Mass Timber Constructability and Costing

February 20, 2025

Presented by

Kate Carrigg, PE

Image: 1 De Haro / Perkins&Will / DCI Engineers / Photo Kyle Jeffers

Understanding how mass timber differs from other building systems is key to cost effectiveness.

The Canyons
Kaiser+Path / catena consulting engineers / R&H Construction
Photo Marcus Kauffman

Agenda

Mass Timber Constructability and Costing

	11:00 – 12:00 pm	***Mass Timber for General Contractors***
	12:00 – 12:05 pm	Break
	12:05 – 1:05 pm	***Costing Resources for Mass Timber Projects***

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

AIA Approved Continuing Education

Course Description

How do general contractors meet the growing demand for mass timber buildings? With widespread adoption of building codes that allow the expanded use of mass timber, and more successful U.S. projects, many seasoned construction professionals are seeking to expand their knowledge and pursue this market. These firms often have limited familiarity with the products and practicalities of design, potential sourcing opportunities, and differences in applying trades to a modern mass timber structure vs. steel or concrete. This presentation is intended to help contractors better understand the nuances involved in a mass timber project and provide a basis for training installation crews and sub-contractors new to these systems. Topics include mass timber products, connection considerations, preconstruction coordination and interactions between the manufacturer and design/construction teams, material installation and protection, safety, and where to seek additional cost and schedule efficiencies.

Learning Objectives

1. Discuss and compare mass timber systems commonly used for buildings in the U.S.
2. Describe the variety of connections that may be used to connect columns, beams, and panels on a mass timber project.
3. Evaluate the objectives and impacts of preconstruction coordination and how the planning and design process differs from projects built with other materials.
4. Summarize the proper installation of mass timber elements, and methods for protecting the materials from moisture, dirt, and damage on site.

Topics

- Introduction to Mass Timber
- Connections, Fasteners, and Hardware
- Installation and Material Protection
- Safety Considerations

Topics

- **Introduction to Mass Timber**
- Connections, Fasteners, and Hardware
- Installation and Material Protection
- Safety Considerations

Introduction

Mass timber refers to a category of wood framing styles typically characterized by large, engineered wood panels paired with timber beams and columns.

Catalyst
MGA | Michael Green Architecture / KPFF
Photo Benjamin Benschneider

Prefabrication

- Panels planed, sanded, cut to size
- Openings cut with CNC (Computer Numerically Controlled) routers
- 3rd party inspection at factory
- Custom designed and engineered
- Delivered/ installed in predetermined sequence

Photo Credit:
Sissi Slotover-Smutny

BCB0

Field Fabrication and Penetrations

Holes, notches and other alterations should be made during fabrication to the greatest extent possible

Some may also be done in the field.

Modeling/Fabrication Schedule

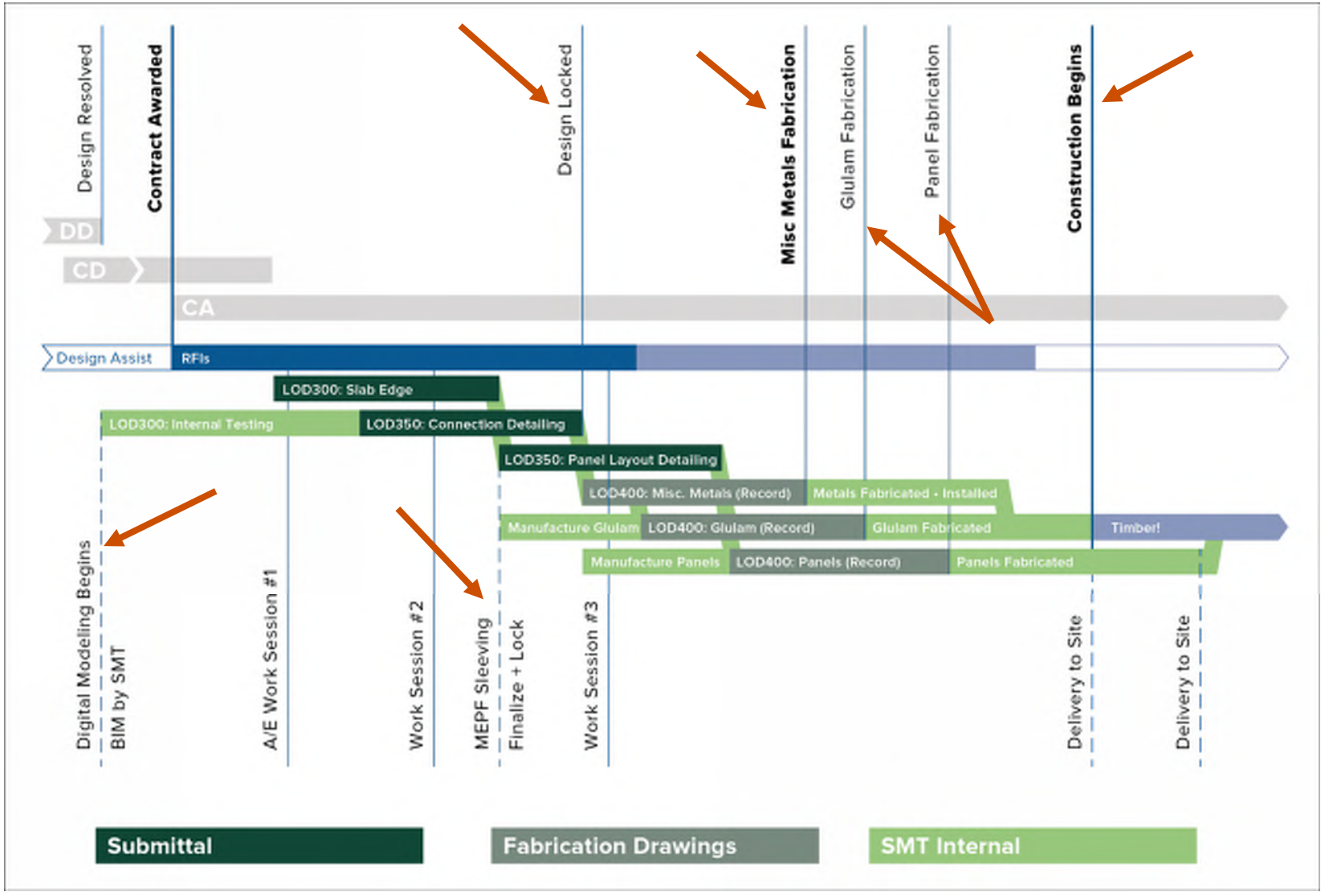


Image Timberlab

Builder input is essential to optimizing costs.

- Identify and coordinate with MEP/FP subs and other material trades.
- Coordinate site logistics/planning and schedule.
- Establish design goals through discussions with owner, designer and builder.
- Undertake 3D modeling during design.
- Schedule steel component modeling so it doesn’t delay the mass timber.

Mass Timber Products

Panels

- Cross-Laminated Timber / CLT
- Glue-Laminated Timber / GLT
- Nail-Laminated Timber / NLT
- Dowel-Laminated Timber / DLT

The Canyons
Kaiser+Path / catena consulting engineers / R&H Construction
Photo Marcus Kauffman

Columns and Beams

- Glue-Laminated Timber / Glulam
- Structural Composite Lumber / SCL

Glulam beams

Boise Cascade

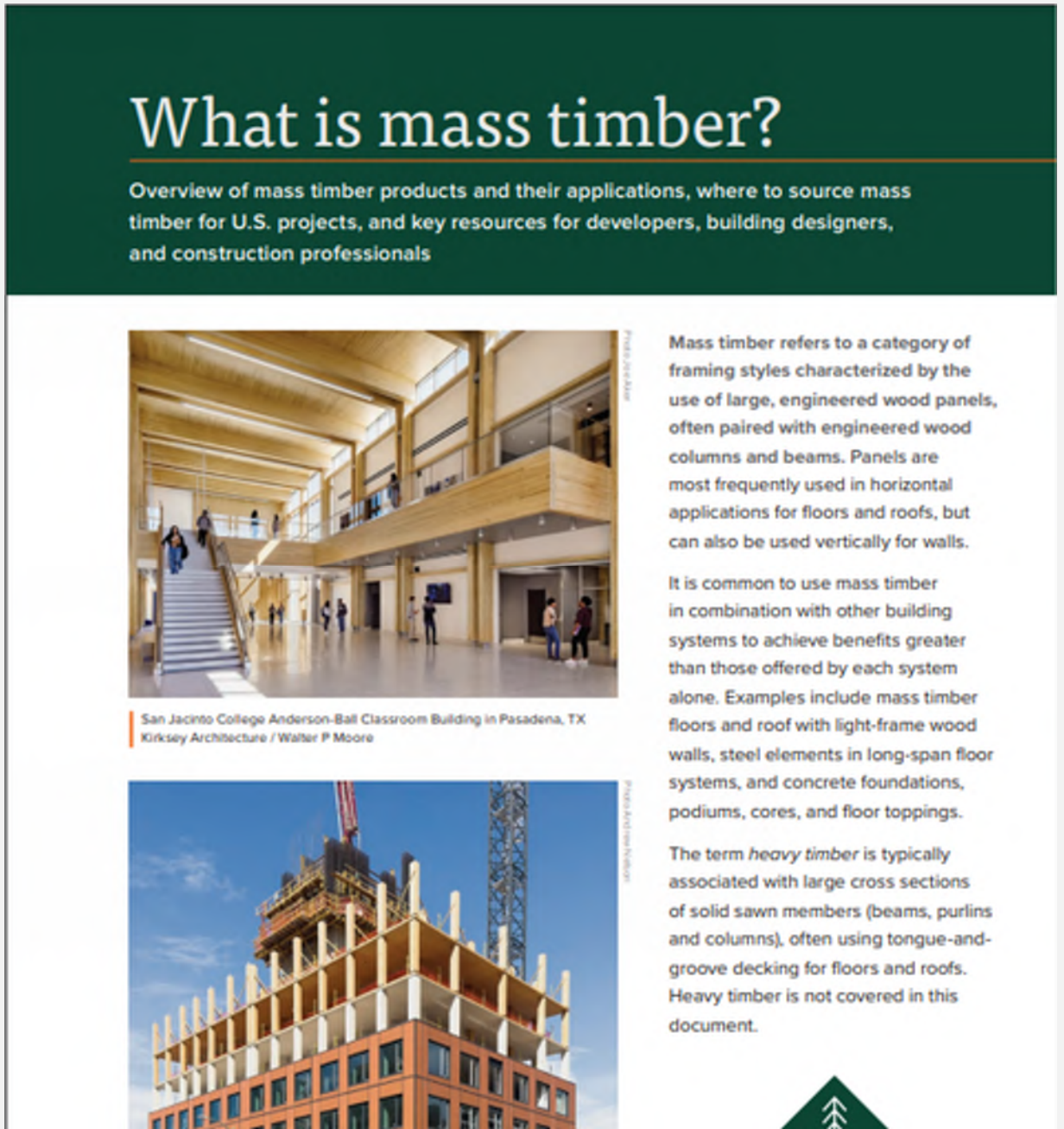
SCL columns

Weyerhaeuser

Mass Timber Products

Free Resource:

www.woodworks.org



What is mass timber?

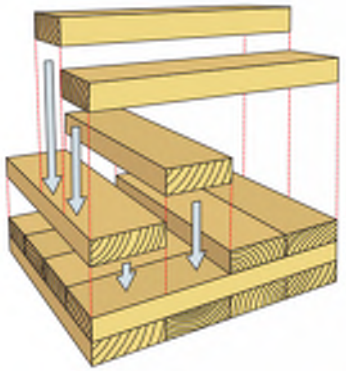
Overview of mass timber products and their applications, where to source mass timber for U.S. projects, and key resources for developers, building designers, and construction professionals

San Jacinto College Anderson-Ball Classroom Building in Pasadena, TX
Kirksey Architecture / Walter P Moore

Mass timber refers to a category of framing styles characterized by the use of large, engineered wood panels, often paired with engineered wood columns and beams. Panels are most frequently used in horizontal applications for floors and roofs, but can also be used vertically for walls.

It is common to use mass timber in combination with other building systems to achieve benefits greater than those offered by each system alone. Examples include mass timber floors and roof with light-frame wood walls, steel elements in long-span floor systems, and concrete foundations, podiums, cores, and floor toppings.

The term *heavy timber* is typically associated with large cross sections of solid sawn members (beams, purlins and columns), often using tongue-and-groove decking for floors and roofs. Heavy timber is not covered in this document.



Cross-Laminated Timber (CLT)

Solid sawn laminations

Cross-Laminated Timber (CLT)

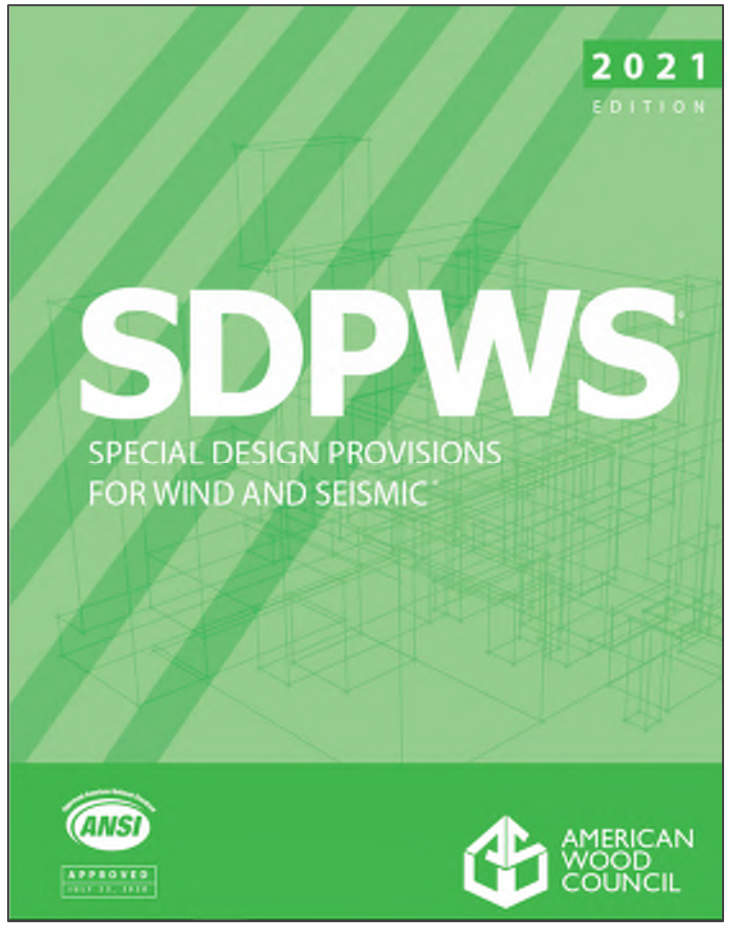
SCL laminations

Photo: Freres Lumber

Photo: LendLease

Photo: LEVER Architecture

2021 Special Design Provisions for Wind and Seismic



- New CLT Shear Wall requirements
- New CLT Diaphragm requirements

Glue-Laminated Timber (GLT)

Plank orientation

Photo: StructureCraft

Nail-Laminated Timber (NLT)

Photo: Think Wood

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Photo: Manasc Isaac Architects/Fast + Epp

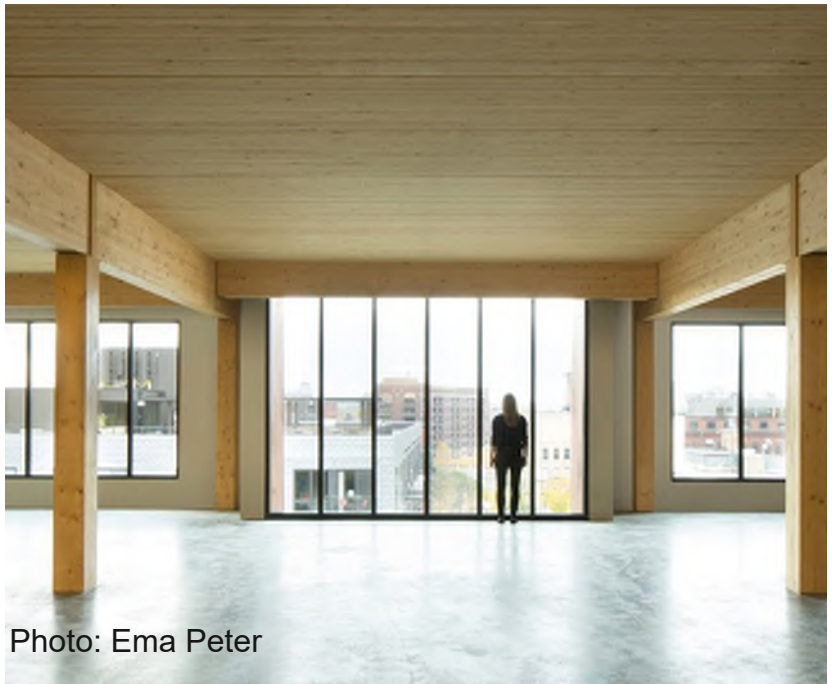


Photo: Ema Peter

Photo: StructureCraft

- Plywood sheathing is often added to one face of the panel to act as a structural diaphragm.
- This also allows the product to be used as a shear wall.

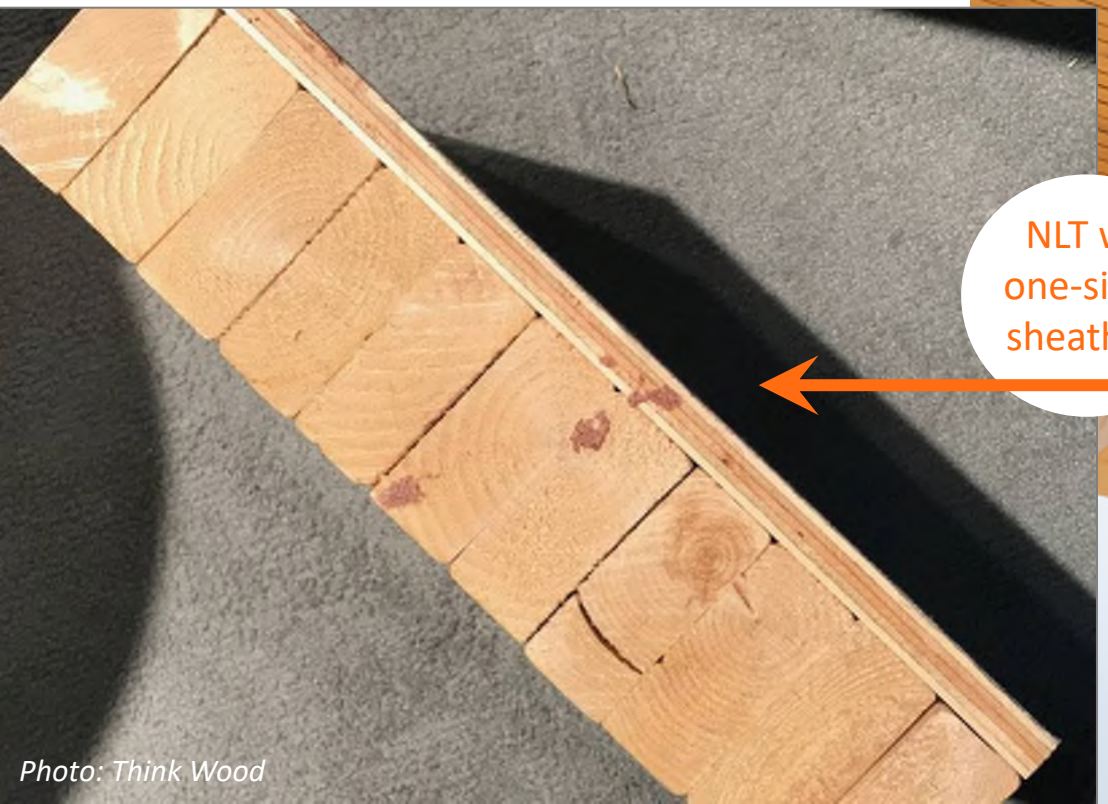
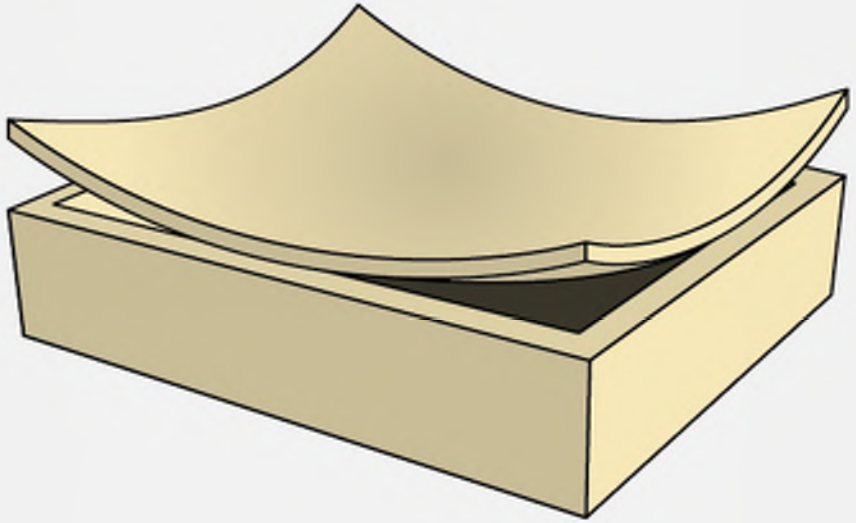


Photo: Think Wood

The Soto / Cheyne Smith Photography

CLT

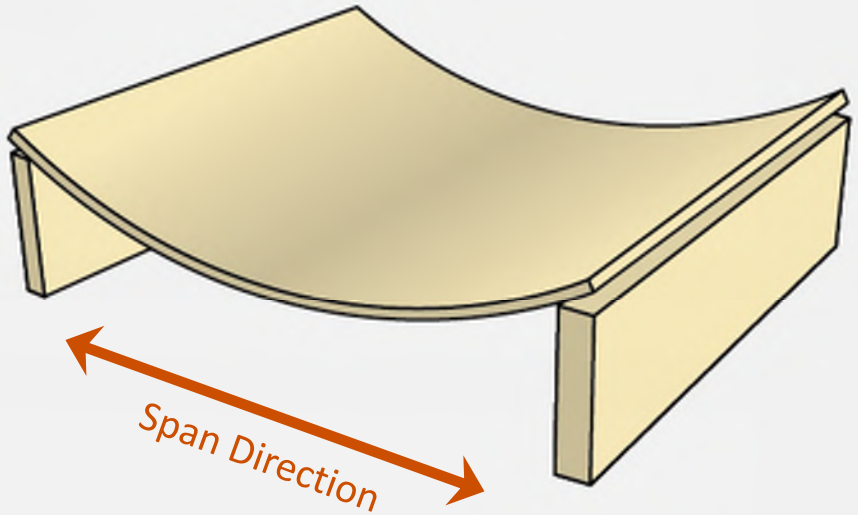
bends in two directions



Deformation of two-way slab

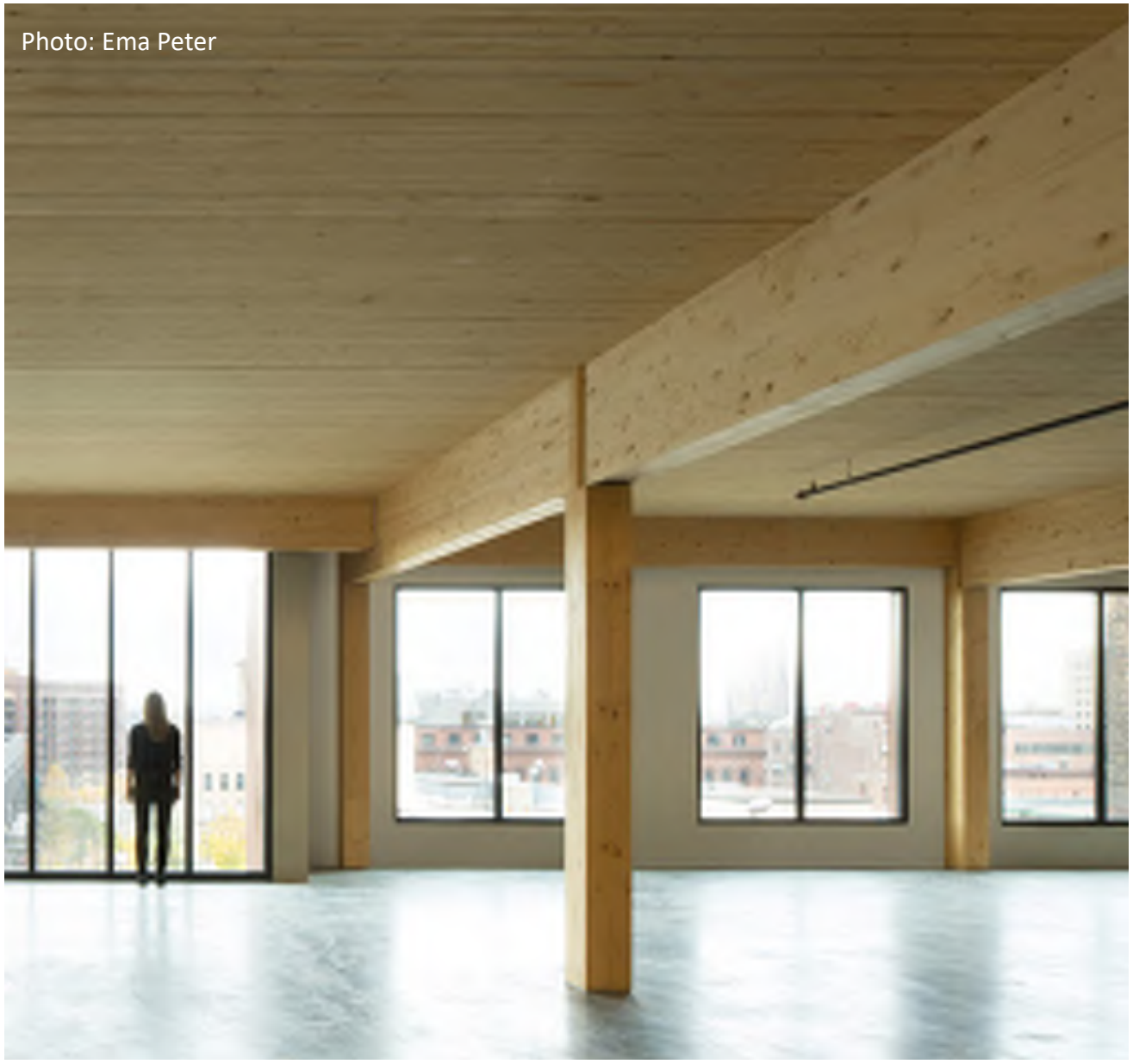
GLT, DLT and NLT

bend in one direction only



Deformation of one-way slab

Images WoodWorks



POST, BEAM + PLATE

POST + PLATE

HONEYCOMB

HYBRID LIGHT-FRAME + MASS TIMBER

LEVER Architecture, photo Jeremy Bittermann

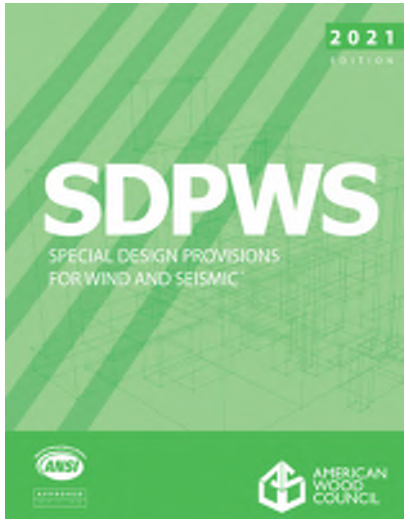
HYBRID CONCRETE + MASS TIMBER

HYBRID CONCRETE + STEEL

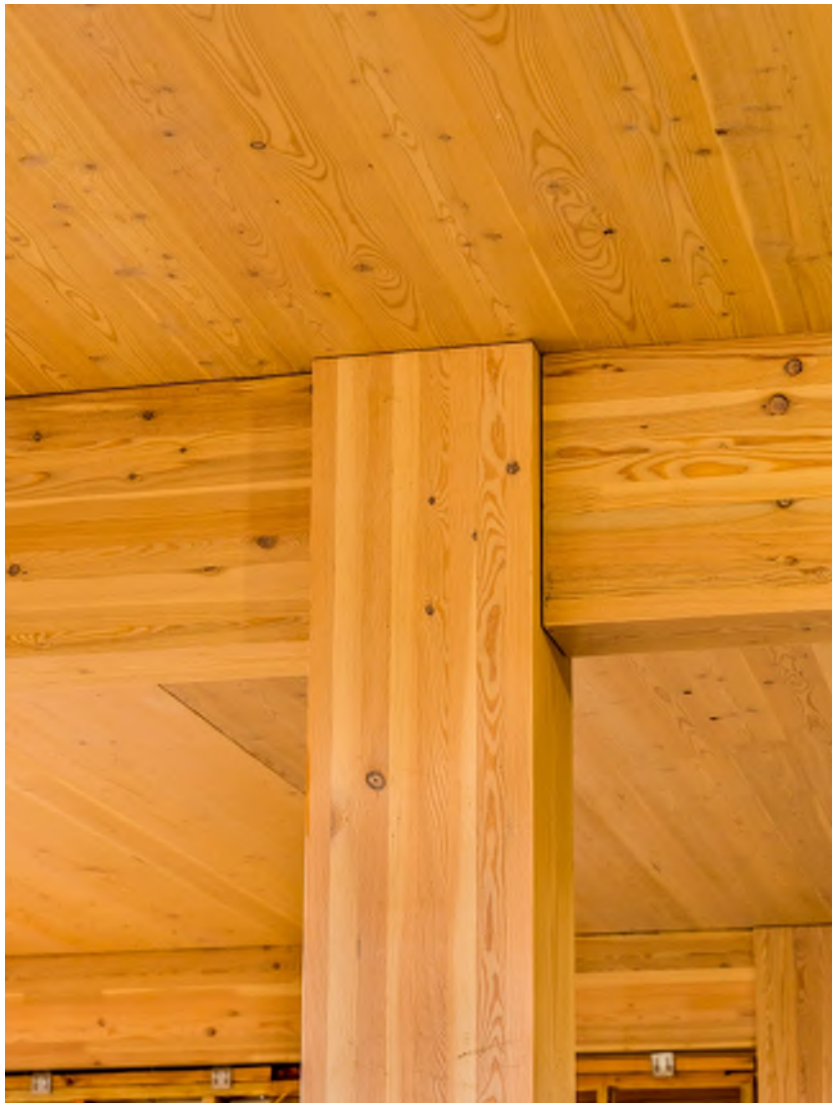
Lateral Systems

Prescriptive Code Compliance:

- ☑ CLT Shear Walls (65 ft max) –
  Per 2021 SDPWS/ASCE 7-22
- ☑ Light Frame Wood Shear Walls (65 ft max)
- ☑ Concrete Shear Walls
- ☑ Steel Braced Frames



Mass Timber: Structure is often Finish

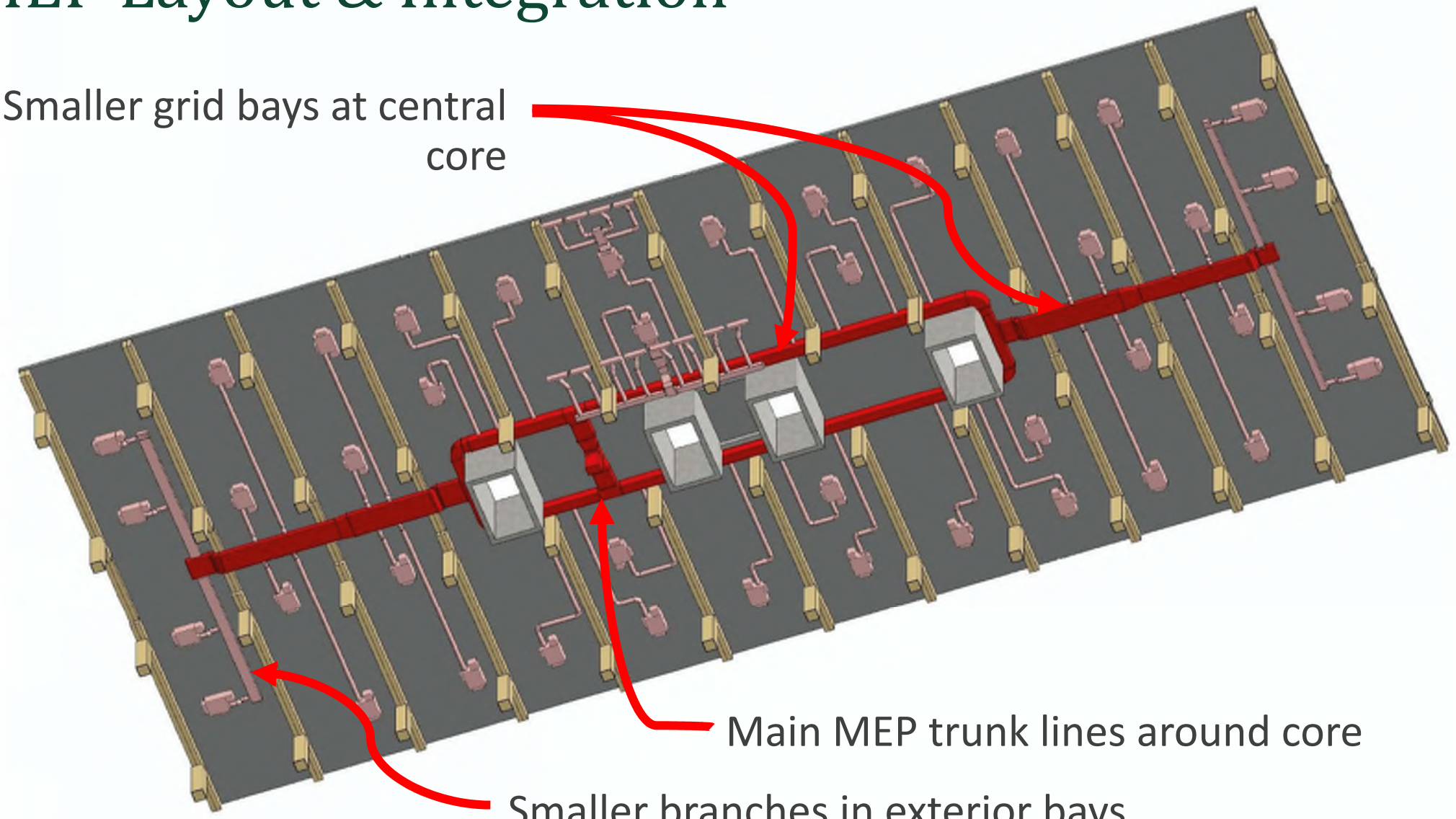


Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman | Architect: Kaiser + PATH

MEP Layout & Integration

- Set Realistic Owner Expectations About Aesthetics
- MEP fully exposed, or limited exposure?

