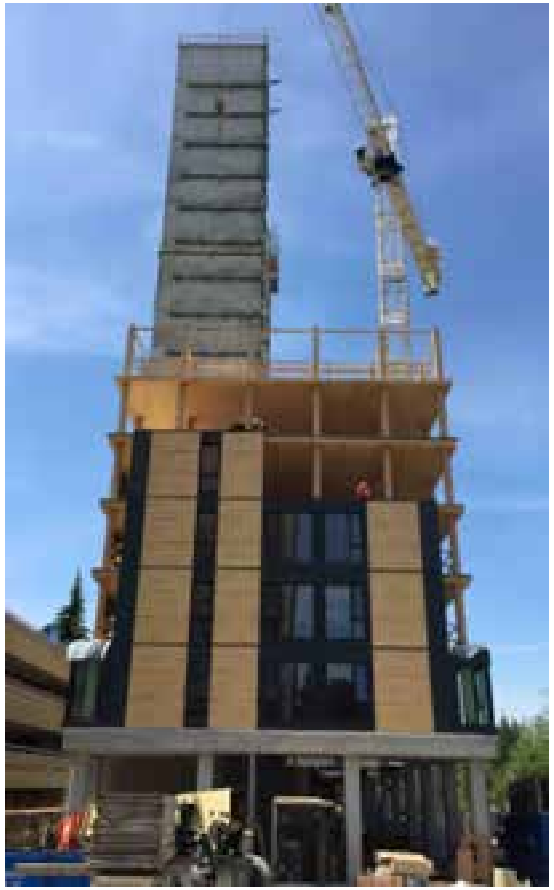


IMAGE: SEAGATE STRUCTURES

STEEL OR CONCRETE SEISMIC SYSTEM:

- COMMONLY USED WITH GLAZING/CURTAIN WALLS
- MAY USE RIGID OR SEMI-RIGID (IF USED WITH FRAMES AT EXTERIOR) ANALYSIS

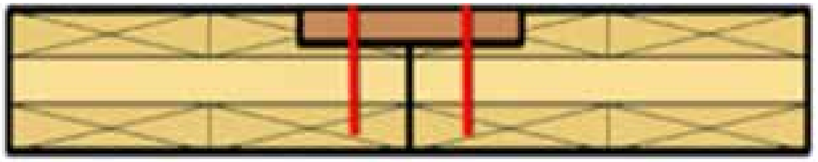
LIGHT FRAME SHEARWALLS:

- TYPICAL FOR 1-5 STORIES
- TYPICALLY ASSUME FLEXIBLE DIAPHRAGM
- NEED AMPLE WALL AT PERIMETER

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

Photo Credit: structurecraft Builders

Photo: Structurlam

Photo Credit: alex schreyer

NEW MASS TIMBER CONNECTIONS INDEX

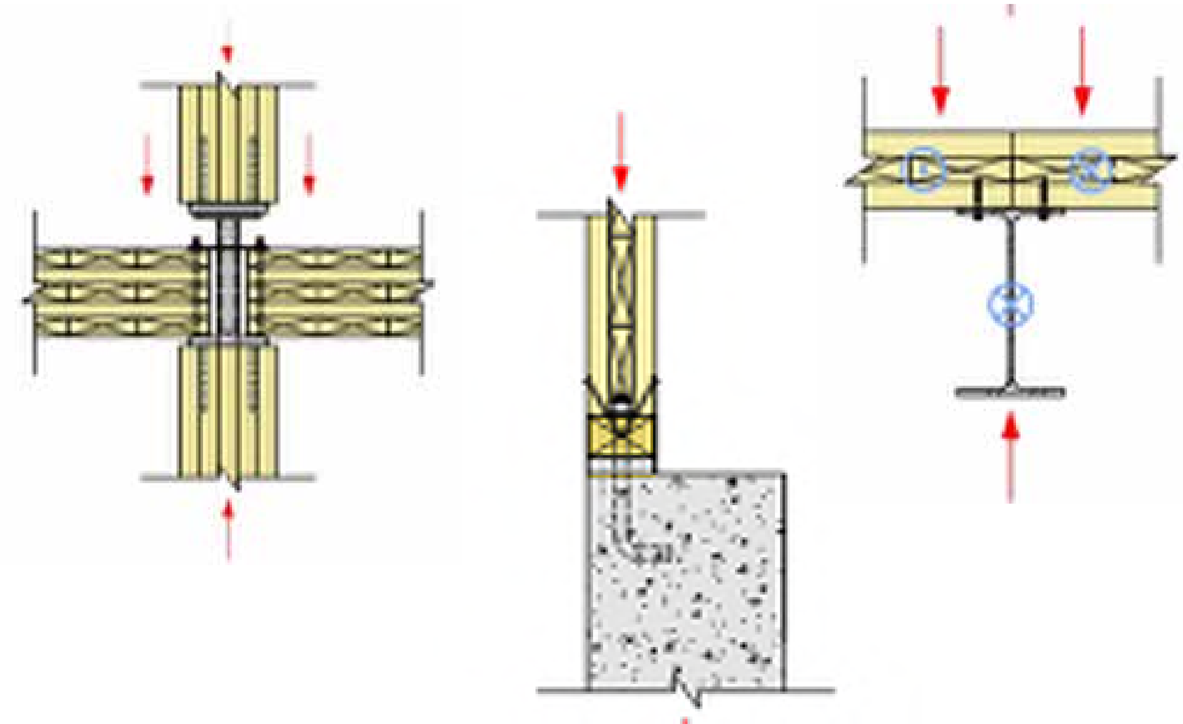
WoodWorks™
WOOD PRODUCTS COUNCIL

KL&A
Engineers & Builders

OZ
ARCHITECTURE
URBAN DESIGN
INTERIOR DESIGN

SWINERTON
MASS TIMBER

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

Photo Credit: StructureCraft

Photo Credit: GLI Partners

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

Credit: WoodWorks

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

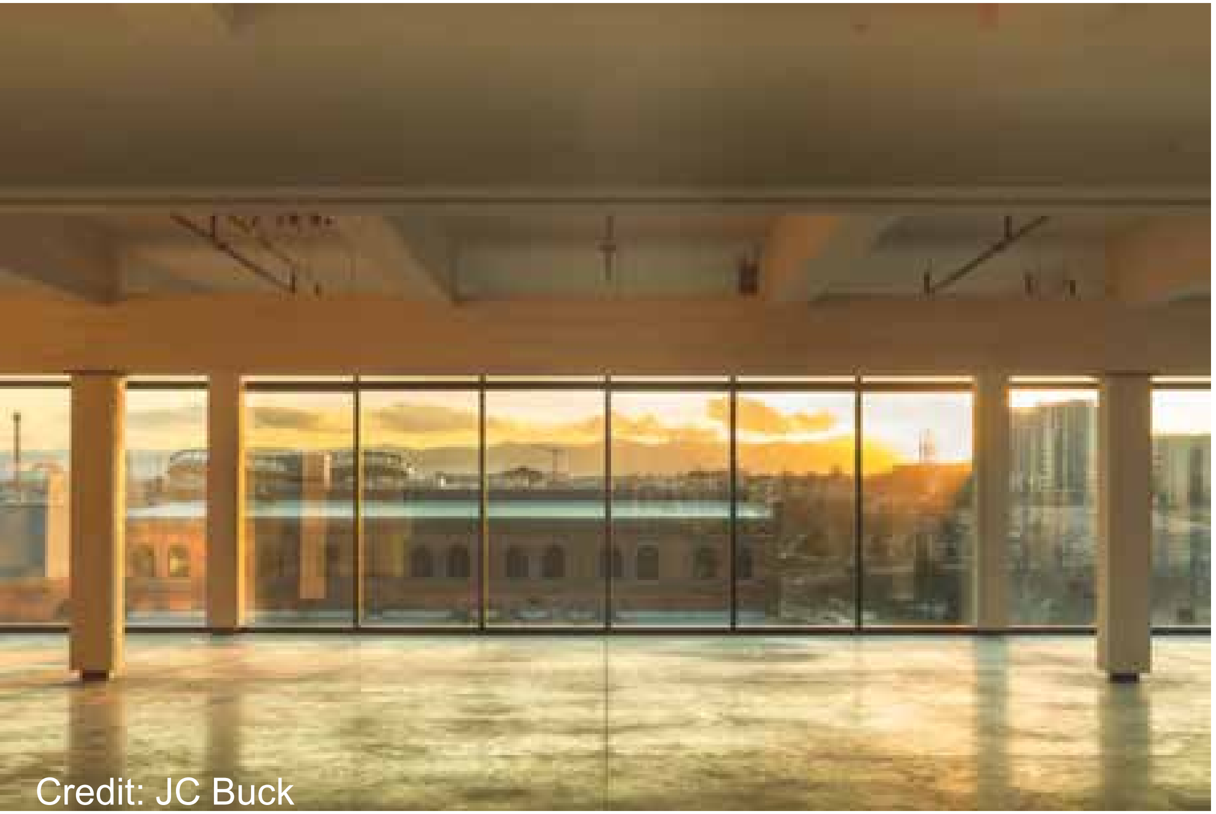

Credit: WoodWorks


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

MEP Layout & Integration

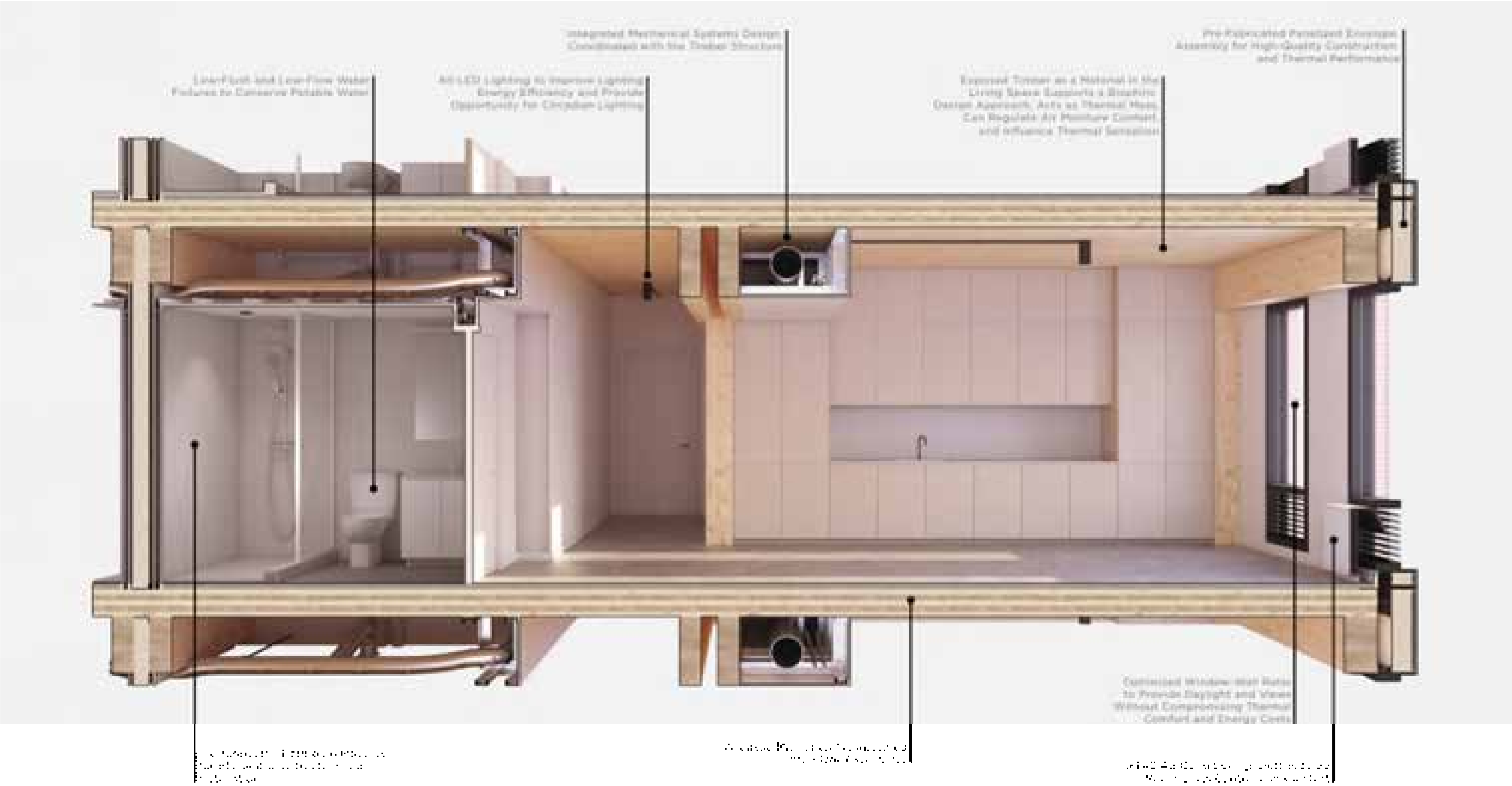
In raised access floor (RAF) above MT
- Impact on head height
- Concealed space code provisions


Credit: Global IFS

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

MEP SYSTEMS, ROUTING, INTEGRATION



INTEGRATED SYSTEMS

Credit: John Klein, Generate Architecture

UNDERSTANDING INSURANCE

INSURANCE PERSPECTIVE ON MASS TIMBER

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

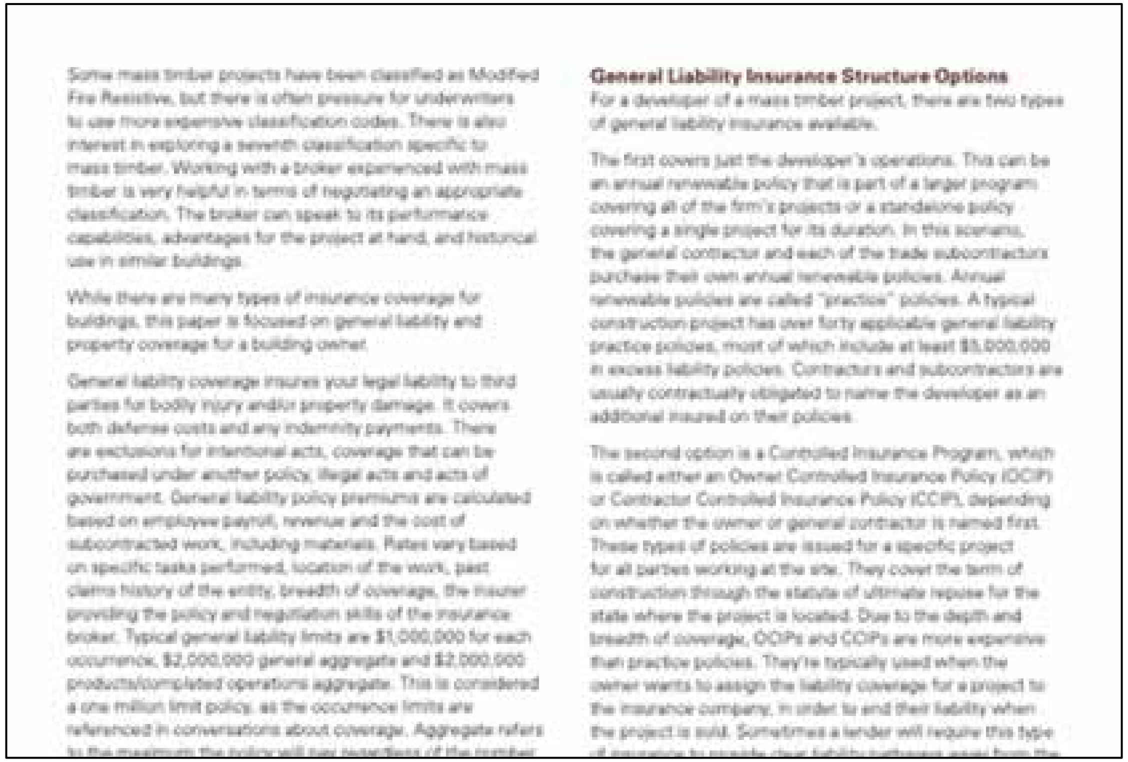
- Important to understand the significant differences in how mass timber performs in the event of a fire, etc. when compared to light wood-frame and all other building materials

Photo Credit: StructureCraft

Photo Credit: GLI Partners

Insurance Perspective on Mass Timber

- Mass timber insurance resource for insurers, developers, contractors & designers
- Free download at woodworks.org



Some mass timber projects have been classified as Modified Fire Resistive, but there is often pressure for underwriters to use more expensive classification codes. There is also interest in exploring a seventh classification specific to mass timber. Working with a broker experienced with mass timber is very helpful in terms of negotiating an appropriate classification. The broker can speak to its performance capabilities, advantages for the project at hand, and historical use in similar buildings.

While there are many types of insurance coverage for buildings, this paper is focused on general liability and property coverage for a building owner.

General liability coverage insures your legal liability to third parties for bodily injury and/or property damage. It covers both defense costs and any indemnity payments. There are exclusions for intentional acts, coverage that can be purchased under another policy, illegal acts and acts of government. General liability policy premiums are calculated based on employee payroll, revenue and the cost of subcontracted work, including materials. Rates vary based on specific tasks performed, location of the work, past claims history of the entity, breadth of coverage, the insurer providing the policy and negotiation skills of the insurance broker. Typical general liability limits are $1,000,000 for each occurrence, $2,000,000 general aggregate and $2,000,000 products/completed operations aggregate. This is considered a one million limit policy, as the occurrence limits are referenced in conversations about coverage. Aggregate refers

General Liability Insurance Structure Options

For a developer of a mass timber project, there are two types of general liability insurance available.

The first covers just the developer's operations. This can be an annual renewable policy that is part of a larger program covering all of the firm's projects or a standalone policy covering a single project for its duration. In this scenario, the general contractor and each of the trade subcontractors purchase their own annual renewable policies. Annual renewable policies are called "practice" policies. A typical construction project has over forty applicable general liability practice policies, most of which include at least $5,000,000 in excess liability policies. Contractors and subcontractors are usually contractually obligated to name the developer as an additional insured on their policies.

The second option is a Controlled Insurance Program, which is called either an Owner Controlled Insurance Policy (OCIP) or Contractor Controlled Insurance Policy (CCIP), depending on whether the owner or general contractor is named first. These types of policies are issued for a specific project for all parties working at the site. They cover the term of construction through the statute of ultimate repose for the state where the project is located. Due to the depth and breadth of coverage, OCIPs and CCIPs are more expensive than practice policies. They're typically used when the owner wants to assign the liability coverage for a project to the insurance company, in order to end their liability when the project is sold. Sometimes a lender will require this type

Insurance for Mass Timber Construction: Assessing Risk and Providing Answers

One of the exciting trends in building design is the growing use of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction. Mass timber products have inherent fire resistance and can be left exposed in many applications and building sizes, achieving the triple function of structure, finish and fire resistance. Because of their strength and dimensional stability, these products offer an alternative to steel, concrete and masonry for many applications, but have a much lighter carbon footprint. It is this combination of exposed structure and strength that developers and designers across the country are leveraging to create innovative designs with a warm yet modern aesthetic.

As mass timber construction has proliferated across the U.S., a number of project teams have run into the same issue: insurance companies unfamiliar with these types of buildings can be reluctant to provide insurance.

The challenge has presented itself in two forms: builder's risk insurance (or course of construction) and property insurance (after building is complete and occupied). Relative risks are assessed differently for each, and each requires a unique approach. For example:

- Construction-phase risks associated with fire are different in mass timber buildings than with most other framing systems. Since the timber elements have inherent fire-resistance capabilities, a building can have a certain level of passive fire resistance after the frame is erected. Protection doesn't rely on (and wait for installation of) materials such as spray-applied
- In addition to safety, property insurance for mass timber buildings requires an understanding of performance related to things like moisture, durability and building enclosure detailing. Much of the property insurance discussion is also site-specific—e.g., is the area prone to flooding, earthquakes or high winds? Mass timber has been tested against potential natural disasters, and numerous test and research reports are available.

