Mass Timber Boot Camp: Fundamentals of Design and Construction

March 25, 2025

Presented by WoodWorks

Founders Hall, Foster School of Business, University of Washington / LMN Architects / Magnusson Klemencic Associates / Photo Tim Griffith

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

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Course Description

This seminar offers a thorough introduction to mass timber construction, tailored for architects, engineers, and construction professionals who are new to mass timber or still developing their expertise. The course will define mass timber, the types of products available, design strategies, and best practices for successful implementation. Technical topics will include structural performance, fire safety, occupant comfort, and key considerations during construction. Additionally, participants will receive a primer on how to implement mass timber from a code perspective and what construction types under the International Building Code (IBC) can be utilized.

Learning Objectives

1. Learn what mass timber products are available and understand their benefits, including structural versatility, prefabrication, lighter carbon footprint, aesthetic differentiation, and reduced labor costs.
2. Learn to navigate the International Building Code (IBC) provisions that permit mass timber construction and understand the specific requirements for building height, floor area, fire-resistance ratings, and the protection of exposed wood surfaces.
3. Highlight best practices for managing vibration and acoustics in mass timber structures, including floor system design, connections, and the integration of sound insulation materials to meet occupant comfort standards.
4. Discuss methods for protecting mass timber during construction and throughout the building's lifespan, including moisture control measures, detailing, weather protection, and sealing techniques to prevent water intrusion and ensure long-term durability.

Agenda

Mass Timber Boot Camp: Fundamentals of Design and Construction	
Patrick Duffy	Mass Timber Component Overview
	Leveraging WIN
Momo Sun	Key Early Design Decisions
	Construction Types
	Fire Design
	MEP Considerations
	Occupant Comfort
5 Minute Stretch Break	
Mike Romanowski	Mass Timber in Construction
	Moisture Management & Protection
Q&A Discussion	

Mass Timber Construction: Products, Performance & Design

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Patrick Duffy, P.E.

Photo: Structurlam

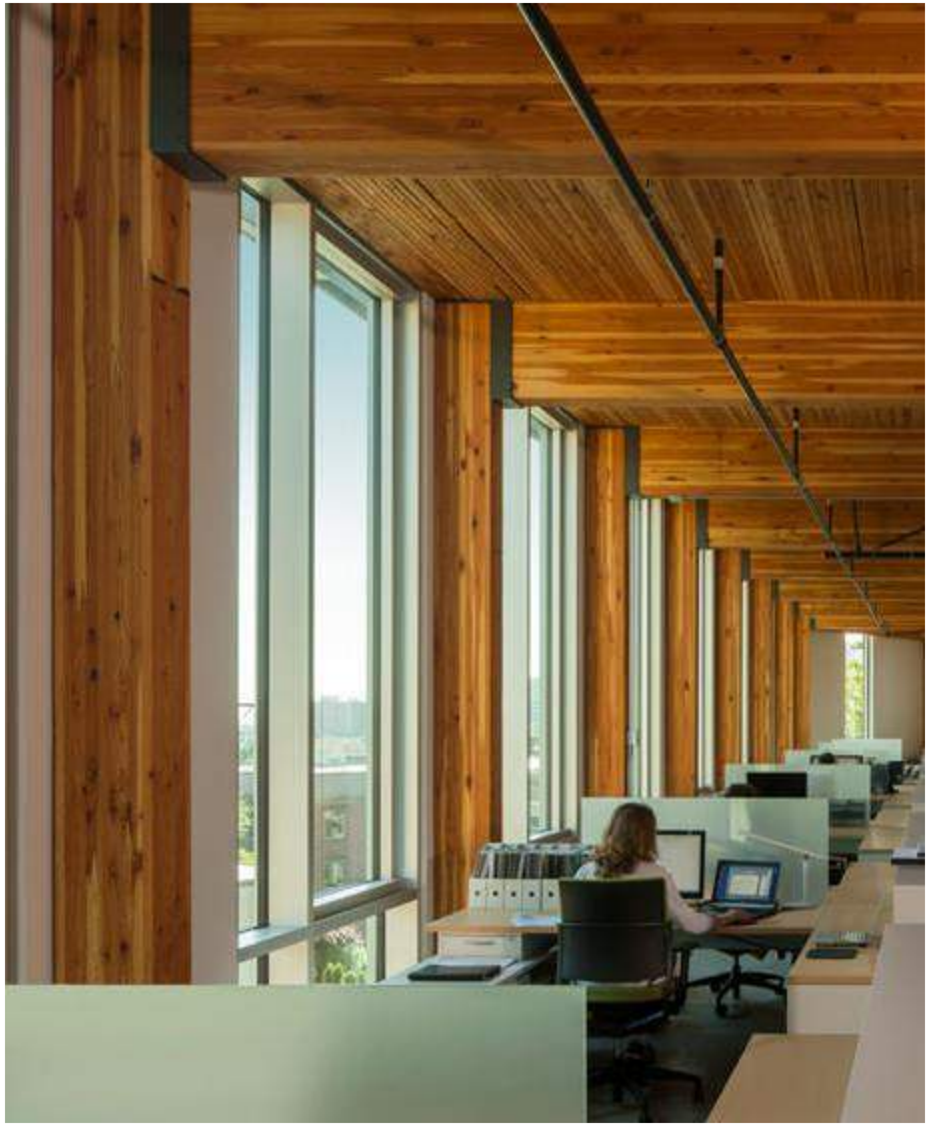
Mass Timber – What is it?

- Large panelized solid wood formed from small wood members
    - CLT, NLT, Glulam, Etc.

- Floor, roof and wall framing

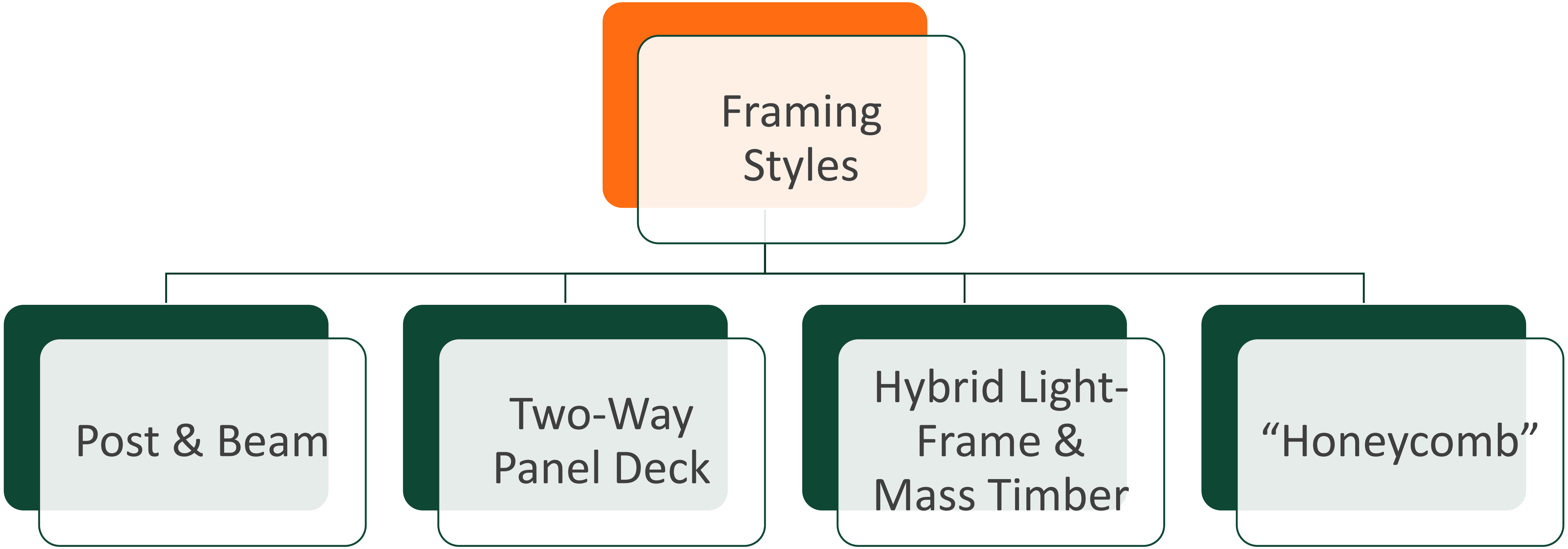
Light-Frame Wood
Photo: WoodWorks

Heavy Timber
Photo: Benjamin Benschneider

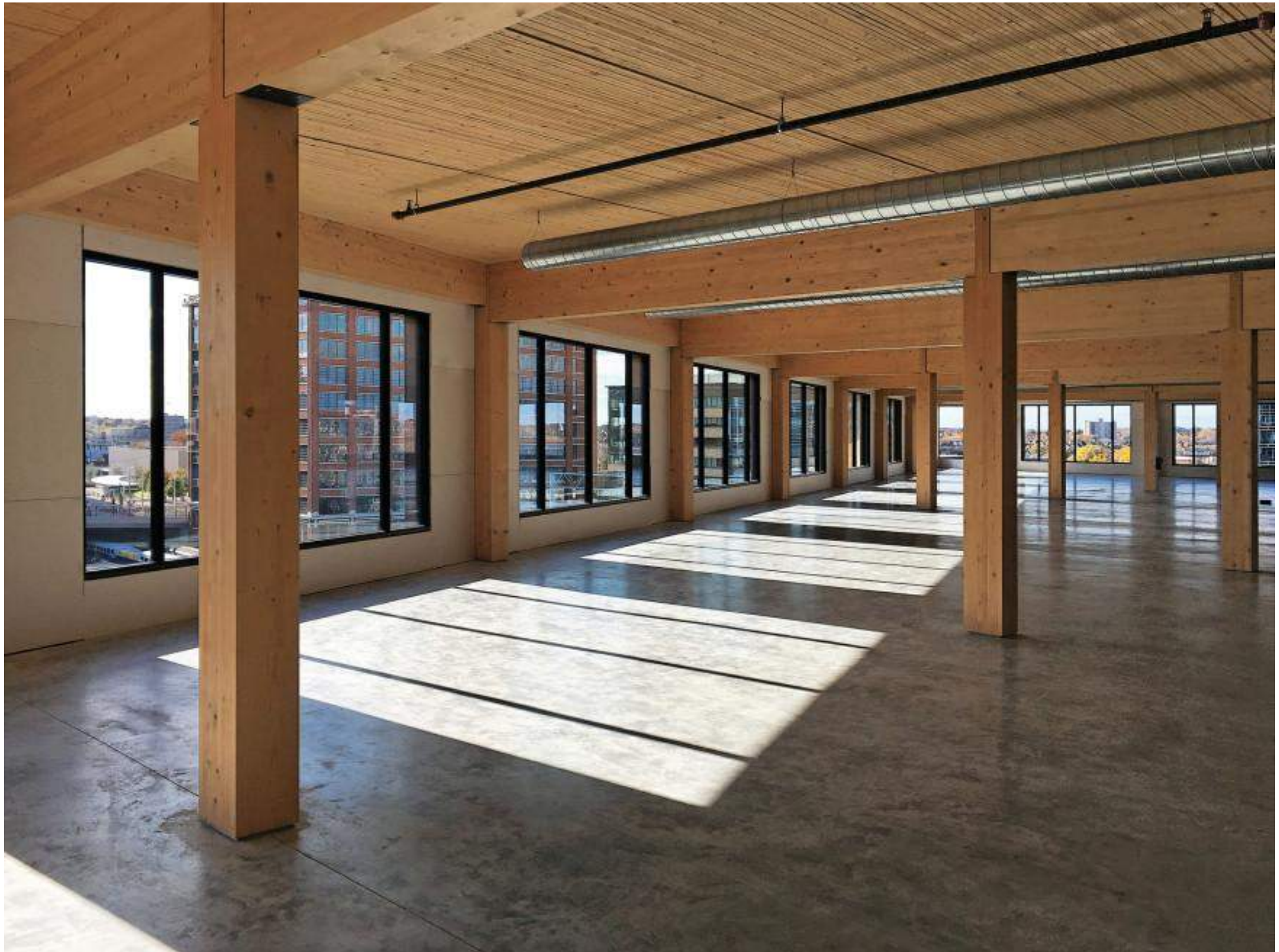


Mass Timber
Photo: John Stamets

Mass Timber Framing Systems



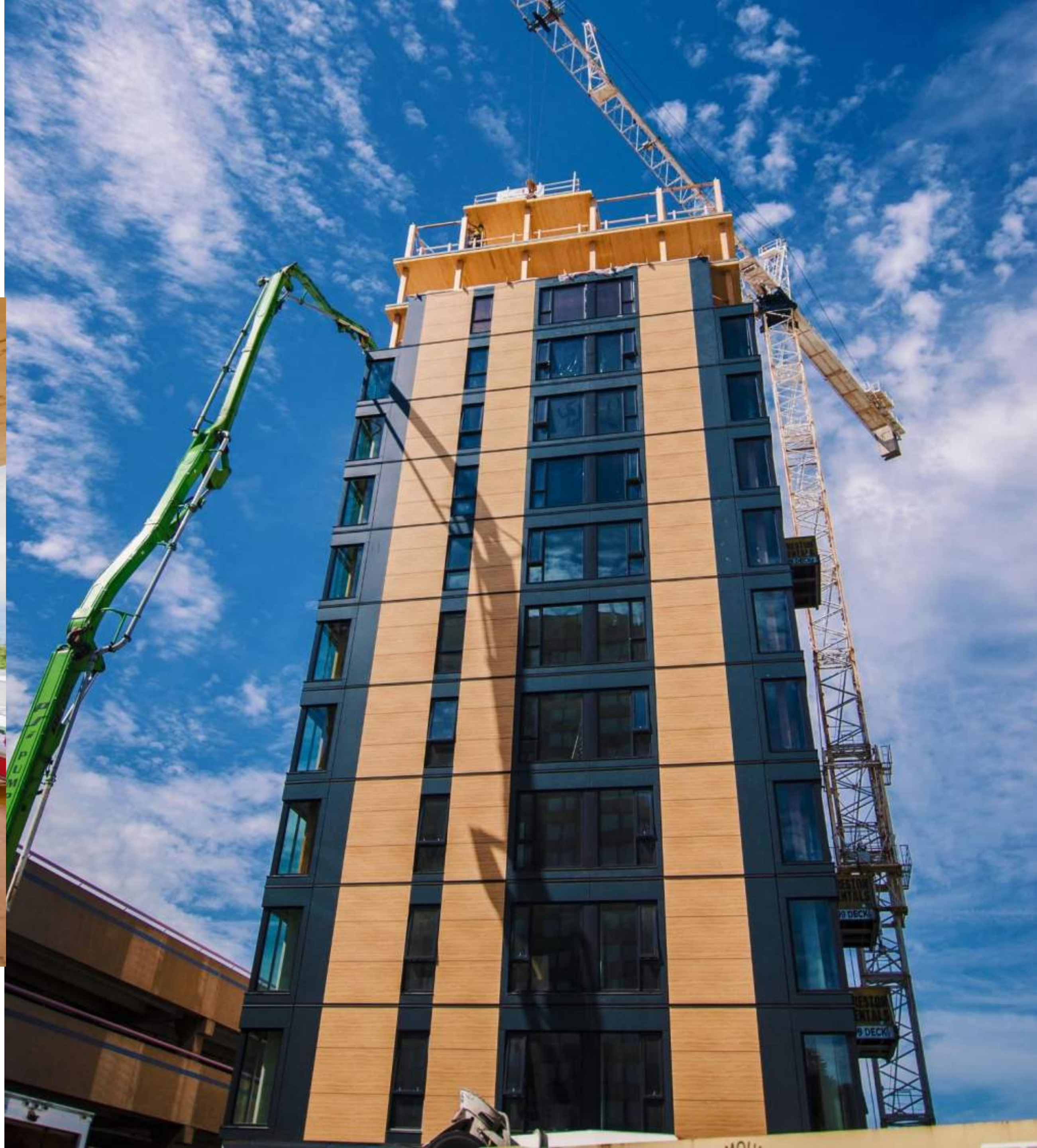
Post and Beam



T3 Minneapolis
Minneapolis, MN
Image Credit: Blaine Brownell

Two-Way Panels

Brock Commons
Vancouver, BC
Images: Acton Ostry Architects



Hybrid Light-Frame & Mass Timber

Carbon 12
Portland, OR
Image: WoodWorks

Virtuoso
Vancouver, BC
Image: Seagate Structures

Honeycomb

Candlewood Suites on
Redstone Arsenal
Huntsville, AL
Image Credit: LendLease

Mass Timber Framing Systems

- Framing Styles
  - Post & Beam
  - Two-Way Panel Deck
  - Hybrid Light-Frame & Mass Timber
  - “Honeycomb”

Vertical framing (columns & beams) commonly glulam

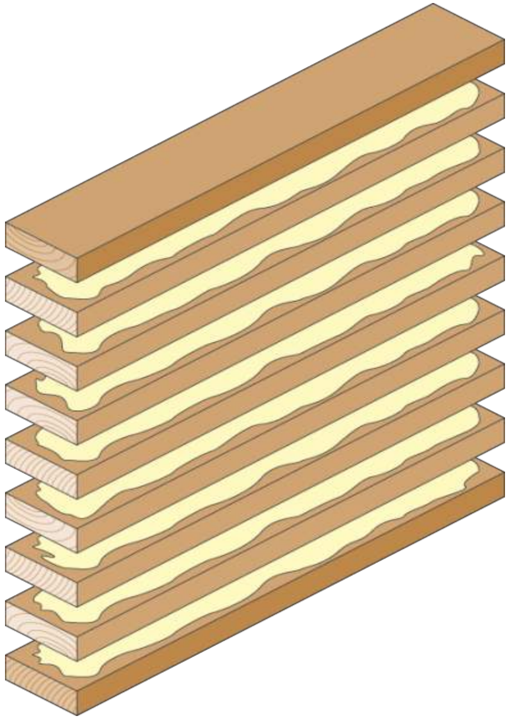
Glulam

Oregon State University – Cascades-
Edward J. Hall, SRG Partnership, catena
consulting engineers, Photo Swinerton

Glulam

Glulam = structural composite of lumber and adhesives

- Recognized in IBC 2303.1.3 using ANSI/AITC A 190.1 and ASTM D 3737
- Floors, roof purlins, beams, arches, columns



Glulam Specs

Typical Widths

- 3-1/8”, 3-1/2”, 5-1/8”, 5-1/2”, 6-3/4”, 8-3/4”, 10-3/4”, 12-1/4”

Typical Depths

- Based on number of lams: 6” to 60”+
- Western species lams: Typically 1-1/2” thick
- Southern pine lams: Typically 1-3/8” thick

Typical Species

- Douglas-Fir, Southern Pine, Spruce
- Also available in Cedar & others

FIGURE 1

BEAM CROSS SECTION

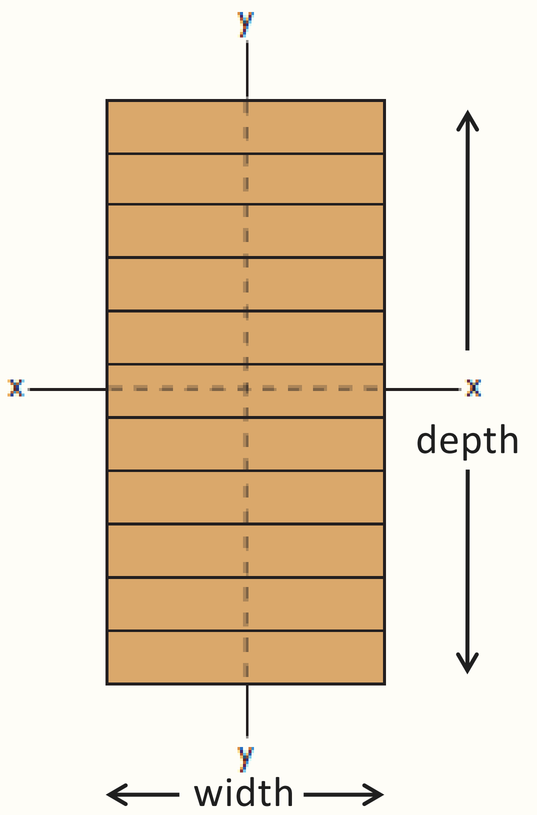
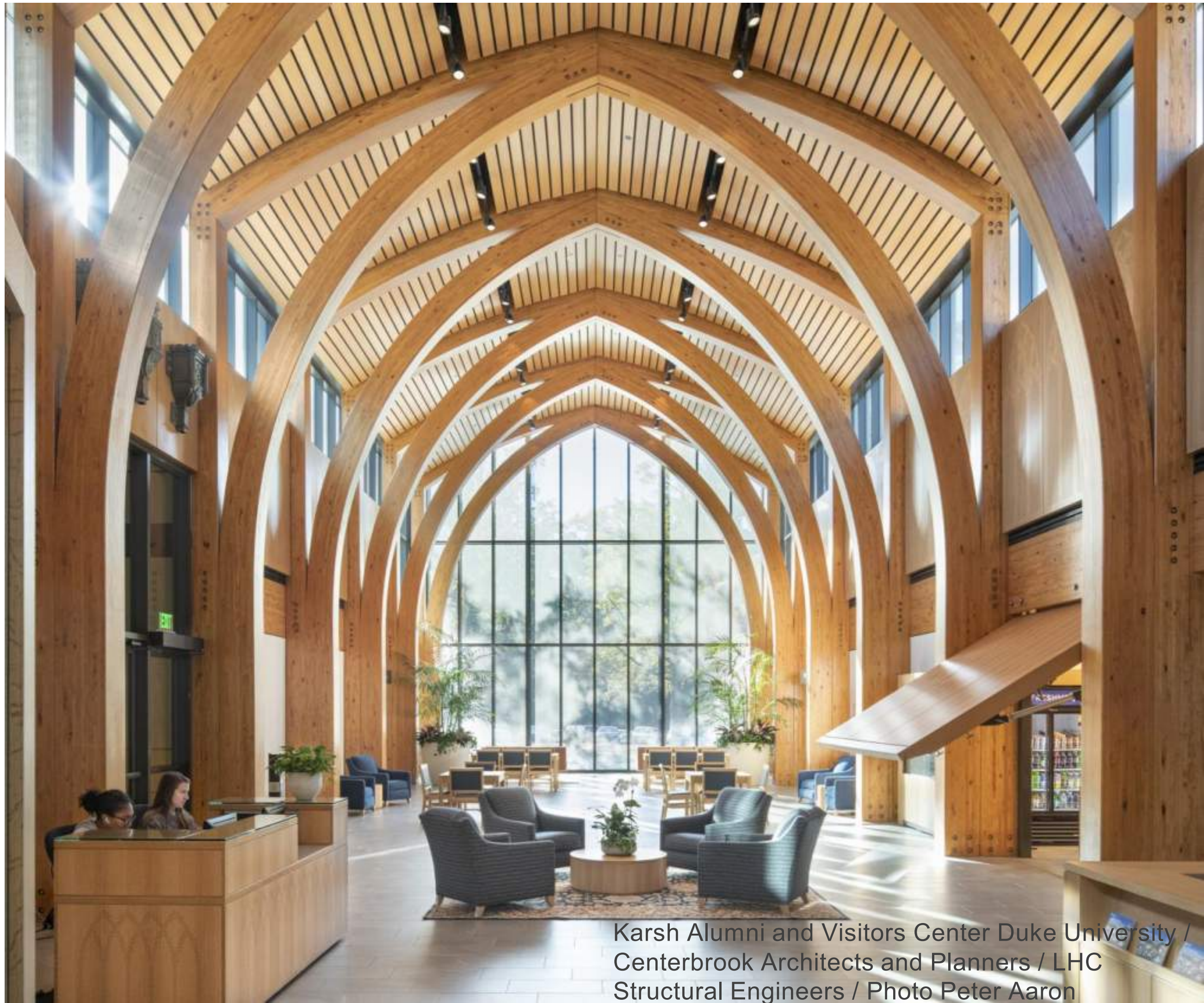


Image: APA Glulam Product Guide

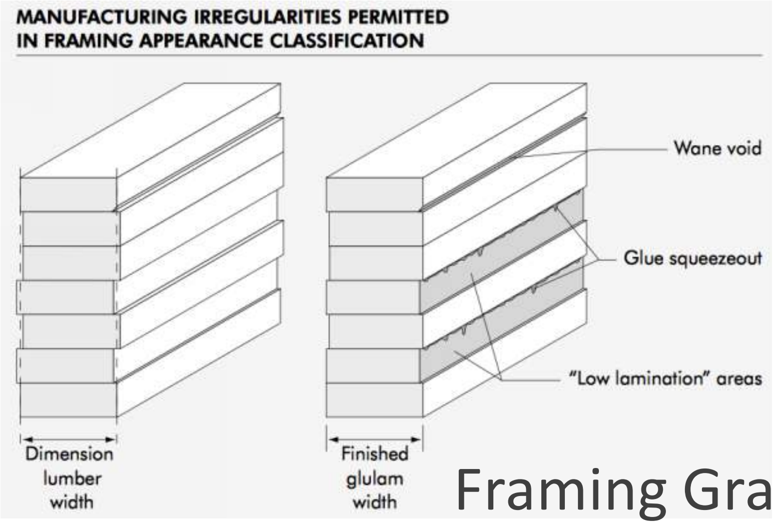
Glulam Specs

- Preservative treated (PT) readily available
- Fire retardant treated (FRT) may be available
- Can be cambered, curved, tapered
- Various Appearance Grades



Karsh Alumni and Visitors Center Duke University / Centerbrook Architects and Planners / LHC Structural Engineers / Photo Peter Aaron

Glulam Appearance Grades



Framing Grade

Industrial Grade

Architectural Grade

Premium Grade

Images: American Laminators

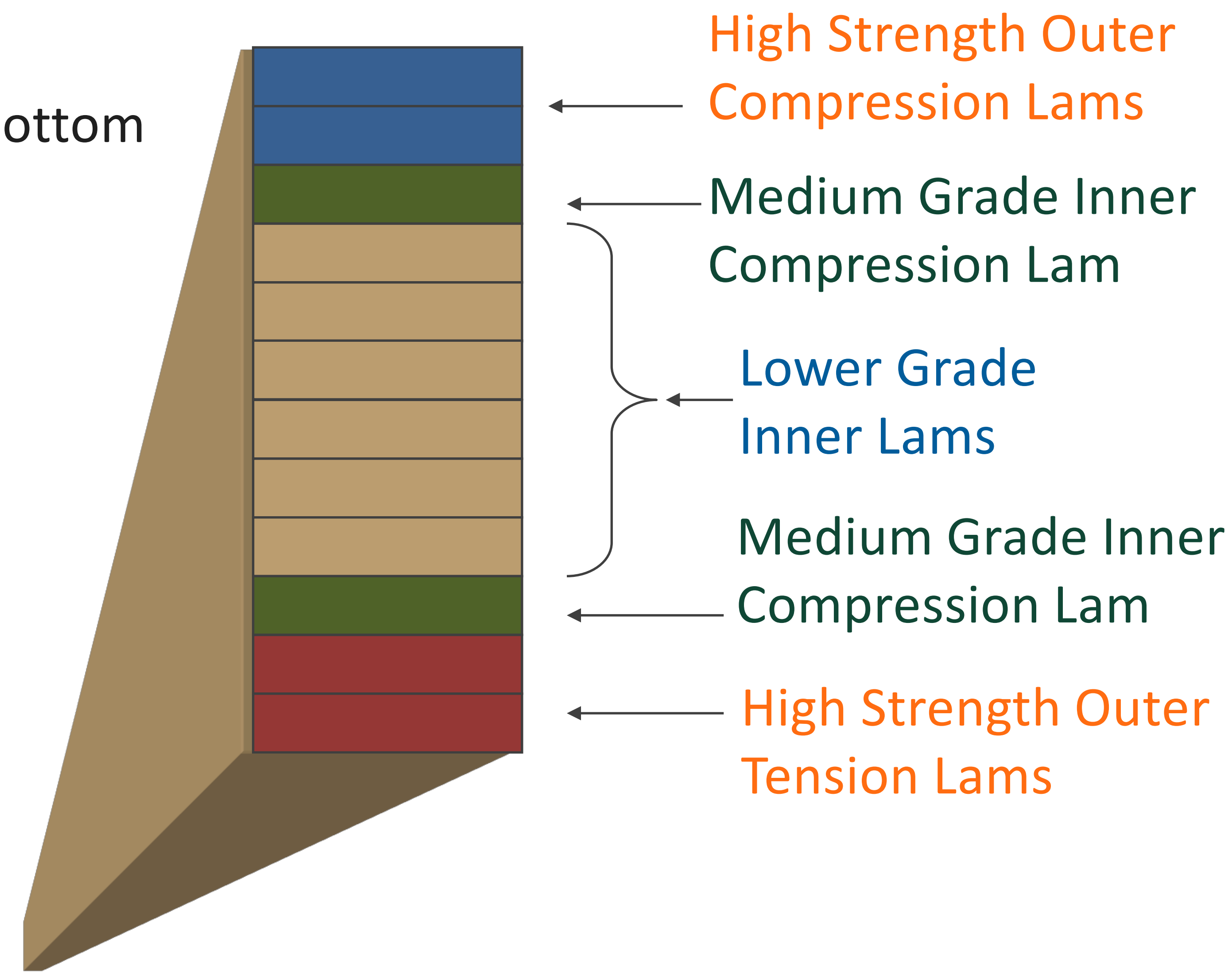
Glulam Layup

Lamination strengths vary:

» Higher strength at top and bottom

» Lower strength in center

Image: APA



Glulam Built-Up Sections

Built-Up Sections:

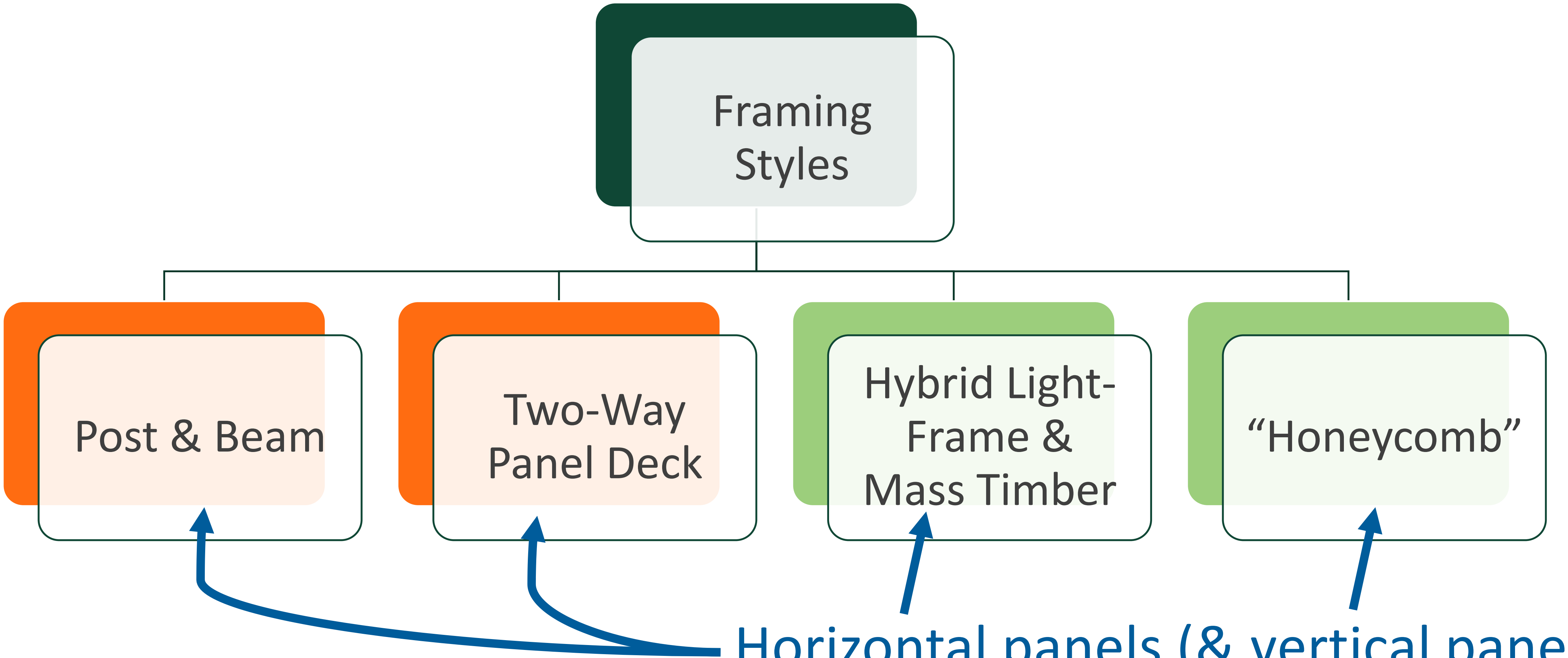
- Available from some manufacturers
- Widths of 24”+ available

Photo: Unalam

Flexibility of Spans and Shapes

Richmond Olympic Oval, Richmond, BC, Canada
Design Team: Cannon Design Architecture, Fast + Epp, Glotman Simpson
Photo Credit: Stephanie Tracey, Craig Carmichael, Jon Pesochin, KK Law Creative, Ziggy Welsch

Mass Timber Framing Systems



Horizontal panels (& vertical panels in “honeycomb”) many panel options

Nail-Laminated Timber (NLT)

Photo: Think Wood

Photo: Ema Peter

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Photo: StructureCraft

Glue-Laminated Timber (GLT) Plank orientation

Photo: StructureCraft

Photo: Manasc Isaac Architects/Fast + Epp

Cross-Laminated Timber (CLT)
Solid sawn laminations

Cross-Laminated Timber (CLT)
SCL laminations

Photo: Freres Lumber

Photo: LendLease

Photo: LEVER Architecture

Nail Laminated Timber

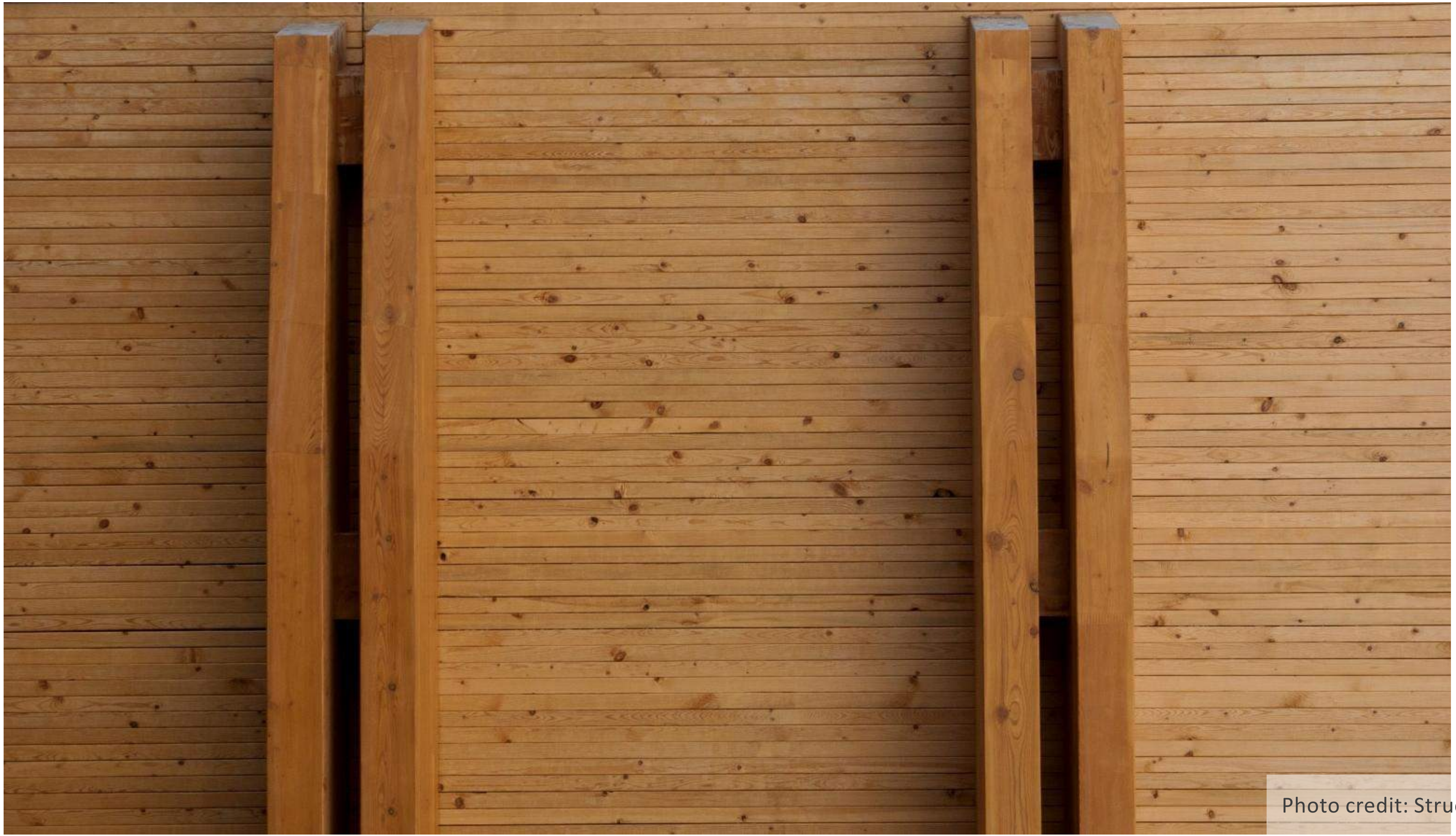


Photo credit: StructureCraft Builders

Nail Laminated Timber (NLT) Panels

What is it?

- Mechanically laminated to create solid timber panel
- Dimension lumber on edge
  - Nominal 2x, 3x, or 4x thickness
  - 4 in. to 12 in. width
- Laminations fastened with nails

Image: Think Wood

Nail Laminated Timber (NLT) Panels

When does the code allow it to be used?

- IBC defines NLT as mechanically laminated decking per IBC 2304.9.3

- Permitted anywhere that combustible materials and heavy timber are allowed, plus more

Nail Laminated Timber (NLT) Panels

When is it used?

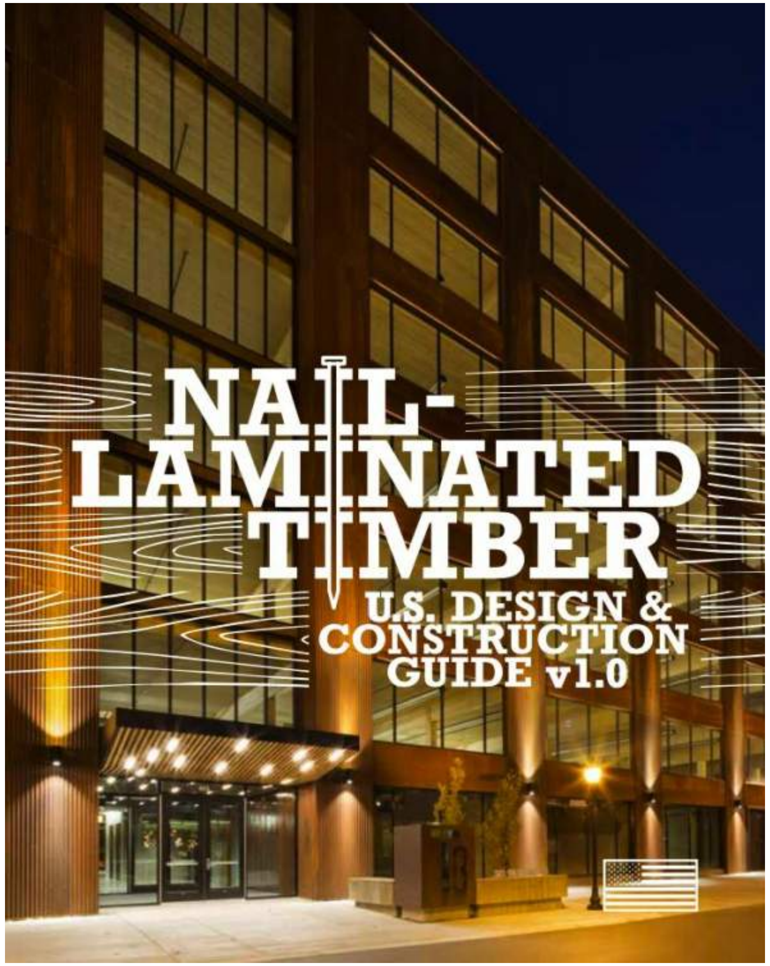
- Floor and roof panels
- Diaphragms (with Plywood/ OSB added to one face)
- Walls, shafts, etc.

Photo credit: StructureCraft Builders

Nail Laminated Timber (NLT) Panels

Content includes:

- » Architecture
- » Fire
- » Structure
- » Enclosure
- » Supply and Fabrication
- » Construction and Installation
- » Erection engineering
- » Free download at www.thinkwood.com/nltguide



Nail Laminated Timber (NLT) Panels

NLT shrinkage/ expansion design:

» Leave one ply out per 8’-10’ wide panel

Dowel Laminated Timber (DLT)

Photo credit: StructureCraft Builders

Dowel Laminated Timber (DLT) Panels

What is it?

» Similar to NLT

  » Dowels instead of Nails connecting lams

» Lams usually finger jointed

» Common in Europe

» Not recognized in IBC

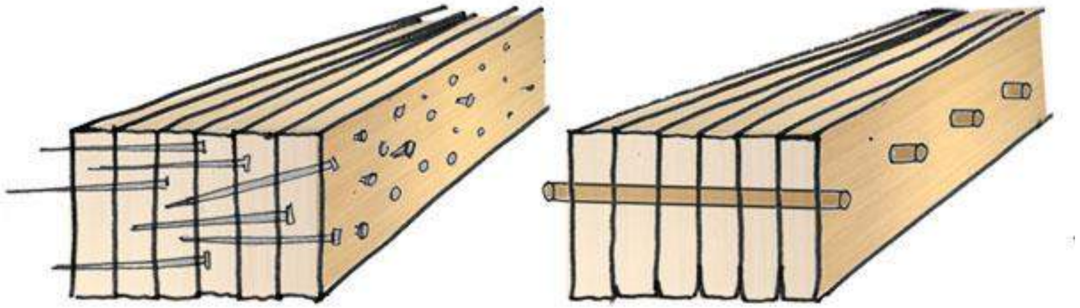


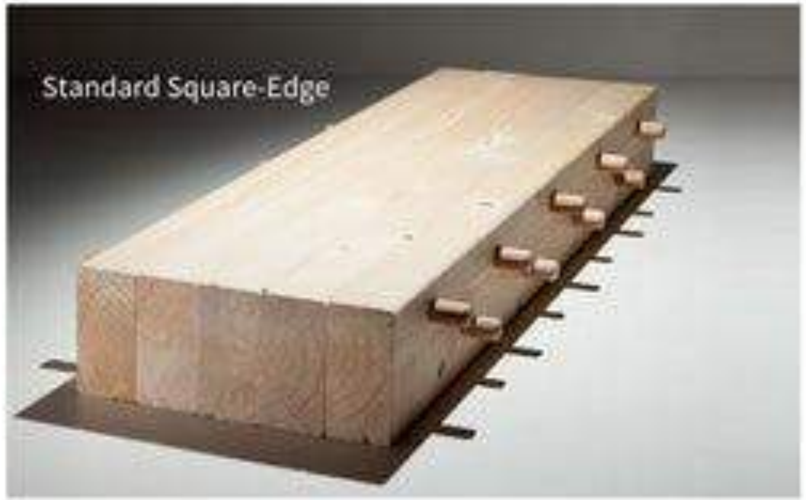
Photo credit: StructureCraft

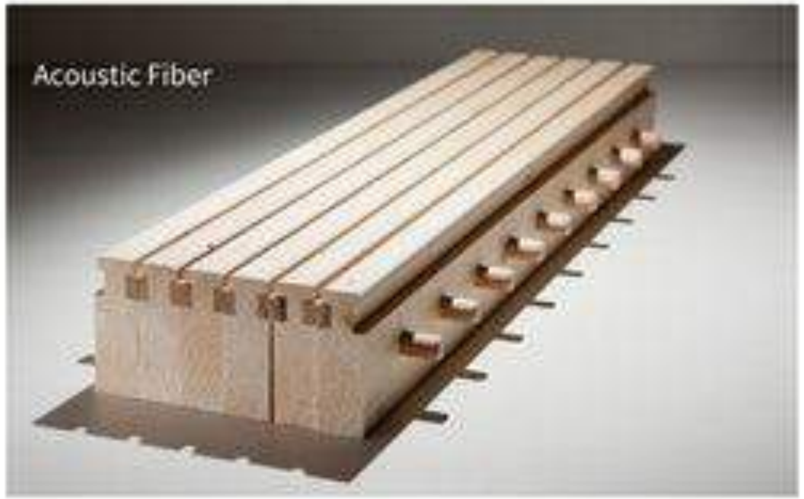
Dowel Laminated Timber (DLT) Panels

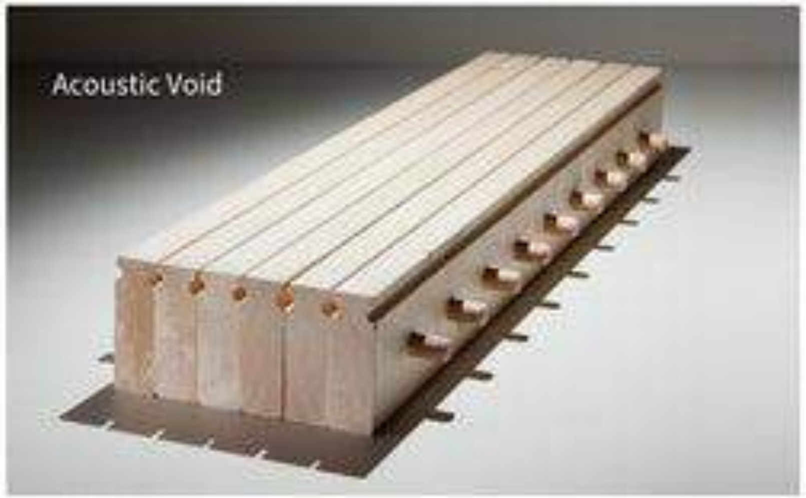
- Resources:
  - Timber Framers Guild (for dowel design)
  - DLT Design Guide

Credit: StructureCraft

Dowel Laminated Timber Profile Options







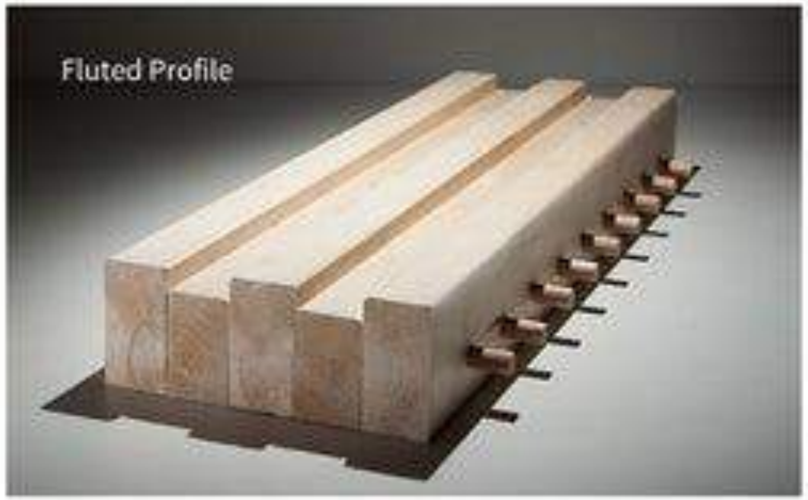


Photo credit: StructureCraft

Glue Laminated Timber (GLT) Panels

Photo credit: Structure Fusion

Photo credit: Unalam

Glue Laminated Timber (GLT) Panels

What is it?

- Similar to glulam beams on their side
- Same code references and manufacturing standards as glulam beams and columns
- Watch design stresses and layups
  - Spec uniform layup (all lams same species & grade)

Image source: StructureCraft

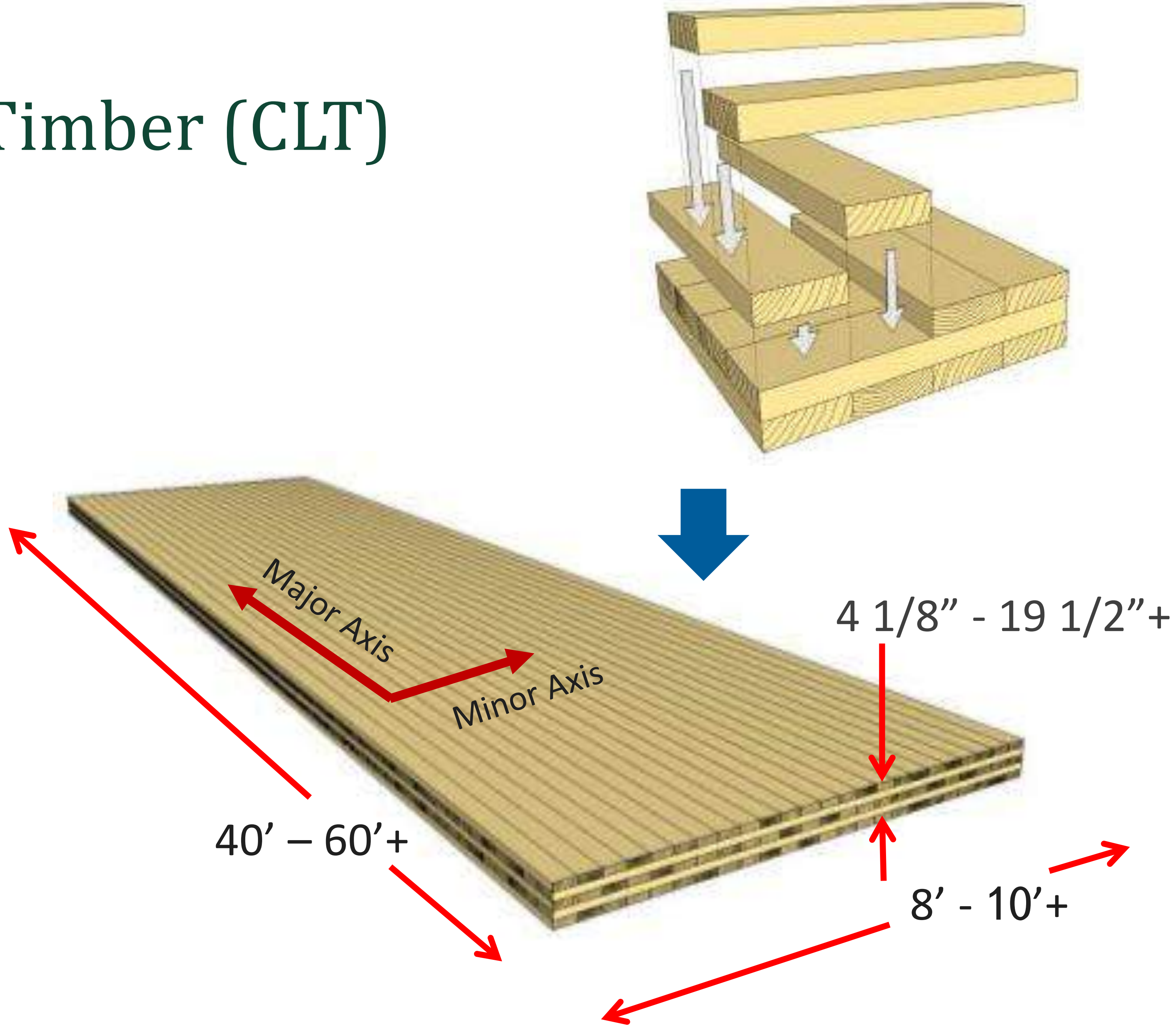
Image source: Manasc Isaac Architects / Fast + Epp

Cross Laminated Timber (CLT)

Cross Laminated Timber (CLT)

What is it?

- » Solid wood panel
- » Solid sawn lams
- » 3+ layers
- » 90° cross-lams



Cross Laminated Timber (CLT) Common Layups

3-ply 3-layer

5-ply 5-layer

7-ply 7-layer

9-ply 9-layer

7-ply 5-layer

9-ply 7-layer

Cross Laminated Timber (CLT) Panel Fabrication

SPRINGER

SPRINGER®

THE WOOD-MECHANISING COMPANY

Cross Laminated Timber (CLT) Prefabrication

- Panels planed, sanded, cut to size
- Openings cut with CNC routers
- 3rd party inspection at factory
- Custom designed and engineered
- Panels delivered/ installed in predetermined sequence

Photo Credit:
Sissi Slotover-Smutny

Cross Laminated Timber (CLT)

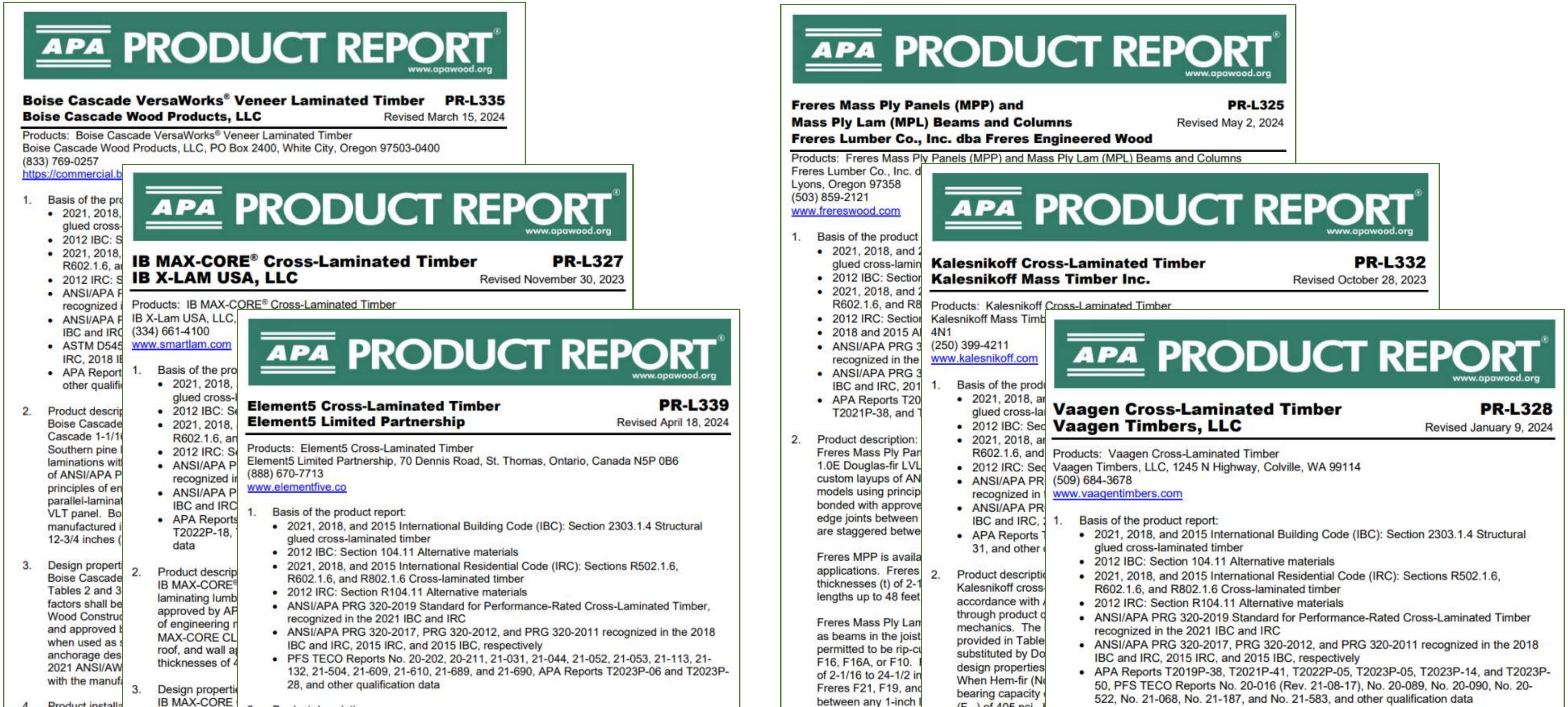
» Since 2015 IBC, CLT defined in Chapter 2 Definitions:

[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 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.

Cross Laminated Timber (CLT) Product Reports



Mass Plywood Panels (MPP)

Mass Plywood Panels (MPP)

What is it?

- » Thicknesses in 1” Increments
- » Structural properties in APA PR-L325

MPP

Table 1. ASD Reference Design Values[a,b,c] for Freres MPP (For Use in the U.S.)

MPP Layup	Layup ID	Thickness, t_p (in.)	Major Strength Direction				Minor Strength Direction			
			$(F_bS)_{eff,f,0}$ (lbf-ft/ft)	$(EI)_{eff,f,0}$ (10^6 lbf-in.^{2}/ft)	$(GA)_{eff,f,0}$ (10^6 lbf/ft)	$V_{s,0}$ (lbf/ft)	$(F_bS)_{eff,f,90}$ (lbf-ft/ft)	$(EI)_{eff,f,90}$ (10^6 lbf-in.^{2}/ft)	$(GA)_{eff,f,90}$ (10^6 lbf/ft)	$V_{s,90}$ (lbf/ft)
F16	F16-2	2	1,110	16	0.82	2,190	210	2.8	0.17	695
	F16-3	3	1,870	51	1.23	2,190	355	9.0	0.26	695
	F16-4	4	3,325	122	1.64	2,925	630	21	0.34	930
	F16-5	5	5,200	238	2.05	3,650	985	42	0.43	1,160
	F16-6	6	7,500	410	2.46	4,375	1,420	72	0.69	1,390
	F16-7	7	10,200	652	2.66	5,100	1,930	114	0.81	1,630
	F16-8	8	13,325	973	3.04	5,825	2,525	170	0.91	1,860
	F16-9	9	16,850	1,385	3.42	6,575	3,200	242	1.04	2,090
	F16-10	10	20,825	1,900	3.80	7,300	3,950	333	1.15	2,320
	F16-11	11	25,175	2,529	4.18	8,025	4,775	443	1.27	2,550
	F16-12	12	29,975	3,283	4.56	8,750	5,675	575	1.38	2,775

For SI: 1 in. = 25.4 mm; 1 ft = 304.8 mm; 1 lbf = 4.448N

(a) Tabulated values are allowable design values.