MEP Layout & Integration



Credit: ARUP

Acoustical Design – Mass Timber

Example mass timber floor assembly:

- Finish floor (if applicable)
- Underlayment (if finish floor)
- 1.5” to 3” thick concrete/gypcrete topping
- Acoustical mat
- Wood structural panel (if applicable)
- Mass timber floor panels

Image: AcoustiTECH

Acoustic Design

Free Resources:

www.woodworks.org

WoodWorks
WOOD PRODUCTS COUNCIL

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

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

T3 Minneapolis
Architect: MGA | Michael Green Architecture, DLR Group
Structural Engineer: Magnusson Klemencic Associates
Design Assist + Build: StructureCraft

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.

Inventory of Acoustically Tested Mass Timber Assemblies

WOODWORKS
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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:

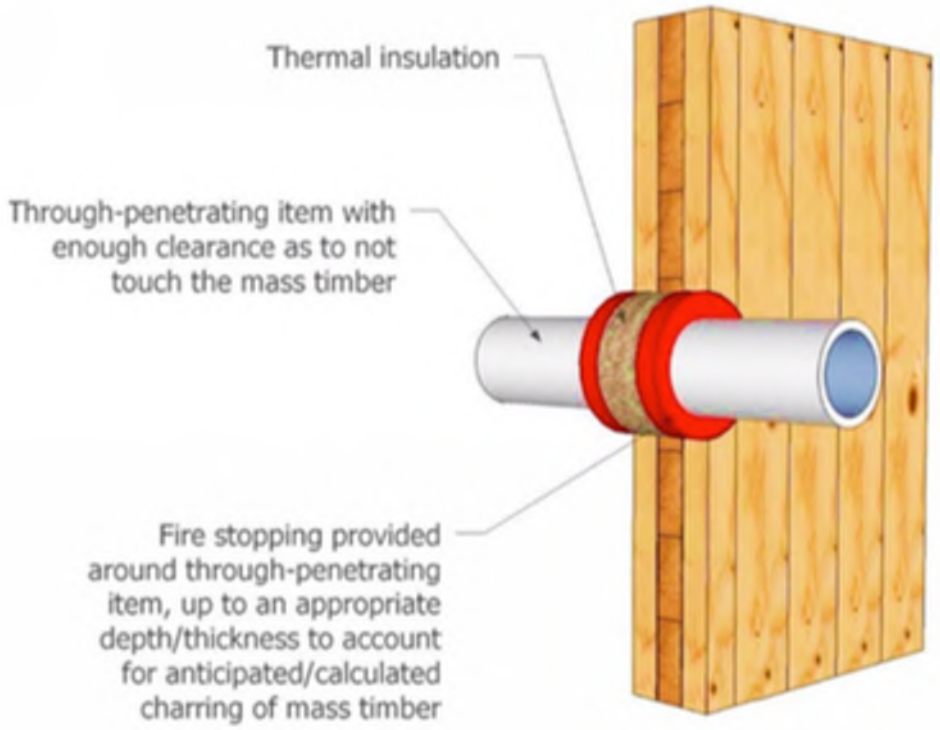
Mass timber has inherent fire protection.

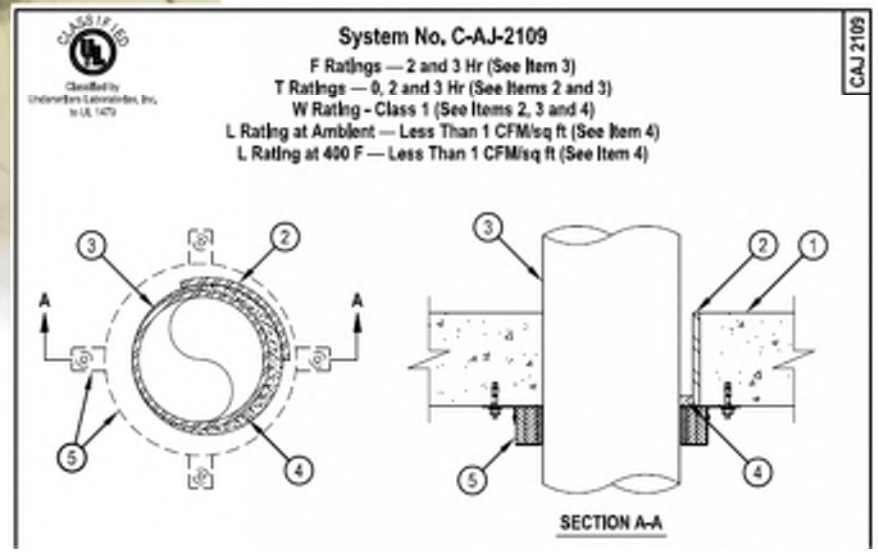
Elements char at a slow and predictable rate during a fire, retaining strength and allowing time to evacuate the building.

Photo David Barber / Arup

Penetrations & Firestopping

Most firestopping systems include combination of fire safing (eg. noncombustible materials such as mineral wool insulation) plus fire caulk



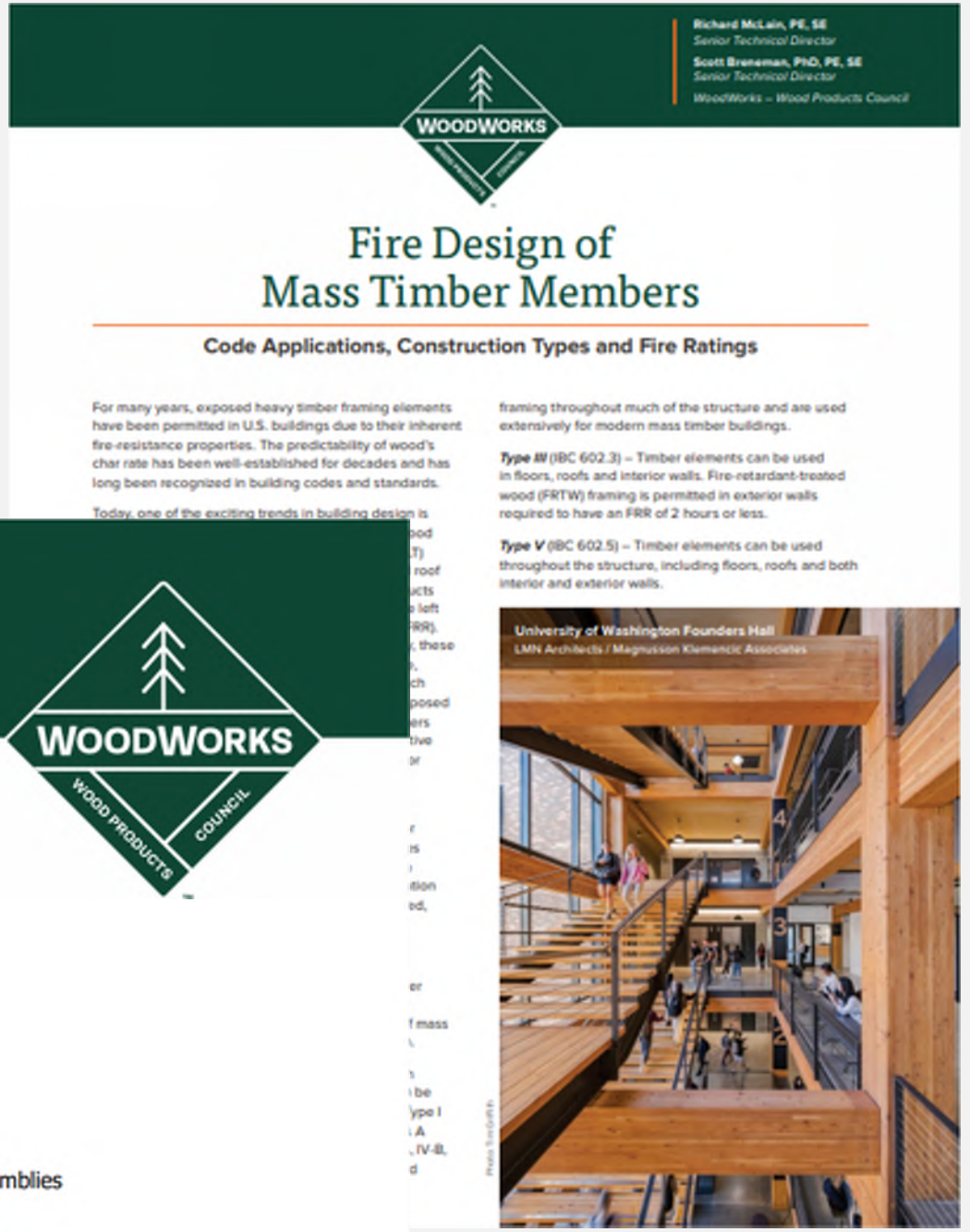


Photos: AWC/FPInnovations/Hilti

Fire Design

Free Resources:

www.woodworks.org



Richard McLain, PE, SE
Senior Technical Director
Scott Breneman, PhD, PE, SE
Senior Technical Director
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.

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

Inventory of Fire Resistance-Tested Mass Timber Assemblies & Penetrations

WOODWORKS
WOOD PRODUCTS COUNCIL

Following is a list of mass timber assemblies and penetration fire stopping systems in mass timber assemblies that have been tested for fire-resistance. Sources are noted at the end of this document. For free technical assistance on any questions related to the fire-resistance 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:

Construction Types and Fire Protection

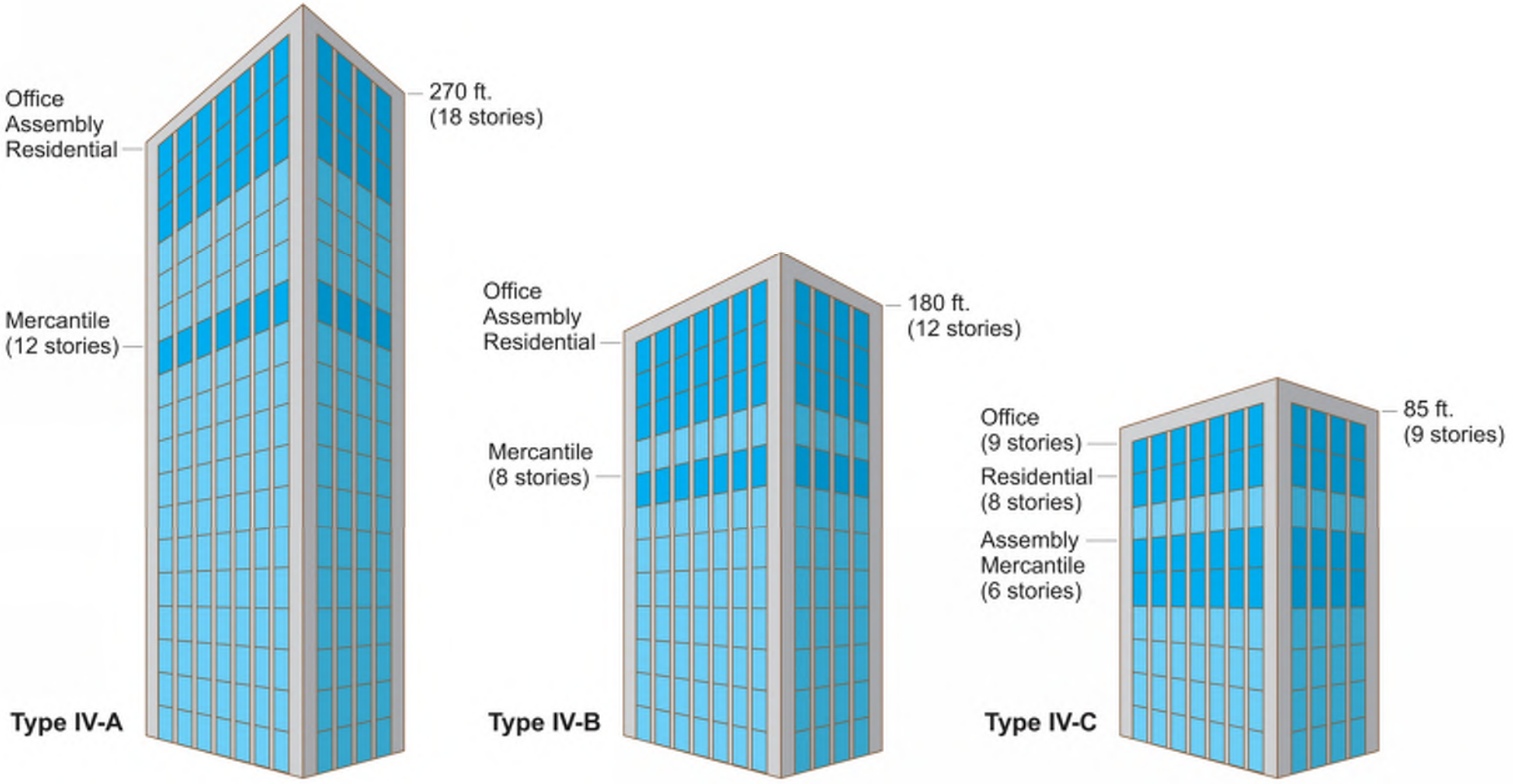
Fire-Resistance Rating Requirements for Building Elements (Hours)

Building Element	Type I		Type II		Type III		Type IV				Type V	
	A	B	A	B	A	B	HT	A	B	C	A	B
Primary structural frame[f] (see Section 202)					1[b]	0	HT	3	2	2	1[b]	0
Bearing walls Exterior[e,f] Interior					 1	 0	2 1/HT	3	2	2	1 1	0 0
Nonbearing walls and partitions Exterior								See Table 602				
Nonbearing walls and partitions Interior[d]					0	0	See Section 2304.11.2	0*	0*	0*	0	0
Floor construction and associated secondary members (see Section 202)					1	0	HT	2	2	2	1	0
Roof construction and associated secondary members (see Section 202)		1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1-1/2	1	1	1[b,c]	0

**Nonbearing interior wall partitions in Types IV-A, IV-B and IV-C must be of mass timber construction or of noncombustible materials per IBC 602.4*

Source: 2021 IBC Table 601 / See IBC for footnotes

2021 IBC: Tall Mass Timber Construction Types



Topics

- Introduction to Mass Timber
- **Connections, Fasteners, and Hardware**
- Installation and Material Protection
- Safety Considerations

Connection Design

- Structural capacity
- Shrinkage
- Fire Resistance
- Aesthetics
- Constructability
- Cost

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

Connection Design

Free Resources:

www.woodworks.org

Erin Kinder, PE and
Greg Kingsley, PhD, PE
KL&A Engineers & Builders

WOODWORKS

Mass Timber Connections Index

Optimal Connection Considerations

This paper is a companion piece to the Index of Mass Timber Connections, available on the WoodWorks website ***here****.*

The popularity of mass timber structures continues to grow throughout the United States as owners, developers, architects, and contractors embrace the environmental benefits, aesthetics, and increased construction speed of this innovative building type. As the number of structures increases, there is a heightened desire for detailed analysis of the cost drivers. It is generally understood that greater wood volume equates to increased cost, and it is

of cost-optimal connection types while balancing the other considerations addressed in this paper. Additional connection examples can be found in WoodWorks' **CAD/Revit tool**.

Connection Classes

To organize the index, structural connections were grouped into three categories or 'Connection Classes' that share common attributes regarding cost, constructability, and fire rating. These classes are defined and illustrated in Table 1 as Class 1, Class 2, and Class 3. Class 1 connections require only mass timber elements and structural fasteners. Class 2 connections are custom steel fabricated elements, made up of components such as plates and angles, and include structural fasteners. Class 3 connections are prefabricated proprietary connectors available from suppliers such as Simpson Strong-Tie, Rothoblaas, MiTek, and others. Class 3 connections are often backed by supporting tests for strength and fire rating.

In general, Class 1 connections are the least expensive and simplest to install, but they may not always meet other project constraints. Class 2 and 3 connections are generally more costly; however, Class 3 connections may be most appropriate when hidden connections are desired, or if fire-resistance ratings are important.

Platte Fifteen
LOCATION:
Denver, Colorado
OWNER:
Crescent Real Estate LLC
ARCHITECT:
OZ Architecture
STRUCTURAL ENGINEER:
KL&A Engineers & Builders

This index is a compilation of connections used in mass timber construction. Mass timber elements are solid wood pieces with inherent fire resistance due to their mass, as defined in the International Building Code (IBC). Examples of mass timber include but are not limited to cross-laminated timber (CLT), either made with solid sawn or structural composite lumber (SCL), nail-laminated timber (NLT), dowel-laminated timber (DLT), glue-laminated timber (glulam or GLT), and other SCL products such as laminated veneer lumber (LVL) and laminated strand lumber (LSL). These products can be used as structural floors, roofs, walls, columns and/or beams, and the connections in this index reflect a broad spectrum of applications. Depending on the unique constraints of each project, the connection choice made by the designer may be influenced by aesthetics, load carrying capacity, fire-rating requirements, quality assurance requirements, cost and/or constructability.

The purpose of the index is to facilitate the designer's selection of project-appropriate connections. It includes structural connections created for WoodWorks by **KL&A Engineers & Builders** in cooperation with **Swinerton Builders**. For information on these firms and their mass

WoodWorks Index of Mass Timber Connections

Prefabricated and Precise

- Tight fabrication tolerances
- Computer Numerically Controlled (CNC) connections

Photo: Structurlam

Photo credit: naturally:wood

Fabrication and Connection Considerations

- Tolerances
- Connection “class”
- Factory vs. field
- Fire resistance
- Inspections

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

Manufacturer Tolerances: CLT

Thickness

- Shall not exceed 20"

CLT Dimensional Tolerances

- Thickness: ± 1/16" or 2% of the CLT thickness, whichever is greater
- Width: ± 1/8" of the CLT width
- Length: ± 1/4" of the CLT length

Squareness

- The length of the two panel face diagonals measured between panel corners shall not differ by more than 1/8"

Straightness

- Deviation of edges from a straight line between adjacent panel corners shall not exceed 1/16"

Albina Yard
LEVER Architecture / KPFF / REWORKS
Photo LEVER Architecture

Manufacturer Tolerances: Glulam Beams, Columns

Width

- ± 1/16"

Depth

- ± 1/8" per foot of depth
- Minus 3/16" or 1/16" per foot of depth, whichever is larger

Length

- Up to 20 feet: ± 1/16"
- Over 20 feet: ± 1/16" per 20 feet of length or fraction thereof

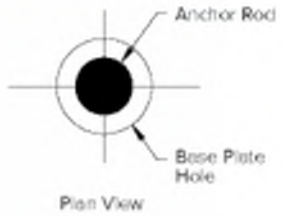
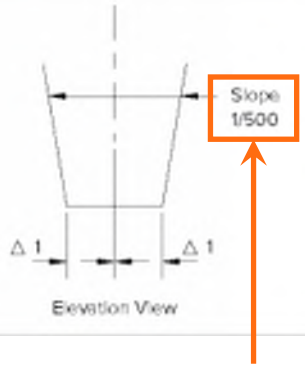
NOTE: As-received materials typically have tolerances even LESS than those above.

Ascent
New Land Enterprises
Korb + Associates / Thornton Tomasetti / Swinerton Mass Timber / C.D. Smith Construction
Photo WoodWorks

Tolerances Between Materials

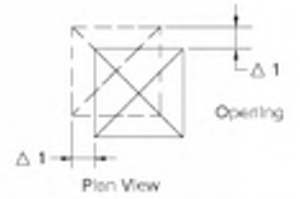
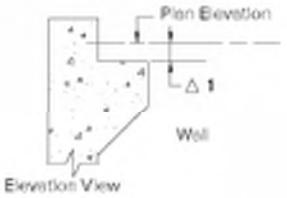
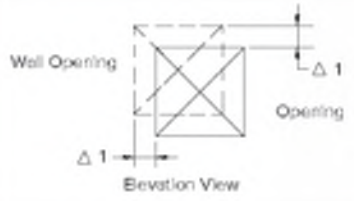
» Examples of tolerances for steel and concrete.

APPENDIX 1: Industry Tolerance Standards for Mass Timber

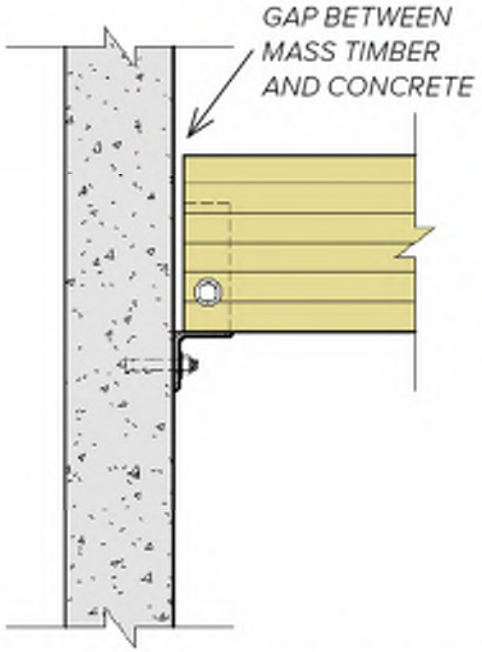
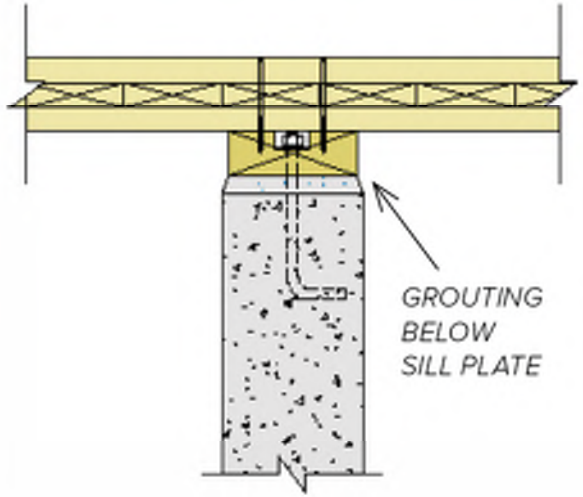
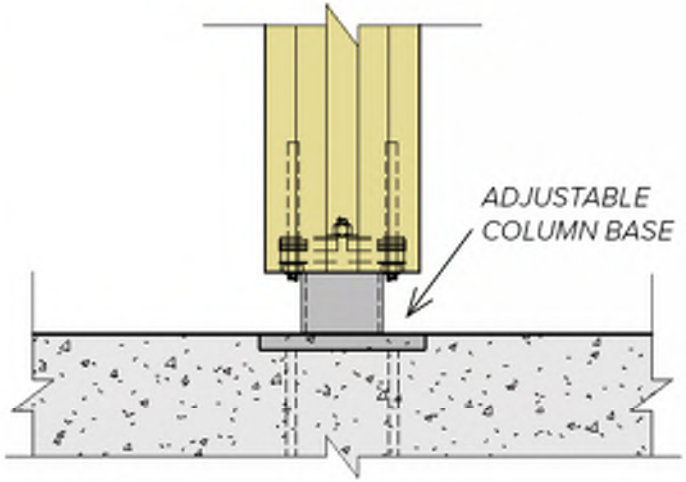
Tolerance Condition	Construction	Allowable Tolerances		Standard Reference
Anchor Rod Holes in Base Plates	Steel Base Plate	Rod / Hole Diameter 3/4"Ø / 1-5/16"Ø 7/8"Ø / 1-9/16"Ø 1"Ø / 1-7/8"Ø 1-1/4"Ø / 2-1/8"Ø 1-1/2"Ø / 2-3/8"Ø 1-3/4"Ø / 2-7/8"Ø 2"Ø / 3-1/4"Ø 2-1/2"Ø / 3-3/4"Ø		AISC-360 (Recommended Sizes for Anchor Rod Holes)
Steel Column Location at Base	Steel Column	Δ1 = +1/4"		AISC-360 (Recommended Sizes for Anchor Rod Holes)

Maximum "out of plumbness" of the column, per AISC 360 Section C2

APPENDIX 1: Industry Tolerance Standards for Mass Timber

Tolerance Condition	Construction	Allowable Tolerances		Standard Reference
Edge Location of All Openings Deviation from Plan	Slap Opening	Δ1 = ±1/2"		ACI-117-10
Vertical Deviation for Wall or Opening	Wall & Column	Δ1 = ±1"		ACI-117-10
Horizontal & Vertical Deviation for Wall Opening	Wall Opening	Δ1 = ±1/2"		ACI-117-10

Tolerance Solutions

Solution	Gap Between Mass Timber Beam and Concrete Wall	Grouting Below Sill Plate at Mass Timber Panel to Concrete Wall	Adjustable Column Base at Mass Timber Column to Concrete
Connection example			
	Beam Perpendicular to Wall Connected to Face of Wall	Panel Bears at Top of Wall	Column Bears on Concrete with Adjustable Standoff Base

Connection Class

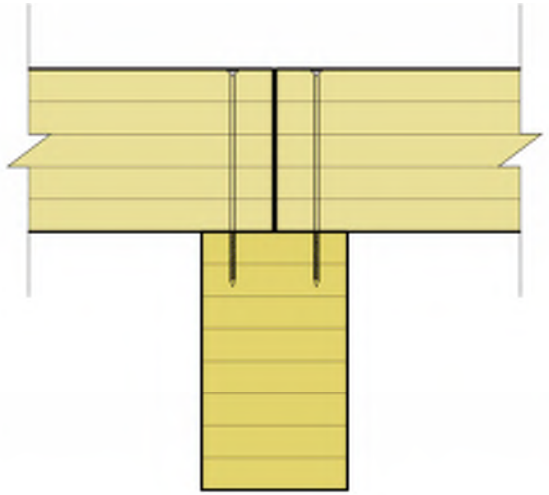
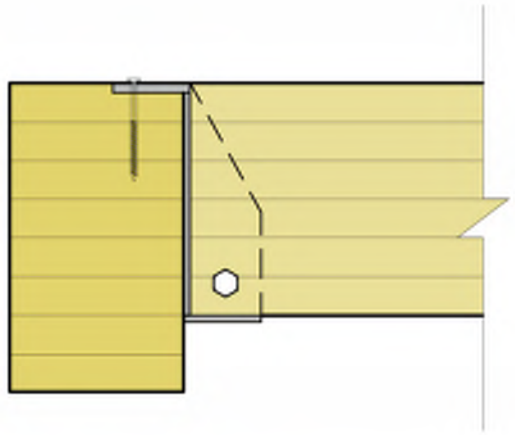
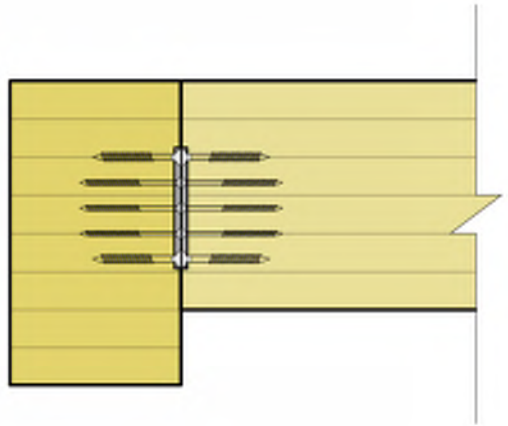
Connection class	**Class 1**	**Class 2**	**Class 3**
Class description	Requires only mass timber elements and fasteners	Utilizes steel fabricated elements, with components such as angles and plates, and includes fasteners	Prefabricated proprietary connectors
Connection example			
	Beam Bears on Girder*	Beam Bears on Steel Bearing Seat with Knife Plate*	Beam Connected to Girder with Proprietary Concealed Connector*

*Table 8 in the ***Index of Mass Timber Connections***

Fastener Types

Install tip:

Always follow the manufacturer's installation instructions for screws, bolts, hardware, connections, and connectors.

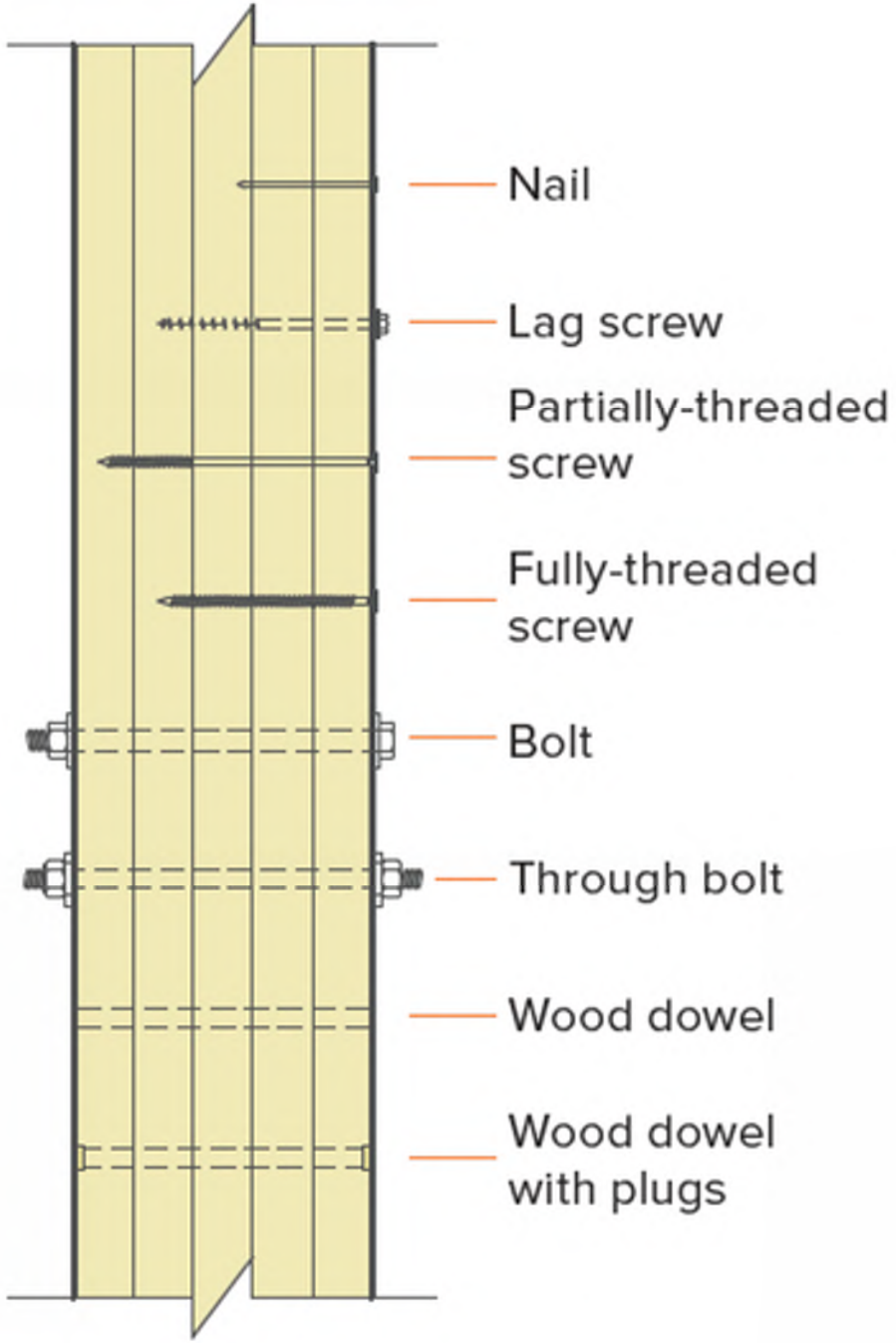
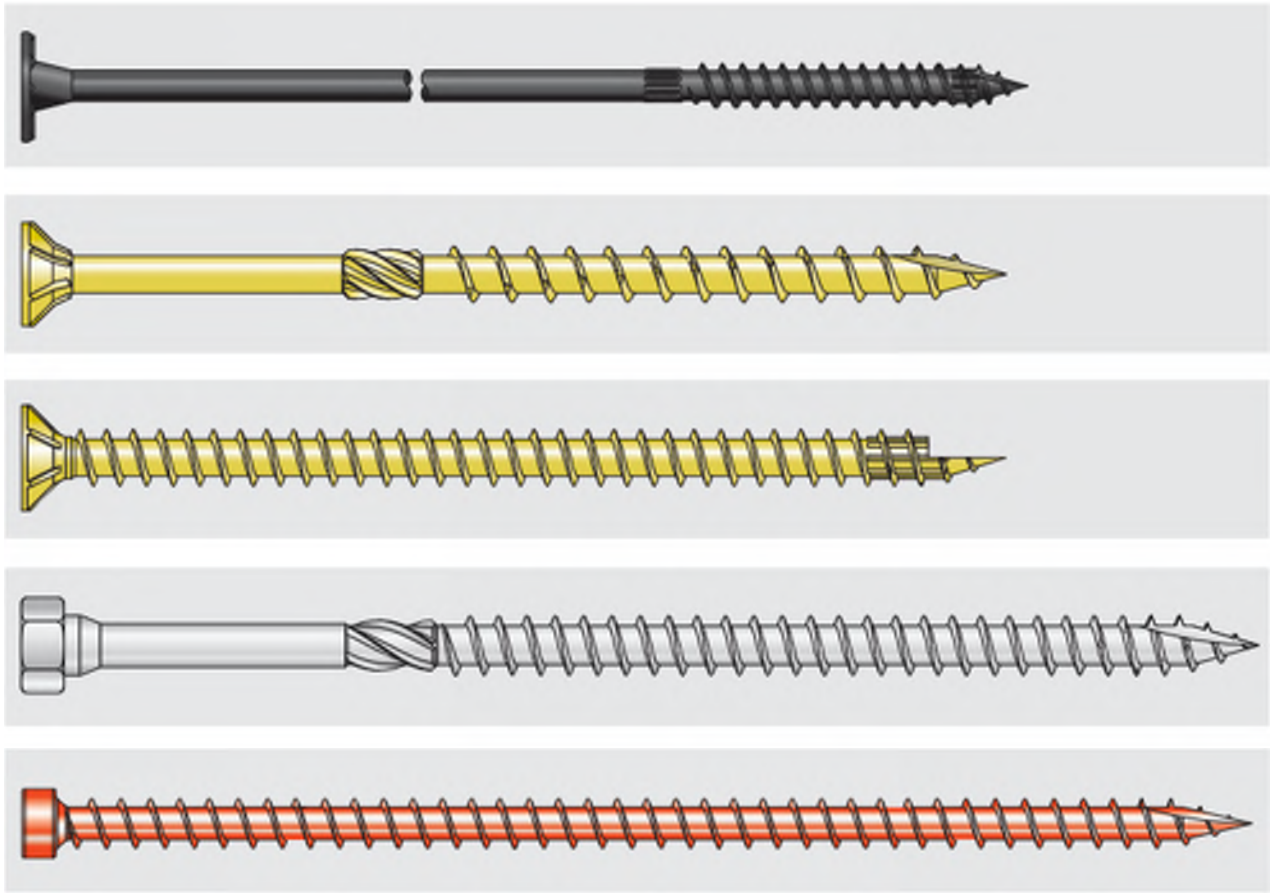


Image KL&A Engineers & Builders

Screws are the most common fastener type in mass timber construction.

