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Mass Timber Overview: Systems, Products & Codes

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Photo: Structurlam

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

Course Description

How do contractors answer the ever-growing demand from architects and ownership groups for mass timber buildings? The growth of this budding industry can be slowed by a lack of will and lack of know-how among seasoned construction professionals who know how to build, understand the onus of “architectural intent,” and must ultimately take on financial responsibility to deliver the dream of a new building system. This presentation will introduce mass timber products and building systems and then consider why some mass timber projects die at concept, what leads to the resistance, and how the development, architectural, engineering, and construction community can overcome assumptions to achieve success with mass timber projects of various scales and typologies. Particular emphasis will be given to preconstruction coordination, holistic approaches to costing and scheduling studies, project delivery methods, and how to achieve the highest level of cost efficiency.

Learning Objectives

1. Understand the preconstruction manager's role in material procurement and MEP coordination of code-compliant mass timber projects.
2. Highlight effective methods of early design-phase cost estimation that keeps mass timber options on the table.
3. Discuss potential construction schedule savings realized through the use of prefabricated mass timber elements.
4. Explore best practices for interaction between manufacturer, design team and preconstruction manager that can lead to cost efficiency and safety on site.

PRESENTATION OUTLINE

1. MASS TIMBER OVERVIEW

- Structural Solutions
- Connections
- Projects
- Products

2. CONSTRUCTION MANAGEMENT

- Risk Analysis (Risks & Solutions)
- Economics (What does it cost?)
- Logistics (Schedule & Coordination)

MASS TIMBER PRODUCTS

Nail-Laminated Timber (NLT)

Photo: StructureCraft

Nail-Laminated Timber (NLT)

Photo: StructureCraft

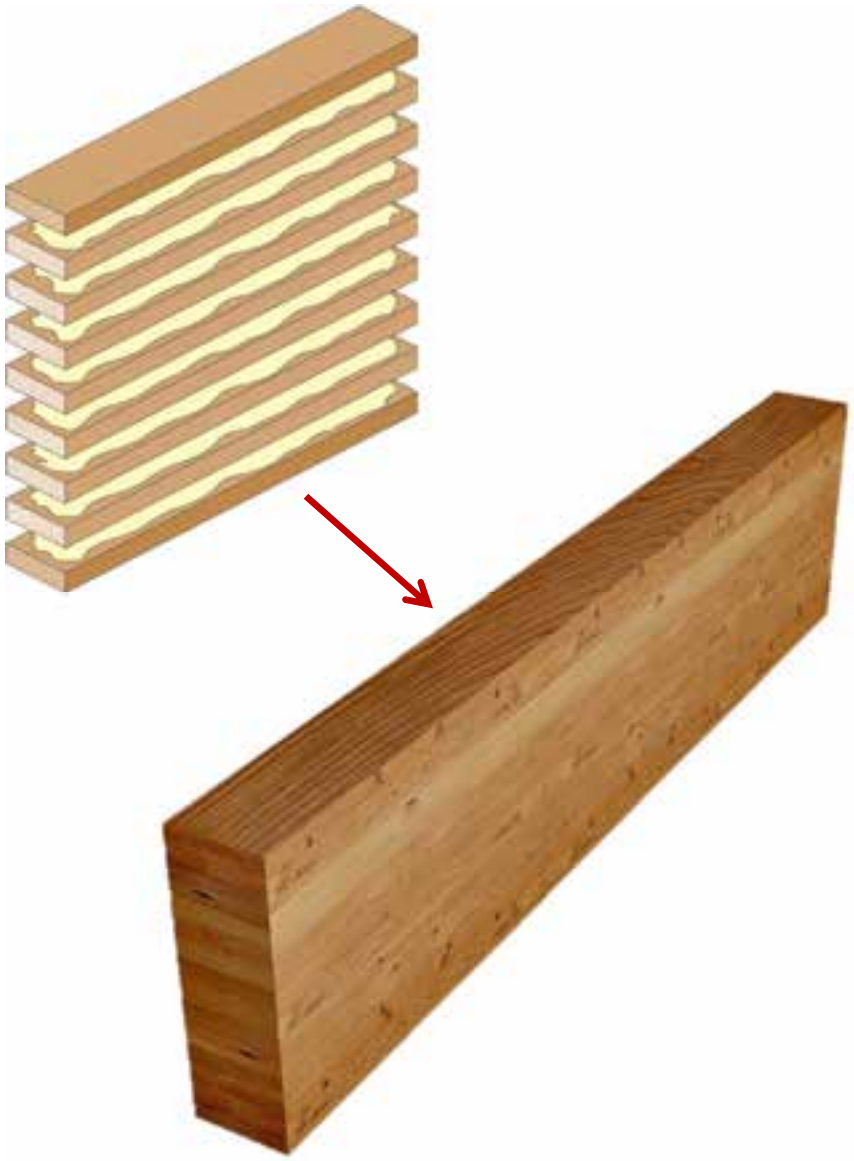
Photo: Think Wood

MASS TIMBER PRODUCTS

TONGUE AND GROOVE DECKING - 1885

Glue Laminated Timber (GLT) - 1906

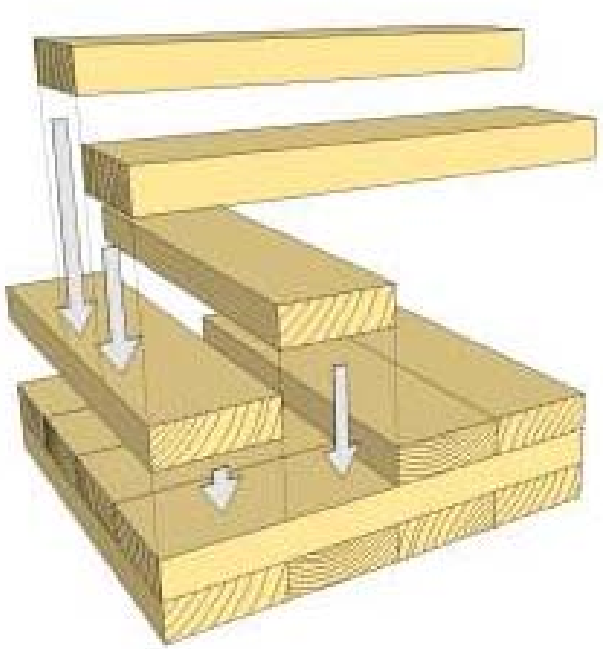
Photo: Manasc Isaac Architects/Fast + Epp

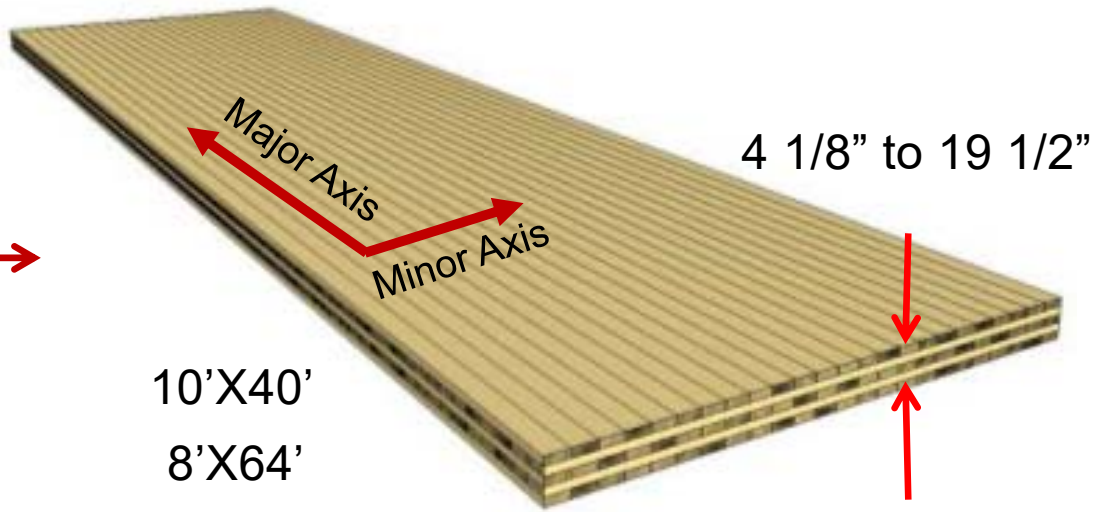


Glue Laminated Timber (GLT)

Cross-Laminated Timber (CLT) - 1994

Cross-Laminated Timber (CLT)

