



CA Codes for Mass Timber Buildings: Project Approvals and Fire Performance

Chelsea Drenick, SE
April 21, 2022



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River Edge, Kitchen & Associates
photo courtesy of McAlvain Construction

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Questions? Ask me anything.



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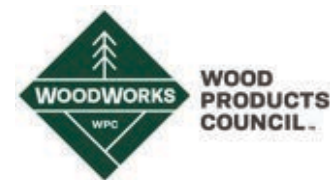
901 East Sixth, Thoughtbarn-Delineate Studio,
Leap!Structures, photo Casey Dunn





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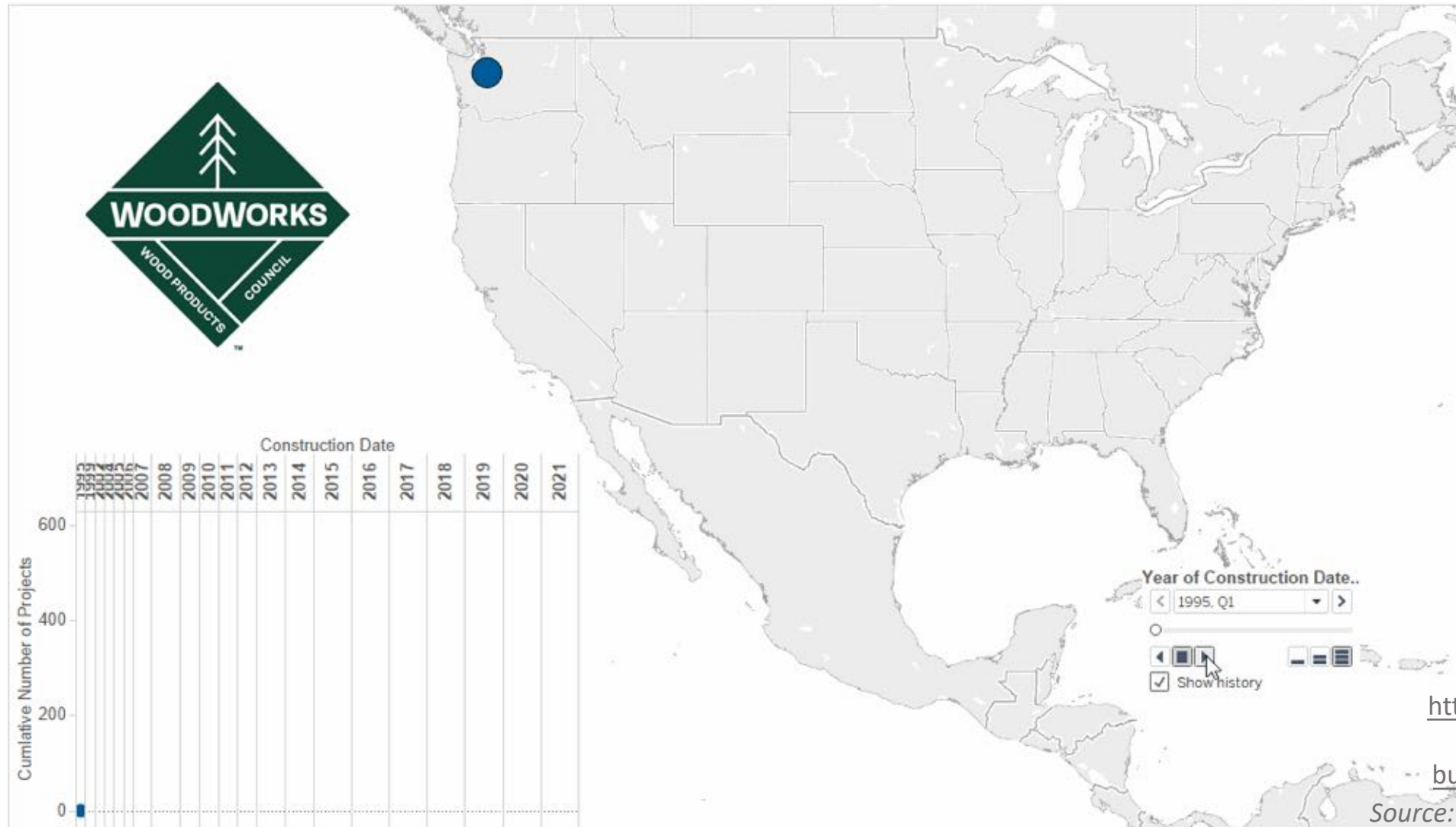


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Current State of Mass Timber Projects

As of June 2021, in the US, **1,169** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.



* This total includes modern mass timber and post-and-beam structures built since 2013

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



Course Description

Mass timber construction has experienced tremendous growth in the US over the past decade, and California is no exception. Now with expanded code provisions for mass timber buildings in the July 2021 California Building Code (CBC) updates, the construction of tall mass timber structures up to 18 stories is possible. These provisions are based on three new construction types introduced in the 2021 International Building Code—Types IV-A, IV-B and IV-C—with CBC amendments. This by-invitation educational event, intended for building officials and plan reviewers who are assessing specific projects as well as building designers working on mass timber designs, will address practical details related to implementing the provisions in California. Following a review of mass timber's fire performance, the State Fire Marshall's office will describe the process undertaken to adopt the new provisions, and why the California Building Standards Commission unanimously approved them. An interactive discussion on project approvals, plan reviews, and building official interactions on mass timber buildings will lend key insights into what those having jurisdictional authority can look for on project submittals, and what those submitting project drawings can expect for review and feedback. Building officials and designers can expect to take away the knowledge they need to assess and pursue mass timber projects.

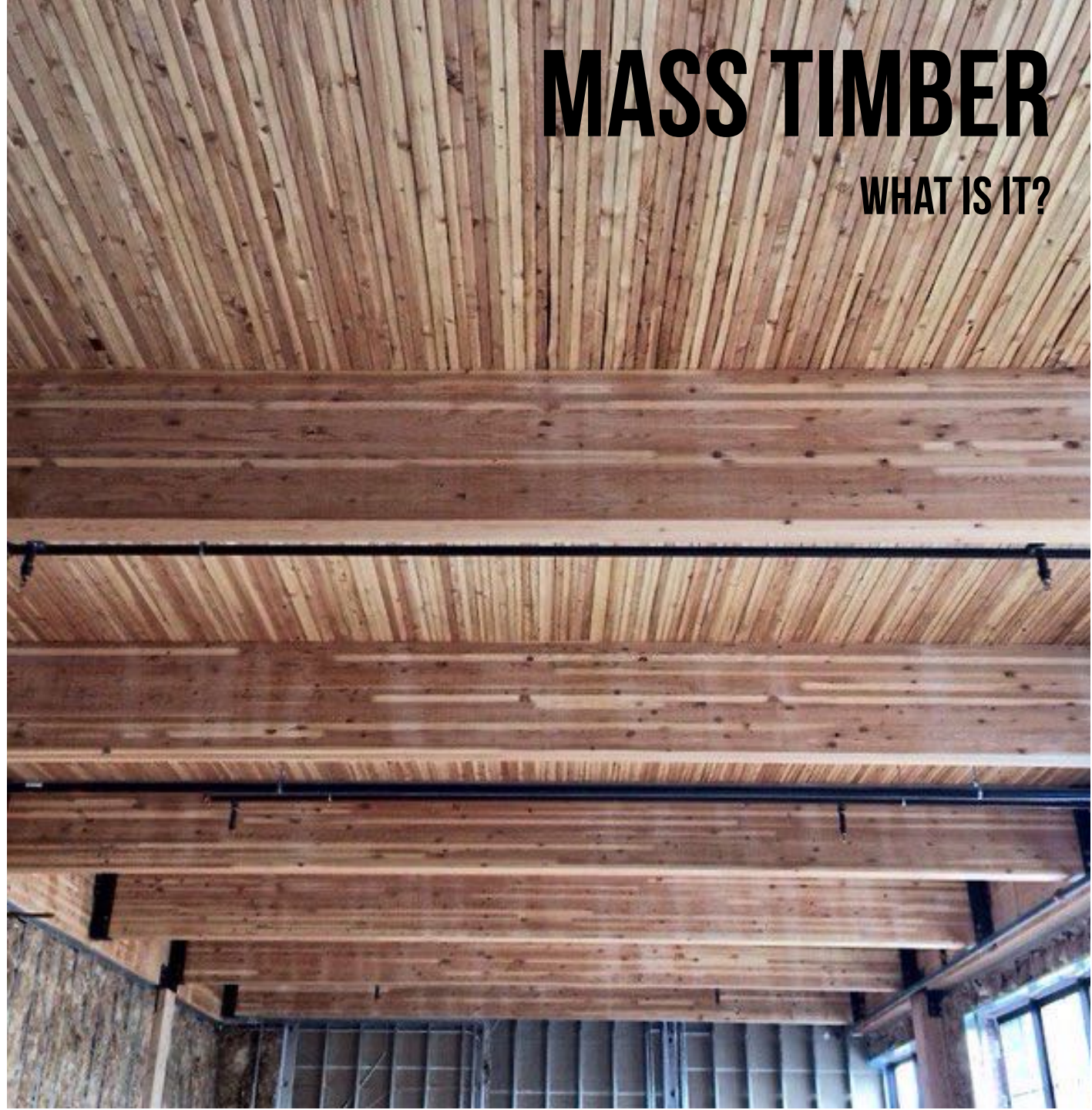
Learning Objectives

1. Review the mass timber and tall mass timber code provisions in the International Building Code and California Building Code and understand their application to office, commercial, and multi-family projects.
2. Highlight the extensive testing that led to the creation of three new tall mass timber construction types, and describe the roles of these tests in evaluating the fire performance and safety of mass timber in high-rise structures.
3. Discuss the fire-resistance design of exposed mass timber elements and assemblies, noting applicability and code compliance for topics such as construction types, connections, and firestopping details.
4. Introduce key lessons learned and common questions related to plan review and site inspections of mass timber projects.