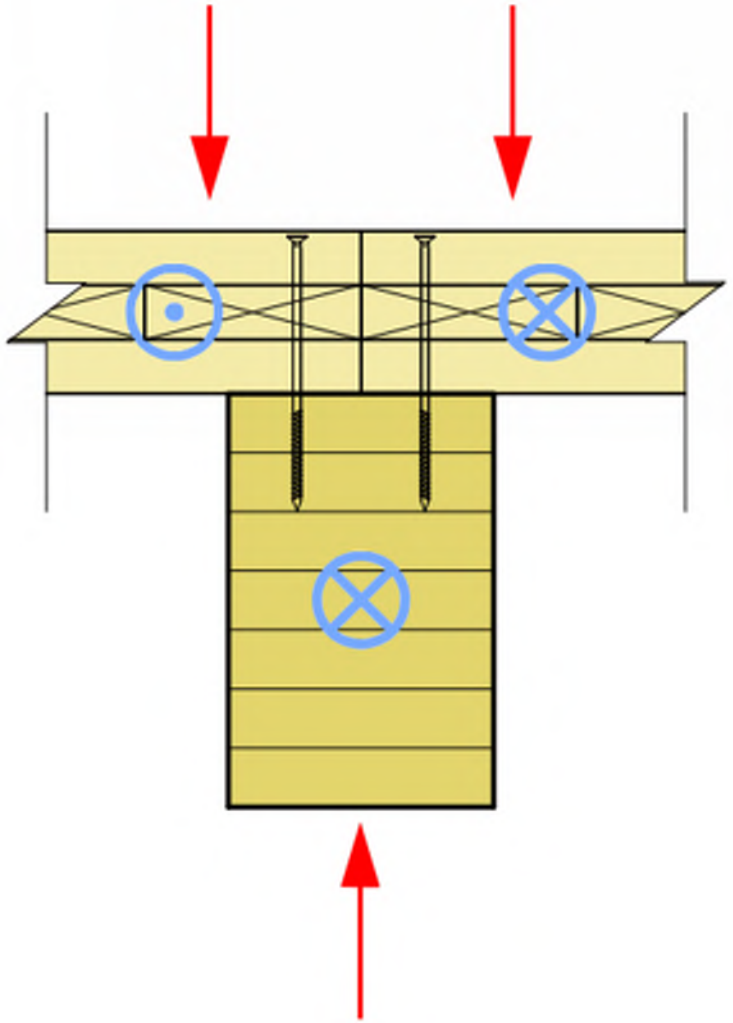
- Lag or proprietary
- Proprietary screws are usually self-drilling
- Fabricators may have preferred screw manufacturers
- Diameter typically 1/4" or greater; wide range of lengths
- Partially or fully threaded

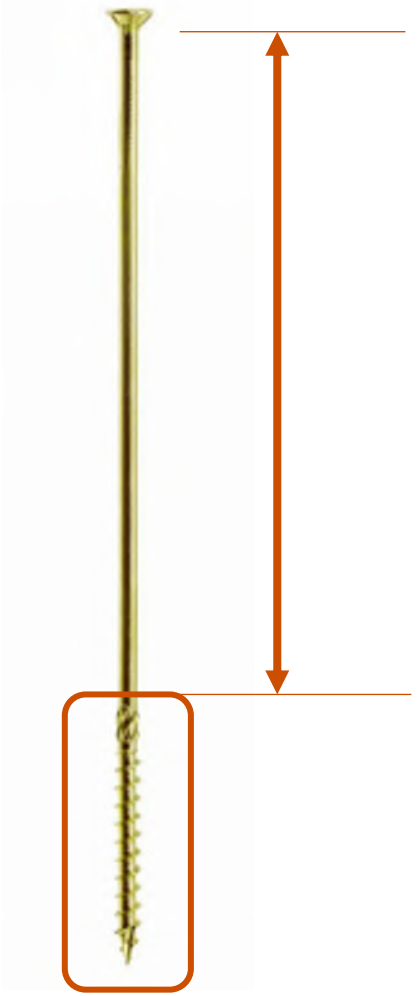


Images ***Simpson Strong-Tie***

Panel to Beam

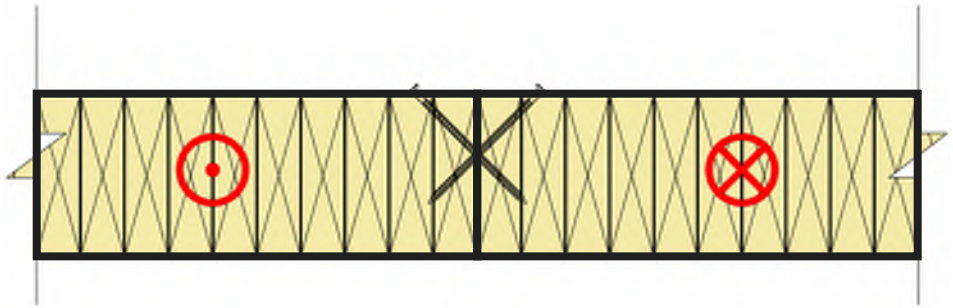
- Floor or roof panel bears on wood beam
- Attachment is made with partially-threaded screws, typically 12" to 18" **depending on panel thickness**





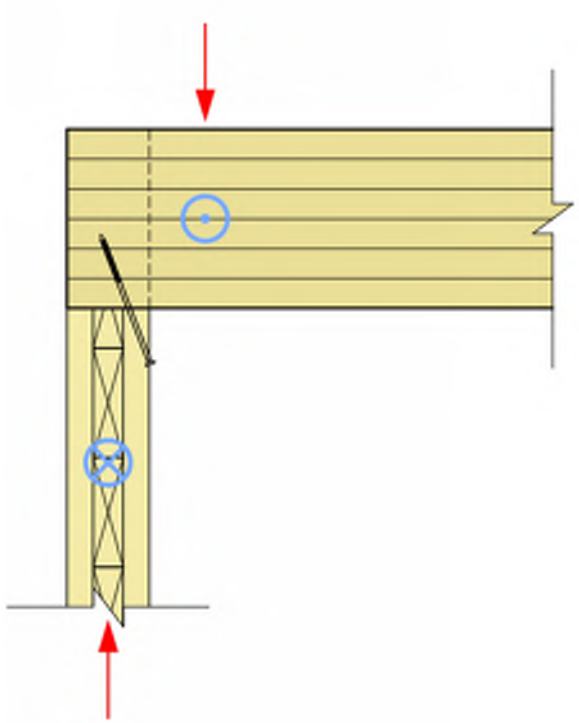
Images WoodWorks / Simpson Strong-Tie

Diagonal Installation



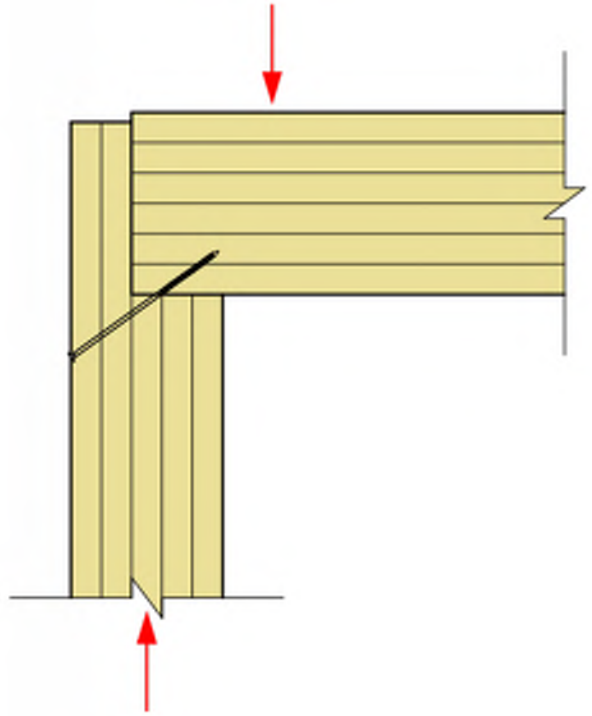
Panel Connects with Screws Across Butt Joint

Fully-threaded screws



Beam Bears on Mass Timber Wall Panel

Partially-threaded screws

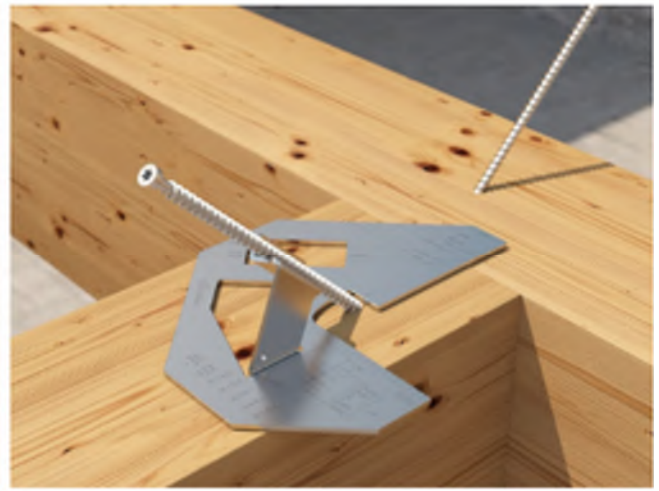


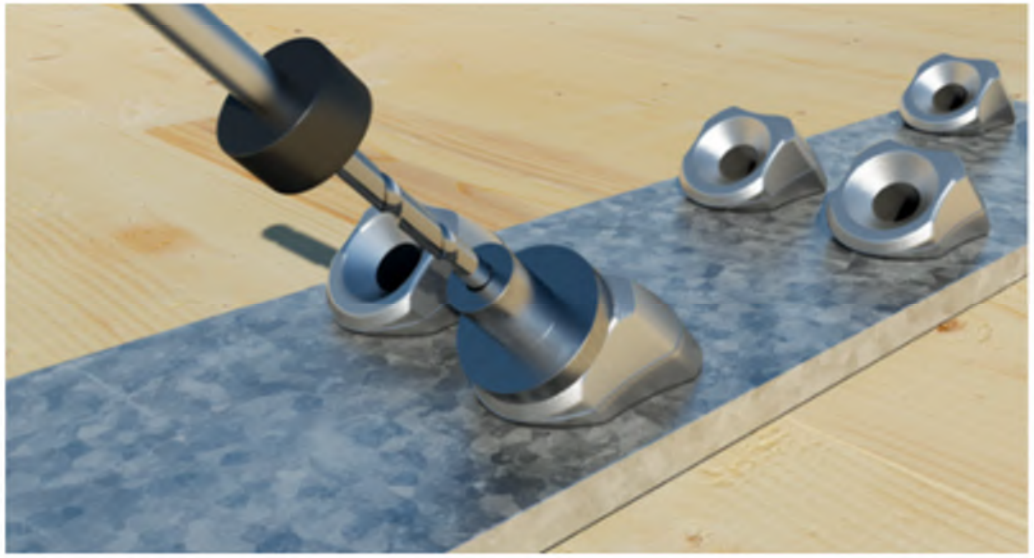
Beam Bears on Column at Notch

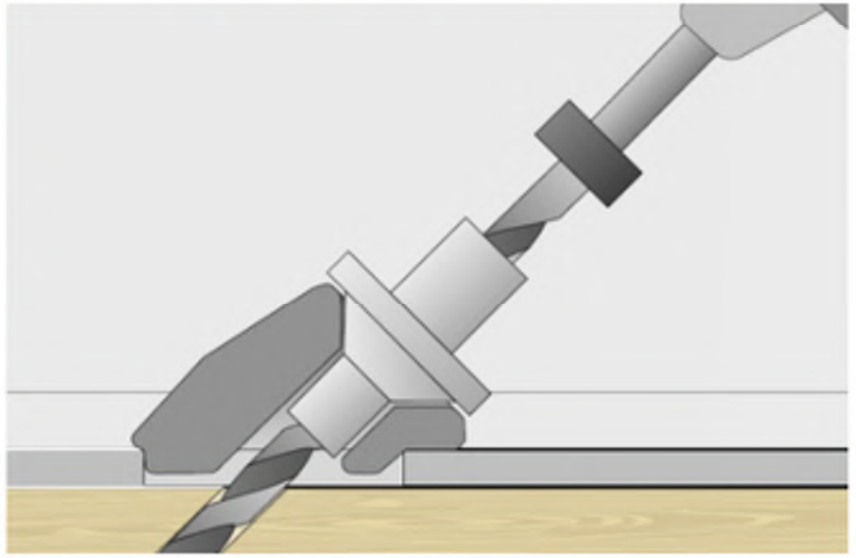
Partially-threaded screws

Images WoodWorks

Templates and Jigs

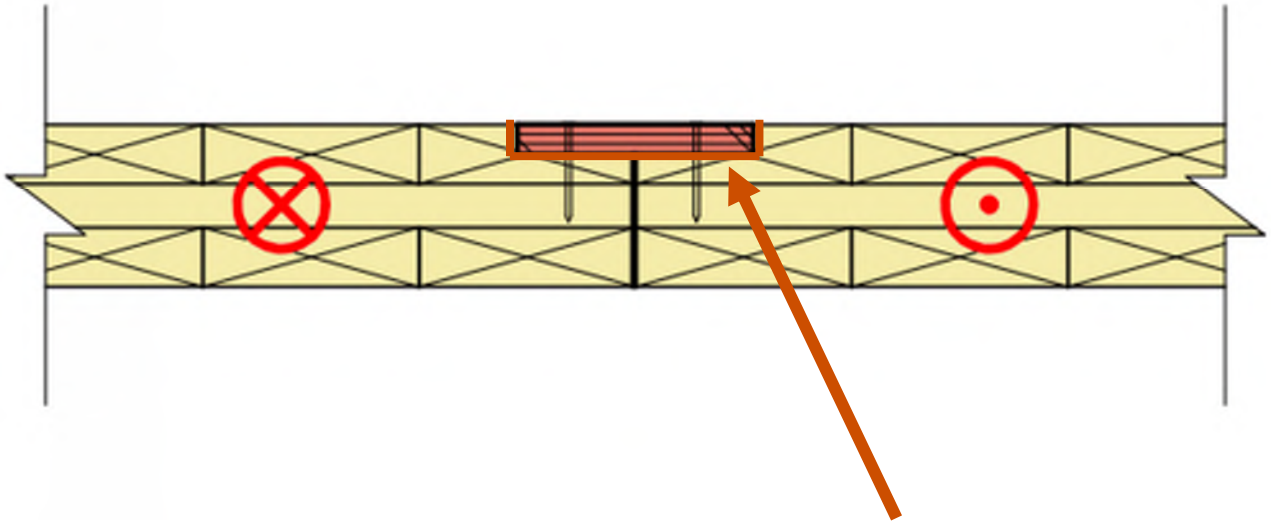


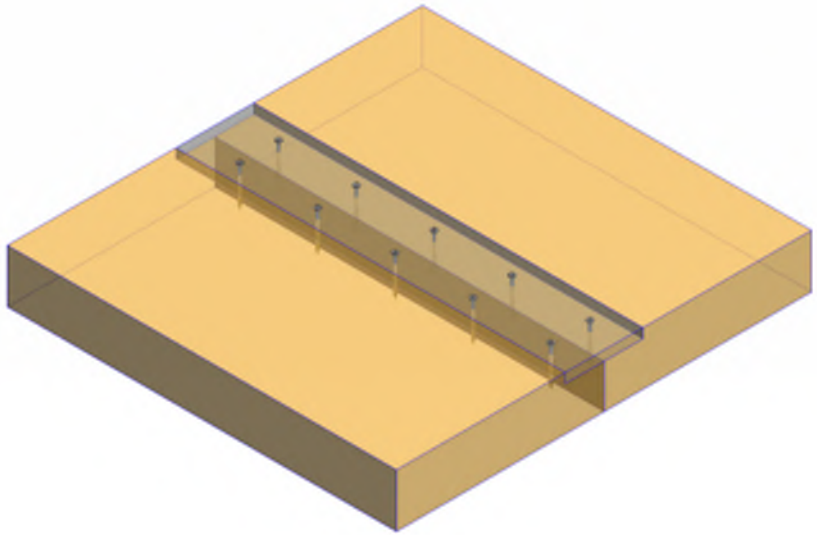




Images Rothoblaas

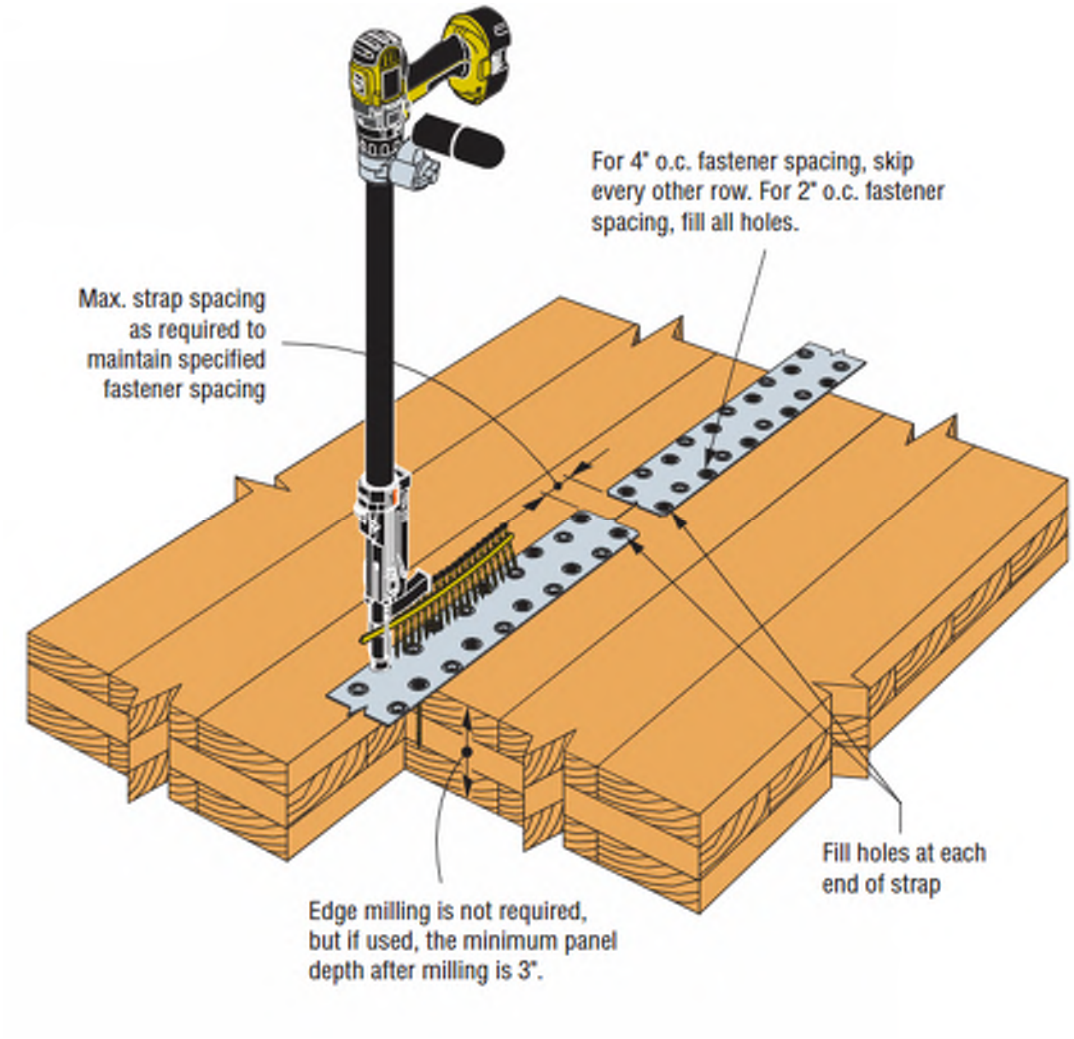
Single Surface Spline





Images WoodWorks

Vender Design Support



Light Diaphragm Spline Strap (LDSS) for Mass Timber

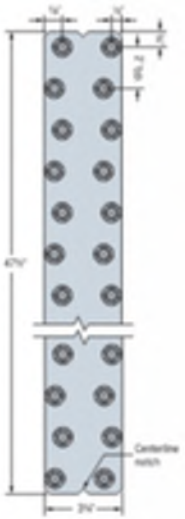
Model No.	Ga.	CLT Layup (min.)	Fasteners	Fastener Spacing (in.)	Allowable Shear Load (lb./ft.)				Slip Modulus Y (lb./in.)
					Wind		Seismic		
					DF/SP	SPF/HF	DF/SP	SPF/HF	
LDSS48	18	Three-ply	#9 x 3" WSV	4	1,030	1,030	1,030	1,030	6,330
				2	2,240	2,240	2,240	2,240	6,330
			0.148" x 2½"	4	430	430	430	430	7,685
				2	820	820	820	820	7,685

1. Allowable loads are based on the use of cross-laminated timber (CLT) grades E1-E4 and V1-V4 material conforming to APA PRG-320.
2. Allowable loads have been increased for wind or seismic loading with no further increase allowed; reduce where other loads govern.
3. Allowable loads are based on lesser of calculations per SDPWS 2021 or assembly tests with a safety factor.
4. Fastener failure modes are Mode IIIs or Mode IV.
5. **Nails:** 0.148" x 2½" = nail dimension listed diameter by length; **Screws:** #9 x 3" WSV = model WSV3S.
6. CLT panel minimum thickness is three-ply = 4.125".
7. The component of diaphragm deflection due to fastener slip at panel-to-panel joints calculated as $\delta_F = Cv_s$, where,
   $C = (L/P_L \times L/P_W)/2$
   P_L = Length of individual CLT panel (ft.); P_W = Width of individual CLT panel (ft.)
   L = Overall length of diaphragm (ft.)
   v_s = Design load per fastener (lb.) / Slip Modulus, Y (lb./in.)

(Reference — Applied Technology Council, 1981. *Guidelines for the design of horizontal wood diaphragms*. Redwood City, CA)

Product Information

Ordering SKU	Description	Quantity
LDSS48	Light Diaphragm Spline Strap (3¾" x 47⅞" x 18 gauge)	1, 10 or 500
PRO300SG2DC2K	Quik Drive PRO300SG2 system kit with Cordless DeWalt® driver	1
PNOSECLIP-LDSS	Quik Drive Nosecilp for LDSS	1



Source Simpson Strong Tie

Hardware

Wide range of:

- plates
- hangers
- straps
- angle brackets
- tie-rod systems
- concealed connectors
- lifting hardware
- and more

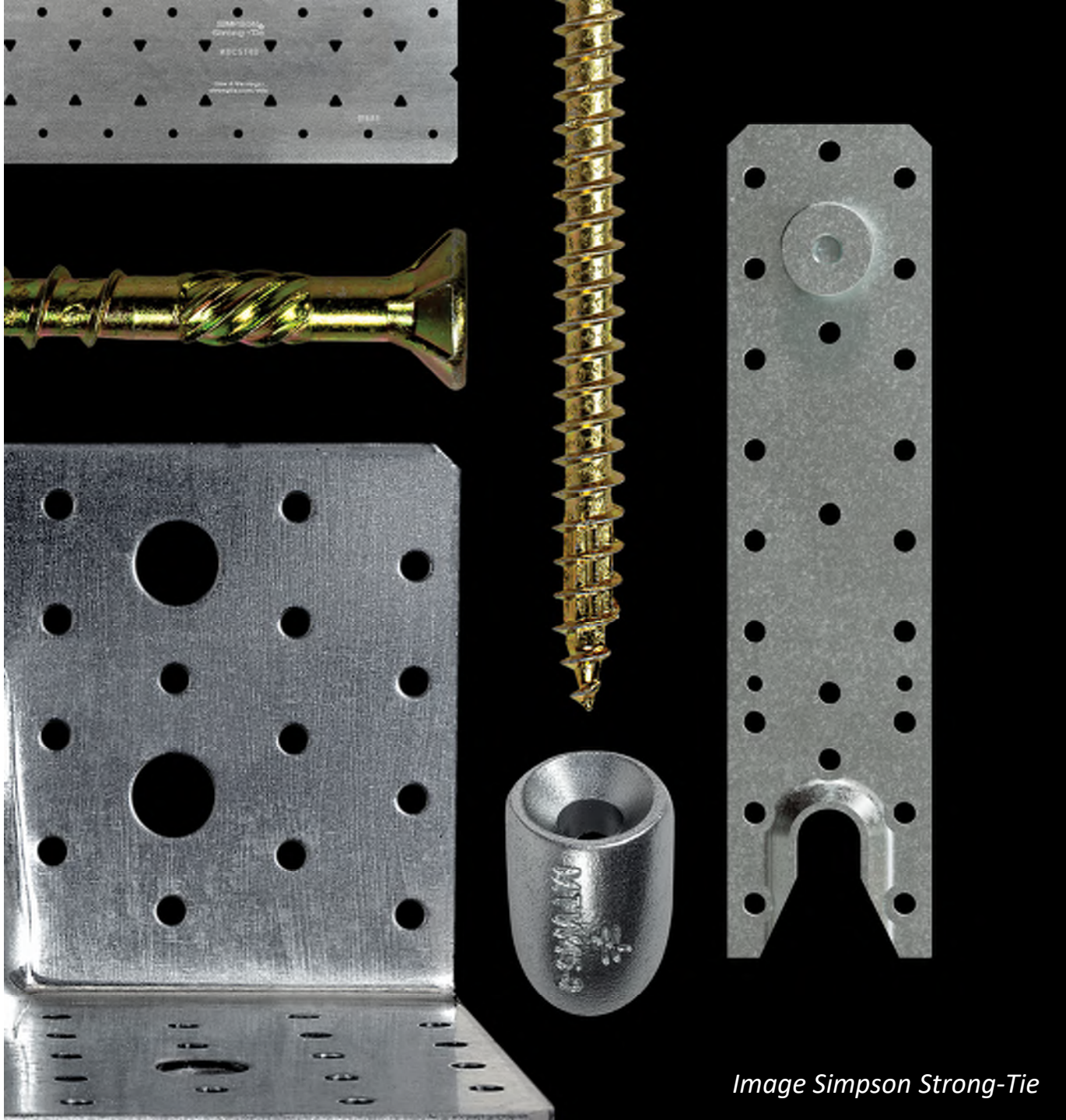
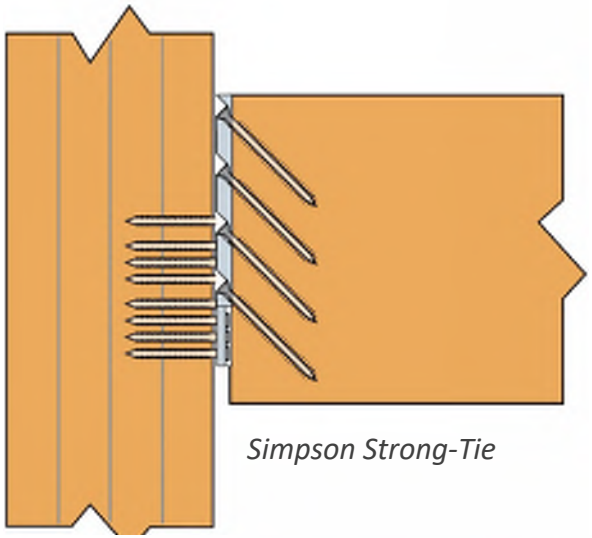
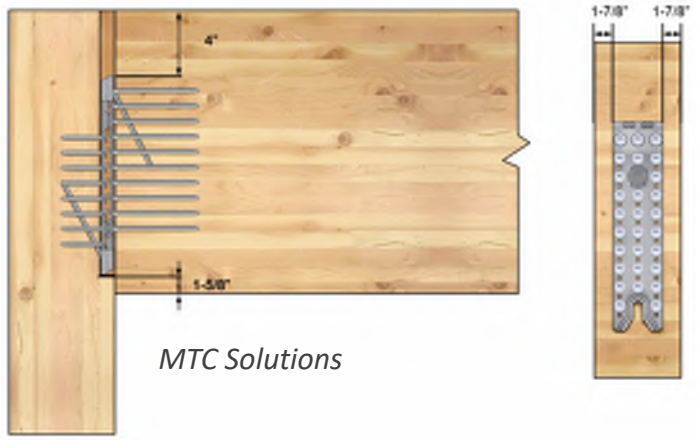


