Mass Timber in Multi-Family: Key Considerations and Advanced Fire Design

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P e e ed b
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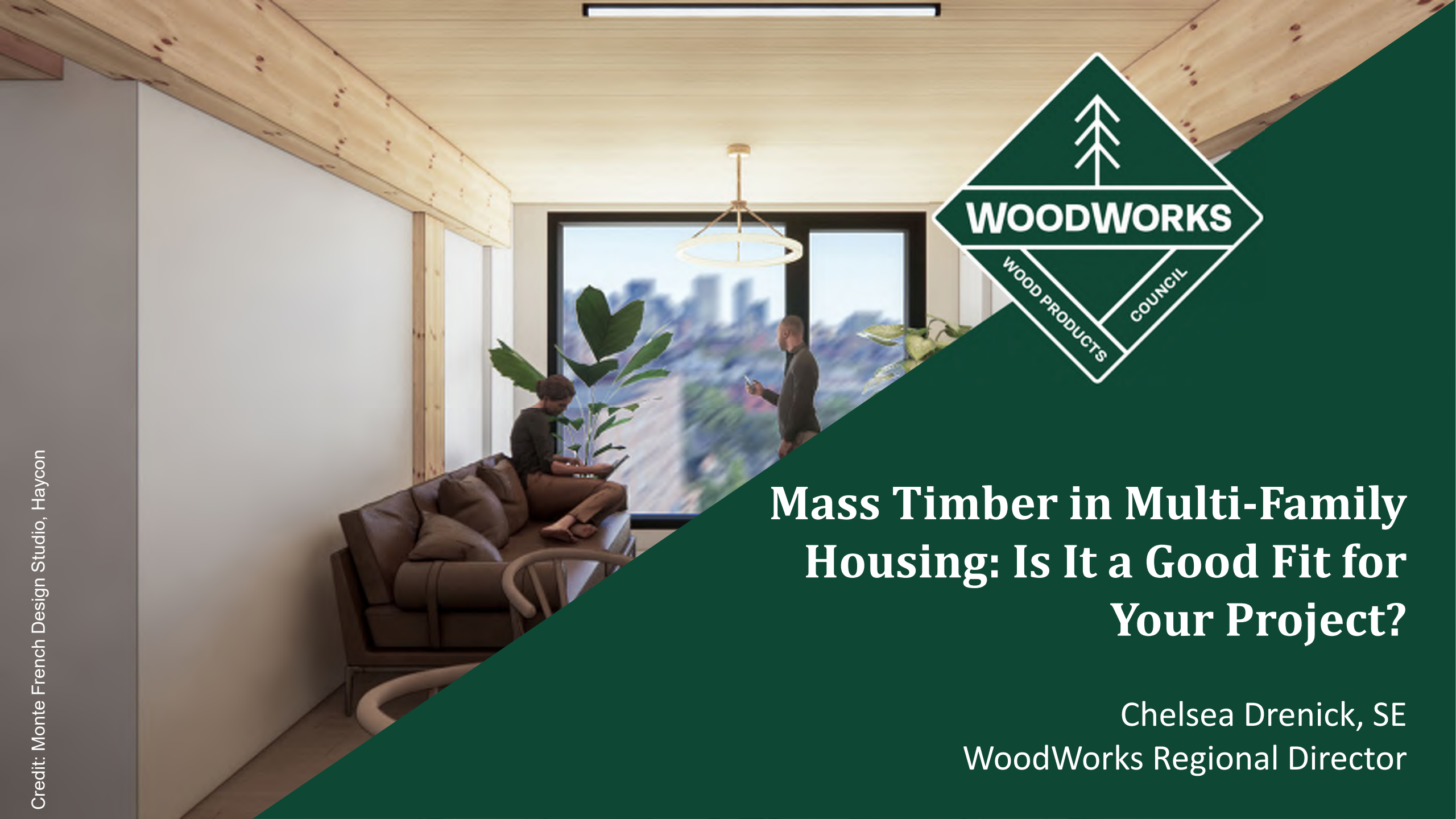
Heartwood, atelierjones, DCI Engineers, rendering atelierjones



Credit: Monte French Design Studio, Haycon

Mass Timber in Multi-Family Housing: Is It a Good Fit for Your Project?

Chelsea Drenick, SE
WoodWorks Regional Director

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

Course Description

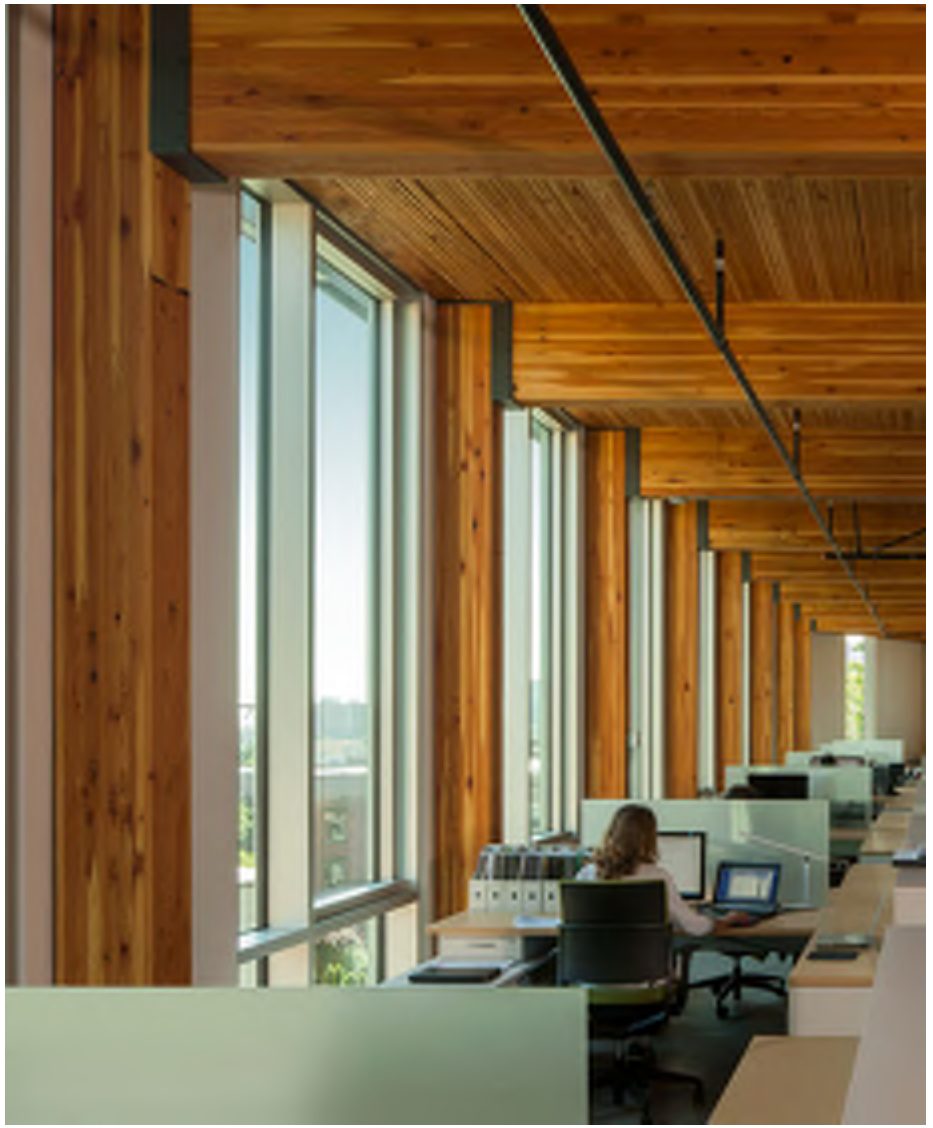
Mass timber is often attached to the stigma of being more expensive than other building materials. Because of this, some people assume it only makes sense for one-off projects where innovation is celebrated but repeatability is not. Is this true, or do its other benefits result in overall cost efficiency? If it is true, how can we expect to build the number of new housing units needed across our country in a sustainable and affordable manner? Typical multi-family housing developments are in the range of 4-6 stories, often utilizing podium or pedestal construction with 1-2 stories of steel and concrete topped with 3-5 stories of light wood framing. Beyond these heights, building codes have historically required steel or concrete framing and, to justify the added costs of these materials, projects often go much taller. This has created a critical gap in housing developments in the range of 6-12 stories. Can mass timber multi-family projects make financial sense in the 4-6 story range, used in conjunction with light wood-frame systems? What new opportunities will the 2021 International Building Code create for mass timber housing in the 6-18 story range? This presentation will answer these questions and much more.

Learning Objectives

1. Evaluate the code opportunities for mass timber structures in residential mid-rise projects.
2. Discuss code-compliant options for exposing mass timber, where up to 2-hour fire-resistance ratings are required, and demonstrate design methodologies for achieving these ratings.
3. Review code requirements unique to hybrid mass timber and light-frame housing projects, and emphasize solutions for criteria such as construction type, fire-resistance ratings and acoustics design.
4. Highlight the unique benefits of using exposed mass timber in taller multi-family buildings.

Light-Frame Wood
Photo: WoodWorks

Heavy Timber
Photo: Benjamin Benschneider



Mass Timber
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)

Photo: StructureCraft

Photo: StructureCraft

Photo: Ema Peter

Photo: Manasc Isaac Architects/Fast + Epp

Common CLT Layups

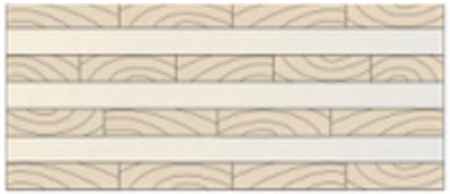
Most Designs
Least $/sf

3-ply 3-layer

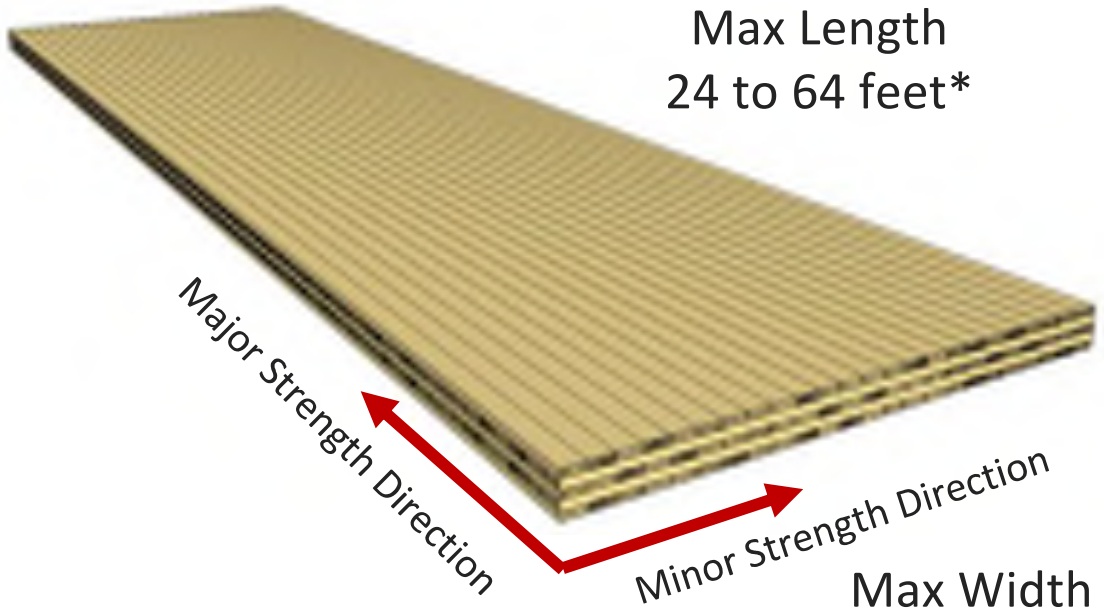
5-ply 5-layer

6 7/8”
(common for multi-family)

7-ply 7-layer



9-ply 9-layer



Max Length
24 to 64 feet*

Max Width
4 to 12 feet*

*All dimensions are approximate.
Consult with manufacturers.

Framing Options for Mass Timber Multi-Family

Mass Timber Floors & Roofs on LWF Bearing Walls

Credit: KL&A Engineers & Builders

Mass Timber Floors & Roofs on Mass Timber Bearing Walls

Credit: Grey Organschi Architecture and Spiritos Properties

Framing Options for Mass Timber Multi-Family

Mass Timber Floors & Roofs on Post & Beam Framing

Credit: ADX Creative and Engberg Anderson

Mass Timber Floors & Roofs on Posts (Flat Plate)

Credit: acton ostry architects

KEY DESIGN CONSIDERATIONS

INTRO, Cleveland, OH. Credit: Harbor Bay Real Estate Advisors

Mass Timber in the IBC: Cross-Laminated Timber (CLT)

- CLT was first recognized in the 2015 IBC
- CLT in the 2021 IBC:
  - 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.

  - Chapter 23: Wood

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

Construction Types – Allowable Materials

IBC/CBC defines 5 construction types: I, II, III, IV, V
A building must be classified as one of these

	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Exterior Wall Material	Non-combustible		Non-combustible		FRTW		CLT (protected)			FRTW (LF, MT), CLT (protected)	Any wood	
Interior Elements	Non-combustible		Non-combustible		Any wood		Heavy Timber			Heavy Timber	Any wood	

Construction Types I-B, II-A, II-B

Where does the code allow wood to be used?

- Mass Timber Roof Construction
- IBC/CBC Table 601, Footnote c:
  - In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.

Wellesley College, Wellesley, MA

Low and Mid-Rise Construction Types

Type III

- Exterior walls non-combustible (may be light frame FRTW)
- Interior elements any allowed by code

Type V

- All building elements any allowed by code

Types III and V can be subdivided:

- A (protected)
- B (unprotected)

Type IV-HT

- Exterior walls non-combustible (may be FRTW OR CLT)
- Interior elements qualify as Heavy Timber
- All light-frame wall (even non-bearing) require 1-hour rating

Construction Types – Allowable Materials

	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Exterior Wall Material	Non-combustible		Non-combustible		FRTW		CLT (protected)			FRTW (LF, MT), CLT (protected)	Any wood	
Interior Elements	Non-combustible		Non-combustible		Any wood		Heavy Timber			Heavy Timber	Any wood	

Construction Types V-A, V-B

Type V Construction:

- Interior Elements (Floors, Roofs, Partitions/Shafts, Etc.)
  - Any material permitted by code, including light frame and mass timber
- Exterior Walls
  - Non-combustible walls: light-gauge steel, curtainwall systems
  - Light-frame walls
  - Mass Timber

Star Lofts, Des Moines, IA

Image: Cutler Development

Construction Types – Allowable Materials

	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Exterior Wall Material	Non-combustible		Non-combustible		FRTW		CLT (protected)			FRTW (LF, MT), CLT (protected)	Any wood	
Interior Elements	Non-combustible		Non-combustible		Any wood		Heavy Timber			Heavy Timber	Any wood	

Construction Types III-A, III-B

Type III Construction:

- Interior Elements (Floors, Roofs, Partitions/Shafts, Etc.)
  - Any material permitted by code, including light frame and mass timber
- Exterior Walls
  - Non-combustible walls: light-gauge steel, curtainwall systems
  - FRTW light-frame walls

The Canyons, Portland, OR

The Canyons, Kaiser+Path, Cantena Consulting Engineers, Photo Jeremy Bittermann

Construction Types – Allowable Materials

	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Exterior Wall Material	Non-combustible		Non-combustible		FRTW		CLT (protected)			FRTW (LF), CLT (protected)	Any wood	
Interior Elements	Non-combustible		Non-combustible		Any wood		Heavy Timber			Heavy Timber	Any wood	

Construction Types IV-HT and IV-A, B, and C

T e IV HT Construction:

- Interior Elements
  - Mass timber, non-combustible, or 1-hour rated light-frame walls
- Exterior Walls
  - Non-combustible
  - CLT covered at exterior face with FRTW or noncombustible sheathing
  - FRTW walls (light-frame)

The Soto, San Antonio, TX

The Soto, Hixon Properties, Lake|Flato, BOKA Powell, StructureCraft, Photo Erika Brown Edwards

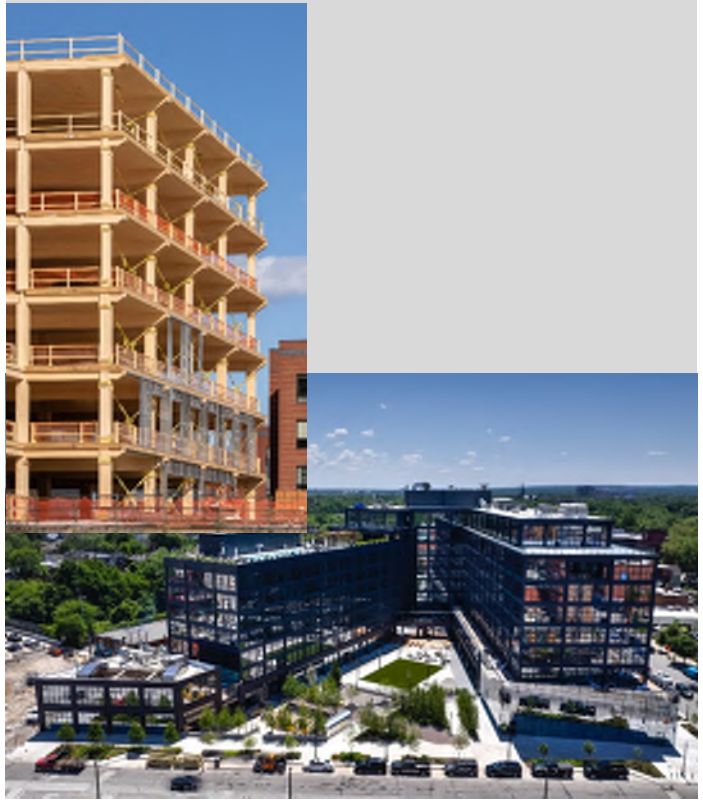
Tall Wood Code Provisions: Construction Types IV-A, B, and C

T e IV A

Photos: Flor Projects

18 STORIES	
BUILDING HEIGHT	270’
PER STORY AREA	324,000 SF
BUILDING AREA	972,000 SF

T e IV B



Photos: ©Prakash Patel

12 STORIES	
BUILDING HEIGHT	180’
PER STORY AREA	216,000 SF
BUILDING AREA	648,000 SF

T e IV C

Monte French Design Studio, Photos: Jane Messinger

9 STORIES	
BUILDING HEIGHT	85’
PER STORY AREA	135,000 SF
BUILDING AREA	405,000 SF

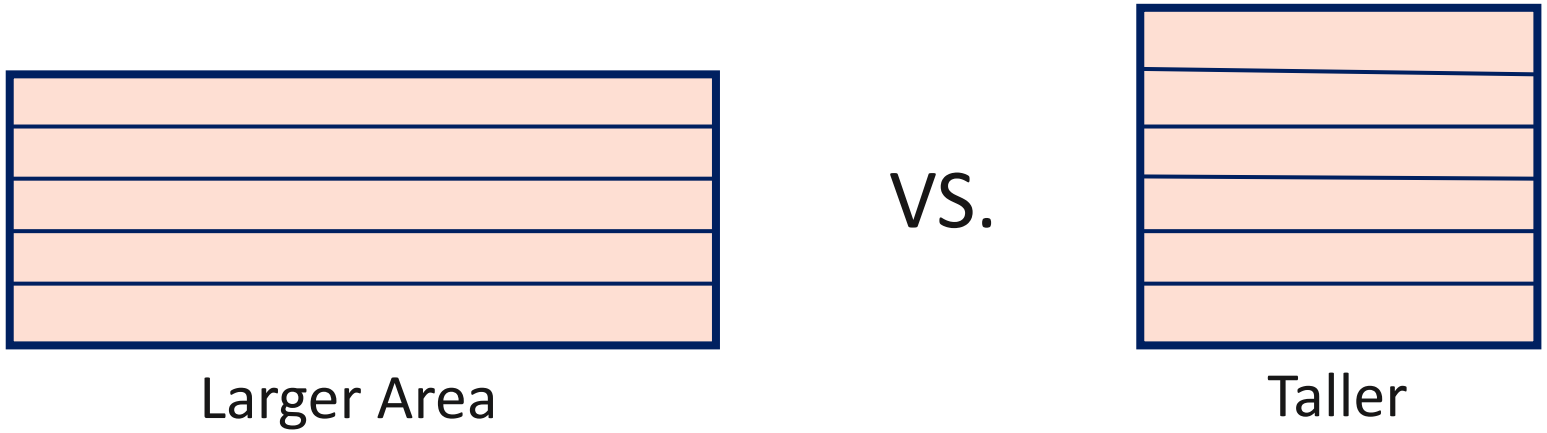
Construction Type – Primarily based on building size & occupancy

	Construction Type (All NFPA13 Sprinklered Values)							
	IV-A	IV-B	IV-C	IV-HT	III-A	III-B	V-A	V-B
Occupancies	Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)							
R	270	180	85	85	85	75	70	60
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)							
R-2	18	12	8	5	5	5	4	3
	Allowable Area Factor (At) for SM, Feet^2 (IBC Table 506.2)							
R-2	184,500	123,000	76,875	61,500	72,000	48,000	36,000	21,000

CALIFORNIA SPECIFIC: CBC Size Limits

CBC has historically not allowed “double-dipping” for sprinkler increases of building area and height for occupancies A, E, H-4, H-5, I, R-1 and R-2

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



CALIFORNIA SPECIFIC: CBC Size Limits

For example, if using sprinkler **a ea i c ea e** , allowable height is **f a d le ha IBC ma limi** for occupancies A, E, H-4, H-5, I, R-1 and R-2

TABLE 504.4—continued
ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a, b, n]

OCCUPANCY CLASSIFICATION	See Footnotes	TYPE OF CONSTRUCTION											
		Type I		Type II		Type III		Type IV				Type V	
		A	B	A	B	A	B	A	B	C	HT	A	B
R-2[h]	NS[d]	UL	11	4	4	4	4	4	4	4	4	3	2
	S13R	4	4	4								4	3
	S (with height increase)	UL	12	5	5	5	5	18	12	8	5	4	3
	S (with area increase)	*UL*	*11*	*4*	*4*	*4*	*4*	*17*	*11*	*7*	*4*	*4[o]*	*2*

Special V-A allowance

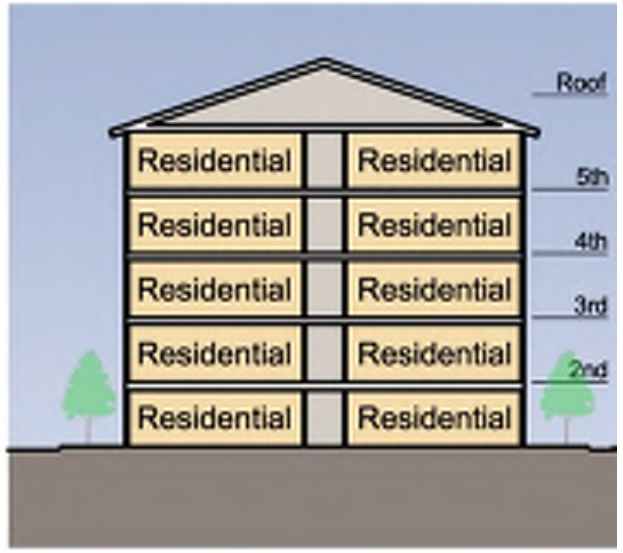
TABLE 506.2[a, b]
ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, or SM, as applicable) IN SQUARE FEET

R-2[h]	NS[d]	UL	UL	24,000	16,000	24,000	16,000	61,500	41,000	25,625	20,500	12,000	7,000
	S13R												
	S1	UL	UL	96,000	64,000	96,000	64,000	246,000	164,000	102,500	82,000	48,000	28,000
	SM (with area increase)	UL	UL	72,000	48,000	72,000	48,000	184,500	123,000	76,875	61,500	36,000	21,000
	SM (with height increase)	*UL*	*UL*	*24,000*	*16,000*	*24,000*	*16,000*	*61,500*	*41,000*	*25,625*	*20,500*	*12,000*	*7,000*

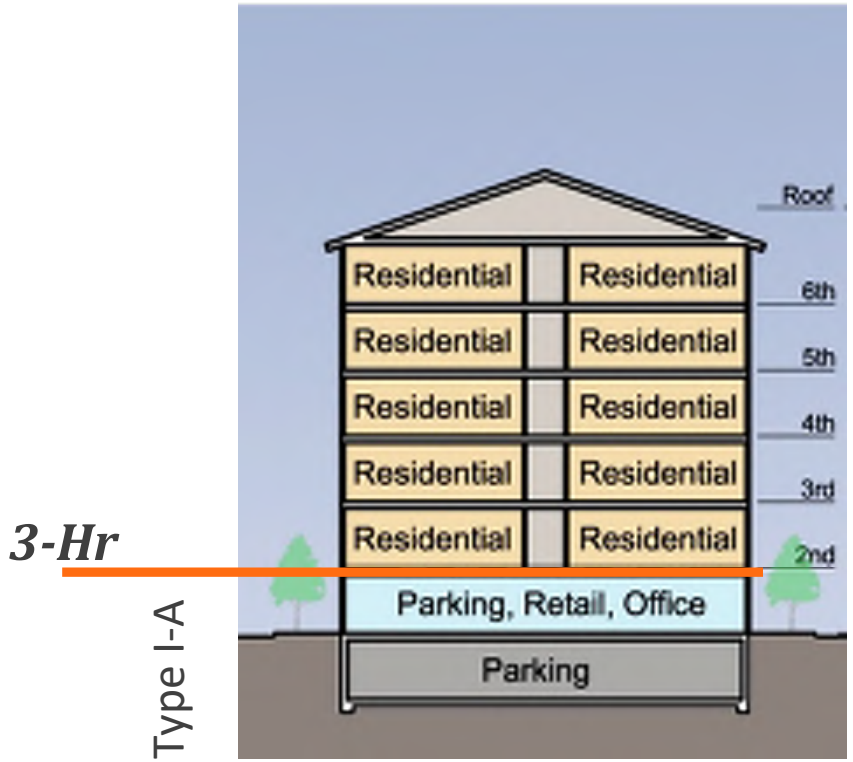
Podium Provisions

Special provisions for podiums (IBC 510.2)

