Tall Wood Construction + Michigan State University STEM Facility Site Tour

June 13, 2025

Presented by

Anthony Harvey, PE

WOODWORKS
WOOD PRODUCTS COUNCIL

MSU STEM Teaching and Learning Facility / Integrated Design Solutions / photo Christofer Lark

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

AIA Approved Continuing Education

Course Description

We are at an exciting confluence in timber construction. The need for sustainable, urban construction has never been higher. Concurrently, mass timber products such as cross-laminated timber have opened the door to many new opportunities for construction, one of which is tall wood. In January 2019, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings of up to 18 stories as part of the 2021 International Building Code (IBC). This presentation will introduce the new tall wood code provisions in depth. Starting with a review of the technical research and testing that supported their adoption, it will then take a detailed look at the new code provisions and methods of addressing the new requirements. Topics will include fire-resistance ratings and allowances for exposed timber, penetrations, sprinklers, connections, exterior walls and much more. Designers can expect to take away the knowledge they need to start exploring tall wood designs on their projects.

Learning Objectives

1. Review the global history of tall wood construction and highlight the mass timber products used in these structures.

2. Explore the work and conclusions of the ICC Ad Hoc Committee on Tall Wood Buildings in establishing 14 new code provisions for the 2021 IBC that address tall wood construction.

3. 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.

4. Review code requirements unique to tall wood buildings, focusing on items such as sprinklers, shaft construction and concealed spaces.

CONSTRUCTION TYPES REVEIW

INTERNATIONAL CODE COUNCIL®

Since its debut, IBC has contained

9 Construction Type options

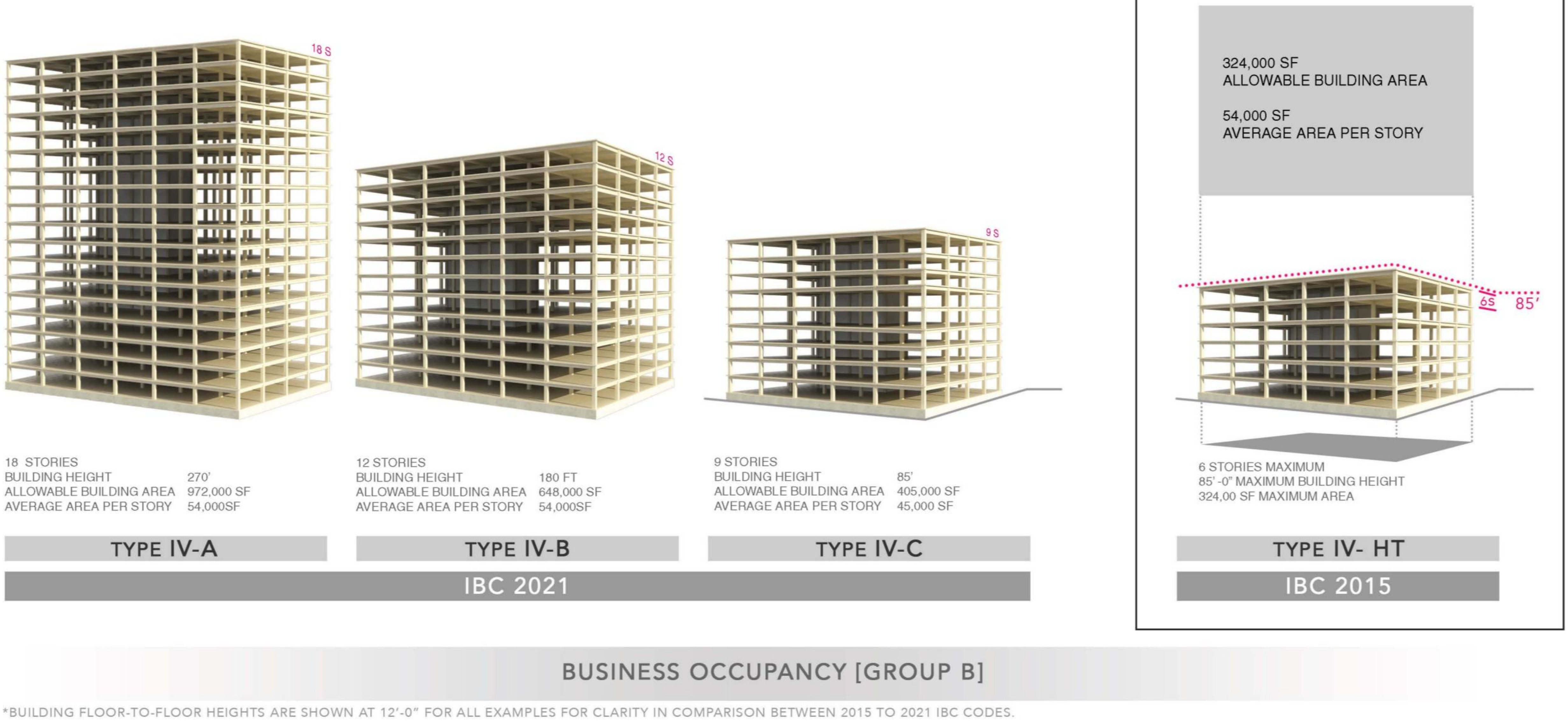
5 Main Types (I, II, III, IV, V) with all but Type IV having sub-types A and B

TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
A	B	A	B	A	B	HT	A	B

2021 IBC Introduces 3 New Tall Wood Construction Types: IV-A, IV-B, IV-C, Previous Type IV is 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 Timber Construction Types



Credit: Susan Jones, atelierjones

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

Tall Wood Building Size Limits

	Construction Type (Unsprinklered Values)					
	I-A	I-B	IV-A	IV-B	IV-C	IV-HT
Occupancies	**Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)**					
A, B, R	Unlimited	160	**65**	**65**	**65**	**65**
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)					
A-2, A-3, A-4	Unlimited	11	**3**	**3**	**3**	**3**
B	Unlimited	11	**5**	**5**	**5**	**5**
R-2	Unlimited	11	**4**	**4**	**4**	**4**
	Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)					
A-2, A-3, A-4	Unlimited	Unlimited	**45,000**	**30,000**	**18,750**	**15,000**
B	Unlimited	Unlimited	**108,000**	**72,000**	**45,000**	**36,000**
R-2	Unlimited	Unlimited	**61,500**	**41,000**	**25,625**	**20,500**

Even so, Sprinklers may be required by 903.2 (all occupancies) and definitely for residential (420.4)

Tall Wood Building Size Limits

	Construction Type (Unsprinklered Values)					
	I-A	I-B	IV-A	IV-B	IV-C	IV-HT
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A, B, R	Unlimited	160	65	65	65	65
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)					
A-2, A-3, A-4	Unlimited	11	3	3	3	3
B	Unlimited	11	5	5	5	5
R-2	Unlimited	11	4	4	4	4
	Allowable Area Factor (At) for SM, Feet^2 (IBC Table 506.2)					
A-2, A-3, A-4	Unlimited	Unlimited	45,000	30,000	18,750	15,000
B	Unlimited	Unlimited	108,000	72,000	45,000	36,000
R-2	Unlimited	Unlimited	61,500	41,000	25,625	20,500

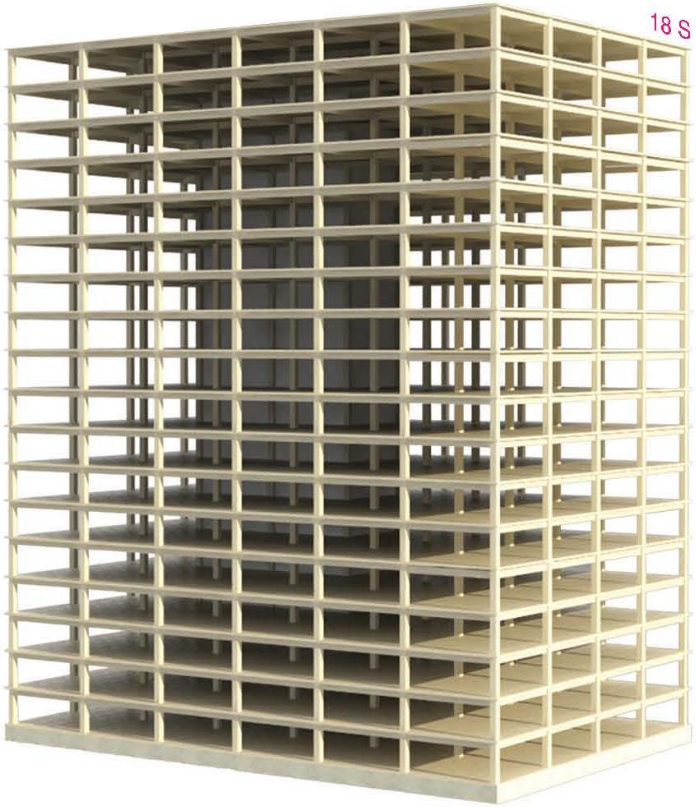
In almost all cases, sprinklers will be required