This paper is intended for developers and owners seeking to purchase insurance for mass timber buildings, for design/construction teams looking to make their designs and installation processes more insurable, and for insurance industry professionals looking to alleviate their concerns about safety and performance.

For developers, owners and design/construction teams, it provides an overview of the insurance industry, including its history, what affects premiums, how risks are analyzed, and how project teams can navigate coverage for mass timber buildings. Insurance in general can seem like a mystery—what determines premium fluctuations, impacts of a

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

WoodWorks Online Event

Kendeda Building for Innovataive Sustainable Design, The Miller Hull Partnership with Lord Aeck Sargent, photo Jonathan Hillyer

1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

T3 Minneapolis, MGA, DLR Group, Magnusson Klemencic Associates, StructureCraft, photo Ema Peter

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

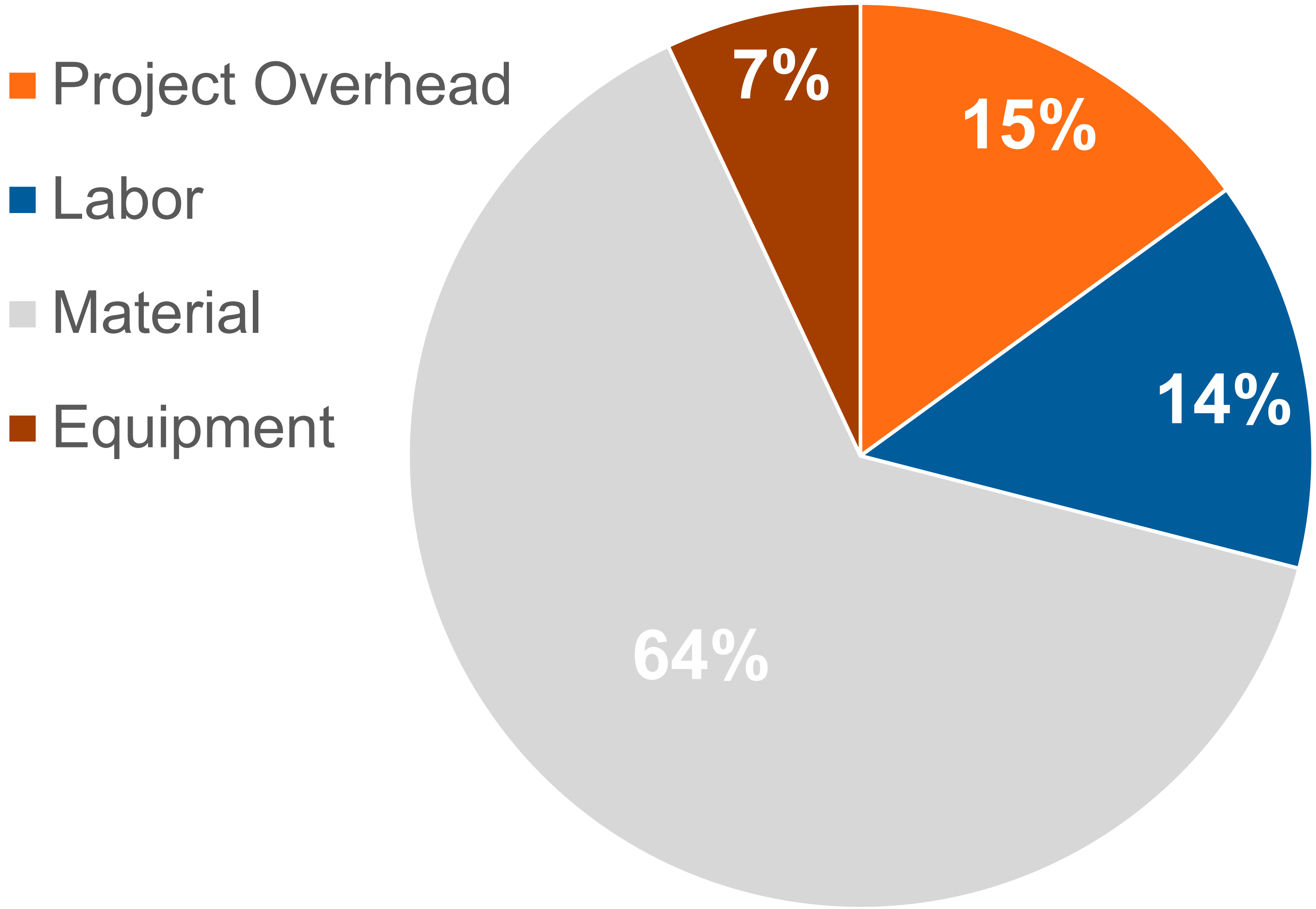
Holistic Costing

$/SF

$/SF

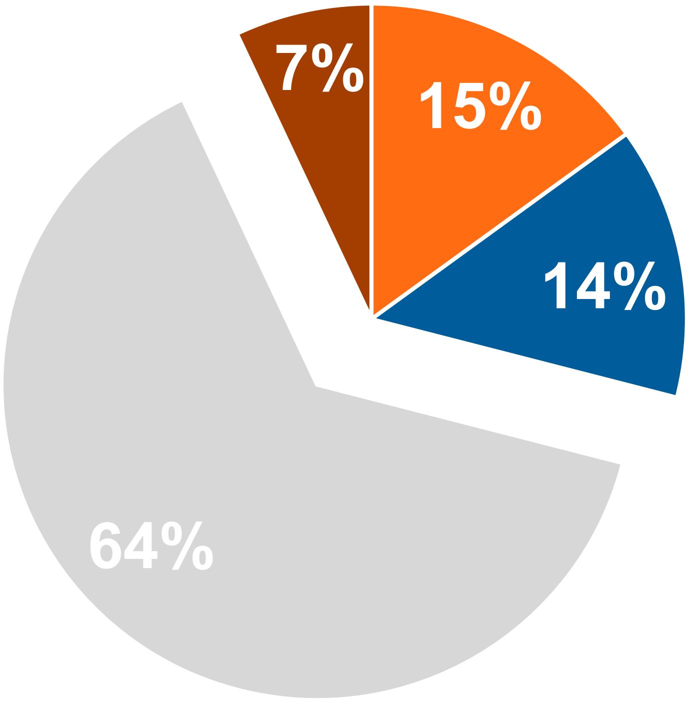
Image: GBD Architects

Anatomy of a Turnkey Mass Timber Package

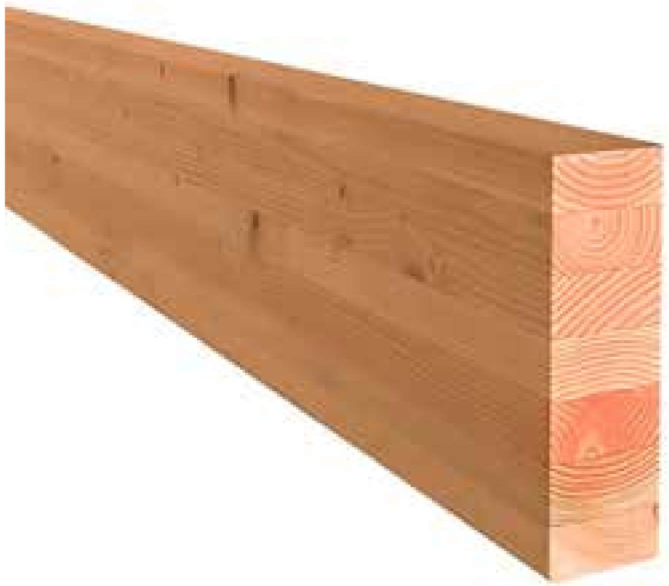


Source: Swinerton

Material (Direct Cost)