**MASS TIMBER IS A
CATEGORY OF FRAMING
STYLES OFTEN USING SMALL
WOOD MEMBERS FORMED
INTO LARGE PANELIZED
SOLID WOOD CONSTRUCTION
INCLUDING CLT, NLT OR
GLULAM PANELS FOR FLOOR,
ROOF AND WALL FRAMING**

MASS TIMBER

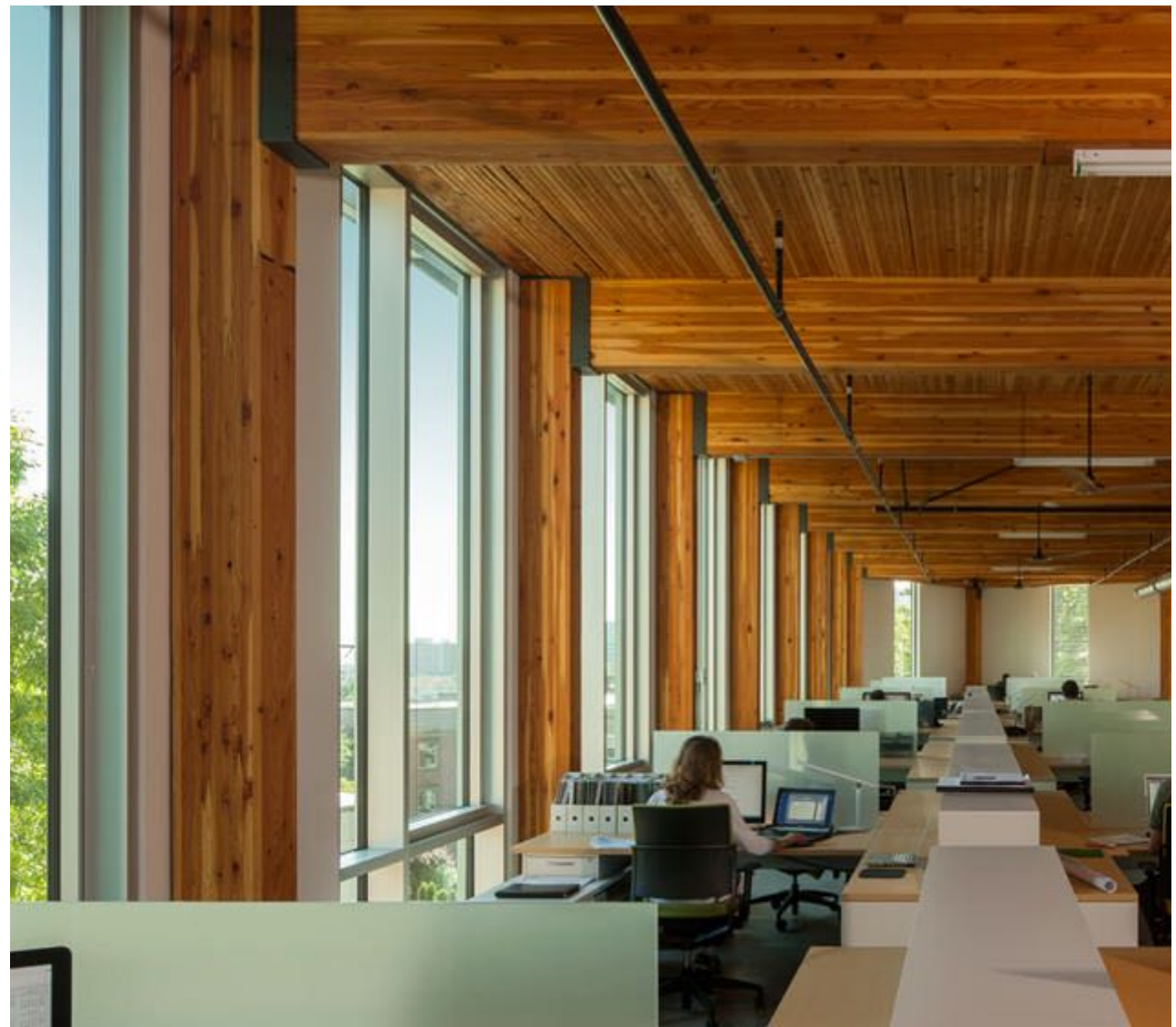
WHAT IS IT?





HEAVY TIMBER

Federal Center South, Seattle, WA
Photo: Benjamin Benschneider



MASS TIMBER

Bullitt Center, Seattle, WA
Photo: John Stamets

Glue Laminated Timber (Glulam)
Beams & columns



Cross-Laminated Timber (CLT)
Solid sawn laminations



Cross-Laminated Timber (CLT)
SCL laminations



Photo: Freres Lumber



Photo: StructureCraft



Photo: LendLease



Photo: LEVER Architecture

Dowel-Laminated Timber (DLT)



Photo: StructureCraft

Nail-Laminated Timber (NLT)



Photo: Think Wood

Glue-Laminated Timber (GLT)
Plank orientation



Photo: StructureCraft



Photo: StructureCraft



Photo: Ema Peter



Photo: Manasc Isaac
Architects/Fast + Epp

Mass Timber Building Options



Post and Beam

Flat Plate

Honeycomb

Mass Timber Building Options



Hybrid: Light-frame



Hybrid: Steel framing

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)



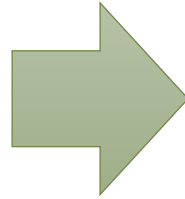
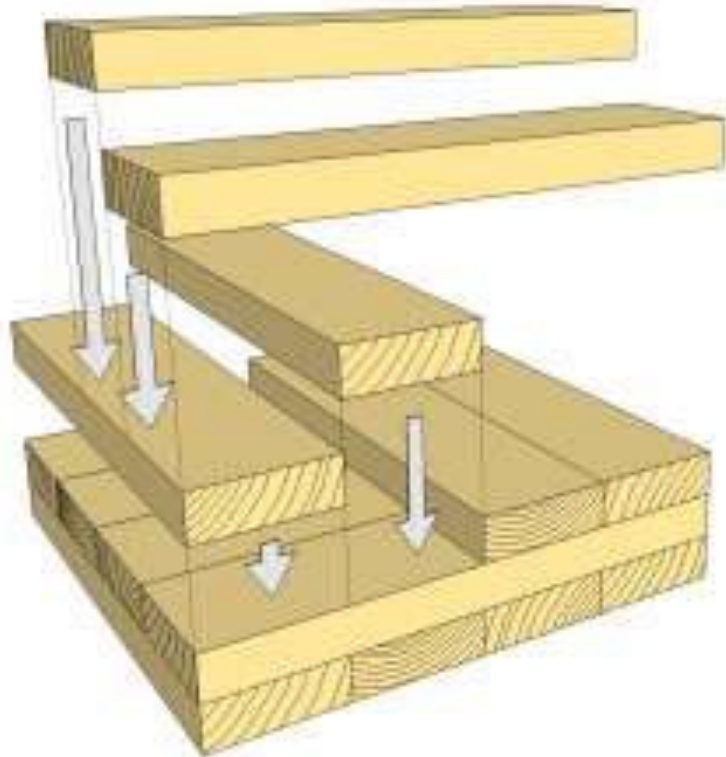
WHAT IS CLT?