- Increases allowable stories…. not allowable building height

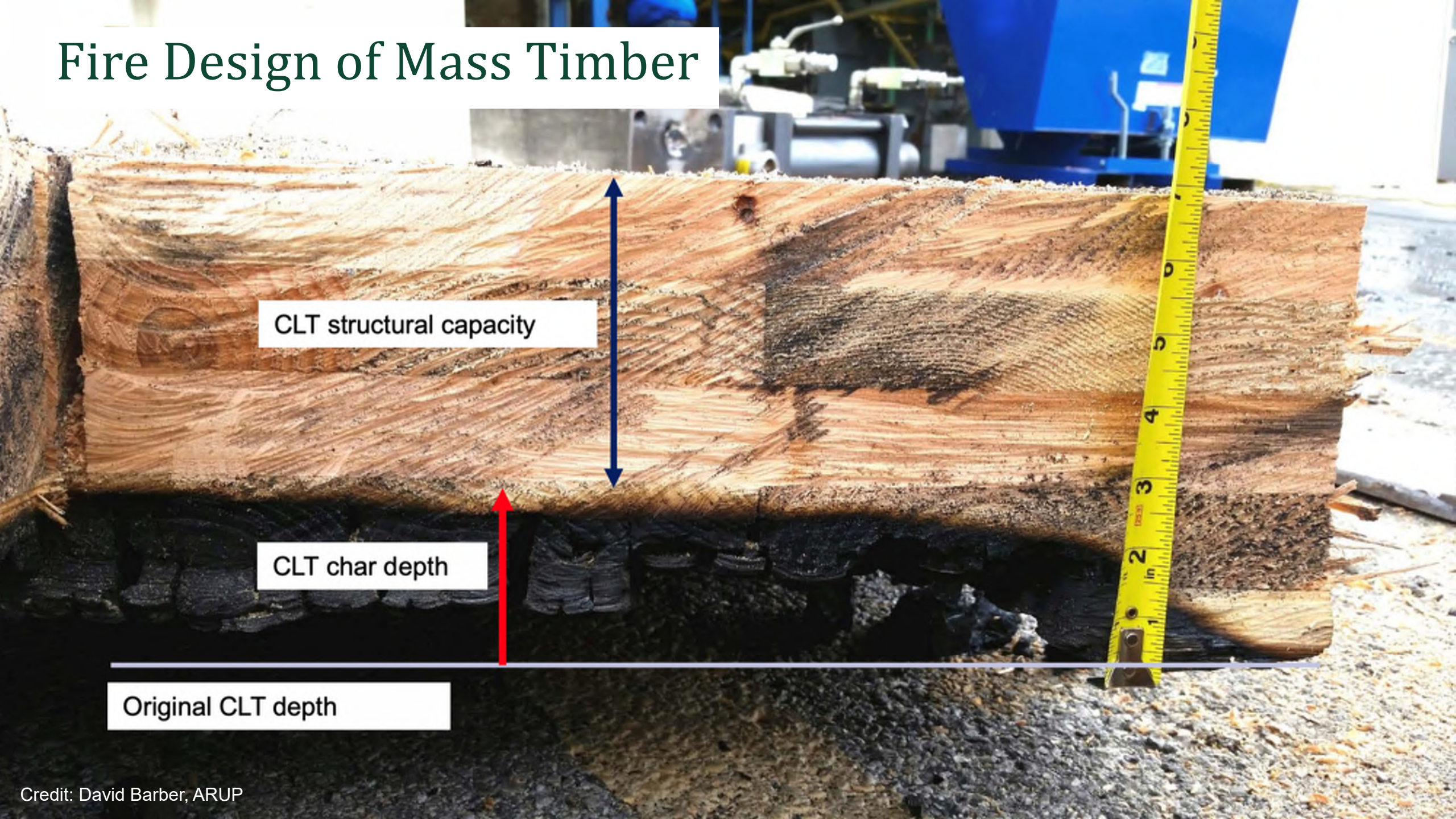


5 story Type III Building



5 story Type III Building
on Top of a Type I-A Podium

Fire Design of Mass Timber



Credit: David Barber, ARUP

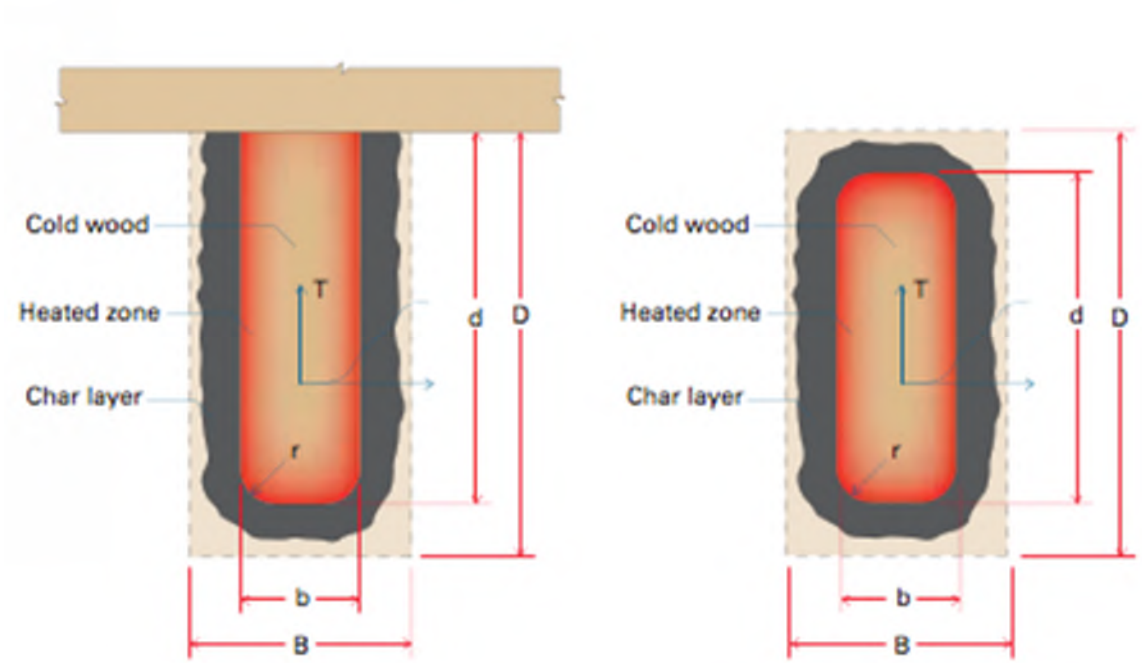
Fire Design of Mass Timber

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

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

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

Source: AWC's NDS



Source: AWC's TR 10

Fire Design of Mass Timber

Driven primarily by construction type.

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

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[b,c]	0
Bearing walls												
Exterior[a,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1½	1	1	HT	1[b,c]	0

Dwelling Unit Separation Requirements

IBC f h i al a embl e

Fire-resistance = 1 hour

except = 0.5 hour in IIB, IIIB and VB

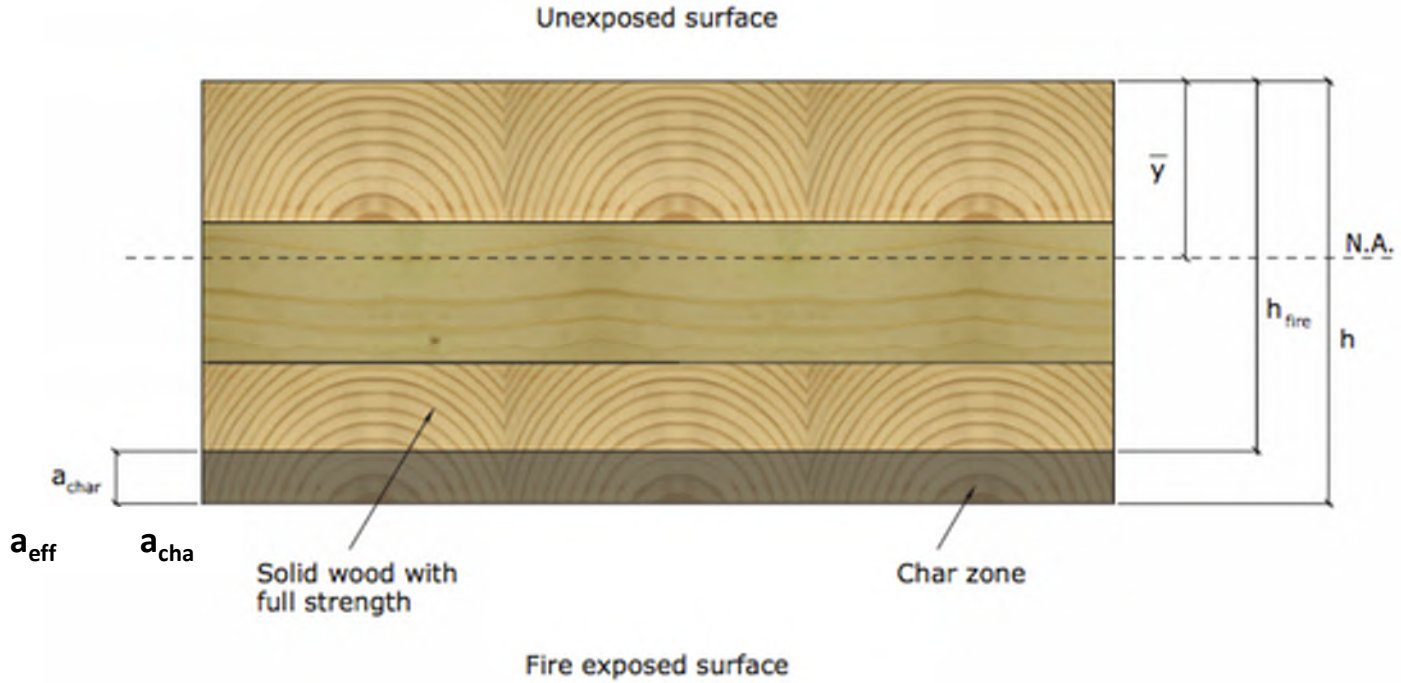
708.3 Fire-resistance rating. *Fire partitions* shall have a *fire-resistance rating* of not less than 1 hour.

Exceptions:

1. Corridor walls permitted to have a $^1/_2$-hour *fire-resistance rating* by Table 1020.1.
2. *Dwelling unit* and *sleeping unit* separations in buildings of Types IIB, IIIB and VB construction shall have *fire-resistance ratings* of not less than $^1/_2$ hour in buildings equipped throughout with an *automatic sprinkler system* in accordance with Section 903.3.1.1.

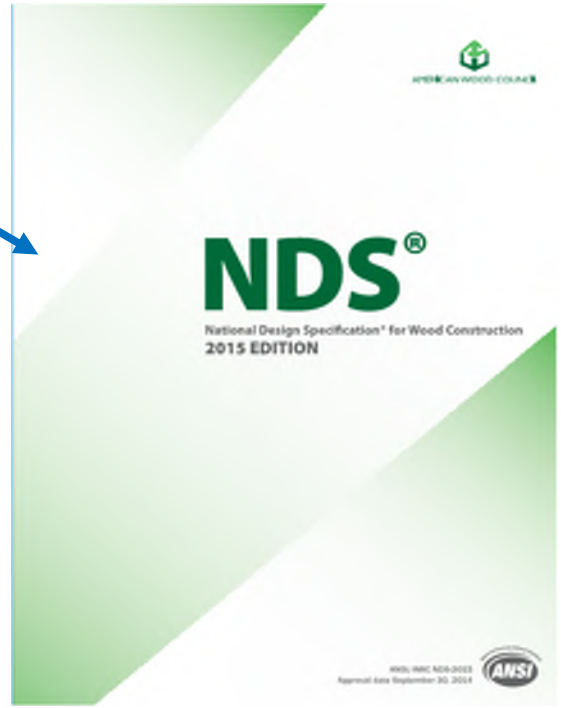
Fire Design of Mass Timber

- Demonstrating fire resistance rating (FRR) of mass timber:
  - 1. Calculations in accordance with IBC/CBC 722 (NDS Chapter 16)
  - 2. Tests in accordance with ASTM E119



Fire Design of Mass Timber

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



Code Path for Exposed Wood Fire-Resistance Calculations

IBC 703.3
Methods for determining fire resistance

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

IBC 722
Calculated Fire Resistance

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

NDS Chapter 16
Fire Design of Wood Members

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

Fire Design of Mass Timber

- https://www.woodworks.org/mass-timber-fire-acoustic-database/

Database

Application Type

- Fire-Resistance Rated Mass Timber Floor/Roof Assemblies 31
- Fire-Resistance Rated Mass Timber Wall Assemblies 26
- Firestop Systems For Penetrations in Mass Timber Assemblies 57
- Fire-Resistance Rated Mass Timber Connections 19
- Perimeter Fire Containment Systems in Mass Timber Structures 5
- Noncombustible Protection of Mass Timber Building Elements 4

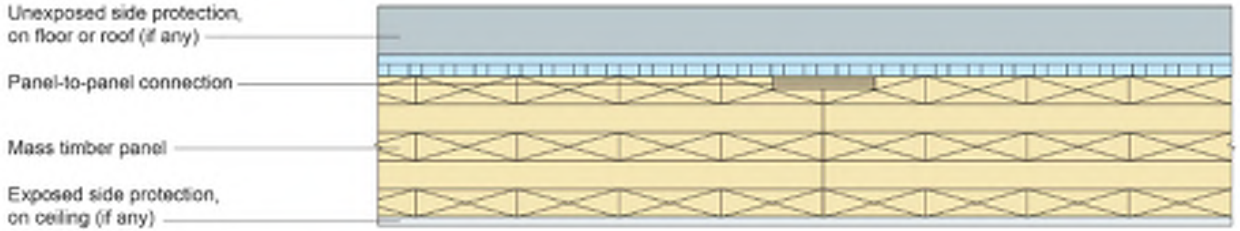
Mass Timber Panel

- CLT 109
- CLT (SCL) 1
- NLT 3
- DLT 3
- GLT 2
- SCL 1
- T&G

Number of Layers

- 1 to 3 39
- 4 to 5 78
- 6 to 7 2
- 8+

Fire-Resistance Rated Mass Timber Floor/Roof Assemblies



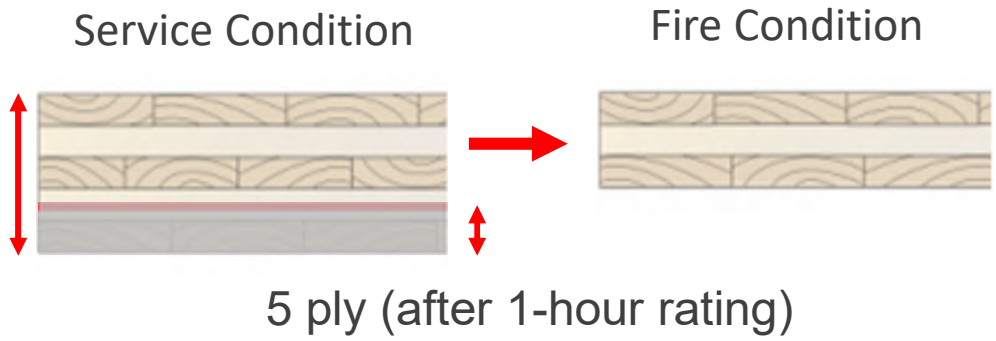
Fire-resistance ratings of assemblies are demonstrated through fire-resistance tests, recognized calculations, or approved alternatives. The IBC recognizes US testing standards ASTM E119 and UL 236 while the Canadian standard ULC S101 has the same fire exposure and performance criteria. Fire-resistance ratings developed using these standards may be acceptable to building officials in either country.

Mass Timber Panel	Structural Grade	Exposed Side Protection	Unexposed Side Protection	Panel Connection	Load Rating	Fire-Resistance Rating (Hours)	Test Protocol	Method of Compliance
5-layer 6.89" (175mm) CLT	E1M5 by Structurlam (Mercer)	None	1-1/2" Maxxon Cyp-Grete 2000 over Maxxon reinforcing mesh	Surface Spline	Loaded, See Report	2.5	ASTM E119 & ULC S101	Fire test by Intertek on Feb 22, 2017 Contact Mercer for more Information
5-layer 6.89" (175mm) CLT	V grade by Structurlam (Mercer)	None	None	Surface Spline	Loaded, See Report	2	ASTM E119	Fire test by SwRI on Jan 27, 2022 Contact Mercer for more Information
5-layer 6.89" (175mm) CLT	E grade by Structurlam (Mercer)	None	None	Surface Spline	Loaded, See Report	2	ASTM E119	Fire test by SwRI on Jan 31, 2022 Contact Mercer for more Information
5-layer 5.40" (137mm) CLT	V2 by Katerra (Mercer)	None	None	Half-Lap & Surface Spline	Loaded, See Report	1	ASTM E119	Fire test by SwRI on July 2, 2019 Contact Mercer for more Information

Fire Design of Mass Timber

- Fire Resistance Ratings (FRR)
  - Thinner 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
  - Construction Type -> FRR -> Member size -> Grid (order as needed)

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



Acoustical Design

Code requirements only address residential occupancies:

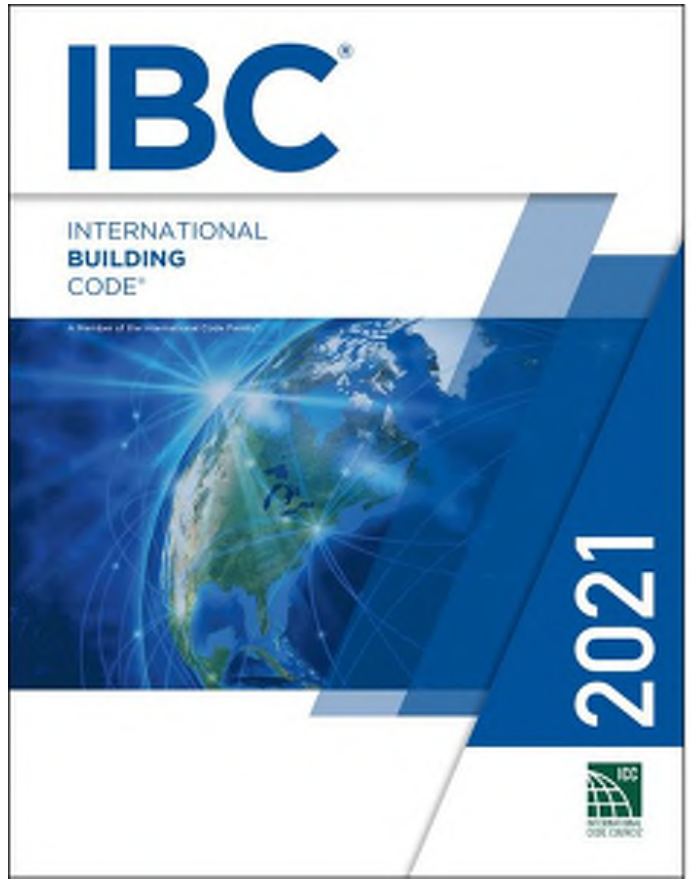
For unit to unit or unit to public or service areas:

Mi STC f if field e ed

- Walls, Partitions, and Floor/Ceiling Assemblies

Mi IIC f if field e ed f

- Floor/Ceiling Assemblies



Acoustical Design

TABLE 1:

Examples of Acoustically-Tested Mass Timber Panels

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

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

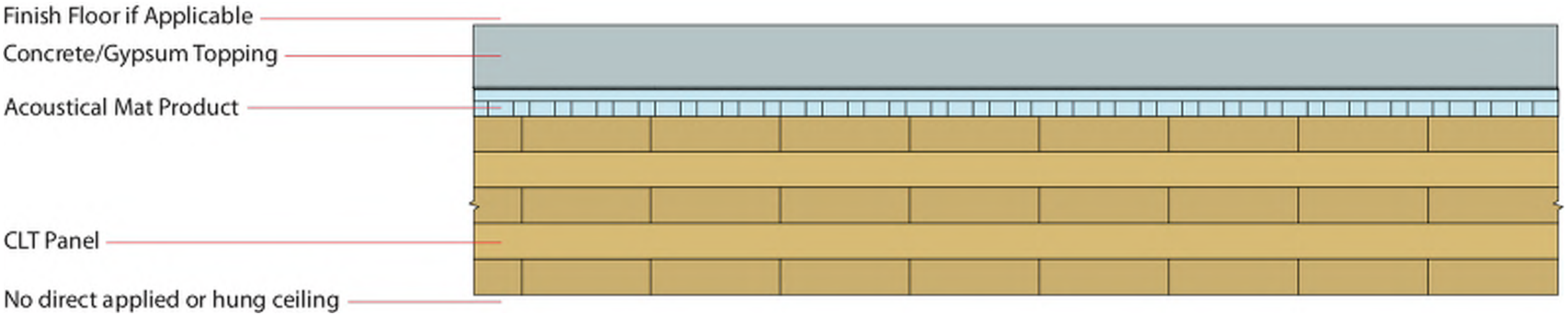
Acoustics & Sound Control

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

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


Image credit: Christian Columbres

Acoustics & Sound Control



Acoustical Design

- https://www.woodworks.org/mass-timber-fire-acoustic-database/

< Back to Mass Timber Fire & Acoustic Database

Assembly Type

- Floor/Roof 532
- Wall 147

Application Type

- CLT/Concrete Composite 7
- Concealed Ceiling 201
- Concrete/Gypsum Topping 138
- Other 108
- Raised Access Floor or Wood Sleepers 78

Mass Timber Panel

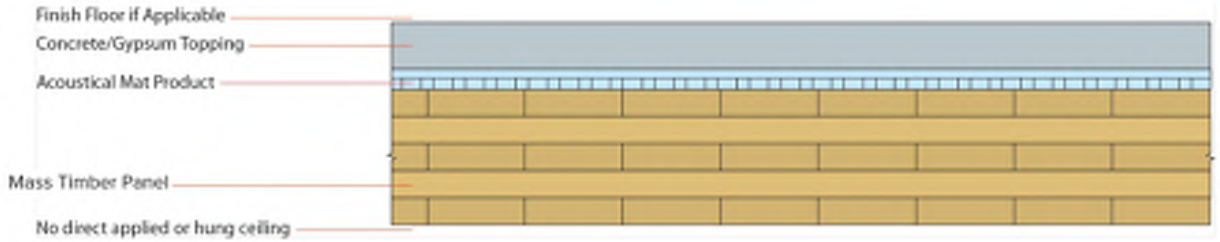
- CLT 507
- CLT (SCL) 56
- NLT 72
- DLT 22
- GLT 4
- T&G 15
- Other 3

Number of Layers

- 1-3 112
- 4-5 367
- 6-7 5
- 8+

el Thickness

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



This illustration shows typical applications and construction for the assemblies listed below. See tested assembly for specific construction materials, connections, required dimensions, and assembly requirements.

Mass Timber Panel	Acoustical Product Between MT Panel and Topping	Topping	Finish Floor	Sound Rating	Impact Rating	Method of Compliance
5-layer 6.89" CLT	Sam-N75 Supreme, 23/32"	2" Levelrock® Brand 2500	Bare Gypsum	60 STC	50 IIC	USG / Intertek Report # R5008.01 -113-11-R0 Contact Product Manufacturer for Additional Information
5-layer 6.89" CLT	Sam-N75 Supreme, 23/32"	2" Levelrock® Brand 2500	2mm, LVT	59 STC	52 IIC	USG / Intertek Report # R5008.02 -113-11-R0 Contact Product Manufacturer for Additional Information
5-layer 6.89" CLT	Sam-N75 Supreme, 23/32"	2" Levelrock® Brand 2500	2mm, LVT with 2mm Topical Mat	59 STC	53 IIC	USG / Intertek Report # R5008.03-113-11-R0 Contact Product Manufacturer for Additional Information
5-layer 6.89" CLT	Sam-N75 Supreme, 23/32"	2" Levelrock® Brand 2500	2mm, LVT with 5mm Topical Mat	59 STC	55 IIC	USG / Intertek Report # R5008.04-113-11-R0 Contact Product Manufacturer for Additional Information
5-layer 6.89" CLT	Sam-N75 Supreme, 23/32"	2" Levelrock® Brand 2500	4.4mm, LVT with Integrated Pad	58 STC	53 IIC	USG / Intertek Report # R5008.07 -113-11-R0 Contact Product Manufacturer for Additional Information

Considerations for Lateral Systems

P e c i i e C de C m lia ce

- ☑ Concrete Shear Walls
- ☑ Steel Braced Frames
- ☑ Light Frame Wood Shear Walls (65 ft max*)
- ☑ Cold-Formed Steel Shear Walls (65 ft max*)
- ☑ CLT Platform Shear Walls (65 ft max*)
- ☒ CLT Rocking Walls

2021 SDPWS, ASCE 7-22

Currently in development!