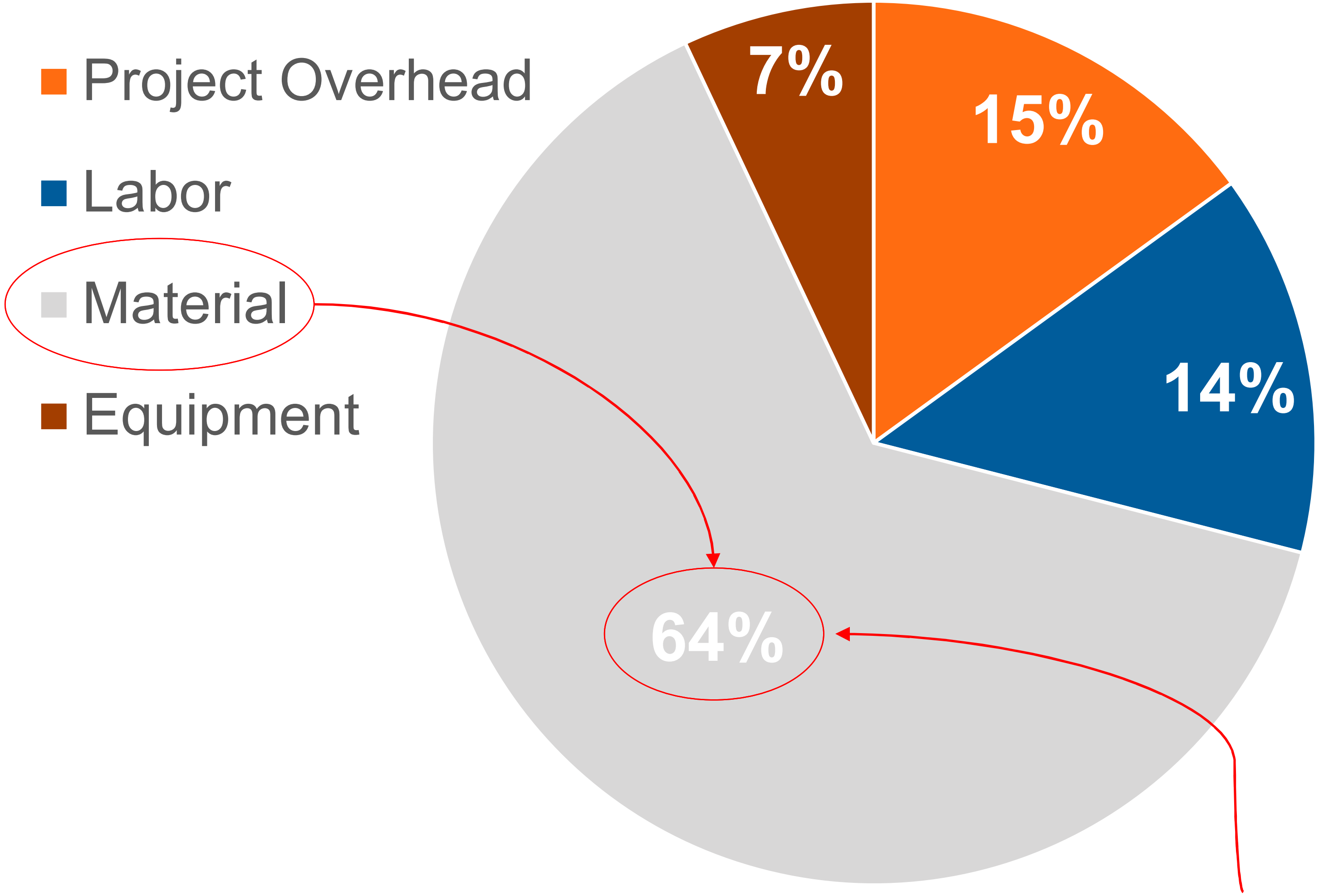
Turnkey Mass Timber Package



or

Source: Swinerton

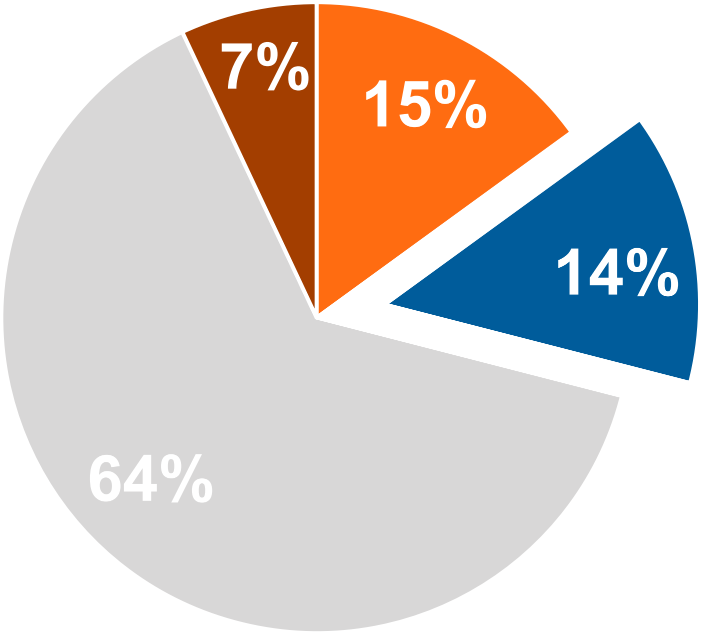
Mass Timber Package Costs



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

Source: Swinerton

Labor (Direct Cost)

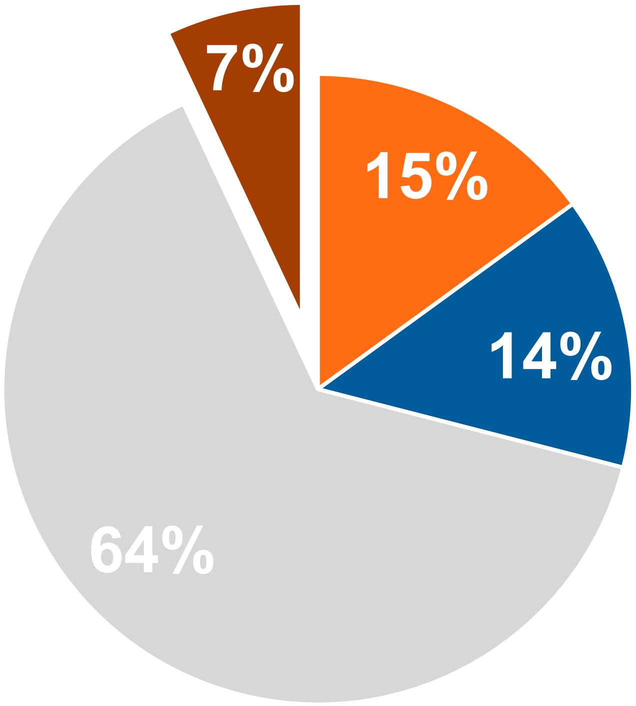


Turnkey Mass Timber Package

Photo: Swinerton

Source: Swinerton

Equipment (Direct Cost)



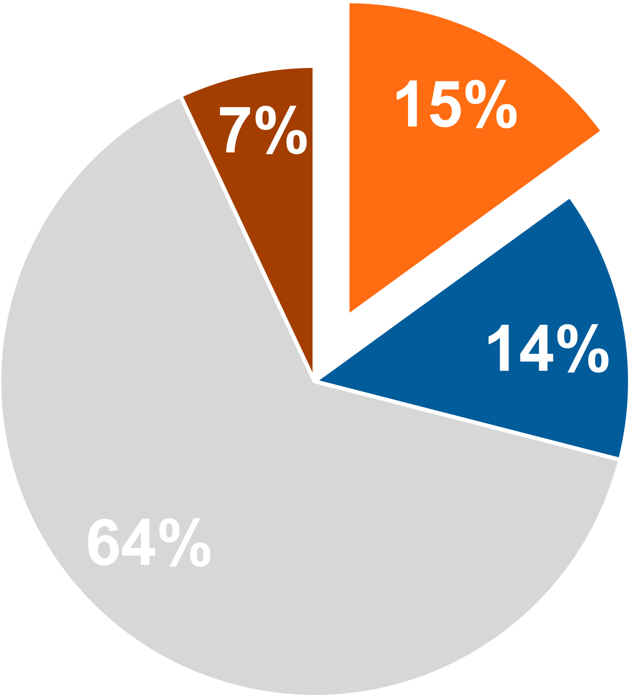
Turnkey Mass Timber Package

Photo: Swinerton

Photo: Alex Schreyer

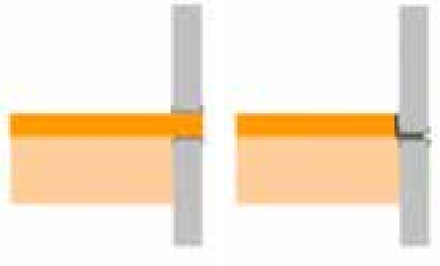
Source: Swinerton

Project Overhead



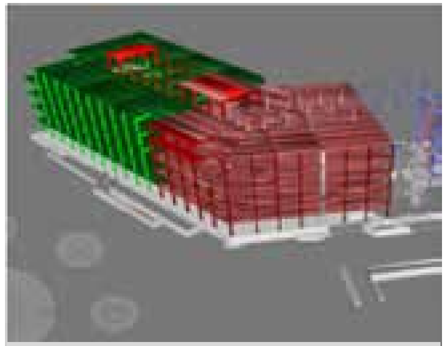
Turnkey Mass Timber Package

Cost Analysis

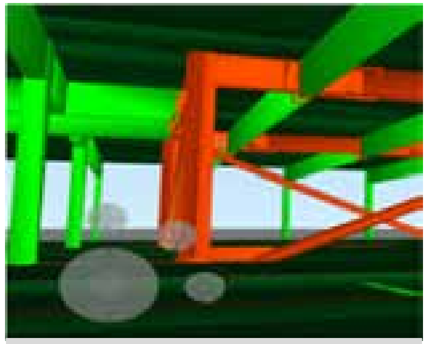


Design Refinement

System Integration



VD&C



Detail Optimization

Logistics Planning

Photos: Swinerton

Source: Swinerton

Total Project Cost Analysis

CONSIDERATIONS:

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

Credit: Hacker Architects

BB0

Sample Procurement Strategies

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

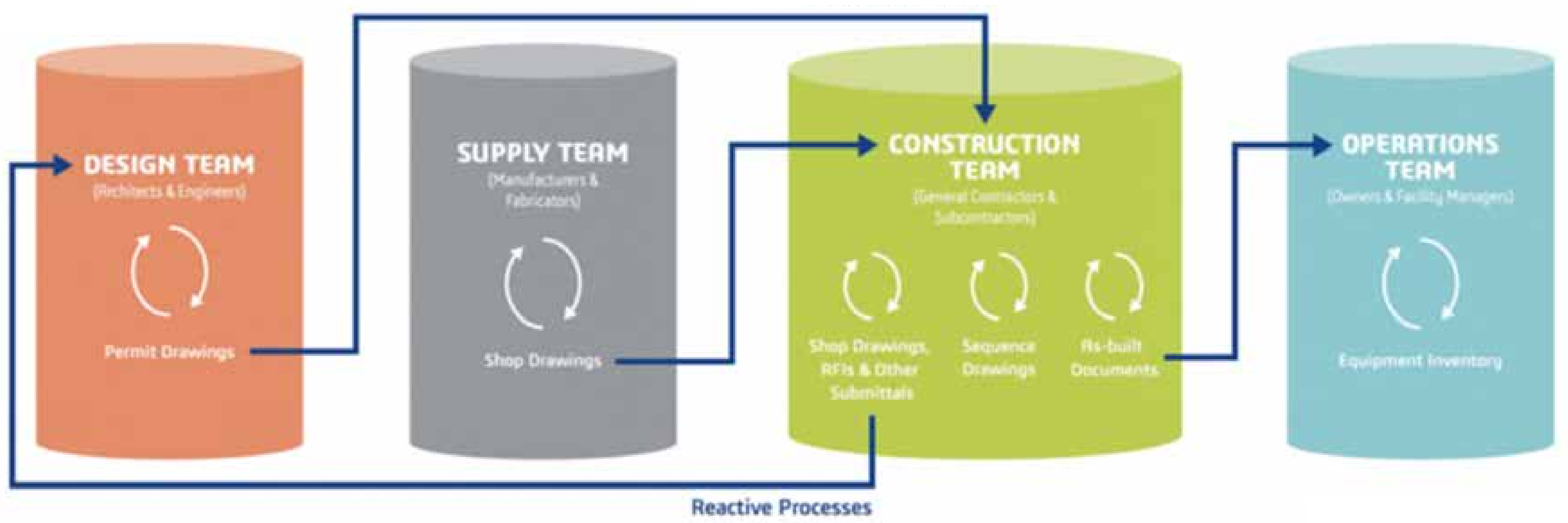
Source: Timberlab

Slide 88

BB0 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

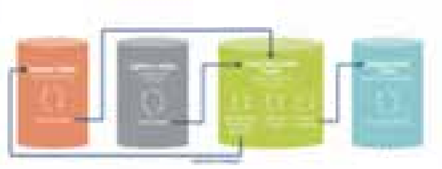
Brandon Brooks, 2022-05-05T19:32:19.356

Potential Cost Impacts: Design-Bid-Build Procurement



Alternate Procurement Option:
Trade Partner/Master Builder Approach

Procurement Strategy is Key to Success



5% Savings

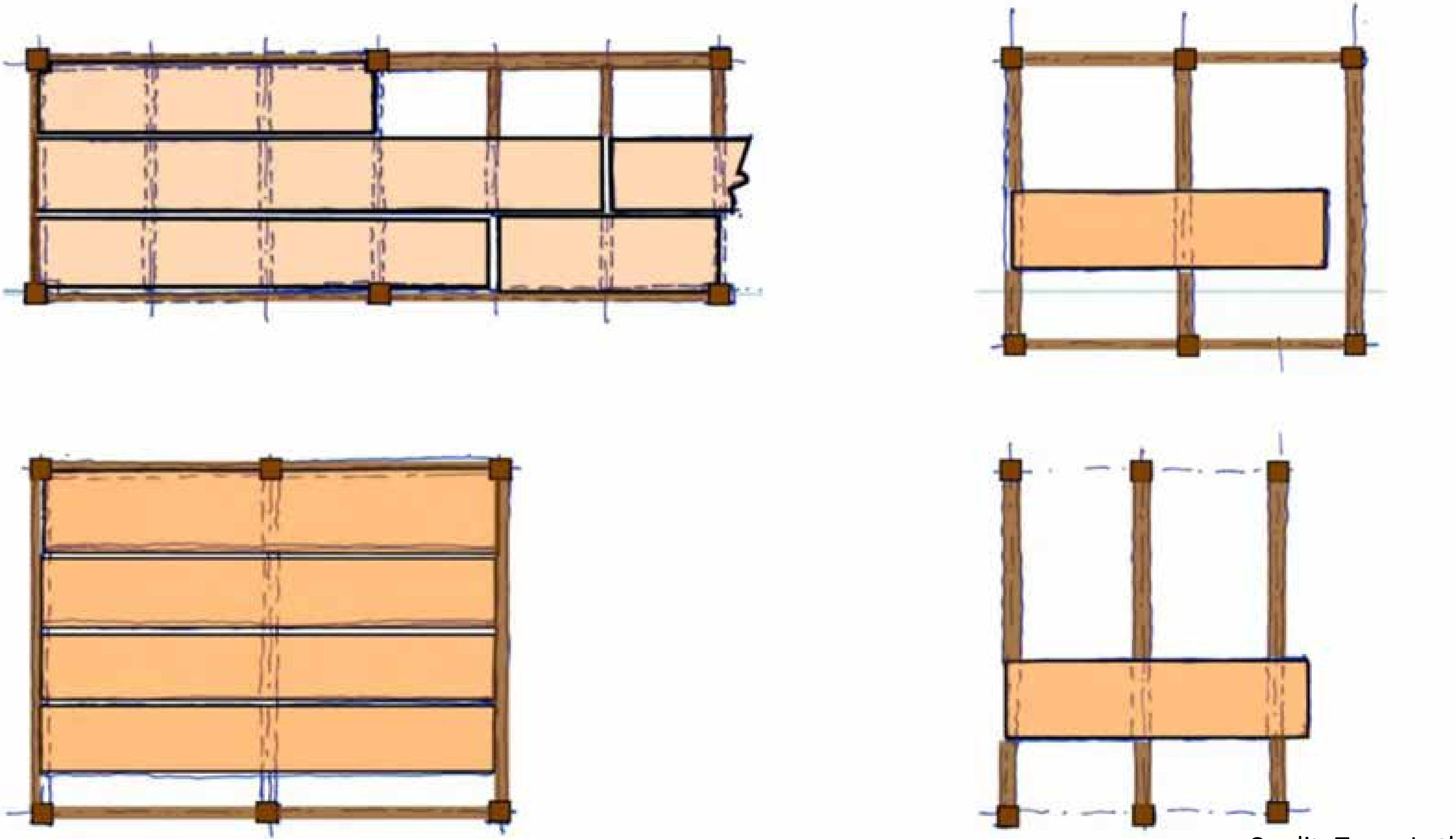
Neutrality

10% Premium

Material Fabrication Planning

Understand the Supply Chain

Photo: Swinerton

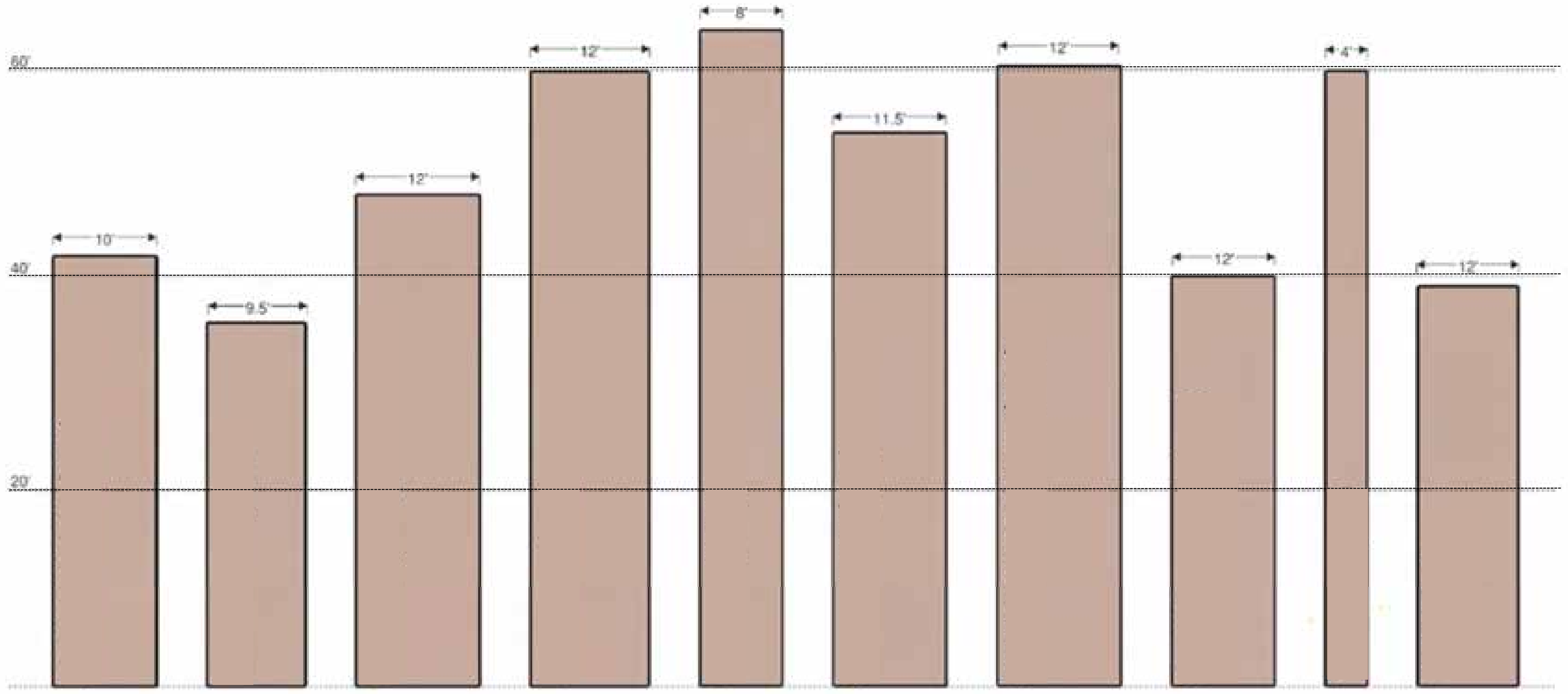


Credit: Tanya Luthi, Entuitive

Understand Manufacturer’s Capabilities