SOLID WOOD PANEL

3 LAYERS MIN. OF SOLID SAWN LAMS

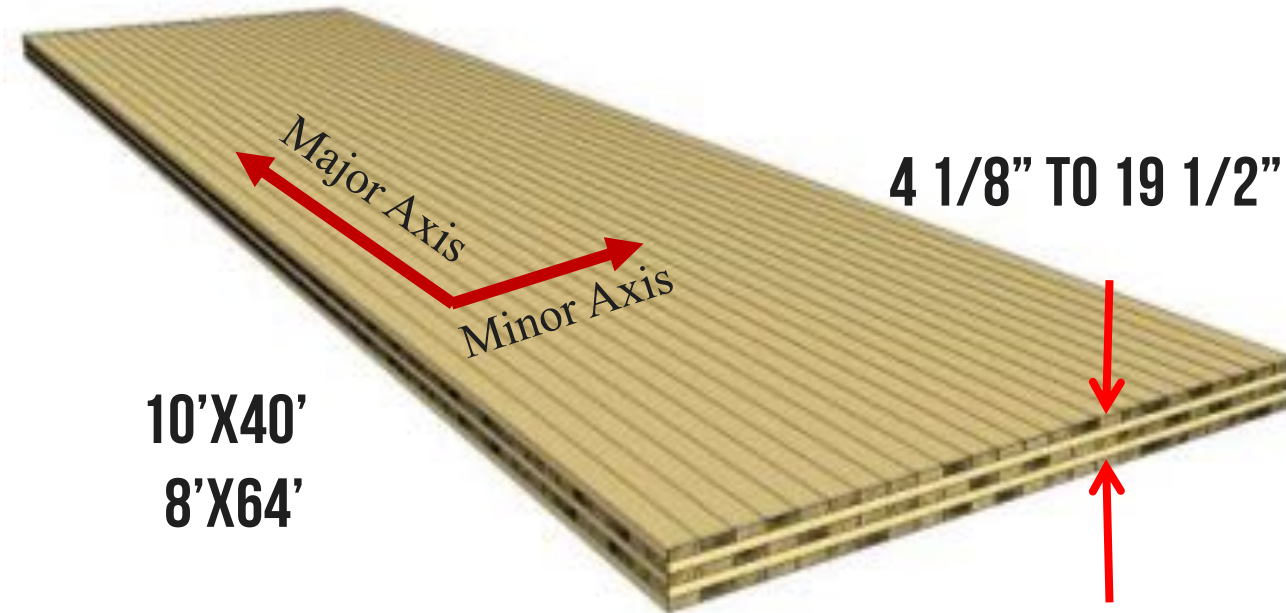
90 DEG. CROSS-LAMS

SIMILAR TO PLYWOOD SHEATHING



MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)



The logo for USNR (United States Naval Research) is displayed in large, bold, red capital letters on a white background, which is part of a large industrial machine.

USNR

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)



PHOTO CREDIT: DR JOHNSON

MASS TIMBER PRODUCTS

CLT PANEL FABRICATION

CROSS-LAMINATED TIMBER (CLT)





MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)

CLT PREFABRICATION

- **FINISHED PANELS ARE PLANED, SANDED, CUT TO SIZE. THEN OPENINGS ARE CUT WITH PRECISE CNC ROUTERS.**
- **THIRD PARTY INSPECTION AT FACTORY**
- **CUSTOM ENGINEERED FOR MATERIAL EFFICIENCY**
- **CUSTOM DESIGNED FOR PROJECT**
- **EACH PANEL NUMBERED, DELIVERED & INSTALLED IN PREDETERMINED SEQUENCE**