**in high seismic zones*

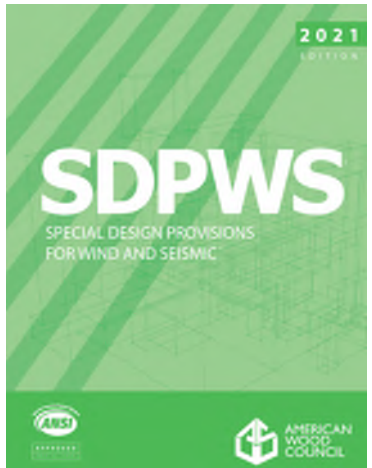
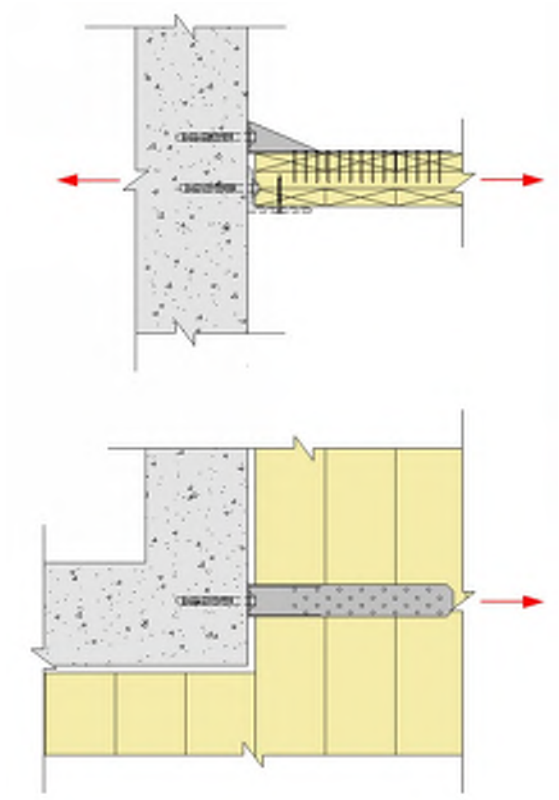


Photo: WoodWorks

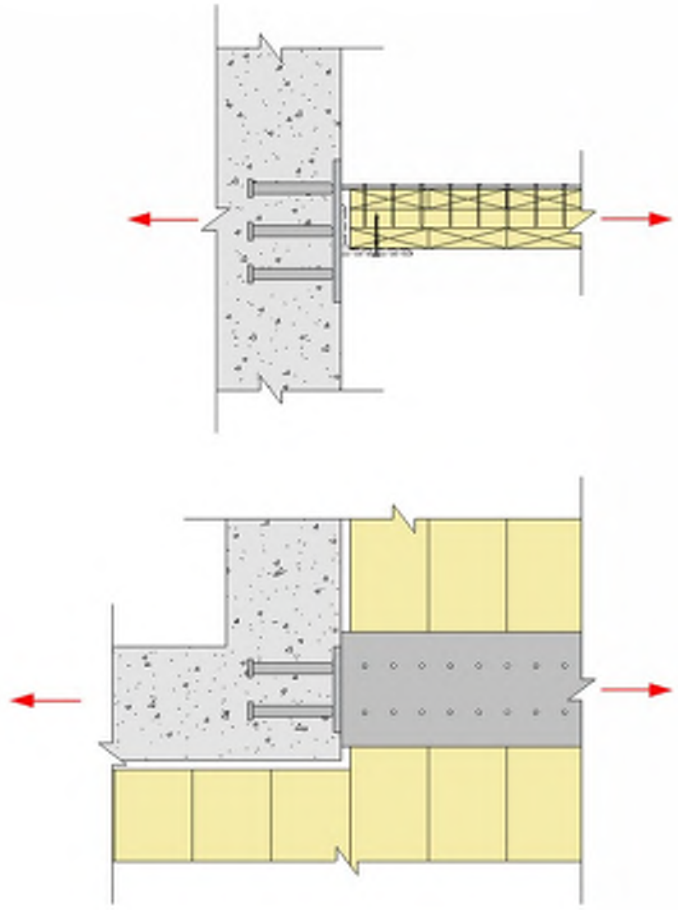
Considerations for Lateral Systems

Connections to concrete core

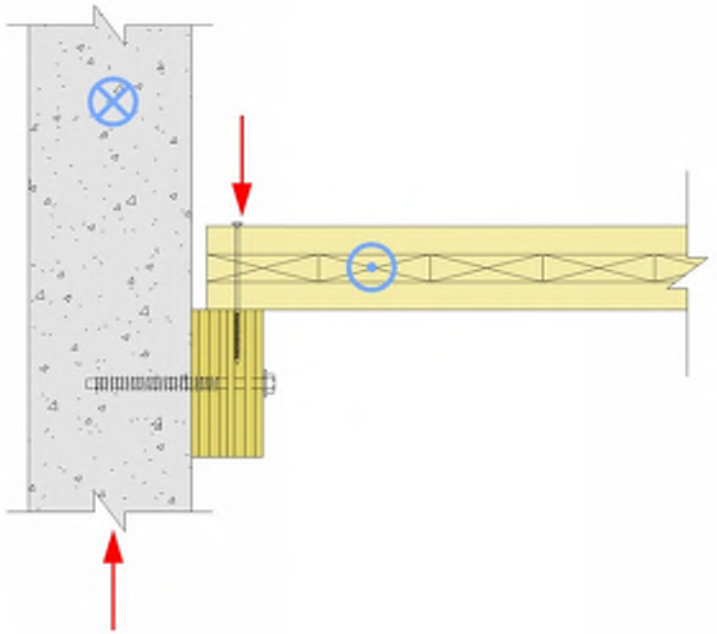
- Tolerances & adjustability
- Drag/collector forces



PLAN VIEW



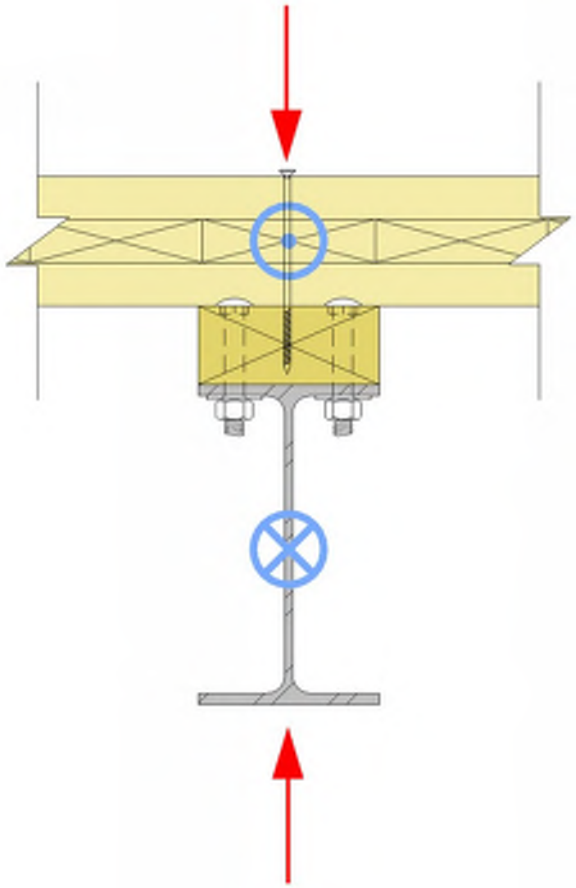
PLAN VIEW

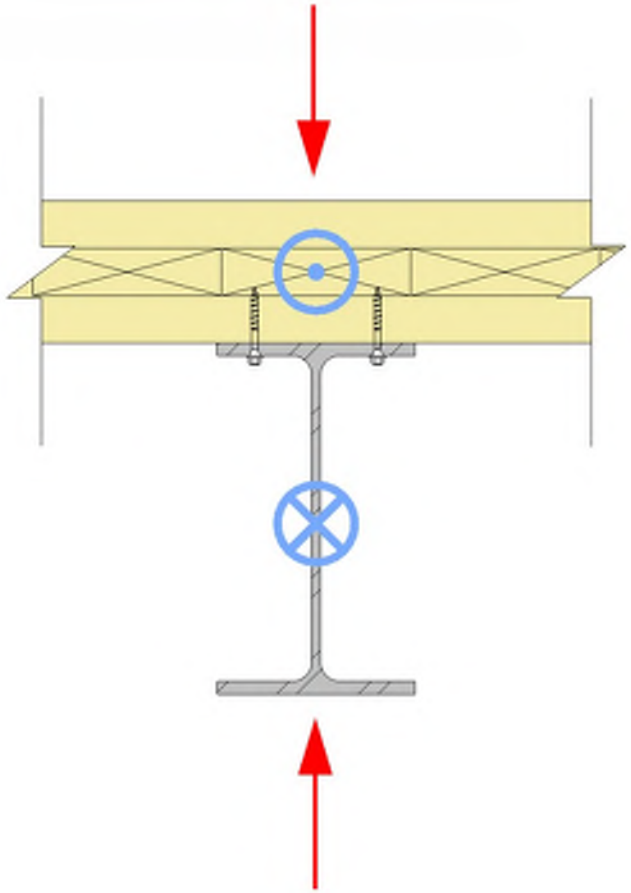


Considerations for Lateral Systems

Connections to steel frame

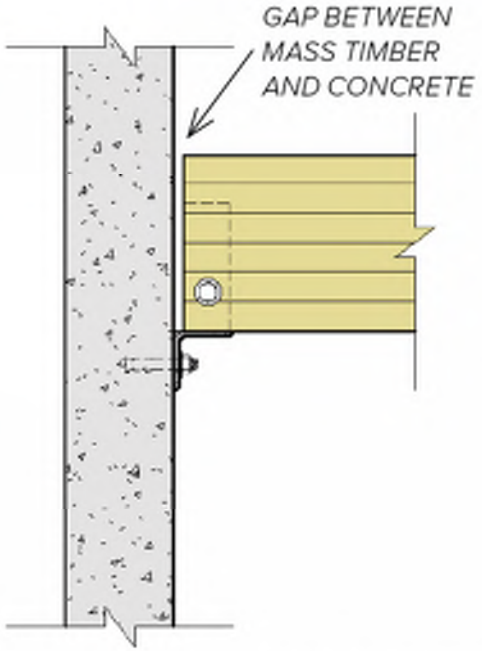
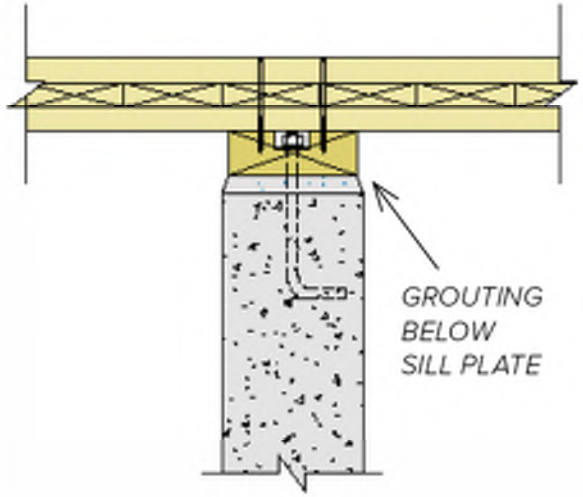
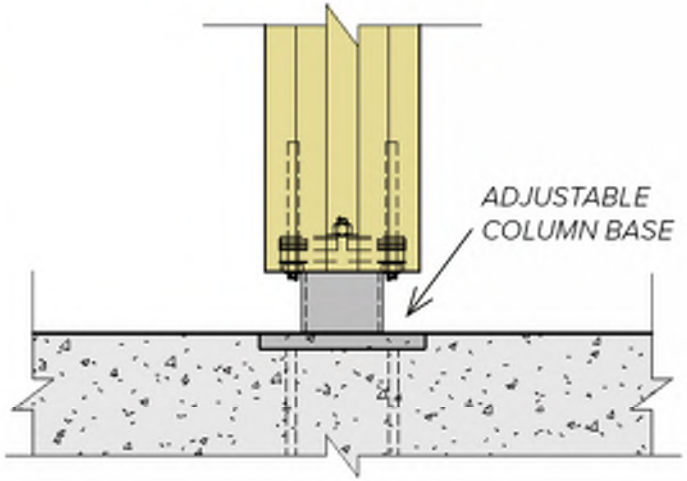
- Tolerances & adjustability
- Ease of installation





Photos: Marcus Kauffmann, ODF

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

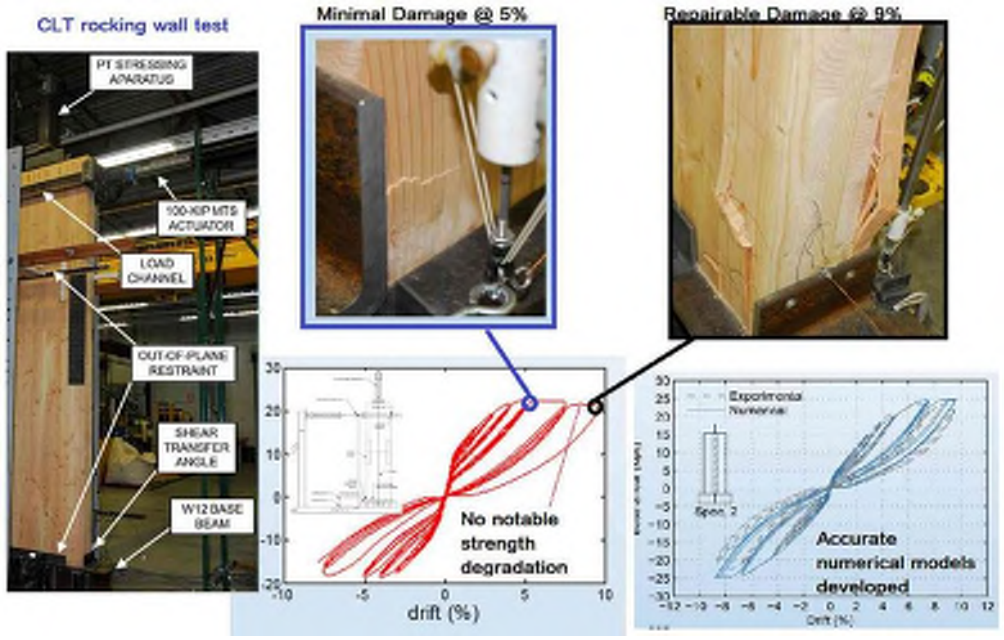
Considerations for Lateral Systems

Wood-frame Shearwalls:

- Code compliant seismic system
- Standard of construction practice well known
- Limited to 65 ft shearwall height (can be on top of a podium)

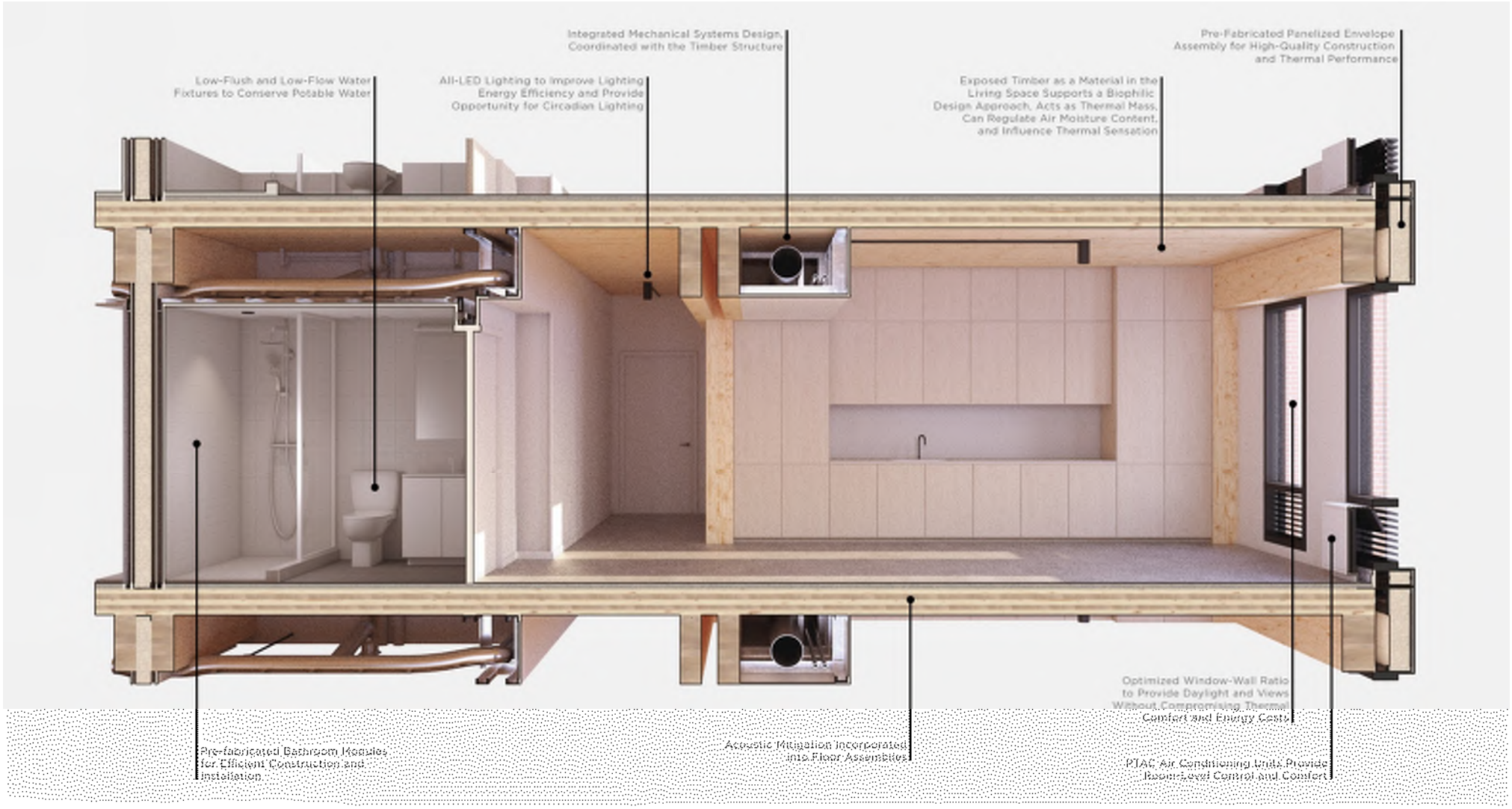
Credit: Jeremy Bittermann & Kaiser + Path

Lateral System Options – CLT Rocking Shear Walls



Source: S. PEI et al. http://nheritallwood.mines.edu/

MEP Systems, Routing and Integration



INTEGRATED SYSTEMS

Credit: John Klein, Generate Architecture

The Tallhouse building system prioritizes the integration of design, engineering, and construction. This results in a high performance building finely tuned to meet energy, comfort, acoustic, and design criteria that has been vetted by constructability experts to ensure fast, efficient production.

Utilizing Pre-Fabricated Facade Panels and Bathroom Modules that are manufactured off-site in factories allows for reducing construction time on-site, higher quality control practices, and safer labor conditions for construction workers. Efficient routing of duct-work conserves material and associated embodied carbon, allowing more exposed timber all while providing the air quality needed for healthy living. Water conserving fixtures reduce potable water use as a precious resource, while maintaining reliable performance.

E LENOX BOSTON MA

STORIES

FT Pa i e H e M l i Famil

Credit: H+O Structural Engineering

E LENOX BOSTON MA

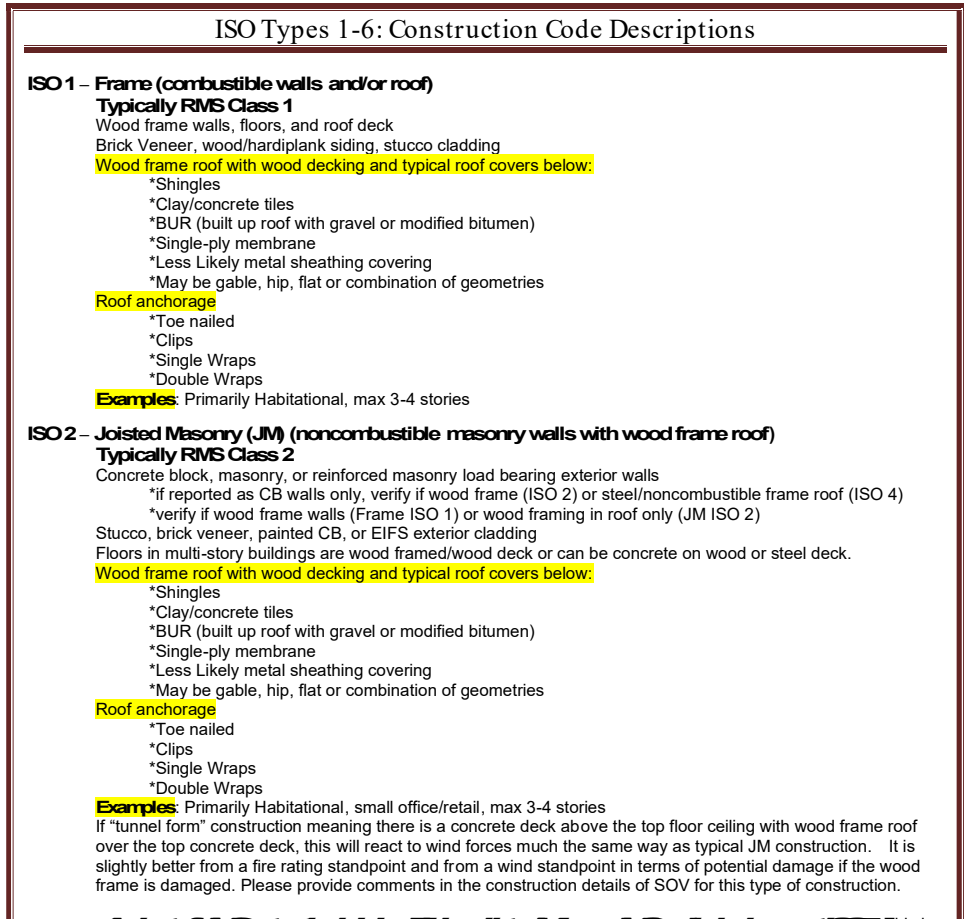
Credit: H + O Structural Engineering

Insurance and Mass Timber

Insurance Challenges

What is causing the challenges with insurance for mass timber projects?

- Insurance industry volatility & hard market
- Lack of loss data
- ISO building classifications (none specific to mass timber)
- Variation of mass timber knowledge among insurance industry



ISO Types 1-6: Construction Code Descriptions

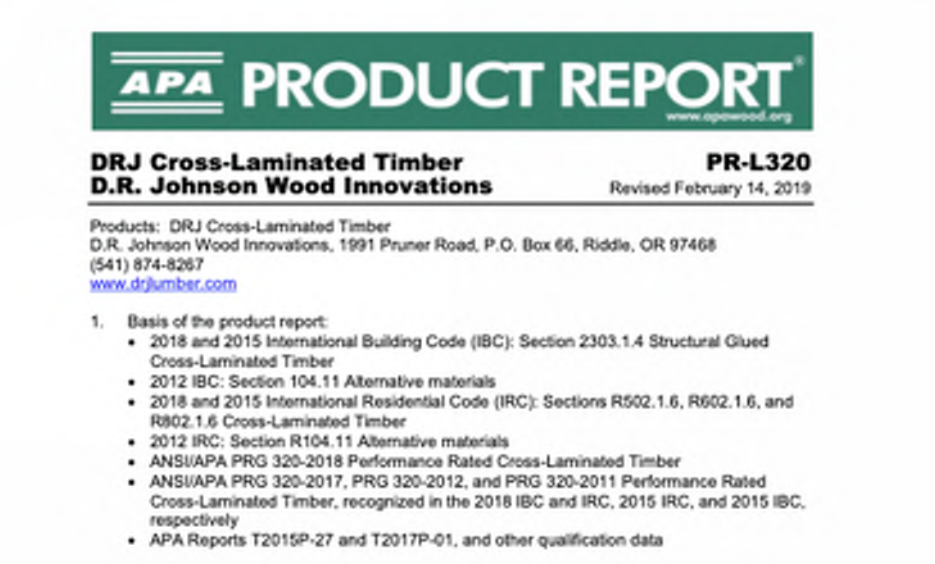
ISO 1 – Frame (combustible walls and/or roof)
Typically RMS Class 1
Wood frame walls, floors, and roof deck
Brick Veneer, wood/hardiplank siding, stucco cladding
Wood frame roof with wood decking and typical roof covers below:
*Shingles
*Clay/concrete tiles
*BUR (built up roof with gravel or modified bitumen)
*Single-ply membrane
*Less Likely metal sheathing covering
*May be gable, hip, flat or combination of geometries
Roof anchorage
*Toe nailed
*Clips
*Single Wraps
*Double Wraps
Examples: Primarily Habitational, max 3-4 stories

ISO 2 – Joisted Masonry (JM) (noncombustible masonry walls with wood frame roof)
Typically RMS Class 2
Concrete block, masonry, or reinforced masonry load bearing exterior walls
*if reported as CB walls only, verify if wood frame (ISO 2) or steel/noncombustible frame roof (ISO 4)
*verify if wood frame walls (Frame ISO 1) or wood framing in roof only (JM ISO 2)
Stucco, brick veneer, painted CB, or EIFS exterior cladding
Floors in multi-story buildings are wood framed/wood deck or can be concrete on wood or steel deck.
Wood frame roof with wood decking and typical roof covers below:
*Shingles
*Clay/concrete tiles
*BUR (built up roof with gravel or modified bitumen)
*Single-ply membrane
*Less Likely metal sheathing covering
*May be gable, hip, flat or combination of geometries
Roof anchorage
*Toe nailed
*Clips
*Single Wraps
*Double Wraps
Examples: Primarily Habitational, small office/retail, max 3-4 stories
If "tunnel form" construction meaning there is a concrete deck above the top floor ceiling with wood frame roof over the top concrete deck, this will react to wind forces much the same way as typical JM construction. It is slightly better from a fire rating standpoint and from a wind standpoint in terms of potential damage if the wood frame is damaged. Please provide comments in the construction details of SOV for this type of construction.

Insurance Perspective on Mass Timber

How do we address the perceived unknowns?