Even so, Sprinklers may be required by 903.2 (all occupancies) and definitely for residential (420.4)

Non-Tall Opportunities – Large Area

	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

Type IV-A

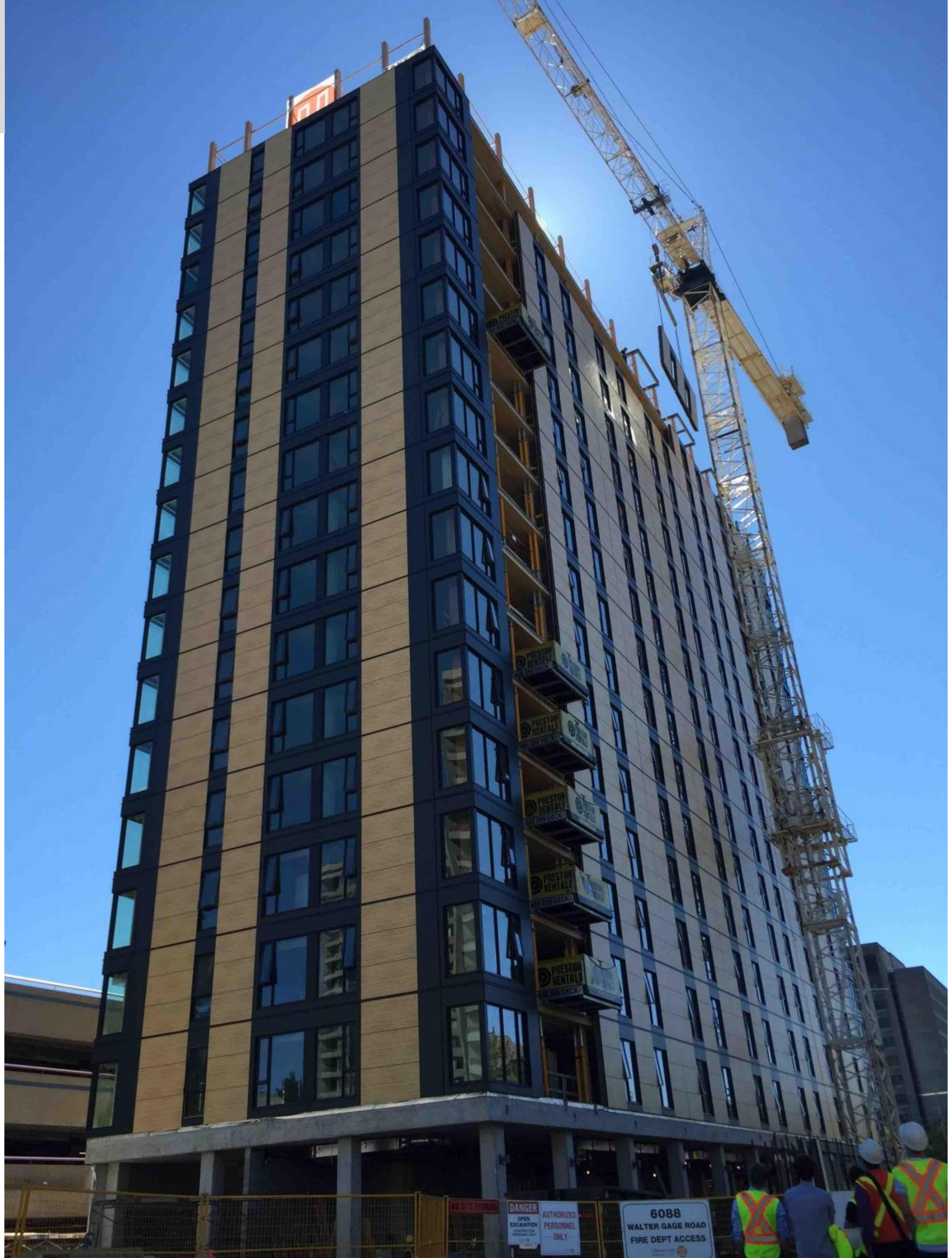


18 STORIES

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

TYPE IV-A

Credit: Susan Jones, atelierjones



Photos: Structurlam, naturally:wood, Fast + Epp

Type IV-A Height and Area Limits

Credit: Susan Jones, atelierjones

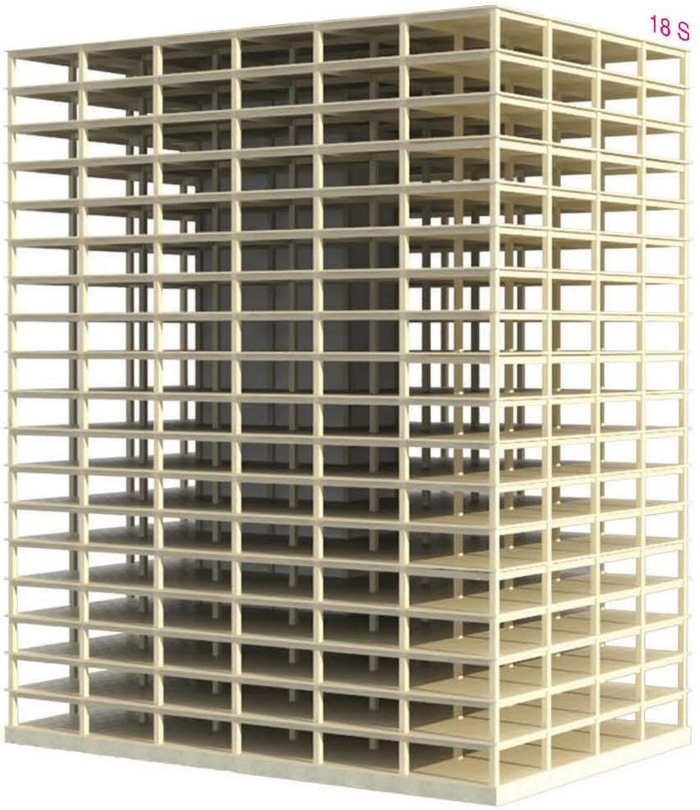
Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	18	270 ft	135,000 SF	405,000 SF
B	18	270 ft	324,000 SF	972,000 SF
M	12	270 ft	184,500 SF	553,500 SF
R-2	18	270 ft	184,500 SF	553,500 SF

Areas exclude potential frontage increase

In most cases, Type IV-A height & story allowances = 1.5 * Type I-B height & story allowances