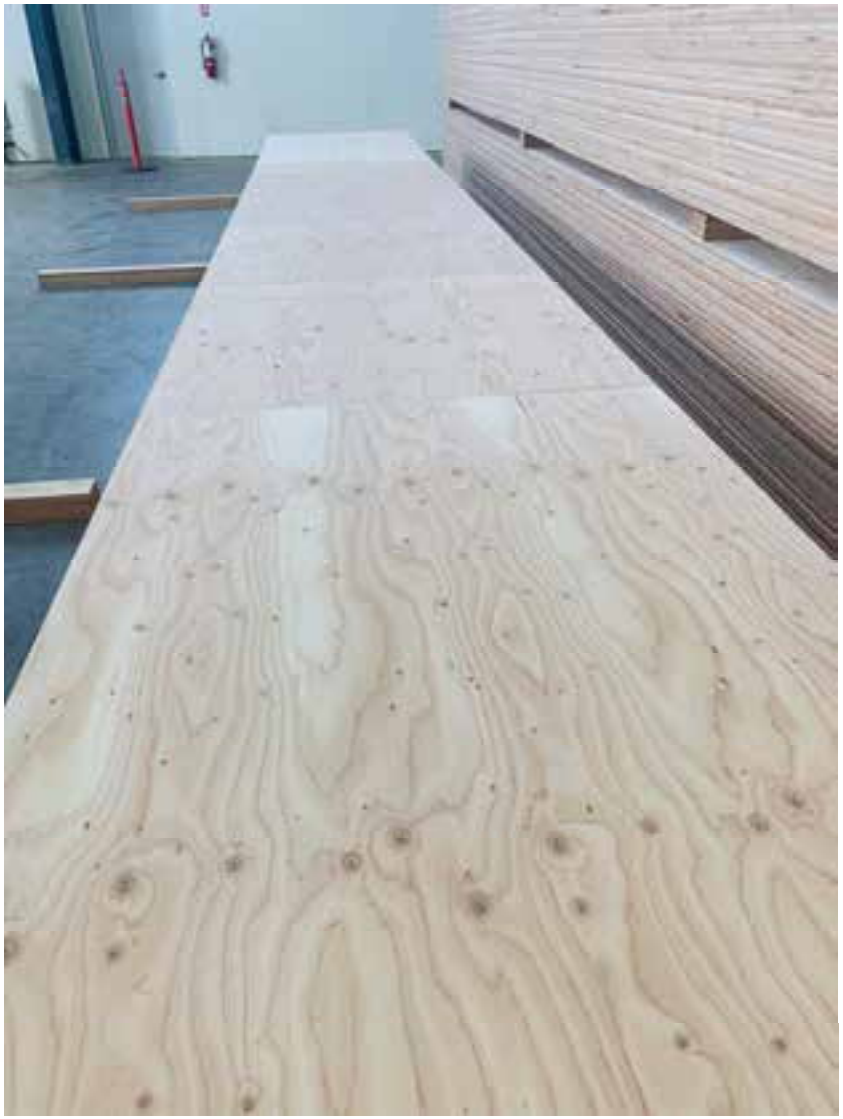




Dowel-Laminated Timber (NLT) - 2018

Photo: StructureCraft

Mass Plywood Panels (MPP) - 2018



Photos: Freres Lumber

MASS TIMBER OVERVIEW

Heavy Timber
Photo: Benjamin Benschneider

Mass Timber
Photo: John Stamets

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Mass plywood panels (MPP)

Photo: Freres Lumber

Decking

Photo: StructureCraft

Photo: LEVER Architecture

Photo: Bernard André Photography

Glue Laminated Timber (GLT)

Cross-Laminated Timber (CLT)

Nail-Laminated Timber (NLT)

Photo: Think Wood

Photo: StructureCraft

Photo: LendLease

Photo: Ema Peter

Photo: Ema Peter

STRUCTURAL SOLUTIONS | POST, BEAM + PLATE

Photo: Seagate Structures

Photo: Lendlease


Photo: John Klein

STRUCTURAL SOLUTIONS | HYBRID STEEL + MASS TIMBER

STRUCTURAL SOLUTIONS | HYBRID CONCRETE + MASS TIMBER

OVERVIEW | CONNECTIONS

Concealed Connectors

Self Tapping Screws

Photos: Rothoblaas

Beam to Column

Photo: StructureCraft

Photo: Structurlam

Column to Foundation

Photo: Alex Schreyer

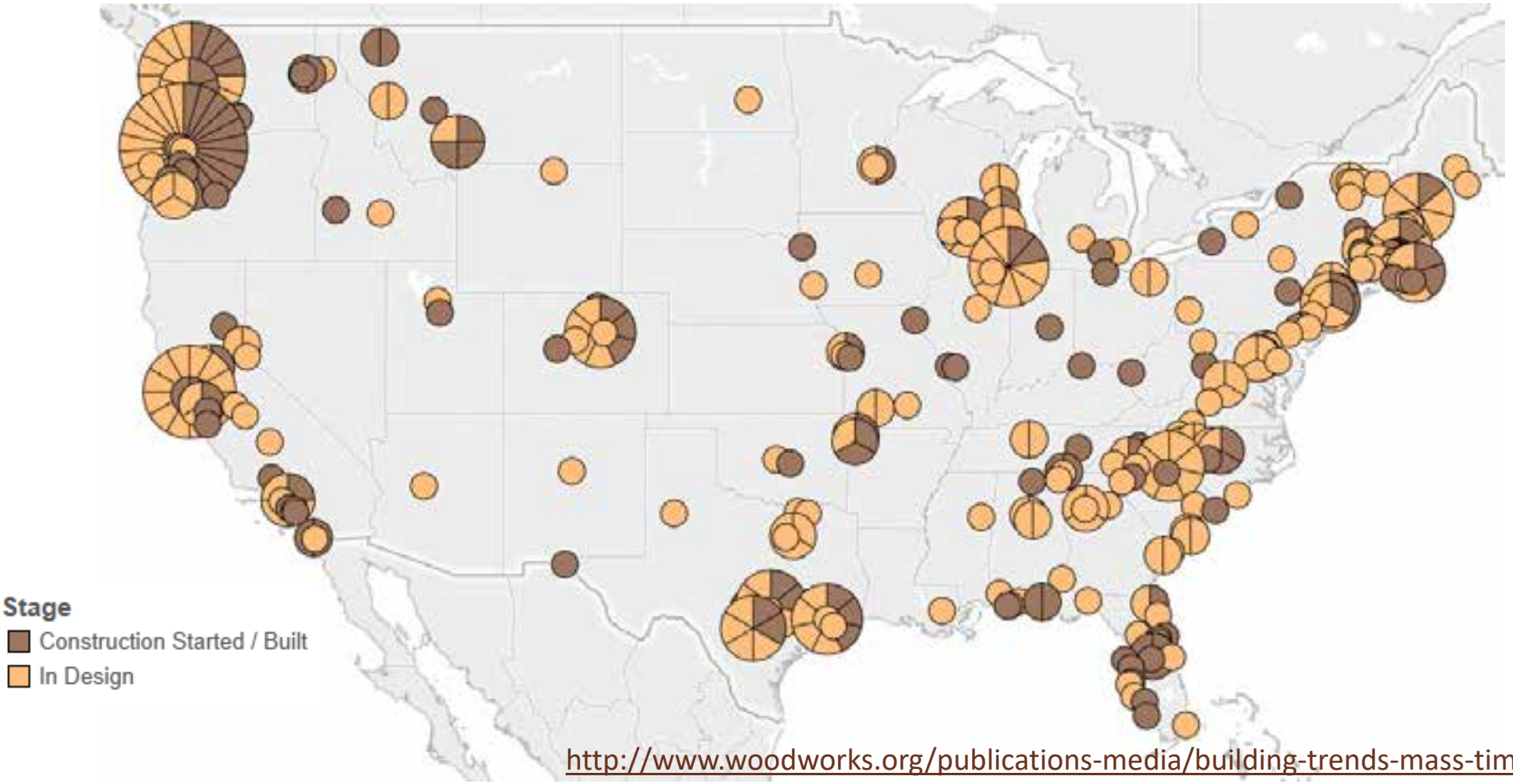
Panel to Panel & Supports

Photo: Charles Judd

Photo: Alex Schreyer

CURRENT STATE OF MASS TIMBER PROJECTS

As of December 2018, **487** multi-family, commercial, or institutional projects have been constructed out of mass timber across the U.S., or they're currently in design.



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

CURRENT STATE OF MASS TIMBER PROJECTS

As of July 2019, **599** multi-family, commercial, or institutional projects have been constructed out of mass timber across the U.S., or they're currently in design.