- Demonstrate extensive testing, research and use
- Provide clarification on commonly misunderstood topics
- Highlight building code recognition and approvals
- Reference product reports, evaluations and 3rd party verifications
- **Ge e a e jec ecific mi iga i a egie**



APA PRODUCT REPORT

DRJ Cross-Laminated Timber **PR-L320**
D.R. Johnson Wood Innovations Revised February 14, 2019

Products: DRJ Cross-Laminated Timber
D.R. Johnson Wood Innovations, 1991 Pruner Road, P.O. Box 66, Riddle, OR 97468
(541) 874-8267
www.drjlumber.com

1. Basis of the product report:
   - 2018 and 2015 International Building Code (IBC): Section 2303.1.4 Structural Glued Cross-Laminated Timber
   - 2012 IBC: Section 104.11 Alternative materials
   - 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 320-2018 Performance Rated Cross-Laminated Timber
   - ANSI/APA PRG 320-2017, PRG 320-2012, and PRG 320-2011 Performance Rated Cross-Laminated Timber, recognized in the 2018 IBC and IRC, 2015 IRC, and 2015 IBC, respectively
   - APA Reports T2015P-27 and T2017P-01, and other qualification data

Photo Credit: US Forest Products Laboratory

Mass Timber Testing and Research

- Mass timber has undergone extensive fire testing and evaluation. Elements, assemblies, connections, penetrations, compartments & more

Photo: AWC/FPInnovations

Photo: LendLease

Credit: ARUP

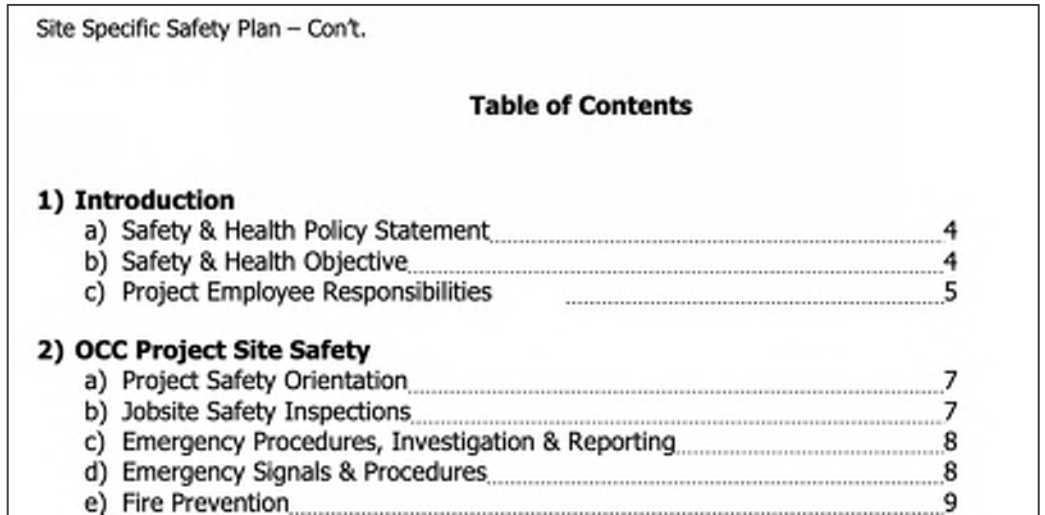
Photo: SLB/ARUP

Mass Timber Project Risk Mitigation

- Each project should evaluate its specific conditions and constraints and create a project-specific risk mitigation plan that addresses items such as:
  - Construction phase moisture protection
  - Long term moisture protection
  - Construction site fire safety & other safety measures
  - Construction schedule impacts

Sample Safety Plan

Address & Location

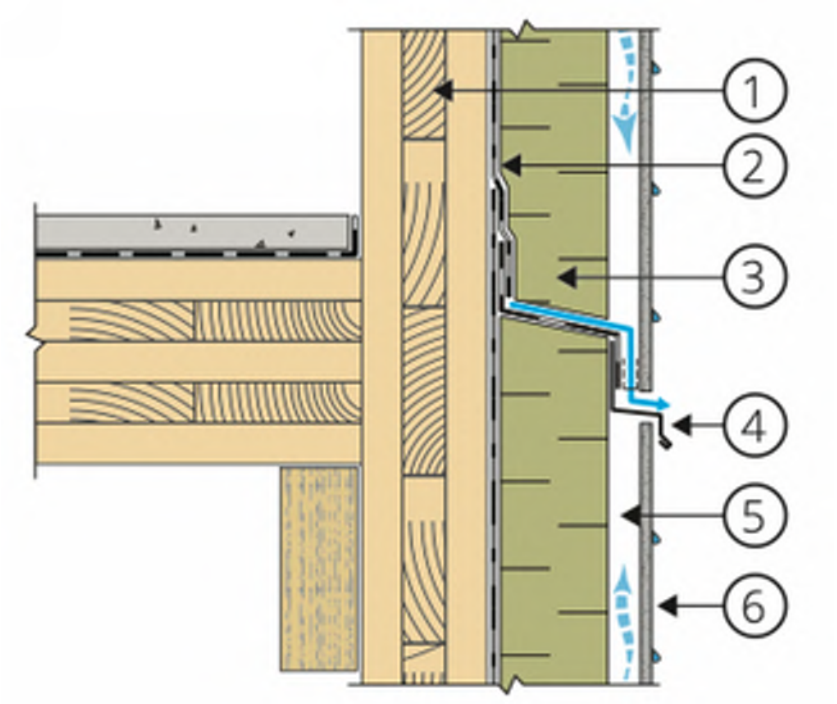


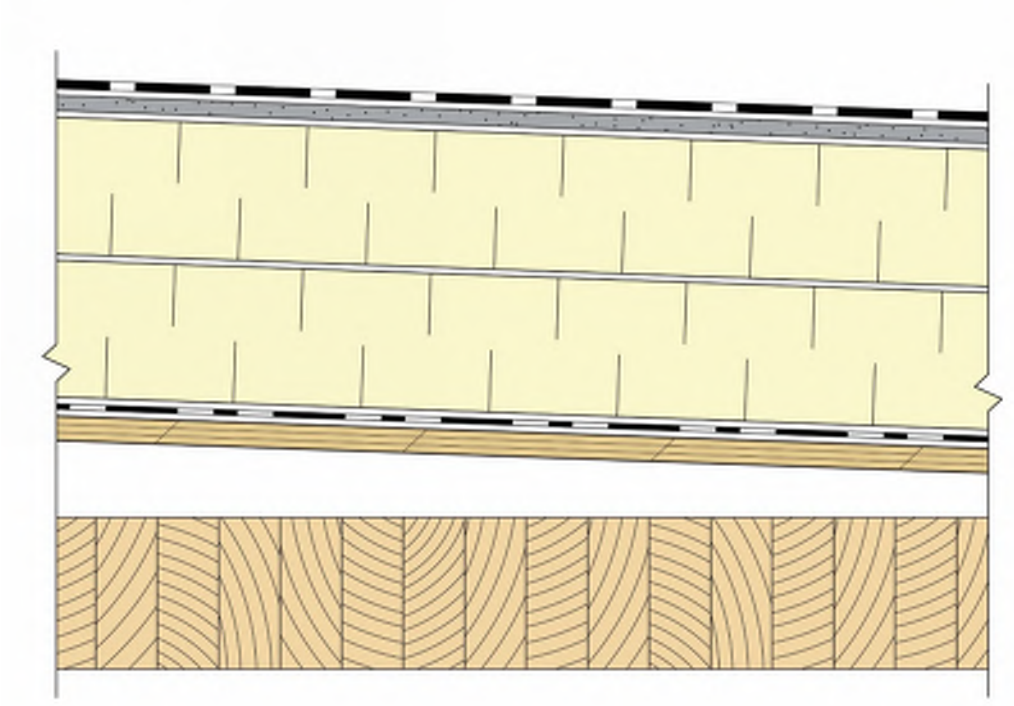
Site Specific Safety Plan – Con't.

Table of Contents

Mass Timber Project Risk Mitigation

- Long term moisture protection achieved through good building enclosure assemblies and details
- Enclosure installation as soon as possible also aids in construction phase moisture protection of interior elements

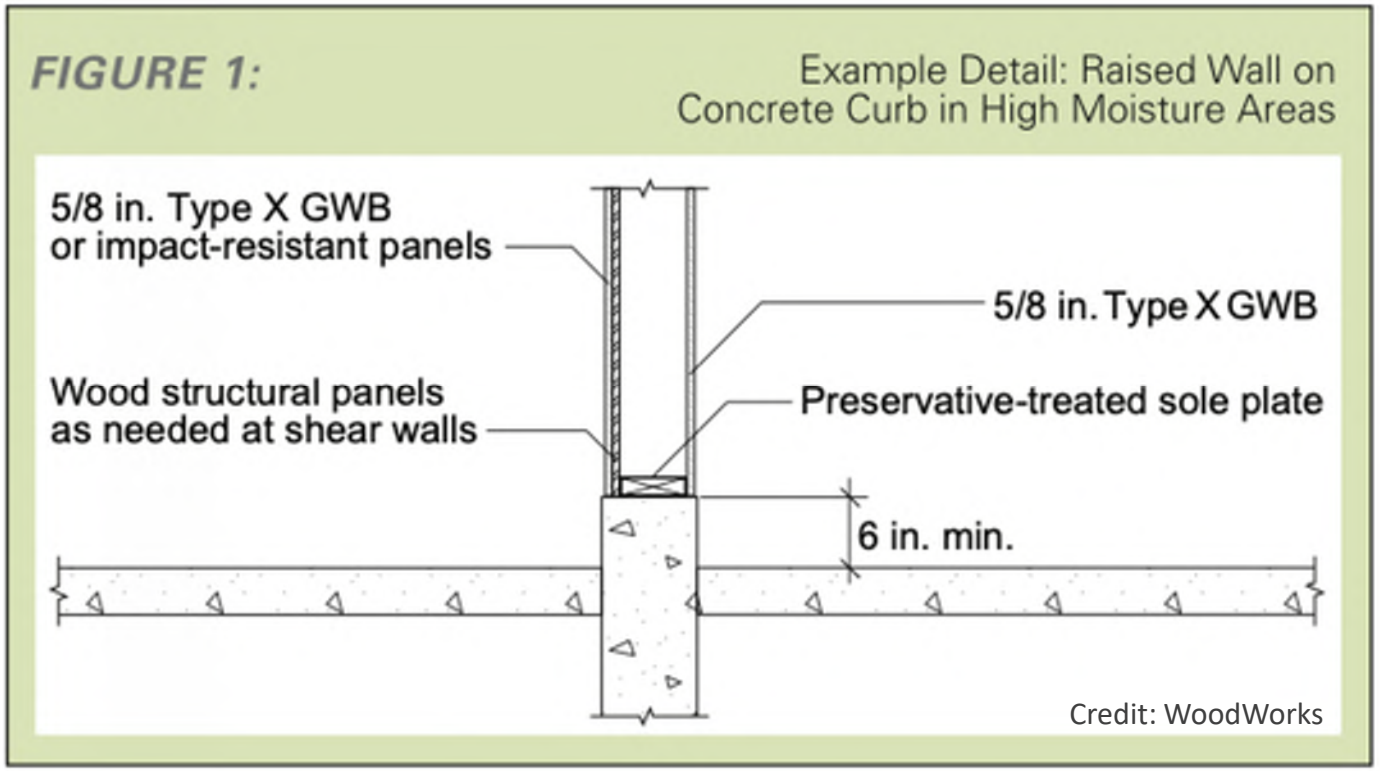




Photos: RDH Building Science

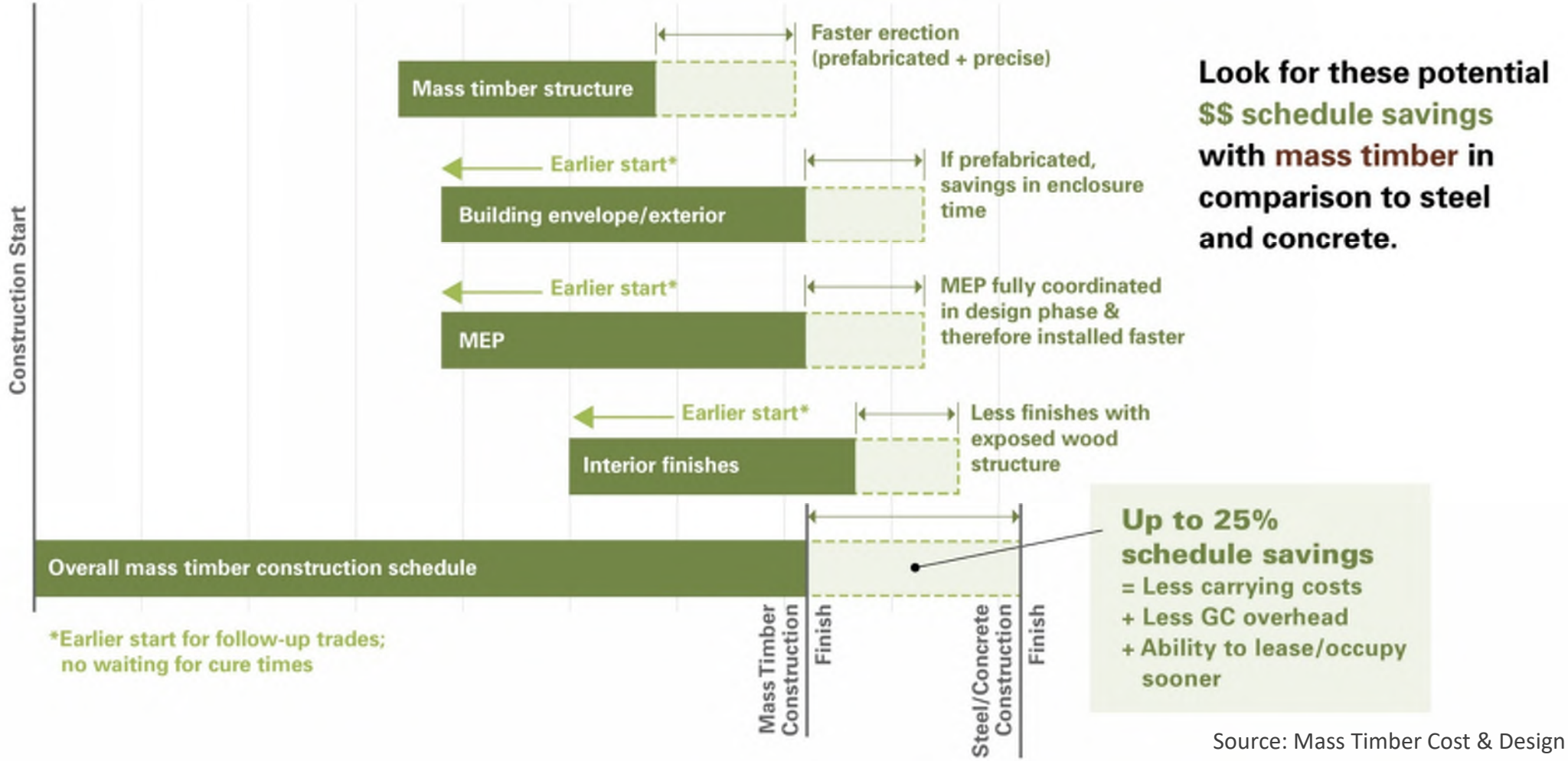
Mass Timber Project Risk Mitigation

- Other moisture protection strategies can be employed for areas more susceptabe to moisture infiltration, i.e. in bathrooms & kitchens
  - Floor drains, curbs, standoff bases



Mass Timber Project Risk Mitigation

- Compressed construction schedule impacts



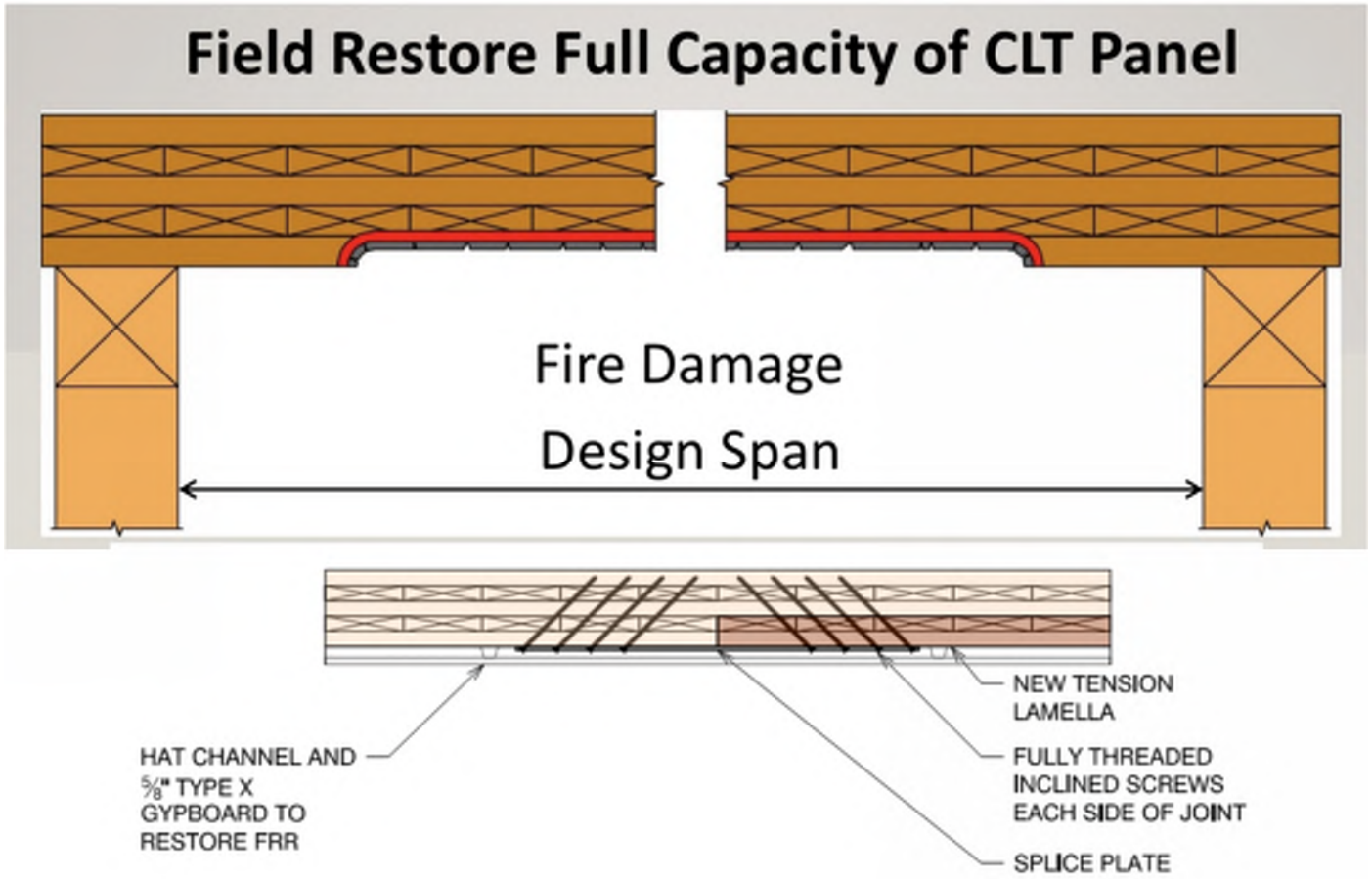
Source: Mass Timber Cost & Design Optimization, WoodWorks

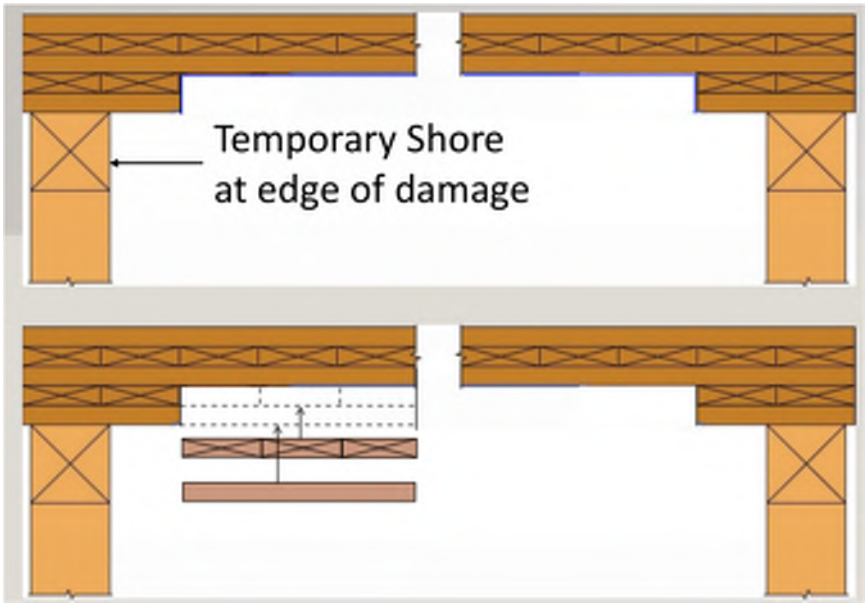
Safety

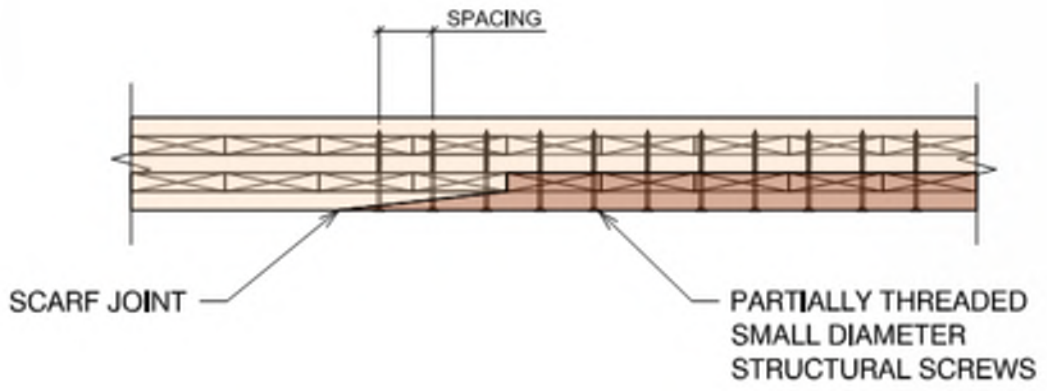
Shorter On-Site Schedule
Fewer On-Site Material Stockpiles

Mass Timber Project Risk Mitigation

- Post-fire repair strategies, depends on extent of damage, fire-resistance requirements



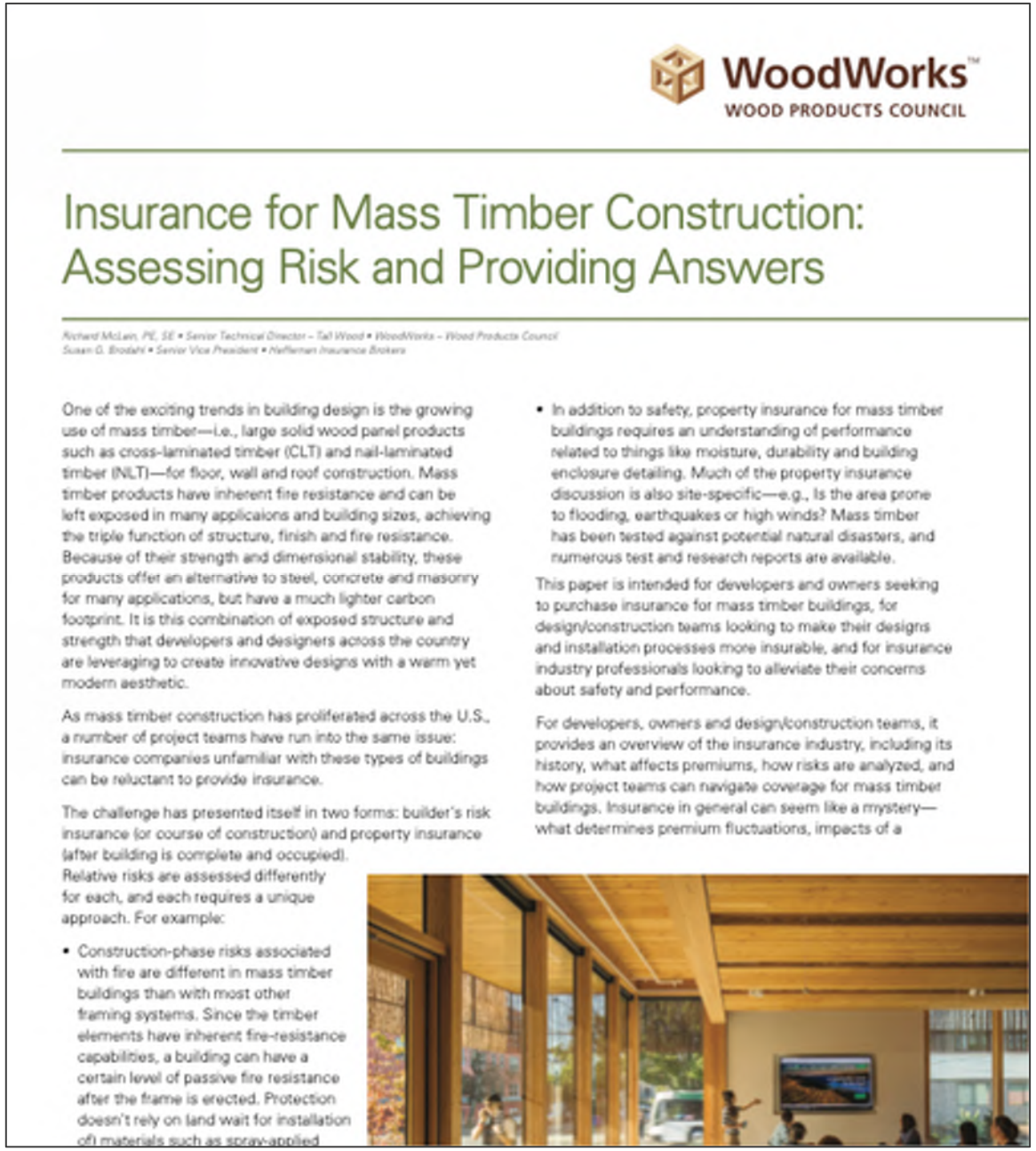




https://cdn-web.iccsafe.org/wp-content/uploads/Post-fire-restoration-of-CLT.pdf

Mass Timber Insurance

- Engage with brokers early – provide project specific risk mitigation strategies
- Utilize WoodWorks free resources:
- https://www.woodworks.org/learn/mass-timber-clt/mass-timber-building-insurance/
- https://www.woodworks.org/resources/mass-timber-project-questionnaire-for-builders-risk-insurance/



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WOOD PRODUCTS COUNCIL

Insurance for Mass Timber Construction: Assessing Risk and Providing Answers

Richard McLain, PE, SE • Senior Technical Director – Tall Wood • WoodWorks – Wood Products Council
Susan G. Brostek • Senior Vice President • Heffernan Insurance Brokers

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

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

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

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

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

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

Low- and Mid-Rise Multi-Family

Credit: ABX Creative and Engberg Anderson

HYBRID LIGHT-FRAME + MASS TIMBER

THE KIND PROJECT SACRAMENTO CA

CANYONS PORTLAND OR

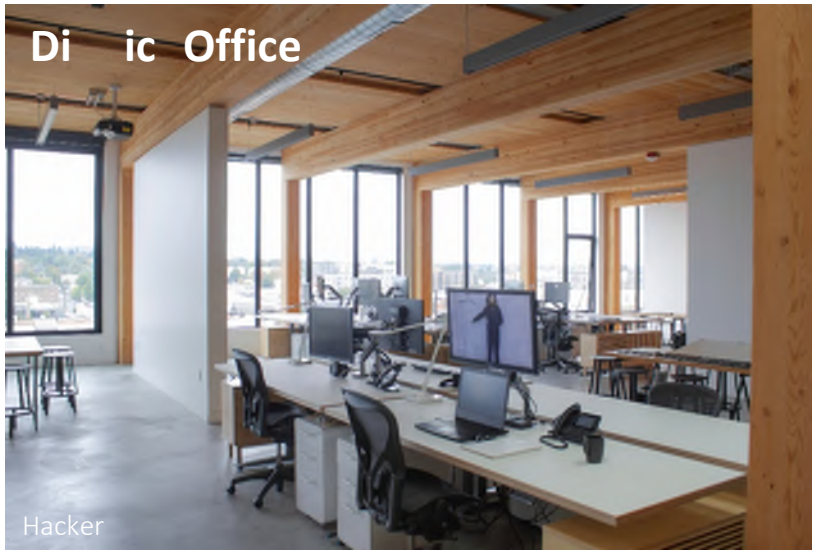
Credit: Jeremy Bittermann & Kaiser + Path