PROJECT TEAM: PERKINS + WILL
DCI ENGINEERS
HATHAWAY DINWIDDIE

ONE DE HARO

SAN FRANCISCO, CA

**4 STORY OFFICE BUILDING, 130,000 SF
SIGNIFICANT SAVINGS ON FOUNDATION
COSTS WITH MASS TIMBER**



IMAGE CREDIT: NORDIC STRUCTURES



IMAGE CREDIT: ALEX NYE

PROJECT TEAM:
KAISER+PATH
R&H CONSTRUCTION

THE CANYONS

PORTLAND, OR

IMAGE CREDIT: MARCUS KAUFFMAN, OREGON DEPARTMENT OF FORESTRY



PROJECT TEAM:
KAISER+PATH
R&H CONSTRUCTION



THE CANYONS

PORTLAND, OR



**PROJECT TEAM: AEDIS ARCHITECTS
DAEDALUS STRUCTURAL ENGINEERING
XL CONSTRUCTION**



TIMBER QUEST

PRE-APPROVED SCHOOL CLASSROOM

3,000 – 9,000 SF

10 WEEK CONSTRUCTION



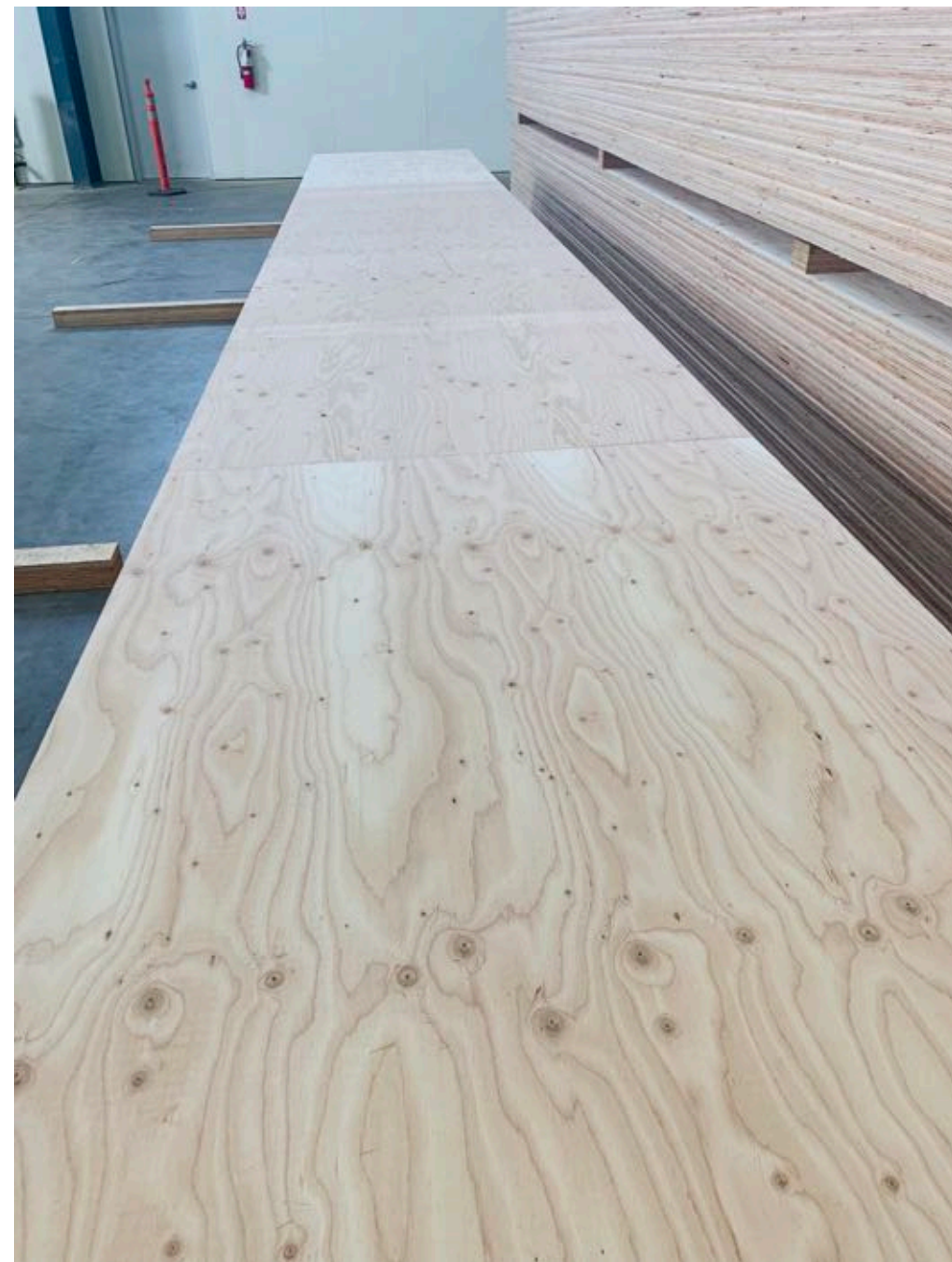
IMAGE CREDIT: XL CONSTRUCTION

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER WITH SCL LAMINATIONS



Photos: Freres Lumber



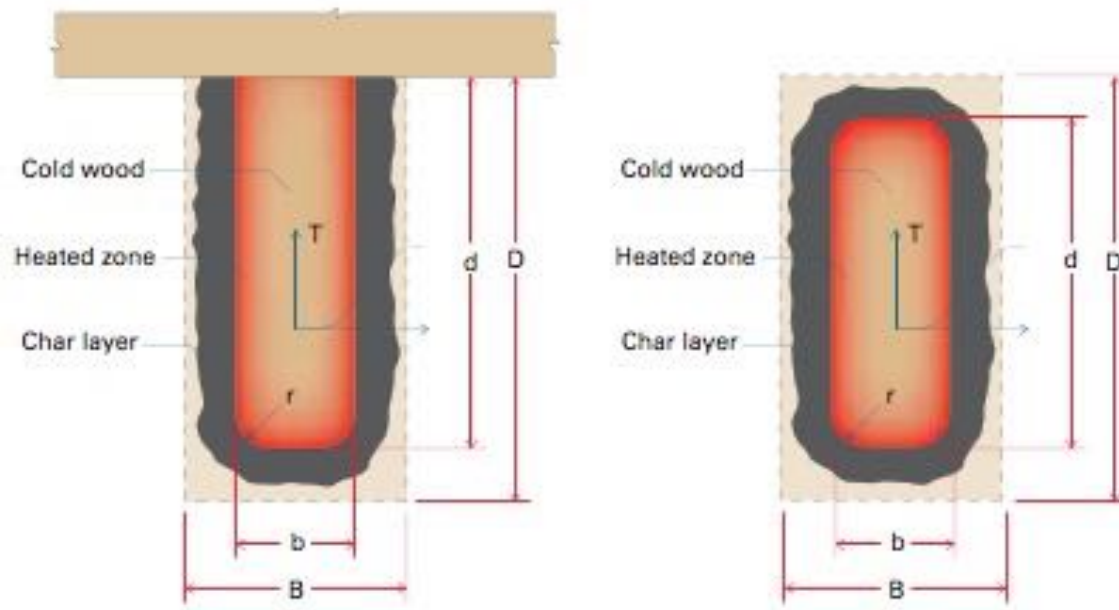
PROJECT ONE

OAKLAND, CA

IMAGE CREDIT: GURNET POINT
LLC

Mass Timber Fire Design

Mass Timber's Fire-Resistive Performance is Well-Tested, Documented and Recognized via Code Acceptance



Source: AWC's TR 10

Table 16.2.1A Char Depth and Effective Char Depth (for $\beta_n = 1.5$ in./hr.)

Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

Source: AWC's NDS



Credit: David Barber, ARUP

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS



IMAGE: SEAGATE STRUCTURES

STEEL OR CONCRETE SEISMIC SYSTEM:

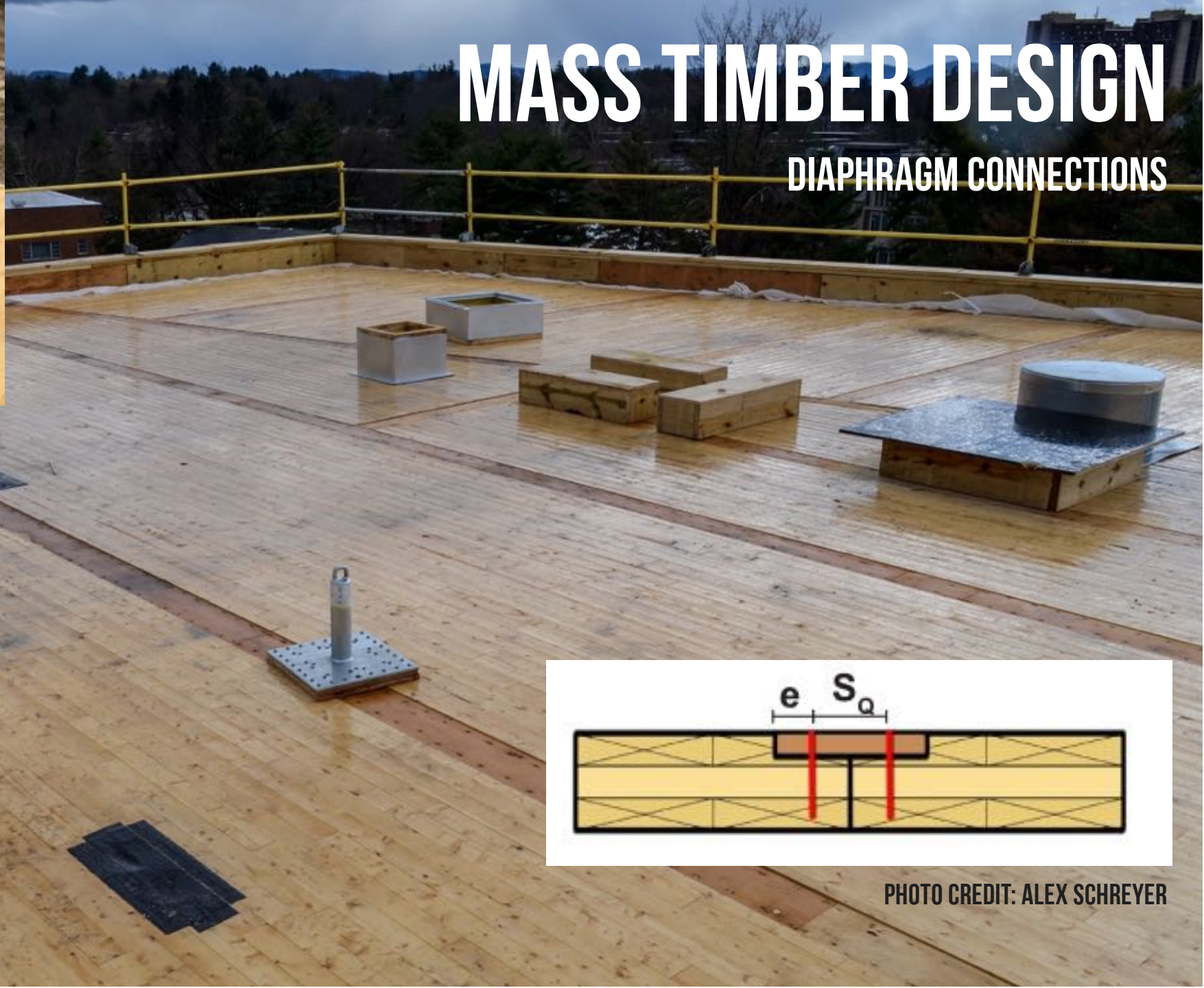
- COMMONLY USED WITH GLAZING/CURTAIN WALLS
- MAY USE RIGID OR SEMI-RIGID (IF USED WITH FRAMES AT EXTERIOR) ANALYSIS

LIGHT FRAME SHEARWALLS:

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



PHOTO CREDIT: CHARLES JUDD



MASS TIMBER DESIGN

DIAPHRAGM CONNECTIONS

PANEL TO PANEL
CONNECTIONS —
SURFACE SPLINE

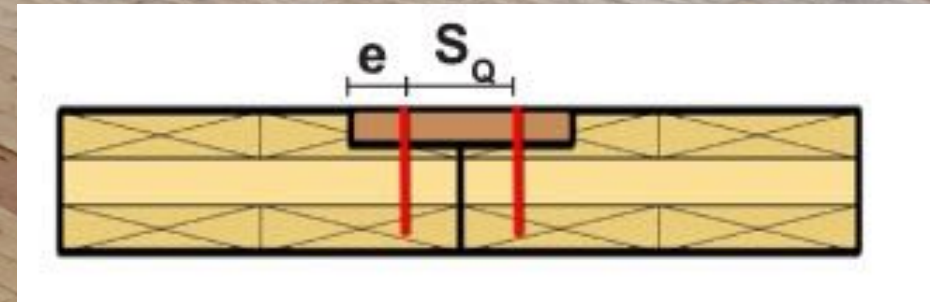


PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS



PHOTO CREDIT: STRUCTURECRAFT BUILDERS



PHOTO: STRUCTURLAM



PHOTO CREDIT: ALEX SCHREYER

Mass Timber Acoustics

Common mass timber floor assembly:

- Finish floor (if applicable)
- Underlayment (if finish floor)
- 1.5" to 4" thick concrete/gypcrete topping
- Acoustical mat
- WSP (if applicable)
- Mass timber floor panels