Type IV-A area = 3 * Type IV-HT area

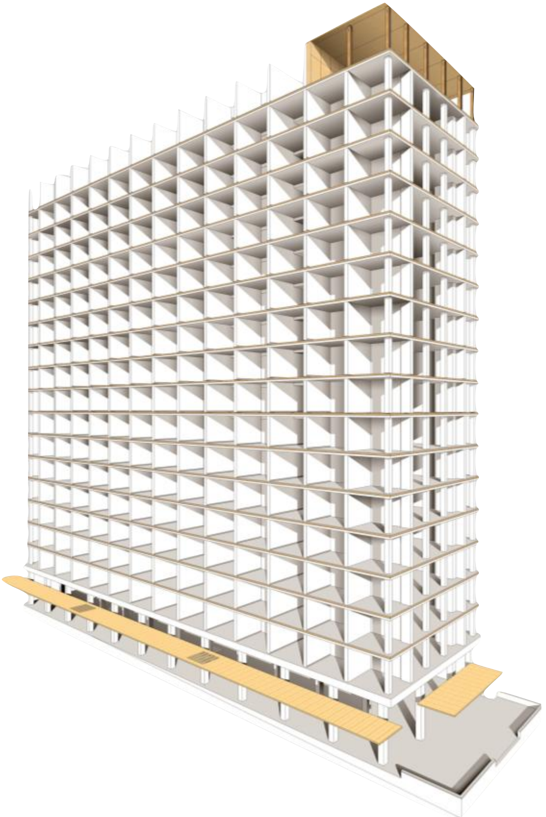
Type IV-A Protection vs. Exposed

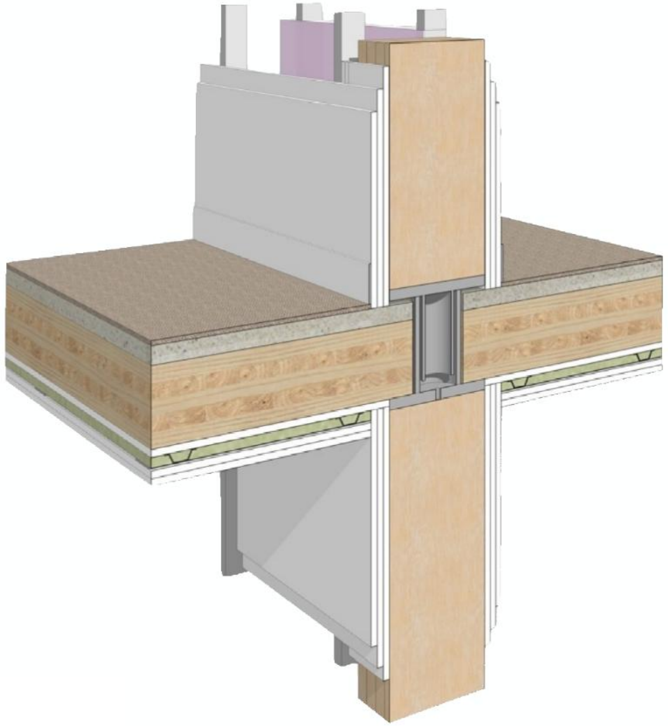


18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-A

Credit: Susan Jones, atelierjones





100% NC protection on all surfaces of Mass Timber

Credit: Acton Ostry Architects, Fast + Epp

Type IV-A Fire Resistance Ratings (FRR)

IV-A

Primary Frame FRR	3 HR (2 HR at Roof)
Ext or Int Bearing Wall FRR	3 HR
Floor Construction FRR	2 HR
Roof Construction FRR	1.5 HR

Type IV-A Fire Resistance Ratings (FRR)

IV-A

	FRR	Min. NC Protection
Primary Frame FRR	3 HR (2 HR at Roof)	120 min (80 min at Roof)
Ext or Int Bearing Wall FRR	3 HR	120 min
Floor Construction FRR	2 HR	80 min
Roof Construction FRR	1.5 HR	80 min

½” Type X Gypsum = 25 min | 5/8” Type X Gypsum = 40 min

Credit: Urban One

Noncombustible Protection (NC)

Where timber is required to be protected, NC must contribute at least 2/3 FRR

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

Noncombustible Protection (NC)

The definition of "Noncombustible Protection (For Mass Timber)" is created to address the passive fire protection of mass timber.

Mass timber is permitted to have its <u>own</u> fire-resistance rating (e.g., Mass Timber only) or have a fire resistance rating based on the fire resistance through a <u>combination</u> of the mass timber fire-resistance plus protection by non-combustible materials as defined in Section 703.5 (e.g., additional materials that delay the combustion of mass timber, such as gypsum board).

Credit: Urban One

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

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

MT Fire Resistance Ratings (FRR)

However, FRR Doesn't always need to be from a combination of MT + NC. In some cases, just NC can be used, in other cases, just MT can be used:

IBC 602.4

Mass timber elements shall meet the fire resistance rating requirements of this section based on <u>either</u> the fire resistance rating of the noncombustible protection, the mass timber, <u>or</u> a combination of both.

Credit: Urban One

MT Type IV Minimum Sizes

In addition to meeting FRR, all MT elements must also meet minimum sizes

These minimum sizes have been in place for old type IV (current type IV-HT) construction and the same minimums sizes also apply to MT used in new types IV-A, IV-B and IV-C

Contained in 2021 IBC 2304.11
(2015 IBC Chap 6)

Photo:: Ema Peter

Type IV Minimum Sizes - Framing

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

Minimum Width by Depth in Inches
See IBC 2018 2304.11 or IBC 2015 602.4 for Details

*3" nominal width allowed where sprinklered


Photo: WoodWorks

Type IV Minimum Sizes – Floor/Roof Panels

Floor Panels/Decking:

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

Roof Panels/Decking:

- 3” thick CLT (nominal thickness)
- 3” NLT/DLT/GLT (nominal thickness)
- 2” decking (nominal thickness)
- 1-1/8” WSP

Photo: StructureCraft

Photos: Aitor Sanchez/ Ewing Cole

Photo: LEVER Architecture

MT Type IV Minimum Sizes – Walls

Exterior Walls for Type IV-A B C

- CLT or Non-combustible

Exterior Walls for Type IV-HT

- CLT or FRTW or Non-combustible
- IBC 2018 - 6” Thick Wall (FTW or CLT)
- IBC 2021 - 4” Thick CLT

MT Type IV Minimum Sizes – Walls

<u>MT Interior Walls in all Type IV:</u>

- Laminated construction 4” thick
- Solid wood construction min. 2 layers of 1” matched boards

<u>Other Interior Walls in Type IV A,B,C</u>

- Non-combustible (0 hr for nonbearing)

<u>Other Interior Walls in Type IV HT</u>

- Non-combustible (1 hr min)
- Wood stud wall (1 hr min)

Verify other code requirements for FRR (eg. interior bearing wall; occupancy separation)

Type IV-A Fire Resistance Ratings (FRR)

IV-A

FRR Examples:

<u>Primary Structural Frame (Beam, Column, Bearing Wall):</u>

3 HR Required

NC protection = at least 120 min

- Use 3 layers of 5/8" type X Gypsum = 120 min (2 HR)
  Mass Timber FRR req'd = 3 HR – 2 HR = 1 HR

Type IV-A Fire Resistance Ratings (FRR)

IV-A

FRR Examples:

<u>Floor Panels:</u>

2 HR Required

NC Protection = at least 80 min

- Use 2 layers of 5/8" type X Gypsum = 80 min (1.33 HR), <u>plus</u>:
  - Mass Timber FRR req'd = 2 HR – 1.33 HR = 40 min, <u>or</u>
- Use 3 layers of 5/8" Type X Gypsum = 120 min (2 HR) and <u>no FRR from MT</u> req'd

Type IV-A Protection

IV-A

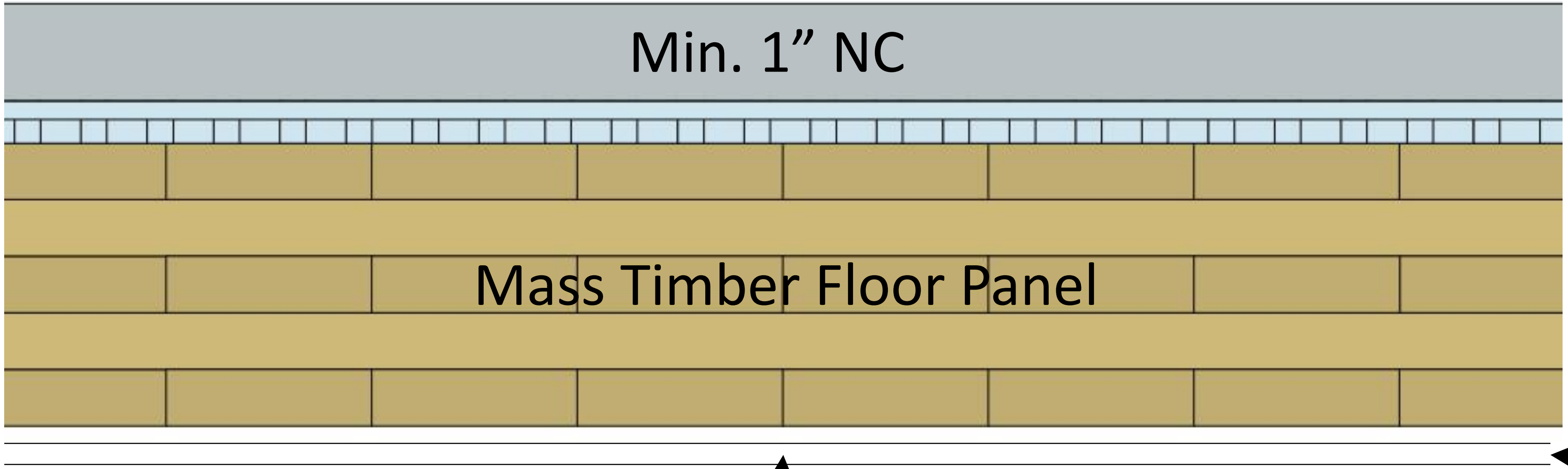
Floor Surface Protection	Min. 1 inch of NC protection
Roof Construction Protection	Min. 2 layers 5/8” type X gyp on inside face
Ext Wall Protection	Min. 1 layer 5/8” type X gyp on outside face Min. 2 layers 5/8” type X gyp on inside face (non-brng) Min. 3 layers 5/8” type X gyp on inside face (brng)