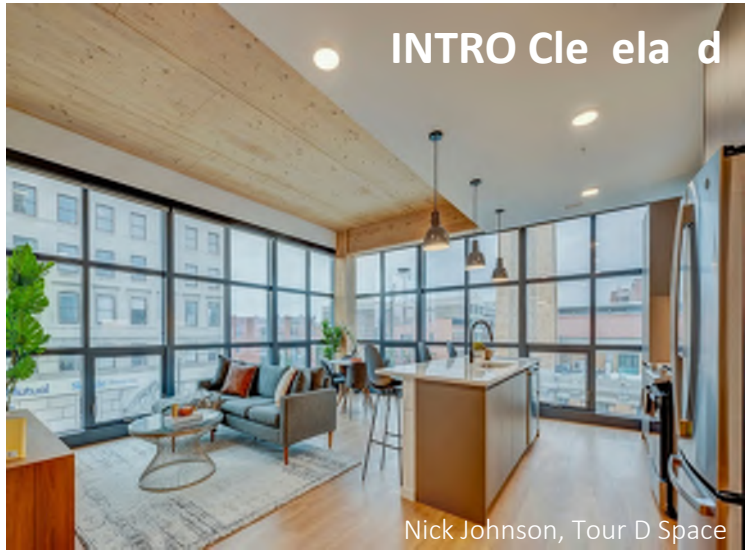
Mass Timber Business Case Studies: Value Creation Analysis

De el me O e ie
- Property Information
- Product Strategy
- Investment Highlights

Q ali a i e Di c i
- Challenges
- Lessons Learned
- Successes

Q a i a i e O e ie
- Development Timeline
- Costs
- Rents
- Lease up





C m a a i e Re A al i

	Ma ke	P F ma	Reali ed
Yield on cost	6.25%	7.00%	7.35%
Cap rate	4.75%	4.50%	TBD
Value/rentable SF	$550/ RSF	$717/ RSF	TBD ($800+/ RSF)
Leverage	65%	65%	N/A

WOODWORKS WOOD PRODUCTS COUNCIL

CONRAD INVESTMENT MANAGEMENT

Multifamily | Office | Industrial | Student Housing

Initial Findings: Residential

Re ide e d l k feel

- Aesthetics seem to be broadly appealing; wider target markets = better market demand
- Robust pre-leasing = lower costs & risks
  - More income sooner = lowers operating & interest budgets
  - Faster to stabilization = faster to refinance
- Tangible distinction = mitigates future supply risk
- Tangible realization of desired brand identities

Quantitative Overview

C		
Total project cost	$32,000,000	
	$457,143 / unit	
Land:	$3,660,000	@ appraised value

	Ma ke S a da d	P F ma	Reali ed
Construction costs (normalized wo/COVID)	$186 (light-frame)	$192 / GSF	$186 / GSF
Construction costs (w/COVID delays + adds)	N/A	N/A	$210 / GSF

NOI			
A a me	Ma ke	Reali ed	
Rental rates (avg. of renovation + new addition)			
Studio	$1,500	$1,722	15% higher
1-BR	$2,000	$2,924	46% higher
2-BR	$2,500	$3,473	39% higher
Occupancy after 13 months (stabilized)	80%	85%	Normal COVID lease-up

Pa ki g Re e e	Ma ke	P F ma	Reali ed
In addition to lease	$125	$130	$135

Re ail	Ma ke	P F ma	Reali ed
Retail rental rates	$32 / RSF/YR	$32/ RSF/YR	$0 / COVID
Rent type (e.g., NNN)	NNN	NNN	N/A
Tenant improvement allowance	$30/SF	$30/SF	N/A
Occupancy after 12 months	90%	90%	0%

Interview with listing retail broker confirmed substantial pre-leasing occurred (60% of space).
COVID 19 pandemic wiped out retail market in latter half of 2020 & all of 2021; forced all retail leased to abandon.
Recent activity is positive with five local, design-oriented tenants proceeding to take majority of space.

**Market standard costs refer to normal cost to build for subject's use, irrespective of structural approach*

Re Pe f ma ce a f Oc be			
Me ic	Ma ke	P F ma	Reali ed
Yield on cost – untrended	5.5%	5.7%	Lower (COVID impact on retail)
Cap rate (mkt vs. appraisal subject conclusion)	4.5%	4.5%	Not yet known
Value per unit	$435,000	$500,000	Not yet known
Leverage	60%	60%	Equal

Timeli e		
E e	Da e	C e C mme
Date of conception (first dollar spent)	January 2018	
Date underwriting finalized (go/no-go decision)	December 2018	Equal
Date equity capital secured	October 2018	Equal
Permitting duration	11 months	Equal
GMP in place	January 2019	
Construction start	February 27, 2019	
Duration of construction (anticipated without COVID)	11 months	10% faster than normal
Duration of construction (realized w/COVID)	12 months	COVID slowed 1 month
Construction completed	September 2020	
Date stabilized (80% occupancy, NOI, or at pro forma or refinanced)	Not yet stabilized (as of October 2021)	COVID impacted leasing

Premium rents, market rate costs, and faster construction (barring Covid)

THE DUKE AUSTIN TX

Credit: WGI

PROJECT ONE OAKLAND CA

Credit: Gurnet Point

Photo: Casey Dunn

Hotel Magdalena

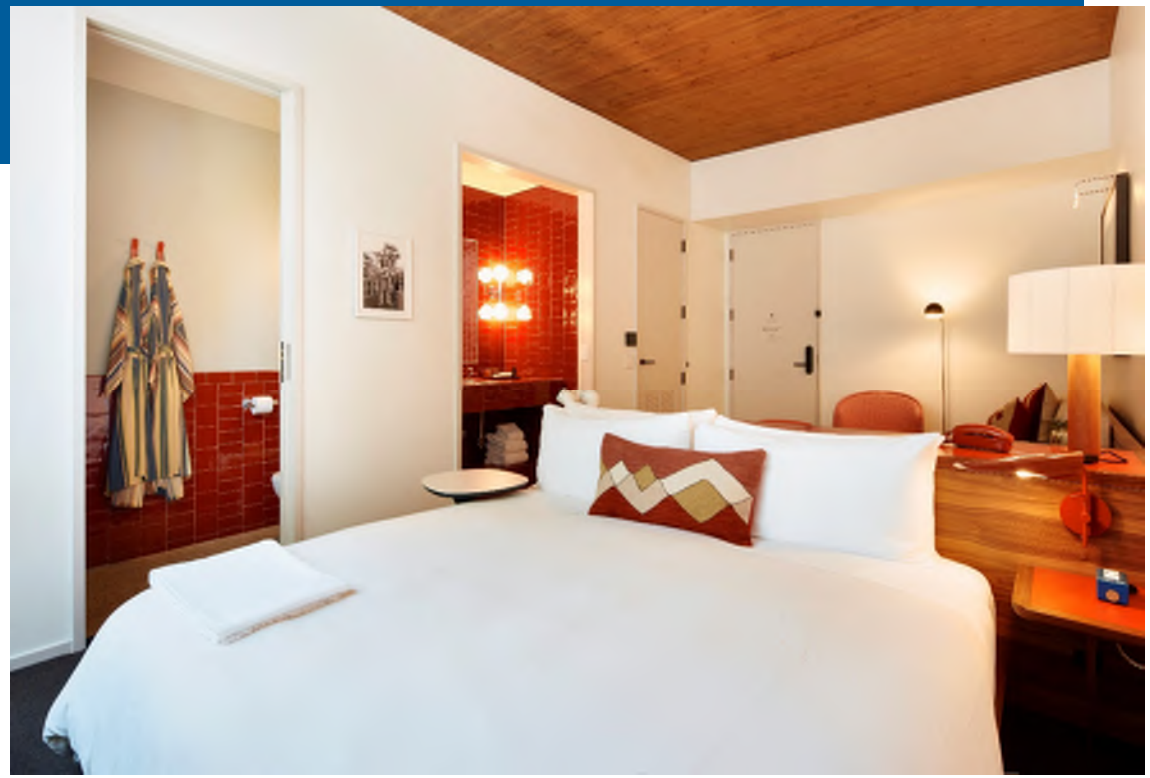
Austin, TX

Building Facts	100,000 sf
	3 buildings: 5, 4, and 3 stories
	Type V-A for MT structures
	Hotel
	Completed 2020
Developer	Bunkhouse Group
Architect	Lake|Flato
Engineer	StructureCraft
General Contractor	MYCON

Hotel Magdalena

Austin, TX

- First Mass Timber boutique hotel in North America
- Exposed wood structure extends to the exterior



Photos: Casey Dunn

Lake|Flato Architects
StructureCraft

Timber Lofts

Milwaukee, WI

68,400 sf, 4 stories

Type III-B

Multi-Family

Completed 2020

WN PROFILE

BUSINESS CASE STUDY

WOOD DESIGN AWARD WINNER

Enberg Anderson Architects
Pierce Engineers
Photo: Enberg Anderson Architects

Timber House

Brooklyn, NY

- 24,000 sf, 6 stories
- Type III-A

Photos: Travis Mark

MESH architectures
Silman

Potential Benefits	Project Goal ✓	Value Add ✓
Fast construction		
Aesthetic Value (Leasing velocity/ premiums) Healthy Building / Biophilia		
Lightweight structure		
Labor shortage solution • small crews • entry level workers		
Just-in-time delivery (ideal for dense urban sites)		
Environmentally friendly (low carbon footprint)		
Healthy forests/ wildfire resiliency & support rural economies		

NIR Center | Photo: Hennebery Eddy Architects | Architect: Hennebery Eddy Architects

New Tall Wood Code Provisions: Advanced Fire Design for Exposed Timber

Kate Carrigg, PE

WoodWorks Regional Director

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Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

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

Course Description

The 2021 International Building Code (IBC) includes a series of changes that significantly expand the opportunities for tall timber structures. Three new construction types—Type IV-A, IV-B and IV-C—will allow the use of mass timber or noncombustible materials in buildings up to 18 stories tall. These new types are based on the previous Heavy Timber construction type (renamed Type IV-HT) but with additional fire-resistance ratings and levels of required noncombustible protection. This presentation will take a detailed look at the new code provisions and methods of addressing requirements for fire resistance and exposed timber. Topics will include allowable building sizes, methods of demonstrating fire-resistance ratings, allowances for exposed timber, and more.

Learning Objectives

1. Explore the three new tall wood construction types and discuss related code provisions such as allowable heights and fire-resistance ratings.

2. Discuss code-compliant options for exposing mass timber, where up to 2-hour fire-resistance ratings are required, and demonstrate design methodologies for achieving these ratings.

3. Review timber exposure strategies for IV-B construction, emphasizing code compliance topics such as horizontal separation and exposure area limits.

4. Highlight resources available to designers for fire-resistance design in tall timber structures, emphasizing tested assemblies, allowances for concealed spaces and contributions of noncombustible protection layers.

Outline

- **Tall Wood Introduction**
  - Non-Combustible Protection and Timber Exposure Allowances
  - Fire Safety During Construction
  - Panel Joints, Connections, and Penetrations
  - Allowable Areas

What is Tall Mass Timber?

Projects which exceed the height and/or story limits of the 2018 IBC (or previous versions)

Photo: WoodWorks
Architect/Developer: oWOW

Tall Mass Timber

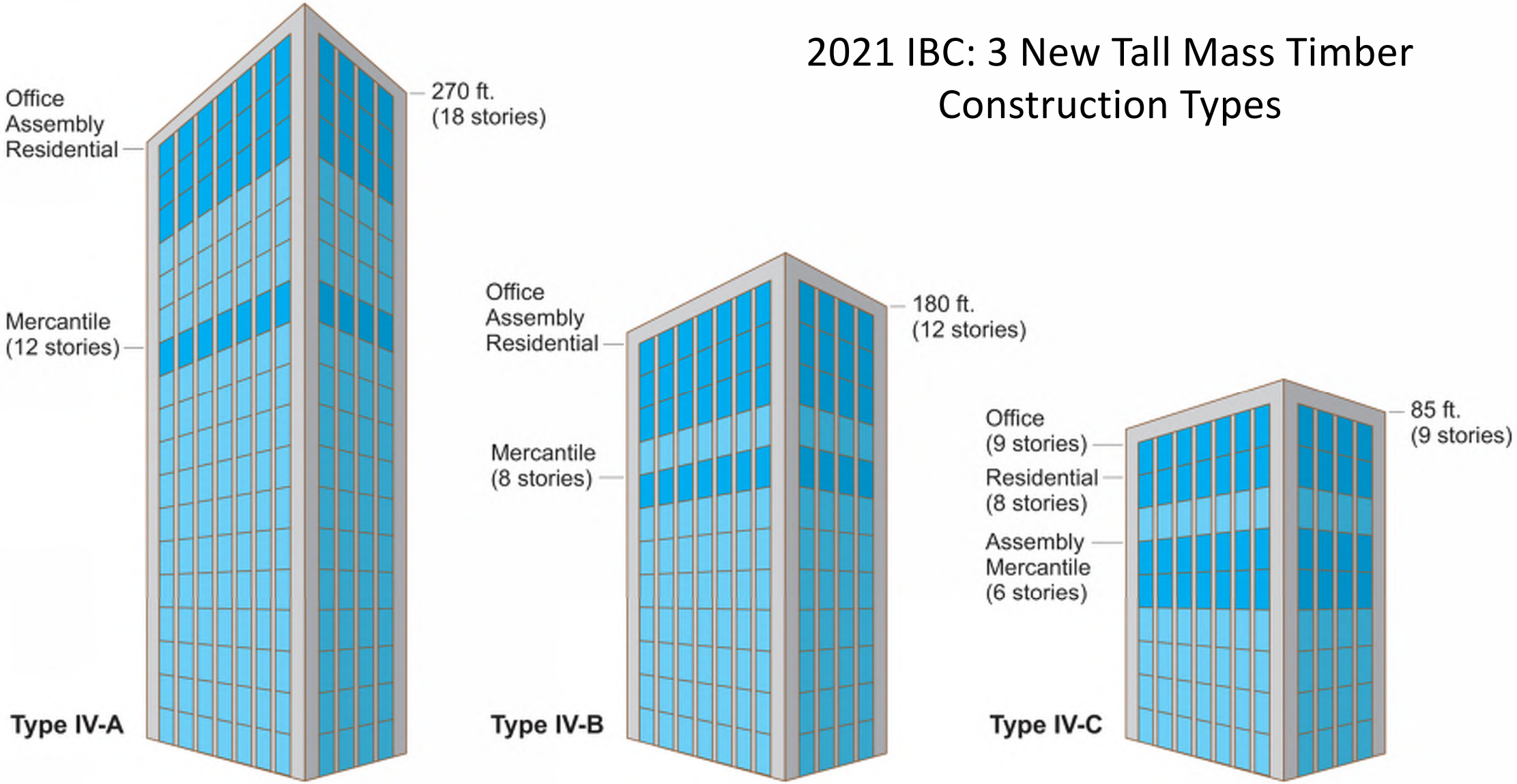
2021 IBC Introduces 3 new tall wood construction types:

- IV-A
- IV-B
- IV-C
- Previous type IV renamed type IV-HT

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B

Tall Mass Timber

2021 IBC: 3 New Tall Mass Timber Construction Types



2015-2018: Building a Code Roadmap

Photos: ICC

2015-2018: Building a Code Roadmap

Photo: Lendlease

2015-2018: Building a Code Roadmap

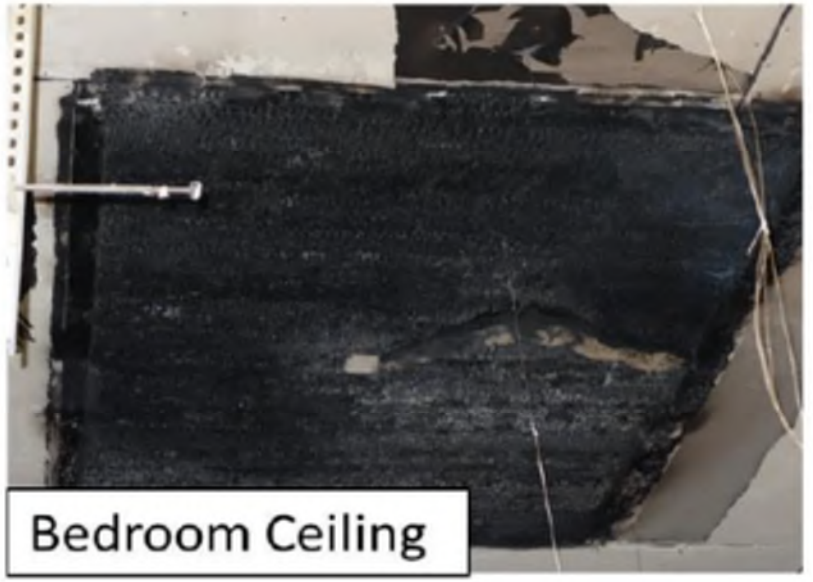

Ignition


Living Room / Kitchen Flashover


Bedroom Flashover


Decay Phase


Living Room Ceiling


Bedroom Ceiling

Photos provided by U.S. Forest Products Laboratory, USDA

Source: AWC

RESEARCH FOUNDATION

RESEARCH FOR THE NFPA MISSION

Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 5 – Experimental Study of Delamination of Cross Laminated (CLT) Timber in Fire

SOUTHWEST RESEARCH INSTITUTE®

6220 CULEBRA ROAD 78238-5166 • P.O. DRAWER 28510 78228-0510 • SAN ANTONIO, TEXAS, USA • (210) 684-5111 • WWW.SWRI.ORG

CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

FIRE TECHNOLOGY DEPARTMENT
WWW.FIRE.SWRI.ORG
FAX (210) 522-3377

DEVELOPMENT OF A FIRE PERFORMANCE ASSESSMENT METHODOLOGY FOR QUALIFYING CROSS-LAMINATED TIMBER ADHESIVES

WFCI

WESTERN FIRE CENTER, INC.

2204 Parrott Way, Kelso, Washington 98626
Phone: 360-423-1400 | Fax: 360-423-5003

Fire Resistance Testing of CLT Floor/Ceiling Assemblies to Establish Contribution of Gypsum Protection

ICC TWB AHC Proposals

Requirements for the new Types of Construction:

- IBC Section 602.4 – Type of Construction (G108-18)
- IBC Section 703.8 – Performance Method for Fire Resistance from Noncombustible Protection (FS5-18)
- IBC Section 722.7 – Prescriptive Fire Resistance from Noncombustible Protection (FS81-18)
- IBC Section 703.9 – Sealants at Edges (FS6-18)
- IBC Section 718.2.1 – Fire and Smoke Protection (FS73-18)
- IBC Section 403.3.2 – High-Rise Sprinkler Water Supply (G28-18)
- IBC Section 701.6 – Owners' Responsibility (F88-18)

  IFC Section 3308.4 – Fire Safety During Construction (F266-18)

Allowable building size limits:

- IBC Table 504.3 – Building Height (G75-18)
- IBC Table 504.4 –Number of Stories (G80-18)
- IBC Table 506.2 – Allowable Area (G84-18)

Housekeeping changes:

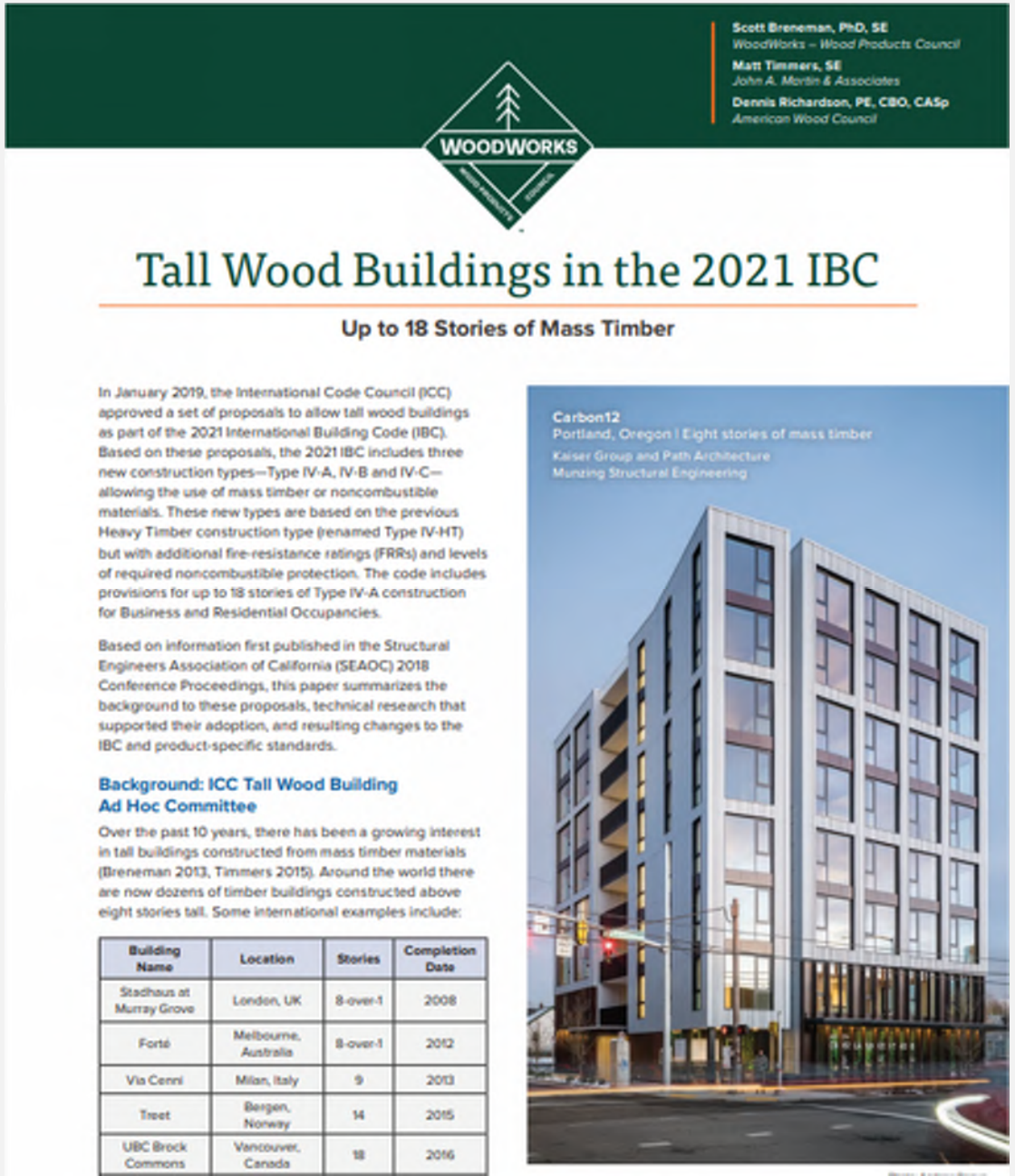
- IBC Section 3102 – Special Construction (G146-18)
- IBC Appendix D – Fire Districts (G152-18)
- IBC Section 508.4 and 509.4 – Fire Barriers (G89-18)

- IBC Table 1705.5.3 Special Inspections (S100-19)
- IBC Section 110.3.5 Connection Protection Inspection (ADM35-19)
- IBC Section 2304.10.1 Connection Fire Resistance Rating (S170-19)

Tall Wood Buildings in the 2021 IBC

Free Resource:

www.woodworks.org



Scott Breneman, PhD, SE
WoodWorks – Wood Products Council
Matt Timmers, SE
John A. Martin & Associates
Dennis Richardson, PE, CBO, CASp
American Wood Council

WOODWORKS

Tall Wood Buildings in the 2021 IBC

Up to 18 Stories of Mass Timber

In January 2019, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (IBC). Based on these proposals, the 2021 IBC includes three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber or noncombustible materials. These new types are based on the previous Heavy Timber construction type (renamed Type IV-HT) but with additional fire-resistance ratings (FRRs) and levels of required noncombustible protection. The code includes provisions for up to 18 stories of Type IV-A construction for Business and Residential Occupancies.

Based on information first published in the Structural Engineers Association of California (SEAOC) 2018 Conference Proceedings, this paper summarizes the background to these proposals, technical research that supported their adoption, and resulting changes to the IBC and product-specific standards.

Background: ICC Tall Wood Building Ad Hoc Committee

Over the past 10 years, there has been a growing interest in tall buildings constructed from mass timber materials (Breneman 2013, Timmers 2015). Around the world there are now dozens of timber buildings constructed above eight stories tall. Some international examples include:

Building Name	Location	Stories	Completion Date
Stadhaus at Murray Grove	London, UK	8-over-1	2008
Forté	Melbourne, Australia	8-over-1	2012
Via Cenni	Milan, Italy	9	2013
Treet	Bergen, Norway	14	2015
UBC Brock Commons	Vancouver, Canada	18	2016

Materials Permitted

602.4 Type IV. Type IV construction is that type of construction in which the building elements are mass timber or noncombustible materials and have fire resistance ratings in accordance with Table 601. Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both and shall be determined in accordance with Section 703.2 or 703.3. The minimum dimensions and permitted materials for building elements shall comply with the provisions of this section and Section 2304.11. Mass timber

Exception: Type IV-HT Construction in accordance with Section 602.4.4.