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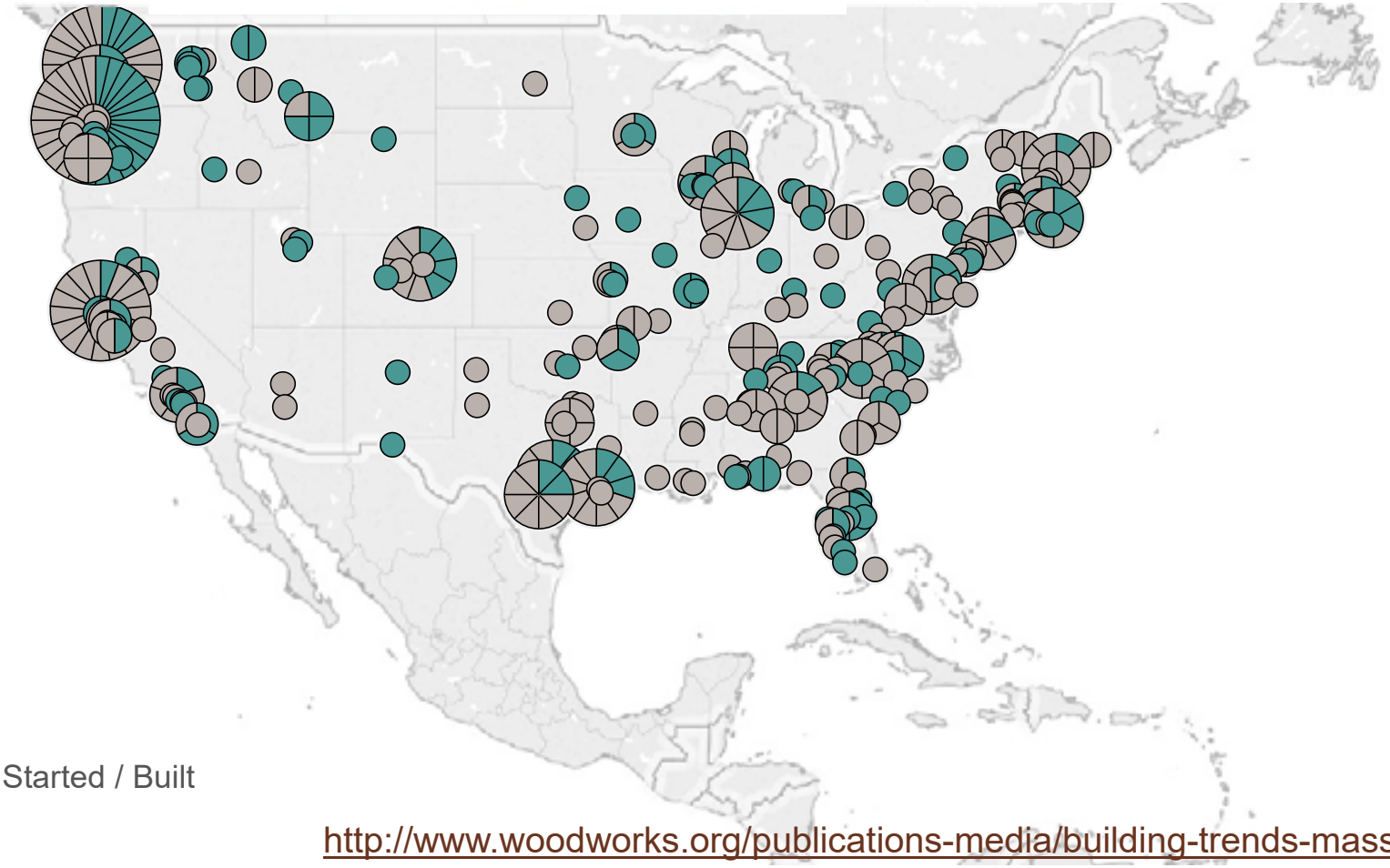


http://www.woodworks.org/publications-media/building-trends-mass-timber/

Mass Timber Projects In Design and Constructed in the US (June 2018)

Stage	Mass Timber	# of Projects
In Design	CLT	124
	NLT	17
	Heavy Timber Decking	31
	Post & Beam	117
	Total	289
Construction Started / Built	CLT	50
	NLT	4
	Heavy Timber Decking	33
	Post & Beam	32
	Total	119
Grand Total		408

State	Stage	
AL	In Design	5
	Construction Started / Built	1
AR	In Design	2
	Construction Started / Built	2
AZ	In Design	2
CA	In Design	40
	Construction Started / Built	15
CO	In Design	7
	Construction Started / Built	7
CT	In Design	4
	Construction Started / Built	2
DC	Construction Started / Built	2
DE	In Design	1
FL	In Design	19
	Construction Started / Built	9
GA	In Design	10
HI	In Design	1
IA	In Design	1
ID	In Design	2
	Construction Started / Built	1
IL	In Design	9
	Construction Started / Built	3
IN	Construction Started / Built	1
KS	In Design	1
KY	Construction Started / Built	1
LA	In Design	2
MA	In Design	17
	Construction Started / Built	9
MD	In Design	7
	Construction Started / Built	1
ME	In Design	5
	Construction Started / Built	1
MI	In Design	2
	Construction Started / Built	1
MN	In Design	1
	Construction Started / Built	1
MO	In Design	2
	Construction Started / Built	2
MT	In Design	3
	Construction Started / Built	3

State	Stage	
NC	In Design	13
	Construction Started / Built	5
ND	In Design	1
NE	In Design	1
	Construction Started / Built	1
NH	In Design	1
NJ	In Design	3
NM	In Design	1
NY	In Design	12
	Construction Started / Built	4
OH	Construction Started / Built	1
OR	In Design	25
	Construction Started / Built	12
PA	In Design	2
	Construction Started / Built	2
RI	In Design	1
	Construction Started / Built	1
SC	In Design	4
	Construction Started / Built	4
TN	In Design	2
	Construction Started / Built	2
TX	In Design	32
	Construction Started / Built	8
UT	In Design	3
VA	In Design	8
VT	In Design	2
	Construction Started / Built	1
WA	In Design	25
	Construction Started / Built	14
WI	In Design	8
	Construction Started / Built	1
WV	In Design	1
	Construction Started / Built	1
WY	In Design	1

EXPANDING THE U.S. CONSTRUCTION MARKET FOR WOOD

WoodWorks is a non-profit organization working to increase the use of wood in buildings other than single-family homes—including multi-family/midrise and all non-residential building types. The opportunity for market share growth is significant.

help@woodworks.org
www.woodworks.org/project-assistance/

A UNIQUE AND NECESSARY ROLE

WoodWorks connects the broader wood industry with individuals who design wood buildings and specify wood products.

- Works directly with building designers and owners
- Removes real-world barriers to wood use
- Creates wood design experts