(b) Tabulated values are limited to MPP manufactured with 1-inch-thick Freres 1.6E Douglas-fir LVL.

(c) Deflection under a specified uniformly distributed load, w, acting perpendicular to the face of a single-span panel may be calculated as a sum of the deflections due to moment and shear effects using the effective bending stiffness, $(EI)_{eff}$, and the effective in-plane (planar) shear rigidity, $(GA)_{eff}$, as follows:

$$\delta = \frac{22.5wL^4}{(EI)_{eff}} + \frac{3wL^2}{2(GA)_{eff}} \quad [1]$$

where: δ = Estimated deflection, inches; w = uniform load, plf;
L = span, feet; $(EI)_{eff}$ = tabulated effective bending stiffness, 10^6 lbf-in.^{2}/ft; and
$(GA)_{eff}$ = tabulated effective in-plane (planar) shear rigidity, 10^6 lbf/ft

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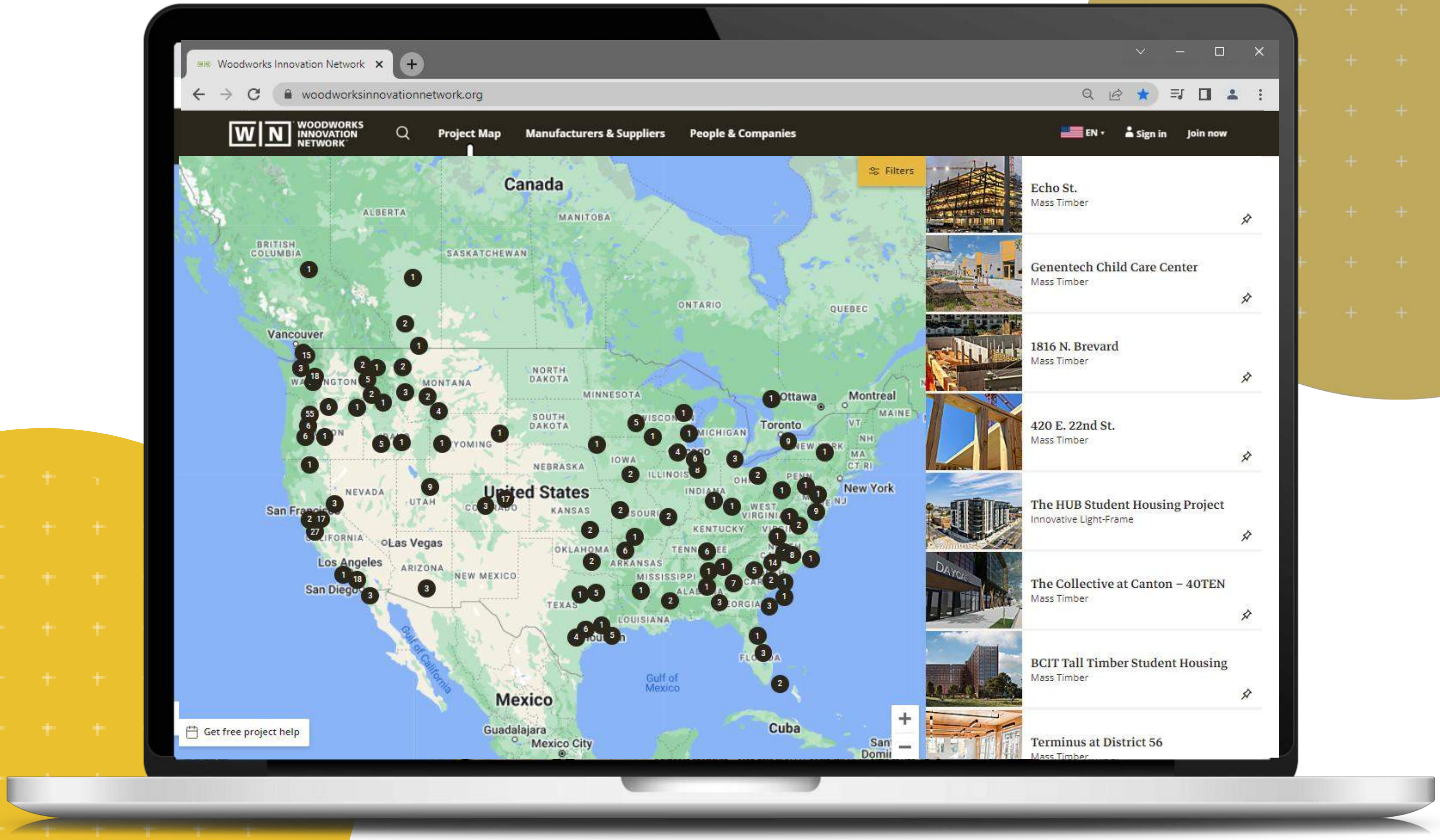
111 East Grand / Neumann Monson Architects
photo Mike Sinclair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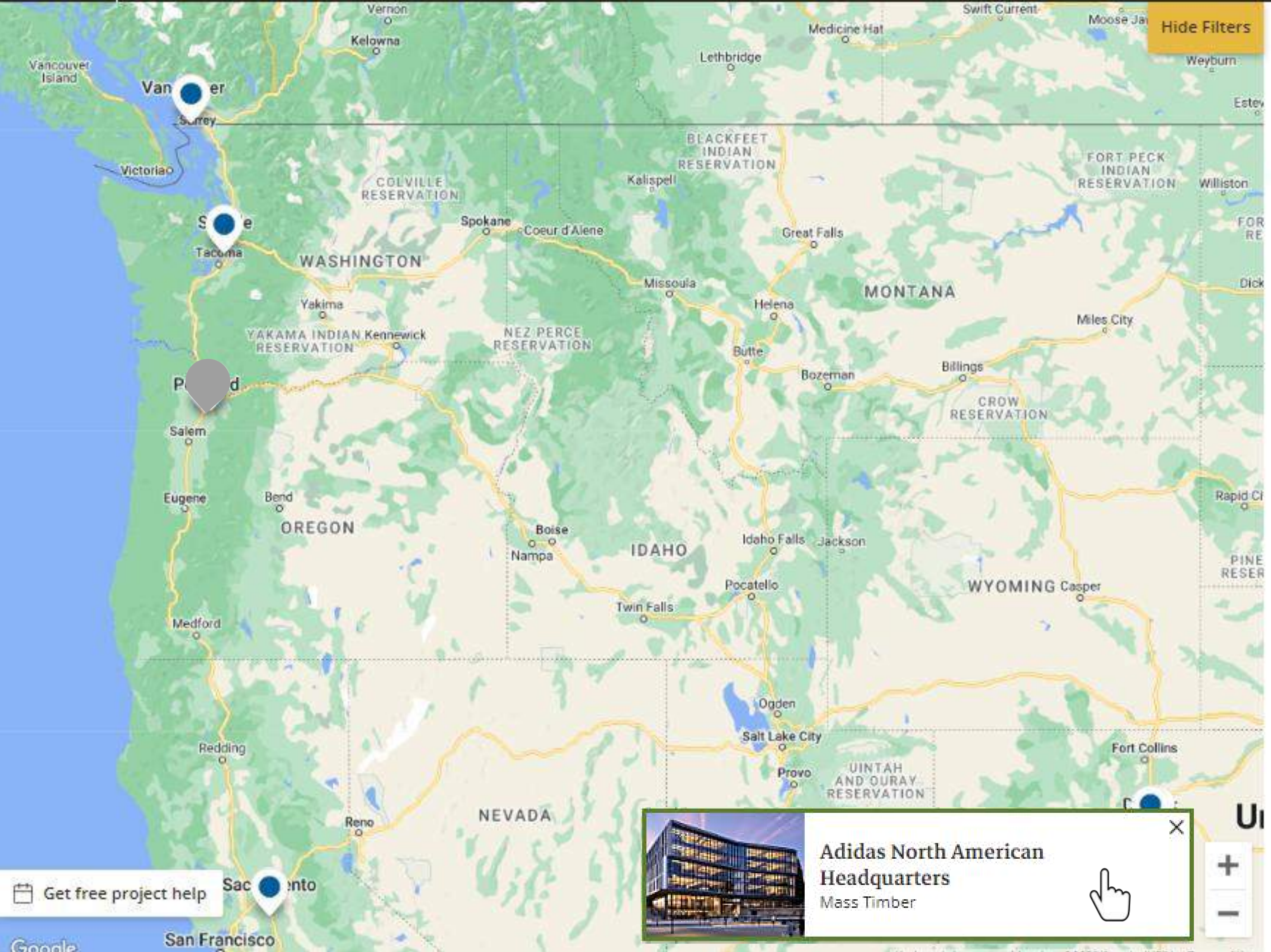
The HUB Student Housing Project
Innovative Light-Frame
The Collective at Canton – 40TEN
Mass Timber
BCIT Tall Timber Student Housing
Mass Timber
Terminus at District 56



- Structural Composite Lumber (e.g. LVL and LSL) 0
- Timber-Frame / Post and Beam 2
- Wood structural panels 0
- Wood-Concrete Composite Systems 0

Other Properties

- Wood Design Award Winner 2
- Affordable Housing 1
- Business Case Study Available 0
- Spec Office 1
- Technical Case Study Available 1

Number of Stories

1 — 12

Year Built

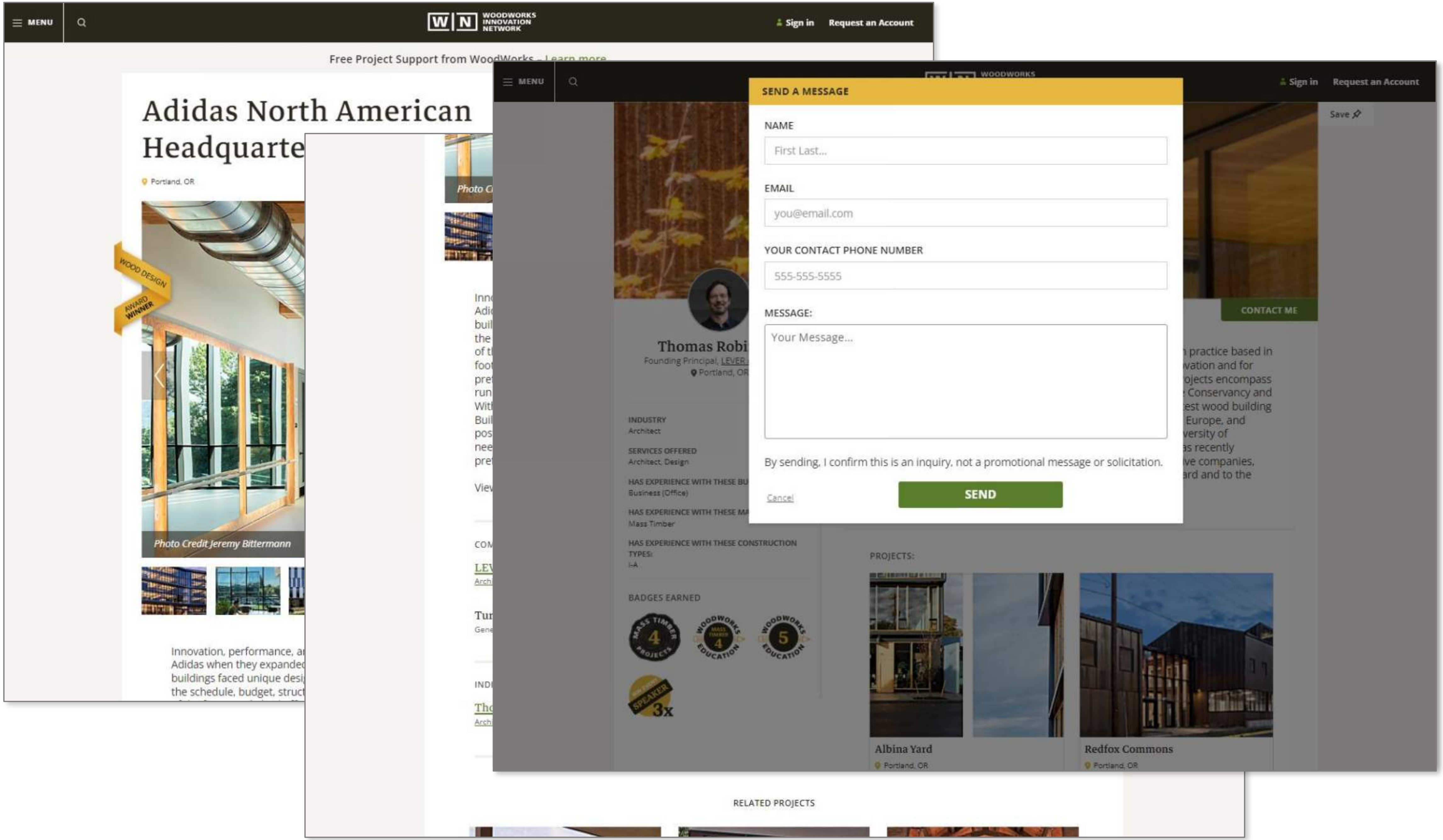
Select...

Construction Types

- I-A 0
- I-B 0
- II-A 0
- II-B 0
- III-A 3
- III-B 1
- IV-A 0
- IV-B 1
- IV-C 0
- IV-HT 2
- Unknown 0
- V-A 0
- V-B 1

Square Footage

- < 10,000 18
- 10,000 - 50,000 72
- 50,000 - 200,000 74
- ■ 200,000 + 8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Mass Timber
HAS EXPERIENCE WITH THESE CONSTRUCTION TYPES:
I-A
BADGES EARNED
MASS TIMBER 4 PROJECTS
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WOODWORKS 5 EDUCATION
SPEAKER 3x
PROJECTS:
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Portland, OR
Redfox Commons
Portland, OR

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Early Design Decisions: Priming Mass Timber Projects for Success

Momo Sun, P.E.

Photo: Structurlam

Outline

- Key Early Design Decisions
- Construction Types
- Fire Design
- Structural Grid
- Connections
- Penetrations & Firestopping
- MEP Layout and Integration
- Lateral Systems
- Acoustics

Key Early Design Decisions

What is the Single Most Important Early Design Decision on a Mass Timber Project? Is it:

Construction Type
Fire-Resistance Ratings
Member Sizes
Grids & Spans
Exposed Timber (where & how much)

MEP Layout
Acoustics
Concealed Spaces
Connections
Penetrations

The Answer is…They All Need to Be Weighed (Plus Others)

Key Early Design Decisions

Early = Efficient

Realize Efficiency in:

- Cost reduction
- Material use (optimize fiber use, minimize waste)
- Construction speed
- Trade coordination
- Minimize RFIs

Commit to a mass timber design from the start

Key Early Design Decisions

Impactful decisions:

- » Grid informs efficient spans, MEP layout
- » Manufacturer capabilities inform member sizes, grids & connections
- » Lateral system informs connections, construction sequencing

And more…

Platte Fifteen, Oz Architecture, KL&A Engineers & Builders, Arch Angle Media

Outline

- Key Early Design Decisions
- Construction Types
- Fire Design
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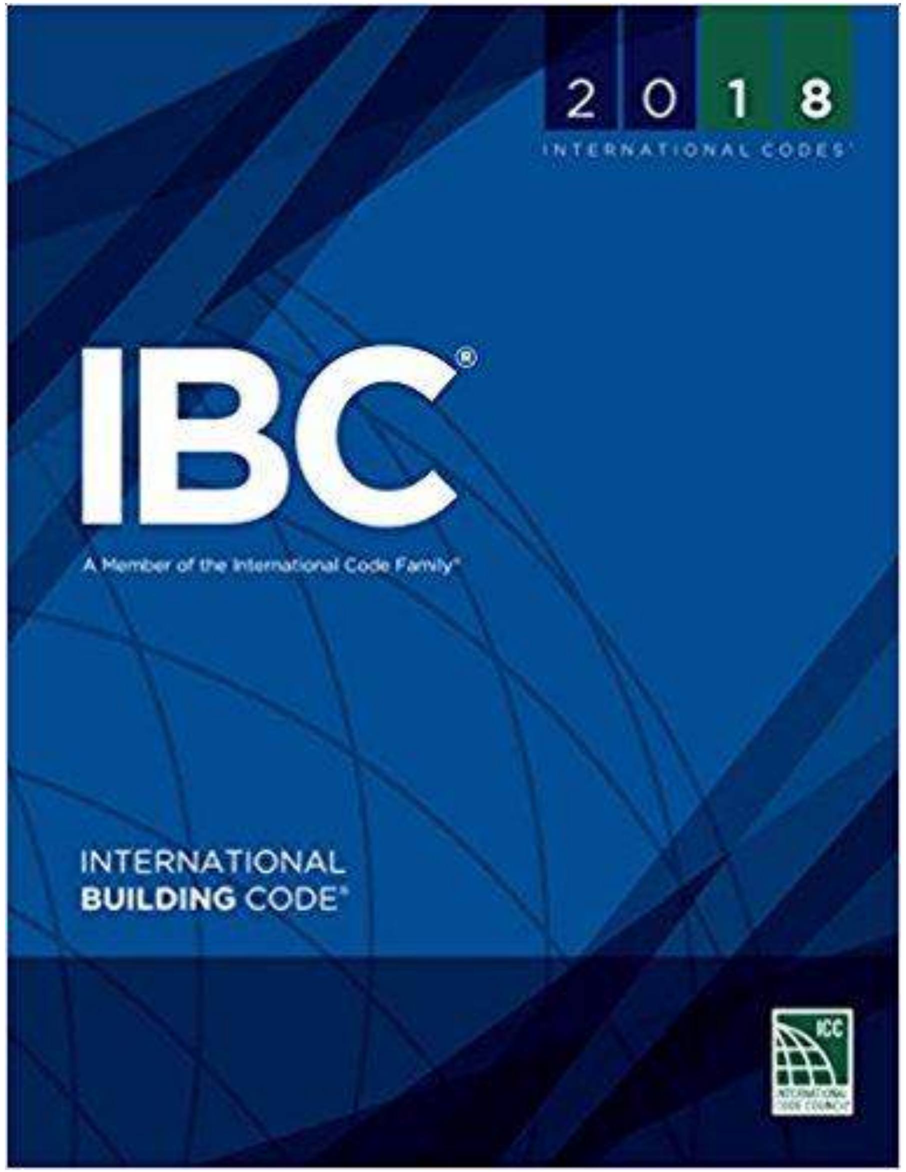
- Connections
- Penetrations & Firestopping
- MEP Layout and Integration
- Lateral Systems
- Acoustics

Construction Types

When does the code allow mass timber to be used?

IBC defines mass timber systems in IBC Chapter 2 and notes their acceptance and manufacturing standards in IBC Chapter 23

Permitted anywhere that combustible materials and heavy timber are allowed, plus more



Construction Types

IBC defines 5 construction types: I, II, III, IV, V

A building must be classified as one of these

Construction Types I & II:

All elements required to be non-combustible materials

However, there are exceptions including several for mass timber

Construction Types

Where does the code allow MT to be used?

Type IB & II: Roof Decking

Image: DeStafano & Chamberlain, Inc, Robert Benson Photography

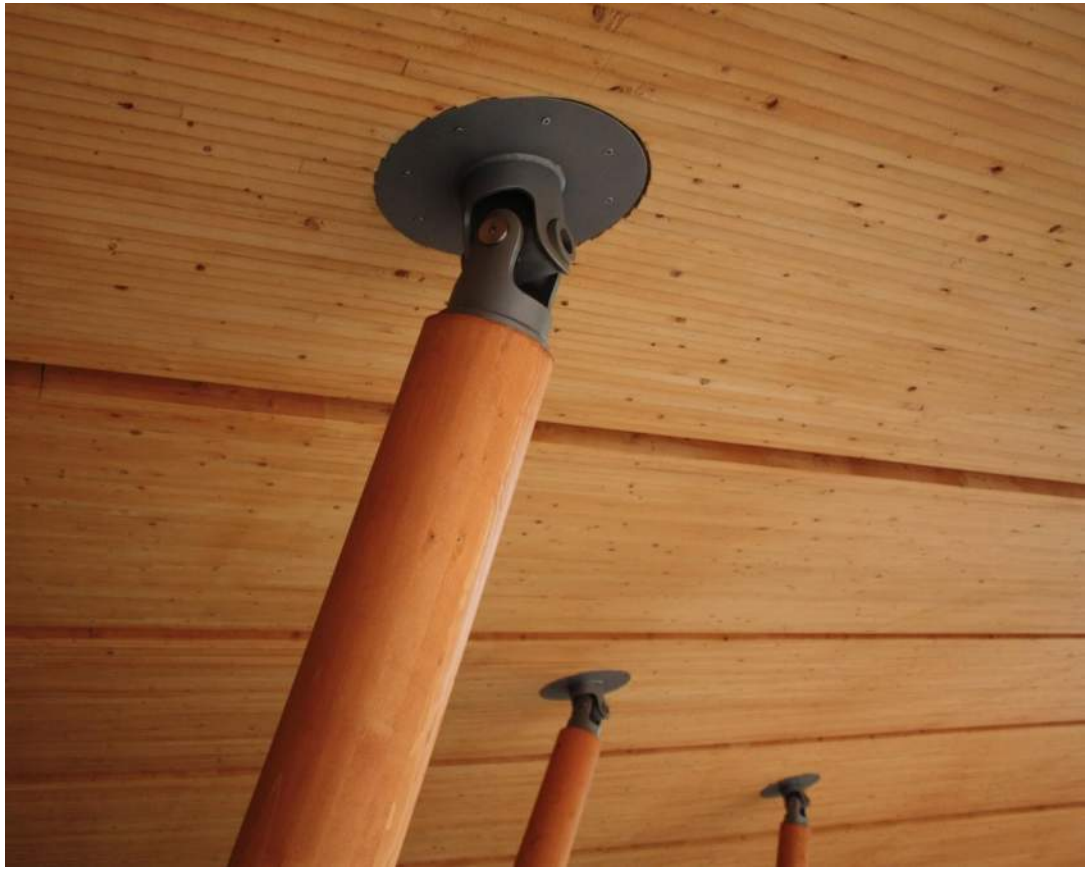


Image: StructureCraft Builders

Construction Types

All wood-framed building options:

Type III

Exterior walls non-combustible (may be FRTW)

Interior elements any allowed by code, including mass timber

Type V

All building elements are any allowed by code, including mass timber

Types III and V are subdivided to A (protected) and B (unprotected)

Type IV (Heavy Timber)

Exterior walls non-combustible (may be FRTW OR CLT)

Interior elements qualify as Heavy Timber (min. sizes, no concealed spaces except in 2021 IBC)

Construction Types

Where does the code allow MT to be used?

Type III: Interior elements (floors, roofs, partitions/shafts) and exterior walls if FRT

ICE Block I, RMW Architecture & Interiors, Buehler Engineering, Bernard André Photography

Construction Types

Where does the code allow MT to be used?

Type IV: Any exposed interior elements & roofs, must meet min. sizes; exterior walls if CLT or FRT. Concealed space limitations (varies by code version)

Image: Perkins + Will

Construction Types

Type IV construction permits exposed heavy/mass timber elements of min. sizes.

Minimum Width by Depth in Inches

Framing		Solid Sawn (nominal)	Glulam (actual)	SCL (actual)
Floor	Columns	8 x 8	$6^3/_4$ x 8¼	7 x 7½
	Beams	6 x 10	5 x 10½	5¼ x 9½
Roof	Columns	6 x 8	5 x 8¼	5¼ x 7½
	Beams*	4 x 6	3 X $6^7/_8$	3½ X 5½

*3” nominal width allowed where sprinklered

See IBC 2018 2304.11 or IBC 2015 602.4 for Details

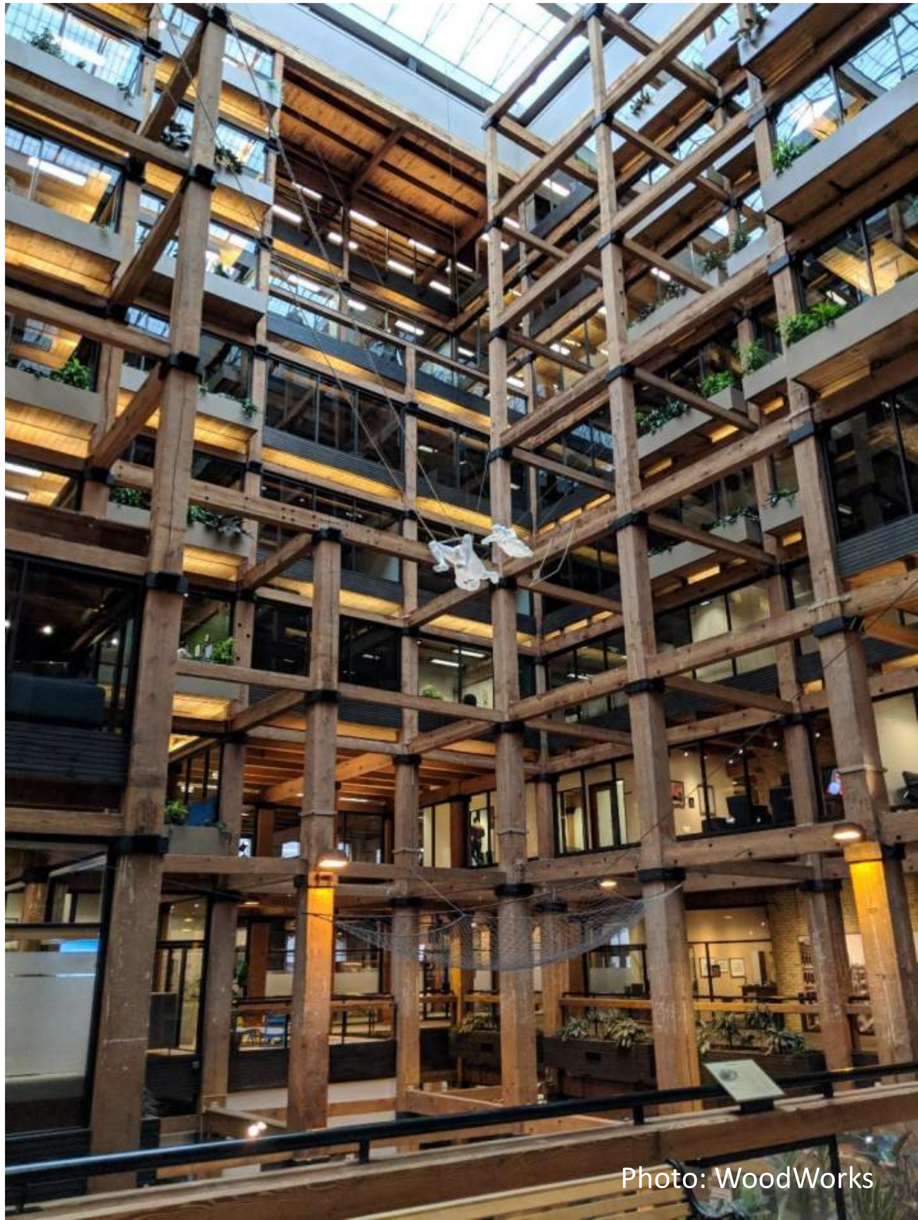


Photo: WoodWorks

Construction Types

Type IV min. sizes:

<u>Floor Panels/Decking:</u>

» 4” thick CLT (actual thickness)
» 4” NLT/DLT/GLT (nominal thickness)
» 3” thick (nominal) decking covered with: 1” decking or 15/32” WSP or ½” particleboard

Photo: StructureCraft

Photo: Aitor Sanchez/ Ewing Cole

Photo: WoodWorks

Construction Types

Concealed spaces solutions paper

Richard McLain, PE, SE
Senior Technical Director – Tall Wood
WoodWorks – Wood Products Council

WOODWORKS WOOD PRODUCTS COUNCIL

Concealed Spaces in Mass Timber and Heavy Timber Structures

Concealed spaces, such as those created by a dropped ceiling in a floor/ceiling assembly or by a stud wall assembly, have unique requirements in the International Building Code (IBC) to address the potential of fire spread in non-visible areas of a building. Section 718 of the 2018 IBC includes prescriptive requirements for protection and/or compartmentalization of concealed spaces through the use of draft stopping, fire blocking, sprinklers and other means. For information on these requirements, see the WoodWorks Q&A, *Are sprinklers required in concealed spaces such as floor and roof cavities in multi-family wood-frame buildings?*[1]

For mass timber building elements, the choice of construction type can have a significant impact on concealed space requirements. Because mass timber products such as cross-laminated timber (CLT) are prescriptively recognized for Type IV construction, there is a common misperception that exposed mass timber building elements cannot be used or exposed in other construction types. This is not the case.