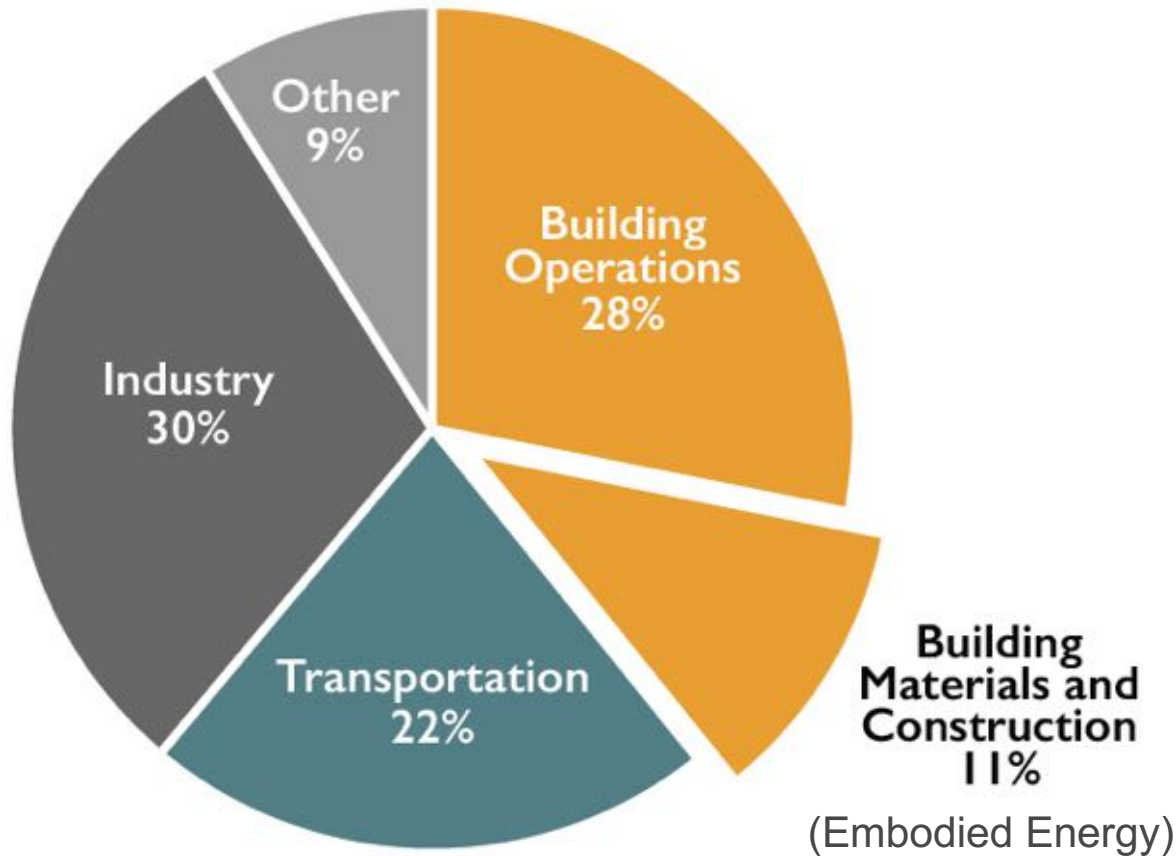


A photograph of a modern interior space, likely a rooftop terrace or a large room with a glass wall. The floor is made of polished, light-colored wood planks. The wall is composed of large glass panels framed by dark metal. Through the glass, a city street is visible, featuring various buildings, including a prominent red brick building and a white building. The sky is overcast with grey clouds. The text "MASS TIMBER UNDERSTANDING THE WHY" is overlaid in white, bold, sans-serif font, with the word "WHY" underlined.

MASS TIMBER UNDERSTANDING THE WHY

New Buildings & Greenhouse Gases

Global CO₂ Emissions by Sector

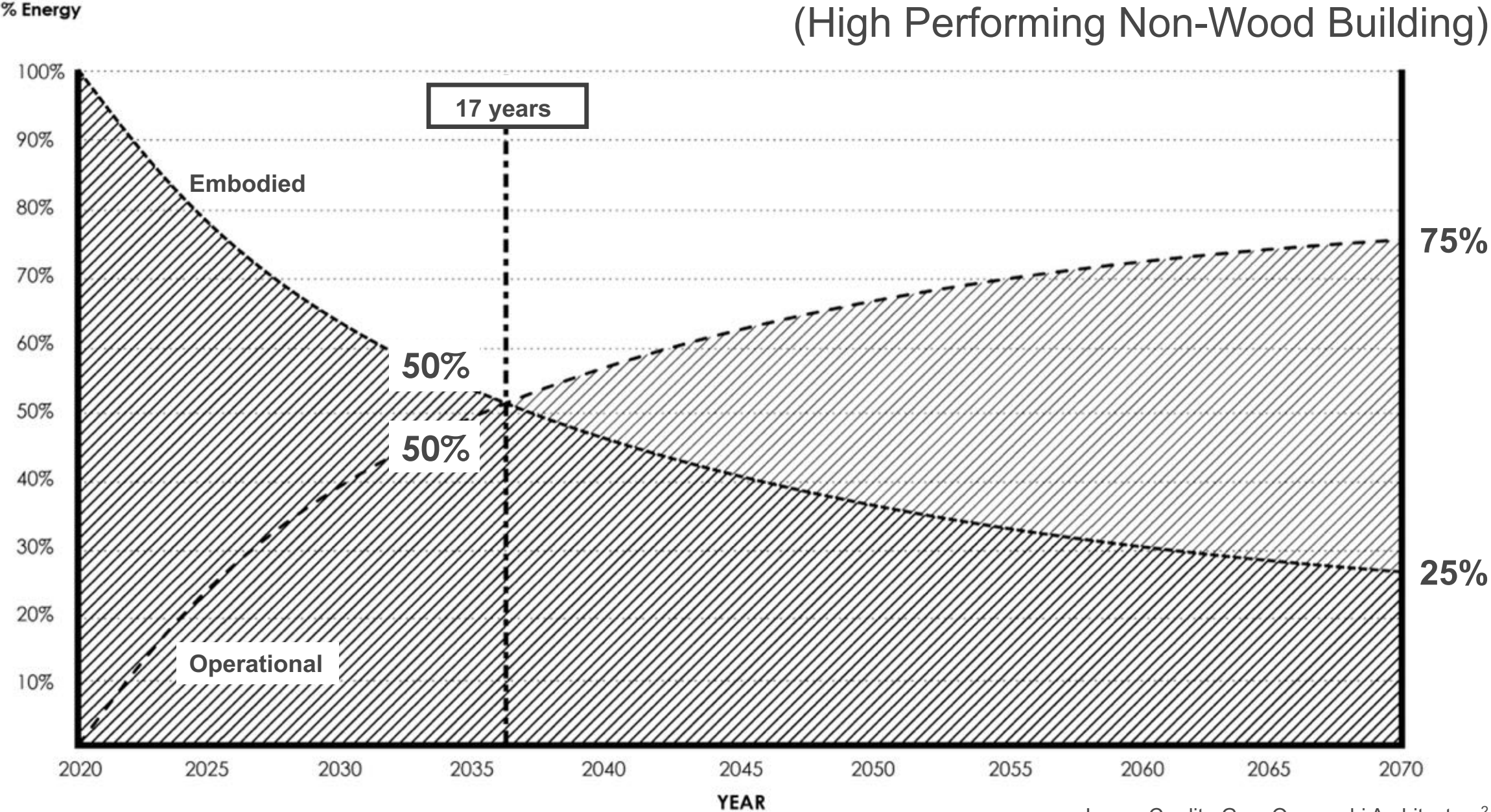


Buildings generate nearly 40% of annual global greenhouse gas emissions (*building operations + embodied energy*)

Embodied Energy (11%): Concrete, iron + steel produce approximately 9% of this (Architecture 2030)

Source: © 2018 2030, Inc. / Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

Embodied vs. Operational Energy (High Performing Non-Wood Building)



Carbon Storage

Wood \approx 50% Carbon (dry weight)