Photo: Nordic Structures

PRECEDENT PROJECTS | UMASS AMHERST DESIGN BUILDING

Photo: ©Albert Vecerka/Esto

Photos: Baumberger Studio/PATH Architecture

PRECEDENT PROJECTS | CARBON 12 | PORTLAND, OR

Photo: Hines

Photo: Corey Gaffer courtesy Perkins + W

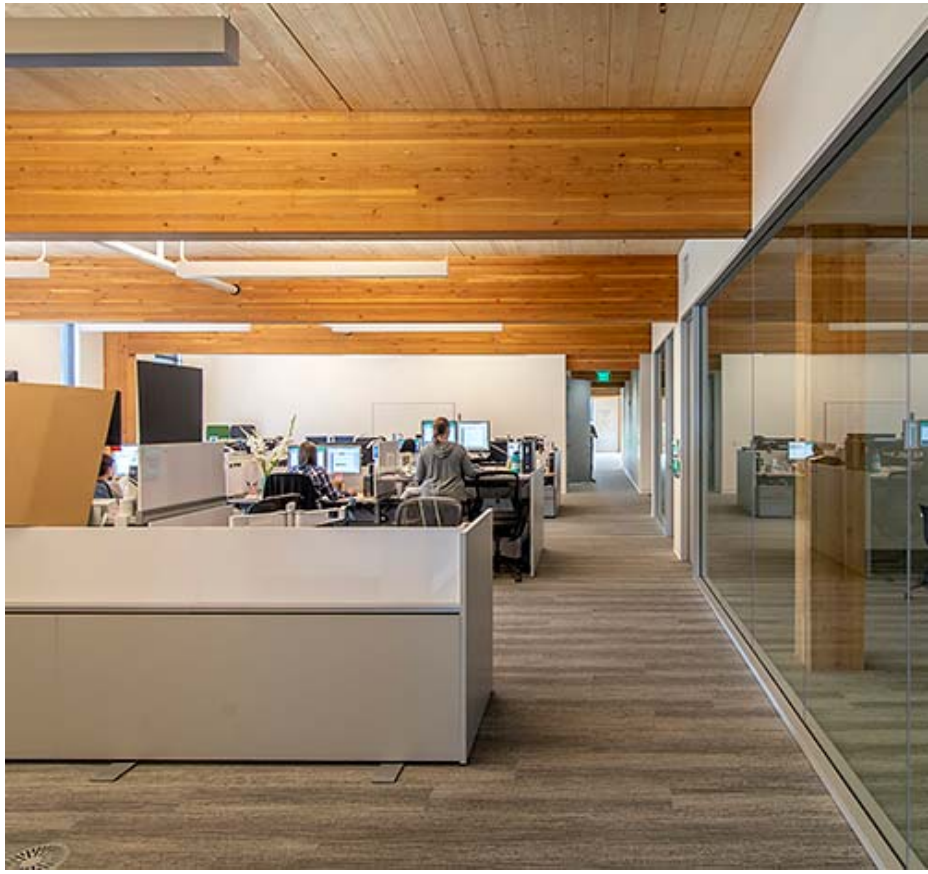
PRECEDENT PROJECTS | T3 MINNEAPOLIS

Photos: StructureCraft

Photo: Hartshorne Plunkard Architectur

Photos: Flank

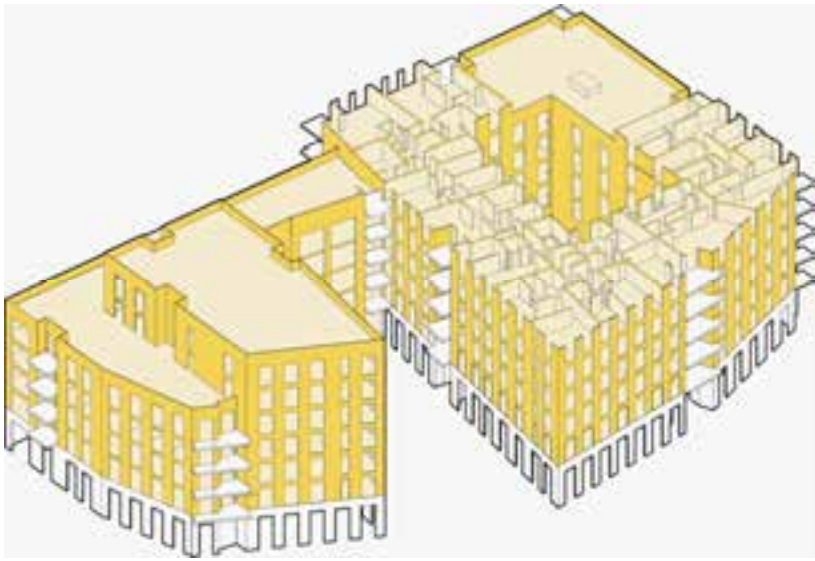
PRECEDENT PROJECTS | 360 WYTHE BROOKYLN, NY



Photos: Swinerton | DJC Orego

PRECEDENT PROJECTS | FIRST TECH CREDIT UNION HILLSBORO, OR

Photos: Michael Elkan | Naturally Wood | UB

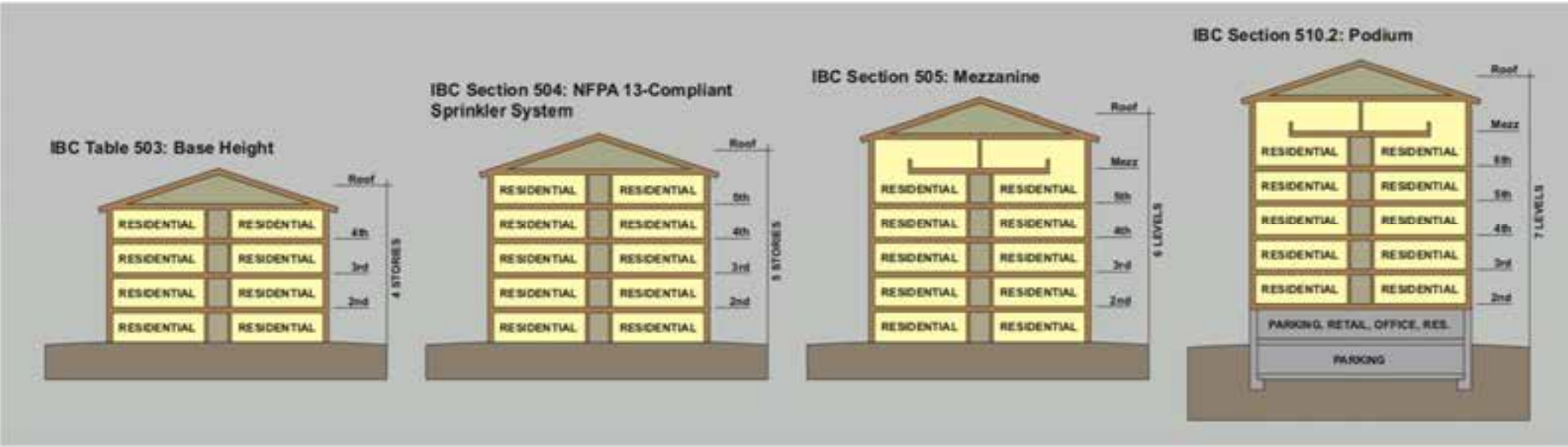


Photos: Daniel Shearin | Waugh Thistleton Architec

Photos: Bygg Mesteren | Voll Arkitekte

MASS TIMBER IN THE CODE

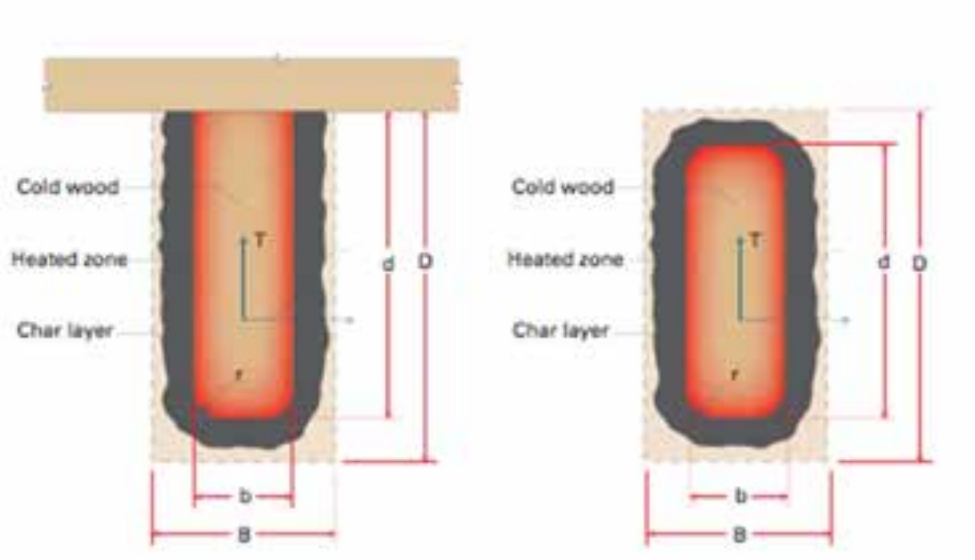
Mass Timber in Low- to Mid-Rise: 1-6 Stories in Construction Types III, IV or V



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

Credit: Susan Jones, atelierjones

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


Credit: David Barber, ARUP

Source: AWC and ATF lab

Source: UC San Diego

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Fire-Resistive Design of Mass Timber Members

Code Applications, Construction Types and Fire Ratings

For many years, exposed heavy timber framing elements have been permitted in U.S. buildings due to their inherent fire-resistance properties. The predictability of wood's char rate has been well-established for decades and has long been recognized in building codes and standards.

Today, 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. Like heavy timber, mass timber products have inherent fire resistance that allows them to be left exposed and still achieve a fire-resistance rating. Because of their strength and dimensional stability, these products also offer a low-carbon alternative to steel, concrete, and masonry for many applications. 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, often for projects that go beyond traditional norms of wood design.

This paper has been written to support architects and engineers exploring the use of mass timber for commercial and multi-family construction. It focuses on how to meet fire-resistance requirements in the International Building Code (IBC), including calculation and testing-based methods. Unless otherwise noted, references refer to the 2018 IBC.

Mass Timber & Construction Type

Before demonstrating fire-resistance ratings of exposed mass timber elements, it's important to understand under what circumstances the code currently allows the use of mass timber in commercial and multi-family construction.

A building's assigned construction type is the main indicator of where and when all wood systems can be used. IBC Section 602 defines five main options (Type I through V) with all but Type IV having subcategories A and B. Types III and V permit the use of wood framing throughout much of the structure and both are used extensively for modern mass timber buildings.

Type III (IBC 602.3) – Timber elements can be used in floors, roofs and interior walls. Fire-retardant-treated wood (FRTW) framing is permitted in exterior walls with a fire-resistance rating of 2 hours or less.

Type V (IBC 602.5) – Timber elements can be used throughout the structure, including floors, roofs and both interior and exterior walls.

Type IV (IBC 602.4) – Commonly referred to as "Heavy Timber" construction, this option

Mass Timber Fire Design Resource

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

MASS TIMBER CONSTRUCTION MANAGEMENT

MASS TIMBER CONSTRUCTION MANAGEMENT

RISK ANALYSIS

Threats to mass timber projects
Strategic project delivery

ECONOMICS

Holistic project estimating
Anatomy of a mass timber package

LOGISTICS

Design Engagement
Schedule
Site Planning

RISK ANALYSIS

ECONOMICS

LOGISTICS

THREE KEY POINTS:

1. Mass timber is a custom building system, not a commodity.
2. Select the right partners for your project.
3. Assess projects holistically when estimating costs.