In addition to Type IV buildings, structural mass timber elements—including CLT, glue-laminated timber (glulam), nail-laminated timber (NLT), structural composite lumber (SCL), and tongue-and-groove (T&G) decking—can be utilized and exposed in the following construction types, whether or not a fire-resistance rating is required:

- **Type III** – Floors, roofs and interior walls may be any material permitted by code, including mass timber; exterior walls are required to be noncombustible or fire retardant-treated wood.
- **Type V** – Floors, roofs, interior walls and exterior walls (i.e., the entire structure) may be constructed of mass timber.
- **Types I and II** – Mass timber may be used in select circumstances such as roof construction—including the primary frame in the 2021 IBC—in Types I-B, II-A or II-B; exterior columns and arches when 20 feet or more of horizontal separation is provided; and balconies, canopies and similar projections.

INTRO, Cleveland | Cleveland, Ohio
Harbor Bay Real Estate Advisors
HPA Architecture

The John W. Olver Design Building at UMass Amherst includes exposed wood structure in some areas and dropped ceilings in others. Architect: Leers Weinzapfel Associates

https://www.woodworks.org/wp-content/uploads/wood_solution_paper-Concealed_Spaces_Timber_Structures.pdf

Construction Types

Where does the code allow MT to be used?

Type V: All interior elements, roofs & exterior walls

Image: Christian Columbres Photography

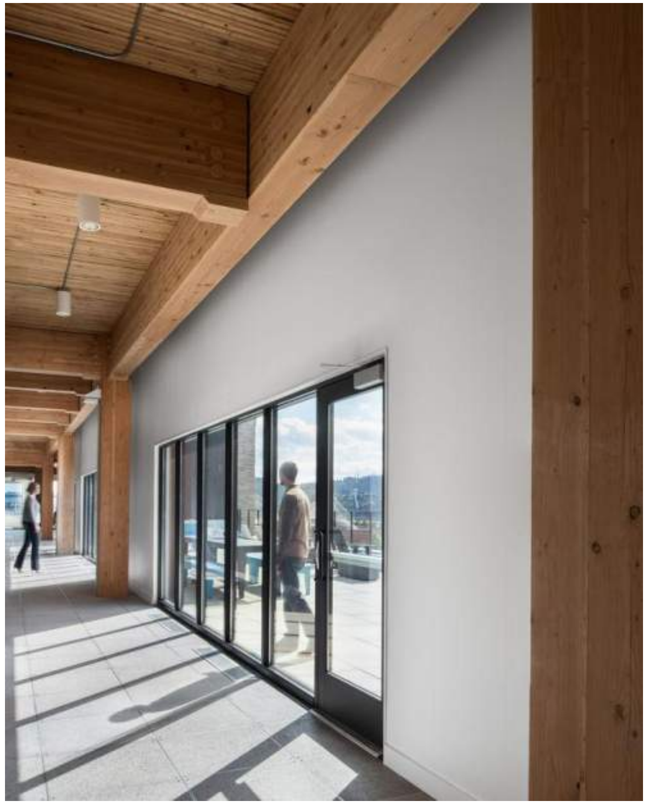
Construction Types

Allowable mass timber building size for group B occupancy with NFPA 13 Sprinkler

Type III: 6 stories

Credit: Ema Peter

Type IV: 6 stories

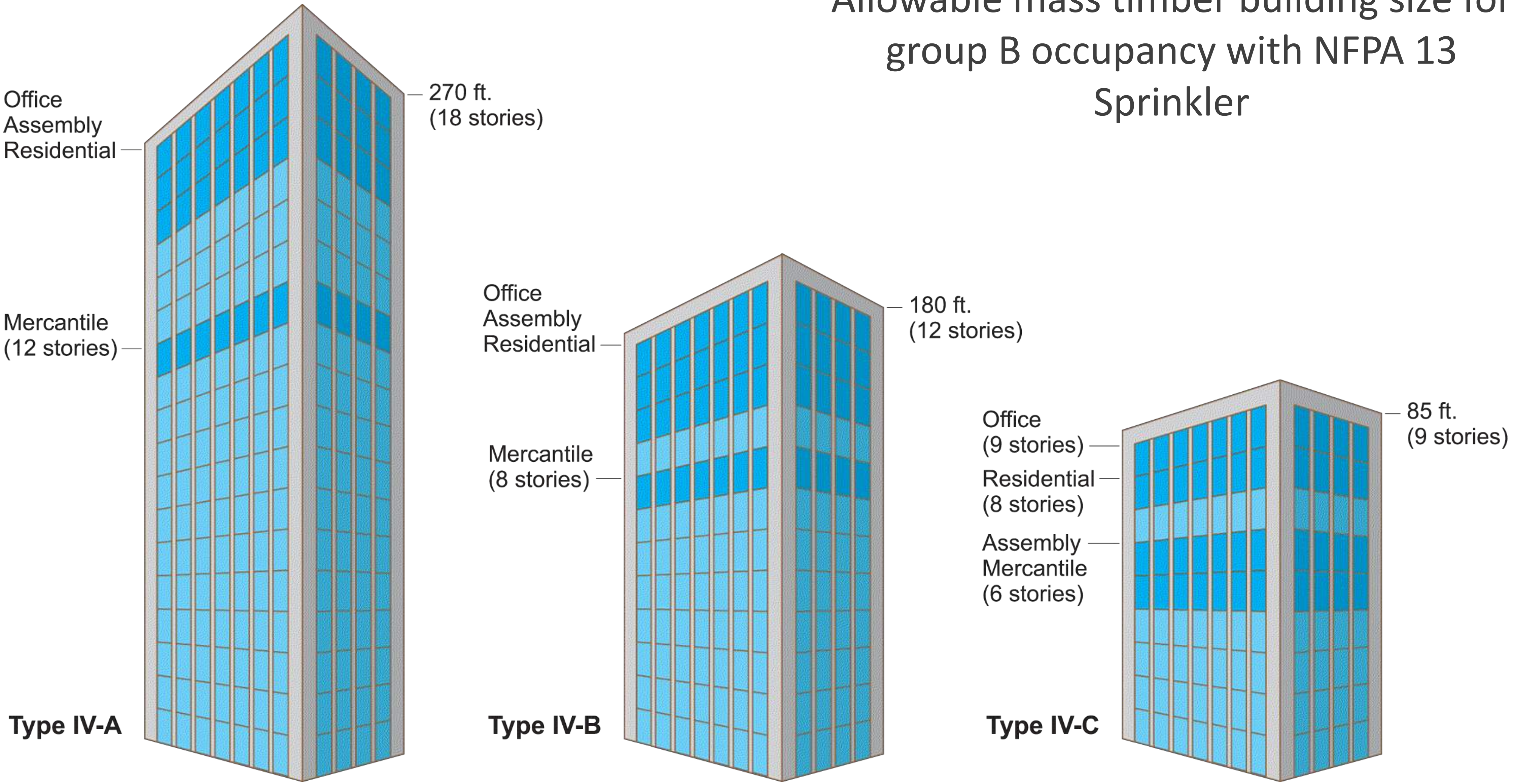


Credit: Christian Columbres Photography

Type V: 4 stories

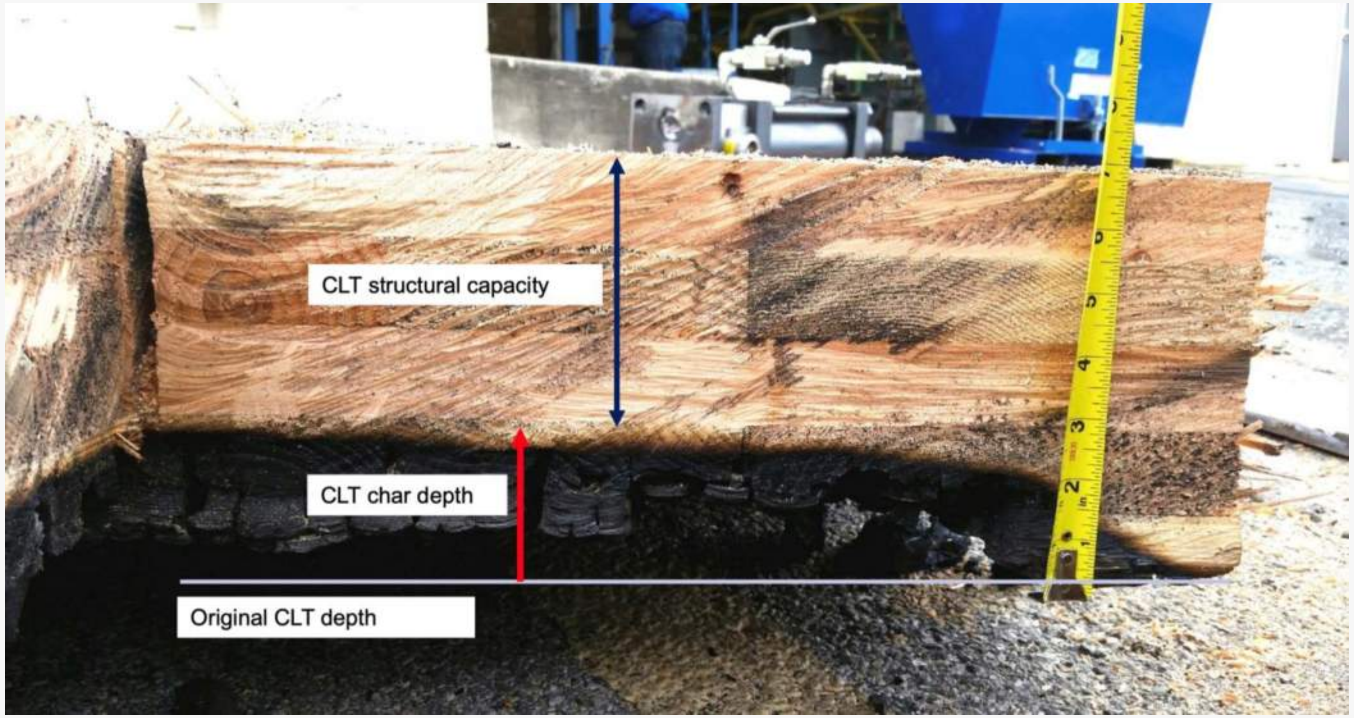
Construction Types

New Options in 2021 IBC
Allowable mass timber building size for group B occupancy with NFPA 13 Sprinkler



Outline

- » Key Early Design Decisions
- » Construction Types
- Fire Design
- » Structural Grid
- » Connections
- » Penetrations & Firestopping
- » MEP Layout and Integration
- » Lateral Systems
- » Acoustics



Key Early Design Decisions

Construction type influences FRR

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	HT	A	B
Primary structural frame[f] (see Section 202)	3[a]	2[a]	1	0	1	0	HT	1	0
Bearing walls Exterior[e, f] Interior	 3 3[a]	 2 2[a]	 1 1	 0 0	 2 1	 2 0	 2 1/HT	 1 1	 0 0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	$1^1/_2$[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

Source: 2018 IBC

Key Early Design Decisions

Construction type influences FRR

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

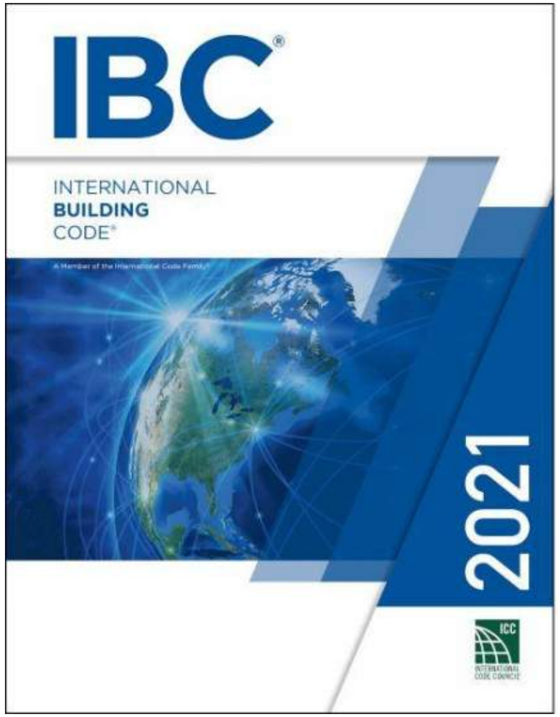
BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a, b]	2[a, b, c]	1[b, c]	0[c]	1[b, c]	0	3[a]	2[a]	2[a]	HT	1[b, c]	0
Bearing walls												
Exterior[e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	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)	$1\frac{1}{2}$[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	$1\frac{1}{2}$	1	1	HT	1[b,c]	0

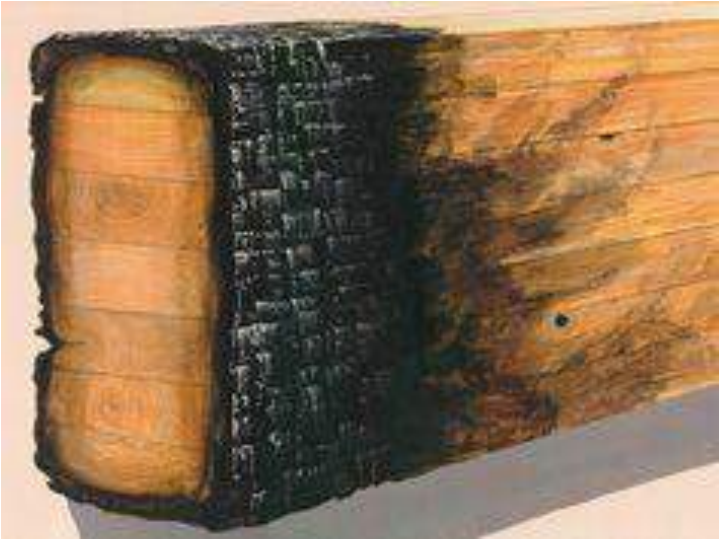
Source: 2021 IBC

Construction type influences FRR

- » Type IV-HT Construction (minimum sizes)
- » Other than type IV-HT: Demonstrated fire resistance

Method of demonstrating FRR (calculations or testing) can impact member sizing





NGC Testing Services

Fire Testing Laboratory

ACCREDITED Testing Laboratory TL-216

TEST REPORT

Page 1 of 53

for

American Wood Council

222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Standard Methods of
Fire Tests of Building Construction and Materials
ASTM E 119 – 11a

Test Report No: WP-1950

Assignment No: K-1089

Subject Material: Cross-Laminated Timber and Gypsum Board Wall Assembly (Load-Bearing)

Test Date: October 4, 2012

Report Date: October 15, 2012

Prepared by: Michael J. Rizzo
Test Engineer

Reviewed by: Robert J. Menchetti
Director, Laboratory Facilities and Testing Services

The results reported in this document apply to specific samples submitted for measurement. No responsibility is assumed for performance of any other specimen. This report may not be reproduced, except in full, without the written approval of the laboratory. The laboratory's test report in no way constitutes or implies product certification, approval or endorsement by this laboratory.

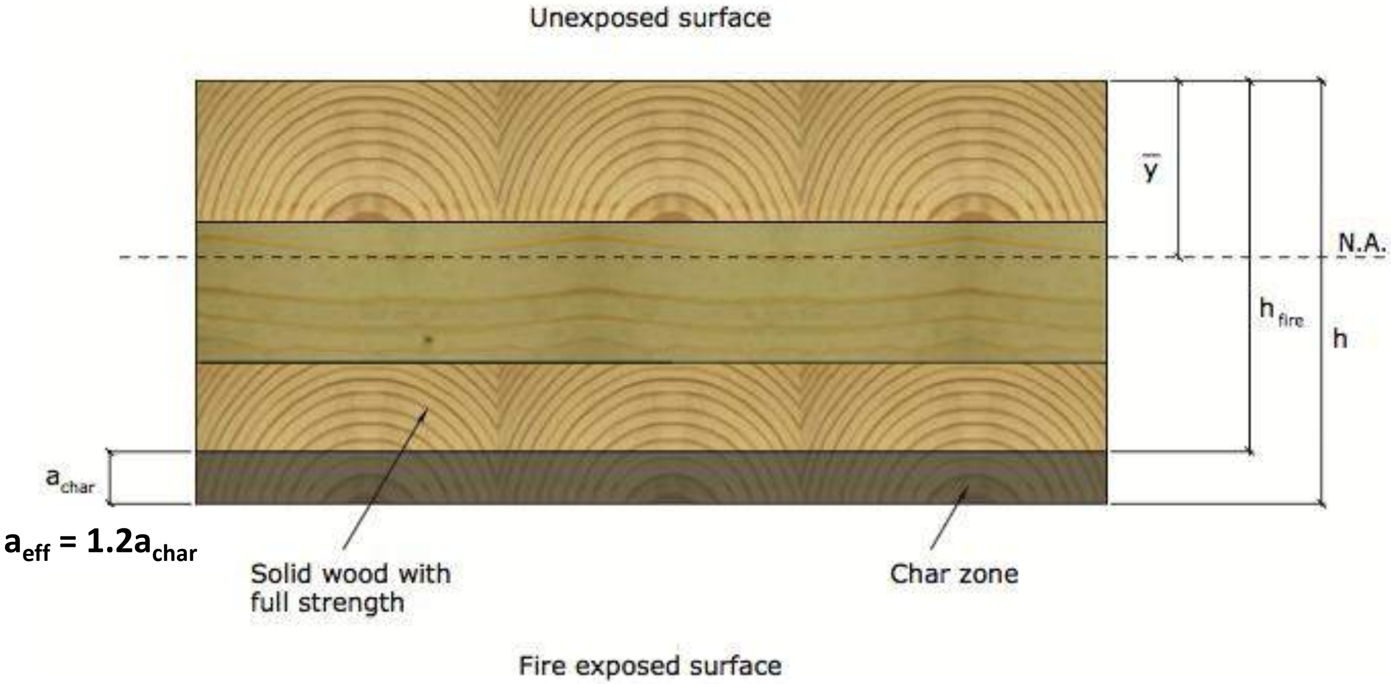
Construction type influences FRR

Which Method of Demonstrating FRR of MT is Being Used?

» Calculations in Accordance with IBC 722 ⟶ NDS Chapter 16

» Tests in Accordance with ASTM E119

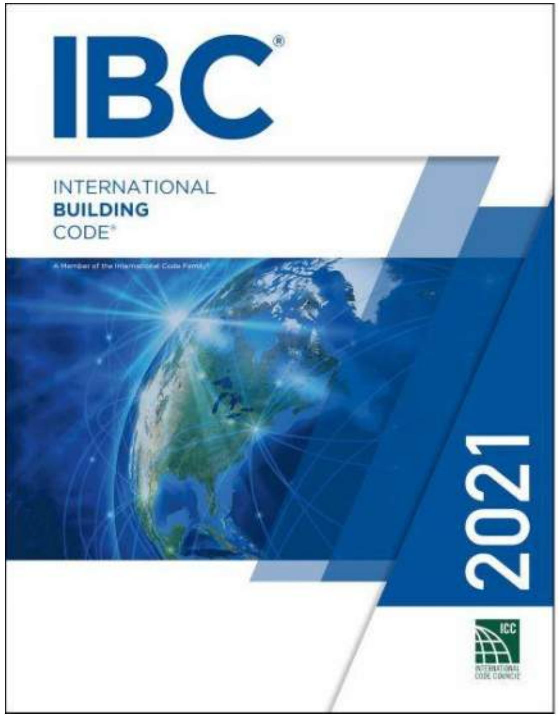

Credit: Urban One

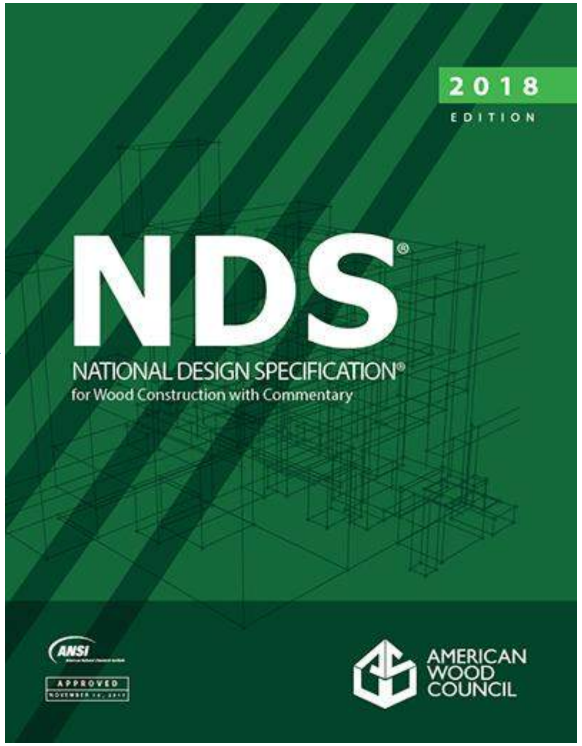


FRR Design of MT

Calculated FRR of Exposed MT:

IBC to NDS code compliance path





Code Path for Exposed Wood Fire-Resistance Calculations

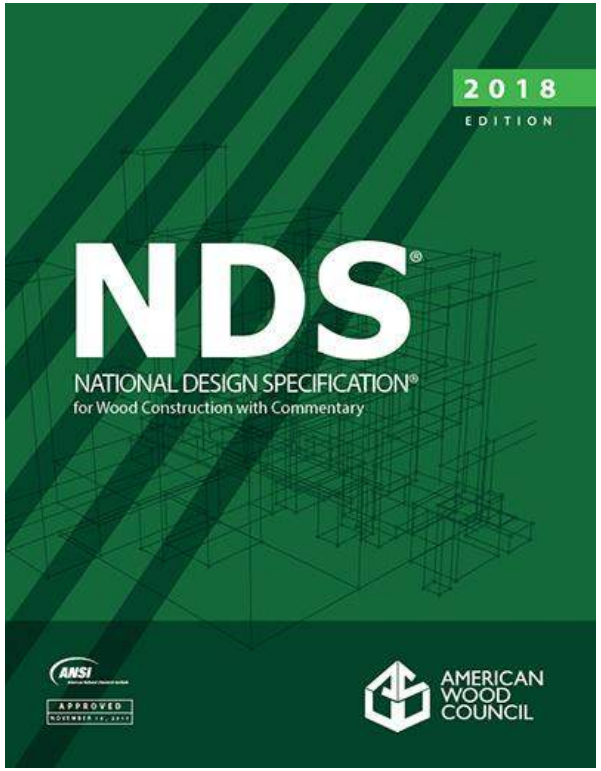
IBC 703.3
Methods for determining fire resistance
- Prescriptive designs per IBC 721.1
- ***Calculations in accordance with IBC 722***
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Alternate protection methods as allowed by 104.11

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.

FRR Design of MT

NDS Chapter 16 includes calculation of fire resistance of NLT, CLT, Glulam, Solid Sawn and SCL wood products




NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION 149

FIRE DESIGN OF WOOD MEMBERS

16

Table 16.2.1B Effective Char Depths (for CLT with β_n=1.5in./hr.)

Required Fire Endurance (hr.)	Effective Char Depths, a_{char} (in.)								
	lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

FRR Design of MT

Nominal char rate of 1.5"/HR is recognized in NDS. Effective char depth calculated to account for duration, structural reduction in heat-affected zone

Credit: ARUP

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

Table 16.2.1B Effective Char Depths (for CLT with β_n=1.5in./hr.)

Required Fire Endurance (hr.)	Effective Char Depths, a_{char} (in.)								
	lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

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 1.5EMSR x SPF #3	2 layers 1/2" Type X gypsum	Half-Lap	None	Reduced 36% 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
5-ply CLT (160mm 6.3")	KLH	CV3M1	None	Half-Lap & Topside spline	None	Loaded, See Manufacturer	1	18	SwRI

FRR Design of MT

Method of demonstrating FRR (calculations or testing) can impact member sizing

Each has unique benefits:

- Testing:
  - Can result in higher FRR for some assemblies when compared to calculations (i.e. 2-hr FRR with 5-ply CLT panel).
  - Seen as more acceptable by some building officials
- Calculations:
  - Can provide more design flexibility
  - Allows for project span and loading specific analysis

FRR Design of MT

Mass Timber Fire Design Resource

» Code compliance options for demonstrating FRR

» Free download at woodworks.org

Richard McLain, PE, SE
Senior Technical Director

Scott Breneman, PhD, PE, SE
Senior Technical Director

WoodWorks – Wood Products Council

WOODWORKS WOOD PRODUCTS COUNCIL

Fire 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 (FRR). Because of their strength and dimensional stability, these products also 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, often for projects that go beyond traditional norms.

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 2021 IBC.

Mass Timber & Construction Type

Before demonstrating FRRs 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); Types I, II, III and V have subcategories A and B, while Type IV has subcategories IV-HT, V-A, IV-B, and IV-C. Types III, IV and V permit the use of wood framing throughout much of the structure and 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 required to have an FRR 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.

University of Washington Founders Hall
LMN Architects / Magnusson Klemencic Associates

Photo: Tim Griffith

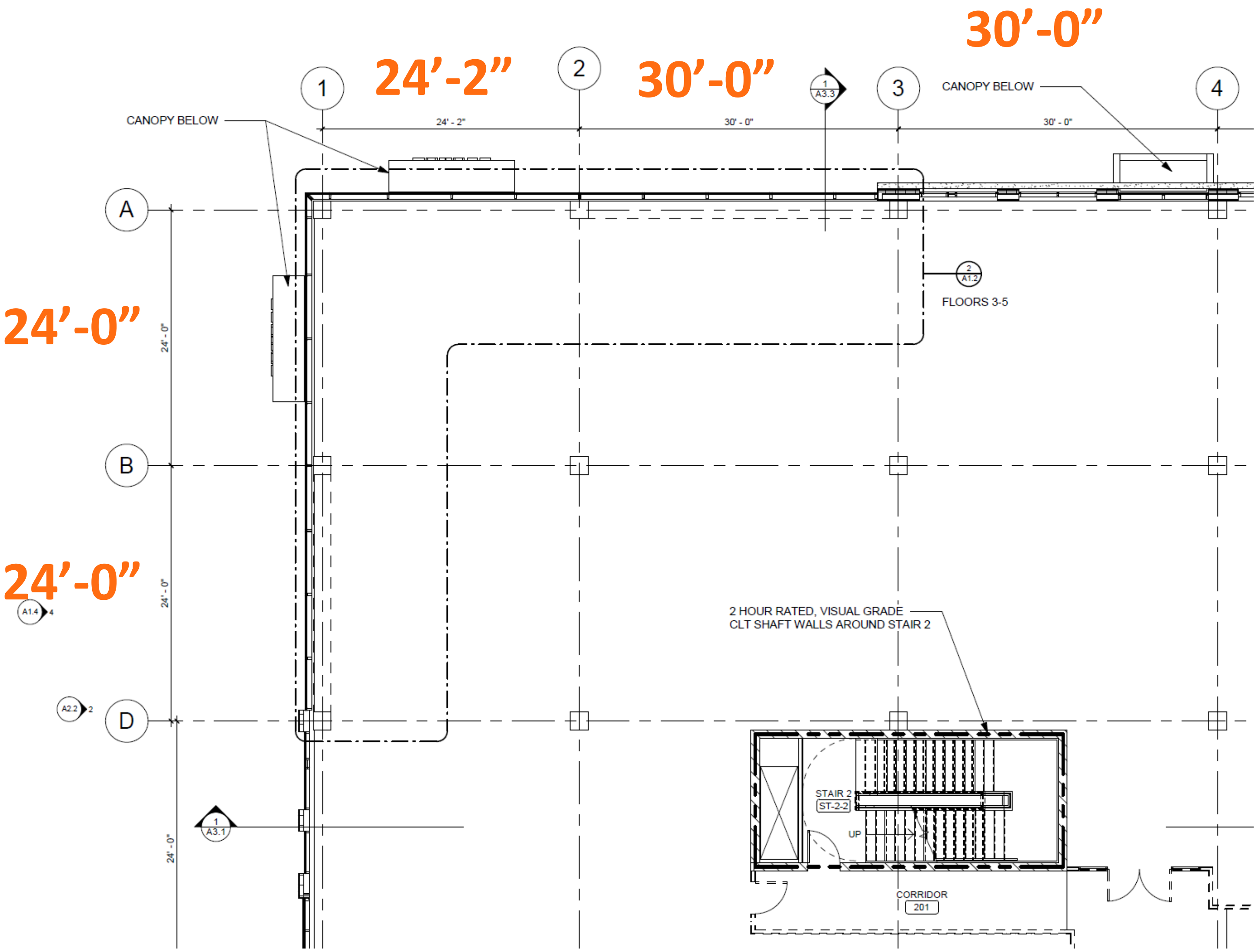
Outline

- Key Early Design Decisions
- Construction Types
- Fire Design
- Structural Grid
- Connections
- Penetrations & Firestopping
- MEP Layout and Integration
- Lateral Systems
- Acoustics