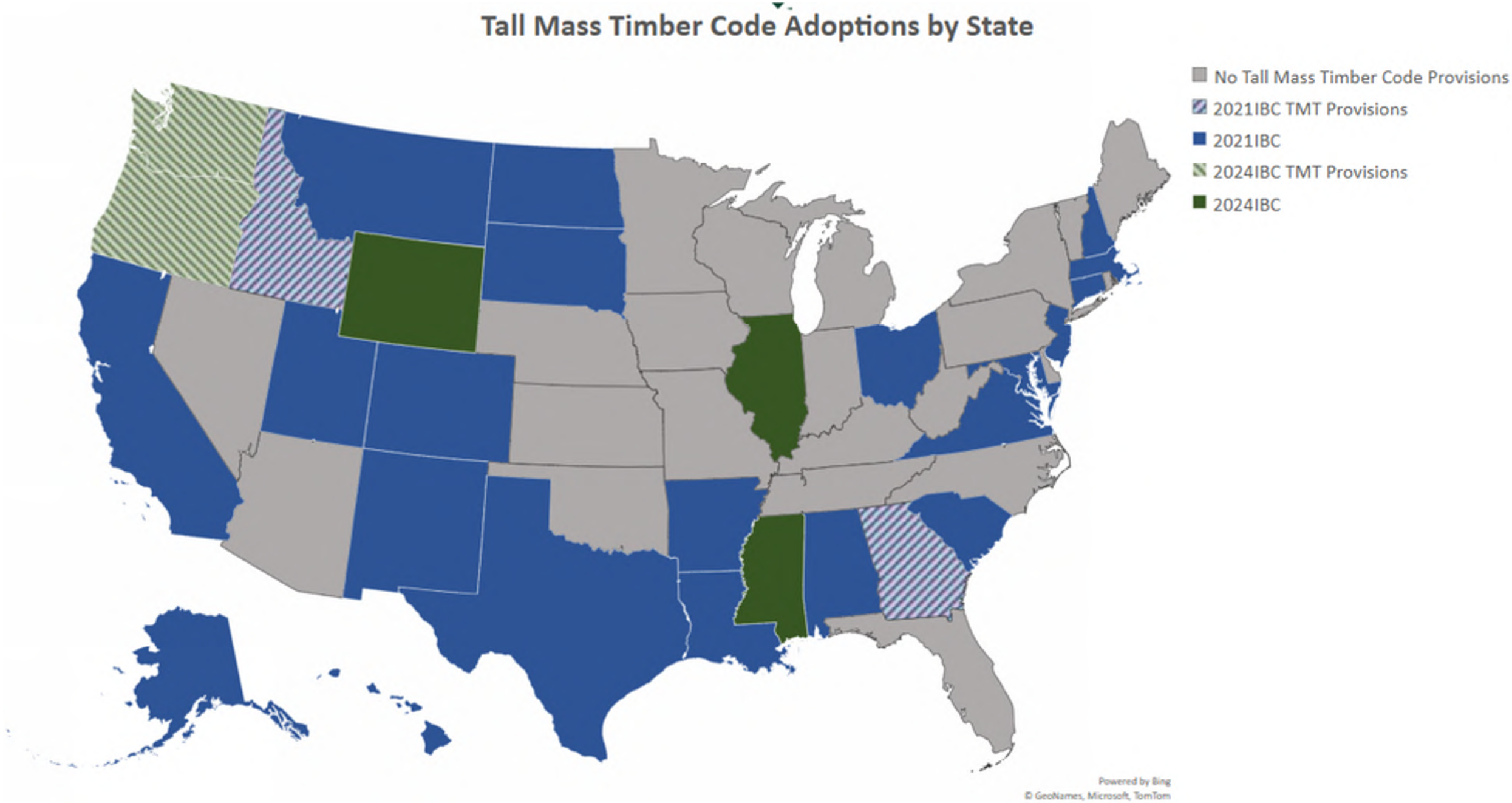
Fire Resistance Ratings

Driven primarily by construction type.

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

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[b,c]	0
Bearing walls												
Exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1½	1	1	HT	1[b,c]	0

Tall Mass Timber Code Adoptions by State



TALL WOOD

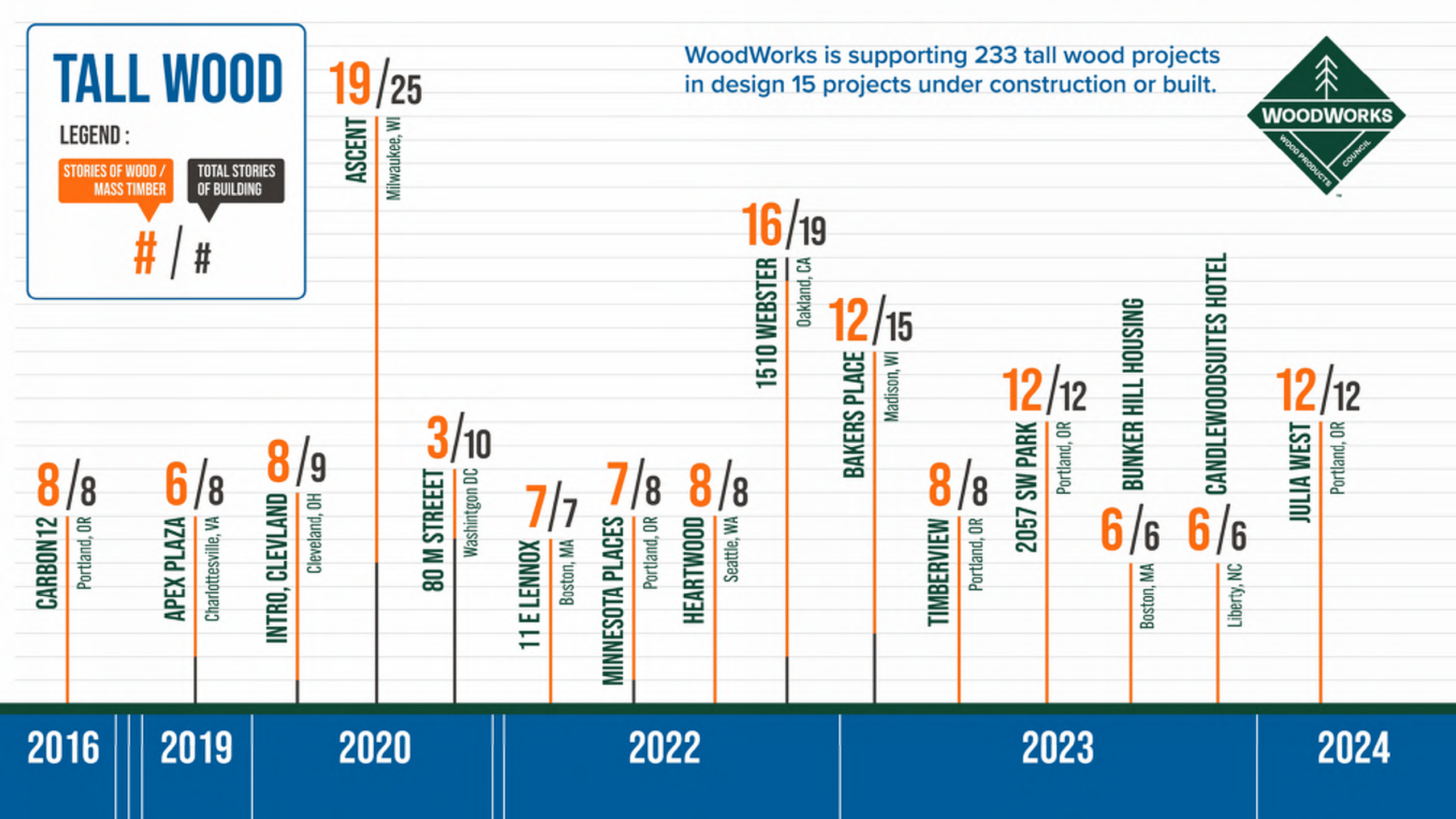
LEGEND :

STORIES OF WOOD / MASS TIMBER

TOTAL STORIES OF BUILDING

/

WoodWorks is supporting 233 tall wood projects in design 15 projects under construction or built.



Ascent

Milwaukee, WI

Korb + Associates Architects
Thronton Tomasetti
Photo: C.D. Smith Construction

Ascent

Milwaukee, WI

493,000 sf, 25 stories total (19 mass timber)

Type IV-HT with code modifications

Multi-Family

Completed 2022

WN PROFILE

BUSINESS CASE STUDY

WOOD DESIGN AWARD WINNER

Korb + Associates Architects
Thronton Tomasetti
Photo: VRX Media Group

Outline

- Tall Wood Introduction
- **Non-Combustible Protection and Timber Exposure Allowances**
- Fire Safety During Construction
- Panel Joints, Connections, and Penetrations
- Allowable Areas

Noncombustible Protection (NC)

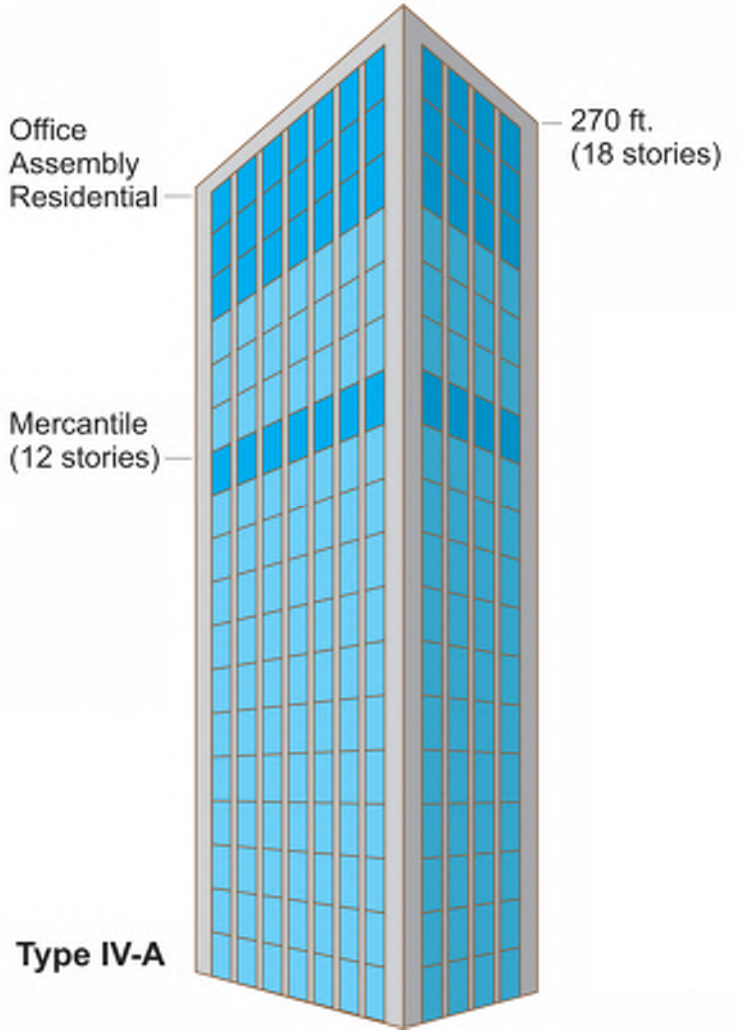
The definition of **“Noncombustible Protection (For Mass Timber)”** was created to address the **passive fire protection** of mass timber.

Credit: WGI

Type IV-A Exposure Limits

100% NC protection on all surfaces of Mass Timber

Photo: Flor Projects



Rendering: oWow

1510 Webster

Oakland, CA

Building Facts	193,290 sf, 18 stories
	16 stories Mass Timber
	Type IV-A
	Mixed Use
	Expected Completion 2024
Developer	oWow
Architect	oWow
Engineer	DCI Engineers
General Contractor	oWow

1510 Webster

Oakland, CA

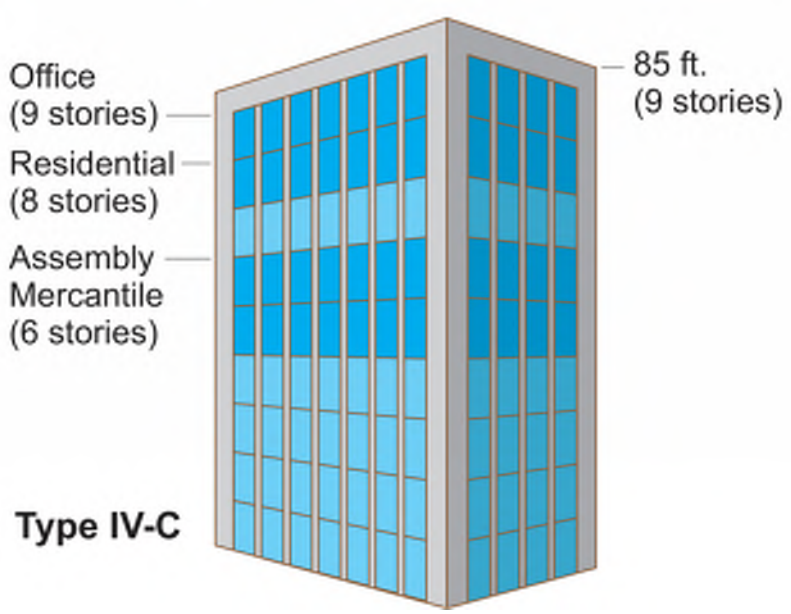
oWow
DCI Engineers
Photo: Flor Projects

Type IV-C Exposure Limits

All Mass Timber surfaces may be exposed

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

Monte French Design Studio
Photo: Jane Messinger



11 E Lenox

Boston, MA

Monte French Design Studio
H+O Structural Engineers
Photo Jane Messinger

Timberview

Portland, OR

Access Architecture
DCI Engineers
Photo Access Architecture

TIMBERVIEW

PORTLAND, OR

- 8 Stories
- Type IV-C
- 105 Affordable Housing Units

WN PROFILE

Access Architecture
DCI Engineers
Photo Access Architecture

Heartwood

Seattle, WA

atelierjones LLC
DCI Engineers
Image: atelierjones LLC

Heartwood

Seattle, WA

66,000 sf, 8 stories

Type IV-C

Workforce Housing

MT / CLT

Wood construction: 1 day per floor

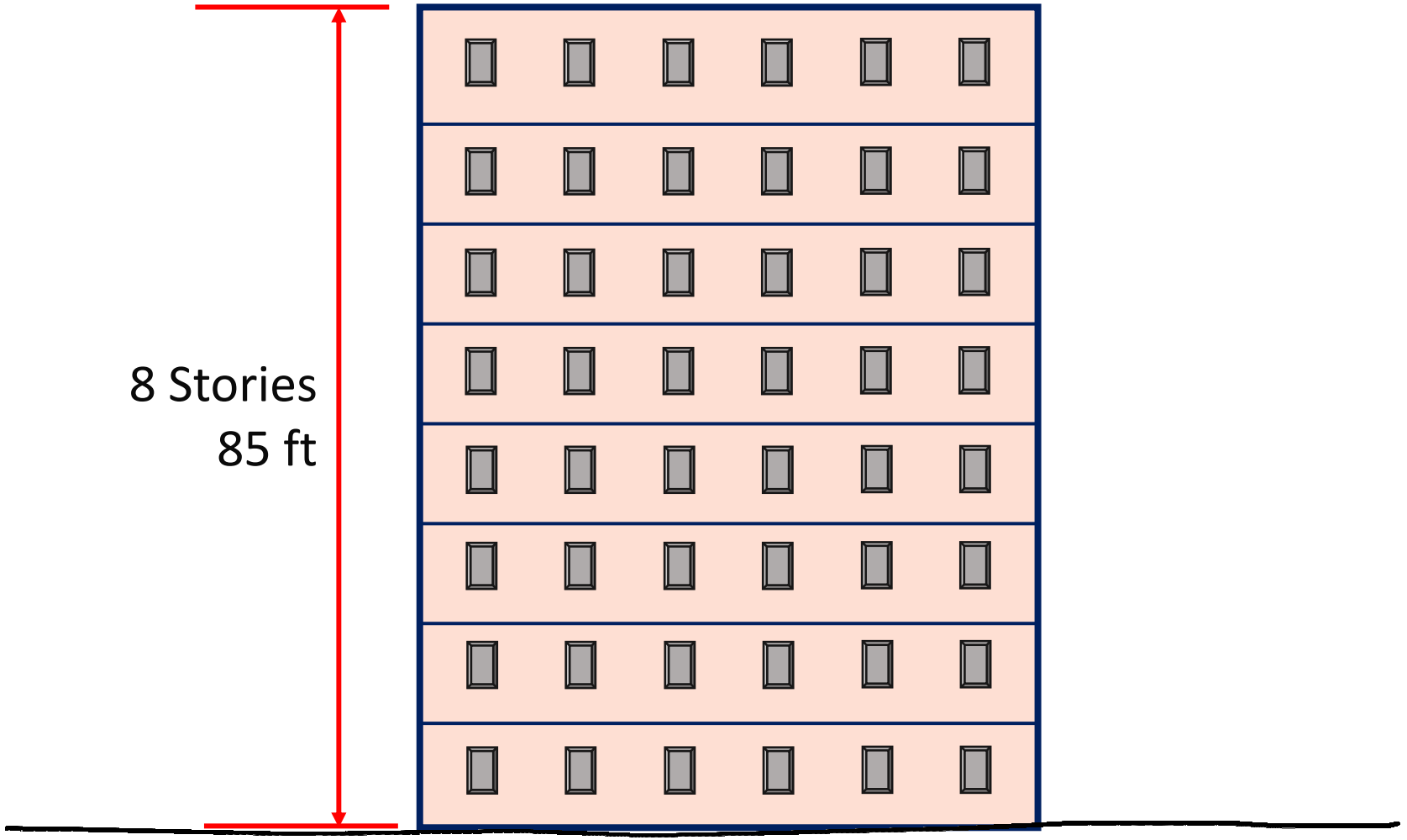
Completed 2023

atelierjones LLC
DCI Engineers
Image: atelierjones LLC

WN PROFILE

IV-A vs. IV-C Construction

Example R-2, Type IV-C Building

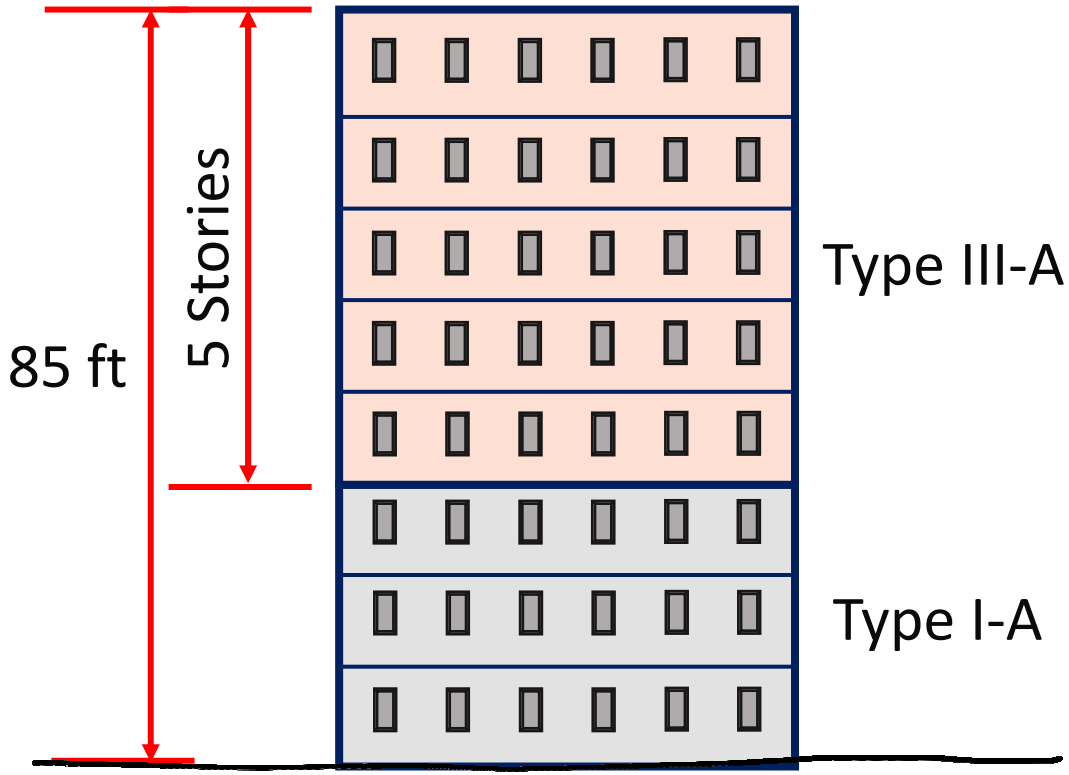


Fire Rating – Driven by Construction Type

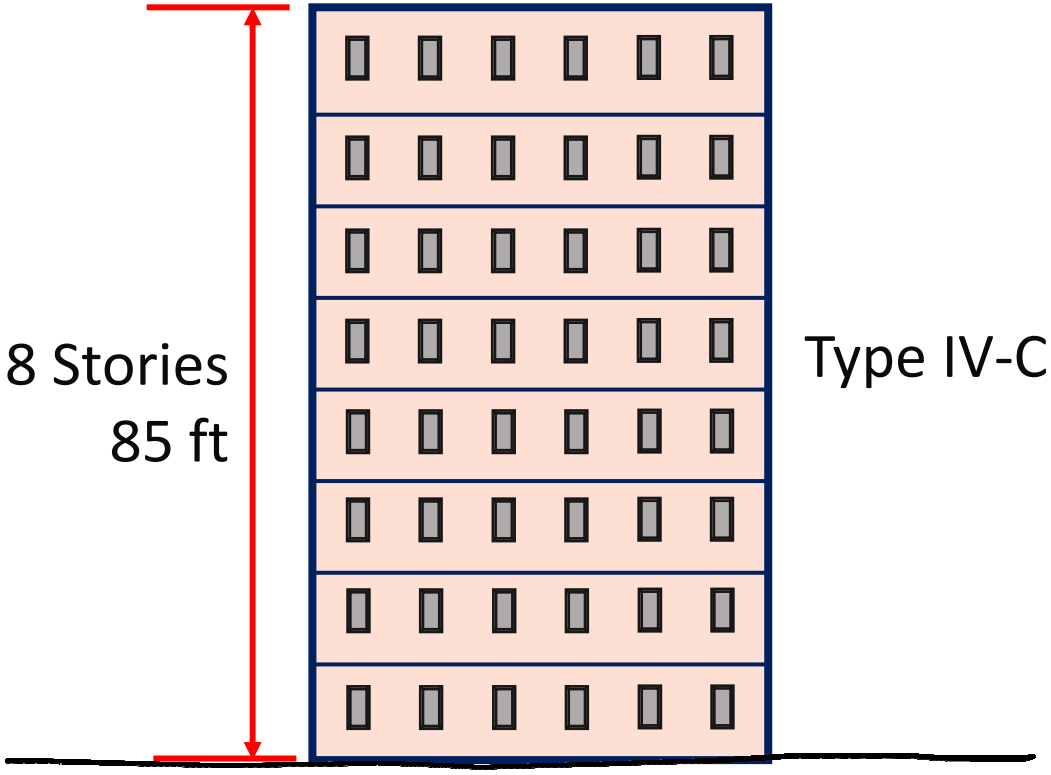
Residential (R-2) Occupancy with NFPA 13 sprinklers

		IV-C	III-A	III-B	V-A
Heights & areas	Area per story (ft^2)	76,875	72,000	48,000	36,000
	Max stories	8	5	5	4
	Max height (ft)	85	85	75	70
Rating Requirements	Primary structural frame	2-hr	1-hr	0-hr	1-hr
	Exterior bearing walls	2-hr	2-hr	2-hr	1-hr
	Interior bearing walls	2-hr	1-hr	0-hr	1-hr
	Nonbearing exterior walls	Table 705.5			
	Nonbearing interior walls	0-hr	0-hr	0-hr	0-hr
	Floor construction	2-hr	1-hr	0-hr	1-hr
	Roof construction	1-hr	1-hr	0-hr	1-hr