Image Simpson Strong-Tie

Concealed Hanger Connectors



Simpson Strong-Tie



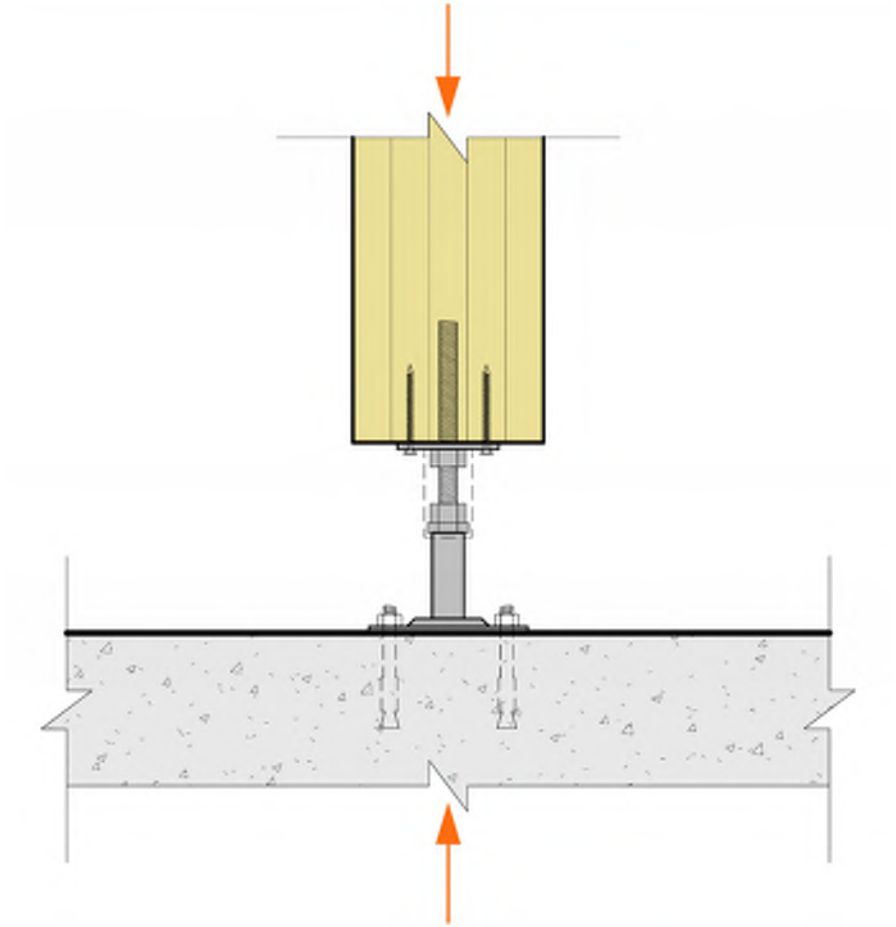
MTC Solutions

MTC Solutions

Concealed Hook Connectors

Images Rothoblaas

Adjustable Column Connector



Column Bears with Proprietary Adjustable Column Base

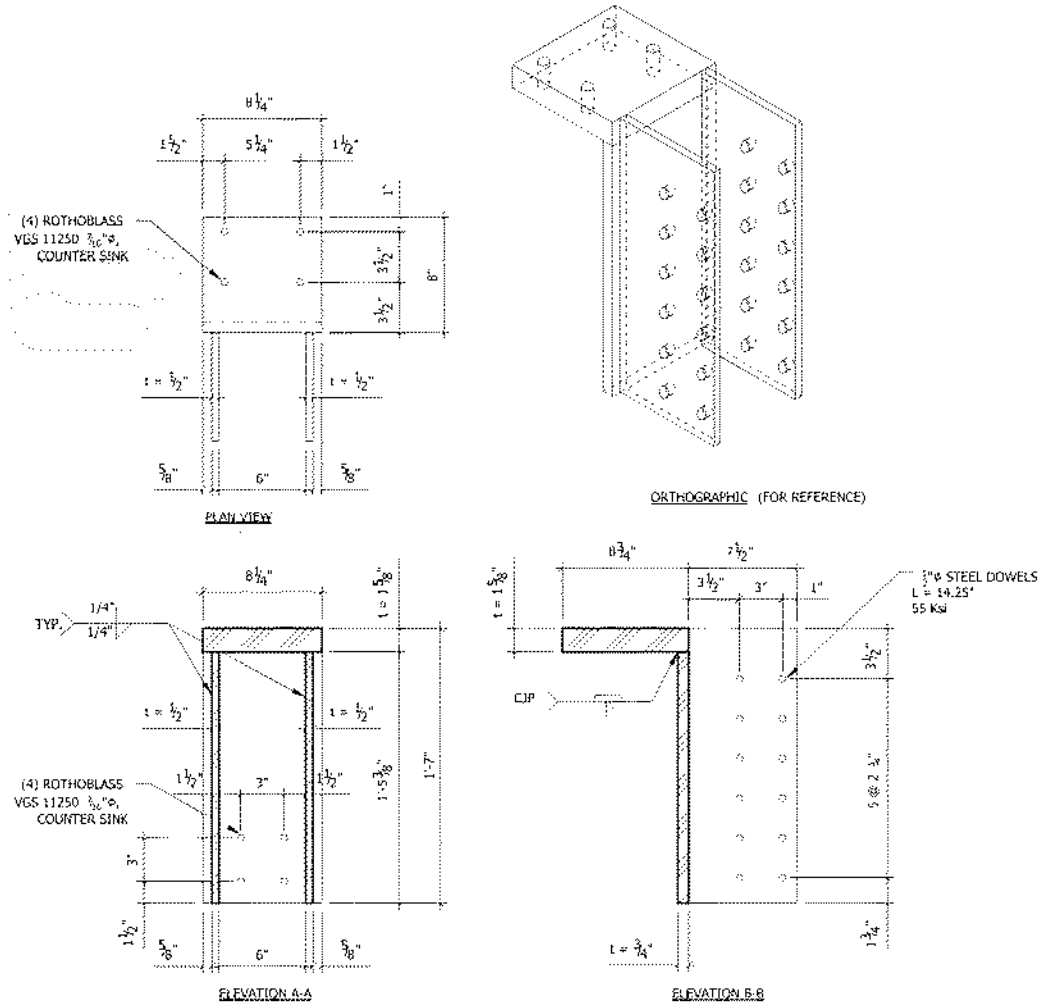
Image WoodWorks

Photos Rothoblaas

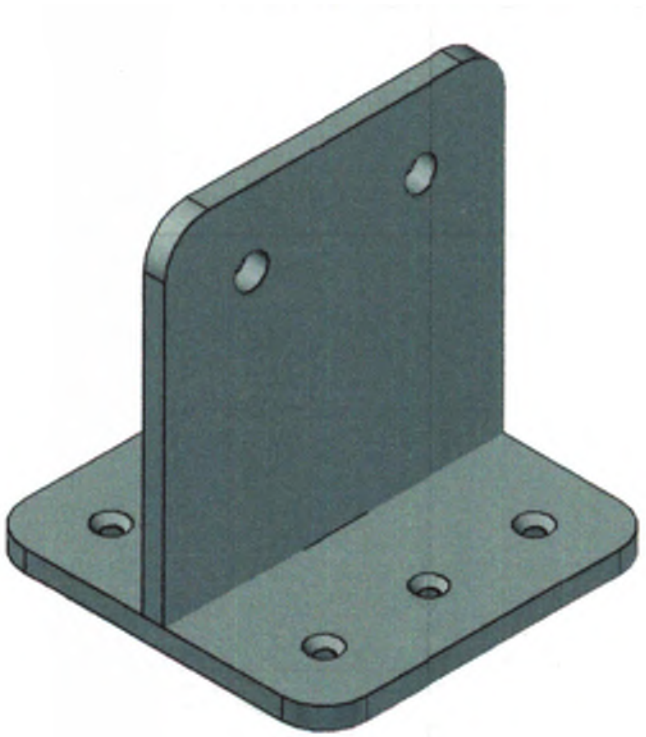
Burwell Center for Career Achievement
Lake|Flato Architects / Shears Adkins Rockmore Architects / KL&A Engineers & Builders / PCL Construction Services
Photos WoodWorks (L); KL&A

Example: Concealed Knife Plate with Holes

Image Foust Fabrication, T3 Timbers

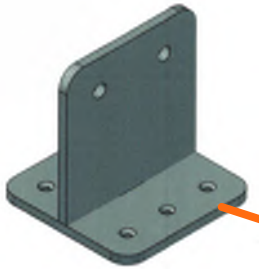


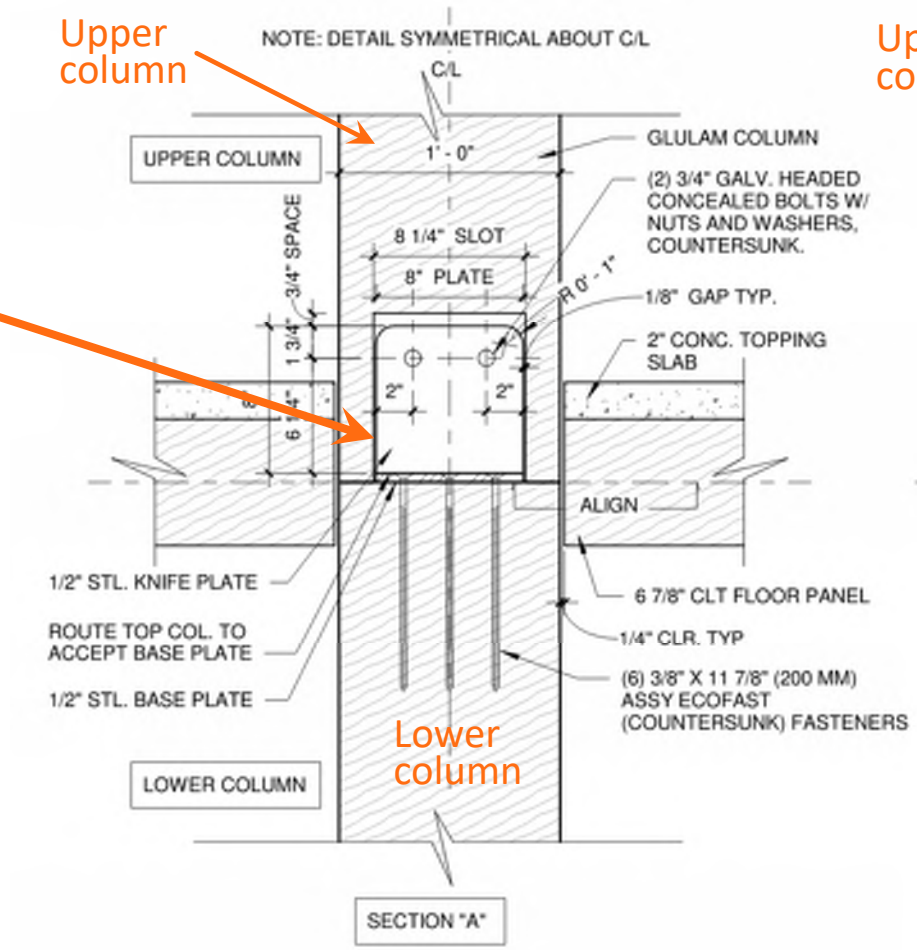
Knife Plate Assembly



Column-to-column
knife plate

Timber House / Photo T3 Timbers





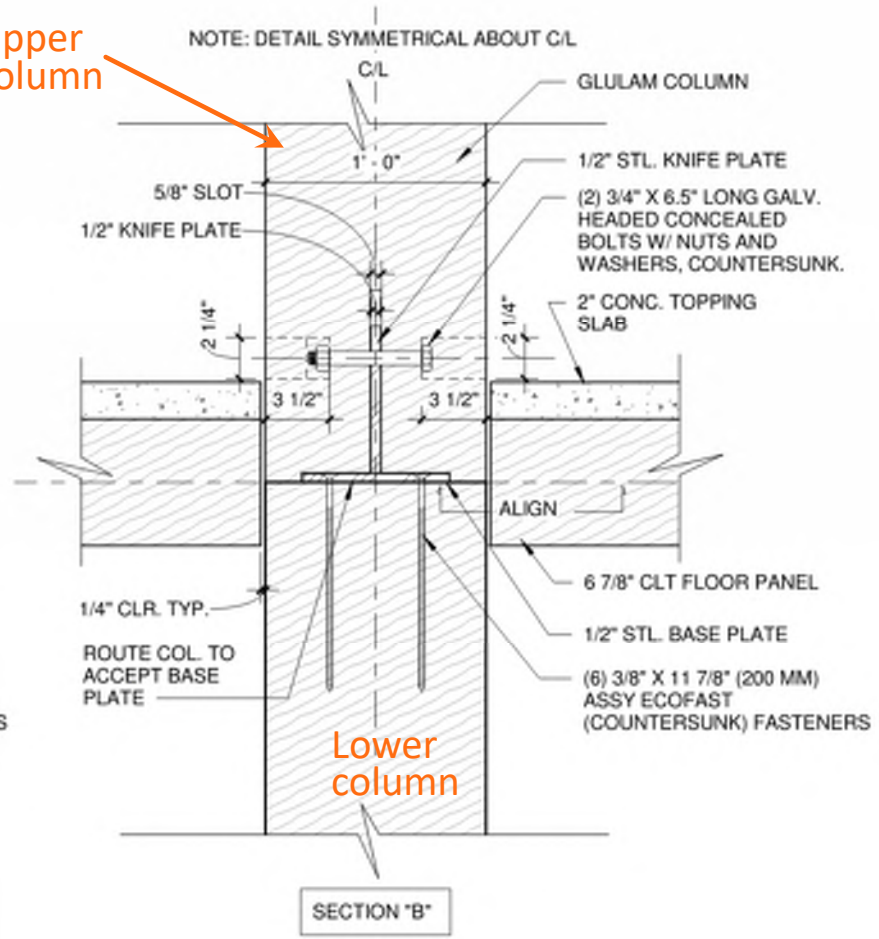
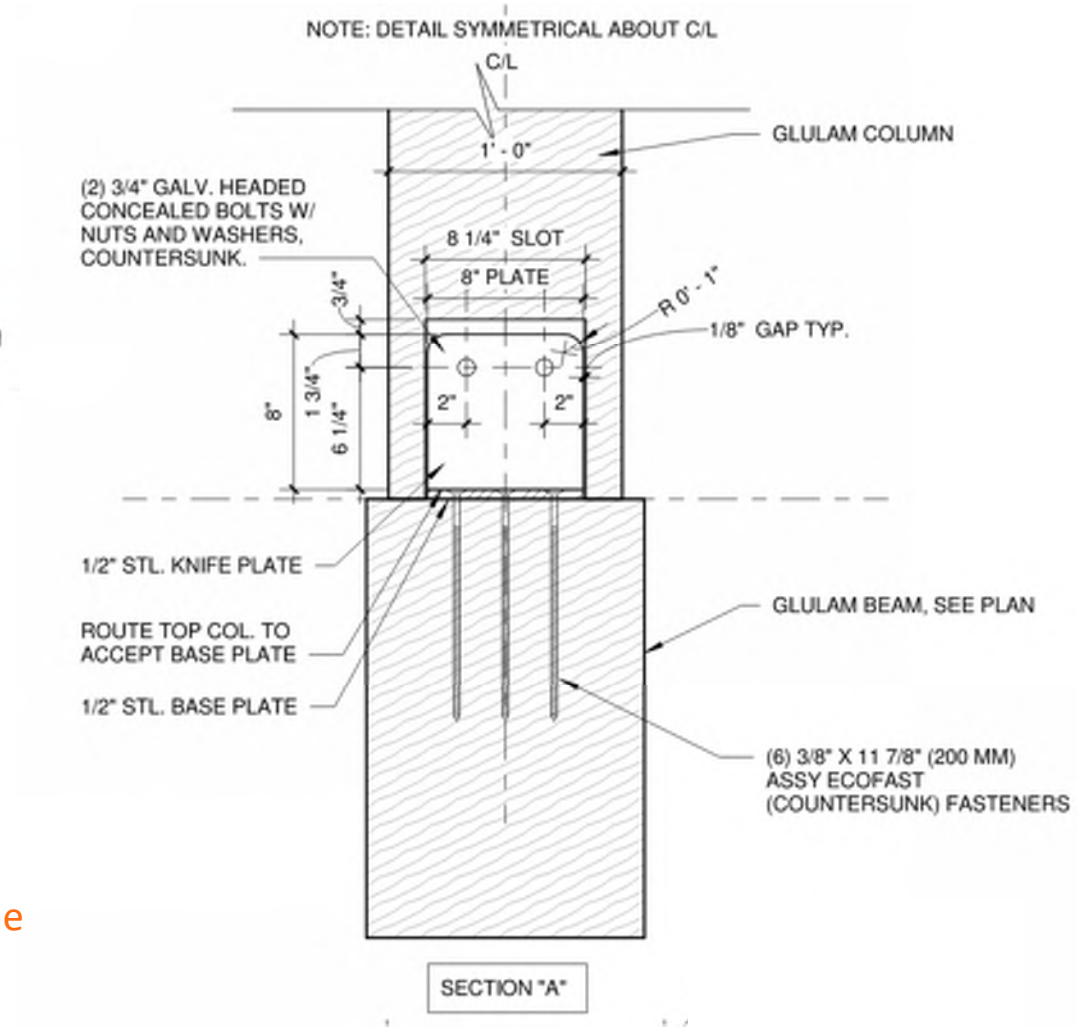


Image Foust Fabrication, T3 Timbers

The same connection can be used for columns to beams:

Knife plate attached to the top of the wood **BEAM**



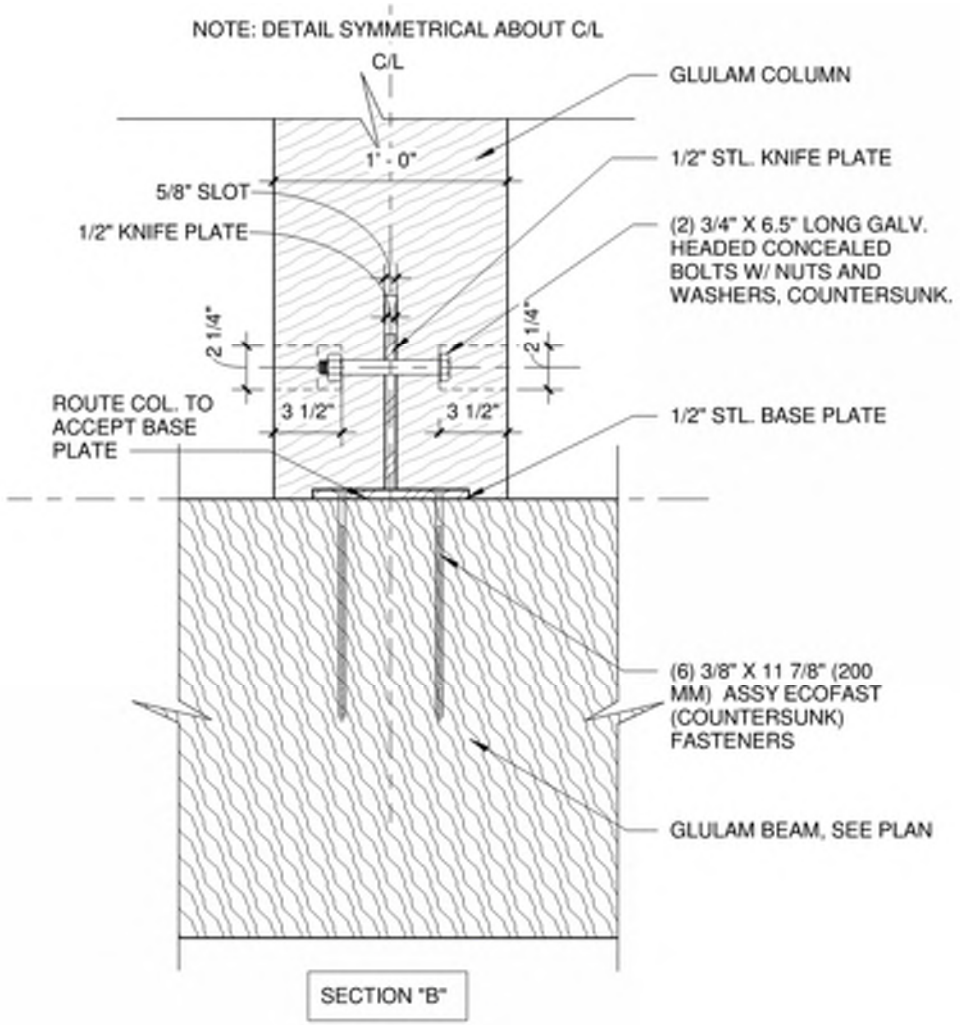


Image Foust Fabrication, T3 Timbers

Or columns to **steel** beams:

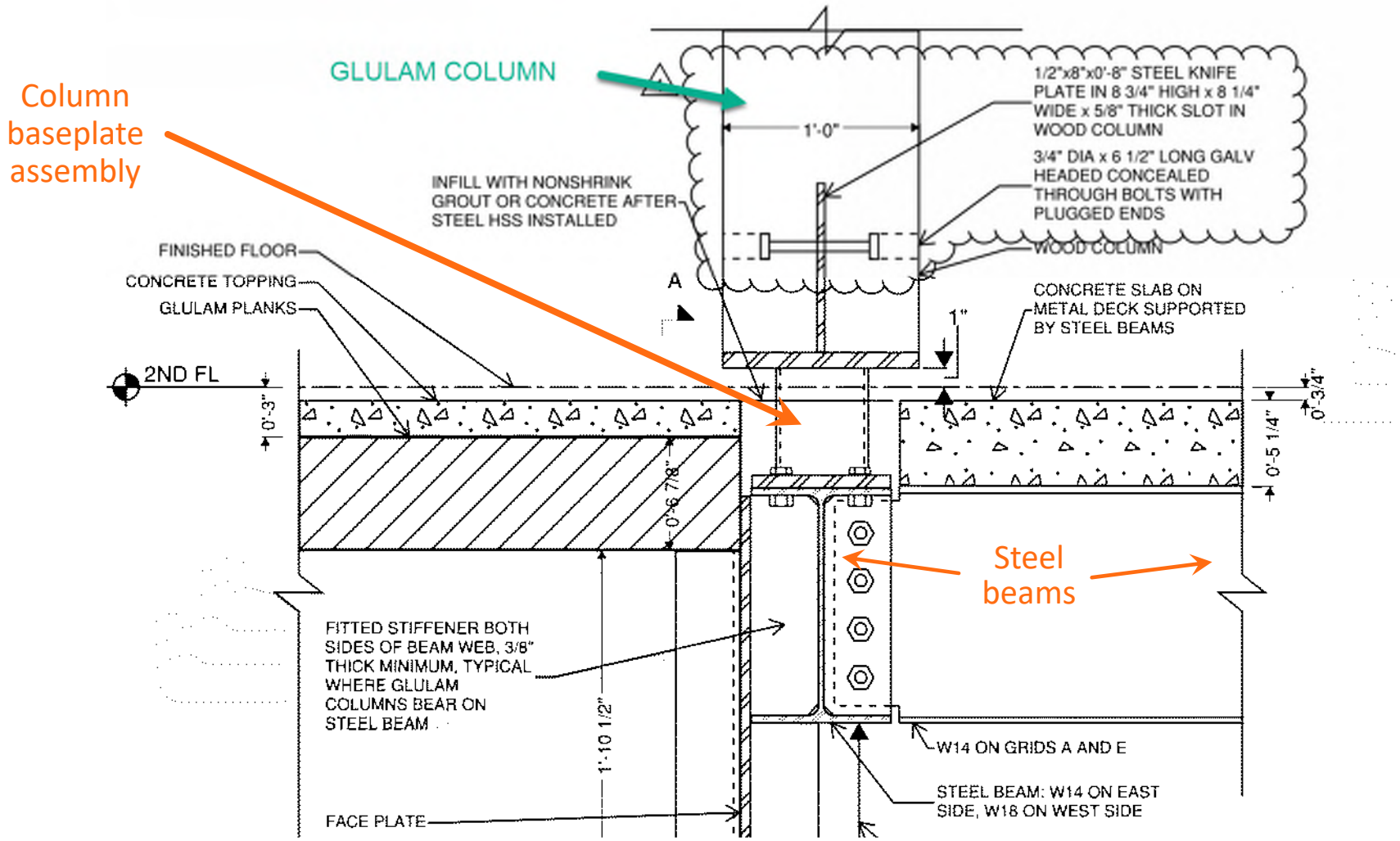


Image Foust Fabrication, T3 Timbers

INTRO

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

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

Concealed vs. Not Concealed

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

Connection Classes and *Fire Ratings*

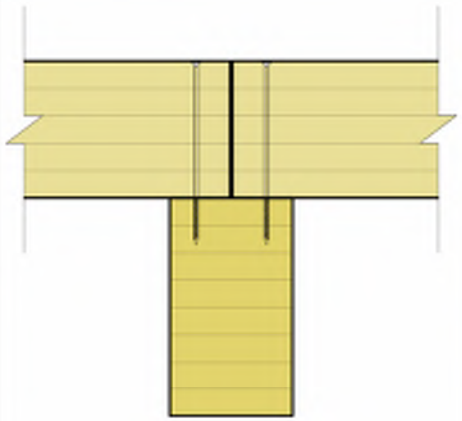
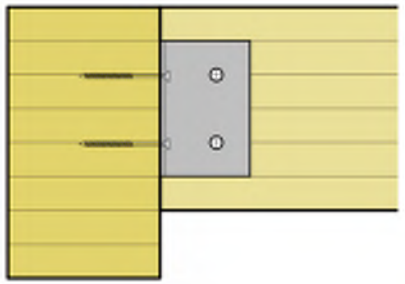
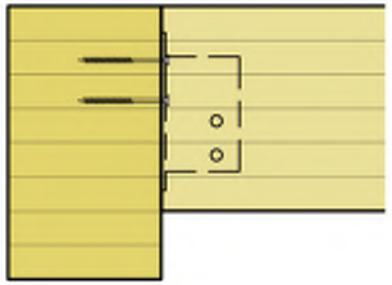
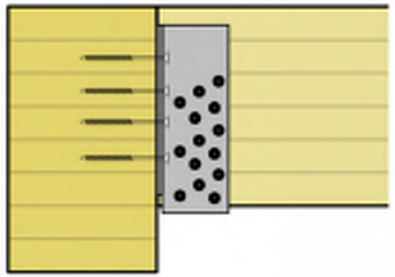
Connection class	**Class 1**	**Class 2**	**Class 3**	**Class 3**
Fire resistance	May be inherently fire resistant according to NDS calculations	Requires additional protection to meet fire-rating requirements	Tested fire-resistance rating (as specified by manufacturer)	Requires additional protection to meet fire-rating requirements
Connection example				
	Beam Bears on Girder*	Beam Connected to Girder with Steel Angles*	Beam Connected to Girder with Concealed Face-Mounted Knife Plate Connector*	Beam Connected to Girder with Proprietary Hanger*

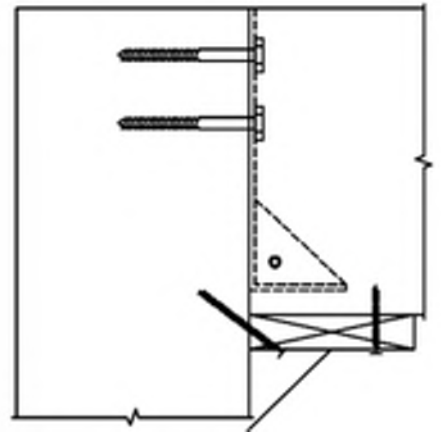
Table 8 in the **Index*

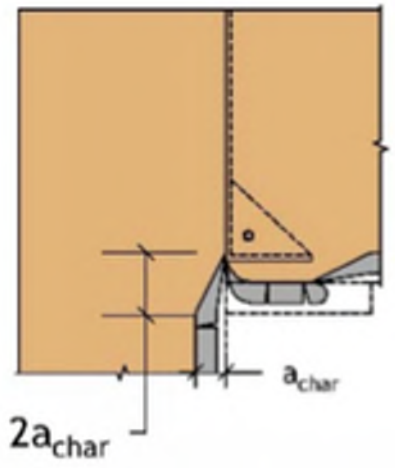
Connections

IBC 2304.10.1 Fire resistance ratings in **Type IV-A, IV-B, or IV-C** construction shall be determined by one of the following:

1. Testing in accordance with Section 703.2 where the connection is part of the fire resistance test.

2. Engineering analysis that demonstrates that the temperature rise at any portion of the connection is limited to an average temperature rise of 250o F (139o C), and a maximum temperature rise of 325o F (181o C), for a time corresponding to the required fire resistance…





Source: AWC's TR 10

Connections

2017 Glulam Beam to Column Connection Fire Tests under standard ASTM E119 time-temperature exposure

Photo: ARUP/SLB

Source: International Building Code

Tall Mass Timber Special Inspections

Required for Type IV-A, IV-B, and IV-C

TABLE 1705.5.3
REQUIRED SPECIAL INSPECTIONS OF MASS TIMBER CONSTRUCTION

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

Topics

- Introduction to Mass Timber
- Connections, Fasteners, and Hardware
- **Installation and Material Protection**
- Safety Considerations

Transportation and Material Handling

Photo Paul Alberts / Ardor Media / naturallywood.com

Never dump or drag panels off trucks

Forklifts and Telescoping Handlers

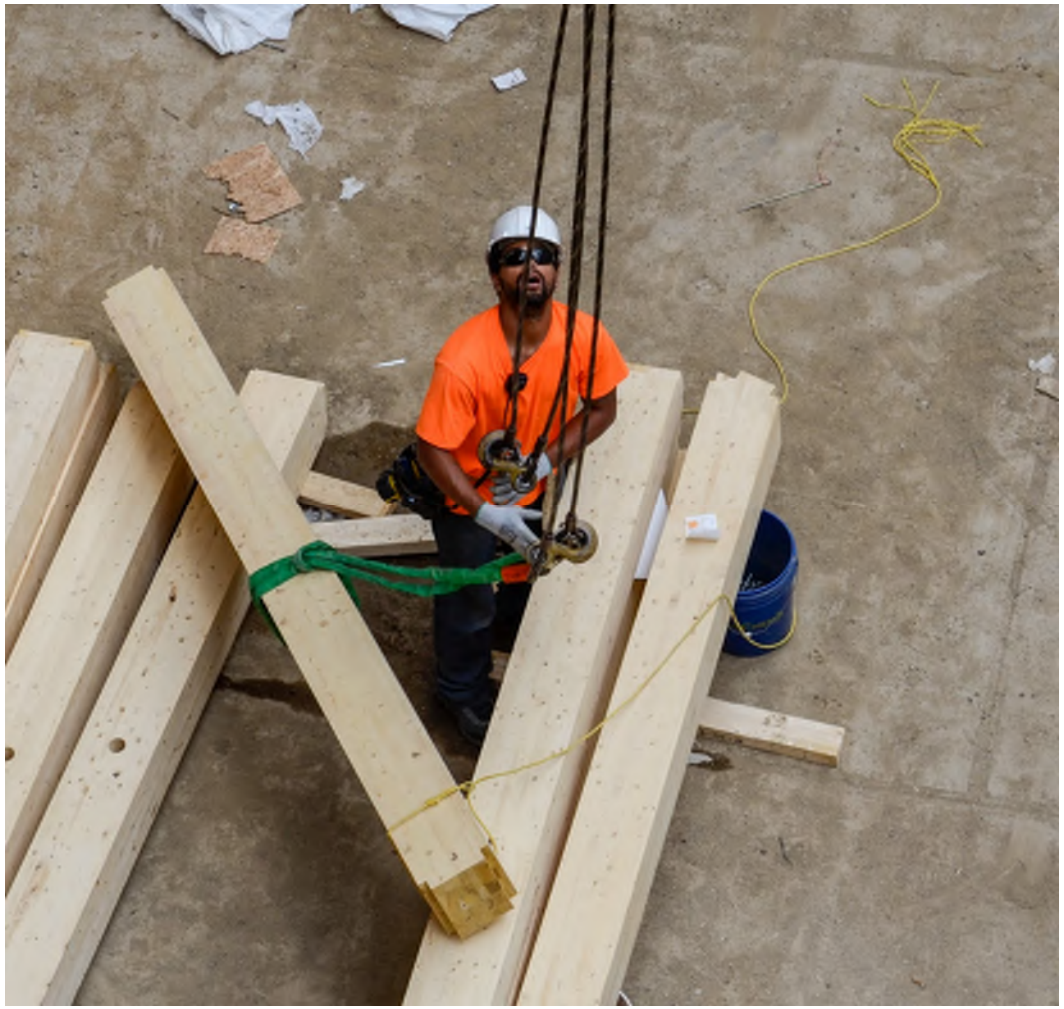
Use forks at least 2/3 of panel width

Organization & Staging

KK Law courtesy naturallywood.com

Photo Swinerton

Installing Columns



John W. Olver Design Building / Photo Alex Schreyer

Set the column

Plumb the column

- Measure using actual size of the column.
- Check exterior vs. interior plumb tolerances.

Install column braces in accordance with bracing plans

Ascent / *Photo WoodWorks*

Installing Beams

Set the beam

- Remove protection material as needed.
- Set the beam and connect to supporting material.

INTRO / Photo Ohio Carpenters Apprentice and Training Program

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

Material Handling

- Lifts provide safe access for workers at height.
- Lift type depends on building size and configuration, site logistics, etc.
- Forklifts (including standard, all-terrain and high capacity), boom lifts and scissor lifts are all commonly used.