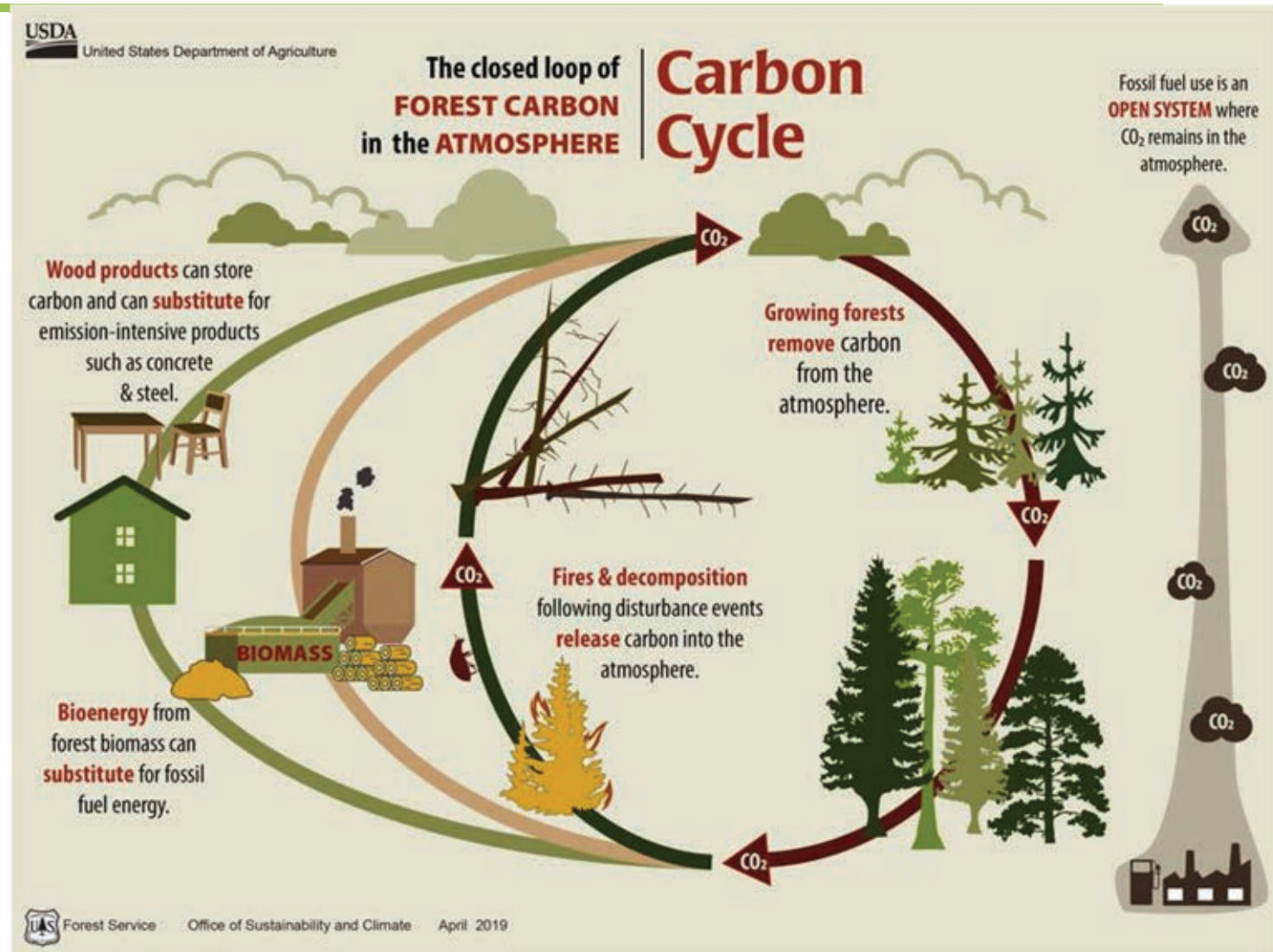
Image: Kaiser + Path



Image: Lever Architecture

Carbon Benefits of Wood

- **Less energy intensive** to manufacture than steel or concrete
- **Less fossil fuel consumed** during manufacture
- **Avoid process emissions**
- Carbon **storage** in forests and **promote forest health**
- Extended carbon **storage** in **products**



Biophilia - Structural Warmth is a Value-Add



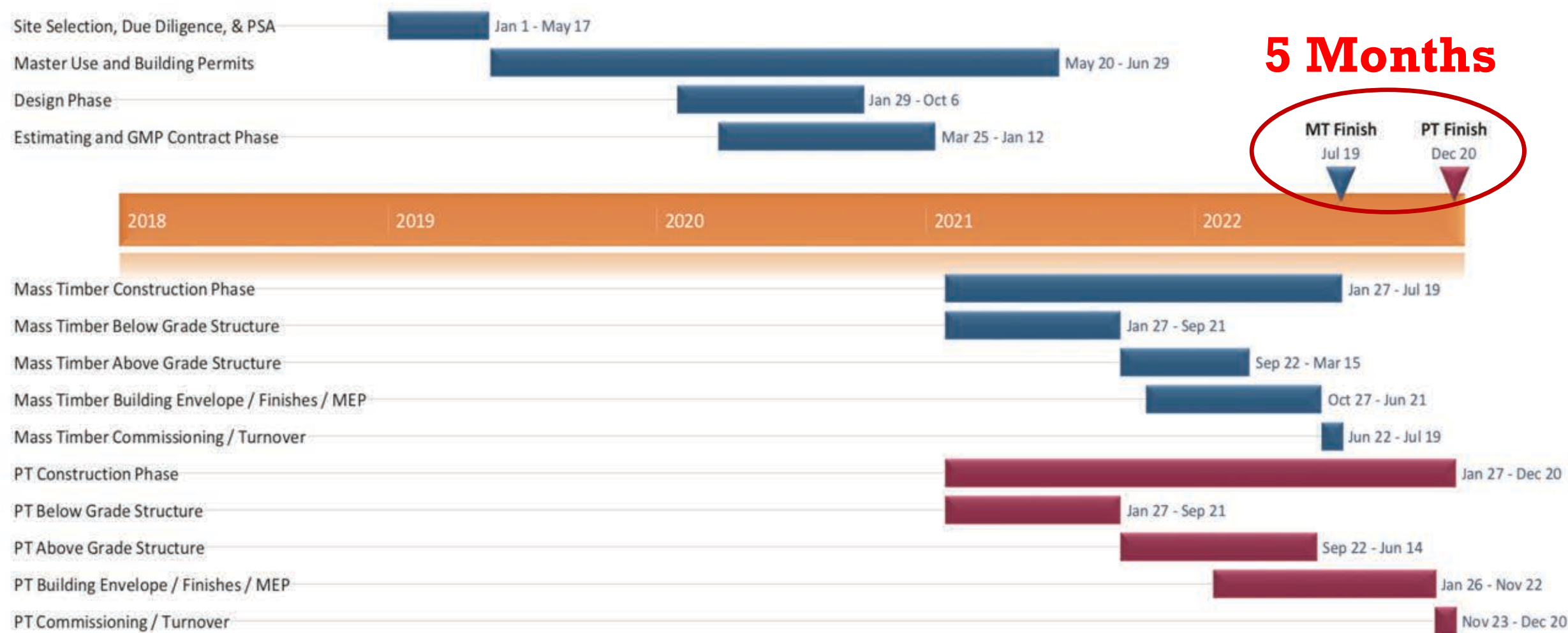
TMBR (unbuilt) Minneapolis, MN | Images: D/O Architects

Construction Impacts: Labor Availability



Photo: Lendlease

Construction Impacts: Schedule



MARKET DRIVERS FOR MASS TIMBER

PRIMARY DRIVERS

- » Construction Efficiency & Speed
- » Construction site constraints – Urban Infill
- » Innovation/Aesthetic