Structural Grid

Grids & Spans

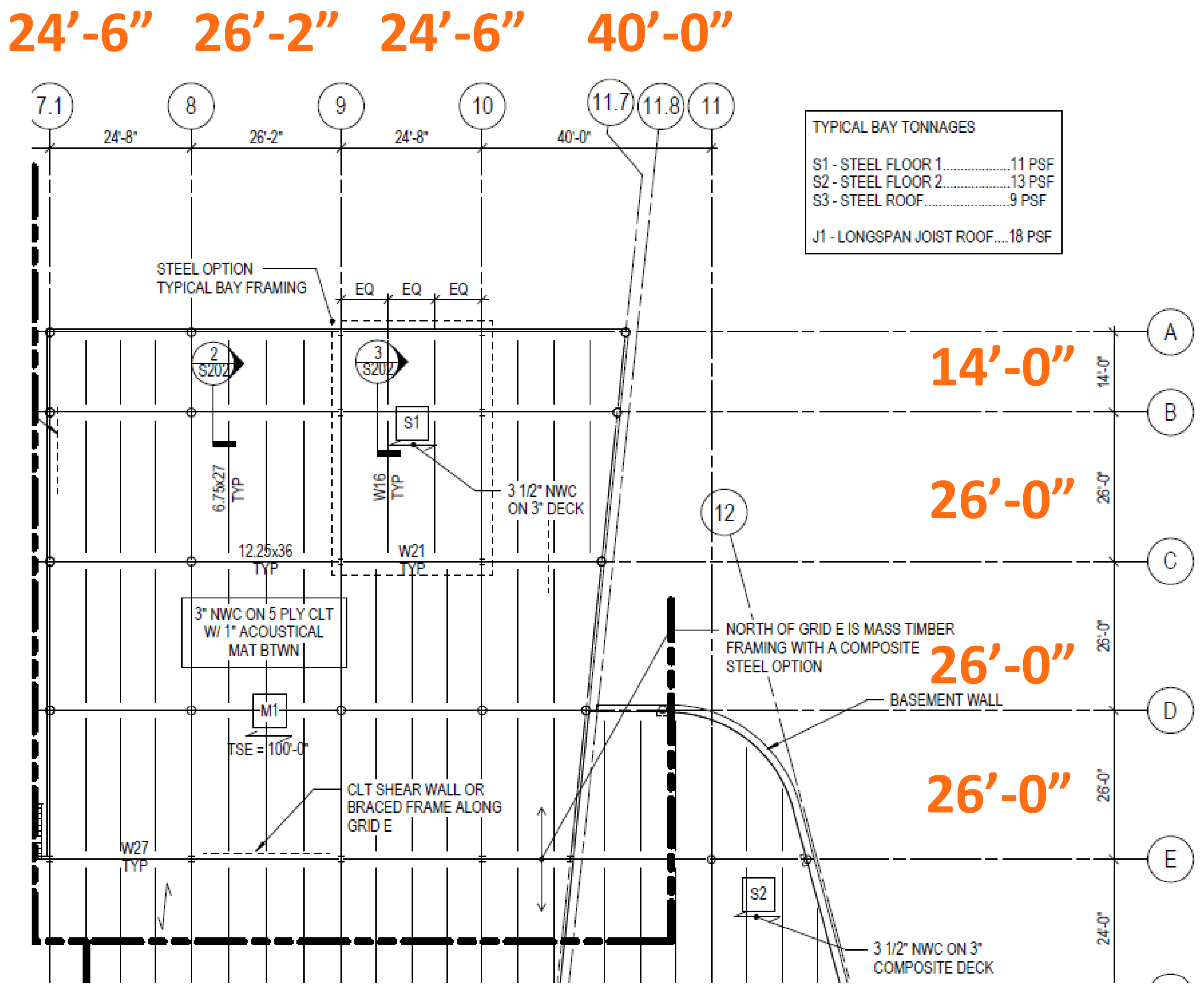
- » Consider Efficient Layouts
- » Repetition & Scale
- » Manufacturer Panel Sizing
- » Transportation



Structural Grid

Grids & Spans

- Consider Efficient Layouts
- Repetition & Scale
- Manufacturer Panel Sizing
- Transportation



Structural Grid

Member Sizes

» Impact of FRR on Sizing

» Impact of Sizing on Efficient Spans

» Consider connections – can drive member sizing

0 HR FRR: Consider 3-ply Panel

» Efficient Spans of 10-12 ft

» Grids of 20x20 (1 purlin) to 30x30 (2 purlins) may be efficient

Albina Yard, Portland, OR
20x20 Grid, 1 purlin per bay
3-ply CLT
Image: Lever Architecture

Structural Grid

Member Sizes

- Impact of FRR on Sizing
- Impact of Sizing on Efficient Spans
- Consider connections – can drive member sizing

1 or 2 HR FRR: Likely 5-ply Panel

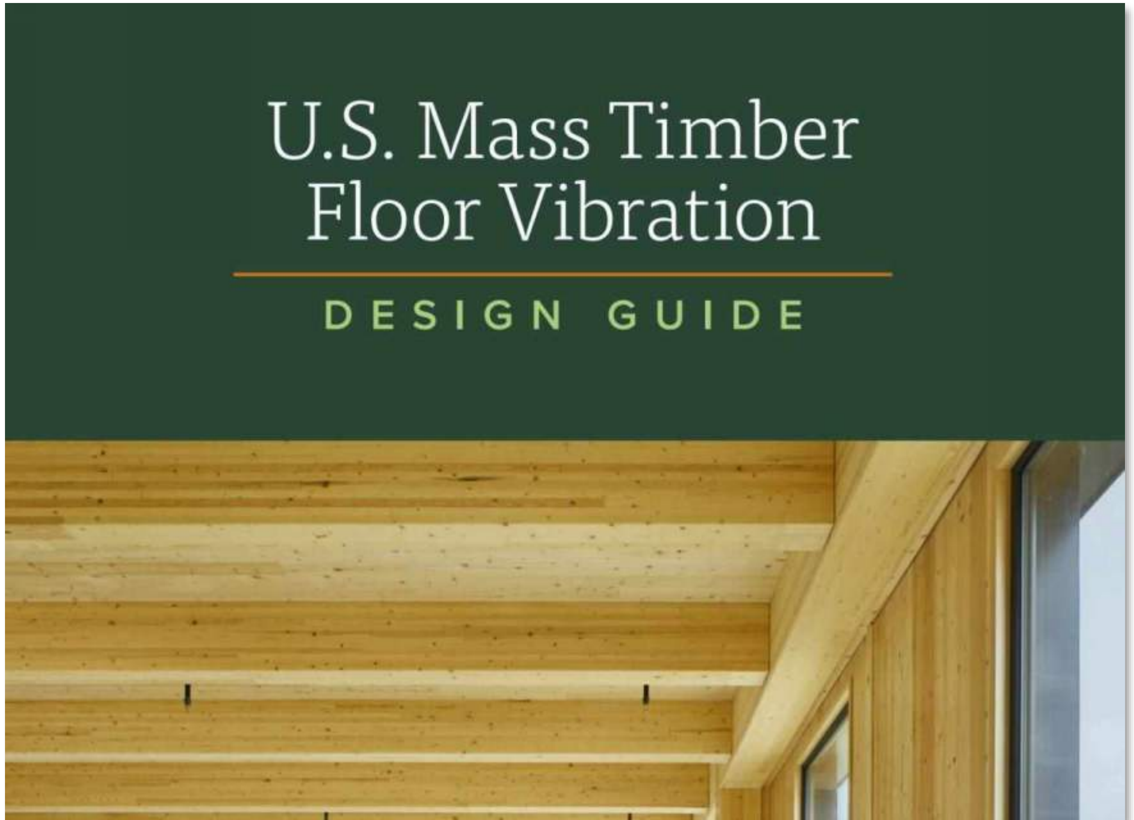
- Efficient spans of 14-17 ft
- Grids of 15x30 (no purlins) to 30x30 (1 purlin) may be efficient

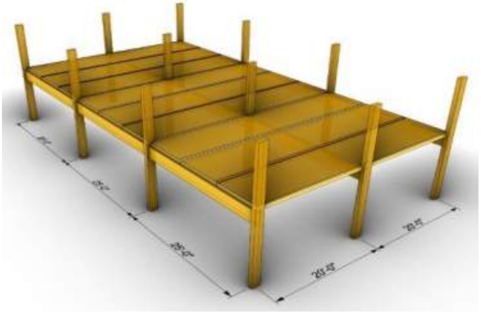
First Tech Credit Union, Hillsboro, OR
12x32 Grid, One-Way Beams
5-ply (5.5”) CLT
Image: Swinerton

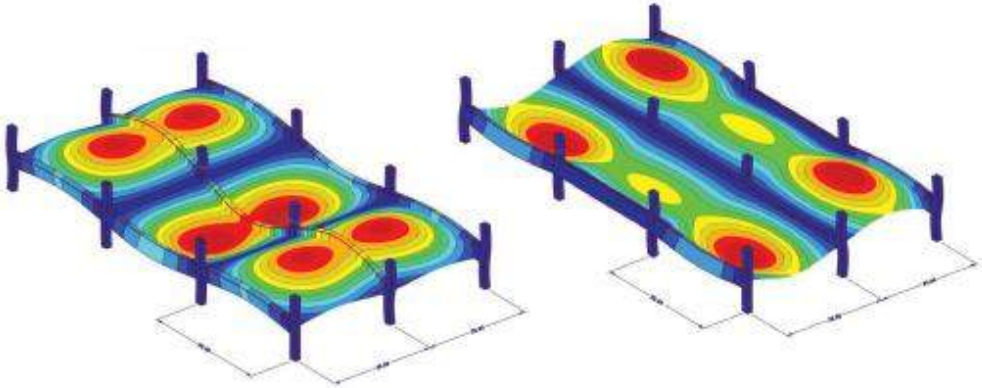
New Mass Timber Floor Vibration Guide

Worked office, lab and residential Examples

Covers simple and complex methods for bearing wall and frame supported floor systems







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Connections

Many ways to demonstrate connection fire protection:

calculations, prescriptive NC, test results, others as approved by AHJ


Photo: John Stamets


Photo: Josh Partee


Photo: Christian Columbres

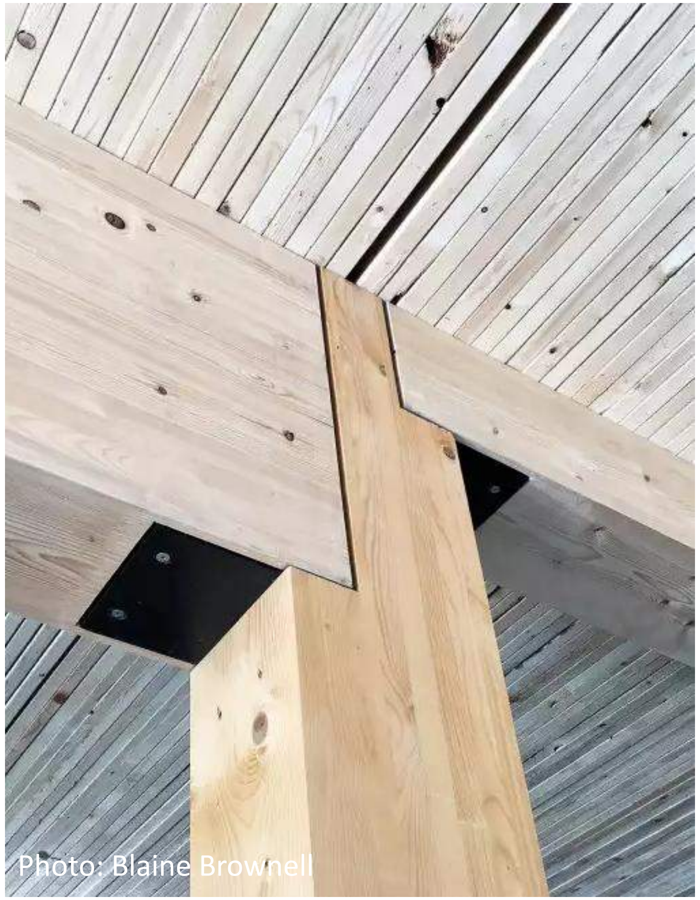
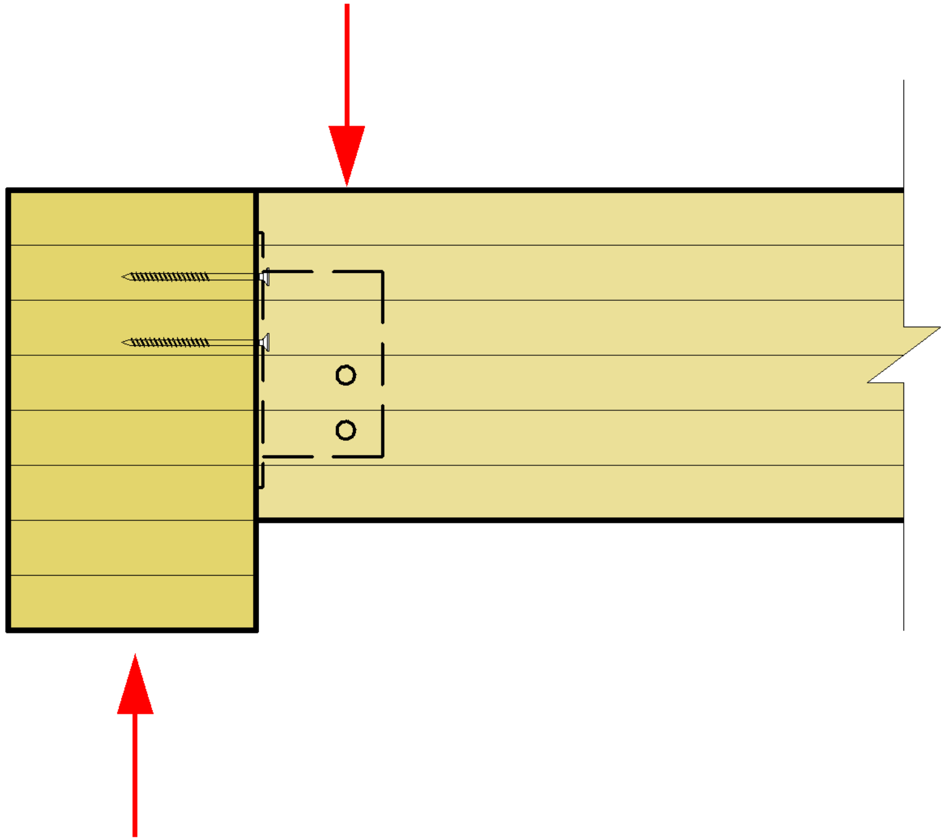


Photo: Blaine Brownell

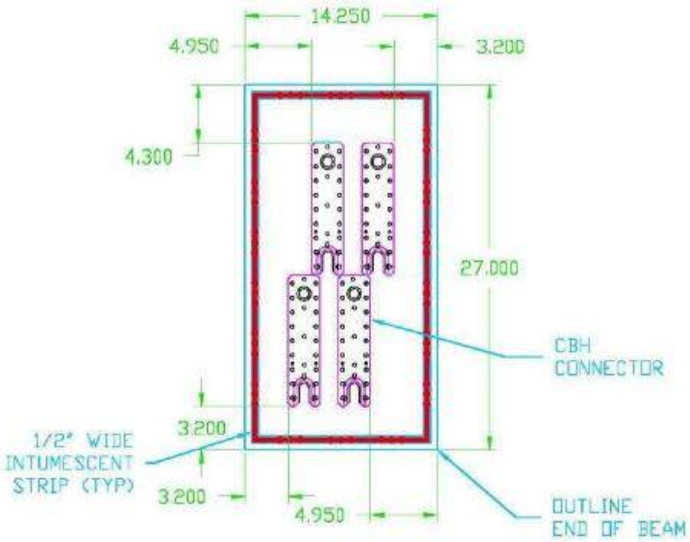
Connections

Steel hangers/hardware fully concealed within a timber-to-timber connection is a common method of fire protection



Connections

Connection FRR and beam reactions could impact required beam/column sizes



Photos: Simpson Strong-Tie

Photo: LEVER Architecture

Connections

Member to member bearing also commonly used, can avoid some/all steel hardware at connection

Connections

Member to member bearing also commonly used, can avoid some/all steel hardware at connection

Style of connection also impacts and is impacted by grid layout and MEP integration

Connections

Other connection design considerations:

» Structural capacity

» Shrinkage

» Constructability

» Aesthetics

» Cost

Credit: Alex Schreyer

Mass Timber Connections Index

A library of commonly used mass timber connections with designer notes and information on fire resistance, relative cost and load-carrying capacity.

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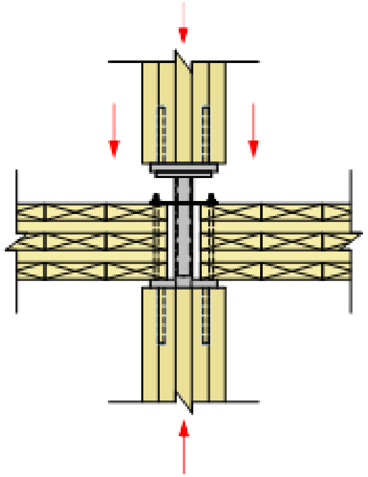
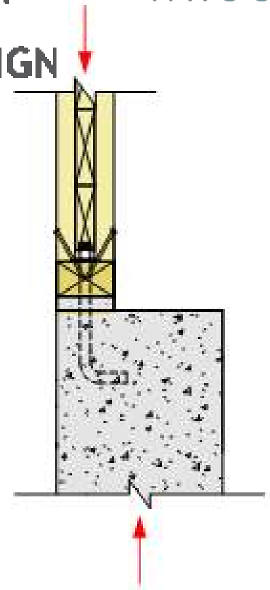
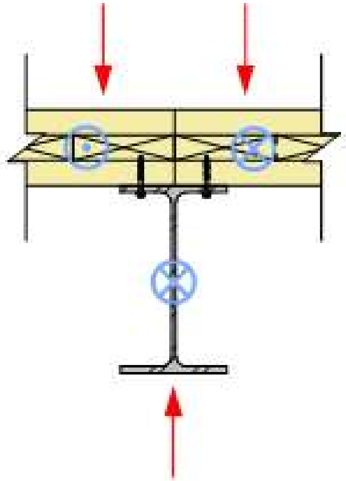
KL&A Engineers & Builders

OZ ARCHITECTURE URBAN DESIGN INTERIOR DESIGN

SWINERTON MASS TIMBER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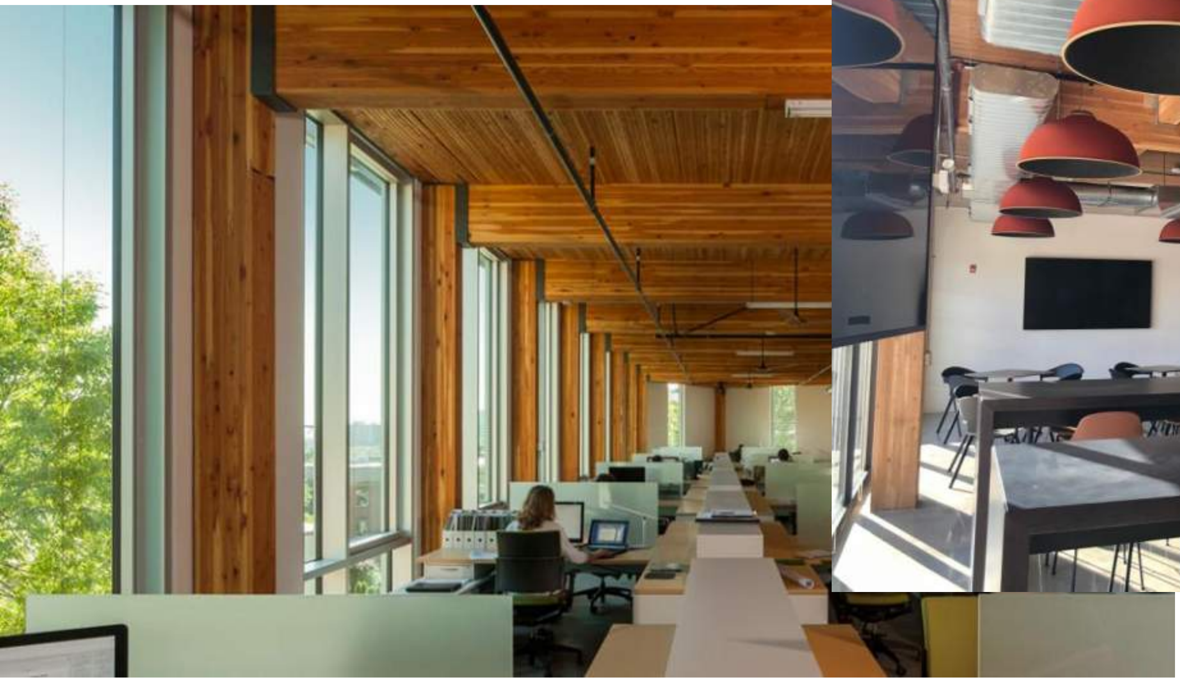
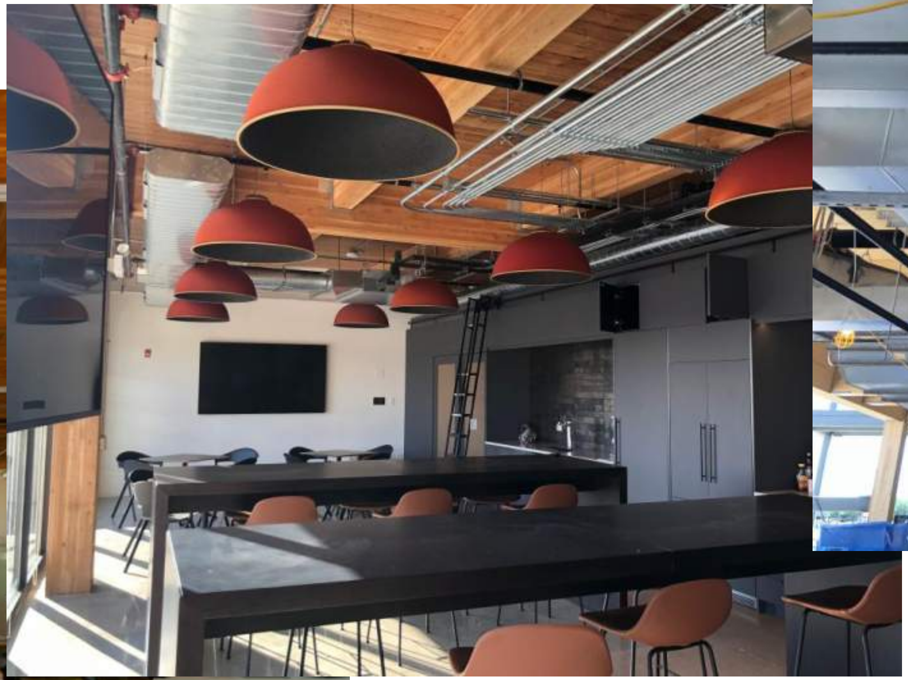
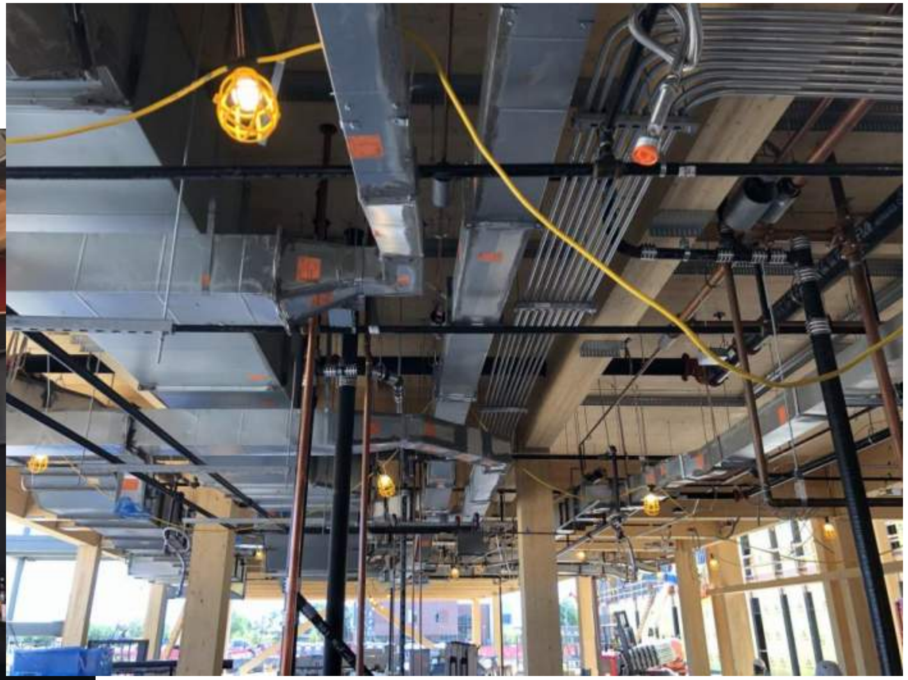
- **MEP Layout and Integration**
- » Lateral Systems
- » Acoustics

MEP Layout & Integration

Set Realistic Owner Expectations About Aesthetics

- MEP fully exposed with MT structure, or limited exposure?
- Also consider acoustic impacts of MEPF routing

MEP Layout & Integration

Key considerations:

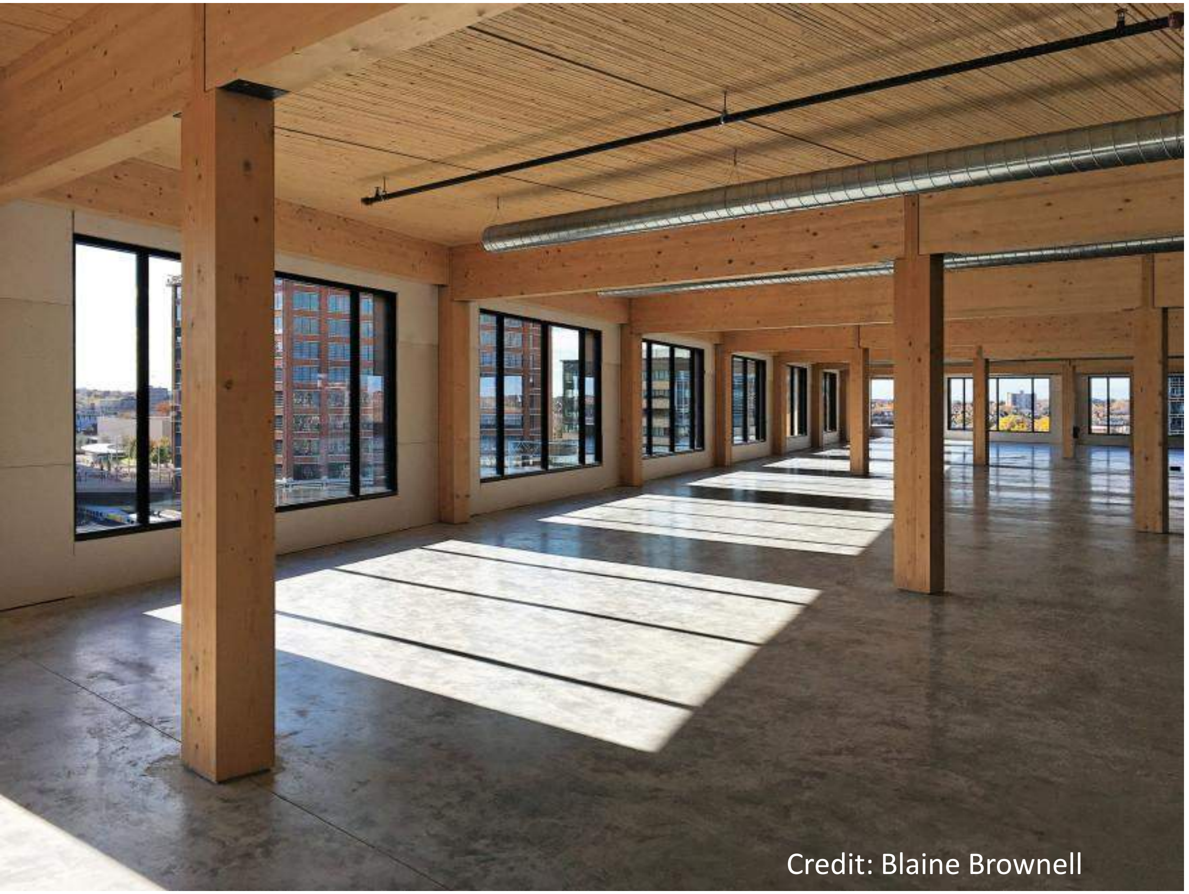
- Level of exposure desired
- Floor to floor, structure depth & desired head height
- Building occupancy and configuration (i.e. central core vs. double loaded corridor)
- Grid layout and beam orientations
- Need for future tenant reconfiguration
- Impact on fire & structural design: concealed spaces, penetrations