Bullitt Center
The Miller Hull Partnership / DCI Engineers / Schuchart Construction
Photo John Stamets

Installing Panels

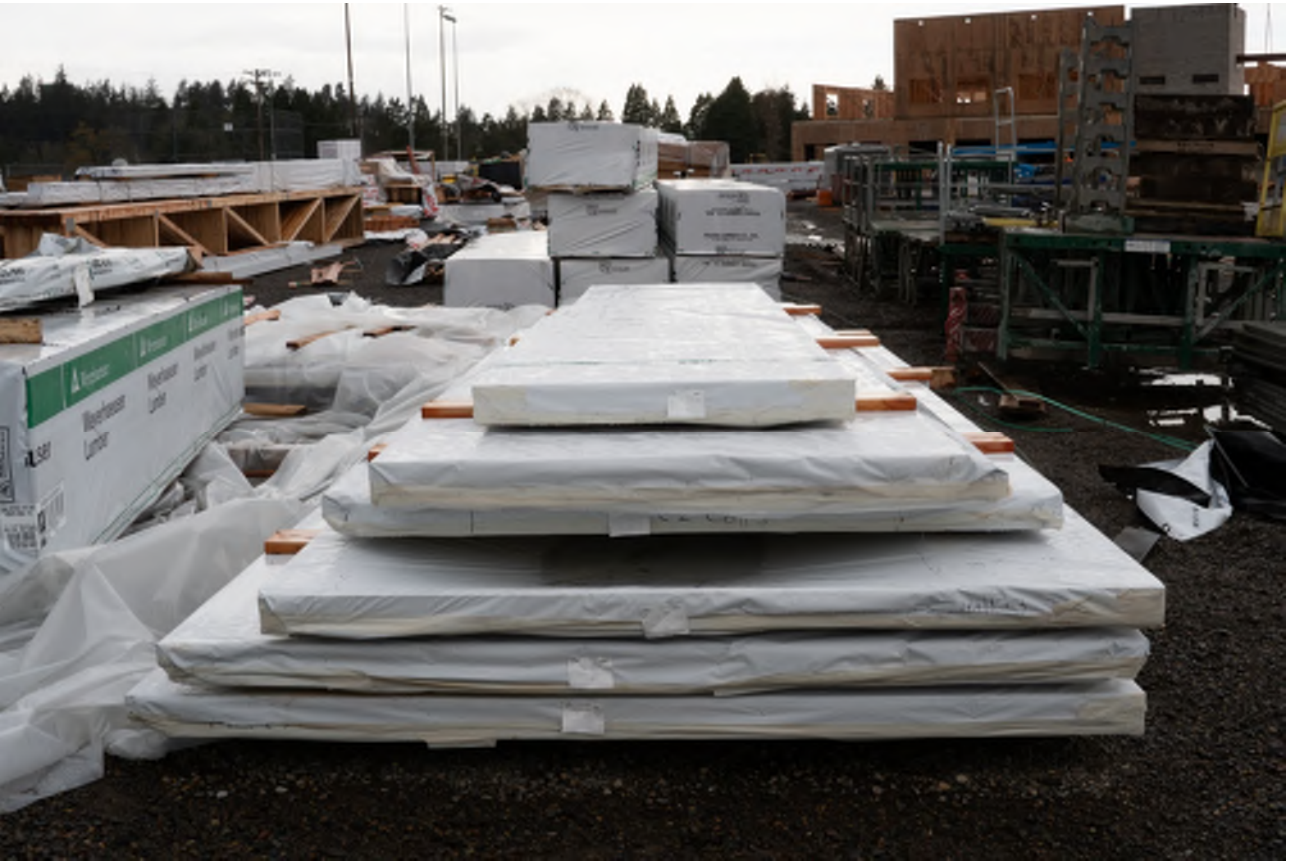
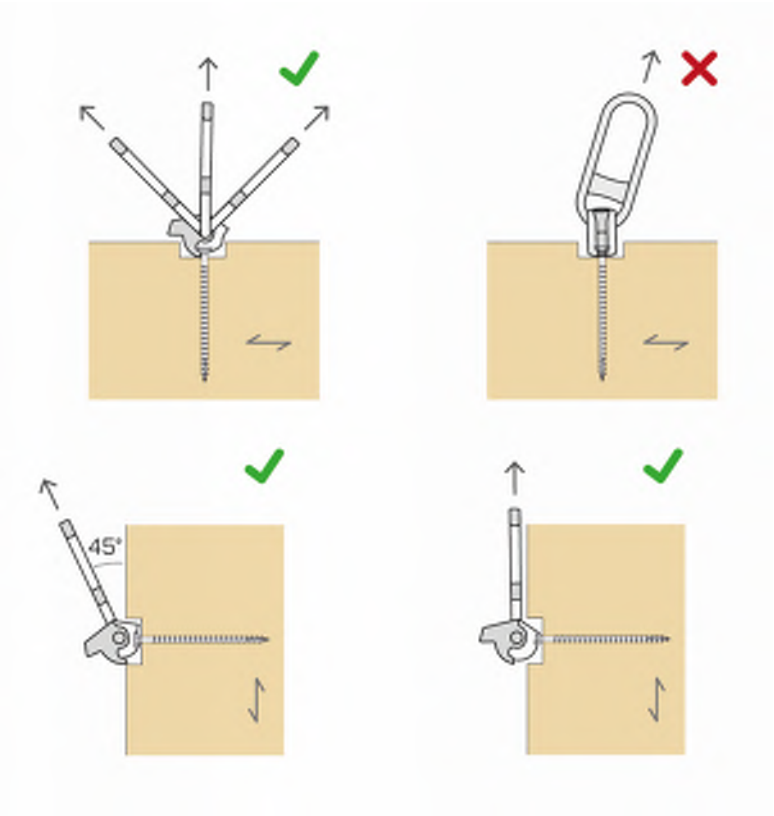


Photo Marcus Kauffman

Photo WoodWorks

Specialty Lifting Connectors



You need to account for the lifting connector screw limitations

Image Rothoblaas (above)

The Canyons
Kaiser + Path / catena consulting engineers / R&H Construction
Photo Marcus Kauffman

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 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

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

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

Membranes can be spray-applied, sheet product (adhesive or non), or board/sheathing product.

Vaproshield

Deflection and Diversion

From Moisture Risk Management Strategies for Mass Timber Buildings,
© 2020 RDH Building Science Inc.

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

Avoid Rust and Stains

Remove metal shavings from holes when drilling plates.

- **Grind metal away from mass timber** elements (also protects against fire).
- For high-strength connections that require oil to install, **wipe off excess oil** immediately after installation.
- **Paint utilities before installing** on a mass timber ceiling and touch up afterwards.

Kendeda Building for Innovative Sustainable Design
The Miller Hull Partnership with Lord Aeck Sargent / Uzun + Case / Skanska USA
Photo Jonathan Hillyer

Cleaning Mass Timber

Sanding and cleaning solutions are the most common ways to remove stains.

Photos WoodWorks

Moisture Monitoring

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

- When materials are received
- Regular intervals
- After rainfall
- Before closing 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

Topics

- Introduction to Mass Timber
- Connections, Fasteners, and Hardware
- Installation and Material Protection
- **Safety Considerations**

Construction Benefits

Photo: Lendlease

Qualified Operators

- Ensure that all equipment operators are trained and understand the capabilities, limitations, hazards, safety features, emergency conditions and environmental impacts of equipment before use.

T3 Atlanta
Hartshorne Plunkard Architecture / DLR Group / StructureCraft / New South Construction / *Photo StructureCraft*

Fire Safety During Construction: (Types IVA, B, C)

2021 International Fire Code 3308.4

- Where building construction exceeds six stories above grade plane, at least one layer of noncombustible protection where required by Section 602.4 of the International Building Code shall be installed on all building elements more than 4 floor levels, including mezzanines, below active mass timber construction before erecting additional floor levels.

- Where building construction exceeds six stories above grade plane required exterior wall coverings shall be installed on all floor levels more than 4 floor levels, including mezzanines, below active mass timber construction before erecting additional floor level.

Type IV-C Exposure Limits

All Mass Timber surfaces may be exposed

- Exceptions: Shafts, concealed spaces, outside face of exterior walls

Type IV-B Exposure Limits

2021 IBC: 20% of ceilings or 40% of walls can be exposed

2024 IBC: 100% of ceilings or 40% of walls can be exposed

- Exceptions: Shafts, concealed spaces, outside face of exterior walls

Type IV-A Exposure Limits

Non-combustible protection required on all surfaces of Mass Timber

Noncombustible Protection (NC) – Types IVA, B, C

Where timber is required to be protected, NC must contribute at least 2/3 of the Fire Resistance Rating

Required Noncombustible Contribution to FRR

FRR of Building Element (hours)	Minimum from Noncombustible Protection (minutes)
1	40
2	80
3 or more	120

Source: 2021 IBC Section 722.7

Fire Safety During Construction: (Types IVA, B, C)

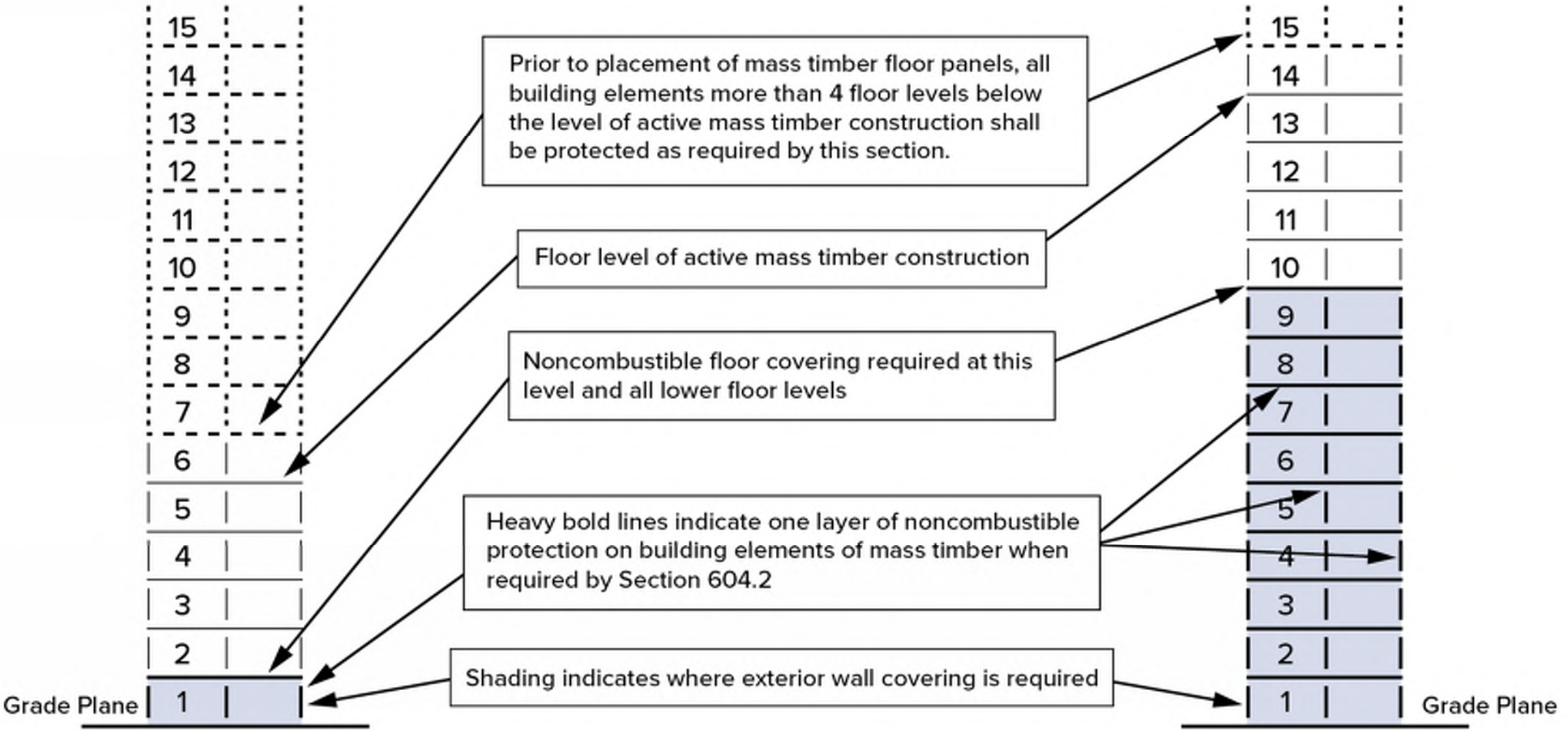


Image International Code Council

Construction Time

Brock Commons

- 1 floor every 3 days
- 17 floors in 9.5 weeks

Brock Commons, Vancouver, BC
Source: naturally:wood

The best way to minimize exposure to moisture is to close in the project quickly.

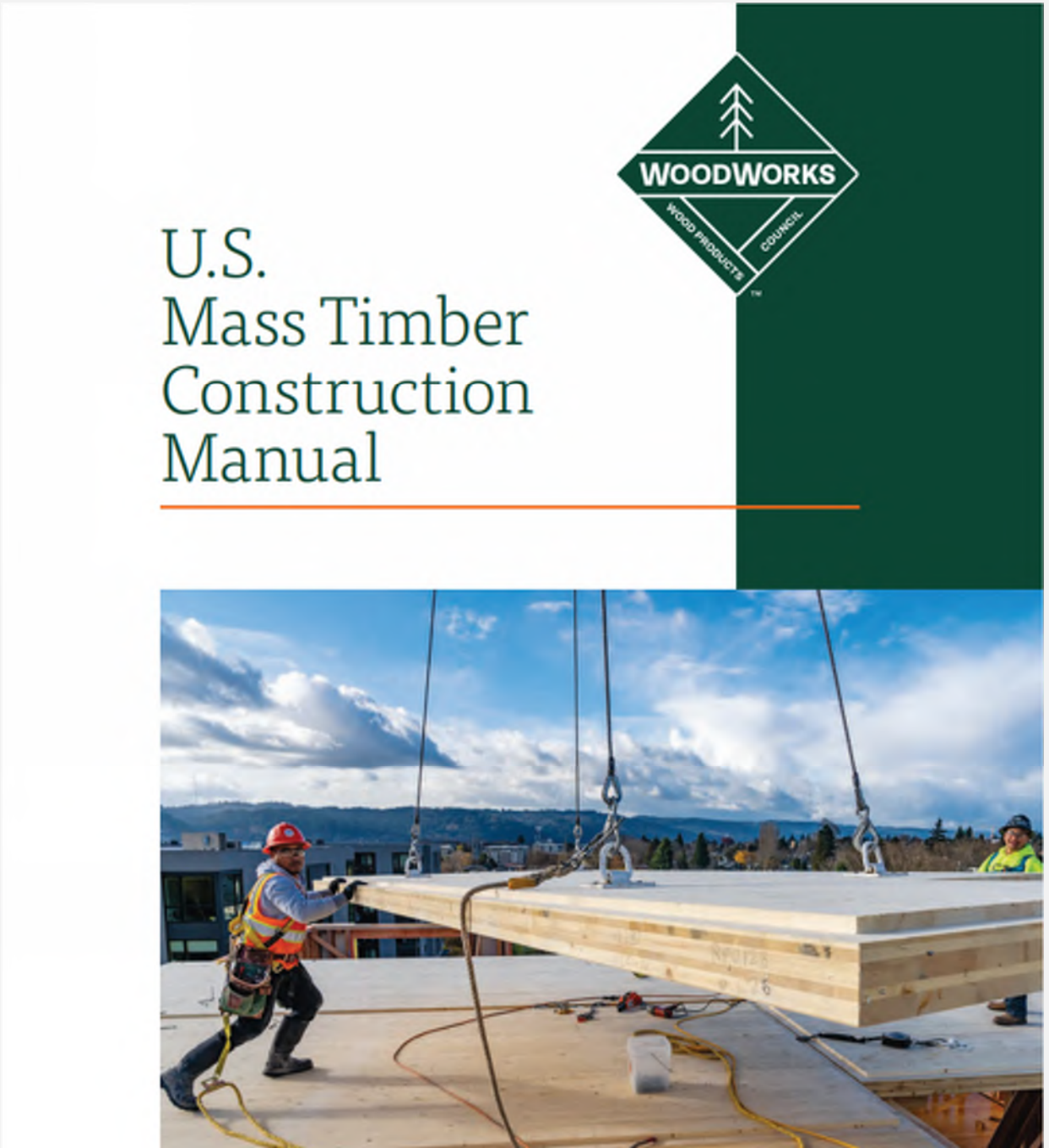
INTRO / Photo Harbor Bay Ventures

Mass Timber Construction Manual

Free Resource:

www.woodworks.org

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



Course Description

Accurate costing is critical to the success of mass timber projects. This presentation reviews essential resources for design teams to help clarify pricing, bidding, and project delivery methods. These aspects put together, are all decisions that influence cost-efficiency and overall project outcomes. Participants will learn how to navigate the complexities of costing and make more informed decisions that benefit their mass timber projects.

Learning Objectives

1. Identify and review available resources for accurately pricing mass timber projects, ensuring clarity in bidding, and project delivery methods that enhance financial planning and project viability.

2. Analyze different project delivery methods for mass timber construction, understanding their financial implications and how to choose the most suitable approach for your project.

3. Learn about the critical decisions and strategies that can impact the cost-efficiency and success of mass timber projects, ensuring adherence to health, safety, and welfare standards.

4. Review strategies to effectively implement best practices in costing and project delivery for mass timber projects, improving overall project outcomes and ensuring economic sustainability.

Factors Influencing Cost

» **Material Availability**:

- Regional differences in availability and pricing

» **Procurement Model**:

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

» **Design Complexity**:

- High impact on material and labor costs

Key Early Design Decisions

Construction Type

Fire-Resistance Ratings

Member Sizes

Grids & Spans

Exposed Timber (where & how much)

MEP Layout

Acoustics

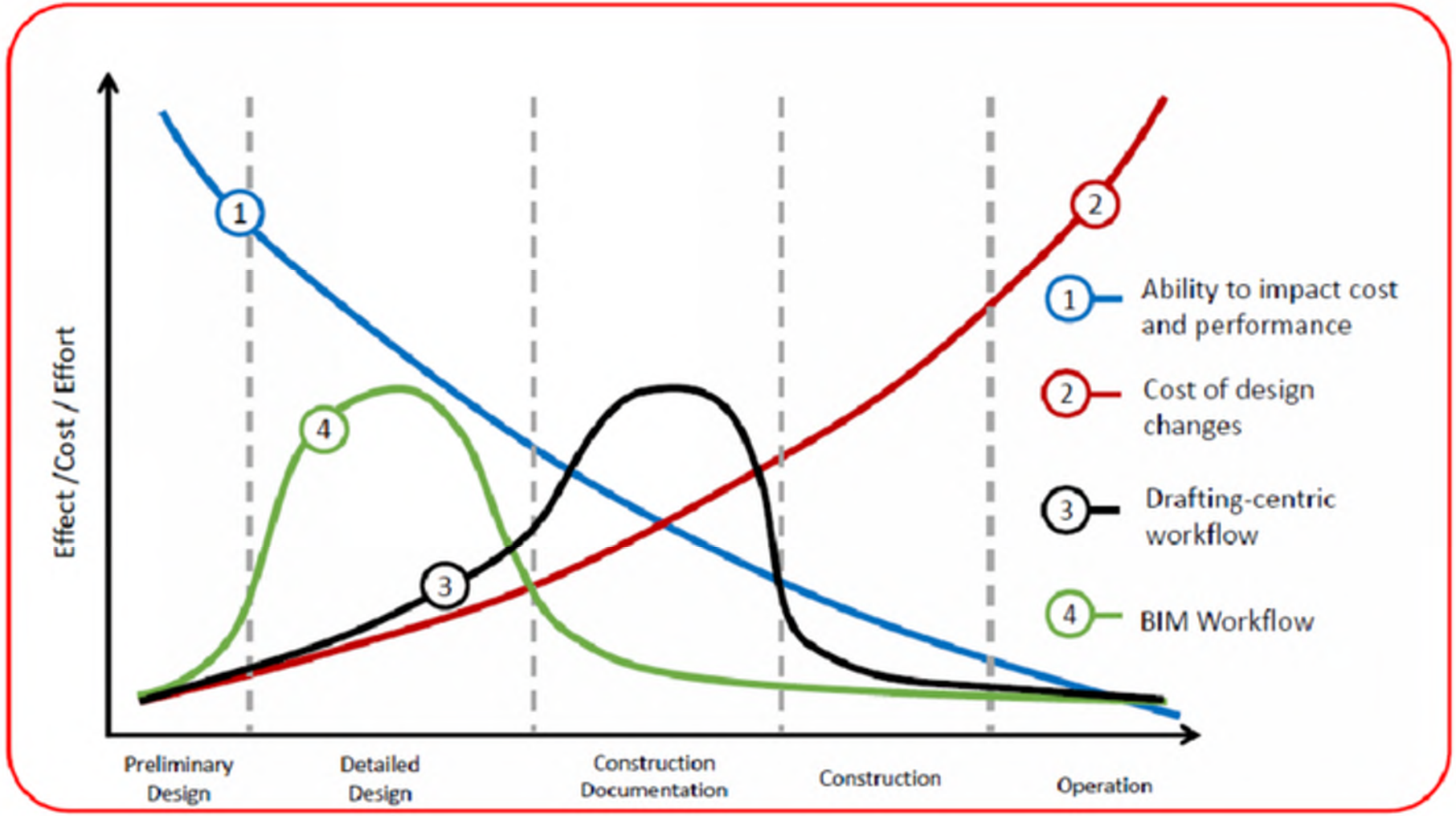
Concealed Spaces

Connections

Penetrations

All Need to Be Weighed (Plus Others)

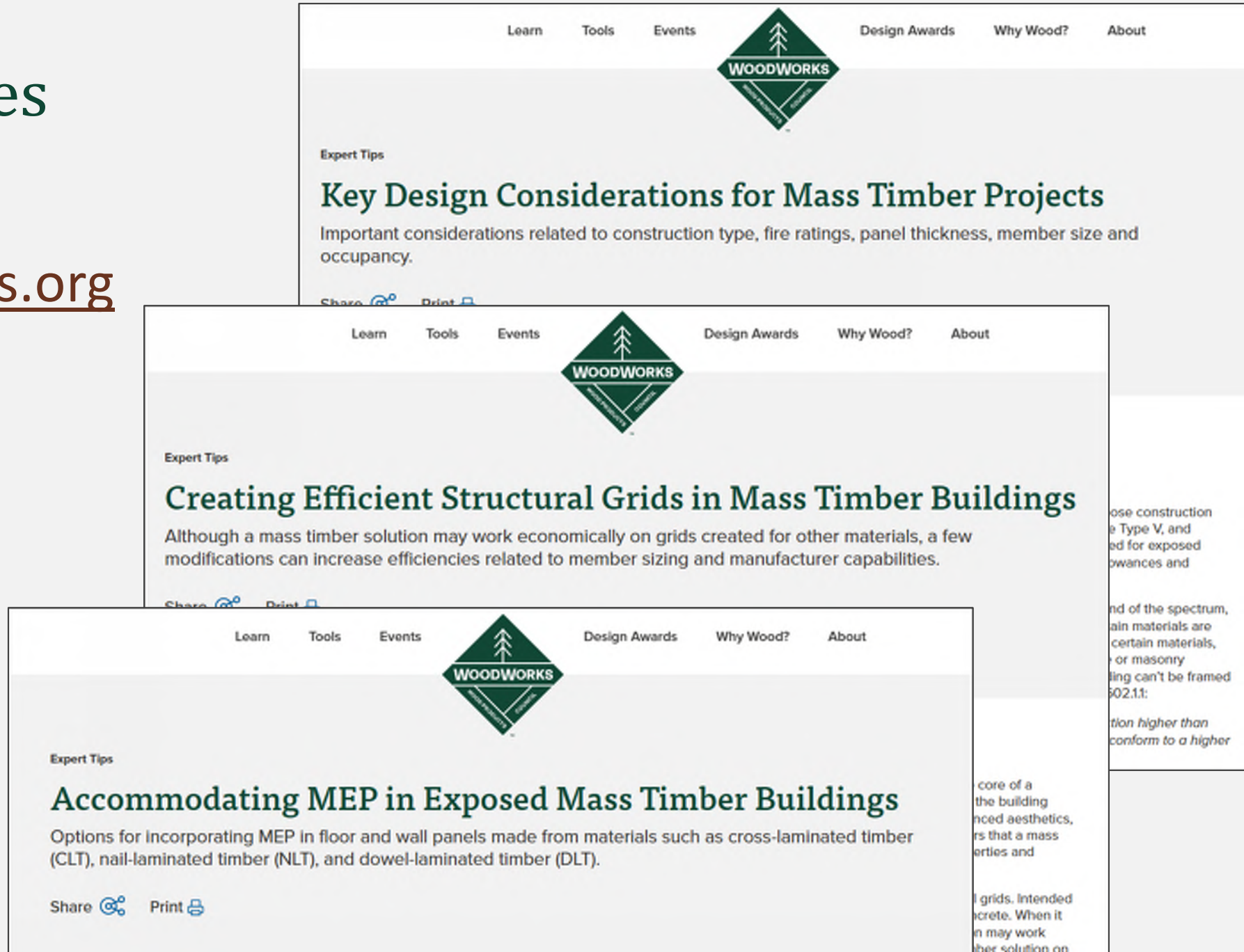
Factors Influencing Cost



Design Resources

Free Resource:

www.woodworks.org



Mass Timber Cost Management

Free Resource:

www.woodworks.org

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 Managing a Mass Timber Project

- Step 1: Do your Homework
- Step 2: Establish a Reliable Pre-Design Budget
- Step 3: Manage Project Costs

Cost Managing a Mass Timber Project

- **Step 1: Do your Homework**
  - Vet potential subcontractors
  - Determine the procurement model

» Step 2: Establish a Reliable Pre-Design Budget

» Step 3: Manage Project Costs

Do Your Homework

Insights for Bids

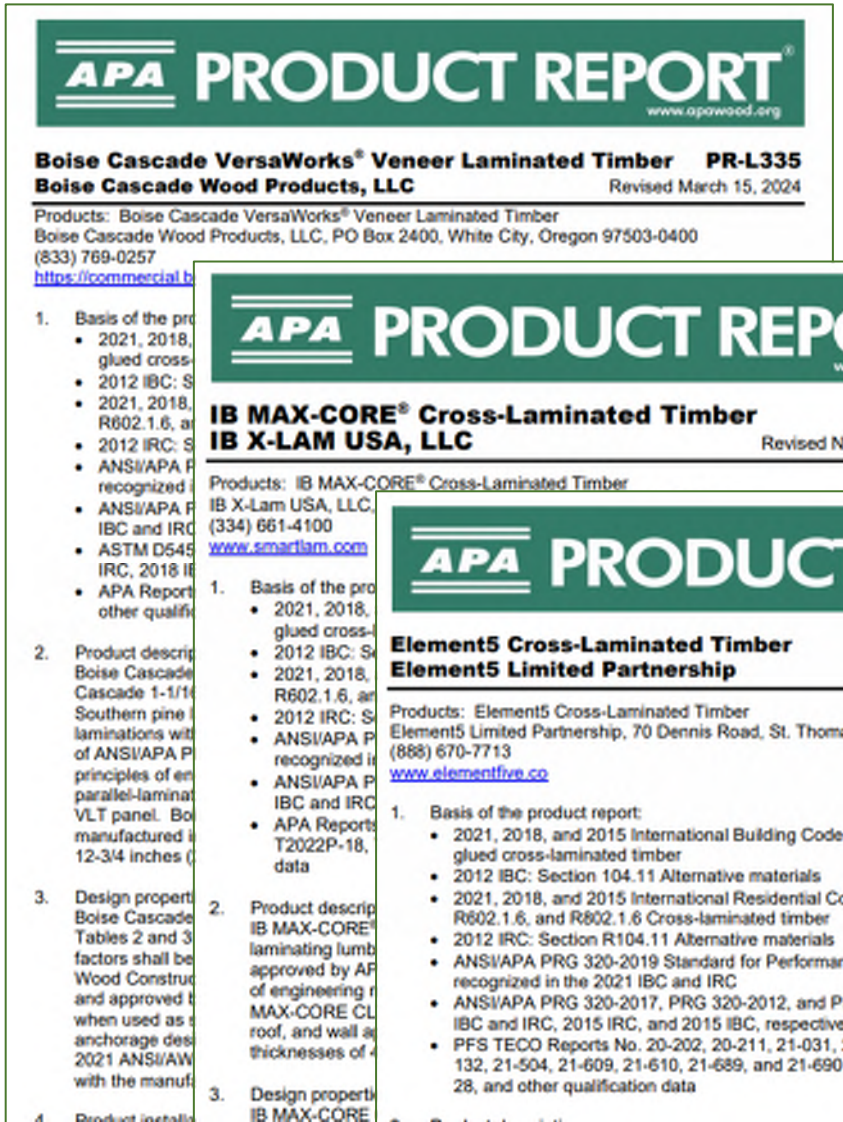
- Not every project is the right fit for every supplier or installer and producing good bids takes time
- Aim for three or four qualified/interested bidders to cover both* supply and installation scopes
- Create a **flexible specification**.
  - Knowing that the project will be CLT doesn't mean that every CLT manufacturer can meet the requirements

Understand Manufacturer's Capabilities

Photo: DR Johnson

- Manufacturers offer different species, grades, and maximum panel/beam sizes
- Manufacturers have specific CNC capabilities
- 3rd Party Fabricators can have additional CNC capabilities
- Trucking/Shipping Logistics and Cost

Cross Laminated Timber (CLT) Product Reports



APA PRODUCT REPORT
www.apawood.org

Boise Cascade VersaWorks® Veneer Laminated Timber **PR-L335**
Boise Cascade Wood Products, LLC Revised March 15, 2024

Products: Boise Cascade VersaWorks® Veneer Laminated Timber
Boise Cascade Wood Products, LLC, PO Box 2400, White City, Oregon 97503-0400
(833) 769-0257
https://commercial.b

1. Basis of the pr
   - 2021, 2018, glued cross-
   - 2012 IBC: S
   - 2021, 2018, R602.1.6, a
   - 2012 IRC: S
   - ANSI/APA P recognized
   - ANSI/APA P IBC and IRC
   - ASTM D545 IRC, 2018 I
   - APA Report other qualifi

2. Product descrip Boise Cascade Cascade 1-1/1 Southern pine laminations wit of ANSI/APA P principles of en parallel-laminat VLT panel. Bo manufactured 12-3/4 inches (

3. Design propert Boise Cascade Tables 2 and 3 factors shall be Wood Construc and approved b when used as anchorage des 2021 ANSI/AW with the manuf

APA PRODUCT REPORT
www.apawood.org

IB MAX-CORE® Cross-Laminated Timber **PR-L327**
IB X-LAM USA, LLC Revised November 30, 2023

Products: IB MAX-CORE® Cross-Laminated Timber
IB X-Lam USA, LLC,
(334) 661-4100
www.smartlam.com

1. Basis of the pro
   - 2021, 2018, glued cross-
   - 2012 IBC: S
   - 2021, 2018, R602.1.6, a
   - 2012 IRC: S
   - ANSI/APA P recognized i
   - ANSI/APA P IBC and IRC
   - APA Reports T2022P-18, data

2. Product descrip IB MAX-CORE laminating lumb approved by AP of engineering MAX-CORE CL roof, and wall a thicknesses of

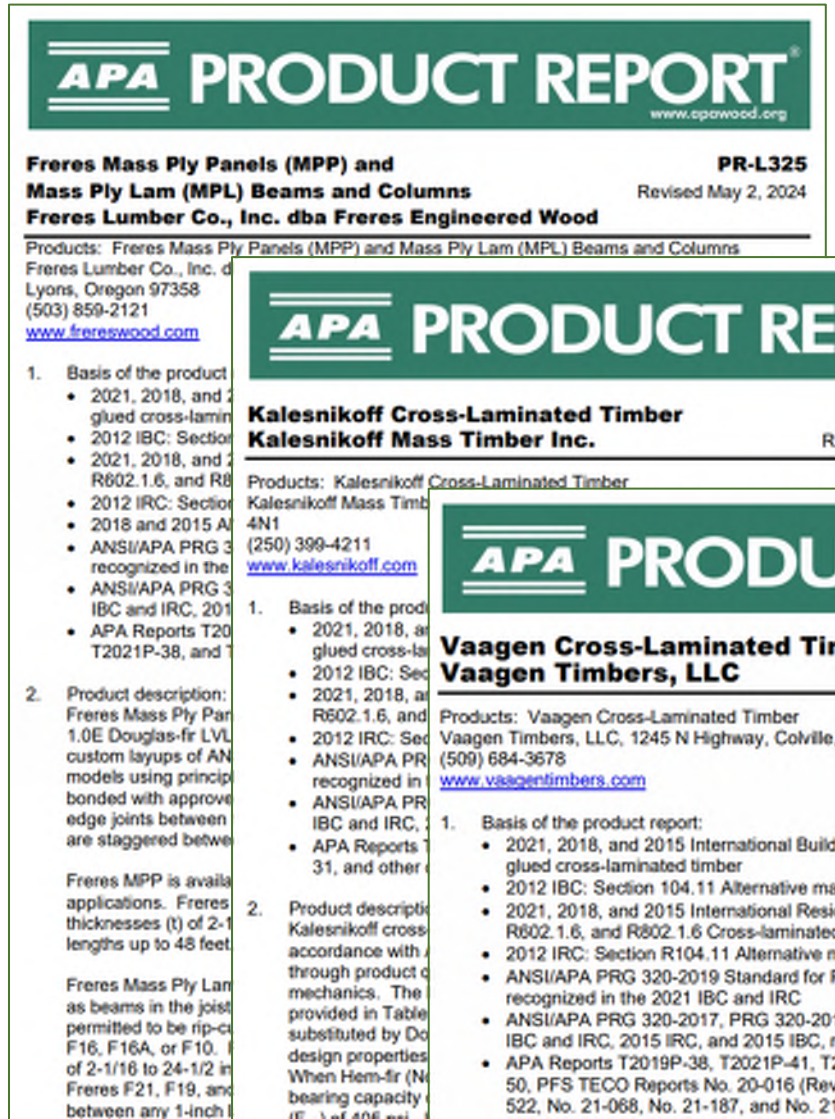
3. Design properti IB MAX-CORE

APA PRODUCT REPORT
www.apawood.org

Element5 Cross-Laminated Timber **PR-L339**
Element5 Limited Partnership Revised April 18, 2024

Products: Element5 Cross-Laminated Timber
Element5 Limited Partnership, 70 Dennis Road, St. Thomas, Ontario, Canada N5P 0B6
(888) 670-7713
www.elementfive.co

1. Basis of the product report:
   - 2021, 2018, and 2015 International Building Code (IBC): Section 2303.1.4 Structural glued cross-laminated timber
   - 2012 IBC: Section 104.11 Alternative materials
   - 2021, 2018, and 2015 International Residential Code (IRC): Sections R502.1.6, R602.1.6, and R802.1.6 Cross-laminated timber
   - 2012 IRC: Section R104.11 Alternative materials
   - ANSI/APA PRG 320-2019 Standard for Performance-Rated Cross-Laminated Timber, recognized in the 2021 IBC and IRC
   - ANSI/APA PRG 320-2017, PRG 320-2012, and PRG 320-2011 recognized in the 2018 IBC and IRC, 2015 IRC, and 2015 IBC, respectively
   - PFS TECO Reports No. 20-202, 20-211, 21-031, 21-044, 21-052, 21-053, 21-113, 21-132, 21-504, 21-609, 21-610, 21-689, and 21-690, APA Reports T2023P-06 and T2023P-28, and other qualification data



APA PRODUCT REPORT
www.apawood.org

Freres Mass Ply Panels (MPP) and **PR-L325**
Mass Ply Lam (MPL) Beams and Columns Revised May 2, 2024
Freres Lumber Co., Inc. dba Freres Engineered Wood

Products: Freres Mass Ply Panels (MPP) and Mass Ply Lam (MPL) Beams and Columns
Freres Lumber Co., Inc. d
Lyons, Oregon 97358
(503) 859-2121
www.frereswood.com

1. Basis of the product
   - 2021, 2018, and glued cross-lamin
   - 2012 IBC: Sectio
   - 2021, 2018, and R602.1.6, and R8
   - 2012 IRC: Sectio
   - 2018 and 2015 A
   - ANSI/APA PRG 3 recognized in the
   - ANSI/APA PRG 3 IBC and IRC, 201
   - APA Reports T20 T2021P-38, and

2. Product description: Freres Mass Ply Par 1.0E Douglas-fir LVL custom layups of AN models using princip bonded with approv edge joints between are staggered betwe

   Freres MPP is availa applications. Freres thicknesses (t) of 2-1 lengths up to 48 feet.