BB0

Understand Manufacturer's Capabilities



Credit: TimberLab

Slide 95

BB0 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

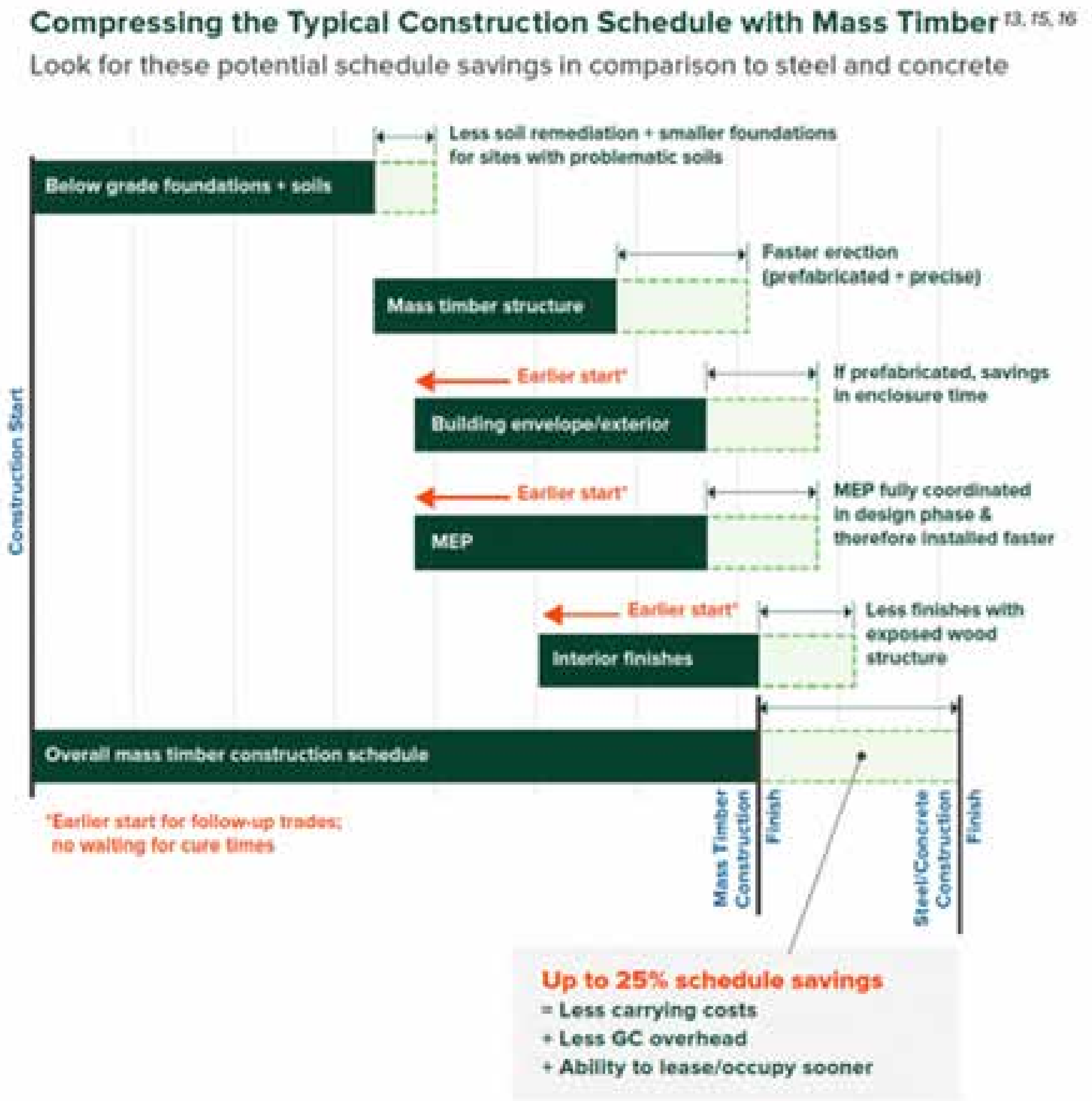
Tolerances: Interface with Other Structural Materials

Photos: Swinerton

Schedule Drivers

Photo: Swinerton

Procurement Approach Determines Schedule



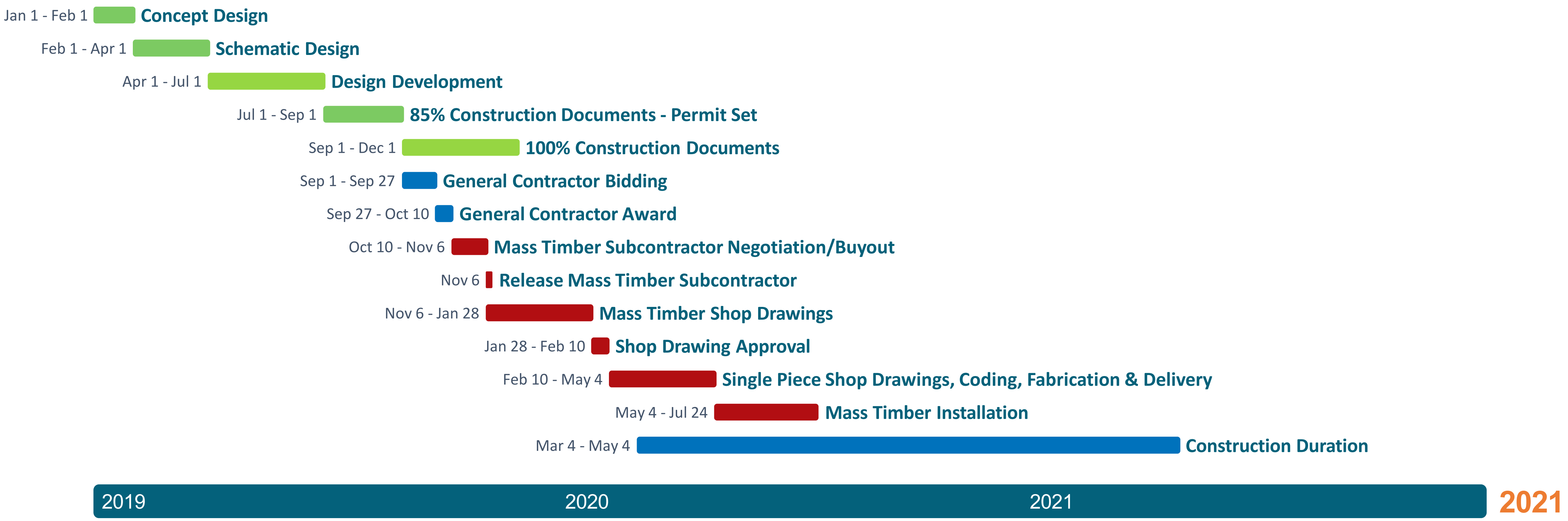
Source: WoodWorks

Slide 99

BB0	We need to reconcile the 25% claim Brandon Brooks, 2022-04-22T21:59:12.687
RM0 0	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? Ricky McLain, 2022-04-25T15:44:58.181

Procurement Approach Determines Schedule

Example 6 Story Type IIIA Project



Source: Swinerton

Design-Bid-Build Procurement

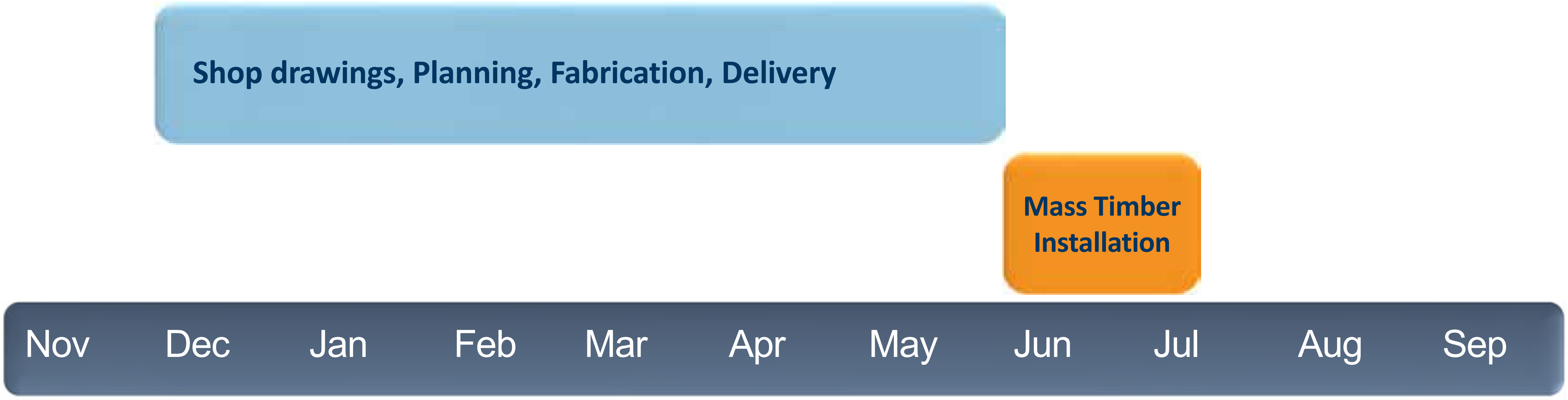
Procurement Approach Determines Schedule