Risk: Cost Analysis of Structure Only

$/SF

$/SF

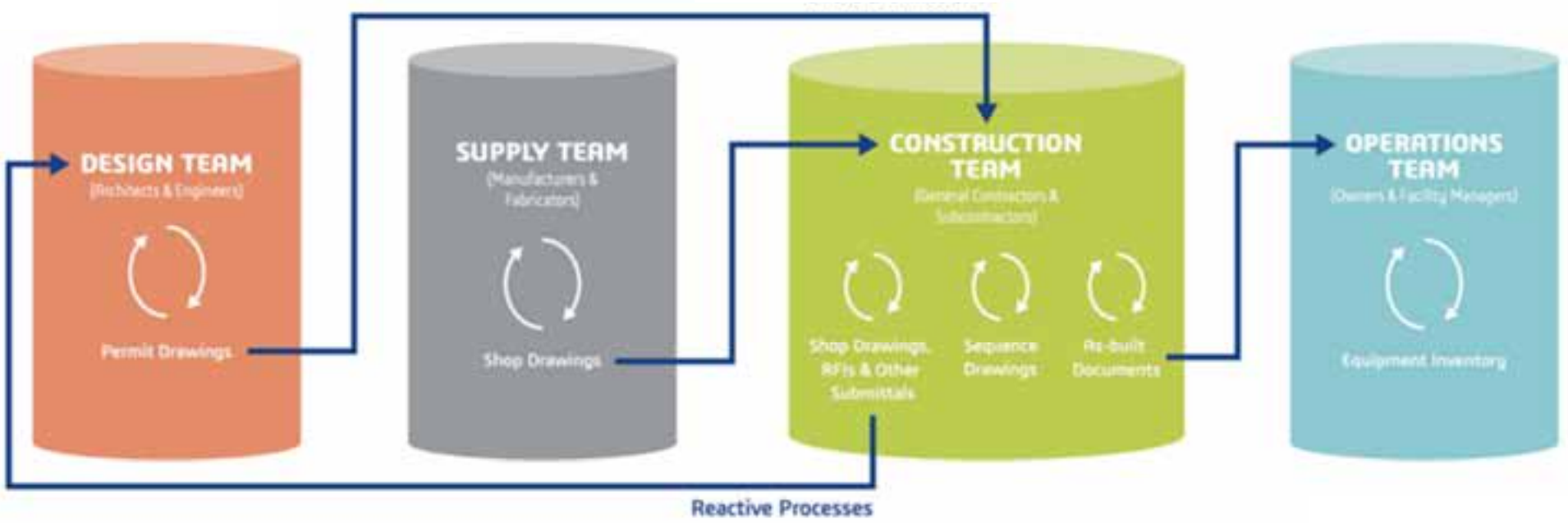
Image: GBD Architects

Risk Mitigation: Total Project Cost Analysis

CONSIDERATIONS:

- Ceiling Treatment
- Floor Topping
- HVAC System & Route
- Foundation Size
- Soil Improvements
- Exterior Skin Coordination
- Value of Time

Risk: Design-Bid-Build Procurement



Procurement Strategy is Key to Success

5% Savings

Neutrality

10% Premium

Risk: Perception of a Commoditized Material

Risk Mitigation: Embrace the Prefab Advantage

Photo: Swinerton

Risk: Lack of Supply Chain Understanding

Risk Mitigation: Complementary Procurement

GC Hires Turnkey Mass Timber Subcontractor	GC Buys Material GC Self-Performs Install GC Coordinates	GC Buys Material GC Subcontracts Labor GC Coordinates

RISK SPECTRUM

+ Hiring Experience Single Point of Responsibility	+ Hiring Experience Single Point of Responsibility Financial Security of strong GC	+ Potential Added Mark-Up
– Prequal Capacity of Sub Potential Added Mark-Up	– Lack of familiarity with supply chain Steep learning curve for coordination	– Multiple layers of coordination Prequal Capacity of Sub

Schedule Savings for Rough-In Trades

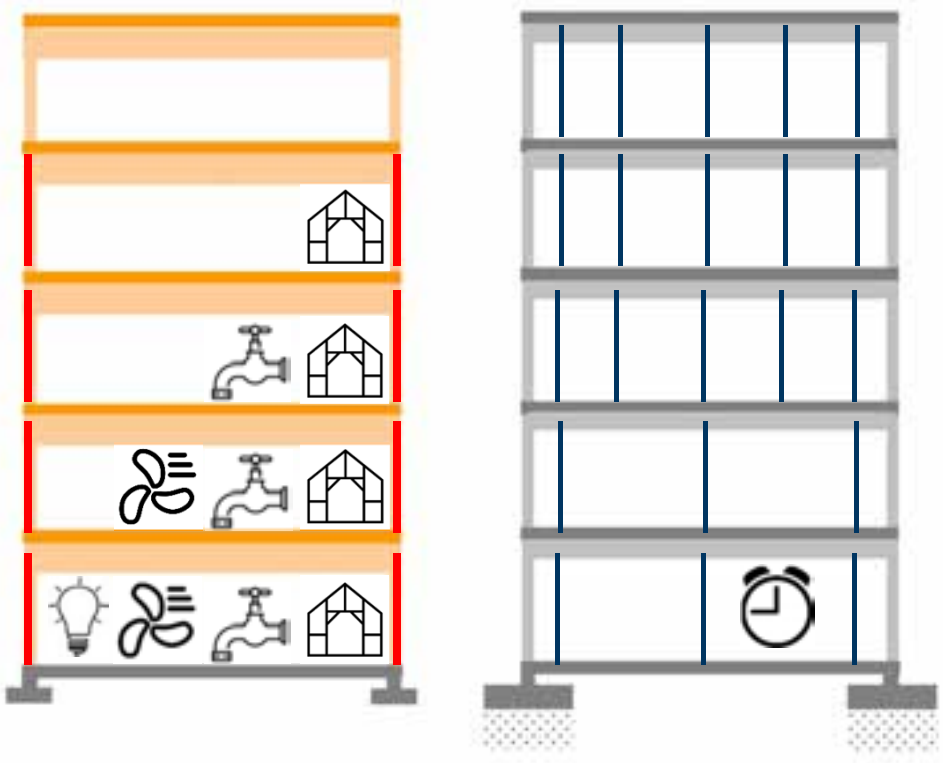
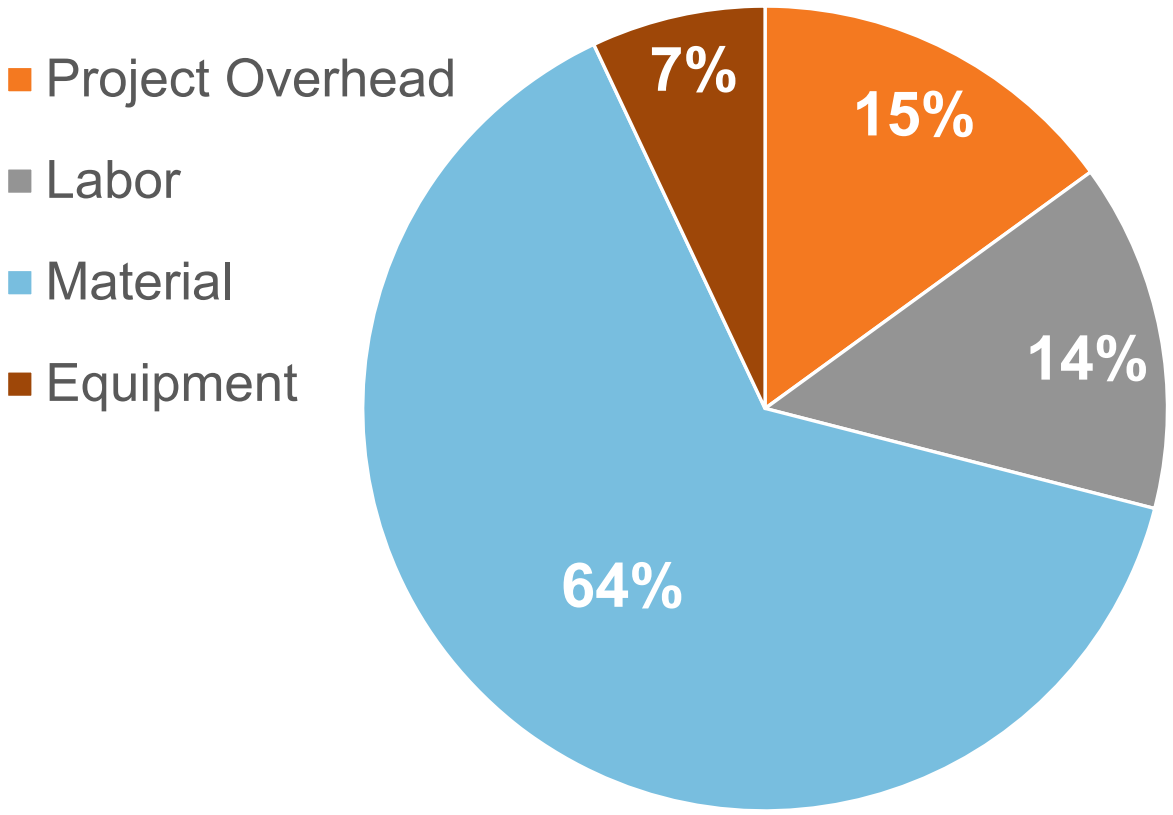