Credit: WoodWorks

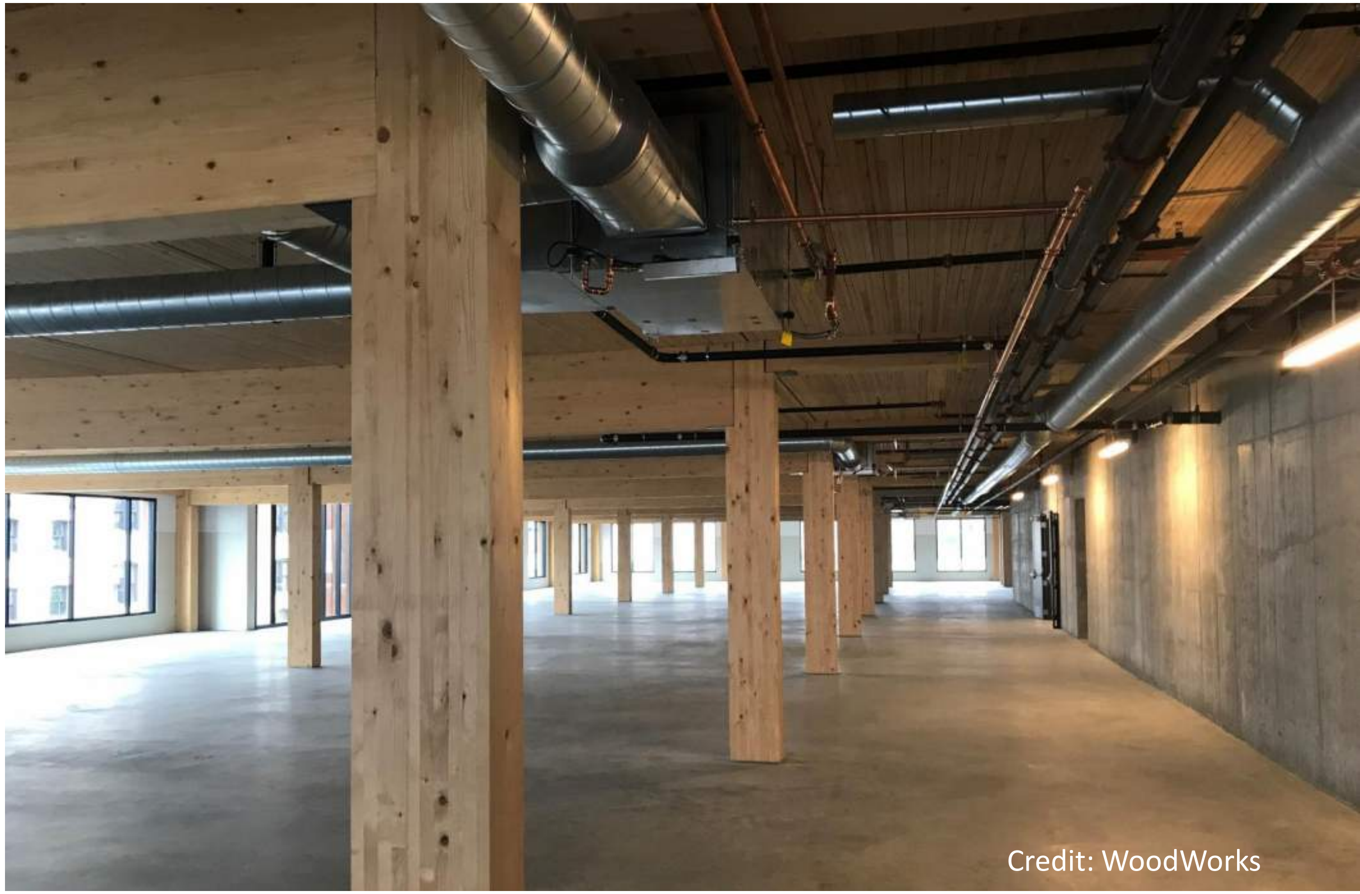
MEP Layout & Integration

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

Credit: Alex Schreyer

Credit: WoodWorks

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

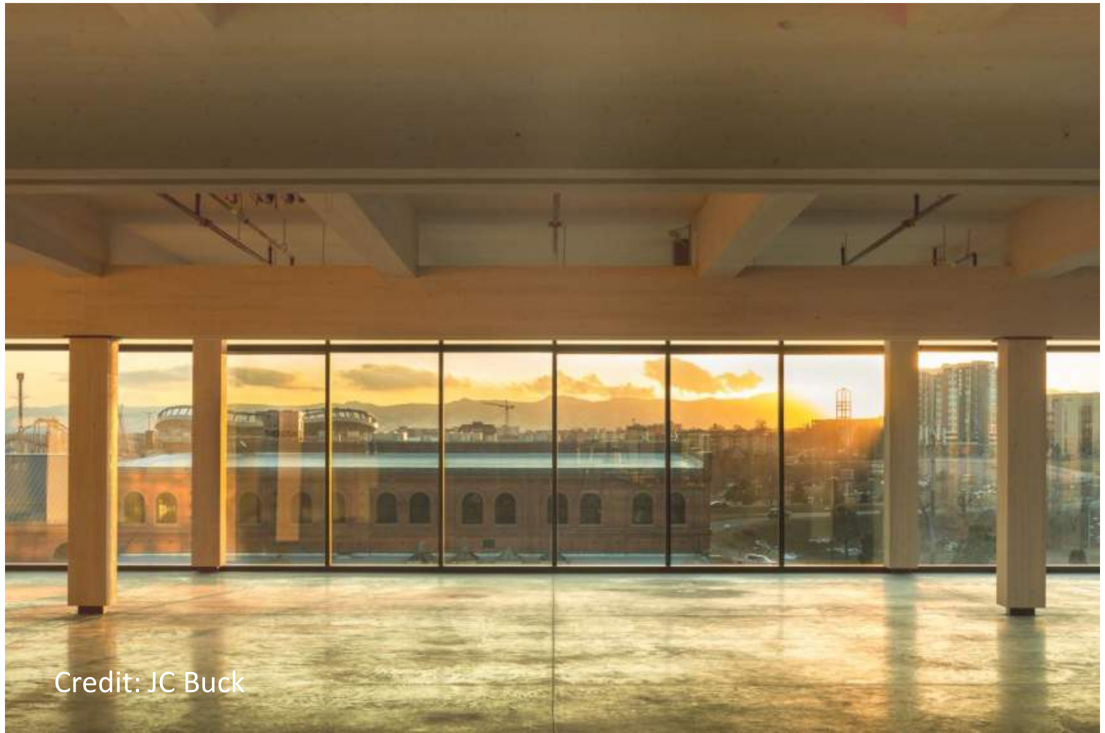
Credit: WoodWorks

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 raised access floor (RAF) above MT

- Aesthetics (minimal exposed MEP)
- Acoustic impacts (usually thinner topping req'd)

RAF

NON-RAF

Credit: BOKA Powell

MEP Layout & Integration

In raised access floor (RAF) above MT

- Impact on head height
- Concealed space code provisions

Outline

- » Key Early Design Decisions
- » Construction Types
- » Fire Design
- » Structural Grid
- » Connections
- » Penetrations & Firestopping
- » MEP Layout and Integration
- **Lateral Systems**
- » Acoustics

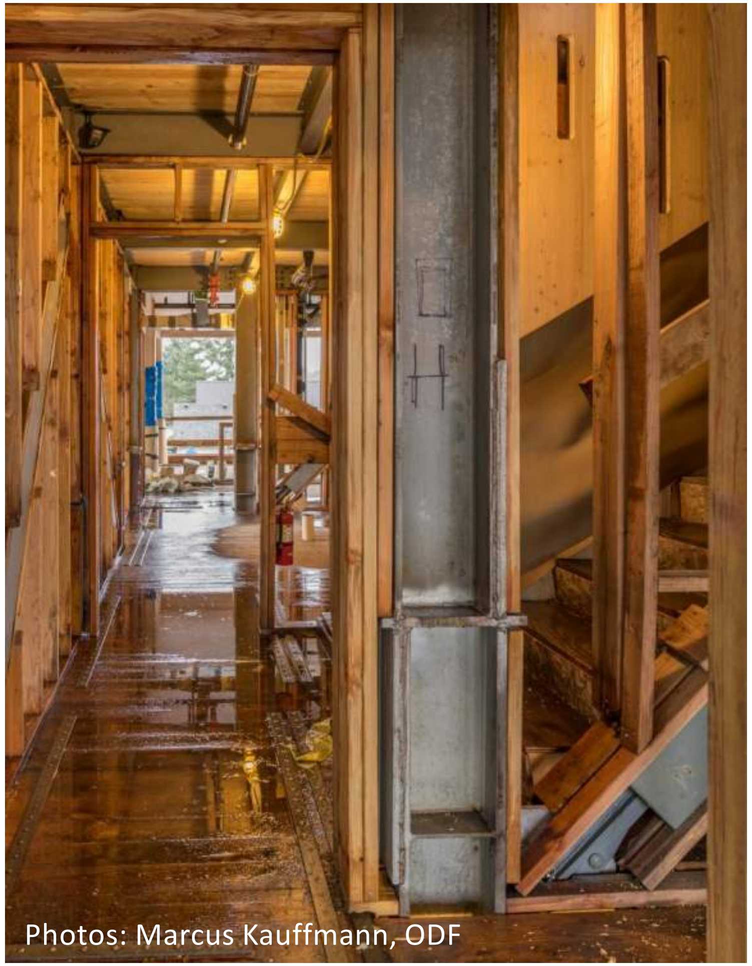
Lateral System Choices

Concrete Shear walls


Credit: Hacker Architects

Lateral System Choices

Steel Braced Frame



Photos: Marcus Kauffmann, ODF

Lateral System Choices

Wood-Frame Shear walls


Credit: KL&A Engineers & Builders

Lateral System Choices

MT Shear walls

Photo: Alex Schreyer

Lateral System Choices

MT Rocking Shear walls

Photo: WoodWorks

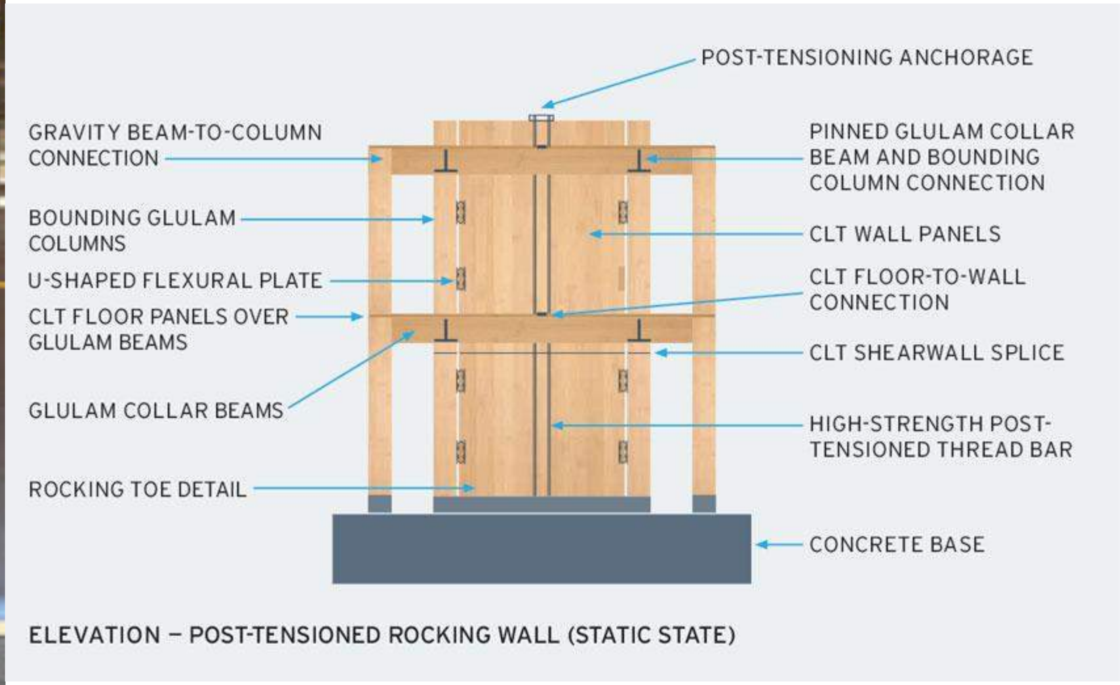


Image: KPFF

Lateral System Choices

Timber Braced Frame

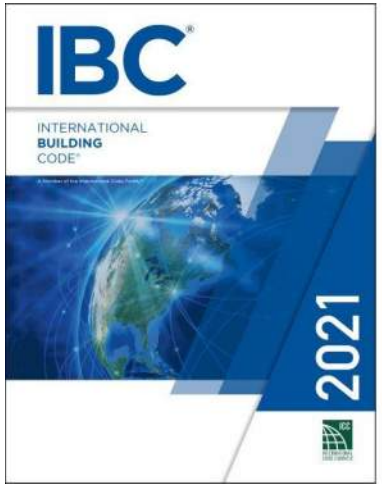
Credit: Alex Schreyer

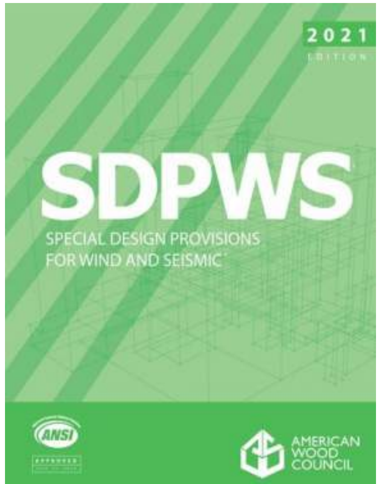
Lateral System Choices

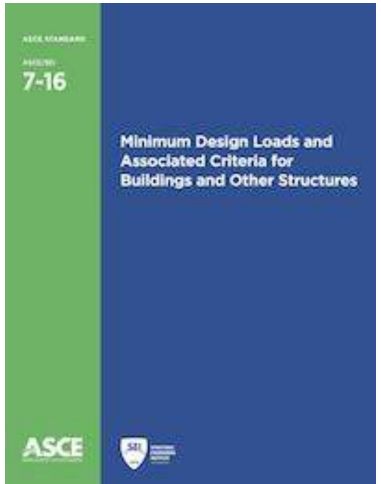
<u>Prescriptive Code Compliance</u>

- Concrete Shear walls ✓
- Steel Braced Frames ✓
- Light Wood-Frame Shear walls ✓
- CLT Shear walls ✓
- CLT Rocking Walls ✗
- Timber Braced Frames ✗

2021 SDPWS
ASCE 7-22







Outline

- » Key Early Design Decisions
- » Construction Types
- » Fire Design
- » Structural Grid
- » Connections
- » Penetrations & Firestopping
- » MEP Layout and Integration
- » Lateral Systems
- » Acoustics

Acoustics & Sound Control

Consider Impacts of:

- Timber & Topping Thickness
- Panel Layout
- Gapped Panels
- Connections & Penetrations
- MEP Layout & Type

Credit: Rothoblaas

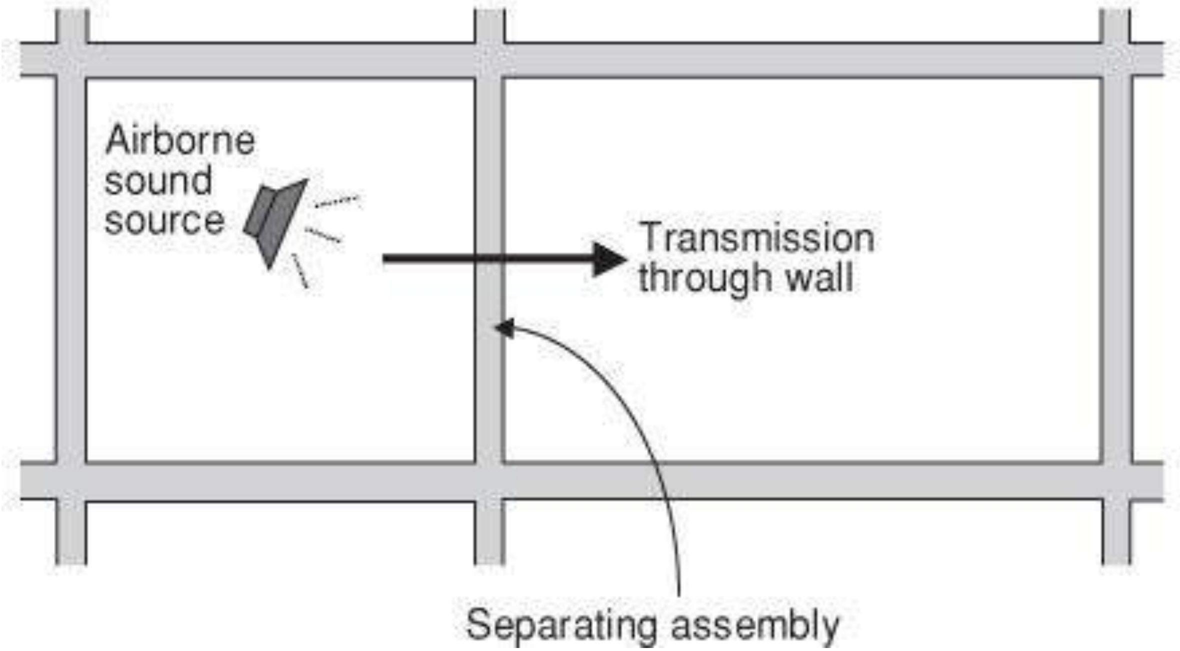
Acoustics & Sound Control

Air-Borne Sound:

Sound Transmission Class (STC)

» Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other

» Applies to walls and floor/ceiling assemblies

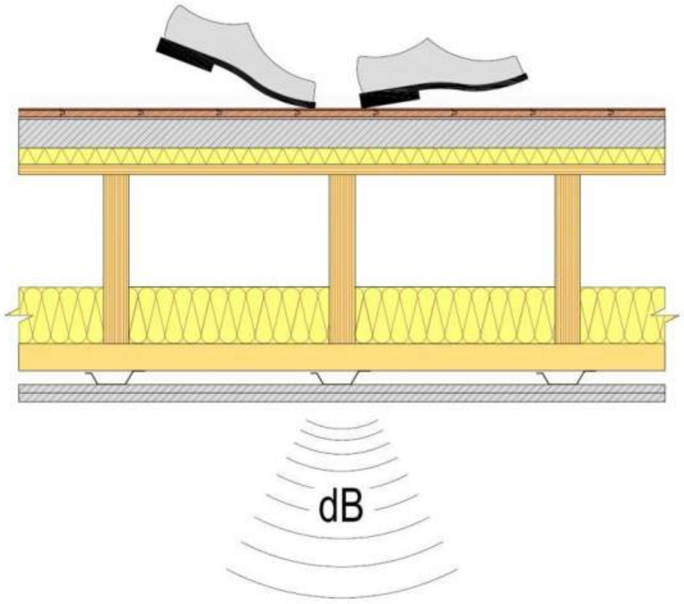


Acoustics & Sound Control

<u>Structure-Borne Sound:</u>

Impact Insulation Class (IIC)

- » Evaluates how effectively an assembly blocks impact sound from passing through it
- » Only applies to floor/ceiling assemblies



Acoustics & Sound Control

Code requirements only address residential occupancies:

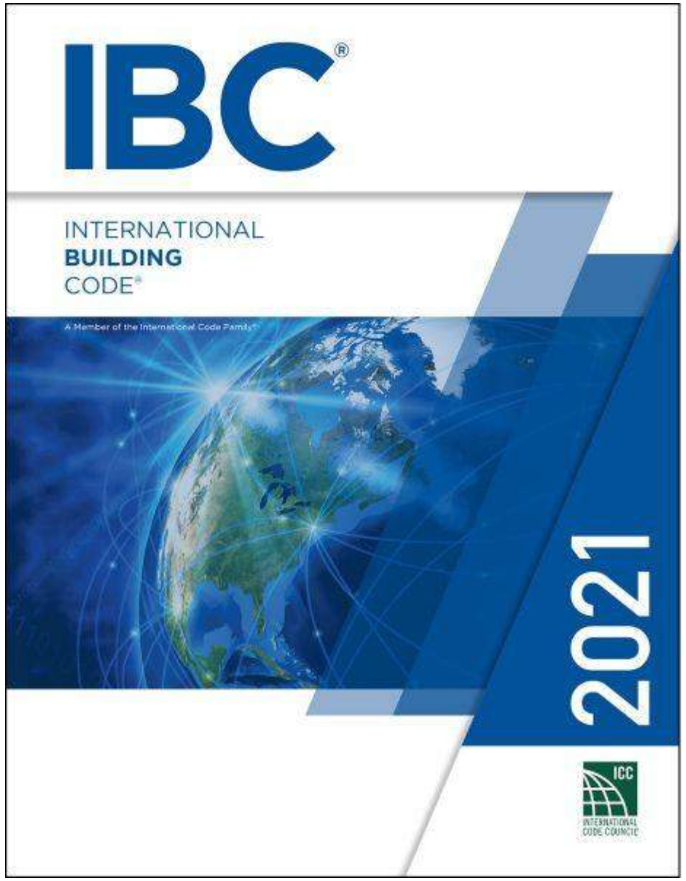
For unit to unit or unit to public or service areas:

Min. STC of 50 (45 if field tested):

» Walls, Partitions, and Floor/Ceiling Assemblies

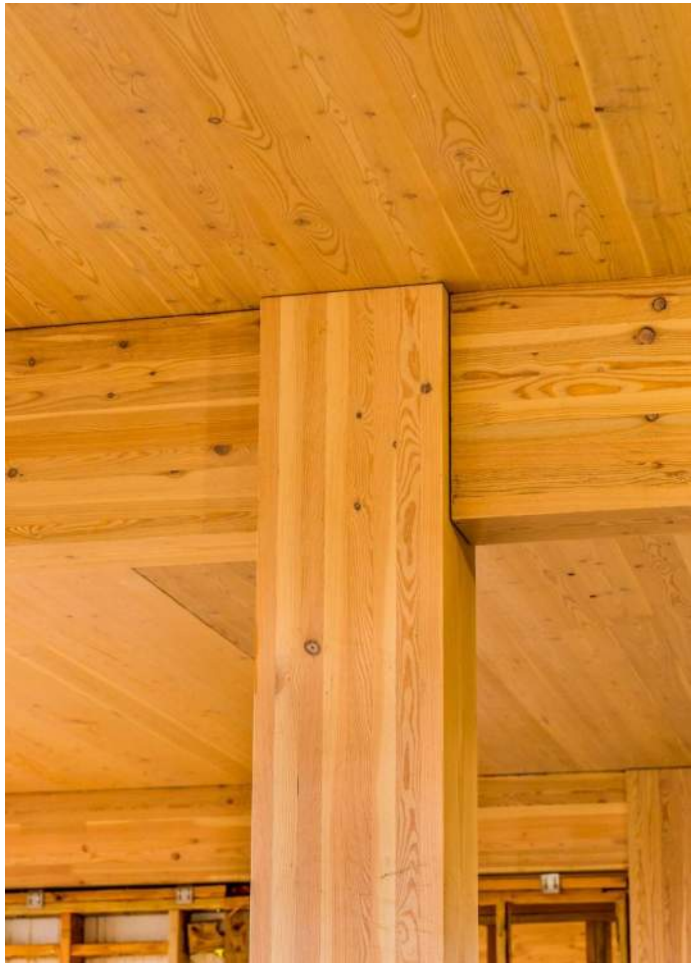
Min. IIC of 50 (45 if field tested) for:

» Floor/Ceiling Assemblies



Acoustics & Sound Control

MT: Structure Often is Finish



Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman | Architect: Kaiser + PATH

Acoustics & Sound Control

But by Itself, Not Adequate for Acoustics

Acoustics & Sound Control

TABLE 1:

Examples of Acoustically-Tested Mass Timber Panels

Mass Timber Panel	Thickness	STC Rating	IIC Rating
3-ply CLT wall[4]	3.07"	33	N/A
5-ply CLT wall[4]	6.875"	38	N/A
5-ply CLT floor[5]	5.1875"	39	22
5-ply CLT floor[4]	6.875"	41	25
7-ply CLT floor[4]	9.65"	44	30
2x4 NLT wall[6]	3-1/2" bare NLT 4-1/4" with 3/4" plywood	24 bare NLT 29 with 3/4" plywood	N/A
2x6 NLT wall[6]	5-1/2" bare NLT 6-1/4" with 3/4" plywood	22 bare NLT 31 with 3/4" plywood	N/A
2x6 NLT floor + 1/2" plywood[2]	6" with 1/2" plywood	34	33

Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks[7]

Acoustics & Sound Control

Regardless of the structural materials used in a wall or floor ceiling assembly, there are 3 effective methods of improving acoustical performance:

1. Add mass
2. Add noise barriers
3. Add decouplers

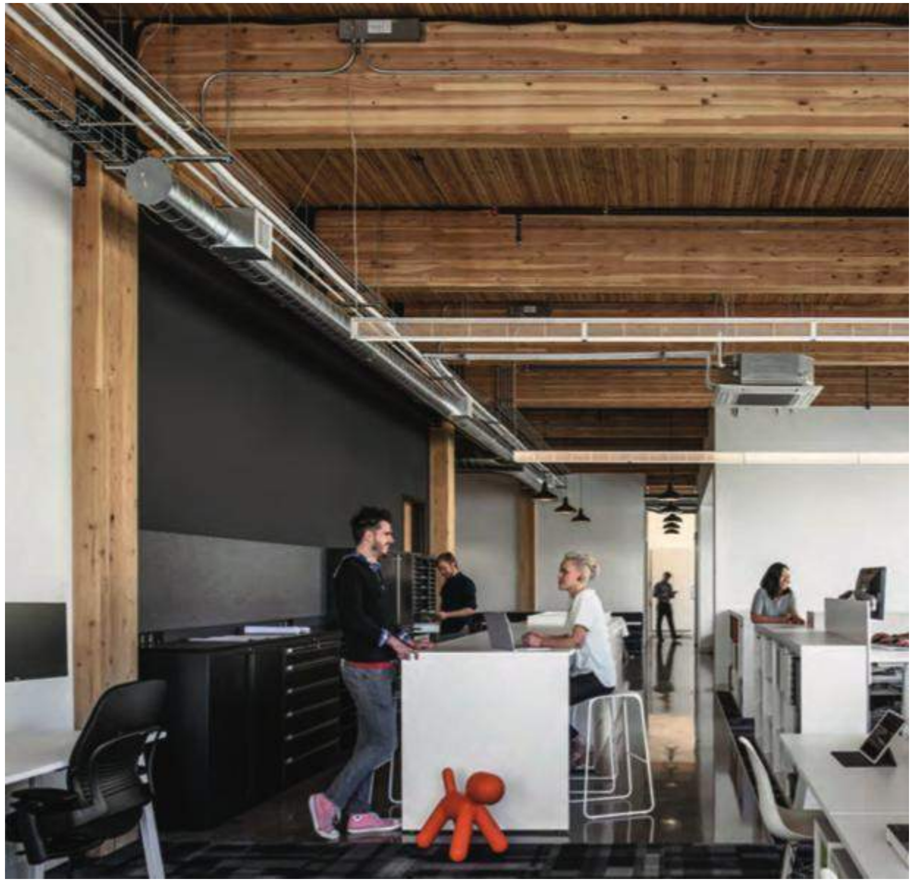


Image credit: Christian Columbres

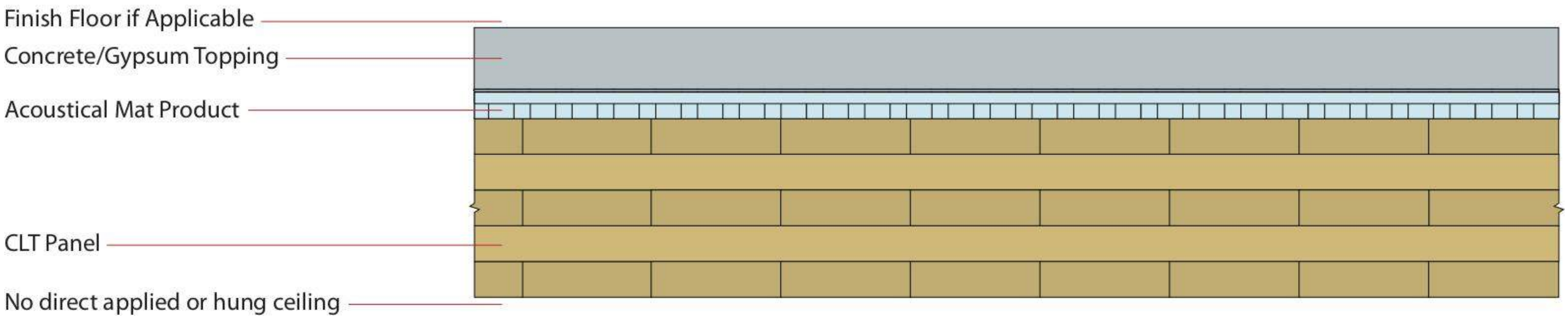
Acoustics & Sound Control

Concrete Slab:	CLT Slab:
6” Thick	6-7/8” Thick
80 PSF	18 PSF
STC 53	STC 41

Acoustics & Sound Control

There are three main ways to improve an assembly's acoustical performance:

1. Add mass
2. Add noise barriers
3. Add decouplers



Acoustics & Sound Control

There are three main ways to improve an assembly's acoustical performance:

1. Add mass
2. Add noise barriers
3. Add decouplers

Acoustical Mat:

» Typically roll out or board products
» Thicknesses vary: Usually ¼" to 1"+

Credit: Maxxon

Acoustics & Sound Control

Acoustical floor underlayments

Photo: AcoustiTECH[10]

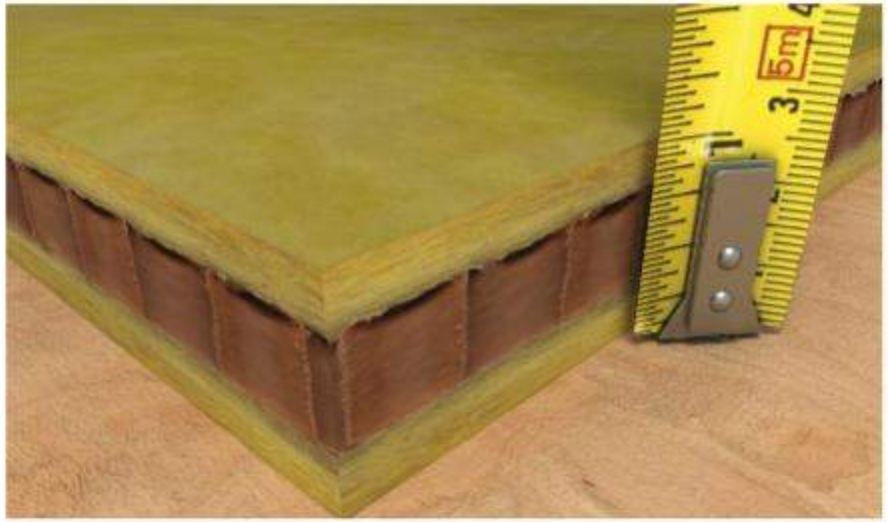


Photo: Kinetics Noise Control, Inc.,[11]

Photo: Maxxon Corporation

Photo: Pliteq Inc.,[12]

Acoustics & Sound Control

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

Credit: AcoustiTECH

Acoustics & Sound Control

Solutions Paper

http://www.woodworks.org/wp-content/uploads/wood_solution_paper-MASS-TIMBER-ACOUSTICS.pdf

WoodWorks™
WOOD PRODUCTS COUNCIL

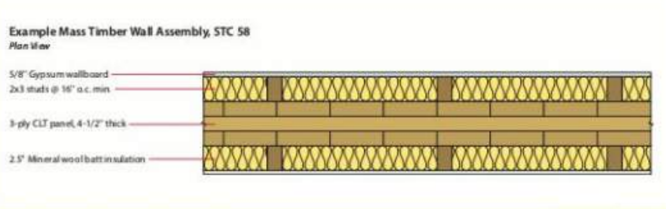
Acoustics and Mass Timber: Room-to-Room Noise Control

Richard McLain, PE, SE • Senior Technical Director • WoodWorks

The growing availability and code acceptance 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 has given designers a low-carbon alternative to steel, concrete, and masonry for many applications. However, the use of mass timber in multi-family and commercial buildings presents unique acoustic challenges.