Example 6 Story Type IIIA Project

Source: Swinerton

Design-Build/Design-Assist Procurement

Procurement Logic for Scheduling



Source: Swinerton

Example 6 Story Type IIIA Project

Procurement Approach Determines Schedule

Photo: Alex Schreyer

Schedule Comparison

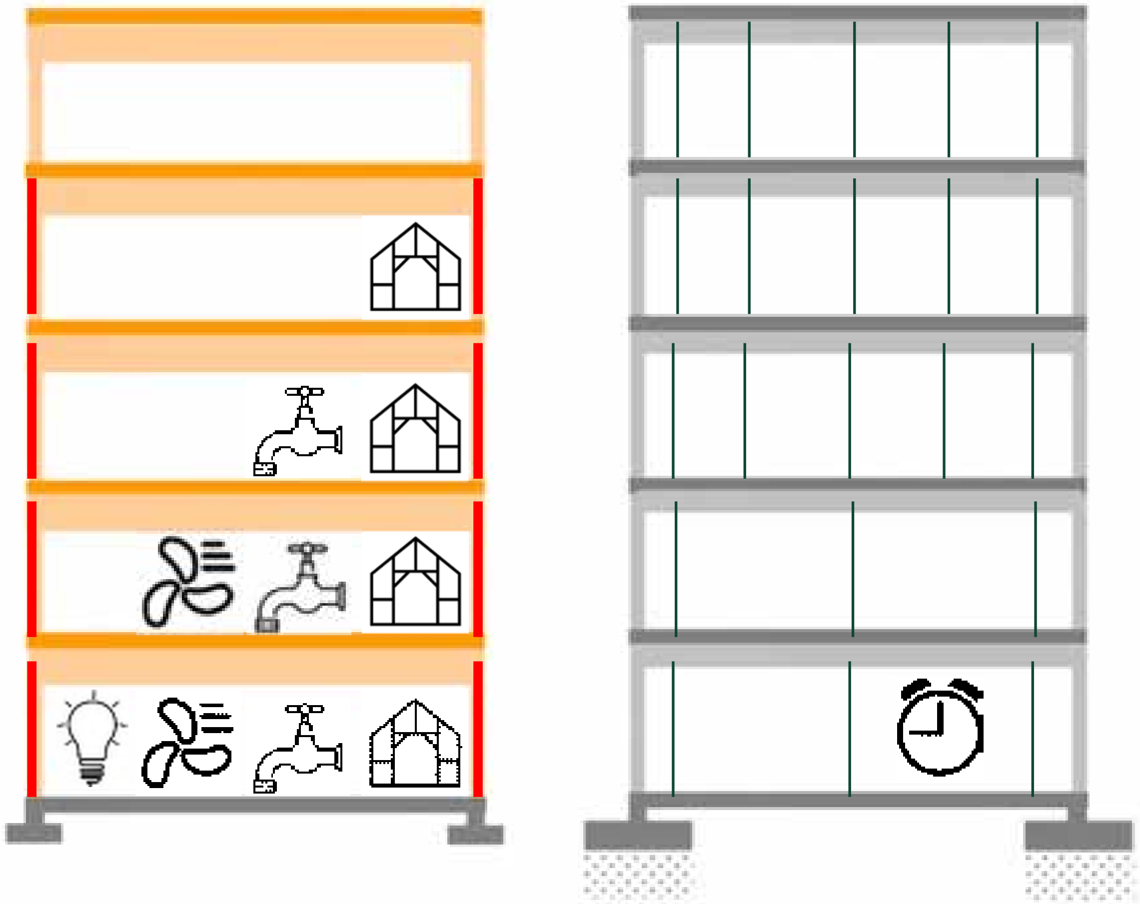


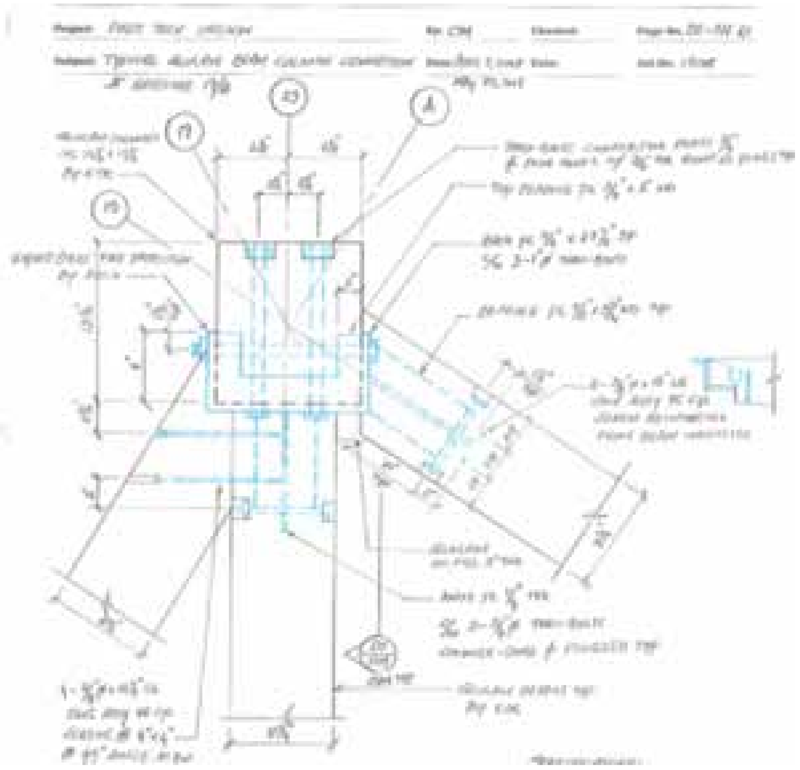
Image: Swinerton

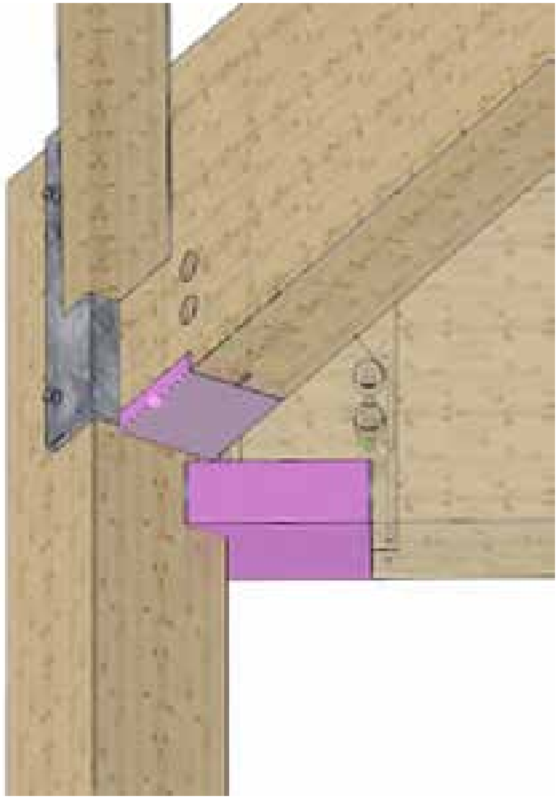
Photo: WoodWorks

Schedule Drivers

Photo: Lendlease

BIM/Digital Twins





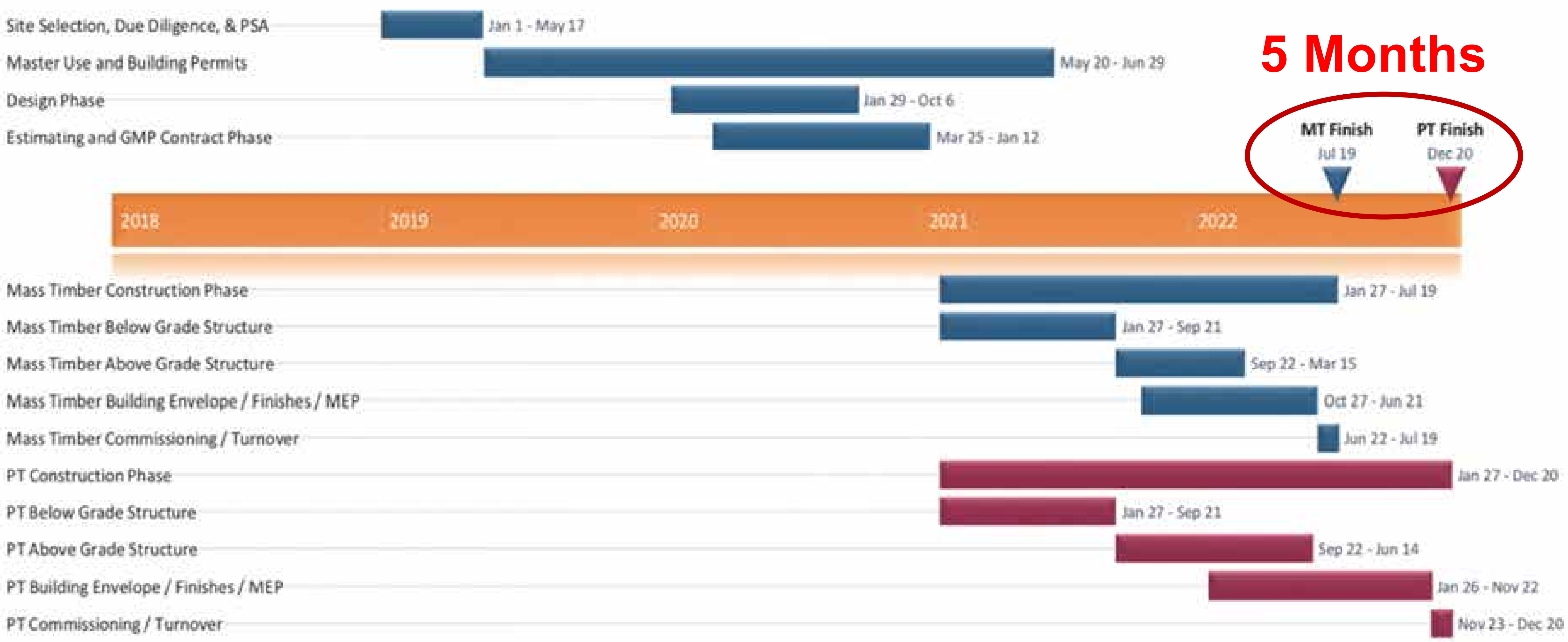
Photos: Swinerton

Schedule Impacts: Hybrid Structures

Look At Schedule Holistically

Photo: StructureCraft Builders

Overall Project Schedule Analysis: 12 Story Type IV-B



Source: Swinerton

Schedule Impact on Cost | Value of Time

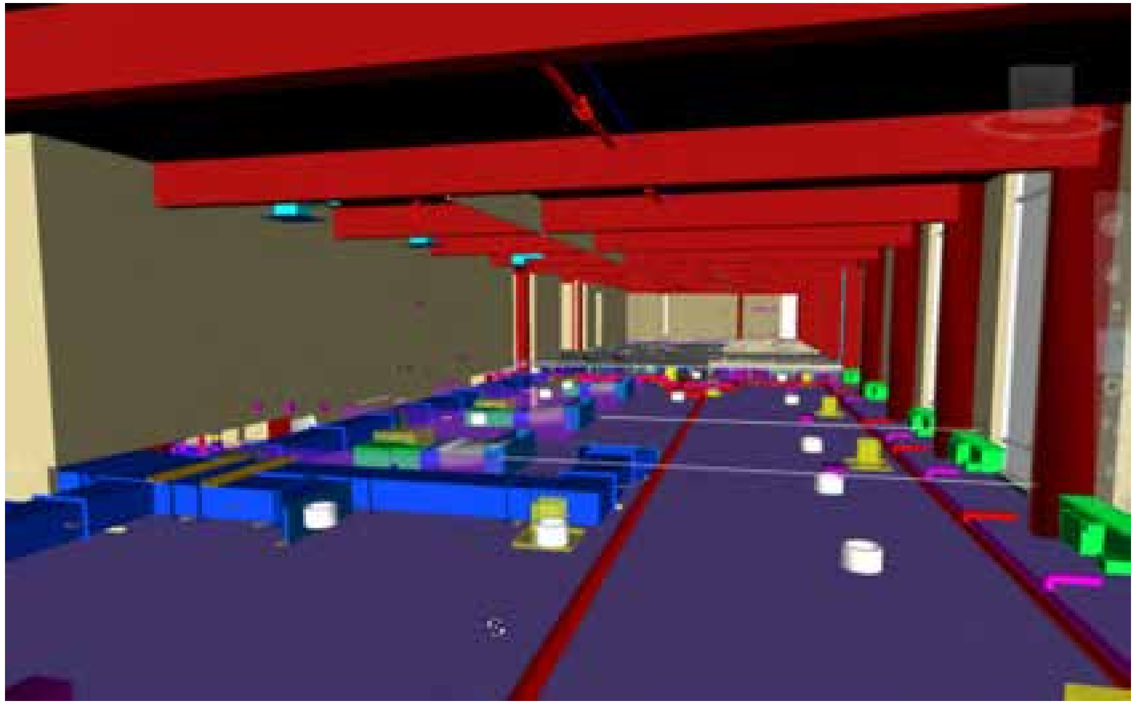
A large-scale MT project can be up to 2% higher in direct costs, but a minimum of 20% lower in project overhead costs. The net result is cost-neutrality and higher value.

Source: Swinerton
Photo: Alex Schreyer

Early Move-In for Rough-In Trades.

Photos: Swinerton

Embracing BIM for Fabrication



Photos: Swinerton

SITE PLANNING

Photo: Swinerton

QA/QC

Photo: Swinerton

SITE INSPECTIONS

Photo: H+O Structural Engineering, Kure Creative

Tall Mass Timber Special Inspections

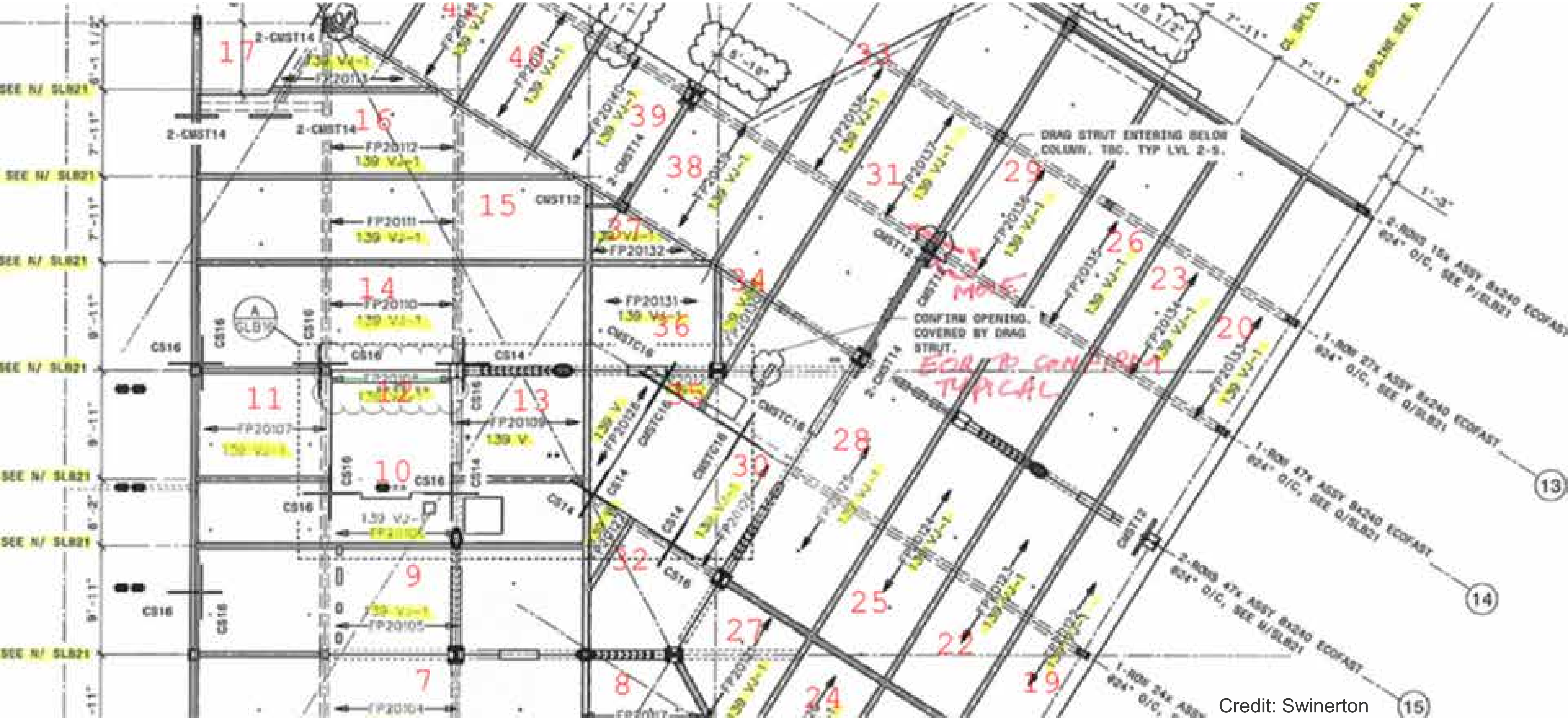