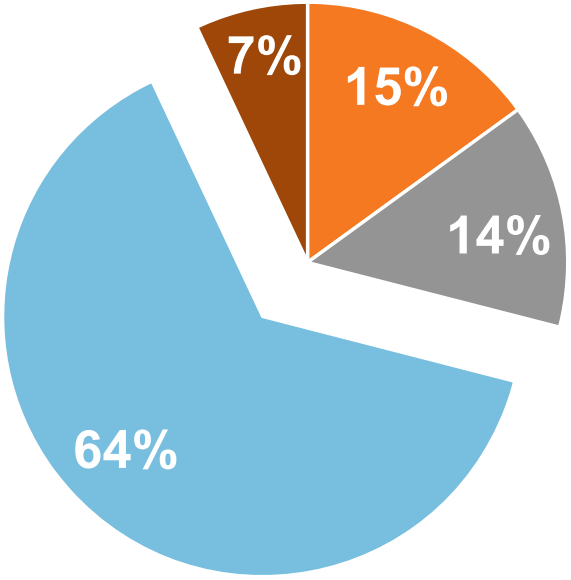
Photo: WoodWorks

Anatomy of a Turnkey Mass Timber Package



Source: Swinerton

Material (Direct Cost)

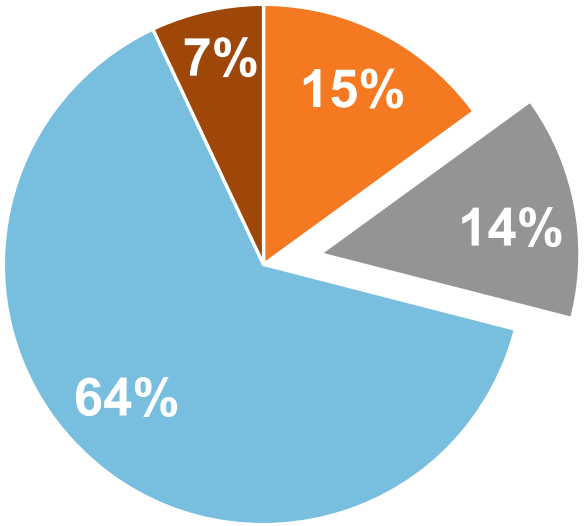


Turnkey Mass Timber Package

or

Source: Swinerton

Labor (Direct Cost)

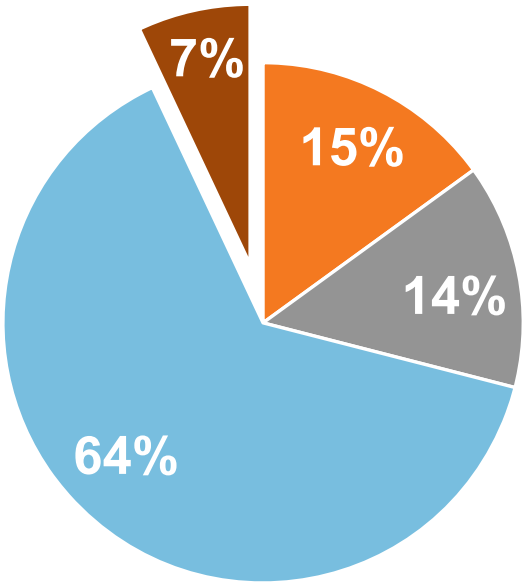


Turnkey Mass Timber Package

Photo: Swinerton

Source: Swinerton

Equipment (Direct Cost)



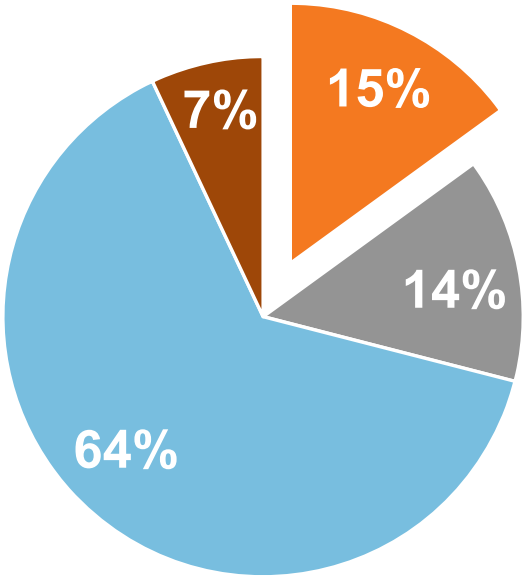
Turnkey Mass Timber Package

Source: Swinerton

Photo: Swinerton

Photo: Alex Schreyer

Project Overhead

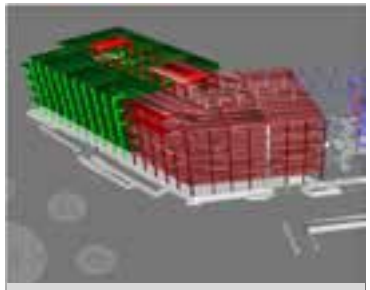


Turnkey Mass Timber Package

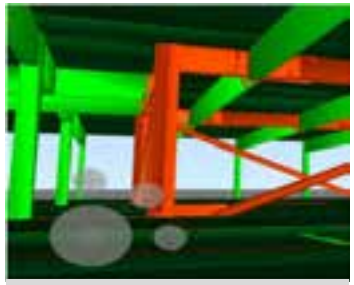
Cost Analysis

Design Refinement

System Integration



VD&C



Detail Optimization

Logistics Planning

Photos: Swinerton

Source: Swinerton

Value Analysis

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


Photo: RMW Architecture & Interiors

Value Analysis

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

Value: Program

Level 1

Level 2

Concept Plan

Hillsboro Community Center at 53rd Ave.

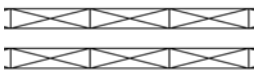
opsis

Cost: Construction Type

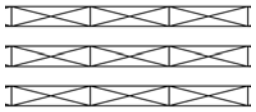
TABLE 601
Fire Resistance Rating Requirements for Building Elements (Hours)