   Freres Mass Ply Lam as beams in the joist permitted to be rip-c F16, F16A, or F10. of 2-1/16 to 24-1/2 i Freres F21, F19, an between any 1-inch

APA PRODUCT REPORT
www.apawood.org

Kalesnikoff Cross-Laminated Timber **PR-L332**
Kalesnikoff Mass Timber Inc. Revised October 28, 2023

Products: Kalesnikoff Cross-Laminated Timber
Kalesnikoff Mass Timb
4N1
(250) 399-4211
www.kalesnikoff.com

1. Basis of the prod
   - 2021, 2018, a glued cross-la
   - 2012 IBC: Sec
   - 2021, 2018, a R602.1.6, and
   - 2012 IRC: Sec
   - ANSI/APA PR recognized in
   - ANSI/APA PR IBC and IRC,
   - APA Reports T 31, and other

2. Product descripti Kalesnikoff cross accordance with through product c mechanics. The provided in Table substituted by Do design properties When Hem-fir (N bearing capacity between any 1-inch

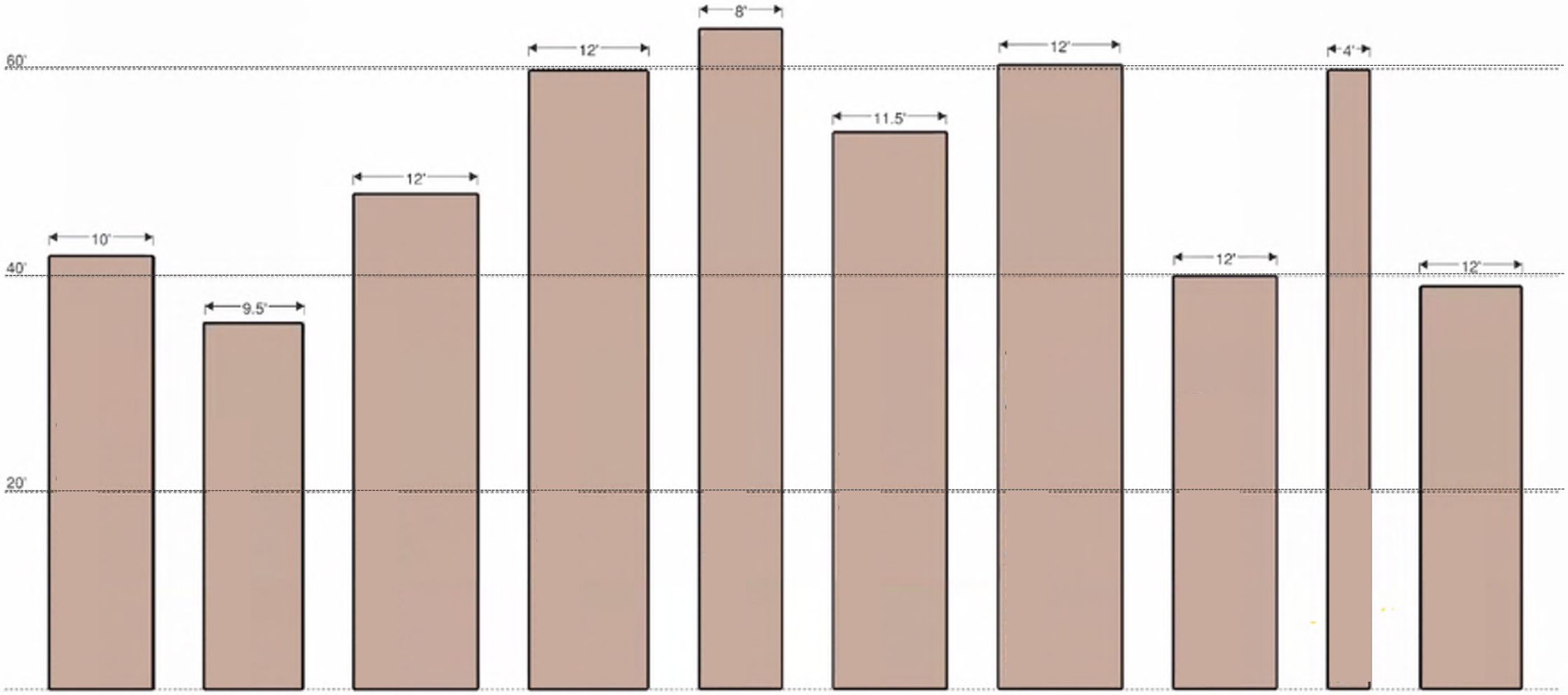
APA PRODUCT REPORT
www.apawood.org

Vaagen Cross-Laminated Timber **PR-L328**
Vaagen Timbers, LLC Revised January 9, 2024

Products: Vaagen Cross-Laminated Timber
Vaagen Timbers, LLC, 1245 N Highway, Colville, WA 99114
(509) 684-3678
www.vaagentimbers.com

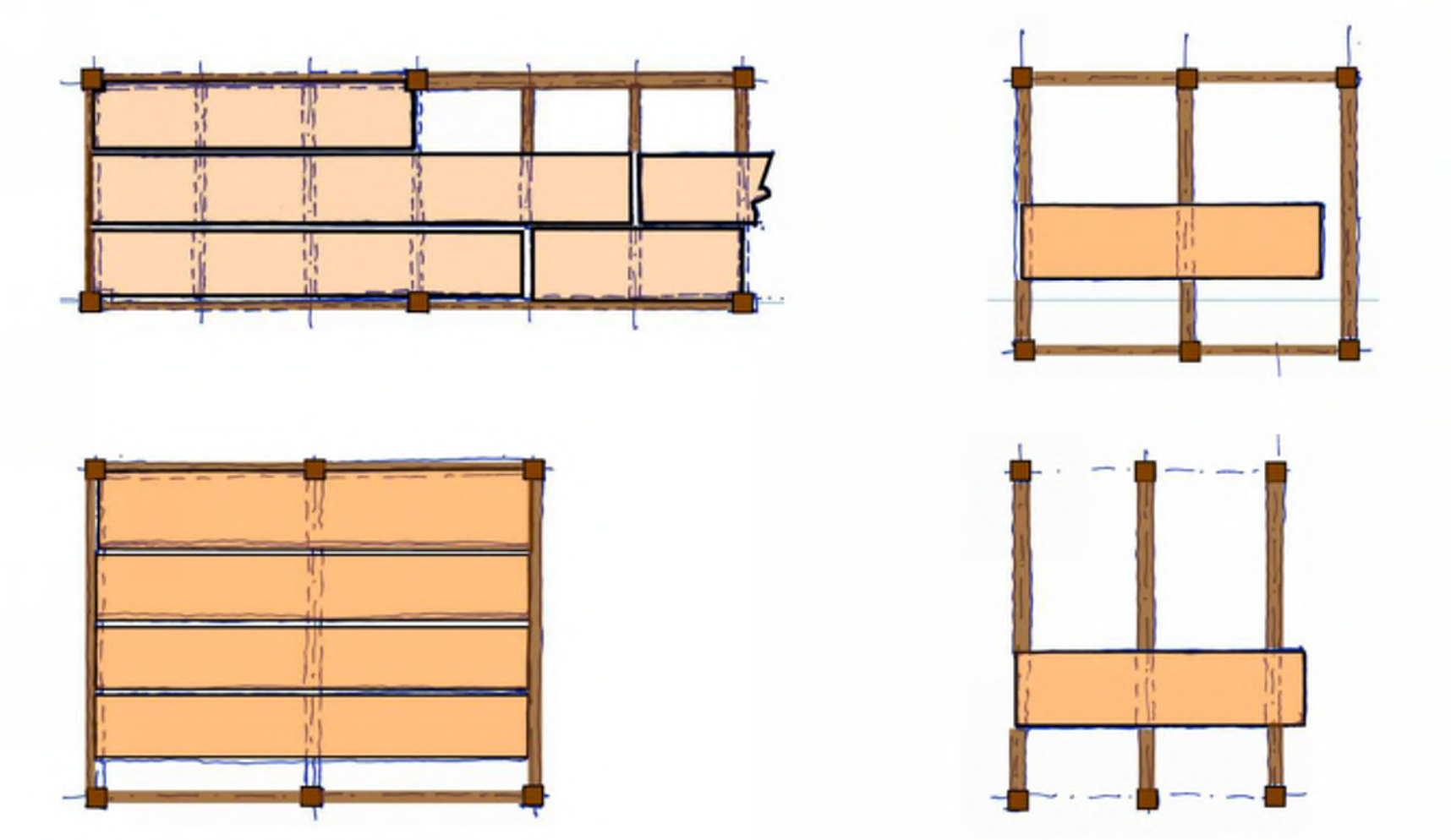
1. Basis of the product report:
   - 2021, 2018, and 2015 International Building Code (IBC): Section 2303.1.4 Structural glued cross-laminated timber
   - 2012 IBC: Section 104.11 Alternative materials
   - 2021, 2018, and 2015 International Residential Code (IRC): Sections R502.1.6, R602.1.6, and R802.1.6 Cross-laminated timber
   - 2012 IRC: Section R104.11 Alternative materials
   - ANSI/APA PRG 320-2019 Standard for Performance-Rated Cross-Laminated Timber recognized in the 2021 IBC and IRC
   - ANSI/APA PRG 320-2017, PRG 320-2012, and PRG 320-2011 recognized in the 2018 IBC and IRC, 2015 IRC, and 2015 IBC, respectively
   - APA Reports T2019P-38, T2021P-41, T2022P-05, T2023P-05, T2023P-14, and T2023P-50, PFS TECO Reports No. 20-016 (Rev. 21-08-17), No. 20-089, No. 20-090, No. 20-522, No. 21-068, No. 21-187, and No. 21-583, and other qualification data

Understand Manufacturer's Capabilities



Credit: TimberLab

Understand Manufacturer's Capabilities



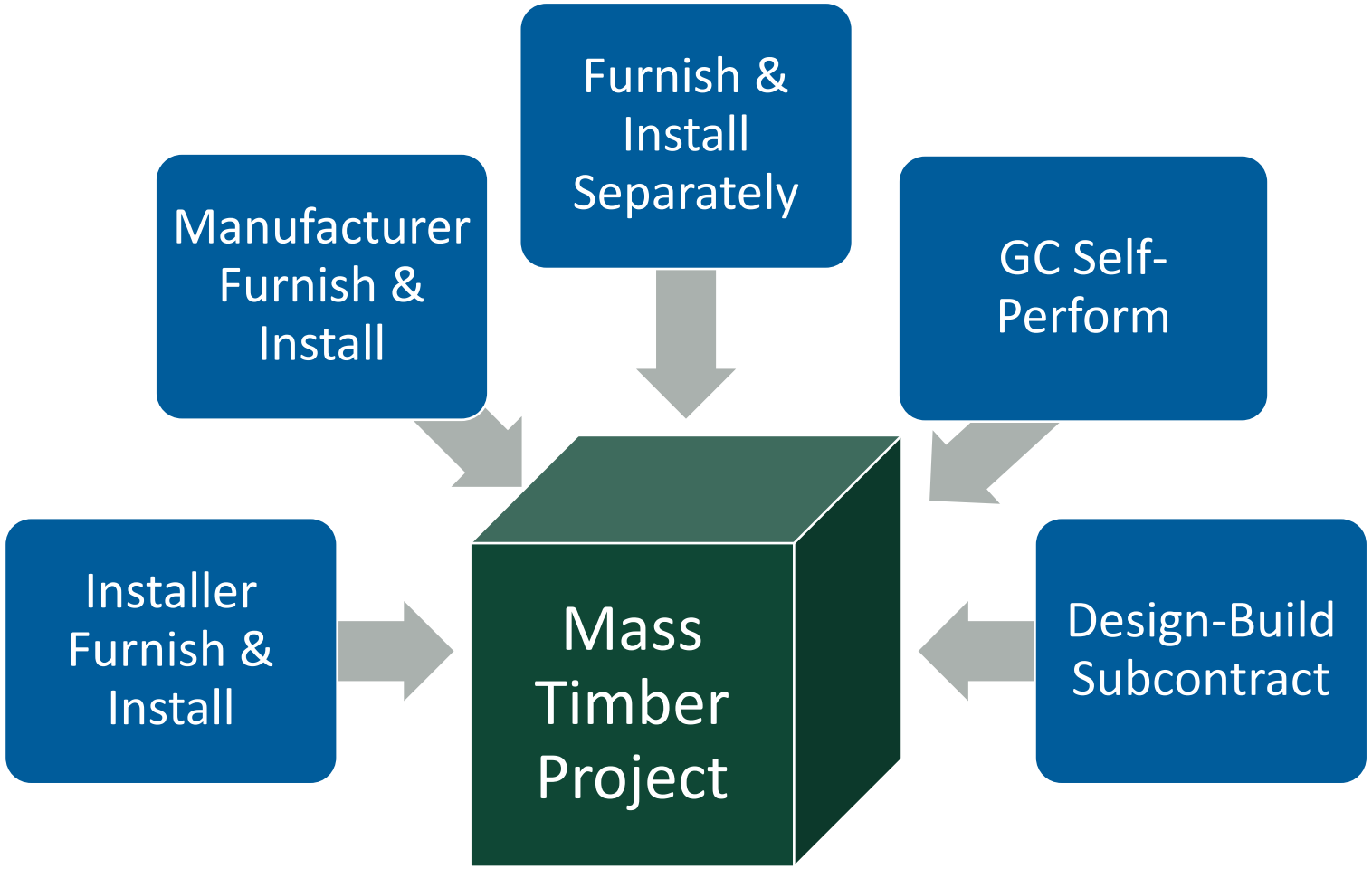
Credit: Tanya Luthi, Entuitive

Vetting Potential Manufacturers and 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?**
  - How does it differ for a smaller project vs. a larger one?

Determine the Procurement Model

Analysis of (a few) Mass Timber Procurement Models



Installer Furnish & Install

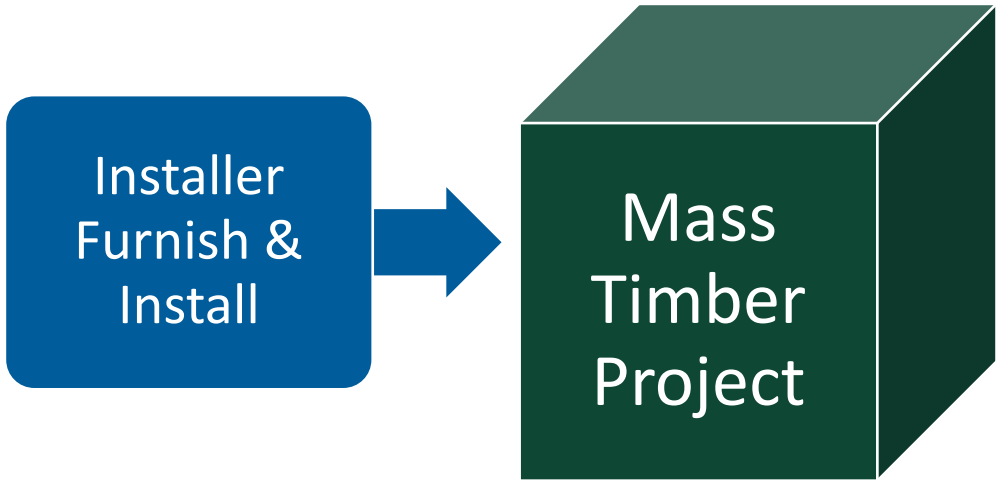
ADVANTAGES

- Recommended for GCs and Project teams with little mass timber experience and for more complicated projects
- Streamlines the process
- Reduces GC Risk
- Opportunity for improving design efficiency (may contribute to overall savings)

DISADVANTAGES

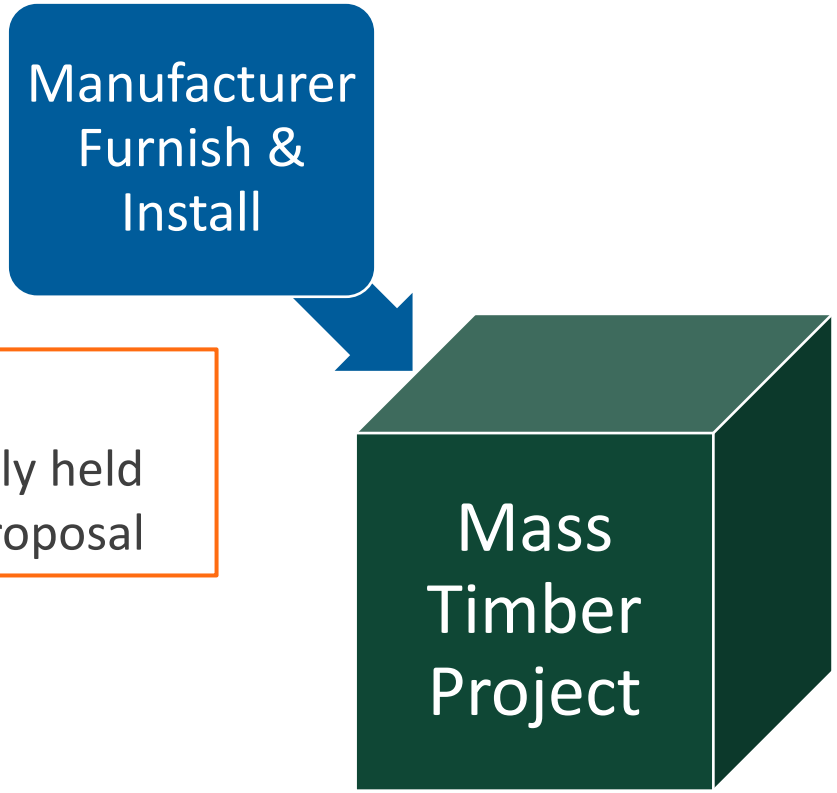
- Can be more expensive (for material)
- Often requires longer bidding time
- Less detail provided on supply cost
- Less ability for GC to control cost

Single Contract between GC and Installer (installer supplies material and installation)



Manufacturer Furnish & Install

Single contract between GC and manufacturer (manufacturer *may* subcontract to installer)



VARIATION

Contracts are separately held but the bid is a joint proposal

ADVANTAGES

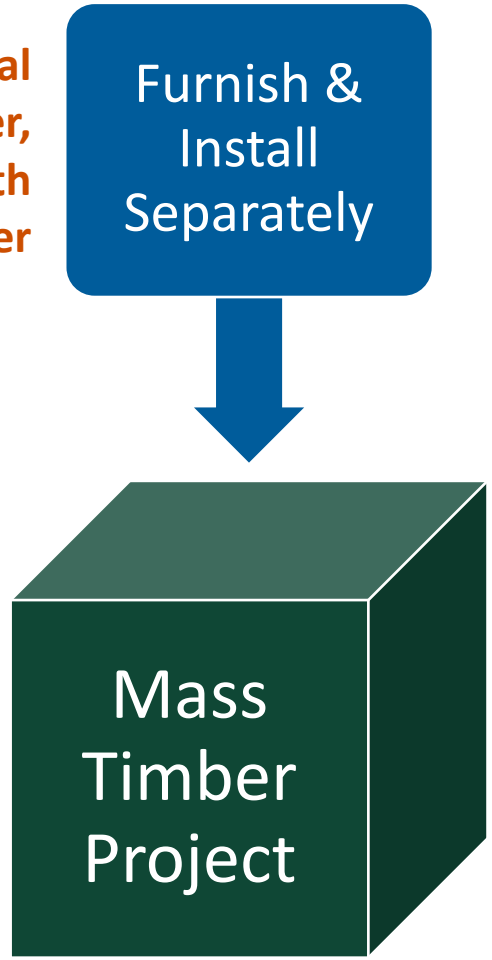
- Recommended for all-timber, straight-forward structures and projects where the GC has less opportunity for significant design modifications.
- Can be less expensive for material (but manufacturer may charge for installation management)

DISADVANTAGES

- Risk of prioritizing efficiency in the factory over site efficiencies
- Creates separation between GC and installer

Furnish and Install Separately

GC procures material direct from manufacturer, separate contract with installer



ADVANTAGES

- Typically yields competitive pricing
- Gives GC the flexibility to choose best fit bidders for each scope

DISADVANTAGES

- Requires more coordination by GC
- Increases GC's risk/liability for scheduling issues (but offers more control)
- Requires GC to have prior supply chain experience and established relationships

GC Self-Perform

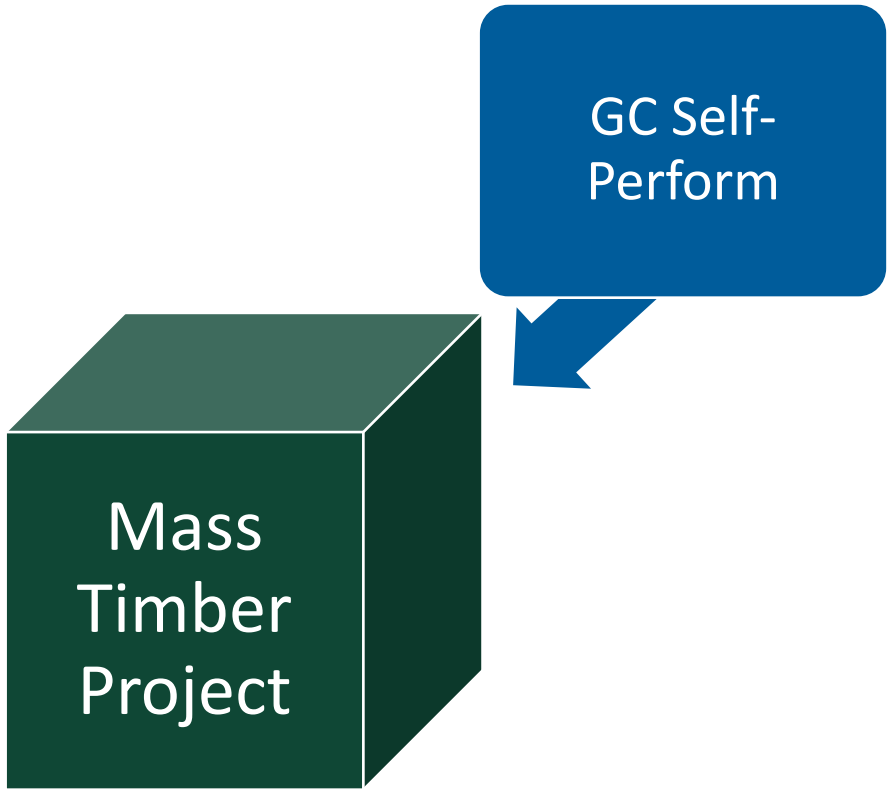
ADVANTAGES

» Offers opportunity for best cost and schedule control (owner may not see savings if the GC uses this model for fee uplift)

DISADVANTAGES

» Increases GC's risk/liability for scheduling issues

» GC must have prior supply chain experience, know the differences between manufacturers/suppliers, and have established relationships



GC procures material direct from manufacturer and self performs install

Photo: C.D. Smith Construction

Ascent

Milwaukee, WI

Building Facts	493,000 sf, 25 stories (total) 19 stories of Mass Timber Multi-Family Completed 2022
Developer	New Land Enterprises
Architect	Korb + Associates Architects
Engineer	Thorton Tomasetti
General Contractor	C.D. Smith Construction

GC Self-Perform

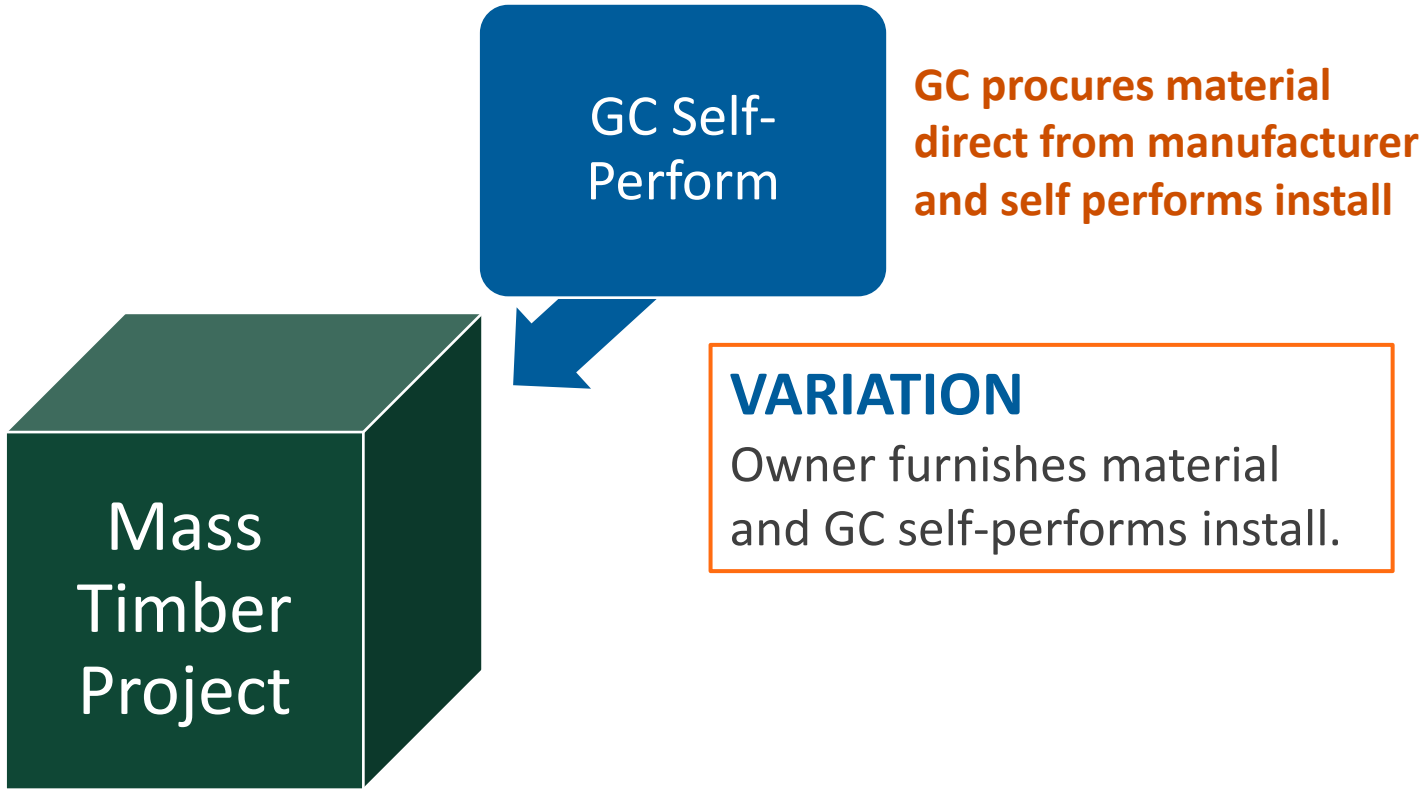
ADVANTAGES

» Offers opportunity for best cost and schedule control (owner may not see savings if the GC uses this model for fee uplift)

DISADVANTAGES

» Increases GC's risk/liability for scheduling issues

» GC must have prior supply chain experience, know the differences between manufacturers/suppliers, and have established relationships



GC procures material direct from manufacturer and self performs install

VARIATION

Owner furnishes material and GC self-performs install.