Credit: Maxxon

Type IV-A Fire Resistance Ratings (FRR)

IV-A

FRR & NC Floor Panel Example: 2 HR



40 minutes
of MT FRR

+

2 layers 5/8” type
X gypsum

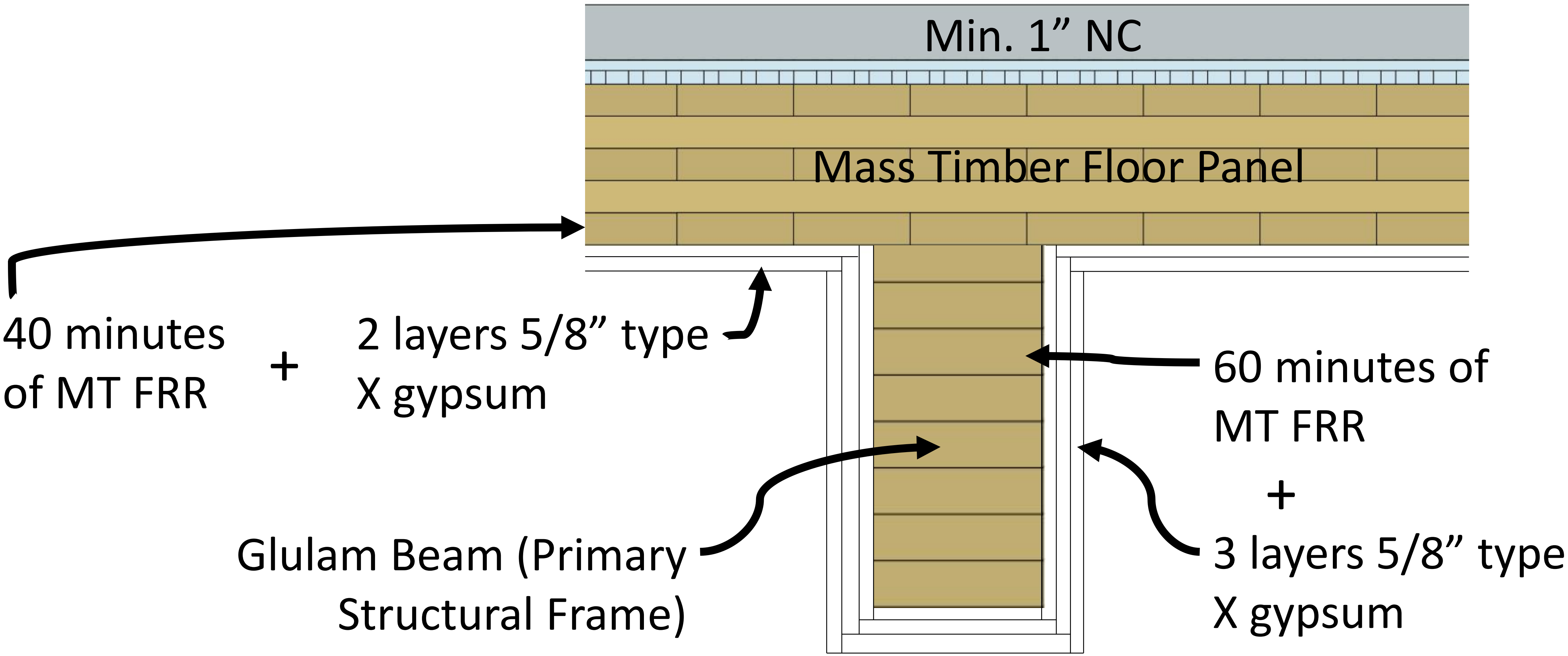
OR

3 layers 5/8” type
X gypsum

Type IV-A Fire Resistance Ratings (FRR)

IV-A

Primary Frame (3 HR) + Floor Panel Example (2 HR):



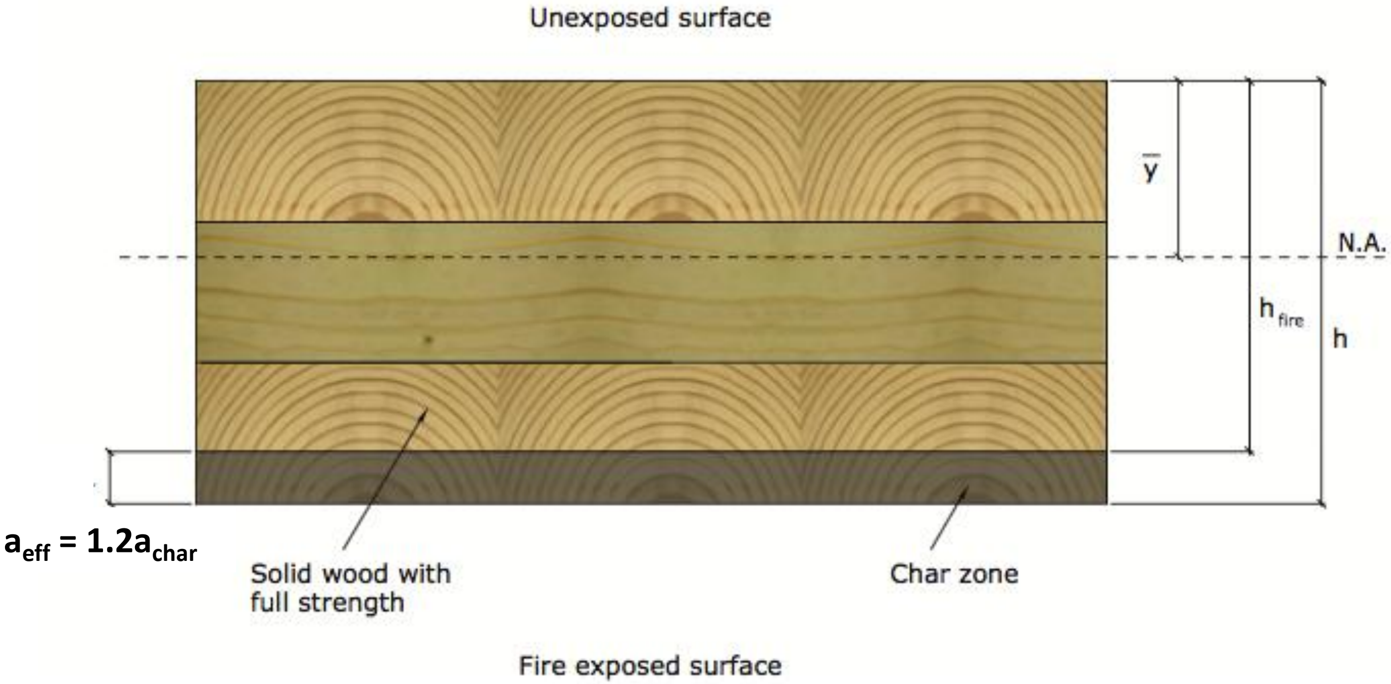
MT Fire Resistance Ratings (FRR)

How do you determine FRR of MT?