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		

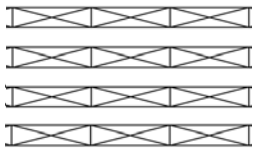
Baseline
0hr & HT



+$10/SF
1hr & maybe 2hr



+$12-15/SF
2hr FRR

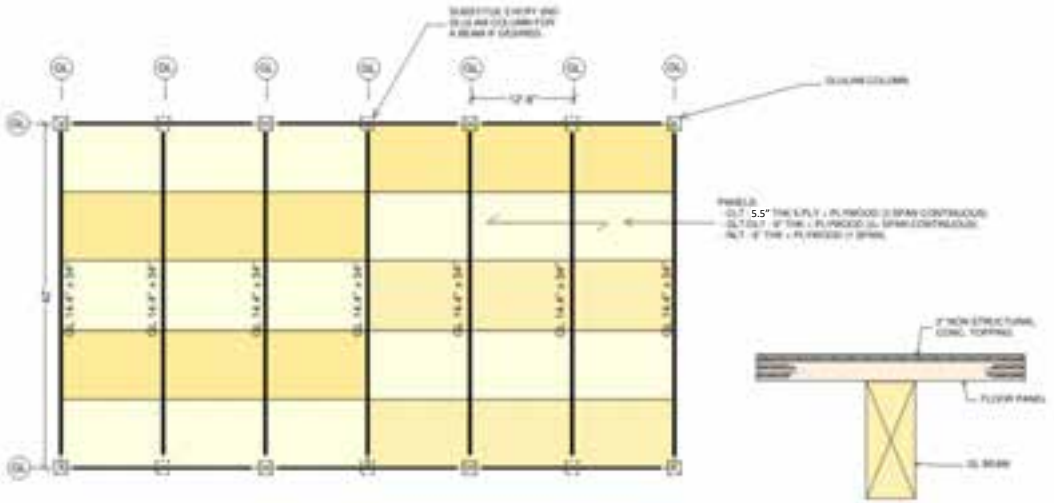


Cost Source: Swinerton

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

Value: Open Floor Plan

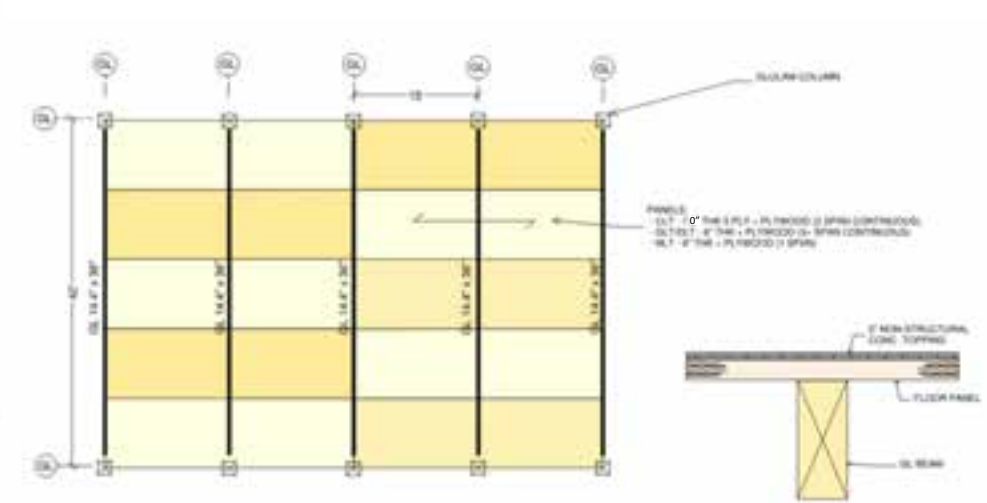
Cost: Structural System & Grid



Baseline

12’-6” Glulam Spacing

5.5” CLT



$ +5%

15’ Glulam Spacing

7” CLT

Source: Seattle Mass Timber Tower Book

Value: Perimeter Glazing

Photos: Mark Bitterman

Tolerances: Interface with Other Structural Materials

SCHEDULE

Photo: Swinerton

Procurement Approach Determines Schedule

Procurement Approach Determines Schedule

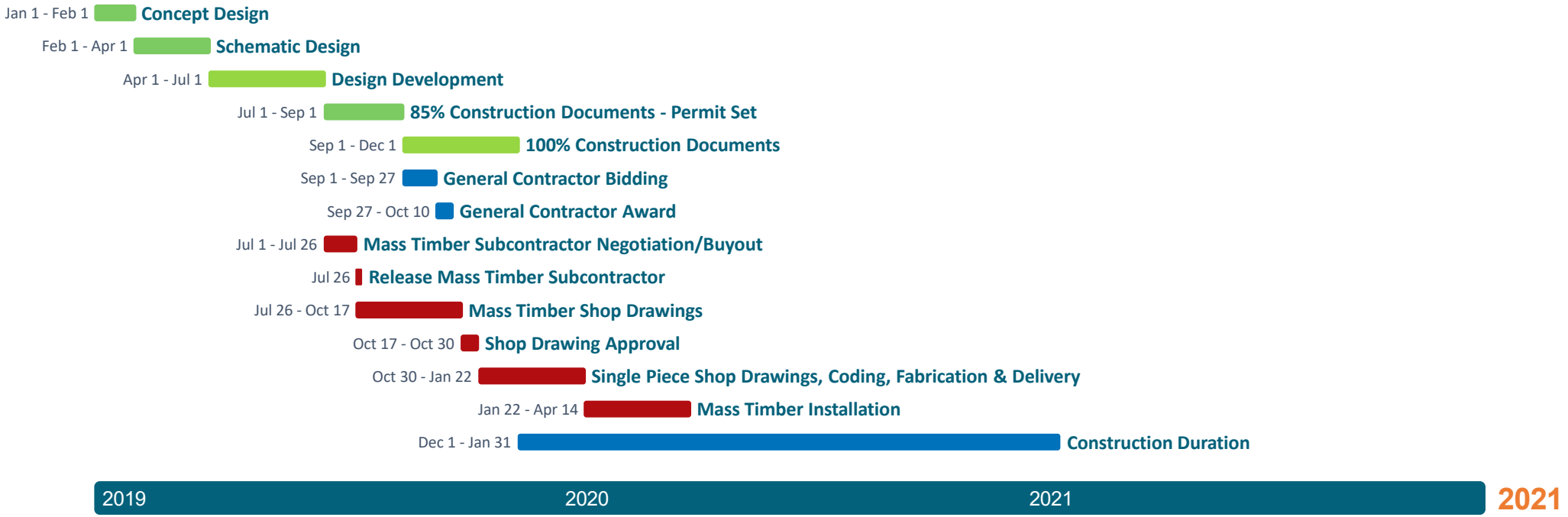
Example 6 Story Type IIIA Project

Source: Swinerton

Design-Bid-Build Procurement

Procurement Approach Determines Schedule

Example 6 Story Type IIIA Project



Source: Swinerton

Design-Build/Design-Assist Procurement

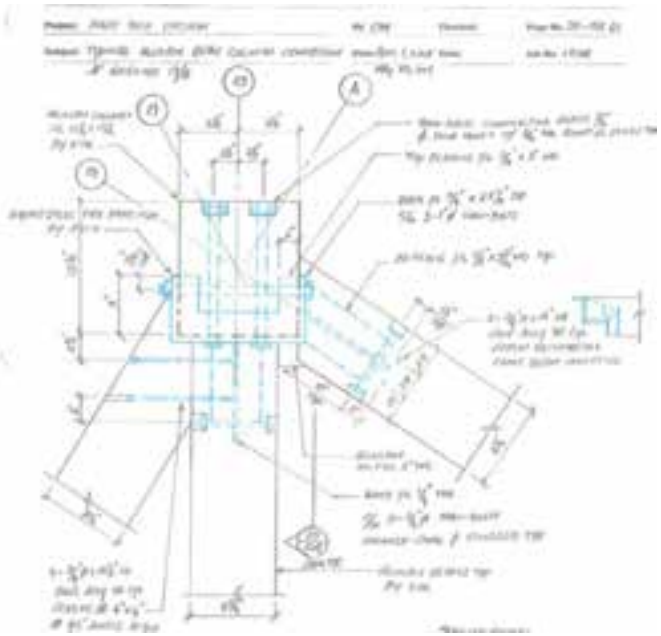
Procurement Logic for Scheduling

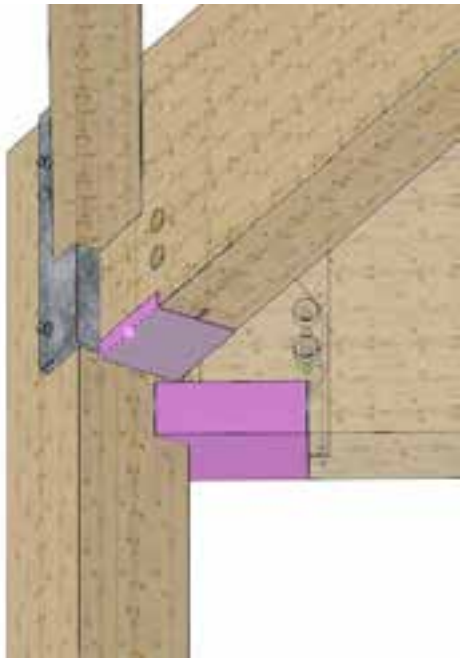
Source: Swinerton

Example 6 Story Type IIIA Project

What are the schedule drivers on a mass timber project?

Schedule Impacts: Translating 2D to 3D





Photos: Swinerton

Schedule Impacts: Hybrid Structures

Photos: Swinerton

Is there a schedule savings with a mass timber structure compared to other structural systems?