SECONDARY DRIVERS

- » Carbon Reductions
- » Structural Performance – lightweight

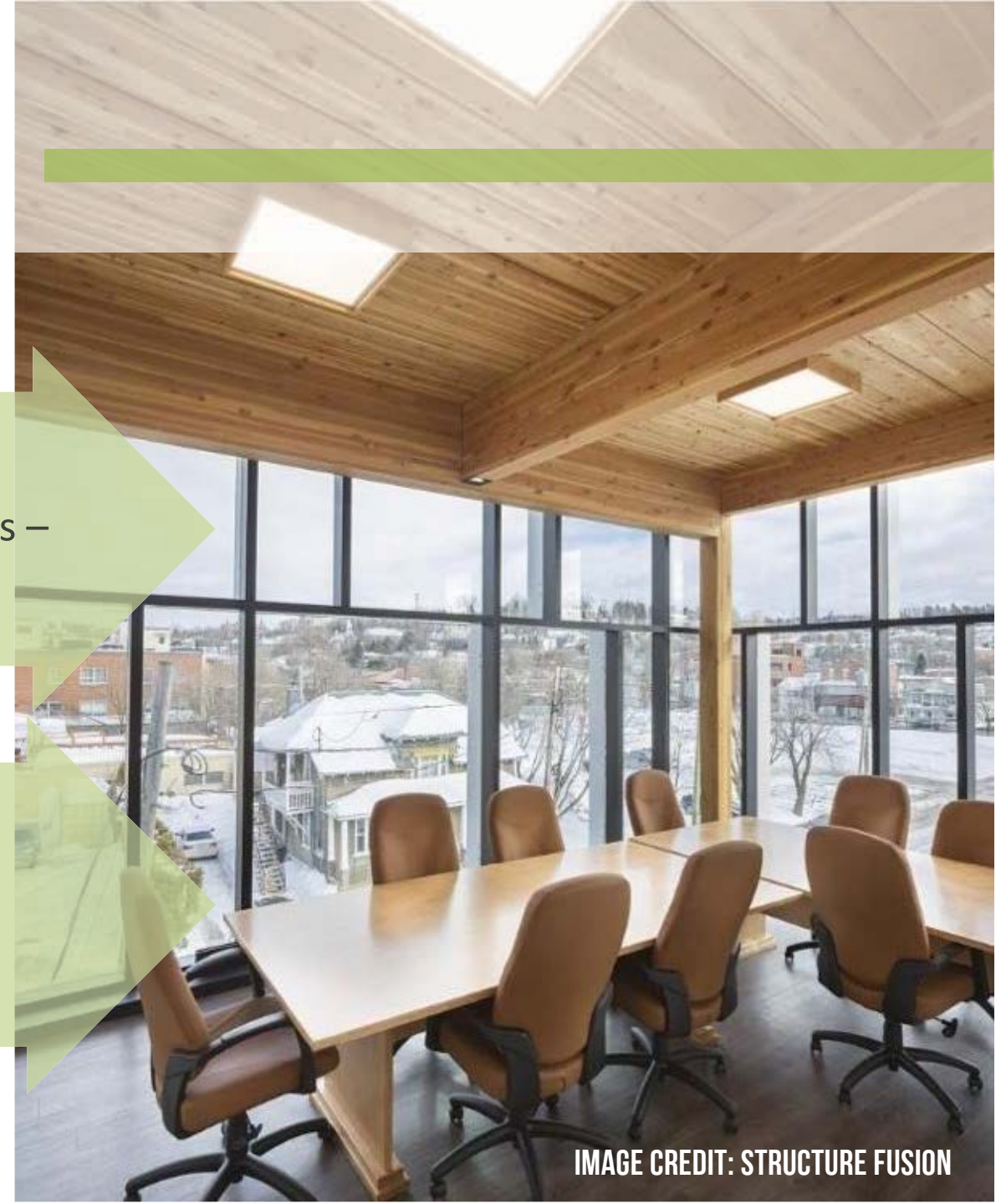


IMAGE CREDIT: STRUCTURE FUSION

MASS TIMBER PRODUCTS

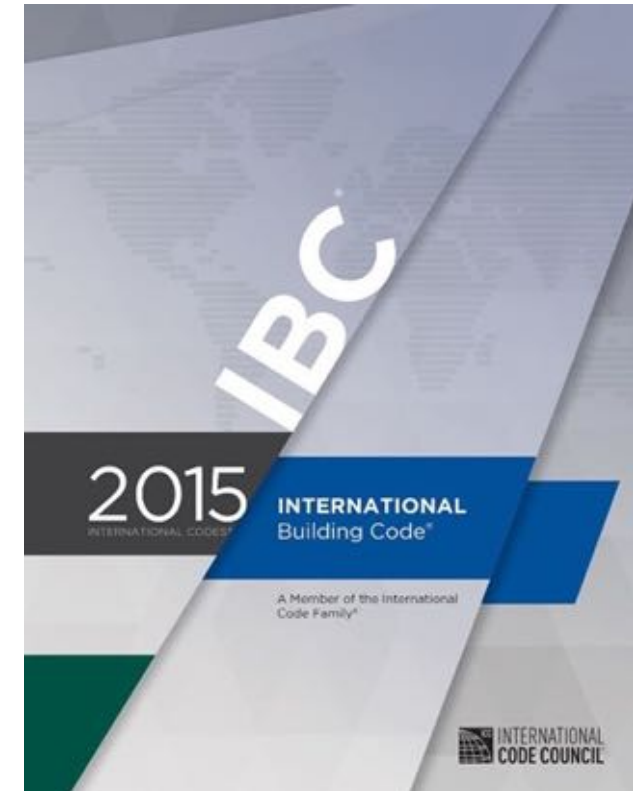
CROSS-LAMINATED TIMBER (CLT)

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

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

AND IS REFERENCED IN CHAPTER 23:

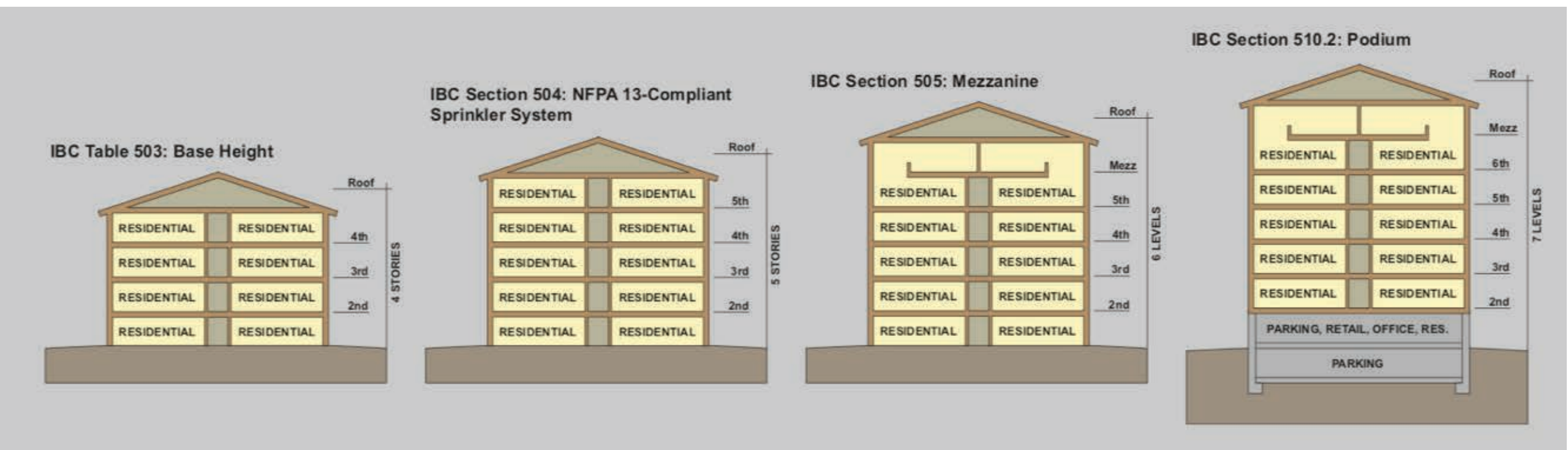
2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.



BEFORE IBC 2021 Code Limit for wood - 6 stories (business) 5 stories (residential) and 85 feet

Over 6 Stories:

Alternate Means and Methods Request (AMMR) through performance based design



Source: WoodWorks



What is allowed with the IBC 2021 provisions?

Type IV-A



18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

Type IV-B



12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

Type IV-C



9 STORIES
BUILDING HEIGHT 85'
ALLOWABLE BUILDING AREA 405,000 SF
AVERAGE AREA PER STORY 45,000 SF

California Building Standards Commission Passes Tall Wood Code Change Proposals

Source: Softwood Lumber Board

"The early adoption of mass timber codes can be a benefit to California in many ways, but I would like to highlight three of those advantages in this proposal.

- 1. It has the potential to **increase the market demand for mass timber production in California** to meet the needs of the construction industry.*
- 2. It will **increase the pace and scale of our wildland fire prevention and forest management goals** of treating 500 thousand acres per year by thinning the forest of smaller diameter trees that can be used in the production of cross laminated timber and other mass timber assemblies.*
- 3. While wood products provide the benefit of storing carbon, another benefit or advantage is that **mass timber construction can also help reduce the carbon footprint** of concrete and steel production."*

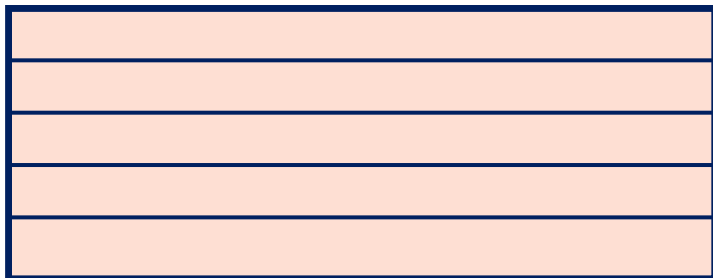
– Chief Mike Richwine, State Fire Marshal

CBC Tall Wood Building Size Limits

The CBC has historically not allowed “double-dipping” for sprinkler increases of building height and area for A, E, H, I, L or R occupancies. The IBC has no such restriction.

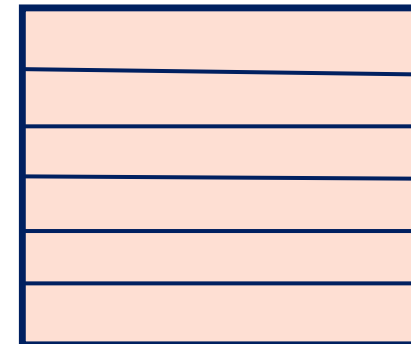
Also specific to the CBC, for multi-story buildings that are A, E, H, I, L or R occupancies, the total allowable building area is equal to the allowable floor area multiplied by the number of stories, not to exceed 2. In the IBC, this value is 3 for all occupancies.

This is also the case for Tall Wood.



Larger Area

VS.



Taller

CBC Tall Wood Building Size Limits

For example, if using the sprinkler area increases, the allowable height in the CBC is 20 ft and 1 story less than the IBC limits for Type IV-A, IV-B and IV-C construction for A, E, H-4, I-4, R-1 and R-2 occupancies.