2 Options:

1. **Calculations in Accordance with IBC 722 → NDS Chapter 16**
2. **Tests in Accordance with ASTM E119**

Credit: Urban One



MT Fire Resistance Ratings (FRR)

MT FRR Calculations Method:

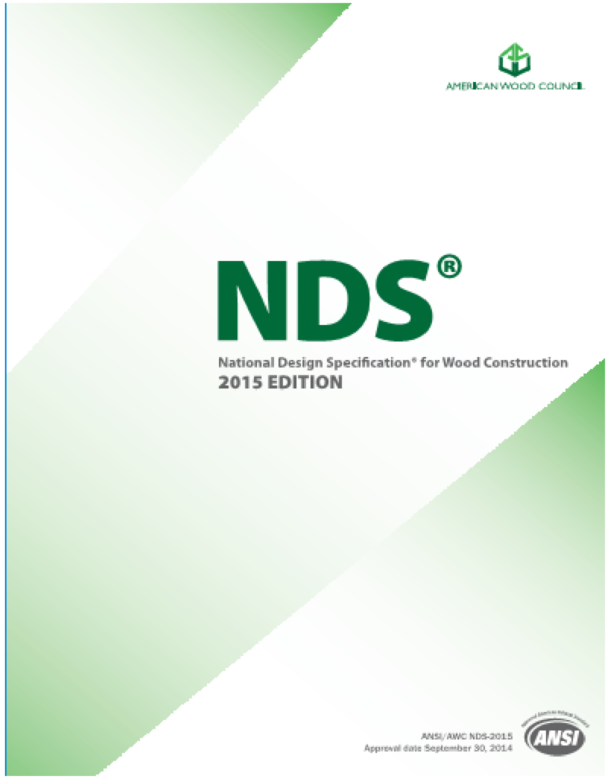
- **IBC 703.3 allows several methods of determining FRR. One is calculations per 722.**
- **722.1 refers to NDS Chapter 16 for exposed wood FRR**

703.3 Methods for determining fire resistance. The application of any of the methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E119 or UL 263. The required *fire resistance* of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures:

3. Calculations in accordance with Section 722.

722.1 General. The provisions of this section contain procedures by which the *fire resistance* of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated *fire resistance* of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with ACI 216.1/TMS 0216. The calculated *fire resistance* of steel assemblies shall be permitted in accordance with Chapter 5 of ASCE 29. The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AF&PA *National Design Specification for Wood Construction (NDS)*.

MT Fire Resistance Ratings (FRR)




NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION 149

FIRE DESIGN OF WOOD MEMBERS

16.1	General	150
16.2	Design Procedures for Exposed Wood Members	150
16.3	Wood Connections	151
Table 16.2.1	Effective Char Rates and Char Layer Thicknesses (for β_n = 1.5 in./hr.)	150
Table 16.2.2	Adjustment Factors for Fire Design	151

16

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

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

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

MT Fire Resistance Ratings (FRR)

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

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

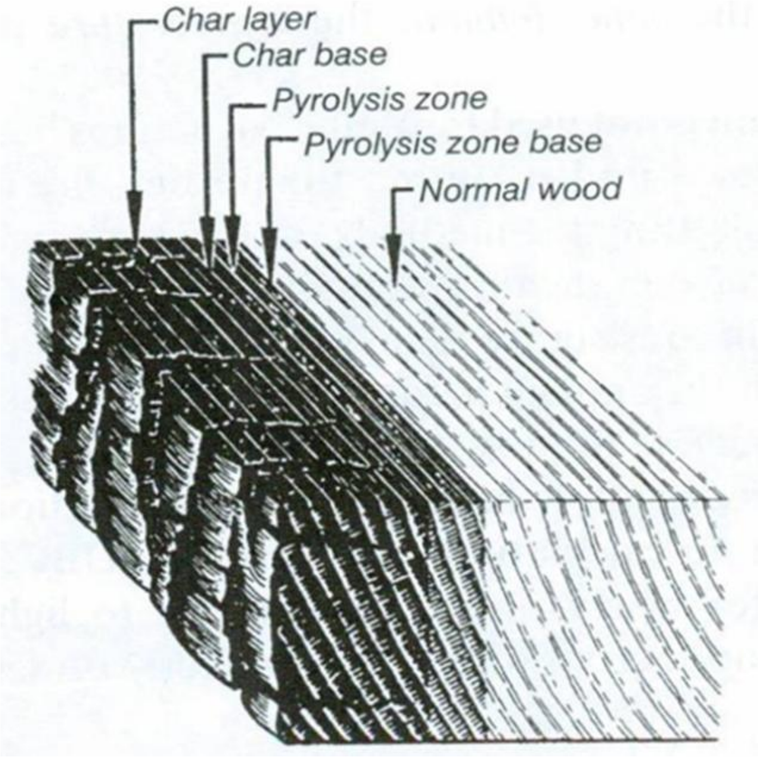
Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

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

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

MT Fire Resistance Ratings (FRR)

Structural capacity check performed on remaining section, with stress increases



Credit: Forest Products Laboratory

Table 16.2.2 Adjustment Factors for Fire Design[1]

			ASD					
			Design Stress to Member Strength Factor	Size Factor[2]	Volume Factor[2]	Flat Use Factor[2]	Beam Stability Factor[3]	Column Stability Factor[3]
Bending Strength	F_b	x	2.85	C_F	C_V	C_{fu}	C_L	-
Beam Buckling Strength	F_{bE}	x	2.03	-	-	-	-	-
Tensile Strength	F_t	x	2.85	C_F	-	-	-	-
Compressive Strength	F_c	x	2.58	C_F	-	-	-	C_P
Column Buckling Strength	F_{cE}	x	2.03	-	-	-	-	-

$$a_{char} = \beta_t t^{0.813}$$ **Solid Sawn, Glulam, SCL**

$$a_{char} = n_{lam} h_{lam} + \beta_t \left(t - \left(n_{lam} t_{gi}\right)\right)^{0.813}$$ **CLT**

$$a_{eff} = 1.2 a_{char}$$ **Effective Char Depth**

MT Fire Resistance Ratings (FRR)

Tested Assemblies Method:

- **Many successful Mass Timber ASTM E119 fire tests have been completed by industry & manufacturers**

NGC Testing Services — Fire Testing Laboratory — IAS ACCREDITED Testing Laboratory TL-216

TEST REPORT for American Wood Council — Page 1 of 53

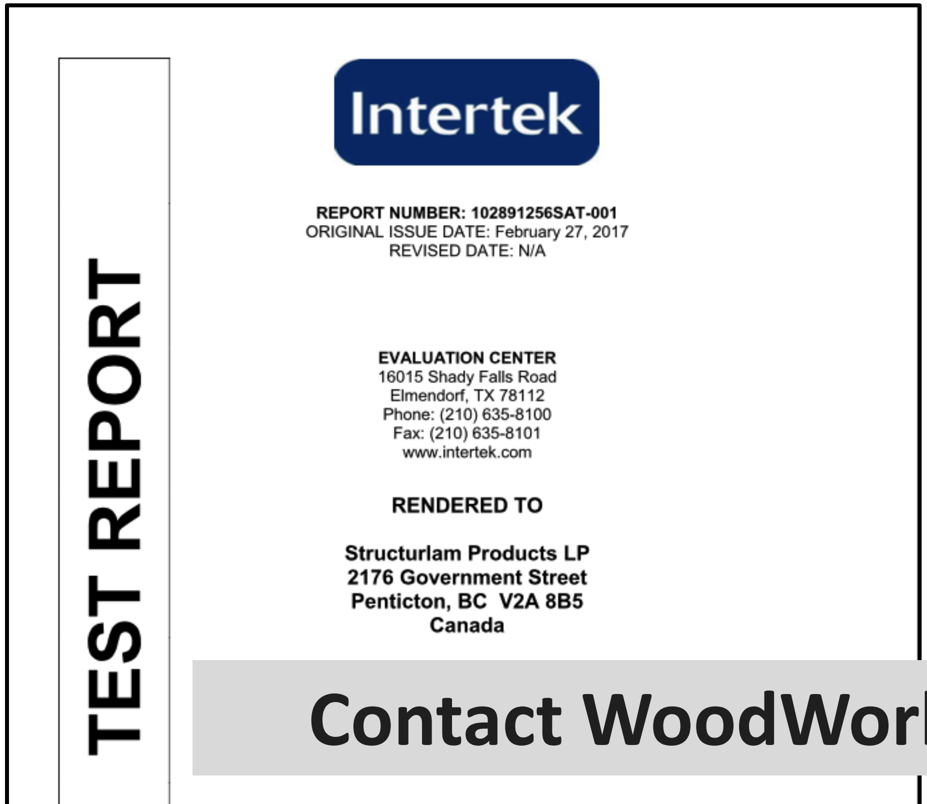
222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