R-2 Occupancy, Type III-A vs Type IV-C



Type III-A over Podium

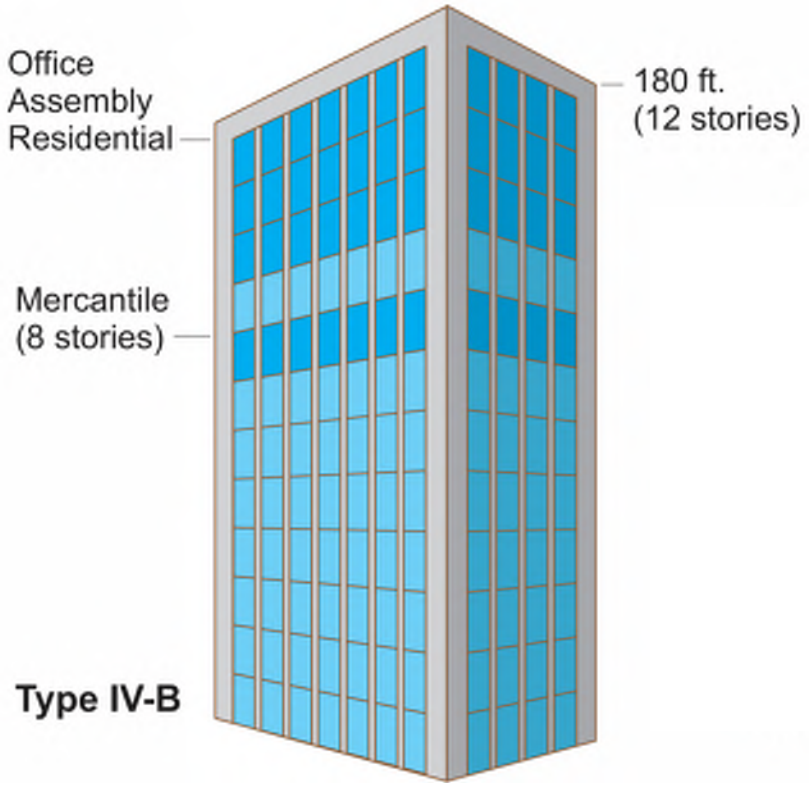


Type IV-C

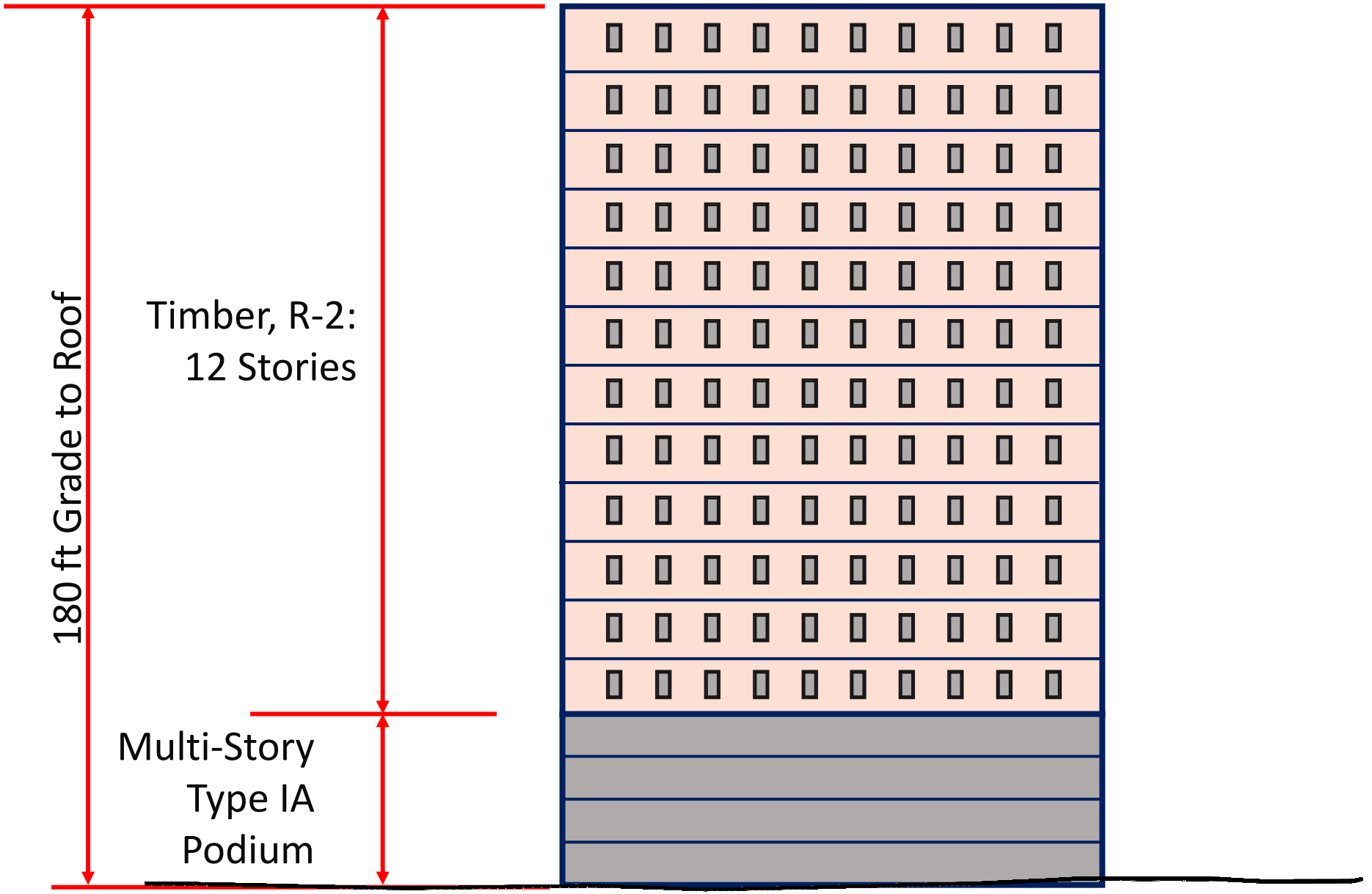
Type IV-B Exposure Limits

Limited Timber Exposure Allowed

Photo: Nick Johnson, Tour D Space



Example Mixed-Use, Type IV-B Building



Type IV-B Protection vs. Exposed (2021 IBC)

Limited Exposed MT allowed in Type IV-B for:

- MT beams and columns which are not integral part of walls or ceilings - no area limitation applies
- MT ceilings and integral beams - up to 20% of floor area in dwelling unit or fire area, or
- MT walls and columns - up to 40% of floor area in dwelling unit or fire area, or

Credit: Kaiser+Path

Type IV-B Protection vs. Exposed

Mixed unprotected areas, exposing both ceilings and walls:

- In each dwelling unit or fire area, max. unprotected area =

$$(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1.0$$

  - U_{tc} = Total unprotected MT ceiling areas
  - U_{ac} = Allowable unprotected MT ceiling areas
  - U_{tw} = Total unprotected MT wall areas
  - U_{aw} = Allowable unprotected MT wall areas

Credit: Kaiser+Path

Type IV-B Protection vs. Exposed

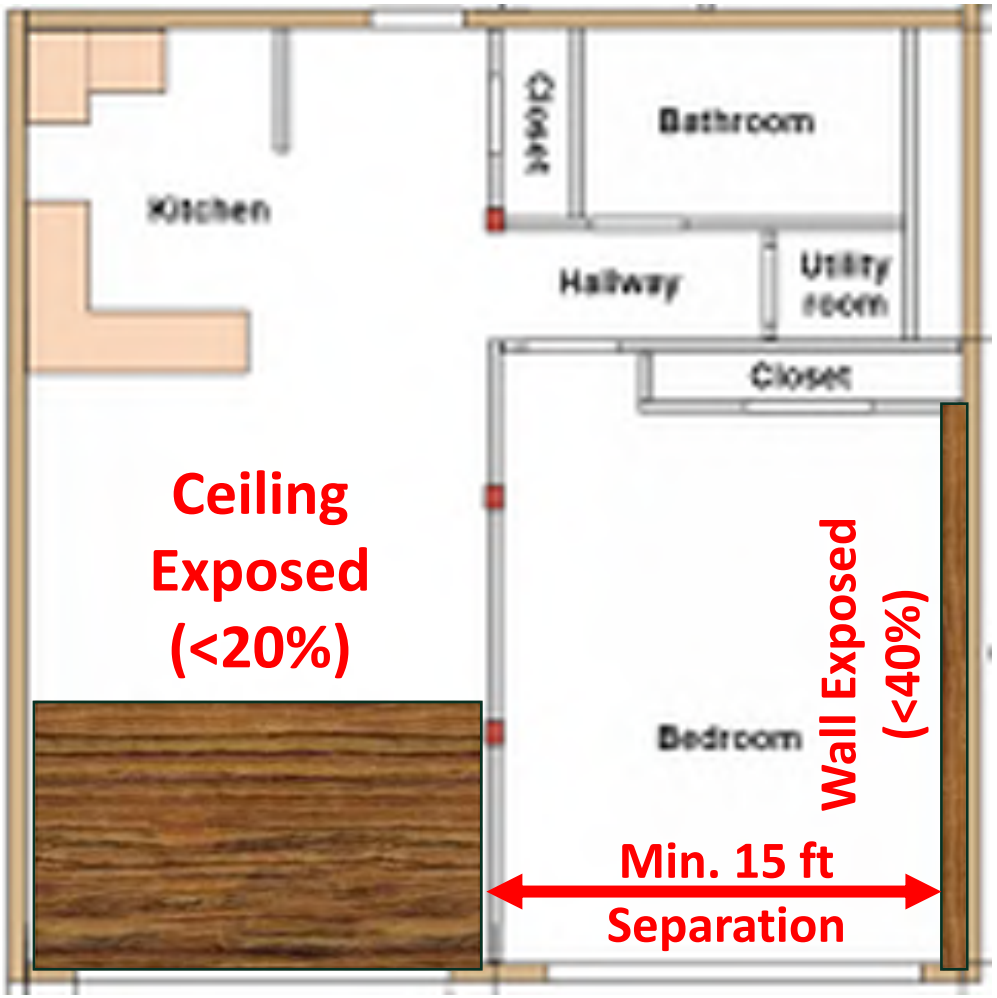
Horizontal separation of unprotected areas:

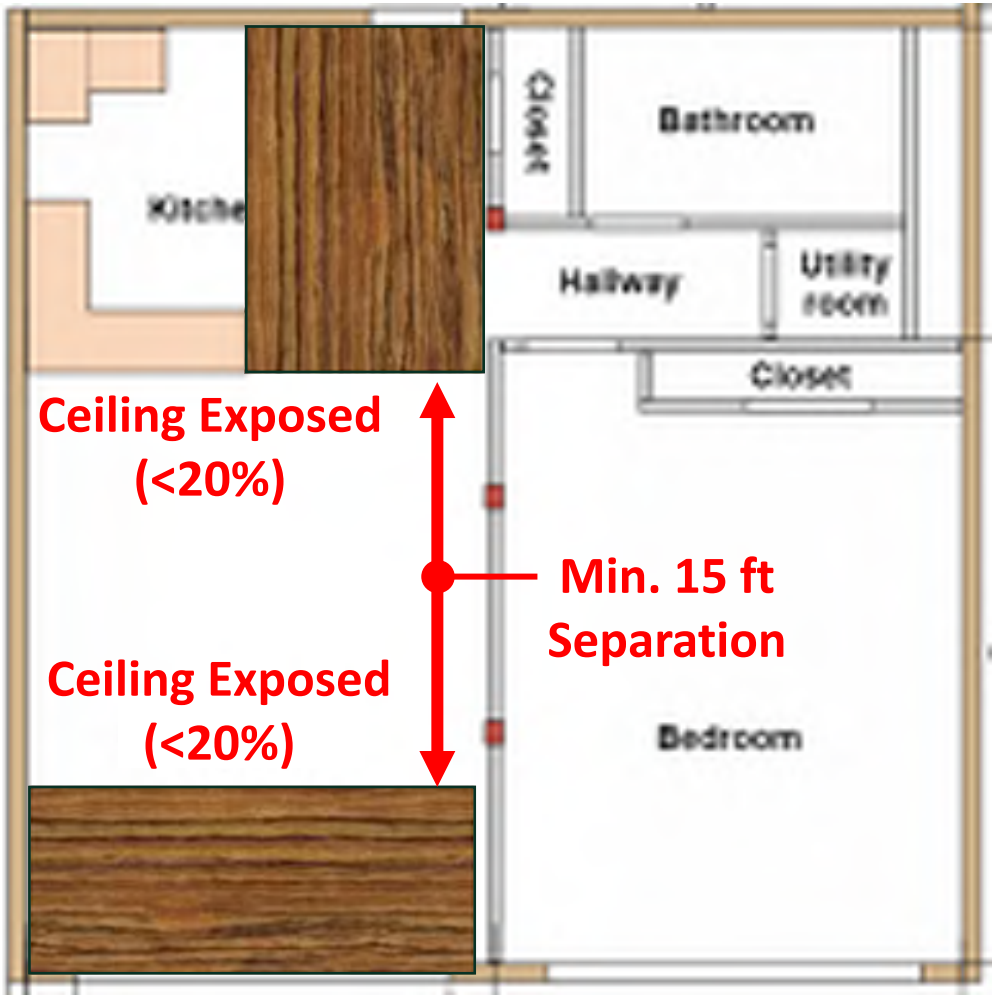
- Unprotected portions of mass timber walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.

Credit: Kaiser+Path

Type IV-B Protection vs. Exposed

2021 IBC Allowances





Credit: AWC

CLT Fire Performance – Char Fall Off

CLT char fall off or heat induced delamination occurs when laminations (or pieces thereof) fall off the underside of a CLT panel under extended fire conditions.

Photo: ARUP

CLT Fire Performance – Char Fall Off

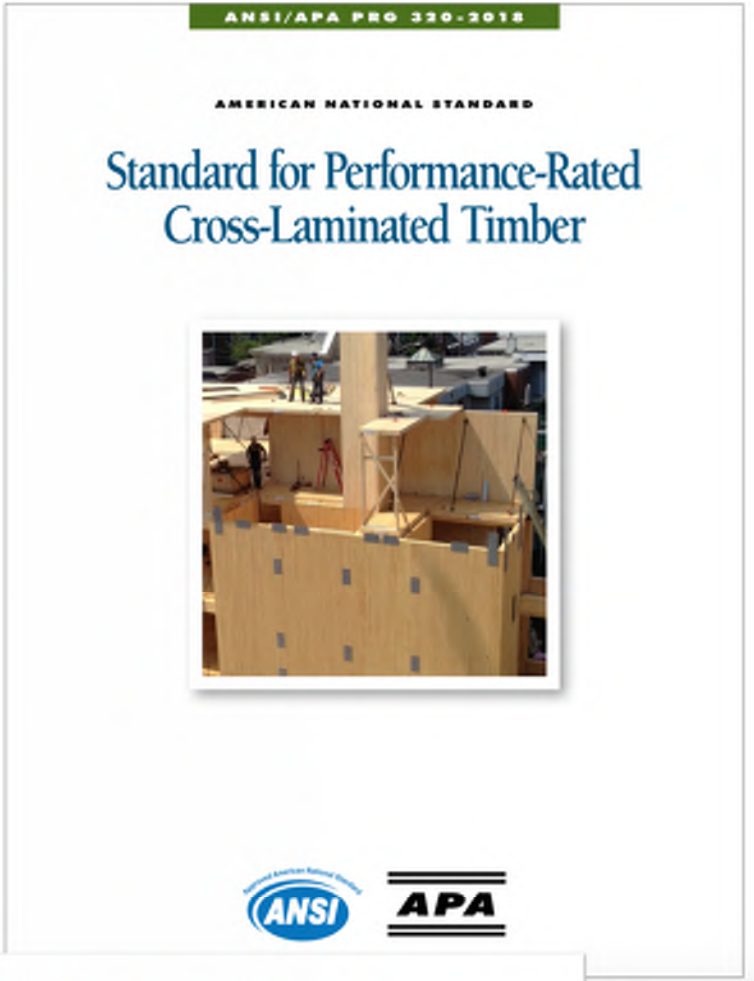
Facts about CLT char fall off:

- Only an item to consider in tall buildings.
- Not applicable when discussing mid-rise mass timber (or any building under types II, III, IV-HT or V)
- Largely a function of adhesive performance under high temps
- Has already been addressed in PRG 320-19

CLT Fire Performance – PRG 320-19

2019 edition (referenced in 2021 IBC) added new elevated temperature adhesive performance requirements validated by full-scale and medium-scale qualification testing to ensure CLT does not exhibit fire re-growth

CLT per PRG 320-19 is req'd in IBC 2021 for all CLT.



ANNEX B. PRACTICE FOR EVALUATING ELEVATED TEMPERATURE PERFORMANCE OF ADHESIVES USED IN CROSS-LAMINATED TIMBER (MANDATORY)

2019-2022: Refining the Code Roadmap


USDA
United States Department of Agriculture

Compartment Fire Testing of a Two-Story Mass Timber Building

Samuel L. Zelinka
Laura E. Hasburgh
Keith J. Bourne
David R. Tucholski
Jason P. Ouellette

Forest Service | Forest Products Laboratory | General Technical Report FPL–GTR–247 | May 2018

Conservatism: ATF lab tests based on older generation CLT adhesives

2018 ATF tests were initiated before the 2019 version of ANSI/APA PRG 320 was published and the tested CLT was not compliant with the new product standard.

Source: RISE, USDA FS FPL & AWC

2019-2022: Refining the Code Roadmap

Fire Safe Implementation of Mass Timber In Tall Buildings

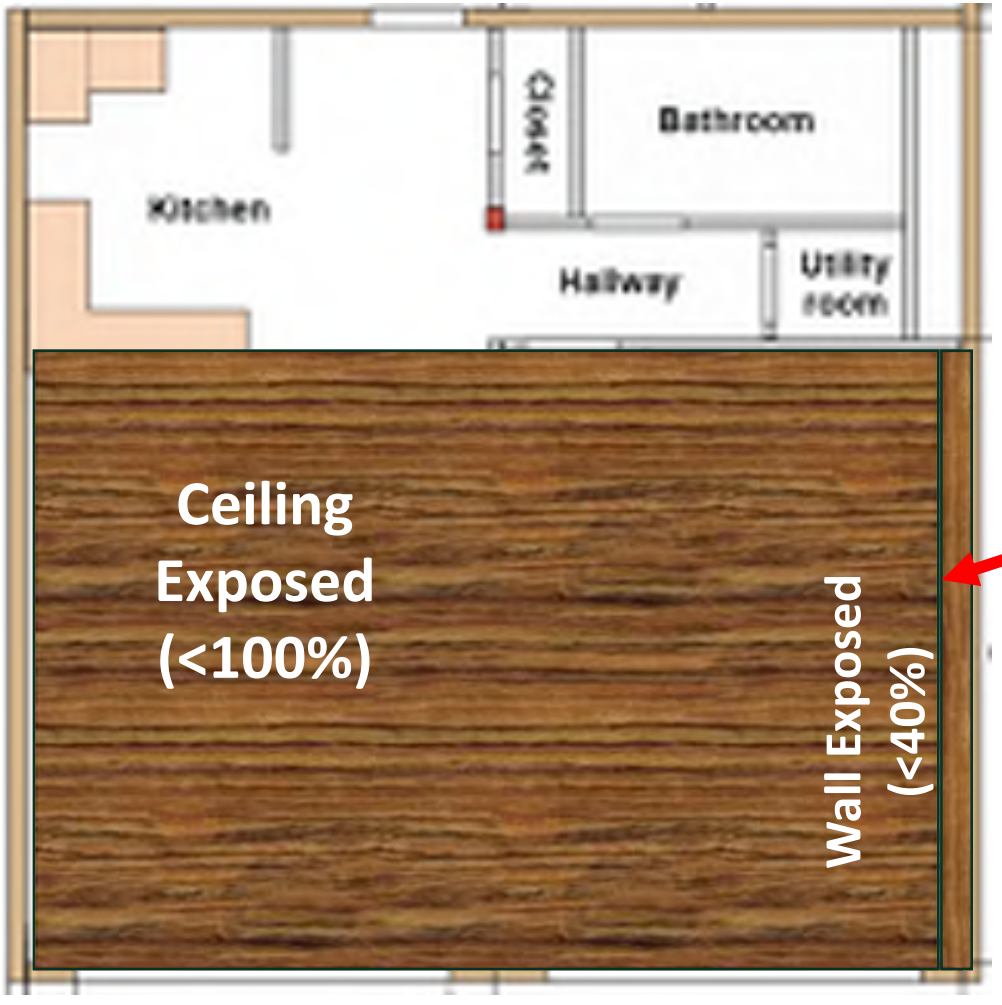
Research of the fire performance of CLT and Glued Laminated Timber buildings, with visible wood surfaces.

The main aim was to identify safe limits of exposed mass timber surface areas that correspond with performance criteria used for previous U.S. Building Code Changes.

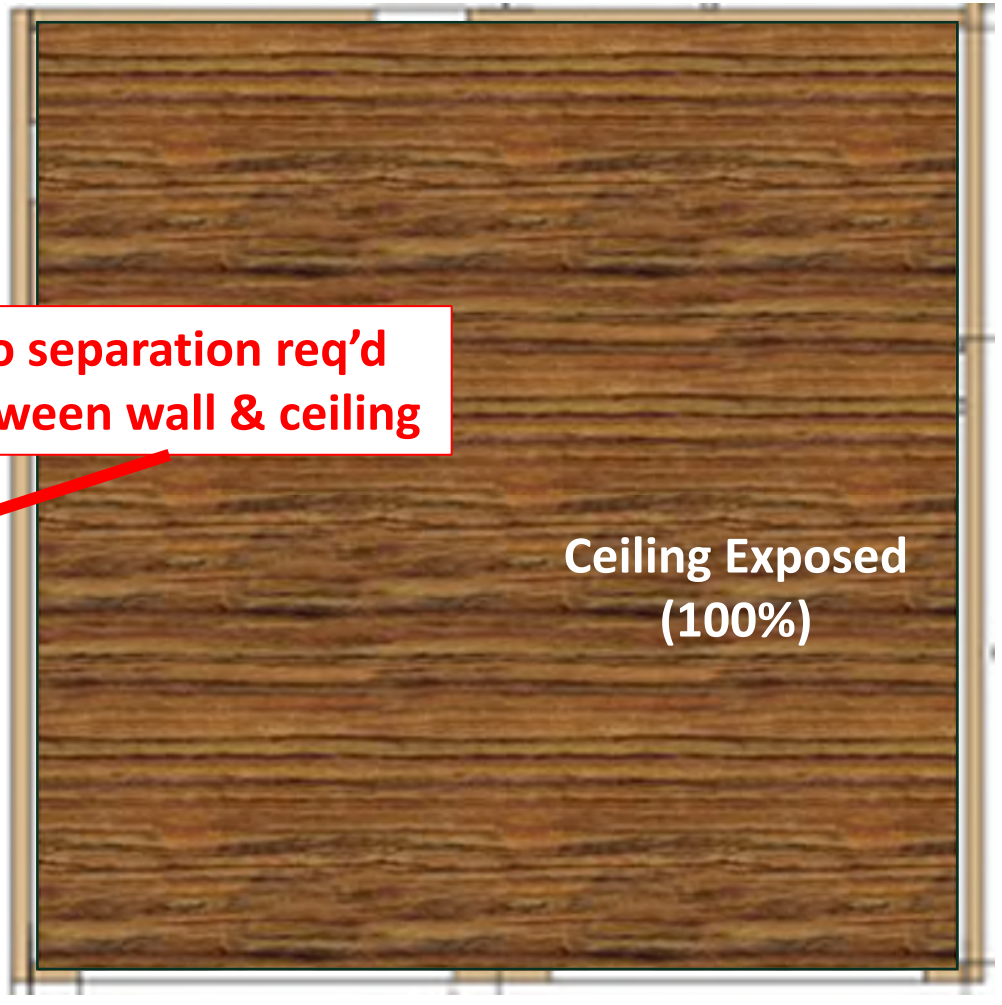
Source: RISE

Type IV-B Protection vs. Exposed

2024 IBC Allowances



No separation req'd between wall & ceiling



Credit: AWC

MT Fire Resistance Ratings (FRR)

IBC 722.7

The fire resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element (MT) added to the protection time of the noncombustible (NC) protection.

+

= FRR

Credit: Urban One

Noncombustible Protection (NC)

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

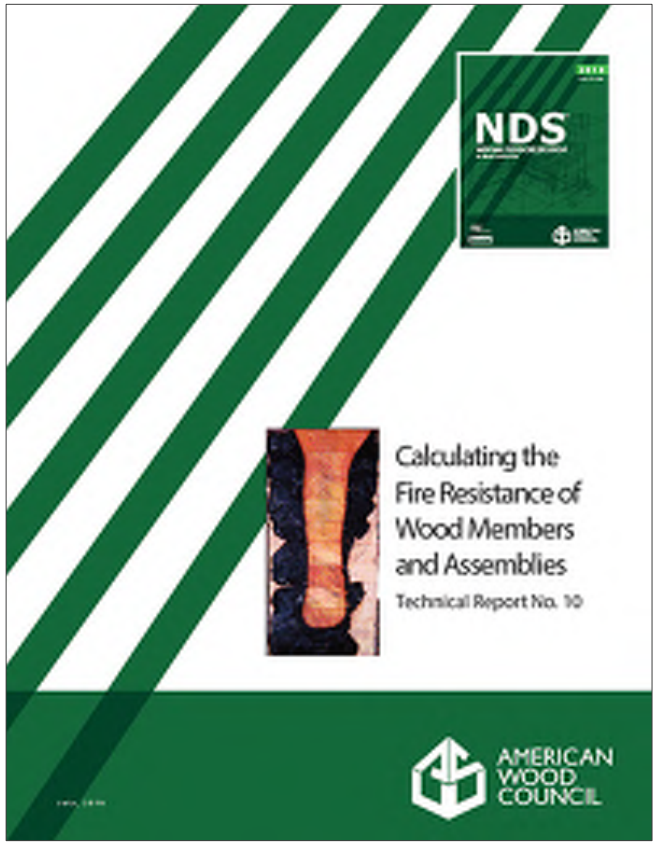
Required Noncombustible Contribution to FRR

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

Source: 2021 IBC Section 722.7

Calculated Fire Resistance of Wood

For Exposed Wood Members: IBC 722.1 References AWC's NDS Chapter 16
(AWC's TR 10 is a design aid to NDS Chapter 16)



Noncombustible Protection (NC)

Prescriptive Noncombustible Contributions to FRR

Type of Protection	Contribution per Layer (minutes)
1/2" Type X gypsum board	25
5/8" Type X gypsum board	40

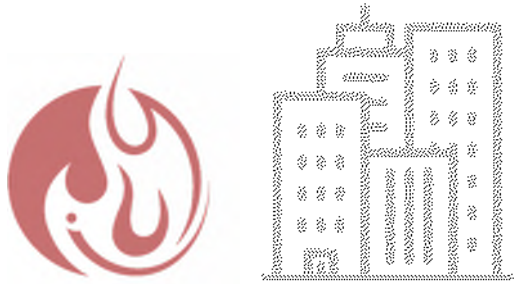
Source: 2021 IBC Section 722.7.1

Required Noncombustible Contribution to FRR

FRR of Building Element (hours)	Minimum from Noncombustible Protection (minutes)	
1	40	1 layer 5/8 Type X
2	80	2 layers 5/8 Type X
3 or more	120	3 layers 5/8 Type X

Source: 2021 IBC Section 722.7

Noncombustible Protection



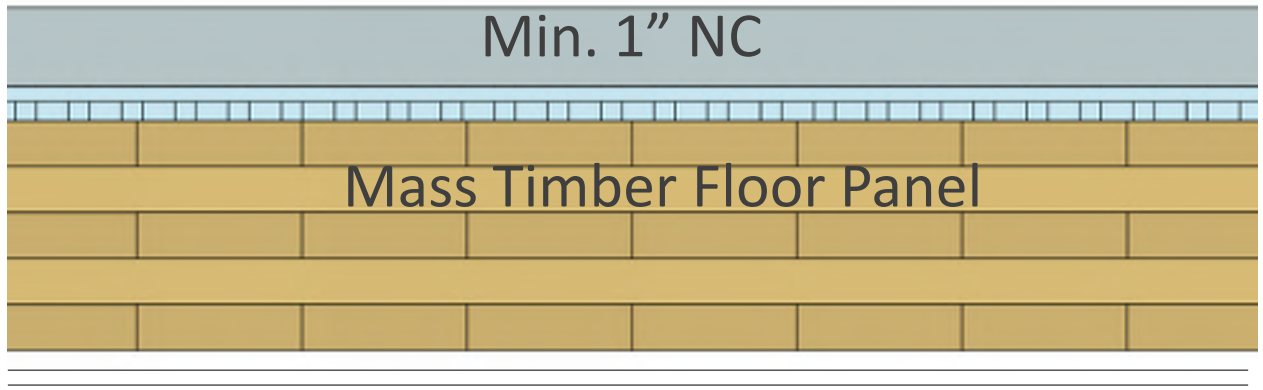
Noncombustible Protection Required

	IV-A	IV-B	IV-C
Below Mass Timber Roof	60 min	40 min*	Not Req.
Primary Frame @ Roof	80 min	40 min*	Not Req.
Primary Frame	120 min	80 min*	Not Req.
Below Mass Timber Floor	80 min	80 min*	Not Req.