OCCUPANCY CLASSIFICATION	TYPE OF CONSTRUCTION				
	SEE FOOTNOTES	TYPE IV			
		<u>A</u>	<u>B</u>	<u>C</u>	HT
B, F, M, S, U	NS ^b	<u>65</u>	<u>65</u>	<u>65</u>	65
	S	<u>270</u>	<u>180</u>	<u>85</u>	85
A, E	NS ^b	<u>65</u>	<u>65</u>	<u>65</u>	65
	<i>S (without area increase)</i>	<u>270</u>	<u>180</u>	<u>85</u>	85
	<i>S (with area increase)</i>	<u>250</u>	<u>160</u>	<u>65</u>	65

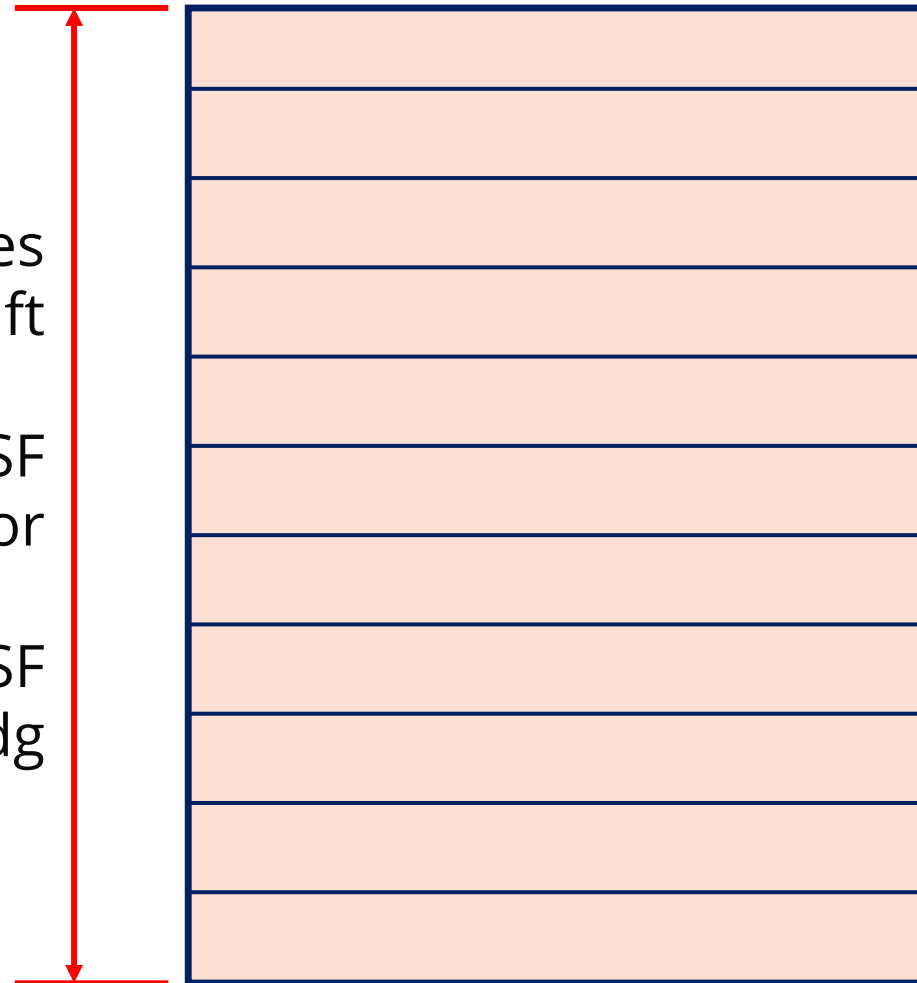
CBC Tall Wood Building Size Limits

	Construction Type (<u>Sprinklered Values</u>)						
	I-A	I-B	<u>IV-A</u>	<u>IV-B</u>	<u>IV-C</u>	IV-HT	III-A
Occupancies	Allowable Building Height above Grade Plane, Feet (CBC Table 504.3)						
B, F, M, S, U, R-3, R-4	Unlimited	180*	<u>270</u>	<u>180</u>	<u>85</u>	85	85
A, E, R-1, R-2 (w/ area increase)	Unlimited	180 (160)	<u>270 (250)</u>	<u>180 (160)</u>	<u>85 (65)</u>	85 (65)	85 (65)
	Allowable Number of Stories above Grade Plane (CBC Table 504.4)						
A-2, A-3, A-4 (w/ area increase)	Unlimited	12 (11)	<u>18 (17)</u>	<u>12 (11)</u>	<u>6 (5)</u>	4 (3)	4 (3)
B	Unlimited	12	<u>18</u>	<u>12</u>	<u>9</u>	6	6
R-1, R-2 (w/ area increase)	Unlimited	12 (11)	<u>18 (17)</u>	<u>12 (11)</u>	<u>8 (7)</u>	5 (4)	5 (4)
	Allowable Area Factor (At) for SM, Feet ² (CBC Table 506.2)						
A-1, A-2, A-3, A-4 (w/ height increase)	Unlimited	Unlimited	<u>135,000</u> <u>(45,000)</u>	<u>90,000</u> <u>(30,000)</u>	<u>56,250</u> <u>(18,750)</u>	45,000 (15,000)	42,000 (14,000)
B	Unlimited	Unlimited	<u>324,000</u>	<u>216,000</u>	<u>135,000</u>	108,000	85,500
R-1, R-2 (w/ height increase)	Unlimited	Unlimited	<u>184,500</u> <u>(61,500)</u>	<u>123,000</u> <u>(41,000)</u>	<u>76,875</u> <u>(25,625)</u>	61,500 (20,500)	72,000 (24,000)

CBC Tall Wood – Sprinkler Increase Options

Example: R-2, Type IV-B Building

w/ area increase



11 Stories
160 ft

123,000 SF
per floor

246,000 SF
total bldg

w/ height increase



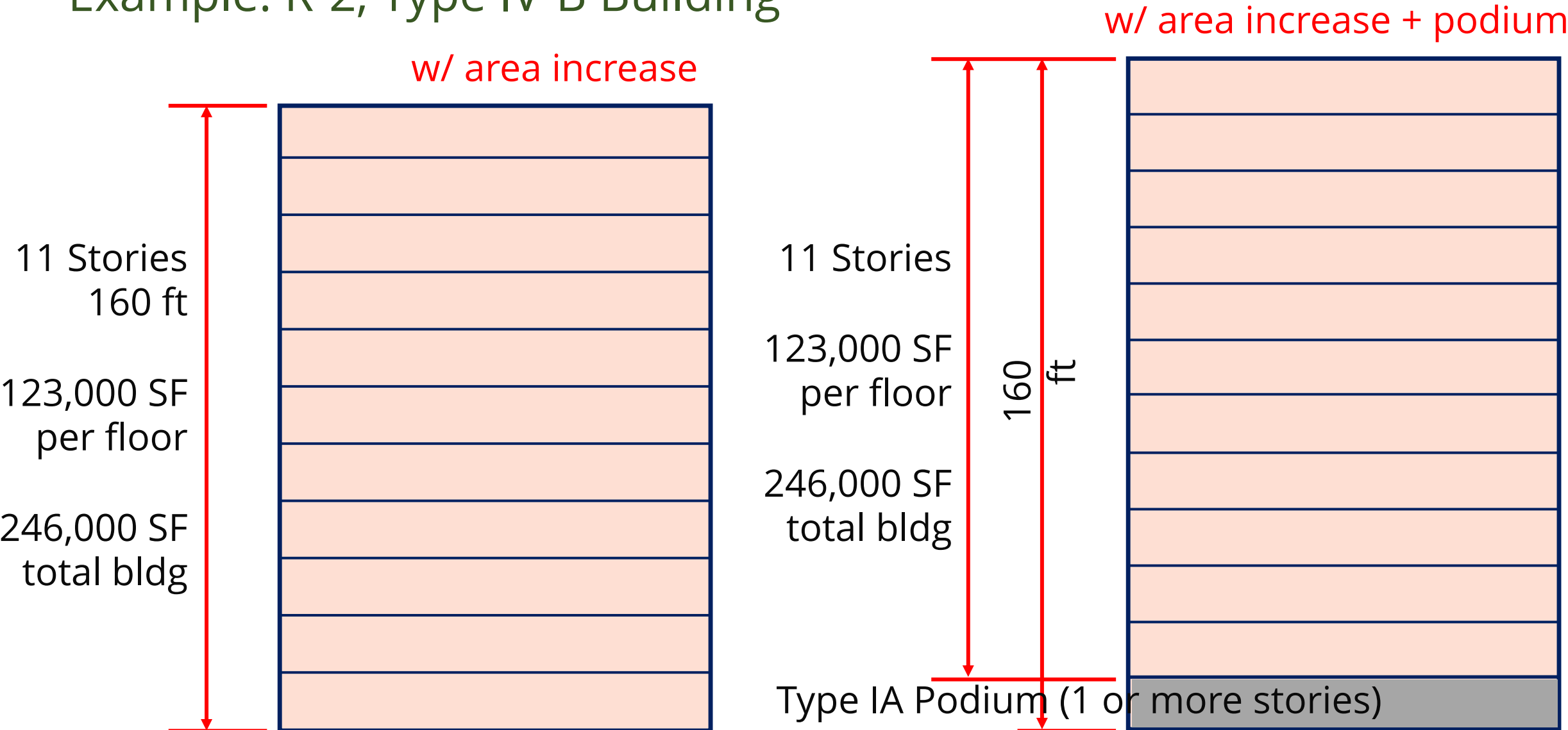
12 Stories
180 ft

41,000 SF
per floor

82,000 SF
total bldg

CBC Tall Wood – Podium Option (w/ Sprinkler Increase)

Example: R-2, Type IV-B Building



THANK YOU

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