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

Test Report No: WP-1950
Assignment No: K-1089
Subject Material: Cross-Laminated Timber and Gypsum Board Wall Assembly (Load-Bearing)
Test Date: October 4, 2012
Report Date: October 15, 2012

Prepared by: Michael J. Rizzo, Test Engineer

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



TEST REPORT

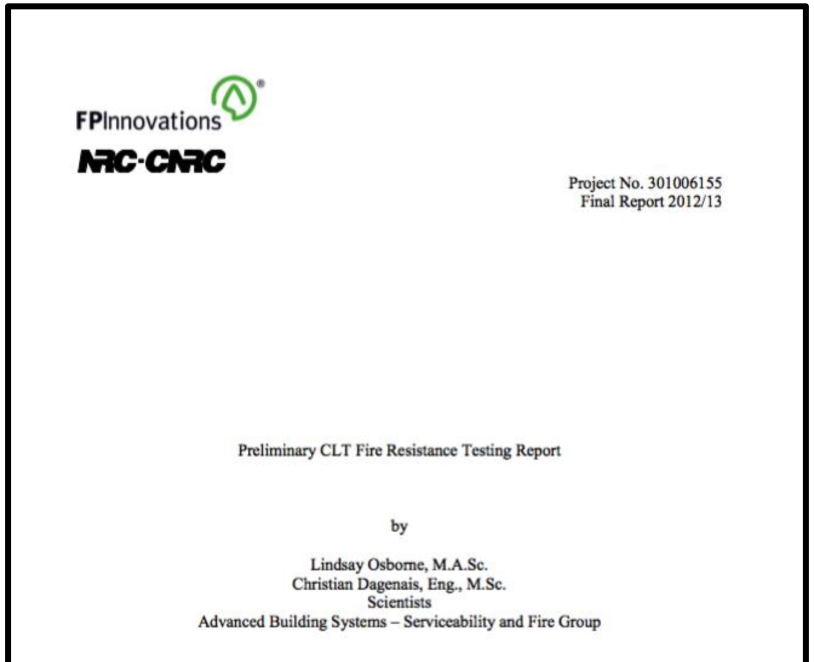
Intertek

REPORT NUMBER: 102891256SAT-001
ORIGINAL ISSUE DATE: February 27, 2017
REVISED DATE: N/A

EVALUATION CENTER
16015 Shady Falls Road
Elmendorf, TX 78112
Phone: (210) 635-8100
Fax: (210) 635-8101
www.intertek.com

RENDERED TO

Structurlam Products LP
2176 Government Street
Penticton, BC V2A 8B5
Canada



FPInnovations — NRC-CNRC

Project No. 301006155
Final Report 2012/13

Preliminary CLT Fire Resistance Testing Report

by

Lindsay Osborne, M.A.Sc.
Christian Dagenais, Eng., M.Sc.
Scientists
Advanced Building Systems – Serviceability and Fire Group

Contact WoodWorks for Inventory of Tests

MT Fire Resistance Ratings (FRR)

Inventory of Fire Tested MT Assemblies

Table 1: North American Fire Resistance Tests of Mass Timber Floor / Roof Assemblies

WoodWorks WOOD PRODUCTS COUNCIL

CLT Panel	Manufacturer	CLT Grade or Major x Minor Grade	Ceiling Protection	Panel Connection in Test	Floor Topping	Load Rating	Fire Resistance Achieved (Hours)	Source	Testing Lab
3-ply CLT (114mm 4.488 in)	Nordic	SPF 1650 Fb 1.5EMSR x SPF #3	2 layers 1/2" Type X gypsum	Half-Lap	None	Reduced 36% Moment Capacity	1	1 (Test 1)	NRC Fire Laboratory
3-ply CLT (105mm 4.133 in)	Structurlam	SPF #1/#2 x SPF #1/#2	1 layer 5/8" Type X gypsum	Half-Lap	None	Reduced 75% Moment Capacity	1	1 (Test 5)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	Nordic	E1	None	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	2	NRC Fire Laboratory March 2016
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer of 5/8" Type X gypsum under Z-channels and furring strips with 3 5/8" fiberglass batts	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	5	NRC Fire Laboratory Nov 2014
5-ply CLT (175mm 6.875")	Nordic	E1	None	Topside Spline	3/4 in. proprietary gypcrete over Maxxon acoustical mat	Reduced 50% Moment Capactiy	1.5	3	UL
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer 5/8" normal gypsum	Topside Spline	3/4 in. proprietary gypcrete over Maxxon acoustical mat or proprietary sound board	Reduced 50% Moment Capactiy	2	4	UL
5-ply CLT (175mm 6.875")	Nordic	E1	1 layer 5/8" Type X Gyp under Resilient Channel under 7 7/8" I-Joists with 3 1/2" Mineral Wool beween Joists	Half-Lap	None	Loaded, See Manufacturer	2	21	Intertek 8/24/2012
5-ply CLT (175mm 6.875")	Structurlam	E1 M5 MSR 2100 x SPF #2	None	Topside Spline	1-1/2" Maxxon Cyp-Crete 2000 over Maxxon Reinforcing Mesh	Loaded, See Manufacturer	2.5	6	Intertek, 2/22/2016
5-ply CLT (175mm 6.875")	DR Johnson	V1	None	Half-Lap & Topside Spline	2" gypsum topping	Loaded, See Manufacturer	2	7	SwRI (May 2016)
5-ply CLT (175mm 6.875")	Nordic	SPF 1950 Fb MSR x SPF #3	None	Half-Lap	None	Reduced 59% Moment Capacity	1.5	1 (Test 3)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	Structurlam	SPF #1/#2 x SPF #1/#2	1 layer 5/8" Type X gypsum	Half-Lap	None	Unreduced 101% Moment Capacity	2	1 (Test 6)	NRC Fire Laboratory
7-ply CLT (245mm 9.65")	Structurlam	SPF #1/#2 x SPF #1/#2	None	Half-Lap	None	Unreduced 101% Moment Capacity	2.5	1 (Test 7)	NRC Fire Laboratory
5-ply CLT (175mm 6.875")	SmartLam	SL-V4	None	Half-Lap	nominal 1/2" plywood with 8d nails.	Loaded, See Manufacturer	2	12 (Test 4)	Western Fire Center 10/26/2016
5-ply CLT (175mm 6.875")	SmartLam	V1	None	Half-Lap	nominal 1/2" plywood with 8d nails.	Loaded, See Manufacturer	2	12 (Test 5)	Western Fire Center 10/28/2016
5-ply CLT (175mm 6.875")	DR Johnson	V1	None	Half-Lap	nominal 1/2" plywood with 8d nails.	Loaded, See Manufacturer	2	12 (Test 6)	Western Fire Center 11/01/2016
5-ply CLT (160mm 6.3")	KLH	CV3M1	None	Half-Lap & Topside spline	None	Loaded, See Manufacturer	1	18	SwRI [illegible]

MT Fire Resistance Ratings (FRR)

WoodWorks™
WOOD PRODUCTS COUNCIL

Fire-Resistive Design of Mass Timber Members

Code Applications, Construction Types and Fire Ratings

Richard McLain, PE, SE • Senior Technical Director • WoodWorks
Scott Breneman, PhD, PE, SE • Senior Technical Director • WoodWorks

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

Today, one of the exciting trends in building design is the growing use of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction. Like heavy timber, mass timber products have inherent fire resistance that allows them to be left exposed and still achieve a fire-resistance rating. Because of their strength and dimensional stability, these products also offer a low-carbon alternative to steel, concrete, and masonry for many applications. It is this combination of exposed structure and strength that developers and designers across the country are leveraging to create innovative designs with a warm yet modern aesthetic, often for projects that go beyond traditional norms of wood design.