Photo: StructureCraft Builders

Overall Project Cost Analysis: 12 Story Type IV-B

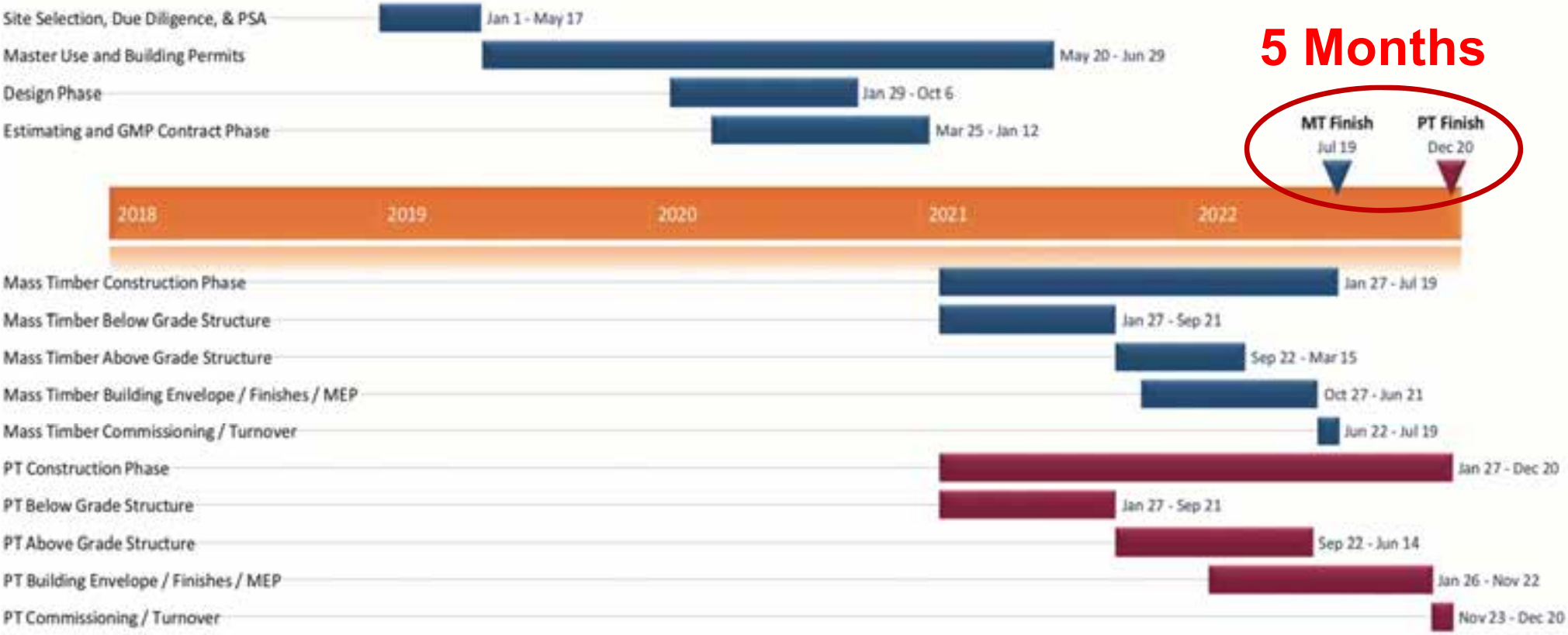
	MASS TIMBER	PT CONCRETE	MASS TIMBER SAVINGS VS. PT CONCRETE (%) *
DIRECT COST OF WORK	86,997,136	85,105,091	2.2%
PROJECT OVERHEAD	9,393,750	11,768,750	-20.2%
ADD-ONS	8,387,345	8,429,368	-0.5%
Total	*104,778,231*	*105,303,209*	*-0.5%*

Source: Swinerton

** Includes 2 layers of gyp on 80% of interior surfaces*


Credit: DLR Group | Fast + Epp

Overall Project Schedule Analysis: 12 Story Type IV-B



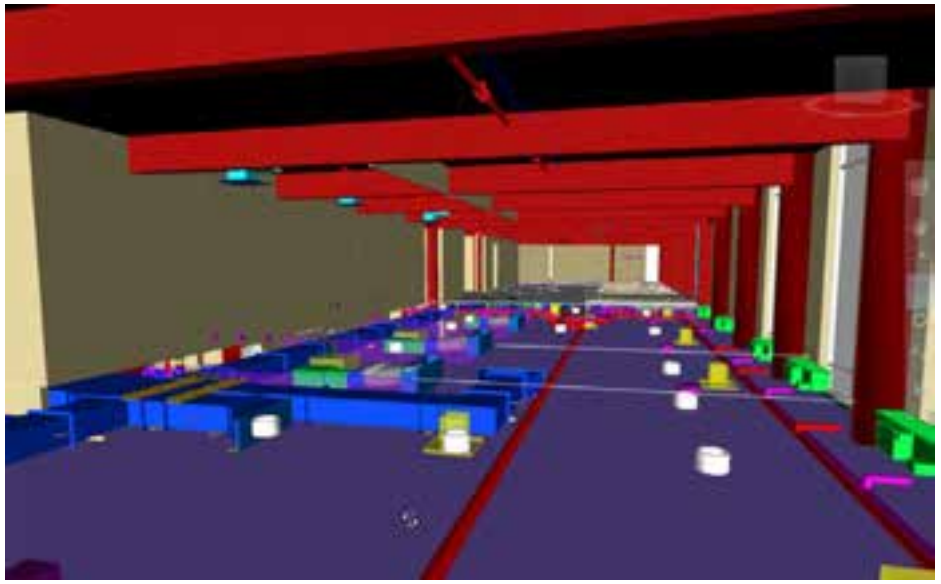
Source: Swinerton

Schedule Impact on Cost | Value of Time

Early Move-In for Rough-In Trades.

Photos: Swinerton

Embracing BIM for Fabrication



Photos: Swinerton

Holistic Schedule Analysis

Shorter Schedule = Lower General Conditions Costs

Photo: Swinerton

SITE PLANNING

Photo: Swinerton

QA/QC

Photo: Swinerton

PICK PLAN

Photo: Swinerton

SITE ORGANIZATION & STAGING

Photo: Swinerton

LOGISTICS PLANNING

Photo: Swinerton

MATERIAL DELIVERY

Photo: Swinerton

Sequencing

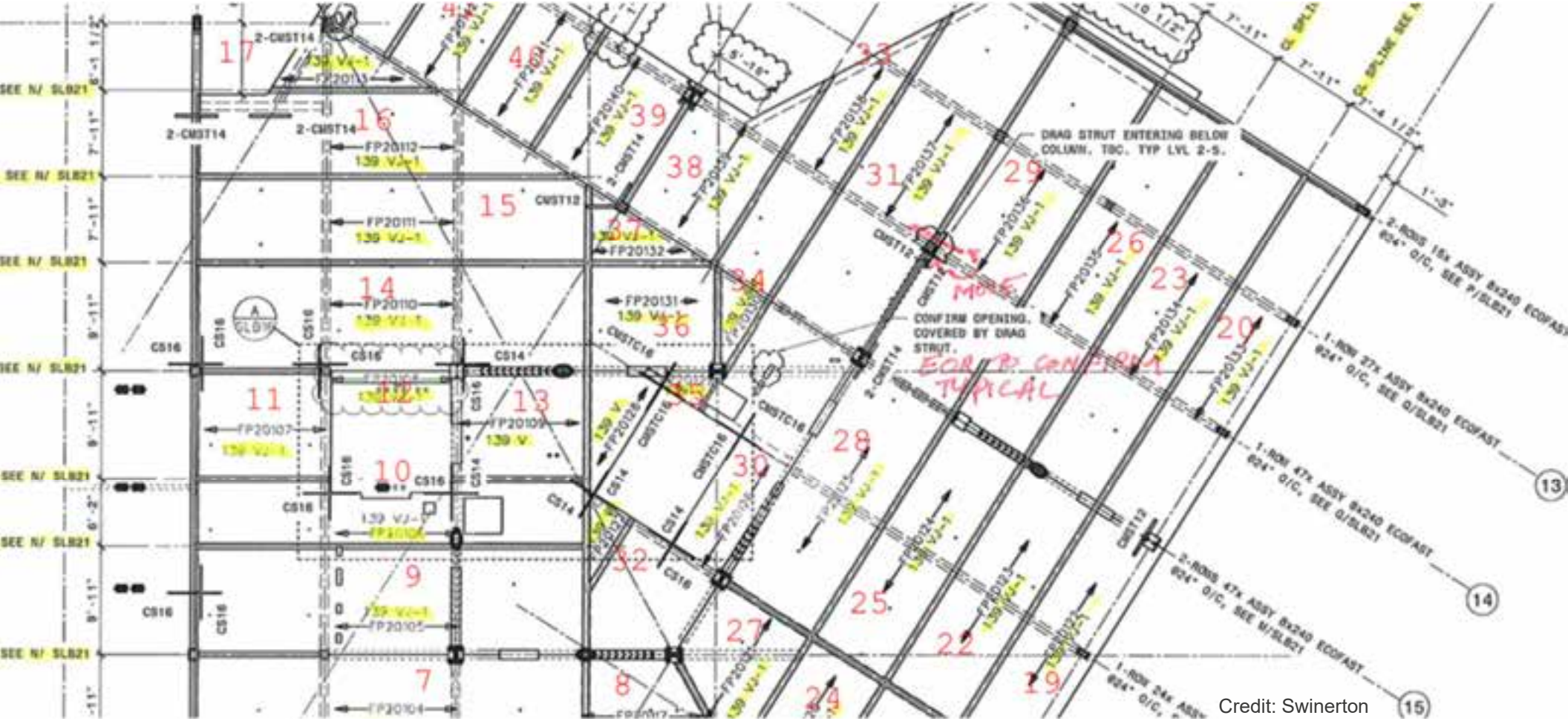

DRAG STRUT ENTERING BELOW COLUMN, TBC. TYP LVL 2-5.
CONFIRM OPENING COVERED BY DRAG STRUT.
TYPICAL
Credit: Swinerton

Photo: Swinerton

Material Protection

Painting steel

Taping joints

Protect end cuts of timber

Photo: Alex Schreyer


UBC

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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