Requirements Per new 602.4. * Some MT permitted to be exposed.

Floor Surface Protection

Min. 1” thick NC protection required on mass timber floors in IV-A and IV-B. Not required in IV-C



Credit: Maxxon

Concealed Spaces in Type IV-C

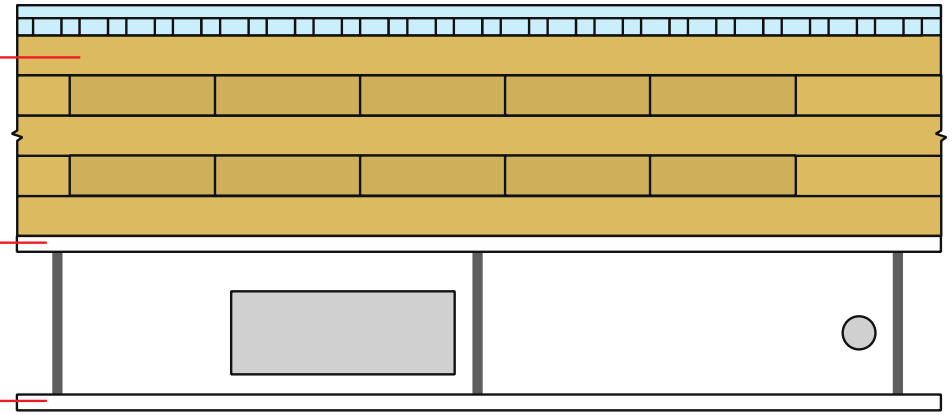
With Dropped Ceiling

Noncombustible material not required

Mass timber floor panel

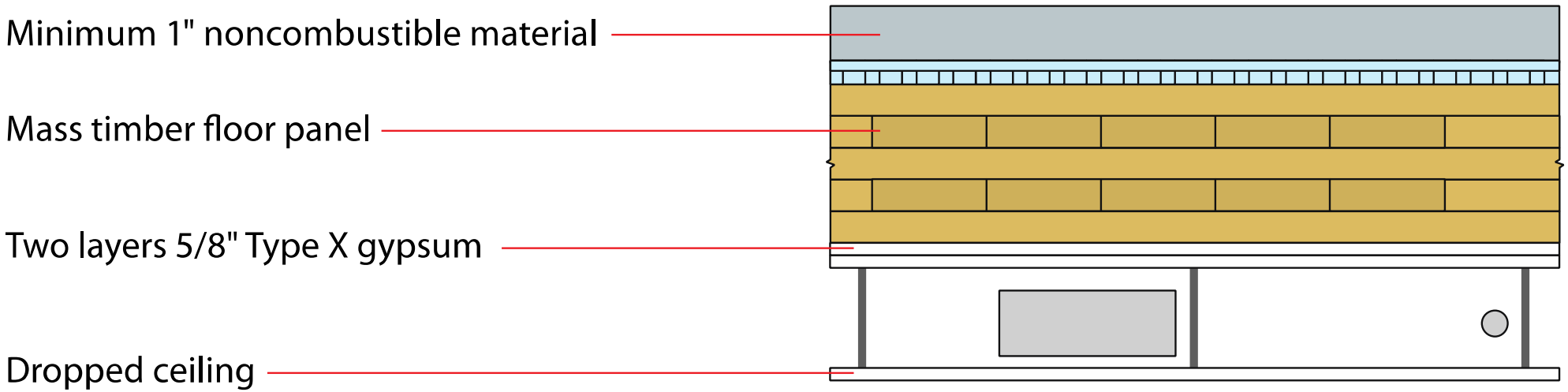
One layer 5/8" Type X gypsum covering all mass timber surfaces within concealed space

Dropped ceiling



Concealed Spaces in Type IV-A and IV-B

With Dropped Ceiling



Exterior Wall Construction

	IV-A, IV-B, IV-C		
Fire Rating (bearing wall)	3 Hr	2 Hr	2 Hr
Mass Timber	Mass Timber / CLT		
Exterior NC Protection	40 Min of NC Protection Required & No Exterior Combustible Coverings Allowed		
Interior NC Protection	Per Interior Requirements		
Light-Frame FRTW	No		

Fire Design for Tall Mass Timber

Free Resources:

www.woodworks.org

Updated May 2022

WOODWORKS

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

Concealed Spaces in Mass Timber and Heavy Timber Structures

Concealed spaces, such as those created by a dropped ceiling in a floor/ceiling assembly or by a stud wall assembly, have unique requirements in the International Building Code (IBC) to address the potential of fire spread in

Allowances and Requirements for Concealed Spaces

Low-Rise and Mid-Rise Structures

uildings, mass timber is typically used tion. Up to and including the 2018 IBC, allowed to have concealed spaces:

ype IV. *Type IV construction is which the exterior walls are of and the interior building elements are ood, heavy timber (HT) or structural thout concealed spaces...*

uildings have received alternate ealed spaces, the lack of prescriptive me designers toward the use of r their mass timber projects. Neither he use of concealed spaces; however, st still comply with the protection

WOODWORKS

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

Demonstrating Fire-Resistance Ratings for Mass Timber Elements in Tall Wood Structures

Changes to the 2021 International Building Code (IBC) have created opportunities for wood buildings that are much larger and taller than prescriptively allowed in past versions of the code. Occupant safety, and the need to ensure fire performance in particular, was a fundamental consideration as the changes were developed and approved. The result is three new construction types—Type IV-A, IV-B and IV-C—which are based on the previous Heavy Timber construction type (renamed Type IV-HT), but with additional fire protection requirements.

One of the main ways to demonstrate that a building will meet the required level of passive fire protection, regardless of structural materials, is through hourly fire-resistance ratings (FRRs) of its elements and assemblies. The IBC defines an FRR as *the period of time a building element, component or assembly maintains the ability*

Outline

- Tall Wood Introduction
- Non-Combustible Protection and Timber Exposure Allowances
- **Fire Safety During Construction**
- Panel Joints, Connections, and Penetrations
- Allowable Areas

Fire Safety During Construction (2021 IFC)

3303.5 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction.

…designed to be greater than six stories above grade plane shall meet the following requirements during construction unless otherwise approved by the fire code official.

1. Standpipes shall be provided in accordance with Section 3314.
2. A water supply for fire department operations, as approved by the fire chief.

Photo: Structurlam

Fire Safety During Construction (2021 IFC)

SECTION 3314

STANDPIPES

3314.1 Where required.

In buildings required to have standpipes by Section 905.3.1, not less than one standpipe shall be provided for use during construction. Such standpipes shall be installed prior to construction exceeding 40 feet (12 192 mm) in height above the lowest level of fire department vehicle access. Such standpipes shall be provided with fire department hose connections at locations adjacent to *stairways* complying with Section 3312.1. As construction progresses, such standpipes shall be extended to within one floor of the highest point of construction having secured decking or flooring.

Credit: IFC

Sprinklers in High Rises

Two Water Mains Required if:

- Building Height Exceeds 420 ft, or
- **Type IV-A and IV-B buildings that exceed 120 ft in height**

Photo: Michael Green Architecture

Fire Safety During Construction

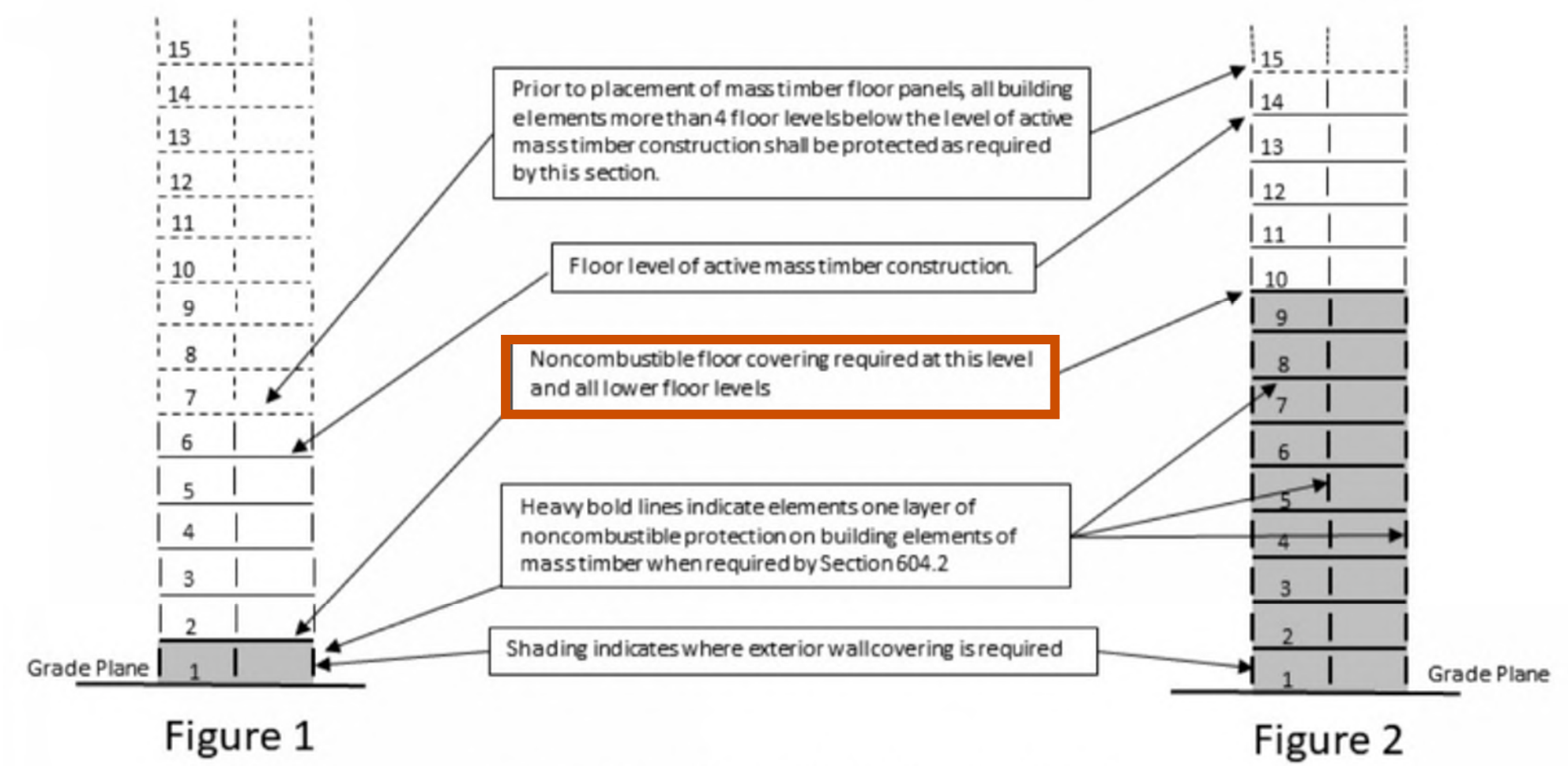
2021 IFC Section 3303.5

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

Exception: Shafts and vertical exit enclosures

Photo: Structurlam

Fire Safety During Construction



Examples of Protection During Construction For Mass Timber Buildings Greater Than 6 Stories Above Grade Plane

Credit: ICC

2019-2022: Refining the Code Roadmap

Change to 2024 IBC: Sequencing of NC topping install

F174-21

IFC: 3303.5

Proponents: David Tyree, representing AWC (dtyree@awc.org); Raymond O'Brocki, AWC, representing AWC (robrocki@awc.org)

2021 International Fire Code

Revise as follows:

3303.5 Fire safety requirements for buildings of Types IV-A, IV-B and IV-C construction. Buildings of Types IV-A, IV-B and IV-C construction designed to be greater than six stories above *grade plane* shall comply with the following requirements during construction unless otherwise *approved* by the *fire code official*:

1. Standpipes shall be provided in accordance with Section 3313.
2. A water supply for fire department operations, as *approved* by the *fire code official* and the *fire chief*.
3. Where building construction exceeds six stories above *grade plane* and noncombustible protection is required by Section 602.4 of the *International Building Code*, at least one layer of noncombustible protection shall be installed on all building elements on floor levels, including mezzanines, more than four levels below active mass timber construction before additional floor levels can be erected.

   ~~**Exception**~~ **Exceptions:**

   1. Shafts and vertical exit enclosures shall not be considered part of the active mass timber construction.
   2. Noncombustible material on the top of mass timber floor assemblies shall not be required before erecting additional floor levels.

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

   Exception: Shafts and vertical exit enclosures shall not be considered part of the active mass timber construction.

Credit: ICC

Outline

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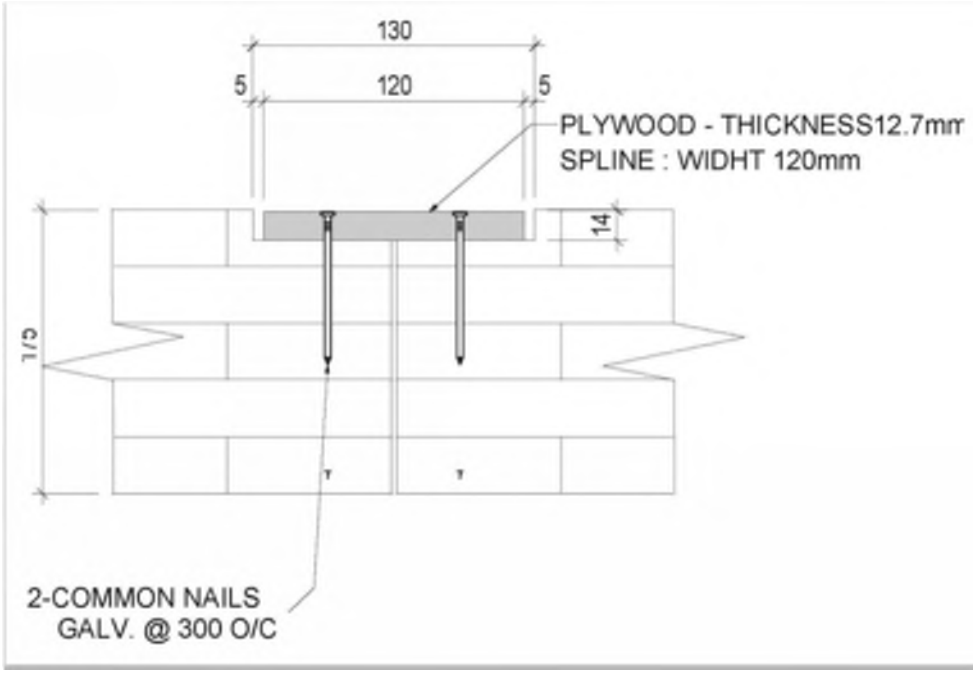
Sealants at MT Panel Edges

703.9 Sealing of adjacent mass timber elements. In buildings of Type IVA, IVB, and IVC construction, sealant or adhesive shall be provided to resist the passage of air in the following locations:

1. At abutting edges and intersections of mass timber building elements required to be fire resistance-rated
2. At abutting intersections of mass timber building elements and building elements of other materials where both are required to be fire resistance-rated.



Sealants at MT Panel Edges

Sealants shall meet the requirements of ASTM C920 (elastomeric joint sealants).

Adhesives shall meet the requirements of ASTM D3498 (gap filling construction adhesives, i.e. not fire caulk).

Exception: Sealants or adhesives need not be provided where they are not a required component of a fire resistance- rated assembly.


Photo: NRCAN


Photo: Charles


Photo: ARUP

Sealants at MT Panel Edges

2021 IBC requires periodic special inspections of adhesive/sealant installation

(when required to be installed)


Photo: NRCAN


Photo: Fast + Epp


Photo: ARUP

Connection Fire Protection

Building elements are required to be FRR as specified in IBC Table 601

Connections between these building elements must be able to maintain FRR no less than that required of the connected members.

Photo: MyTiCon

16.3 Wood Connections

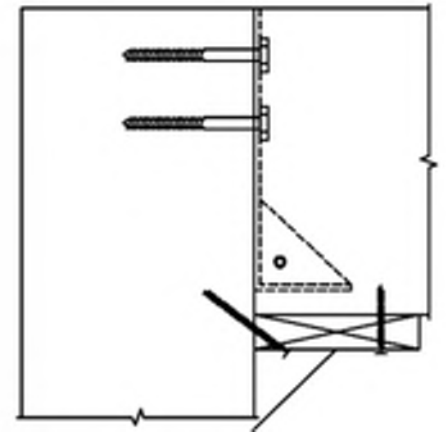
Wood connections, including connectors, fasteners, and portions of wood members included in the connection design, shall be protected from fire exposure for the required fire resistance time. Protection shall be provided by wood, fire-rated gypsum board, other approved materials, or a combination thereof.

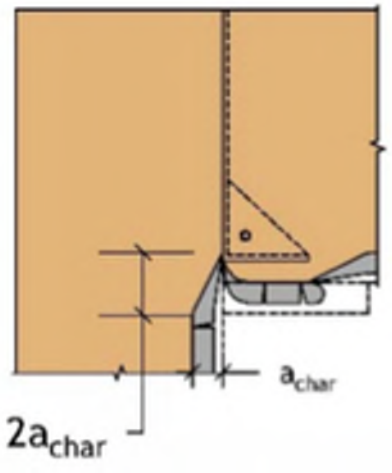
Source: NDS

Fire Resistance of Connections

2304.10.1 Connection fire resistance rating. 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 250° F (139° C), and a maximum temperature rise of 325° F (181° C), for a time corresponding to the required fire resistance rating of the structural element being connected. For the purposes of this analysis, the connection includes connectors, fasteners, and portions of wood members included in the structural design of the connection.





Source: AWC's TR 10

Connection Fire Protection

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

Photo: ARUP/SLB

Connections

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

Tall Mass Timber Inspections

Wood Connection Coverings for Fire-Resistance

110.3.5 Type IV-A, IV-B, and IV-C connection protection inspection. In buildings of Type IV-A, IV-B, and IV-C Construction, where connection fire resistance ratings are provided by wood cover calculated to meet the requirements of Section 2304.10.1, inspection of the wood cover shall be made after the cover is installed, but before any other coverings or finishes are installed.

Inspection of Wood Coverings

Penetration Fire Protection

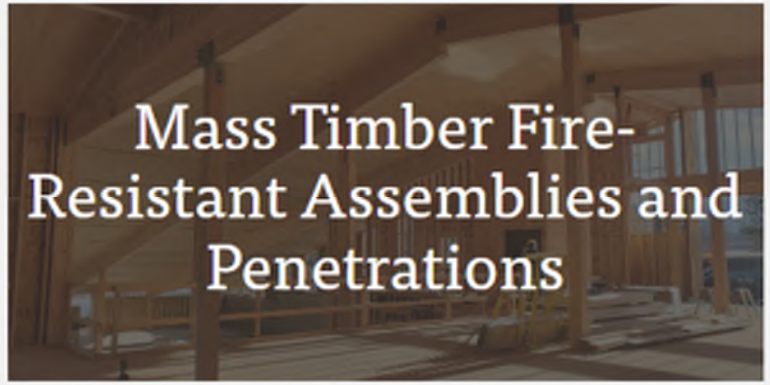
Although not a new code requirement or specific to tall wood, more testing & information is becoming available on firestopping of penetrations through MT assemblies

Photos: AWC/FPInnovations

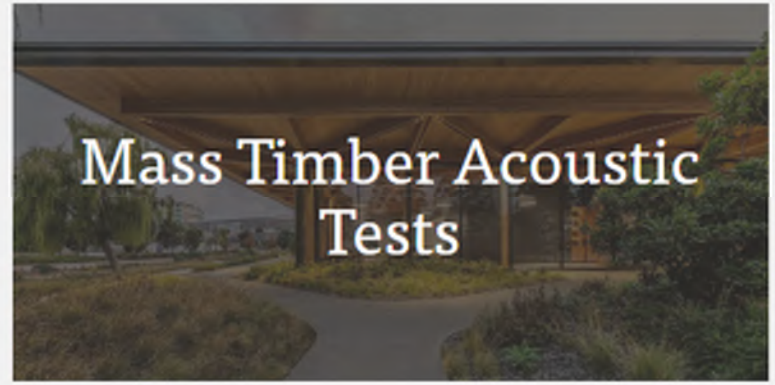
Mass Timber Fire & Acoustic Database

Find fire and acoustically-rated assemblies, connections, and penetrations using this evolving database of systems compliant with North American standards.

This database is aimed at the design community, more specifically architects in the design phase of a structure looking for fire or acoustic assemblies. Engineers can also make use of the database options to determine how a floor or wall has to be assembled to ensure fire resistance or acoustic performance. Participating manufacturers will actively update the database to ensure it includes the latest products and tested assemblies.



Features North American mass timber assemblies, firestopping systems for penetrations and perimeter wall systems, connections, and noncombustible coverings that have demonstrated fire performance through testing and other approved methods



Provides detailed information on mass timber assemblies that have been acoustically tested in the U.S., including STC and ICC ratings and links to the associated test reports

< Back to Mass Timber Fire & Acoustic Database

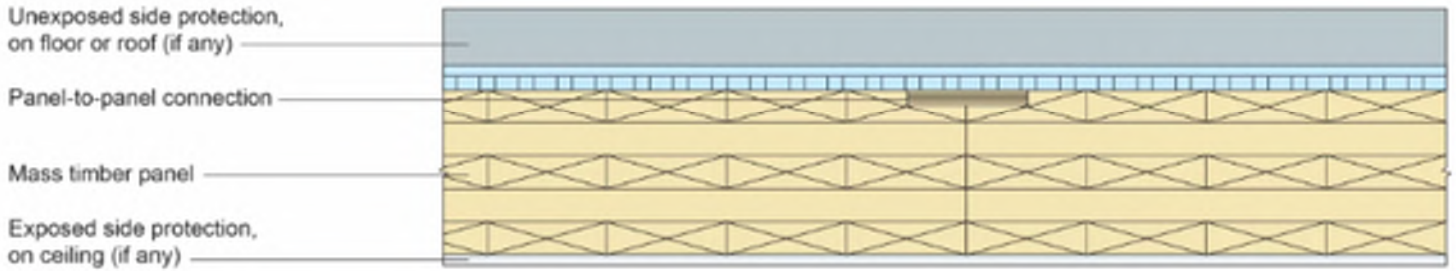
Application Type

- [ ] Fire-Resistance Rated Mass Timber Floor/Roof Assemblies 31
- [ ] Fire-Resistance Rated Mass Timber Wall Assemblies 26
- [ ] Firestop Systems For Penetrations in Mass Timber Assemblies 57
- [ ] Fire-Resistance Rated Mass Timber Connections 19
- [ ] Perimeter Fire Containment Systems in Mass Timber Structures 5
- [ ] Noncombustible Protection of Mass Timber Building Elements 4

Mass Timber Panel

- [ ] CLT 109
- [ ] CLT (SCL) 1
- [ ] NLT 3
- [ ] DLT 3
- [ ] GLT 2
- [ ] SCL 1
- [ ] T&G

Fire-Resistance Rated Mass Timber Floor/Roof Assemblies



Fire-resistance ratings of assemblies are demonstrated through fire-resistance tests, recognized calculations, or approved alternatives. The IBC recognizes US testing standards ASTM E119 and UL 236 while the Canadian standard ULC S101 has the same fire exposure and performance criteria. Fire-resistance ratings developed using these standards may be acceptable to building officials in either country.

Mass Timber Panel	Structural Grade	Exposed Side Protection	Unexposed Side Protection	Panel Connection	Load Rating	Fire-Resistance Rating (Hours)	Test Protocol	Method of Compliance
3-layer 4.13" (105mm) CLT	ANY	None	None	TBD	Varies, Determined by Calculation	1	ASTM E119	Calculated Fire-Resistance Rating by NDS Chapter 16 WoodWorks Paper Fire Design of Mass Timber Members
5-layer 6.88" (175mm) CLT	ANY	None	None	TBD	Varies, Determined by Calculation	1	ASTM E119	Calculated Fire-Resistance Rating by NDS Chapter 16 WoodWorks Paper Fire Design of Mass Timber Members

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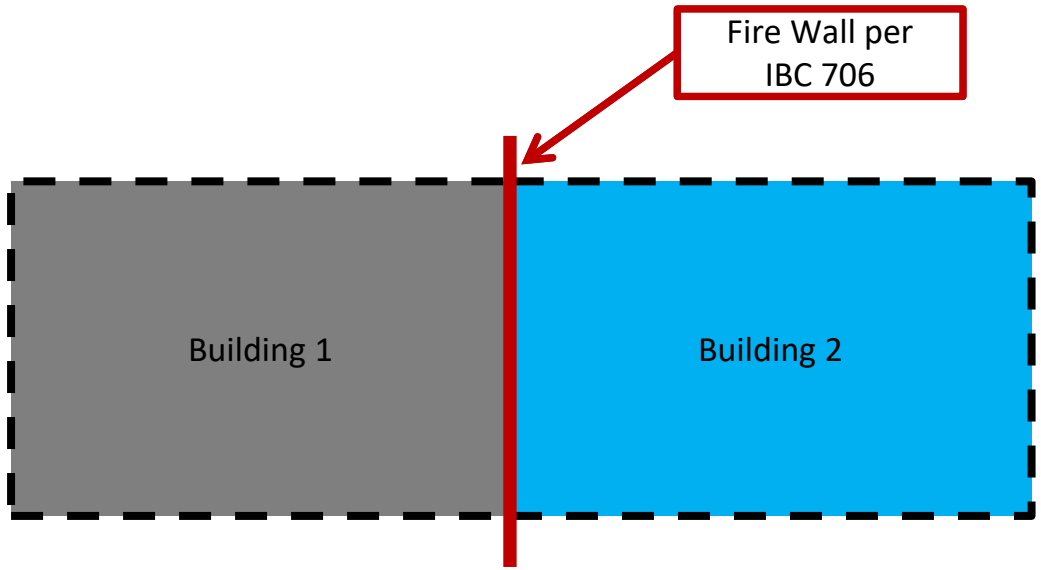
Tall Wood Building Size Limits

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

Fire Walls – IBC 706

Each portion of a building separated by one or more fire walls shall be considered a separate building.



Questions? Ask us anything.

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

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