While laboratory measurements of the impact and airborne sound isolation of traditional building assemblies such as light wood-frame, steel and concrete are widely available, fewer resources exist that quantify the acoustic performance of mass timber assemblies. Additionally, one of the most desired aspects of mass timber construction is the ability to leave a building's structure exposed as finish, which creates the need for asymmetric assemblies. With careful design and detailing, mass timber buildings can meet the acoustic performance expectations of most building types.

FIGURE 3:
Interior CLT partition wall with chase walls on both sides



Source: US CLT Handbook

Mass Timber Assembly Options: Walls

Mass timber panels can also be used for interior and exterior walls—both bearing and non-bearing. For interior walls, the need to conceal services such as electrical and plumbing is an added consideration. Common approaches include building a chase wall in front of the mass timber wall or installing gypsum wallboard on resilient channels that are attached to the mass timber wall. As with bare mass timber floor panels, bare mass timber walls don't typically provide adequate noise control, and chase walls also function as acoustical improvements. For example, a 3-ply CLT wall panel with a thickness of 3.07" has an STC rating of 33.[4] In contrast, Figure 3 shows an interior CLT partition wall with chase walls on both sides. This assembly achieves an STC rating of 58, exceeding the IBC's acoustical requirements for multi-family construction. Other examples are included in the inventory of tested assemblies noted above.

Acoustical Differences between Mass Timber Panel Options

The majority of acoustically-tested mass timber assemblies include CLT. However, tests have also been done on other mass timber panel options such as NLT and dowel-laminated timber (DLT), as well as traditional heavy timber options such as tongue and groove decking. Most tests have concluded that CLT acoustical performance is slightly better than that of other mass timber options, largely because the cross-orientation of laminations in a CLT panel limits sound flanking.

For those interested in comparing similar assemblies and mass timber panel types and thicknesses, the inventory noted above contains tested assemblies using CLT, NLT, glued-laminated timber panels (GLT), and tongue and groove decking.

Improving Performance by Minimizing Flanking

Even when the assemblies in a building are carefully designed and installed for high acoustical performance, consideration of flanking paths—in areas such as assembly intersections, beam-to-column/wall connections, and MEP penetrations—is necessary for a building to meet overall acoustical performance objectives.

One way to minimize flanking paths at these connections and interfaces is to use resilient connection isolation and sealant strips. These products are capable of resisting structural loads in compression between structural members and connections while providing isolation and breaking hard, direct connections between members. In the context of the three methods for improving acoustical performance noted above, these strips act as decouplers. With airtight connections, interfaces and penetrations, there is a much greater chance that the acoustic performance of a mass timber building will meet expectations.

Acoustical isolation strips

Photos: Rothoblaas

Acoustics & Sound Control

NRC·CNRC CONSTRUCTION

Acoustic Testing of CLT and G
Assemblies

Nordic Engineered Wood
Report No. A1-008253.1
19 August 2016

National Research Council Canada / Conseil national de recherches Canada

NATIONAL RESEARCH COUNCIL CANADA

REPORT TO RESEARCH CONSORTIUM FOR WOOD AND WOOD-HYBRID MID-RISE BUILDINGS

s Summary –

ulation in Mid-rise Wood Buil

T: A1-004377.2

014

Conseil national de recherches Canada

CLT (CROSS LAMINATED TIMBER)

CLT	Insulation	Resilient Channel	Ceiling	Min. Topping Depth	Sound Mat	Floor Covering	Sound Rating STC	Sound Rating IIC	Sound Rating Test Number	Maxxon UL Fire Ratings
7"	3½" Batt Insulation	Yes	Suspended Ceiling w/ 5/8" Drywall	3/4"	Acousti-Mat I	UT	54 F-STC		[illegible]	[illegible]
						Carpet and Pad	54 F-STC		[illegible]	
						UT		56 FIIC	[illegible]	
						Carpet and Pad		74 FIIC	[illegible]	

CLT	Insulation	Resilient Channel	Ceiling	Drywall	Min. Topping Depth	Sound Mat	Floor Covering	Sound Rating STC	Sound Rating IIC	Sound Rating Test Number	Maxxon UL Fire Ratings
				No	3/4"	Acousti-Mat I	None	45 F-STC		FP Innovations	[illegible]
							None		36 F-IIC	FP Innovations	

Drywall	Min. Topping Depth	Sound Mat	Floor Covering	Sound Rating STC	Sound Rating IIC	Sound Rating Test Number	Maxxon UL Fire Ratings
No	None	No	None	39 F-STC	22 FIIC	[illegible]	[illegible]

…over of this guide. For assistance determining the right system for your project, contact your Maxxon Regional Representative at (800) 356-7887

Intertek | Architectural Testing

F5500.11-113-11-R0
ACOUSTICAL PERFORMANCE TEST REPORT
ASTM E 90 AND ASTM E 492

Rendered to

PLITEQ INC.

Series/Model: Vintage Floors Wood Flooring on Pliteq GenieMat™ RST02 over Isolation System - Pliteq GenieMat™ FF50 Rubber Underlayment

Specimen Type: Cross Laminated Timber - 175 mm (6.89")

Overall Size: 3023 mm by 3632 mm (119" by 143")

STC	**58**
IIC	**59**

Test Specimen Identification:
Floor Topping: 12.7 mm (0.5") Vintage Floors Wood Flooring
Floor Underlayment: 2 mm (0.08") Pliteq GenieMat™ RST02 Rubber Underlayment
Subfloor Topping: 101.6 mm (4") Concrete Slab
Subfloor Underlayment (Top Layer): 24.8 mm (0.98") Pliteq GenieMat™ FF25 Rubber Underlayment
Subfloor Underlayment (Bottom Layer): 24.8 mm (0.98") Pliteq GenieMat™ FF25 Rubber Underlayment
Floor Slab: 175 mm (6.89") Nordic Wood Products X-LAM Cross Laminated Timber

Reference should be made to Intertek-ATI Report F5500.11-113-11 for complete test specimen description. This page alone is not a complete report.

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KINETICS NOISE CONTROL, INC.
ACOUSTICAL PERFORMANCE TEST REPORT

SCOPE OF WORK
ASTM E90 AND ASTM E492 TESTING ON USG STRUCTURAL PANELS CONCRETE SUBFLOOR WITH RIM-L-2-16 SYSTEM OVER STRUCTURE CRAFT NLT

SPECIMEN TYPE
Nail Laminated Timber - 152 mm

REPORT NUMBER
I8483.04-113-11-R1

TEST DATE
10/11/18

ISSUE DATE 11/16/18 **REVISED DATE** 11/20/18

RECORD RETENTION END
10/11/22

PAGES
12

DOCUMENT CONTROL
ATI 00629 (03/21/18)
RTTDS-R-AMER-Test-2844
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Acoustics & Sound Control

Inventory of Acoustically Tested Mass Timber Assemblies

WOODWORKS
WOOD PRODUCTS COUNCIL

Following is a list of mass timber assemblies that have been acoustically tested as of April 5, 2024. Sources are noted at the end of this document. For free technical assistance on any questions related to the acoustical design of mass timber assemblies, or free technical assistance related to any aspect of the design, engineering or construction of a commercial or multi-family wood building in the U.S., email help@woodworks.org or contact the WoodWorks Regional Director nearest you: http://www.woodworks.org/project-assistance

Contents:

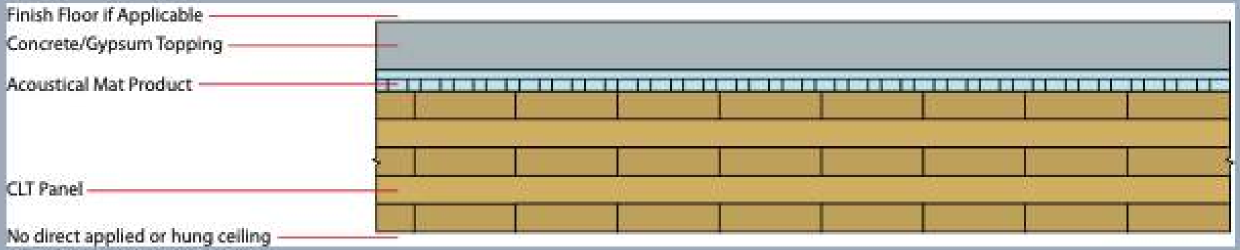
http://bit.ly/mass-timber-assemblies

Acoustics & Sound Control

Inventory of Tested Assemblies

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

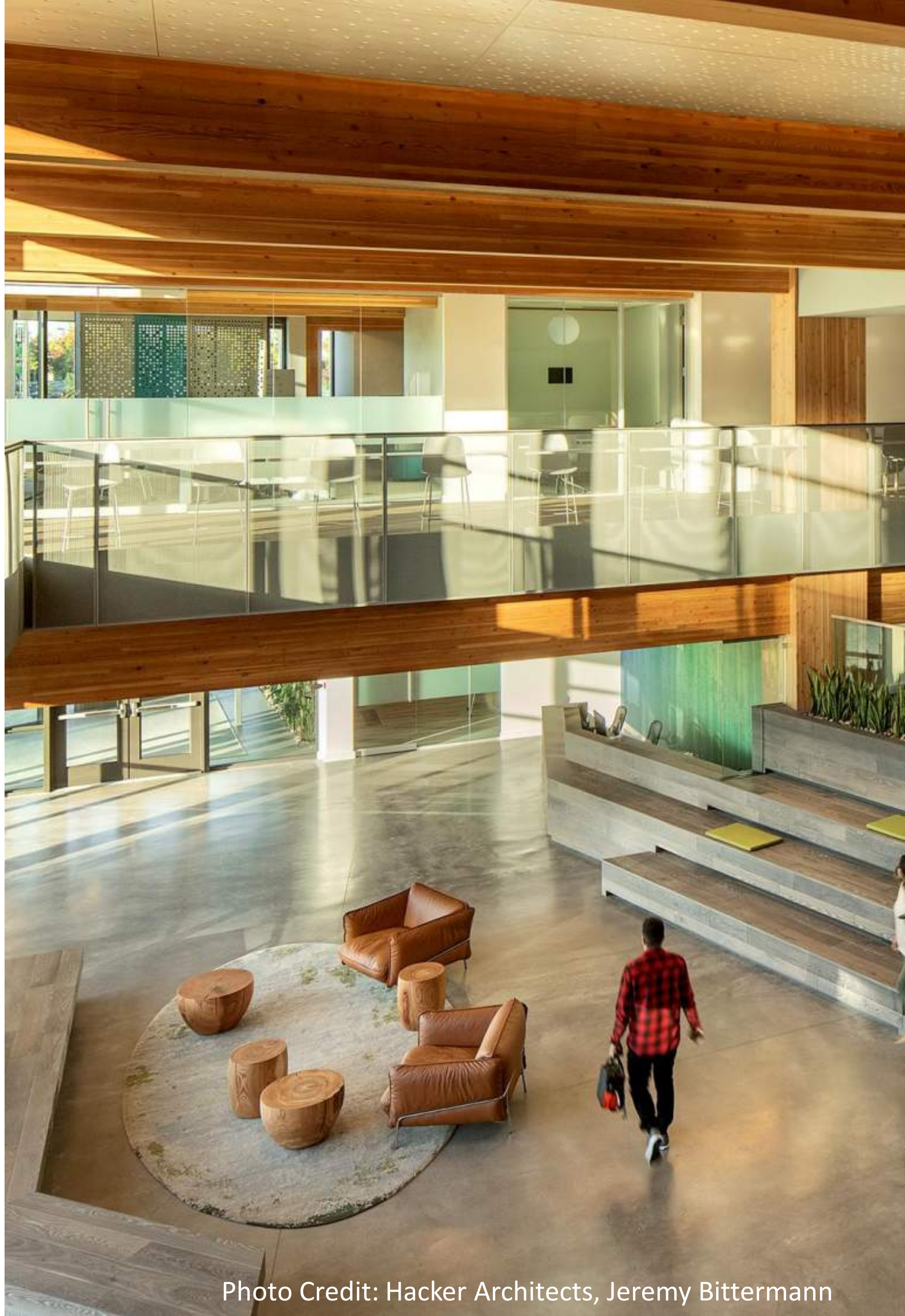
WoodWorks
WOOD PRODUCTS COUNCIL



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

Keys to Mass Timber Success:

- Know Your WHY
- Design it as Mass Timber From the Start
- Leverage Manufacturer Capabilities
- Understand Supply Chain
- Optimize Grid
- Take Advantage of Prefabrication & Coordination
- Expose the Timber
- Discuss Early with AHJ
- Work with Experienced People
- Let WoodWorks Help for Free
- Create Your Market Distinction



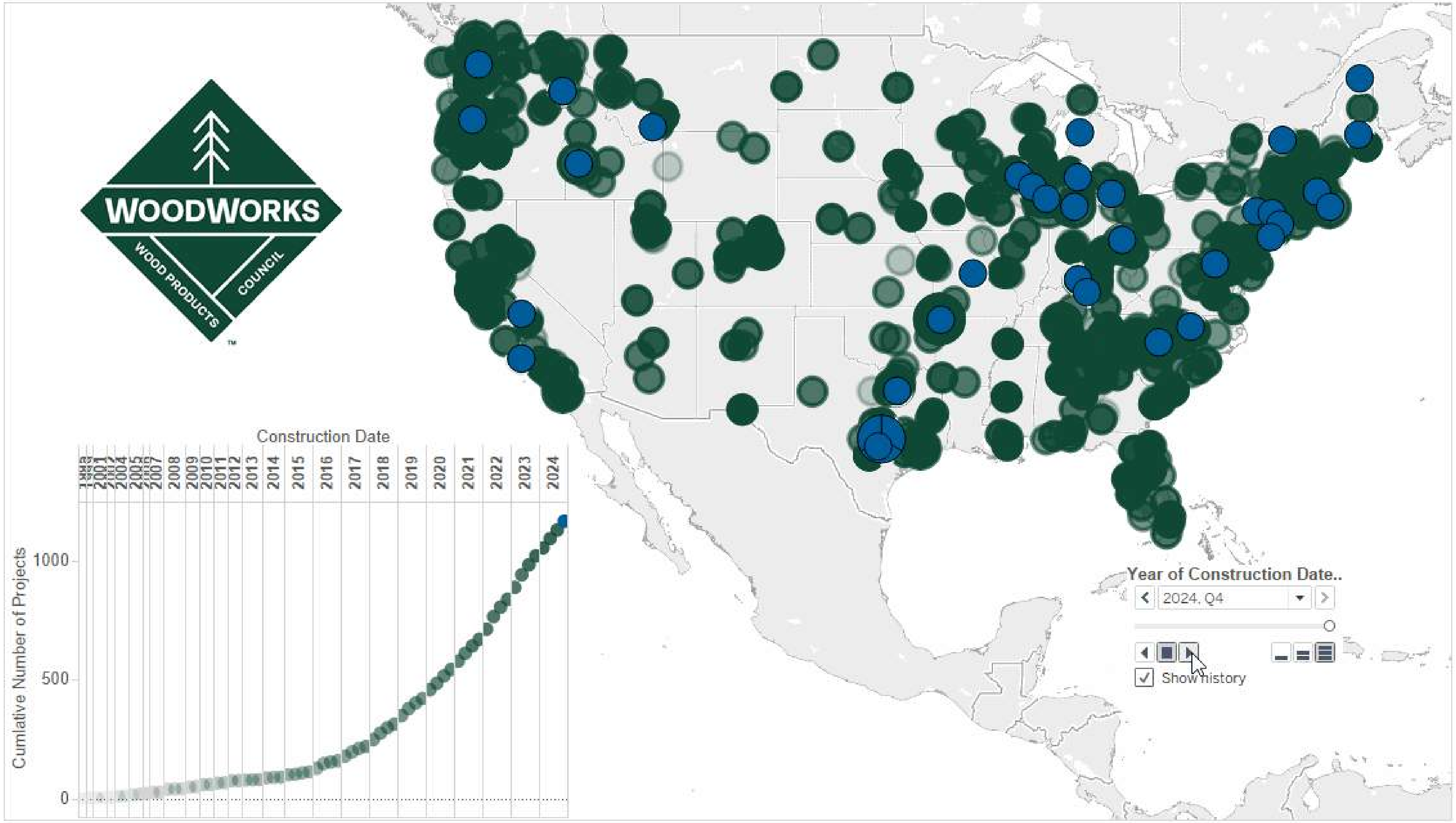
Mass Timber Construction: Costing & Construction Management

Mike Romanowski, SE

Photo: Structurlam

Current State of Mass Timber Projects Over Time

US Market Year-End 2024



WOODWORKS
WOOD PRODUCTS COUNCIL

How to Successfully Cost Manage a Mass Timber Project

Cost-Estimating Considerations for General Contractors

Apex Plaza
William McDonough + Partners / Hourigan

A determining factor in the success of a mass timber project—and whether it goes forward at all—is the general contractor's ability to provide informed cost estimates from the earliest stage of design. However, unlike other materials, there isn't a hundred years of tradition and shared experience to guide budgeting, cost management, and competitive procurement, or readily available cost benchmarking.

This paper is intended to bridge that gap with guidance for minimizing whole project costs and maximizing the value of mass timber projects. It has been written with an emphasis on cross-laminated timber (CLT) and glue-laminated timber (glulam), but applies generally to all mass timber materials. Follow these steps to more confidently cost plan your next wood building.

This paper was developed collaboratively with a design and construction professional who specializes in mass timber construction and has worked on multiple projects for general contractors. Costs, percentages and other values are based on their experience and may differ for other projects.

Step 1: Do Your Homework
- Vet Potential Subcontractors
- Determine the Procurement Model
- Procurement Models

Step 2: Establish a Reliable Pre-Design Budget
- Basic Timber Pricing Dynamics
- Provide this Information for Better Supply Pricing
- Insights for Better Budgeting
- Choose Your List of Bidders
- Adjust Budgets for Other Trades Impacted by Timber

Step 3: Manage Project Costs (not covered)
- Establish Cost Benchmarking
- Understand the Largest Non-Timber Design Cost Levers

Timber Bidding Package – Bidding Checklist (not covered)

https://www.woodworks.org/resources/how-to-successfully-cost-manage-a-mass-timber-project/

Step 1: Do Your Homework

Vet Potential Subcontractors

- Which products do you manufacture vs. which do you supply?
- What services do you typically provide?
- What is the ideal project for your company?
- What is your lead time?

Step 1: Do Your Homework

Determine the Procurement Model

The Importance of Choosing an Appropriate Procurement Model

- Can impact the timber package price by as much as 30% - or more than 5% of total project hard costs

Factors Beyond the GC's Control

- Available resources
- Complexity of the timber system
- What stage the GC is brought on board

Step 1: Do Your Homework

Procurement Models

Installer Furnish and Install

- Single contract between GC and installer; installer supplies material and installation

Manufacturer Furnish and Install

- Single contract between GC and manufacturer; manufacturer subcontracts installer

Furnish and Install Separately

- GC procures material direct from manufacturer; separate contract with installer

GC Self-Perform

Design-Build Subcontract

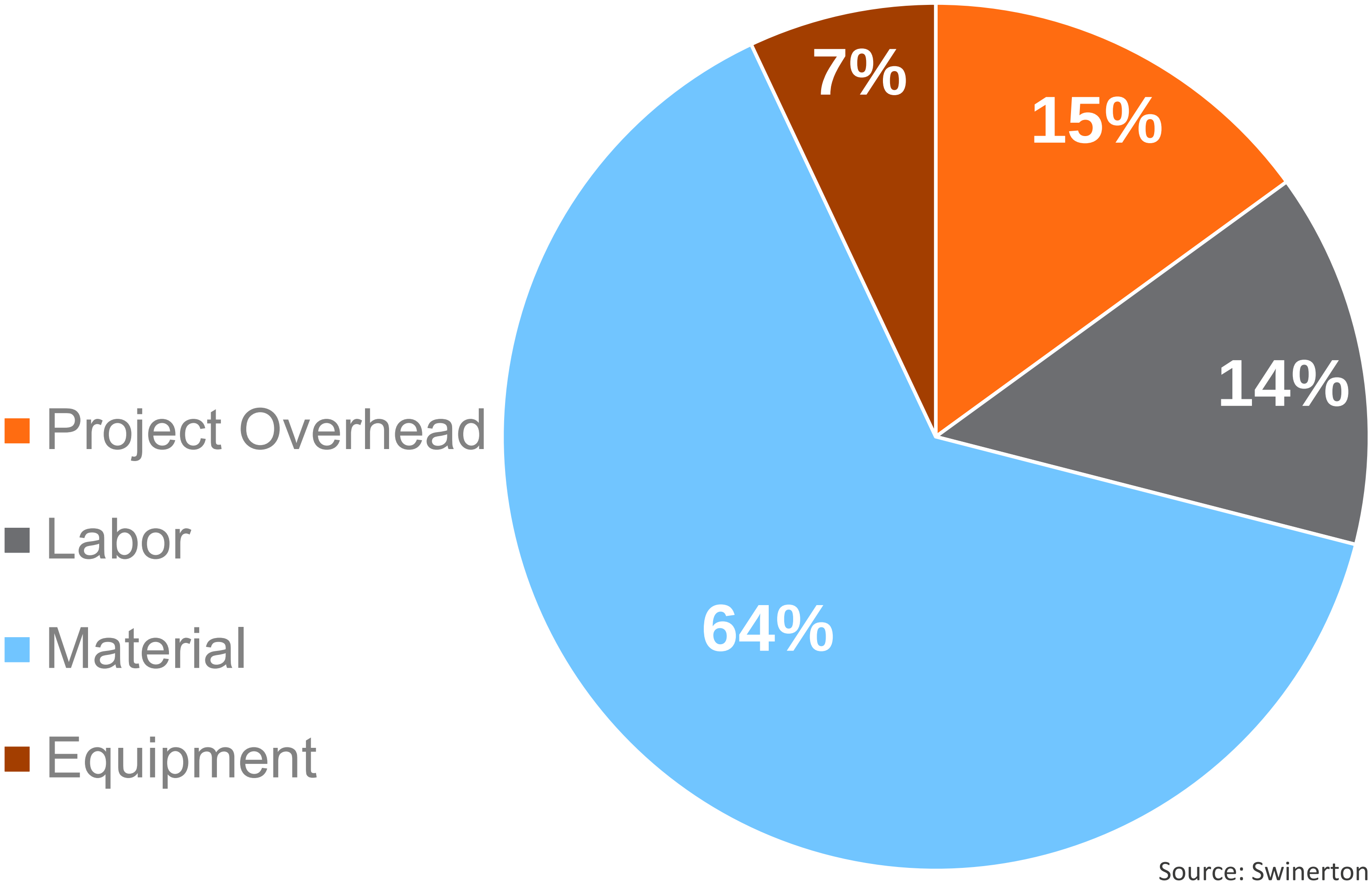
Step 2: Establish a Reliable Pre-Design Budget

Basic Timber Pricing Dynamics

Initial Hurdle

- Most GC’s don’t have access to enough benchmarking data to reliably provide a generic per square foot cost in the structure line item of a conceptual trade package build-up
- The cost of the timber supply package far outweighs the cost of installation

Typical MT Package Costs



Source: Swinerton

Step 2: Establish a Reliable Pre-Design Budget

Provide this Information for Better Supply Pricing

- Components that will be timber
- Grid size and structural typology
- Elements that will be exposed and their fire ratings
- Appearance grade requirements
- Local sourcing and/or forest certification requirements

Step 2: Establish a Reliable Pre-Design Budget

Insights for Better Budgeting

Important to Ask Manufacturers and Suppliers What is Included (and Excluded) from Costs they Provide

- CLT and glulam
- Hardware
- Shipping
- Installation (consider asking for crane and staging yard costs separately)

Step 2: Establish a Reliable Pre-Design Budget

Choose Your List of Bidders

- Good to have three or four qualified/interested bidders to cover both supply and installation scopes if not being bid together
- Not every project is the right fit for every supplier or installer and producing a good bid takes time
- It is important to have a flexible specification to meet the design team's intentions. Knowing that the project will be CLT doesn't mean that every CLT manufacturer can meet the design team's requirements
  - Panel width/length/depth requirements may exclude some manufacturers
  - Material grade and species requirements may exclude some manufacturers
  - Project schedule vs. manufacturer's production capability/workload
  - Range of services provided by bidder (manufacturer/supplier/installer)

Step 2: Establish a Reliable Pre-Design Budget

Adjust Budgets for Other Trades Impacted by Timber

Mass Timber Impacts More than the “Structure” Line Item

- Foundations (primarily in high-rises)
- Separate structural systems (gravity vs. lateral)
- Fire protection (when structure is the finish)
- General conditions (project schedule savings)

Key Takeaways

- A determining factor in the success of a mass timber project – and whether it goes forward at all - is the general contractor’s ability to provide informed cost estimates from the earliest stage of design.
- Unlike other materials, there isn’t a hundred years of tradition and shared experience to guide budgeting, cost management, and competitive procurement, or readily available cost benchmarking.
- This cost management resource is intended to bridge that gap with guidance for minimizing whole project costs and maximizing the value of mass timber projects. It was written with an emphasis on multi-story residential and commercial projects using cross-laminated timber (CLT) and glue-laminated timber (glulam), but can be applied generally to many mass timber materials and applications.