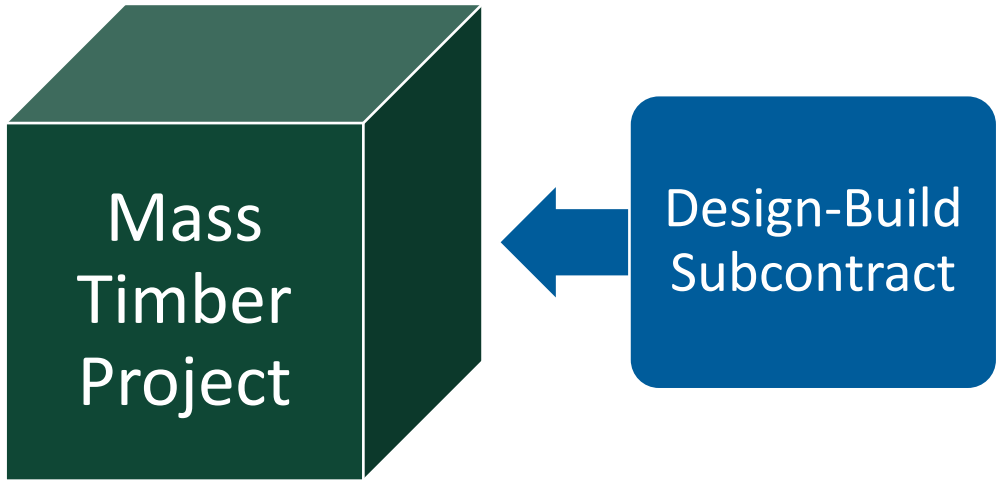
Design Build Subcontract

ADVANTAGES

- Recommended for elaborate, complex projects (or portions of projects) that require a high degree of fabrication or a design team without timber experience.
- Effectively coordinates design and fabrication efficiency

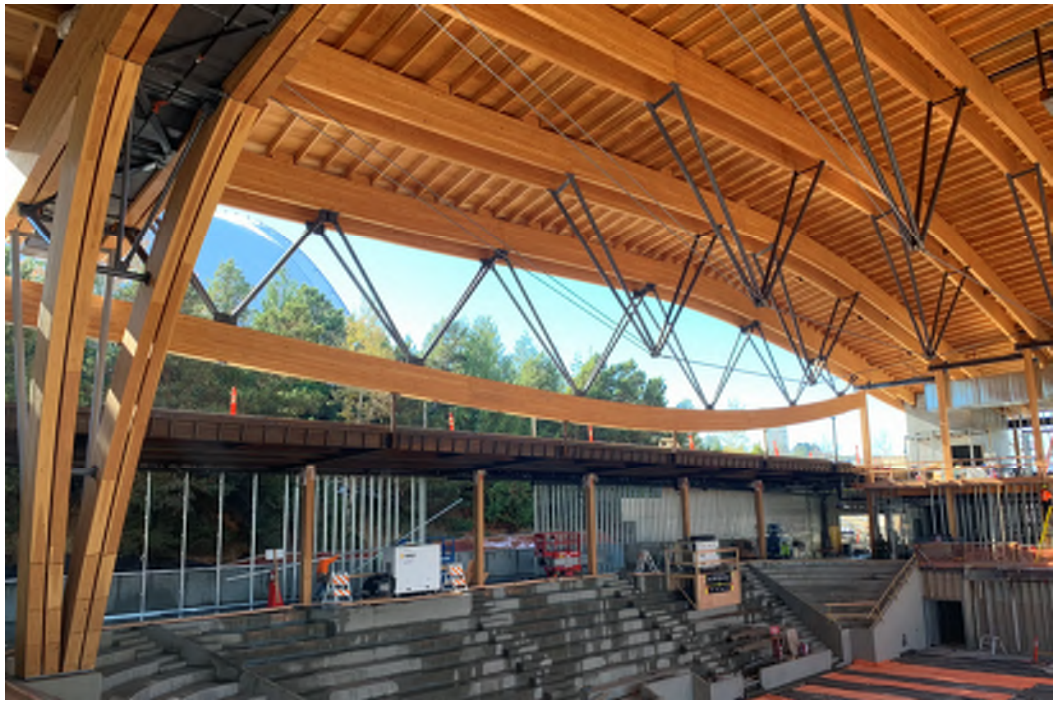
DISADVANTAGES

- Much bigger lift for bidder
- May limit the number of interested/qualified bidders
- Requires a more coordinated bidding process and longer bidding timeframe



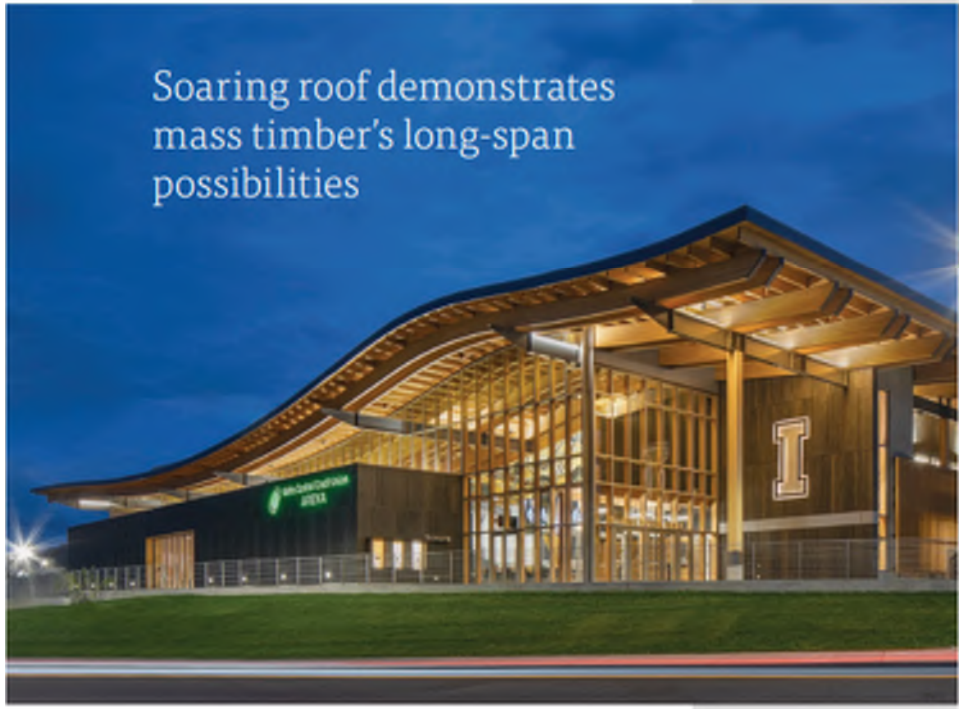
University of Idaho – Idaho Central Credit Union

Moscow, ID



CASE STUDY
Idaho Central
Credit Union Arena

WOODWORKS



Architect: Opsis
Structural Engineer: KPFF
Roof Structure Engineer: StructureCraft
Photos: Opsis Architecture

Cost Managing a Mass Timber Project

- Step 1: Do your Homework
  - Vet potential subcontractors
  - Determine the procurement model

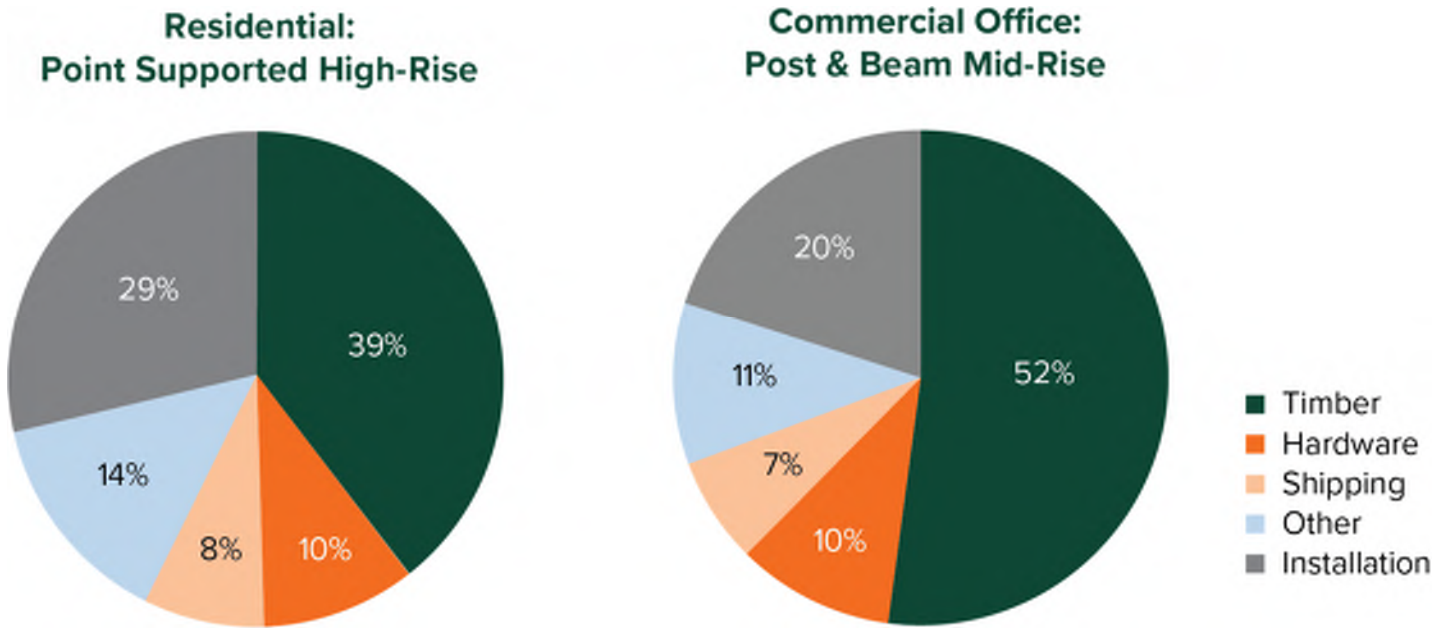
- **Step 2: Establish a Reliable Pre-Design Budget**

- Step 3: Manage Project Costs

Establishing a Reliable Pre-Design Budget

Problem:

Most GCs 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



Establishing a Reliable Pre-Design Budget

- Build up costs using an informed set of assumptions

Pricing Breakdown		
Concept/ Schematic Design	**Design Development**	**Bidding**
Installation	Labor and equipment	Schedule duration
		Crew size
		On-site moisture management
	Crane	Size
		Duration
	Staging yard	Duration
Taxes		

Items in green are not typically included in early pricing; develop separate budgets if needed

Pricing Breakdown		
Concept/ Schematic Design	**Design Development**	**Bidding**
Timber Supply Package	CLT	Floor/roof panels
		Wall panels
		Stair package
		Visual grade
		Temporary sealants
		Factory-applied membranes
		Predrilling/marking
	Glulam	Beams
		Columns
		Blocking/stair package
		Architectural finish
		Certification premium
	Hardware	Connectors
		Preassembly
		Fasteners and splines
		Hardware shipping
	Logistics	CLT shipping
		Glulam shipping
		Temporary storage
	Other	Project management/design assist
		Fabrication model/shop drawings

Establishing a Reliable Pre-Design Budget

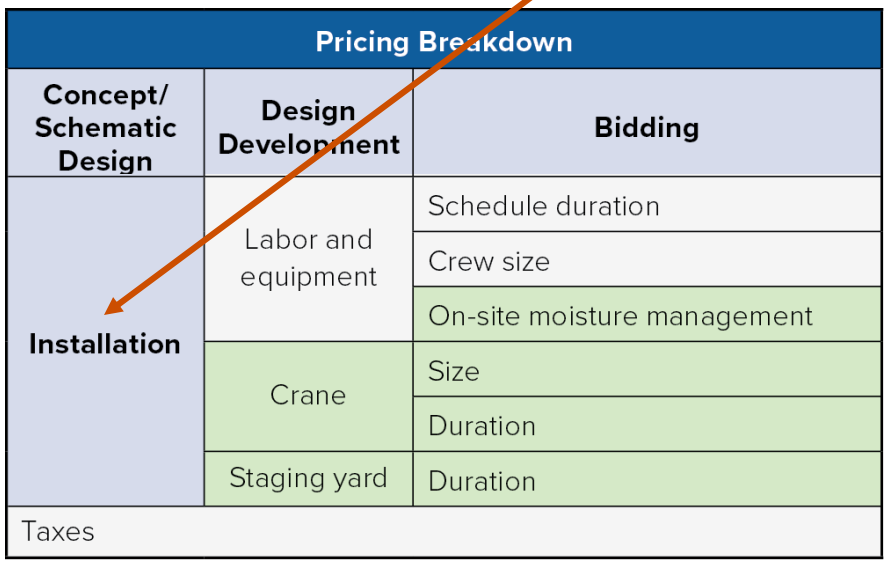
Insights for Bids

- Which components will be timber?
- What is the grid size and structural typology?
- What are the fire ratings?
- What elements will be exposed?
- Are there appearance classification requirements?
- Are there sourcing stipulations or forest certification requirements?

Make sure you can apply volumes to the associated rough costs.

Establishing a Reliable Pre-Design Budget

Insights For Better Budgeting



Pricing Breakdown		
Concept/ Schematic Design	**Design Development**	**Bidding**
Installation	Labor and equipment	Schedule duration
		Crew size
		On-site moisture management
	Crane	Size
		Duration
	Staging yard	Duration
Taxes		

Items in green are not typically included in early pricing; develop separate budgets if needed

» **Installation**

- 15 to 30%
- The cost of installation is a direct result of the number of pieces and how fast they can go together

Establishing a Reliable Pre-Design Budget

Insights For Better Budgeting

- **Shipping**
  - Roughly 4%-8%
  - lower end when material is trucked from a nearby factory
  - upper end when shipped from overseas by container.
  - Trucks are typically governed by weight and can carry an estimated 1,250 to 1,350 ft3 of CLT and 1,000 to 1,200 ft3 of glulam

Pricing Breakdown		
Concept/ Schematic Design	**Design Development**	**Bidding**
Timber Supply Package	CLT	Floor/roof panels
		Wall panels
		Stair package
		Visual grade
		Temporary sealants
		Factory-applied membranes
		Predrilling/marking
	Glulam	Beams
		Columns
		Blocking/stair package
		Architectural finish
		Certification premium
	Hardware	Connectors
		Preassembly
		Fasteners and splines
		Hardware shipping
	Logistics	CLT shipping
		Glulam shipping
		Temporary storage
	Other	Project management/design assist
		Fabrication model/shop drawings

Establishing a Reliable Pre-Design Budget

Insights For Better Budgeting

» **Hardware**

- Beam and column connectors are largest contributor to the hardware line item – can be benchmarked against the cost per ton of steel.
- When building a budget, it is worthwhile to estimate the number of glulam intersections and assume a proprietary connector

Pricing Breakdown		
Concept/ Schematic Design	**Design Development**	**Bidding**
Timber Supply Package	CLT	Floor/roof panels
		Wall panels
		Stair package
		Visual grade
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		Hardware shipping
	Logistics	CLT shipping
		Glulam shipping
		Temporary storage
	Other	Project management/design assist
		Fabrication model/shop drawings

Establishing a Reliable Pre-Design Budget

Insights For Better Budgeting

- **CLT (panels) and Glulam**
  - Usually between 40% and 55% of the installed timber package cost

Pricing Breakdown		
Concept/ Schematic Design	**Design Development**	**Bidding**
Timber Supply Package	CLT	Floor/roof panels
		Wall panels
		Stair package
		Visual grade
		Temporary sealants
		Factory-applied membranes
		Predrilling/marking
	Glulam	Beams
		Columns
		Blocking/stair package
		Architectural finish
		Certification premium
	Hardware	Connectors
		Preassembly
		Fasteners and splines
		Hardware shipping
	Logistics	CLT shipping
		Glulam shipping
		Temporary storage
	Other	Project management/design assist
		Fabrication model/shop drawings

Establishing a Reliable Pre-Design Budget

Insights For Better Budgeting: **Glulams**

- Commodity lumber pricing is an adequate benchmark to a degree
- Glulam costs also impacted by structural grade, species, finish, and sourcing
- Glulam members that exceed “standard” sizing will come at a premium
- Understand the volumes of glulam and CLT separately as the project evolves, as glulam can cost up to 200% more per ft^3/m^3 than CLT

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

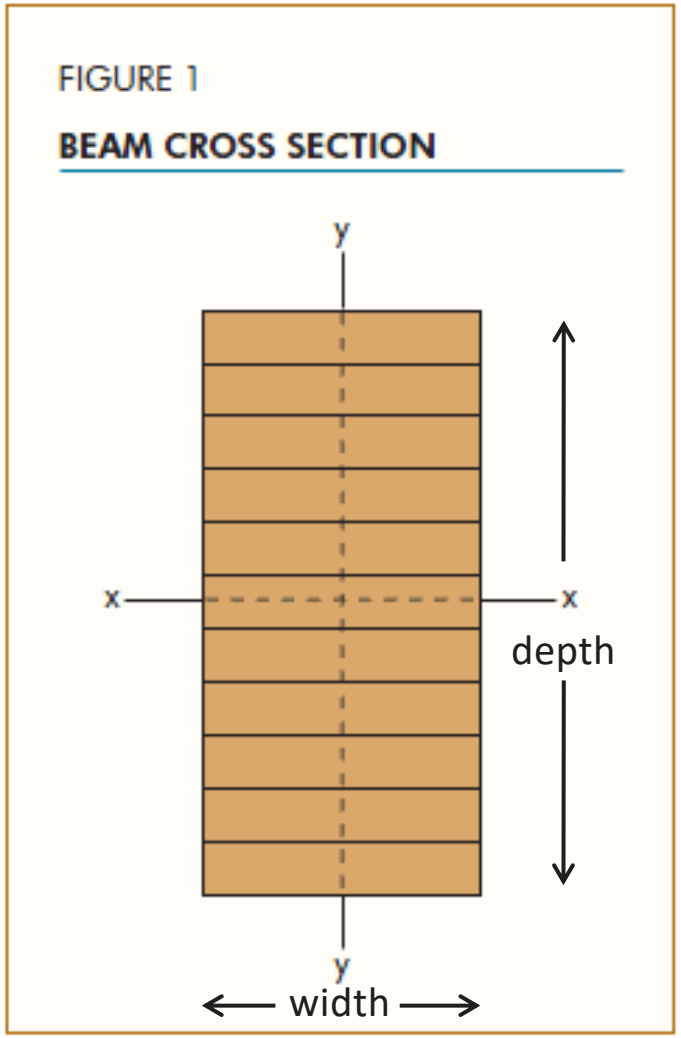


Image: APA Glulam Product Guide

Glulam Built-Up Sections

Built-Up Sections:

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

Establishing a Reliable Pre-Design Budget

Insights For Better Budgeting: **Panels**

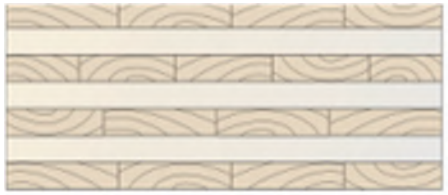
- Commodity lumber pricing is an adequate benchmark to a degree
- Raw material often makes up over 70% of a panel's cost
  - The most material-efficient solution isn't always the best or most cost-effective solution
- Choosing panel characteristics (size, species, grade, etc.) that do not limit your choice of manufacturer will help mitigate pricing volatility

Cross Laminated Timber (CLT) Common Layups

3-ply 3-layer

5-ply 5-layer

7-ply 7-layer



9-ply 9-layer

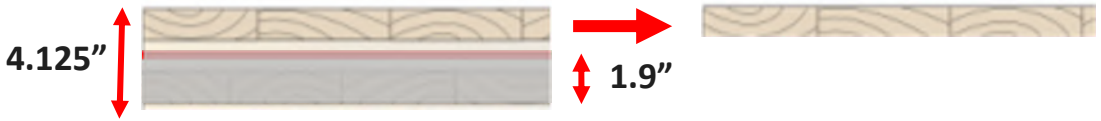
7-ply 5-layer

9-ply 7-layer

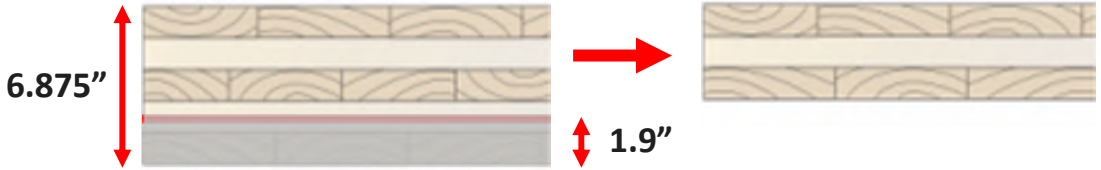
Fire Design of Mass Timber

Fire Resistance Ratings (FRR)

- Thinner CLT panels (i.e. 3-ply) can be difficult to achieve 1+ hour FRR
- 5-ply CLT panels can usually achieve 1- or 2-hour FRR



3 ply (after 1-hour rating)



5 ply (after 1-hour rating)

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

Mass Timber Acoustic Inventory

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

CLT Panel	Concrete/Gypsum Topping	Acoustical Mat Product Between CLT and Topping	Finish Floor	STC[1]	IIC[1]	Source
CLT 3-ply (3.5")	3" concrete	Maxxon Acousti-Mat® 3/4	None	53[2] ASTC	45[2] FIIC	72
CLT 3-ply (4.125")	2" concrete	Pliteq GenieMat™ FF25	None	54	44	89
			LVT on GenieMat RST05	53	48	90
			Eng Wood on GenieMat RST05	53	46	91
			Carpet Tile	52	50	92
	3" concrete	Kinetics® RIM-33L-2-24 System with ¼" Plywood	None	57	45	103
			LVT	-	58	104
			2 layers of ¼" USG Fiberock® on Kinetics® Soundmatt	55	55	105
			LVT on 2 layers of ¼" USG Fiberock® on Kinetics® Soundmatt	-	59	106
			None	57	46	107

Timber-Concrete Composite (TCC) Floor Systems

- Two distinct layers—timber layer and concrete layer—joined by shear connectors
- Can use CLT, GLT, SCL, other engineered wood product, or solid sawn lumber
- Shear “connectors” can be common fasteners, embedded plates, adhesives, or notches cut in the wood

John W. Olver Design Building / Photo Alex Schreyer

Cost Managing a Mass Timber Project

» Step 1: Do your Homework
- Vet potential subcontractors
- Determine the procurement model

» Step 2: Establish a Reliable Pre-Design Budget

» **Step 3: Manage Project Costs**
- Cost Benchmarking
- Non-Timber Cost Levers
- Cost Balancing

Manage Project Costs

Cost Benchmarking

- **Volume efficiency ratio**
  - ft^3/ft^2 provides a simple rule of thumb for estimating future projects

Panel volume usually 65-80% of MT package volume

Type IV-C

Floor panel: 5-ply

2-hr FRR

Purlin: 8.75”x28.5”

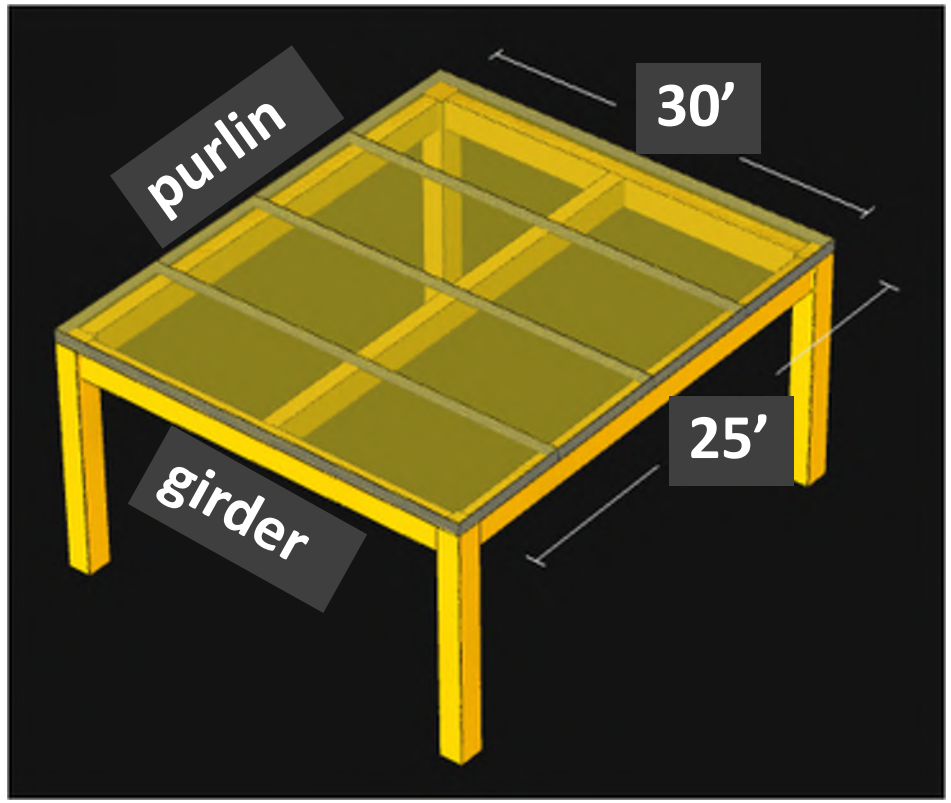
Girder: 10.75”x33”

Column: 13.5”x21.5”

Glulam volume = 183 CF (30% of MT)

CLT volume = 430 CF (70% of MT)

Total volume = 0.82 CF / SF



Source: Fast + Epp, Timber Bay Design Tool

Panel volume usually 65-80% of MT package volume

Type IIIA

Floor panel: 5-ply

1-hr FRR

Purlin: 5.5”x28.5”

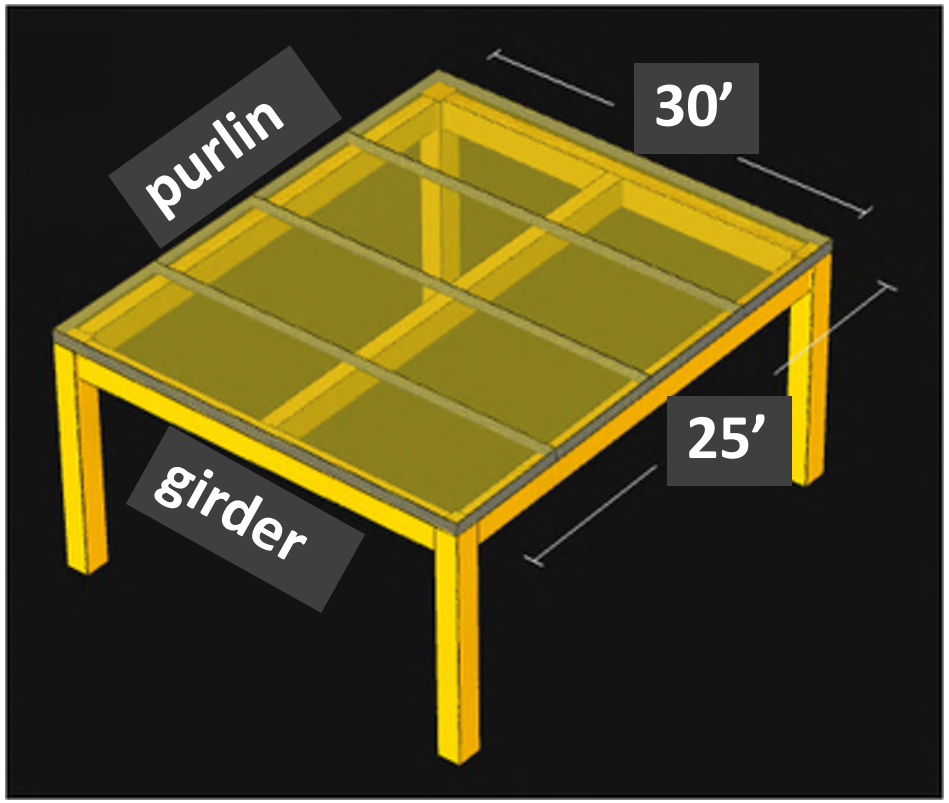
Girder: 8.75”x33”

Column: 10.5”x10.75”

Glulam volume = 118 CF (22% of MT)

CLT volume = 430 CF (78% of MT)

Total volume = 0.73 CF / SF



Source: Fast + Epp, Timber Bay Design Tool

Panel volume usually 65-80% of MT package volume

Type IV-HT

Floor panel: 3-ply (IBC min = 4” CLT)

0-hr FRR (min sizes per IBC)

Purlin: 5.5”x24” (IBC min = 5”x10.5”)

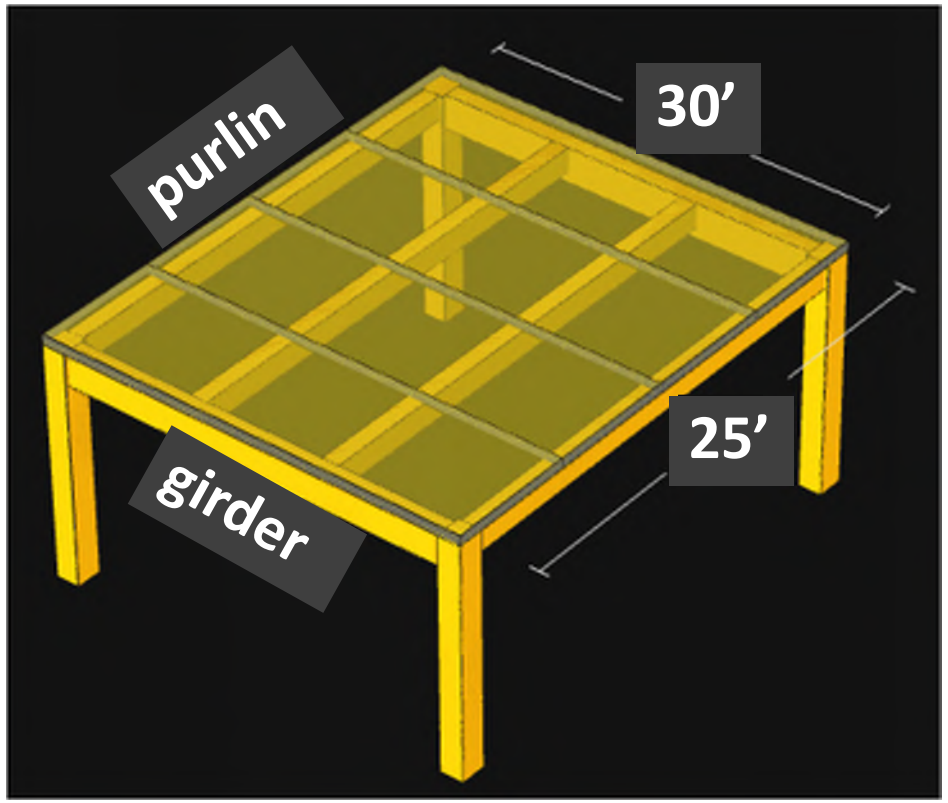
Girder: 8.75”x33” (IBC min = 5”x10.5”)

Column: 10.5”x10.75” (IBC min = 6.75”x8.25”)

Glulam volume = 120 CF (32% of MT)

CLT volume = 258 CF (68% of MT)

Total volume = 0.51 CF / SF



Source: Fast + Epp, Timber Bay Design Tool

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

Panel volume usually 65-80% of MT package volume

Type IV-HT

Floor panel: 3-ply (IBC min = 4” CLT)

0-hr FRR (min sizes per IBC)

Purlin: 5.

Girder: 8.

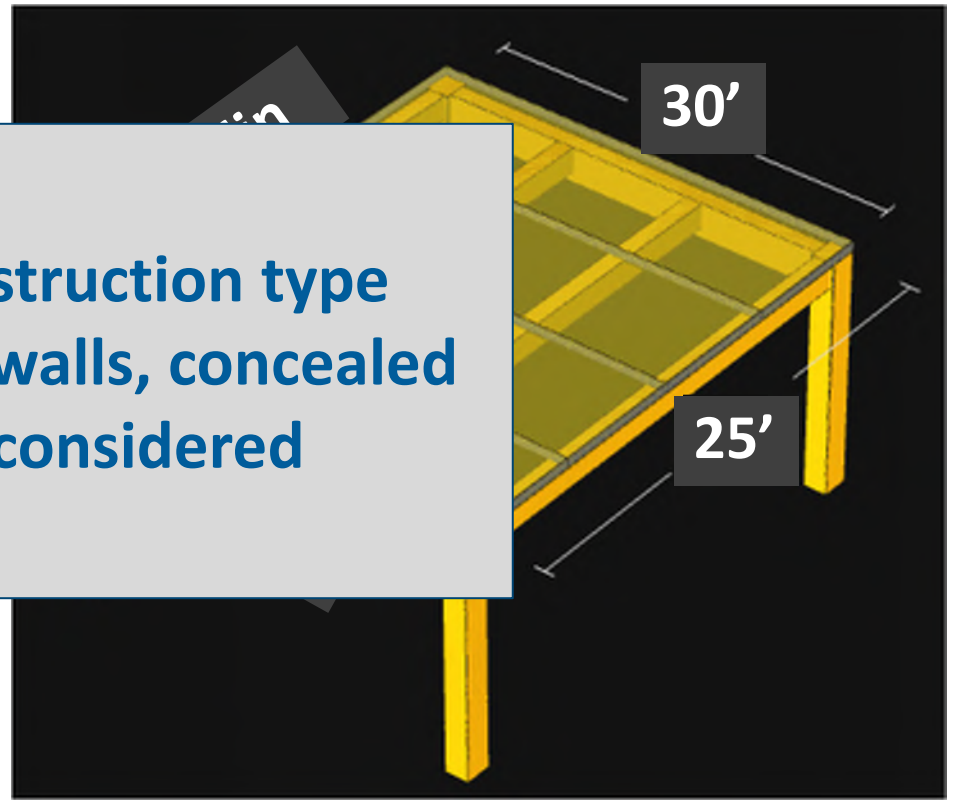
Column:

Glulam v

CLT volume = 258 CF (68% of MT)

Total volume = 0.51 CF / SF

There are other impacts of construction type selection (exterior walls, interior walls, concealed spaces, etc.) that should be considered