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

Mass Timber & Construction Type

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

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

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

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

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

Carbon12 | Portland, Oregon
Kaiser Group | Path Architecture
Munzing Structural Engineering

Mass Timber Fire Design Resource

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

Tall Timber Fire-Resistance Design

WoodWorks™
WOOD PRODUCTS COUNCIL

TECHNICAL BRIEF

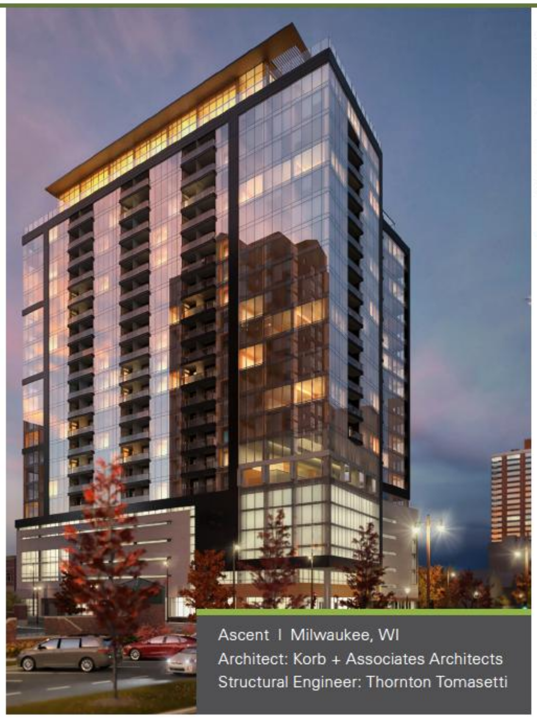
Demonstrating Fire-Resistance Ratings for Mass Timber Elements in Tall Wood Structures

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

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 to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703.*

FRRs for the new construction types are similar to those required for Type I construction, which is primarily steel and concrete.[1] (See Table 1.) They are found in IBC Table 601, which includes FRR requirements for all construction types and building elements; however, other code sections should be checked for overriding provisions (e.g., occupancy separation, shaft enclosures, etc.) that may alter the requirement.



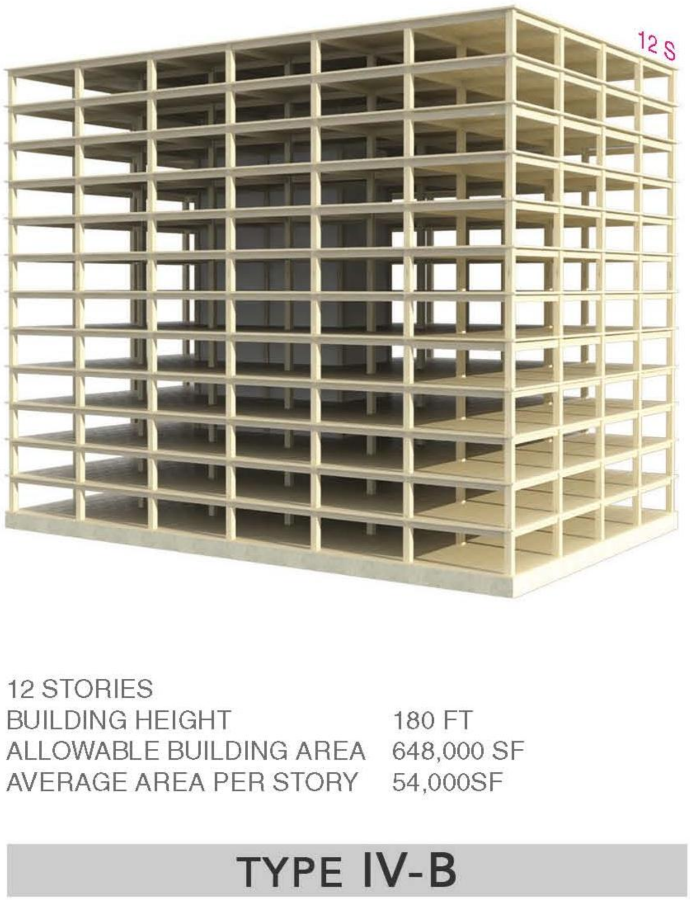
Ascent | Milwaukee, WI
Architect: Korb + Associates Architects
Structural Engineer: Thornton Tomasetti

Image: Korb + Associates Architects

TABLE 1:
FRR Requirements (Hours) for Tall Mass Timber Construction Types and Existing Type I

Building Element	I-A Unlimited stories,	IV-A Max. 18 stories,	I-B Max. 12 stories,	IV-B Max. 12 stories,	IV-C Max. 9 stories,
Interior Bearing Walls	3	3	2	2	2
Roof Construction	1.5	1.5	1	1	1

Type IV-B

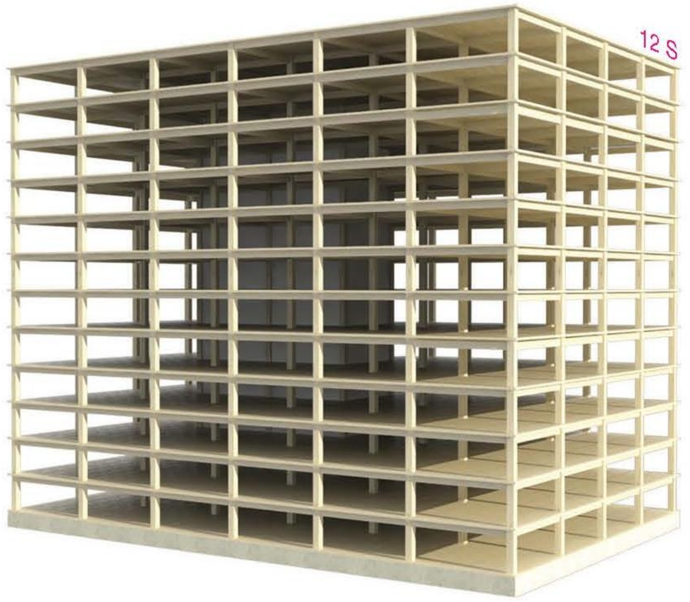


Credit: Susan Jones, atelierjones

Credit: LEVER Architecture

IV-B

Type IV-B Height and Area Limits



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

TYPE IV-B

Credit: Susan Jones, atelierjones

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	12	180 ft	90,000 SF	270,000 SF
B	12	180 ft	216,000 SF	648,000 SF
M	8	180 ft	123,000 SF	369,000 SF
R-2	12	180 ft	123,000 SF	369,000 SF

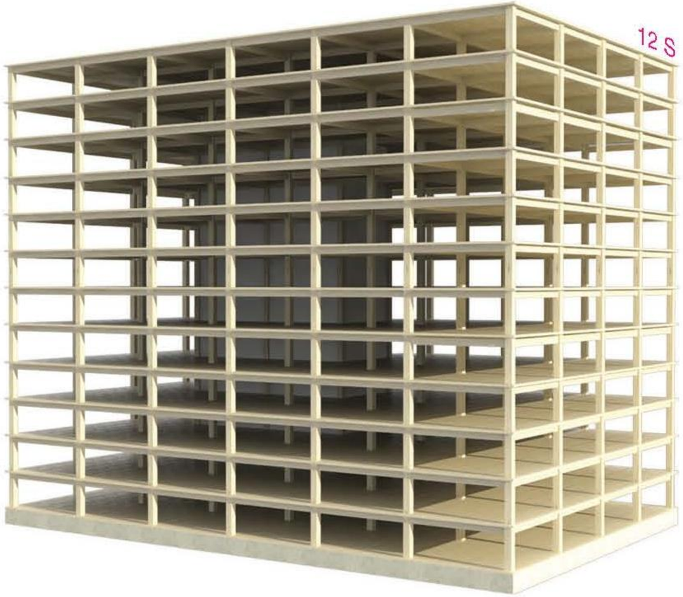
Areas exclude potential frontage increase

In most cases, Type IV-B height & story allowances = Type I-B height & story allowances