TABLE 1705.5.3
REQUIRED SPECIAL INSPECTIONS OF MASS TIMBER CONSTRUCTION

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

Source: International Building Code

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

Sequencing



Credit: Swinerton

PICK PLAN

Photo: Swinerton

MATERIAL DELIVERY

Photo: Swinerton

STAGING

Photo: Swinerton

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

BB0

Photo: Swinerton

Photo: Alex Schreyer

Material Environmental Exposure and Moisture Management

- Enroute
- Onsite
- Post-Install
- Other Material

Slide 122

BB0 Plenty of great tips from Dave Beck and Jeff Chan to expand this section
Brandon Brooks, 2022-04-17T20:41:48.248

RM0 0 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

BB0

Onsite Considerations

Slide 126

BB0 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

Other Materials

BB0

Slide 127

BB0 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

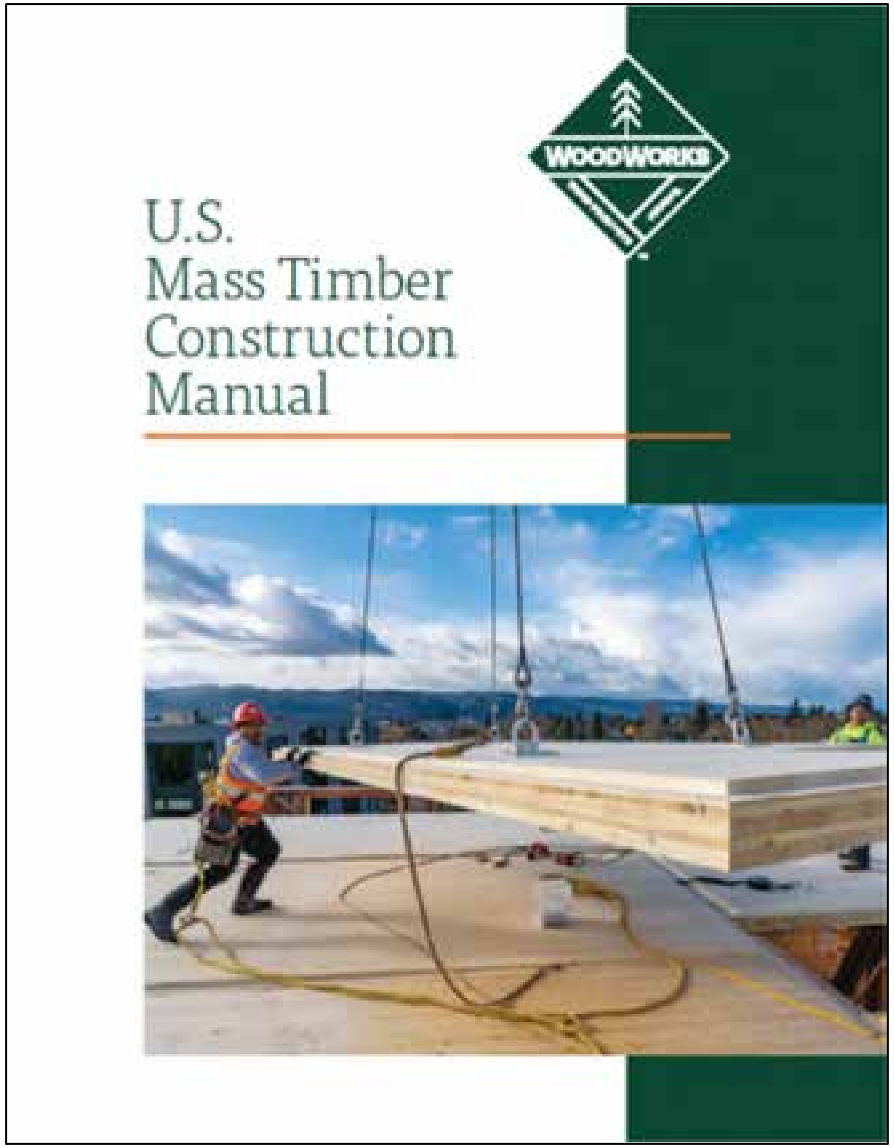
PARTNER WITH CONSTRUCTION ASSOCIATIONS

PROJECT TOURS

ENGAGE WITH GENERAL CONTRACTORS ACROSS THE US

Released on 20 October 2021

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



The Loading Dock, OZ Architecture, KL&A, photo Joe Anastasi

Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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