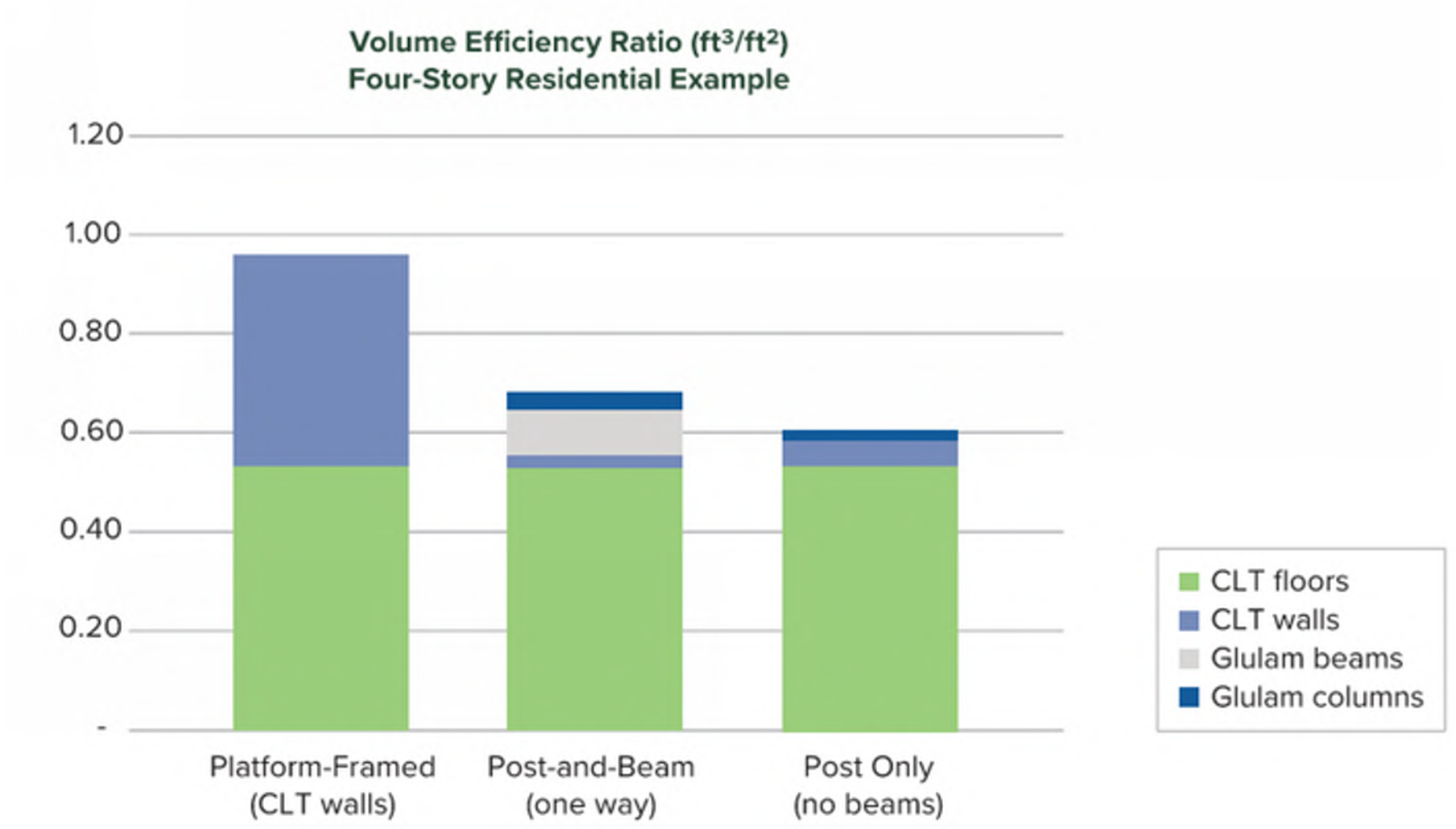


Source: Fast + Epp, Timber Bay Design Tool

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

Manage Project Costs

Cost Benchmarking



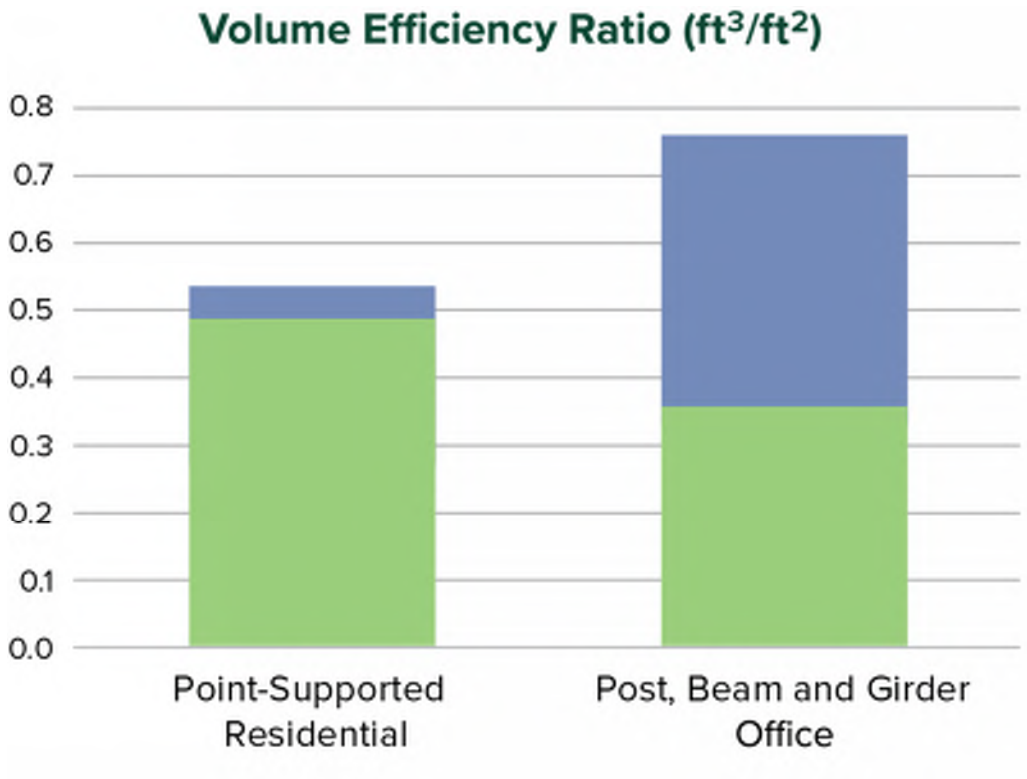
Manage Project Costs

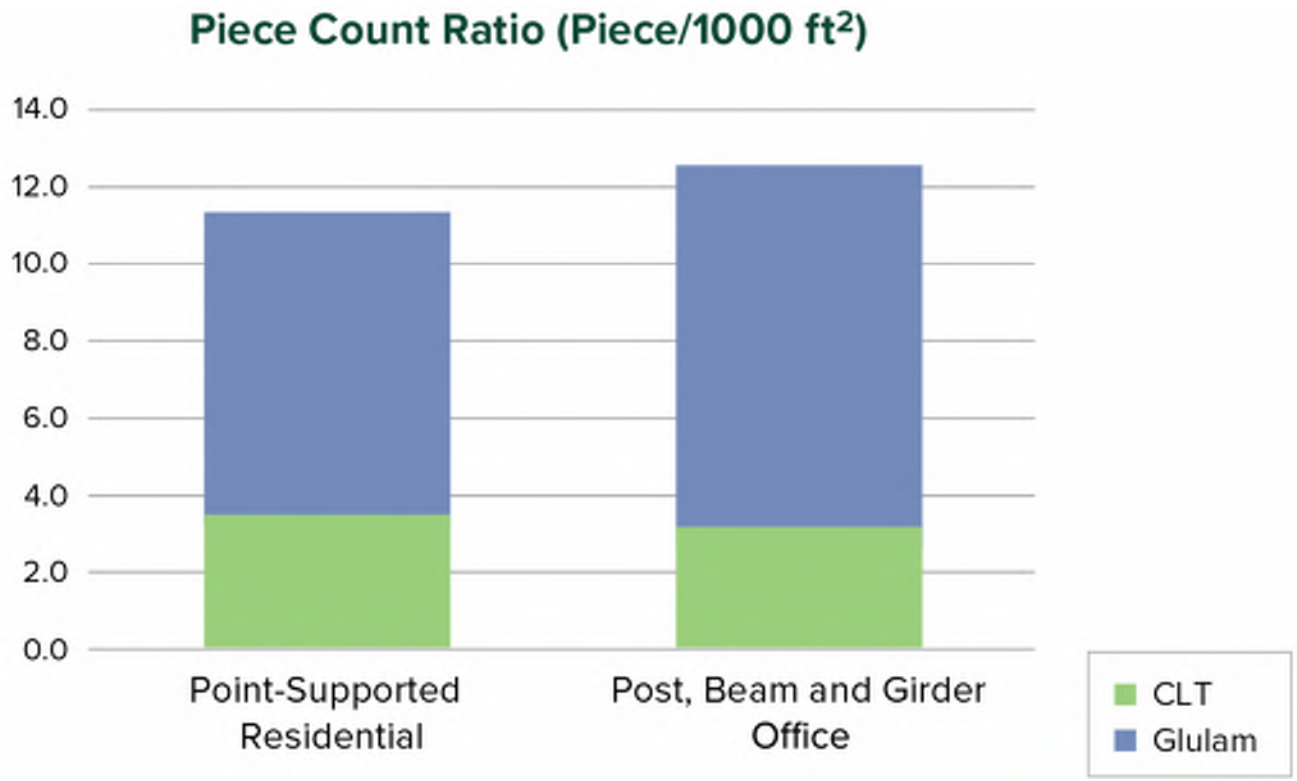
Cost Benchmarking

- **Volume efficiency ratio**
  - ft^3/ft^2 provides a simple rule of thumb for estimating future projects
- **Piece count**
  - cost/piece and piece count/1000 ft^2
  - “What is the estimated number of pieces in relation to the installation cost?”
- **Other**

Manage Project Costs

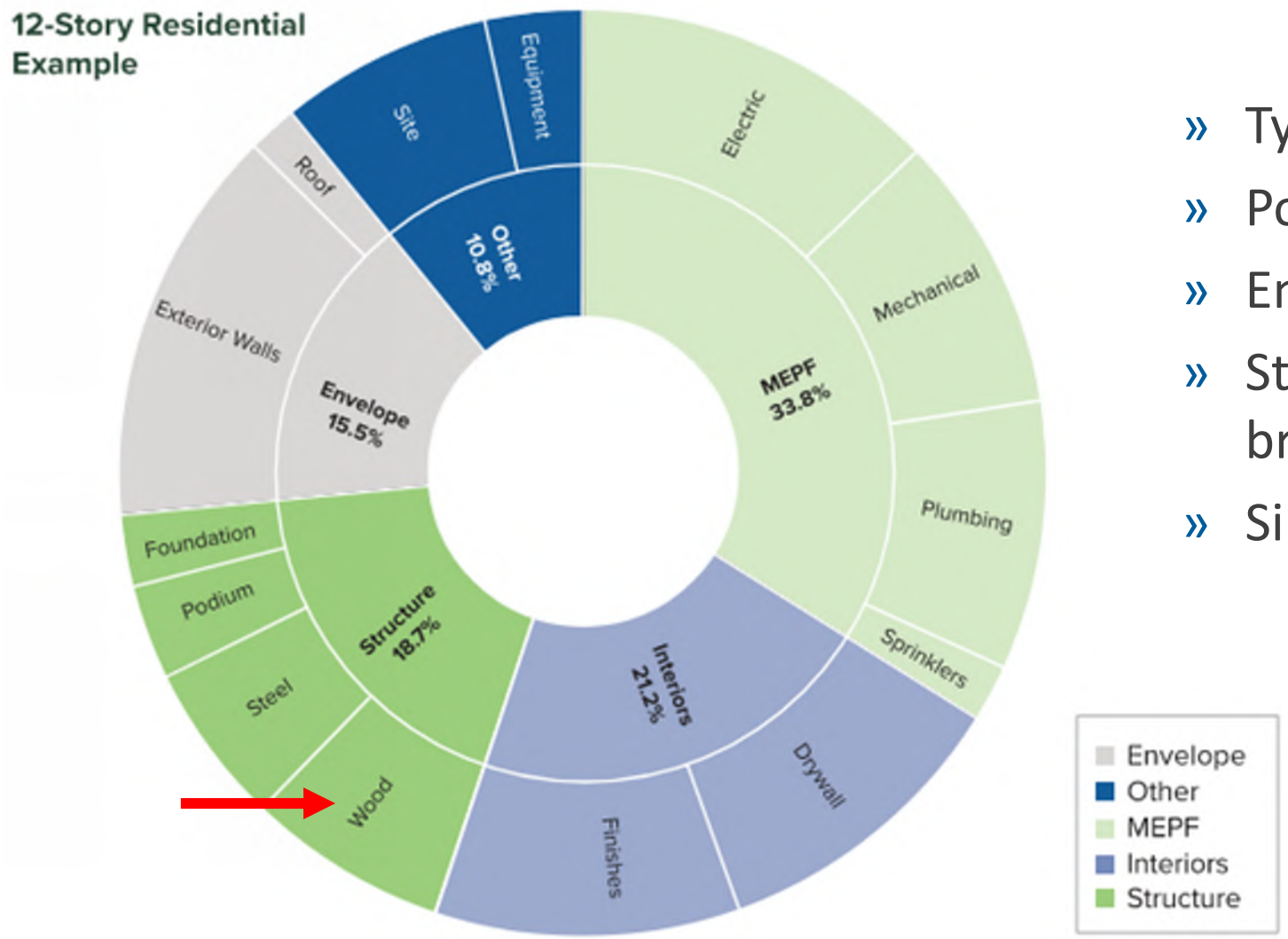
Cost Benchmarking





Manage Project Costs

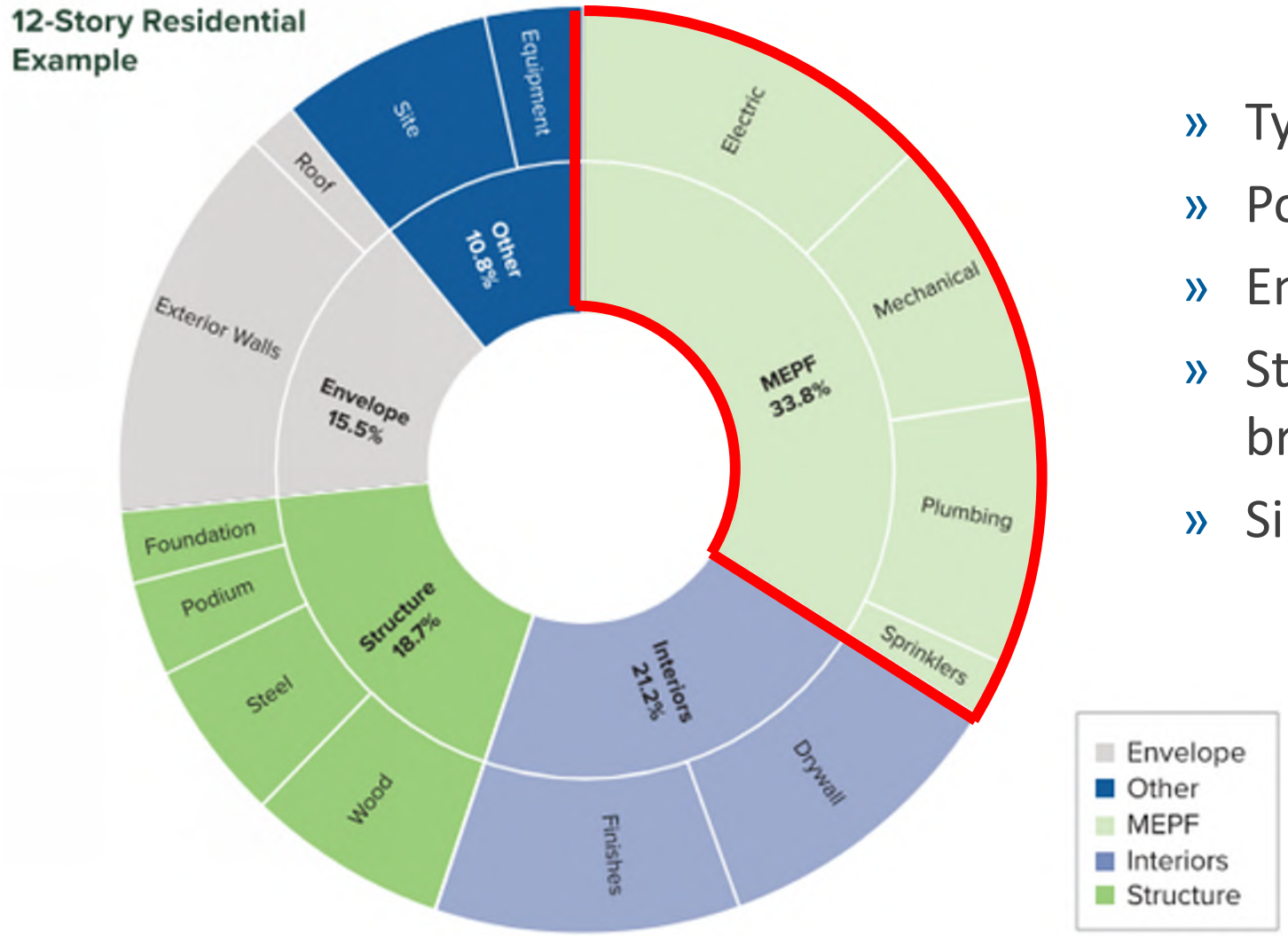
Non-Timber Design Cost Levers



- Type IV-B construction
- Point-supported project
- Encapsulated glulam columns
- Steel buckling-restrained brace core
- Single-story podium

Manage Project Costs

Non-Timber Design Cost Levers



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Manage Project Costs

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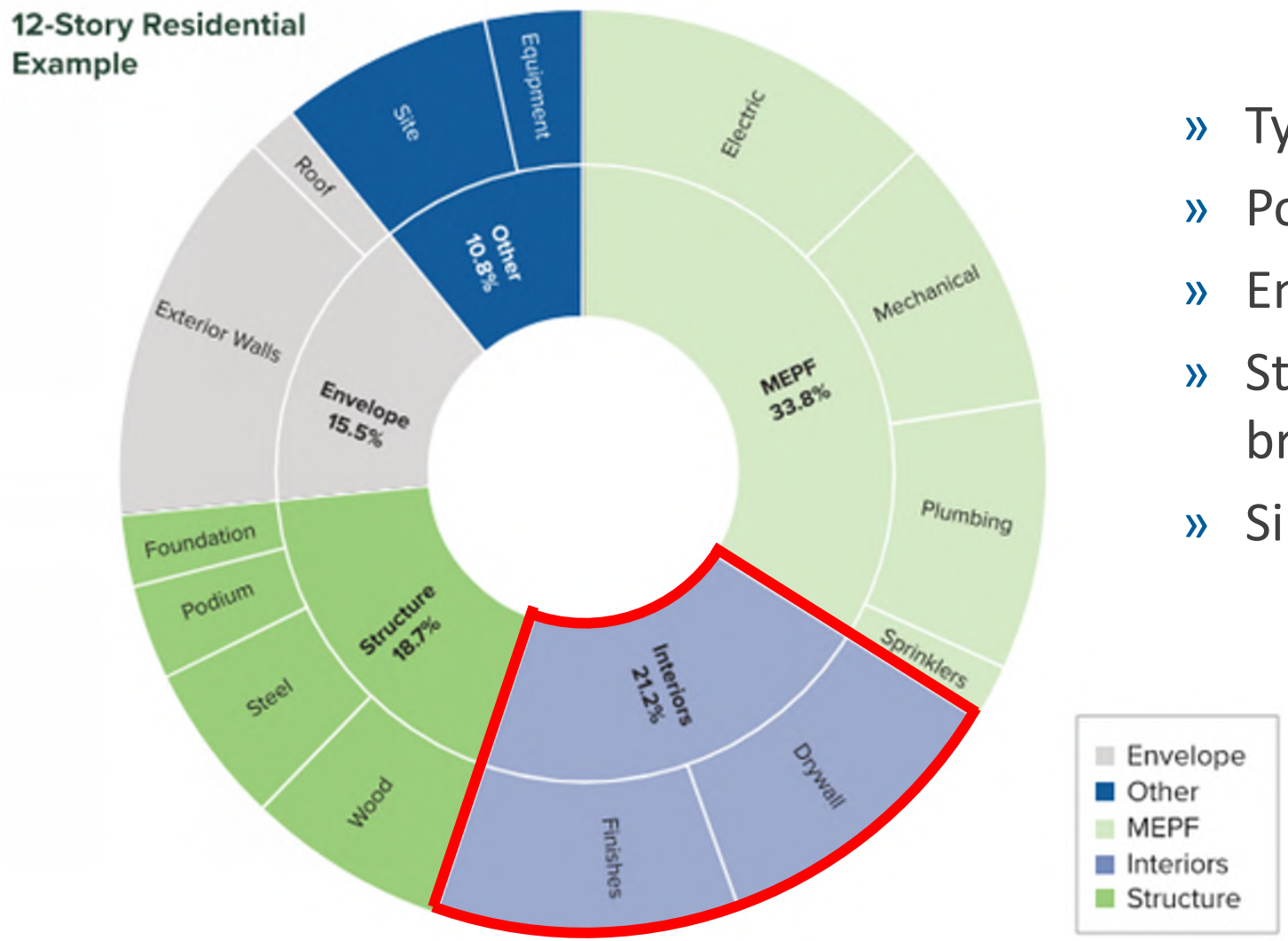

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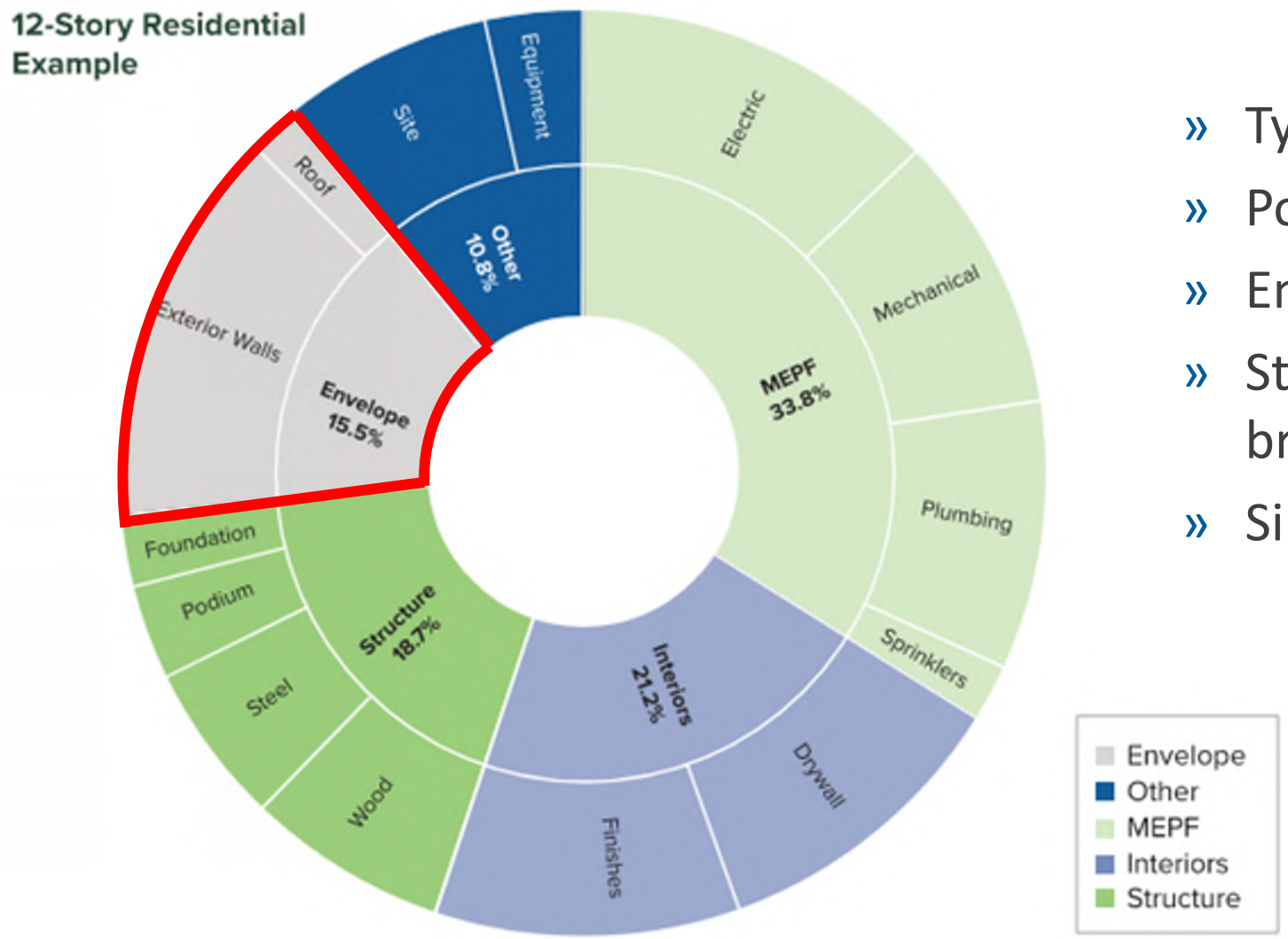
Manage Project Costs

Non-Timber Design Cost Levers



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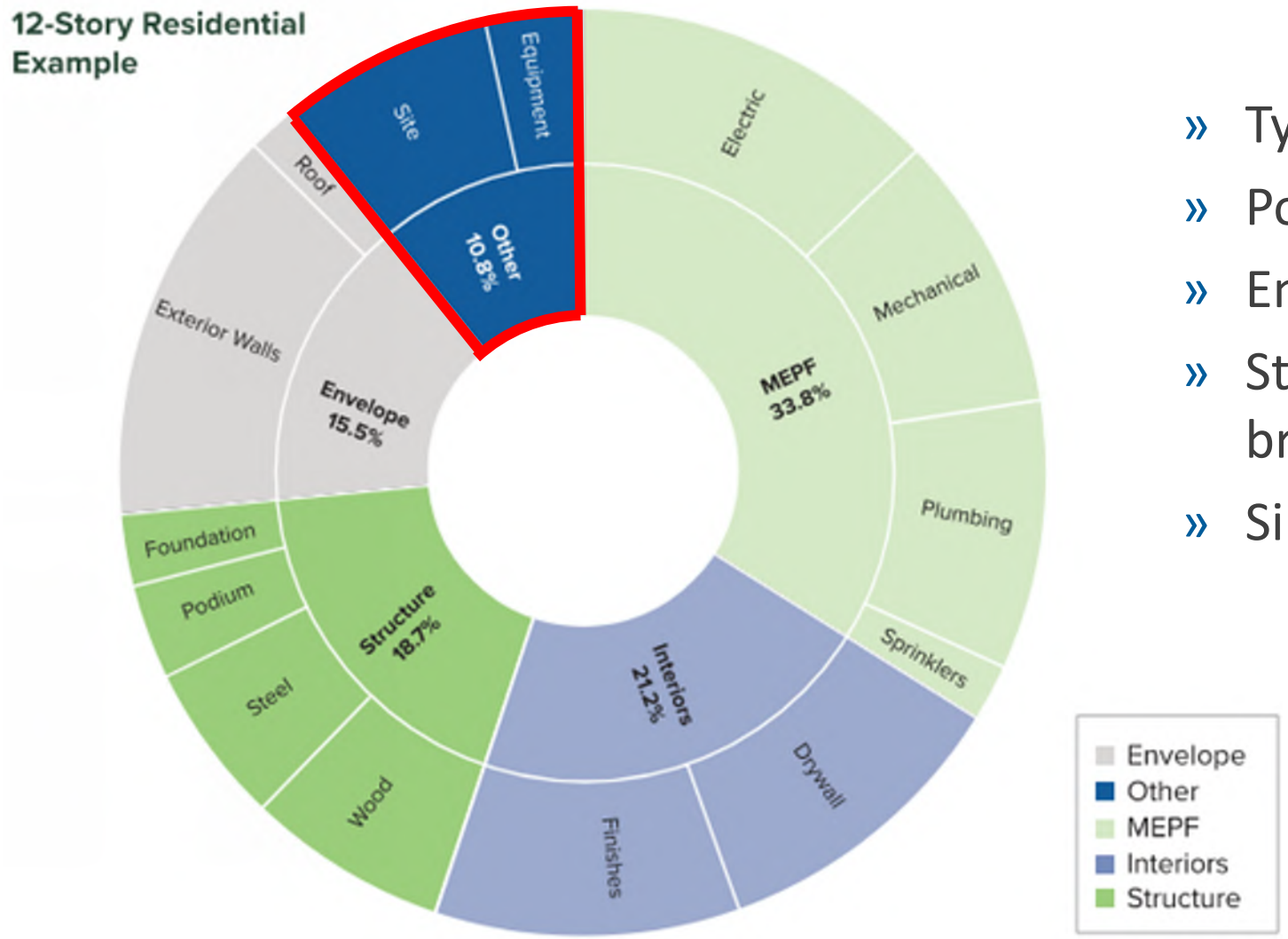
Manage Project Costs

Non-Timber Design Cost Levers



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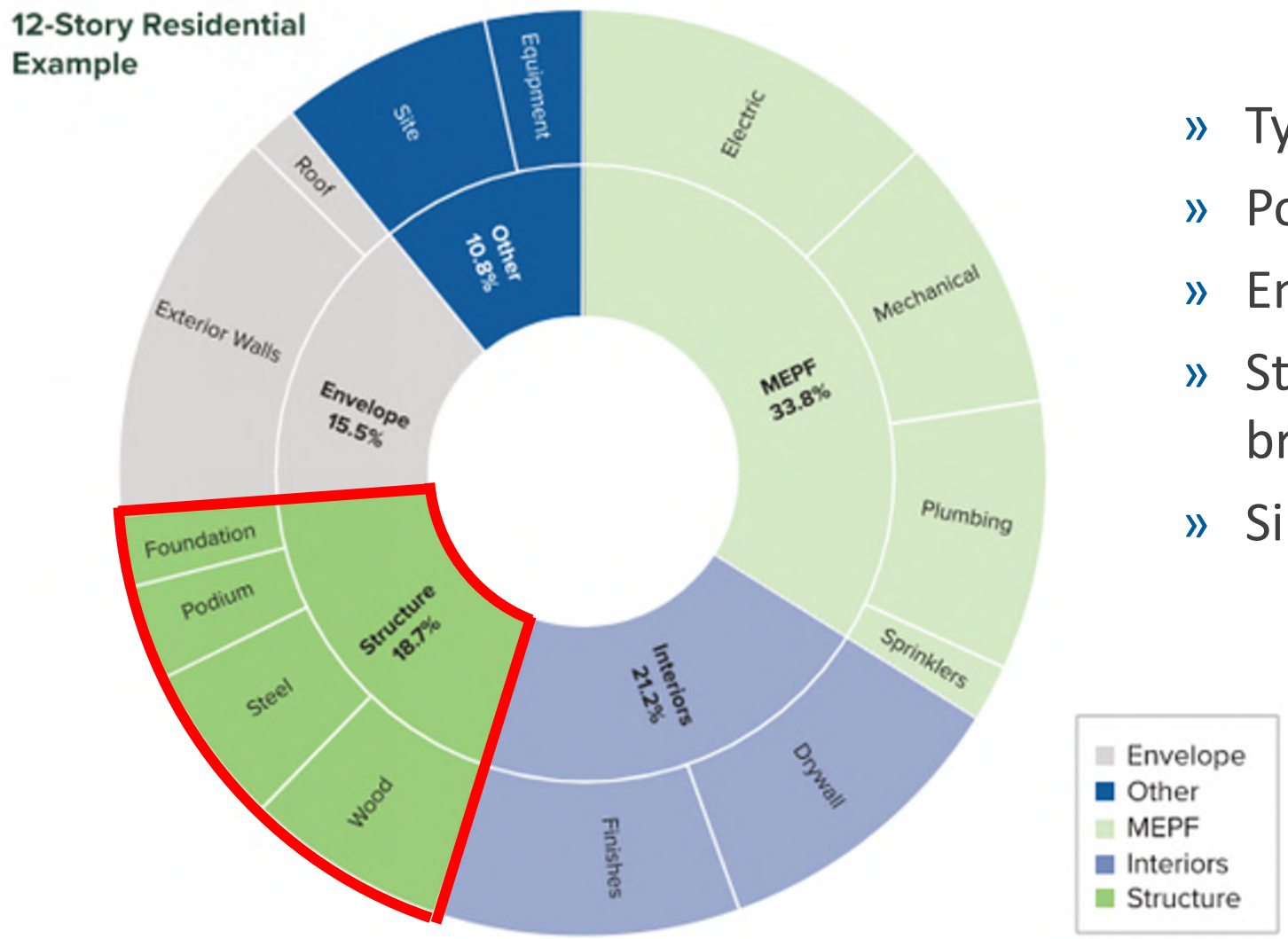
Manage Project Costs

Non-Timber Design Cost Levers



- Type IV-B construction
- Point-supported project
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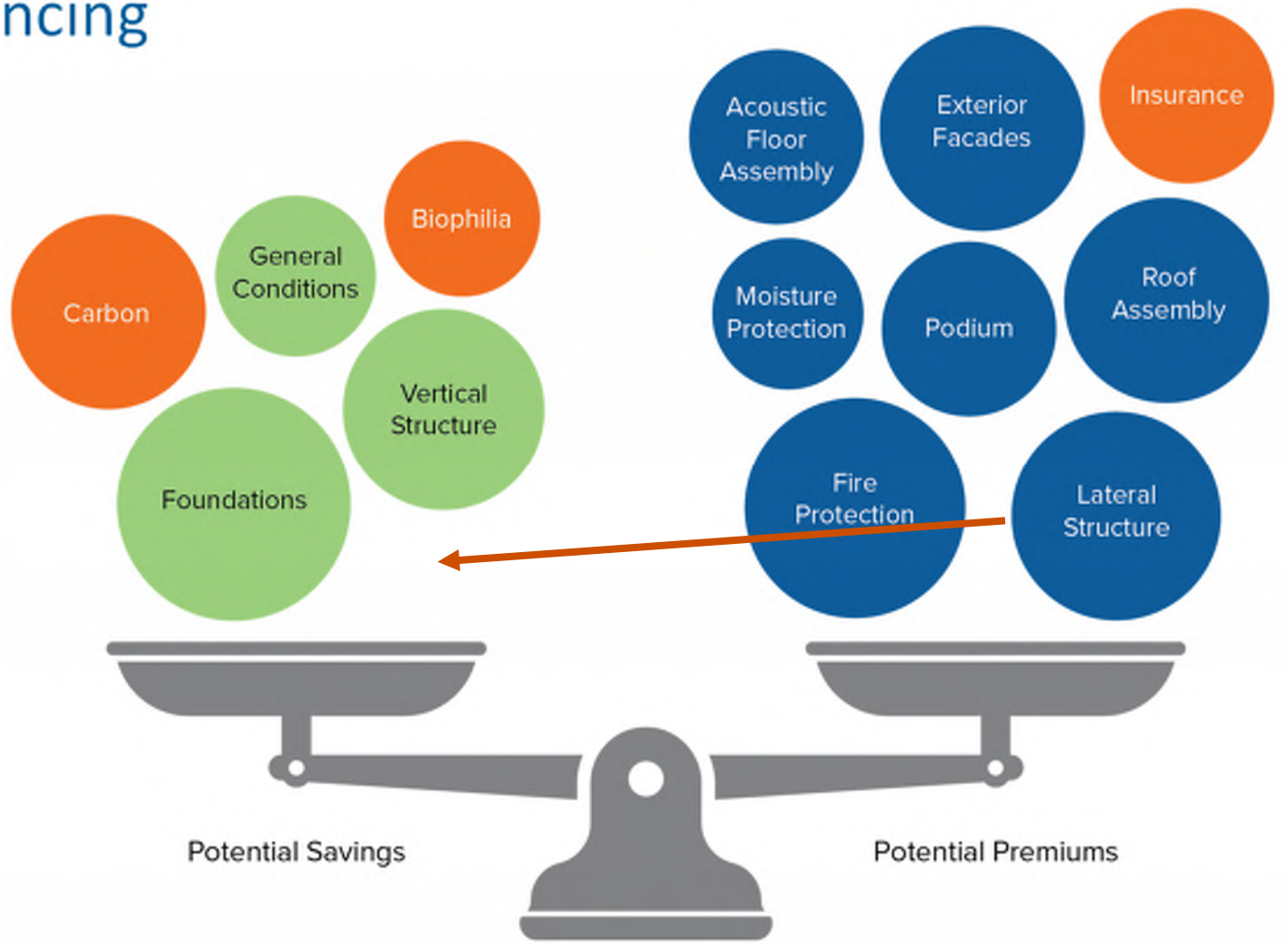
- Single-story podium

Manage Project Costs

Cost Balancing



Adjust budgets for OTHER trades impacted by mass timber

1510 Webster

Oakland, CA

Owner/General Contractor/Architect: oWow
Structural Engineer: DCI Engineers
Photo: Flor Projects

Mass Timber Cost Management

Free Resource:

www.woodworks.org

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

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