MASS TIMBER CONSTRUCTION MANAGEMENT

Procurement Strategy is Key to Success

Design-Build

Design-Bid-Build

5% Savings

Neutrality

10% Premium

Procurement Approach Determines Schedule

Photo: Alex Schreyer

Procurement Approach Determines Schedule

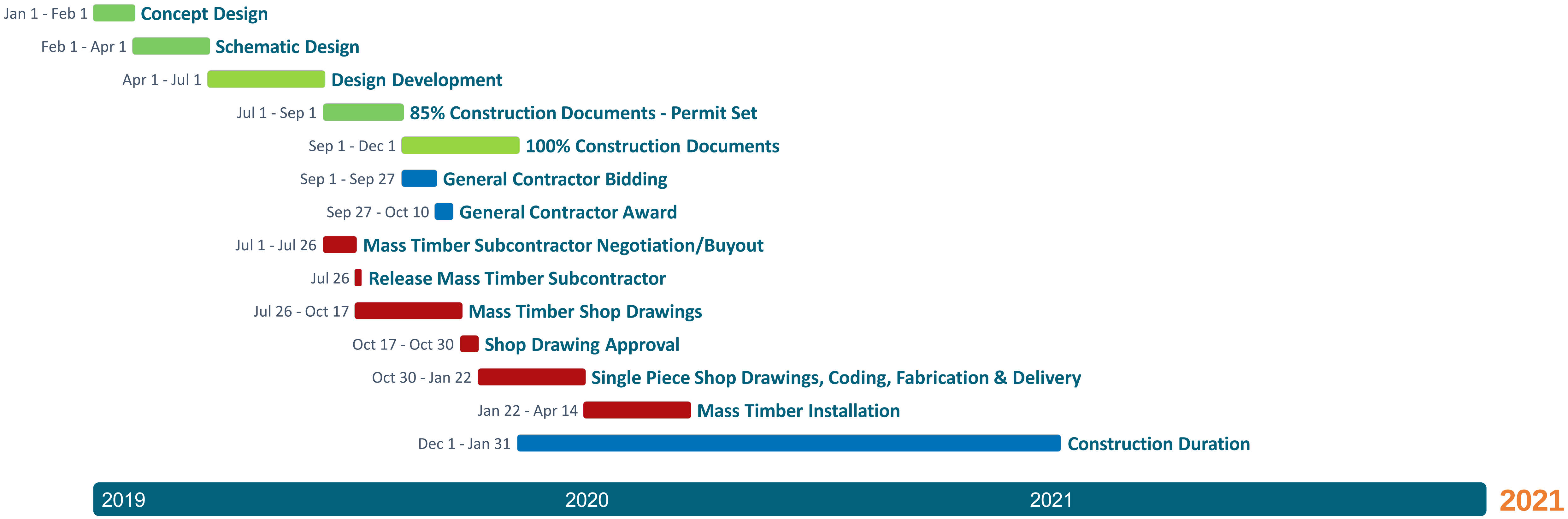
Example 6 Story Type IIIA Project

Source: Swinerton

Design-Bid-Build Procurement

Procurement Approach Determines Schedule

Example 6 Story Type IIIA Project



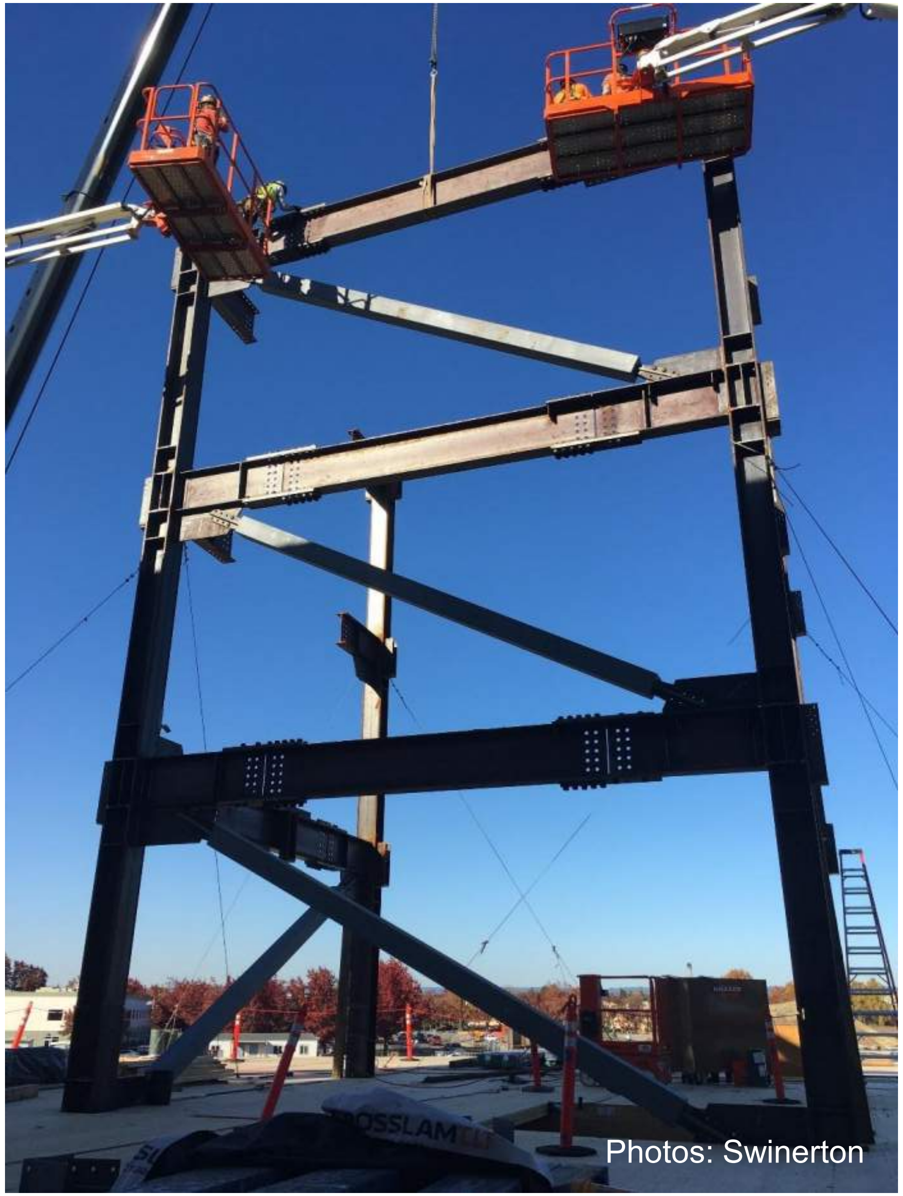
Source: Swinerton

Design-Build/Design-Assist Procurement

What are the Schedule Drivers on a Mass Timber Project?

Photo: Lendlease

Schedule Impacts: Hybrid Structures

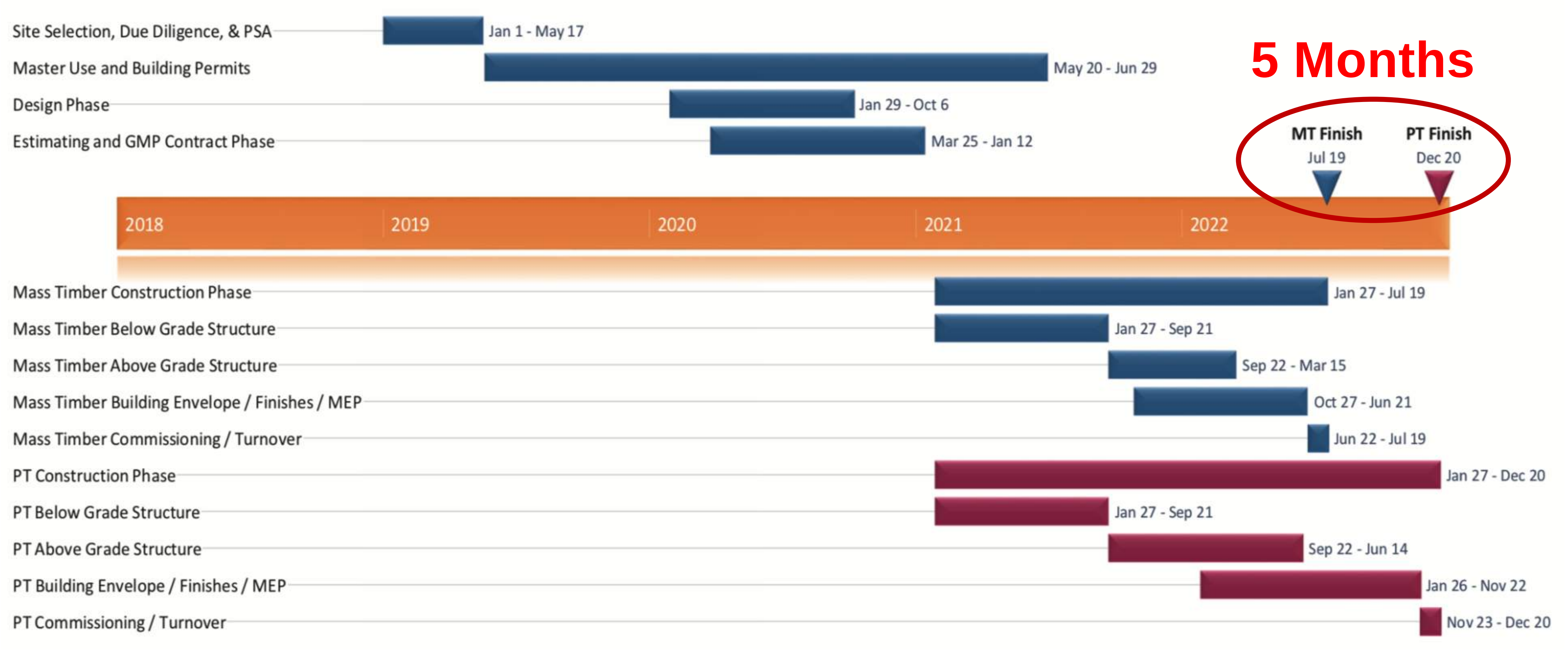


Photos: Swinerton

Is There a Schedule Savings with a Mass Timber Structure Compared to Other Structural Systems?

Photo: StructureCraft Builders

Overall Project Schedule Analysis: 12-Story Type IV-B



Source: Swinerton

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

Credit: DLR Group | Fast + Epp | 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

Schedule Savings for Rough-In Trades

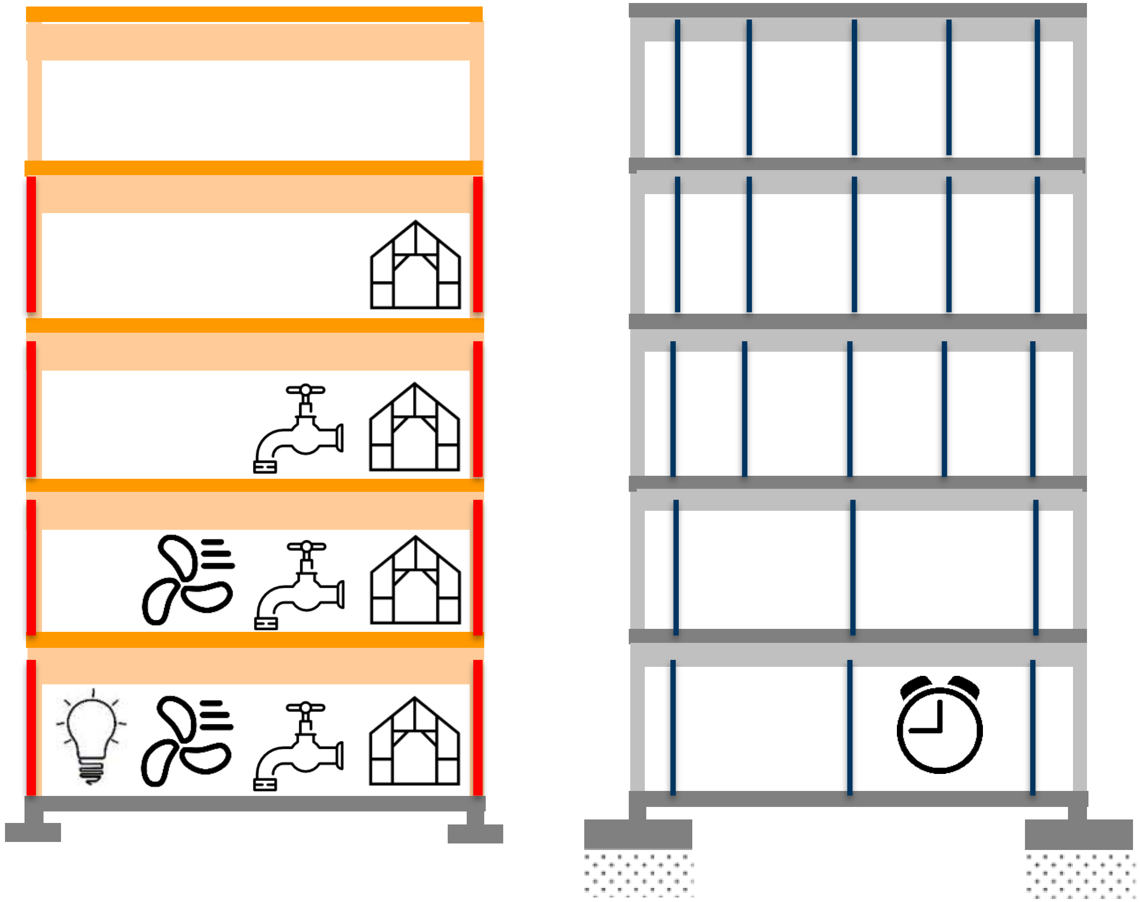


Photo: WoodWorks

Image: Swinerton

Holistic Schedule Analysis

Shorter Schedule = Lower General Conditions Costs

Photo: Swinerton

SITE PLANNING

Photo: Swinerton

Transportation & Storage

Photos Paul Alberts / Ardor Media / naturallywood.com

SITE ORGANIZATION & STAGING

Photo: Swinerton

PICK PLAN

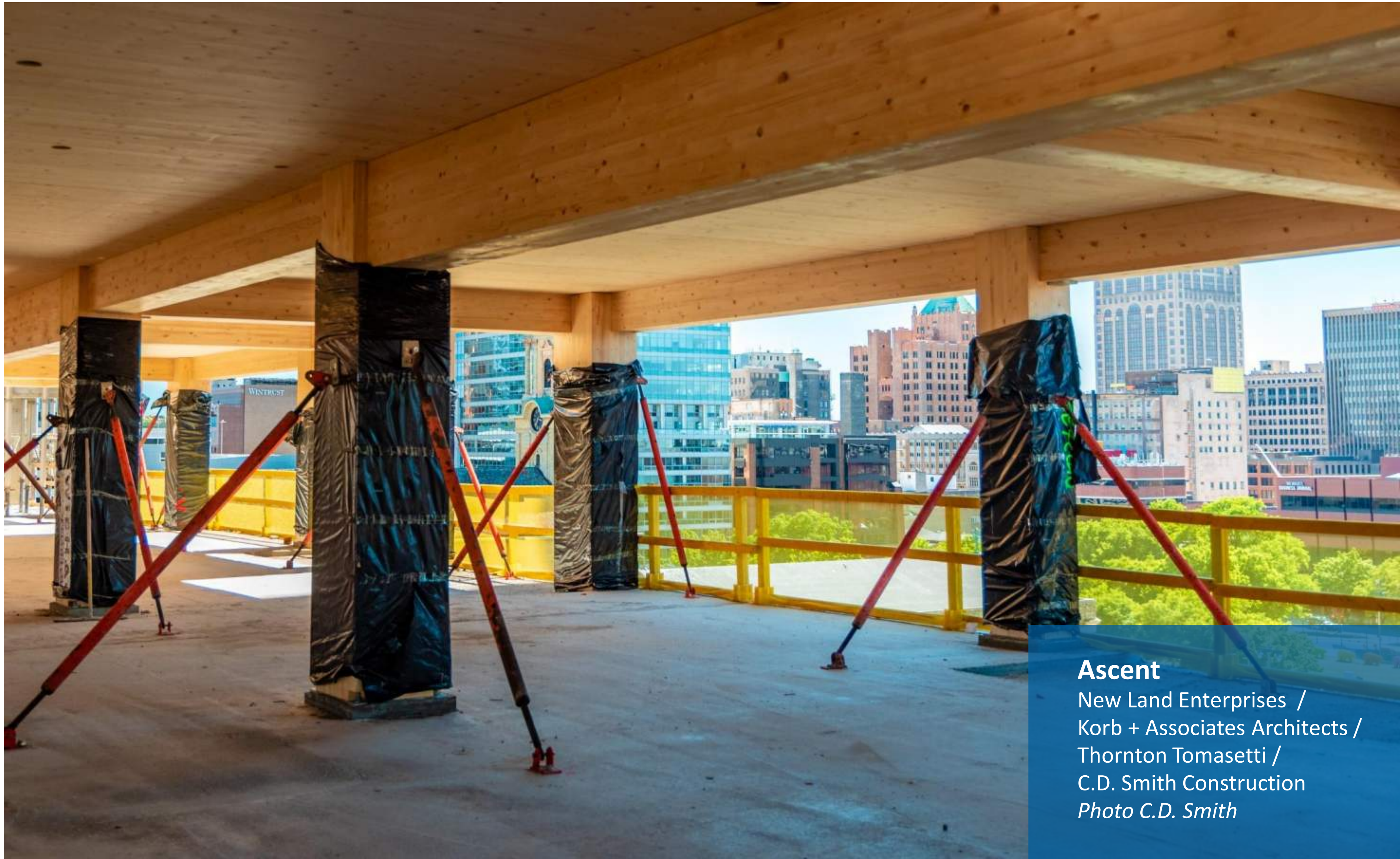
Photo: Swinerton

QA/QC

Photo: Swinerton

Material Protection

- Moisture
- UV rays
- Damage



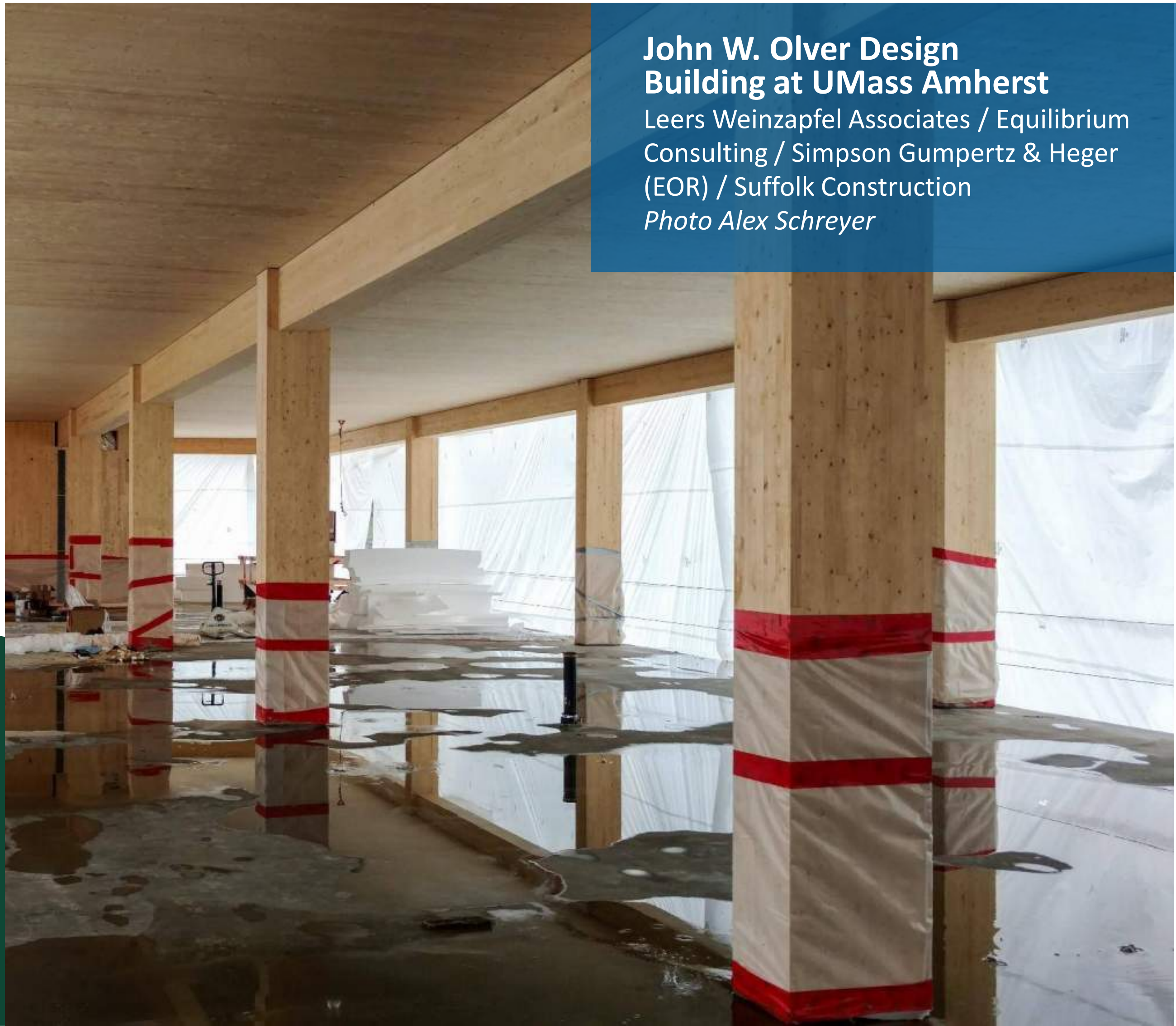
Ascent
New Land Enterprises /
Korb + Associates Architects /
Thornton Tomasetti /
C.D. Smith Construction
Photo C.D. Smith

Moisture Management

Keep wood as dry as possible to avoid:

- Stains and dirt
- Shrinkage and swelling
- Damage from prolonged moisture exposure

Mass timber *can* get wet—and *will* get wet on most projects. That is not a problem, provided an effective moisture management plan is in place.



John W. Olver Design Building at UMass Amherst
Leers Weinzapfel Associates / Equilibrium Consulting / Simpson Gumpertz & Heger (EOR) / Suffolk Construction
Photo Alex Schreyer

Moisture Management Plan

Planning starts at the earliest stage and is collaborative.

Construction team responsibilities include:

- » Construction phase plan; on-site strategies based on risk evaluation
    - » Coverings
    - » Deflection/diversion
    - » Ventilation/drying
- » Anticipating and troubleshoots issues
- » Monitoring

Type and Extent of Protection

- Decision by architect/contractor
- Appearance requirements
- Extent and cost of protection methods
- Protection in fabrication plant and/or on jobsite
- Capability of fabricator
- Capability of installer/moisture protection subcontractor
- Schedule protection plan
- Protection prior to installation
- Protection during installation
- Protection after installation

Moisture Management Responsibility and Risk

- Responsibility for managing and cost of the plan
- Contractor and/or fabricator
- Conditions to be considered
- Schedule delays and revisions
- Construction weather conditions (worst case)

Monitoring Moisture Before, During and After Construction

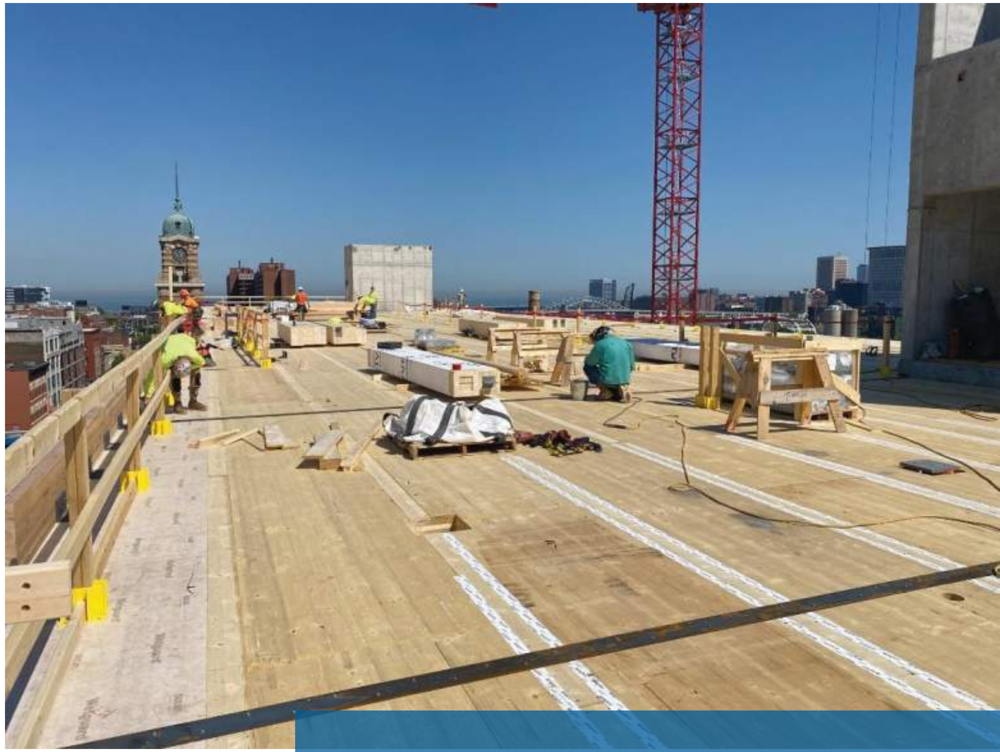
- Coordination with concrete topping activities
- Roofing material
- Columns, beams and floor/wall panels

U.S. Mass Timber Construction Manual / WoodWorks

Factory-Applied Sealants & Coatings

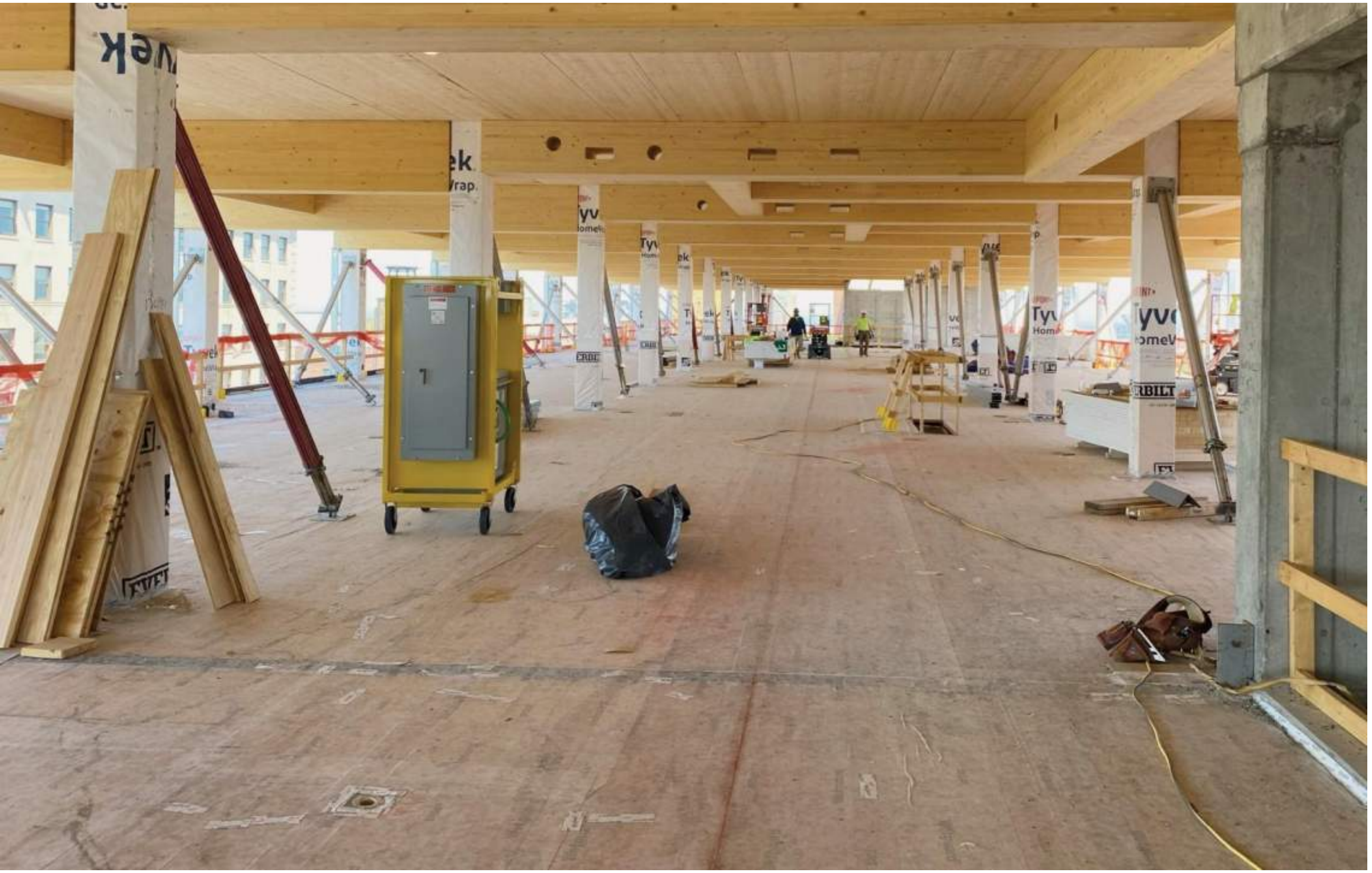
Adidas Headquarters
LEVER Architecture / KPFF / Turner Construction Company
Photo Jeremy Bittermann

Panel Joint Treatment



INTRO
Harbor Bay Ventures / Hartshorne Plunkard Architecture / Forefront Structural Engineers / Fast + Epp / Panzica Construction
Photos WoodWorks

Coverings



INTRO / Photos WoodWorks

Deflection & Diversion

From Moisture Risk Management Strategies for Mass Timber Buildings,

Platte Fifteen
Oz Architecture / KL&A Engineers & Builders / Adolfson & Peterson Construction
Photo WoodWorks

Moisture Monitoring

Monitor the moisture content (MC) of wood materials throughout construction.

- When materials are received
- Regular intervals
- After rainfall
- Before drying in

Product	MC at Manufacture	Desired MC at Project Close-in with Direct-Applied Concrete Toppings
CLT	12% +/- 3%[a]	<16%
GLT	12-16%[b]	<16%
NLT	<19%[c]	<16%
DLT	15-19%[d]	<16%

Sources: [a]PRG-320 standard, [b]ANSI A190.1, [c]Nail-Laminated Timber Design Guide – U.S. Edition, and [d]DLT Design and Profile Guide

The Best Way to Minimize Exposure to Moisture is to Close in the Project Quickly

INTRO / Photo Harbor Bay Ventures

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

Record Your Attendance for CEUs

Funding provided in part by the Softwood Lumber Board