Type IV-B area = 2 * Type IV-HT area

Type IV-B Protection vs. Exposed

IV-B



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

TYPE IV-B

Credit: Susan Jones, atelierjones

Credit: Kaiser+Path

NC protection on all surfaces of Mass Timber except limited exposed areas

~20% of Ceiling or ~40% of Wall can be exposed

Type IV-B Fire Resistance Ratings (FRR)

IV-B

Primary Frame FRR	2 HR (1 HR at Roof)
Ext or Int Bearing Wall FRR	2 HR
Floor Construction FRR	2 HR
Roof Construction FRR	1 HR

Type IV-B Fire Resistance Ratings (FRR)

IV-B

***Applicable to most locations. Limited exposed MT permitted**

	FRR	Min. NC Protection
Primary Frame FRR	2 HR (1 HR at Roof)	80 min* (40 min* at Roof)
Ext or Int Bearing Wall FRR	2 HR	80 min*
Floor Construction FRR	2 HR	80 min*
Roof Construction FRR	1 HR	40 min*

½" Type X Gypsum = 25 min | 5/8" Type X Gypsum = 40 min

Credit: Urban One

Type IV-B Protection

IV-B

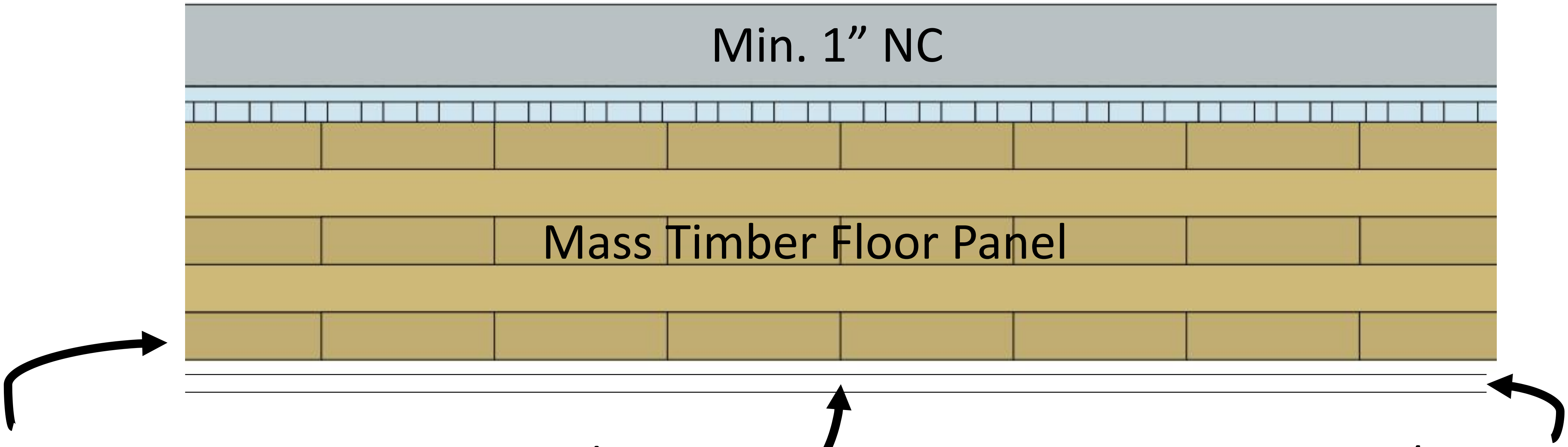
Floor Surface Protection	Min. 1 inch of NC protection
Roof Construction Protection	Min. 1 layer 5/8” type X gyp on inside face*
Ext Wall Protection	Min. 1 layer 5/8” type X gyp on outside face Min. 2 layers 5/8” type X gyp on inside face*

***Applicable to most locations**
Limited exposed MT permitted

Type IV-B Fire Resistance Ratings (FRR)

IV-B

FRR & NC Floor Panel Example: 2 HR



40 minutes of MT FRR* + 2 layers 5/8” type X gypsum* OR 3 layers 5/8” type X gypsum*

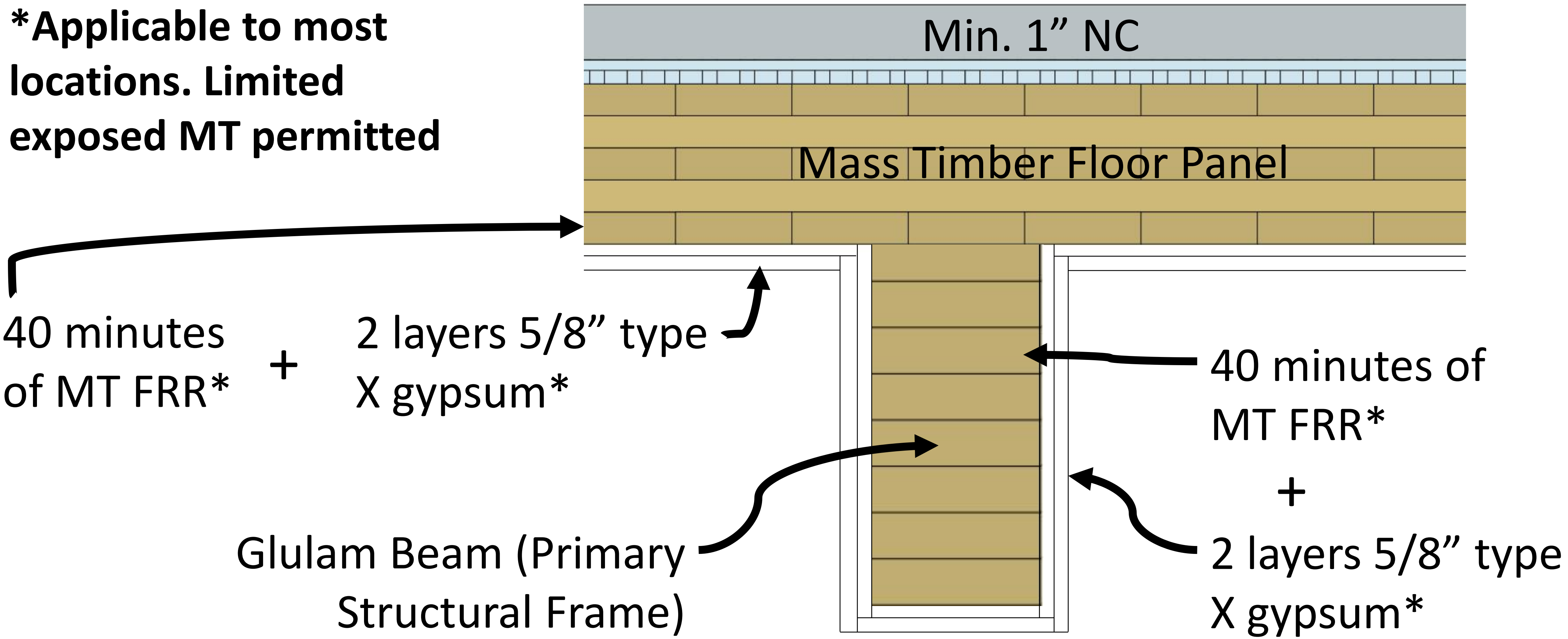
***Applicable to most locations. Limited exposed MT permitted**

Type IV-B Fire Resistance Ratings (FRR)

IV-B

Primary Frame (2 HR) + Floor Panel Example (2 HR):

***Applicable to most locations. Limited exposed MT permitted**



Type IV-B Protection vs. Exposed

IV-B

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 beams up to 20% of floor area in dwelling unit or fire area, <u>or</u>**
- **MT walls and columns up to 40% of floor area in dwelling unit or fire area, <u>or</u>**
- **Combination of ceilings/beams and walls/columns, calculated as follows:**

Credit: Kaiser+Path

Type IV-B Protection vs. Exposed

IV-B

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

IV-B

Design Example: Mixing unprotected MT walls & ceilings

Credit: AWC

800 SF dwelling unit

- U_{ac} = (800 SF)*(0.20) = 160 SF
- U_{aw} = (800 SF)*(0.40) = 320 SF
- Could expose 160 SF of MT ceiling, OR 320 SF of MT Wall, OR
- If desire to expose 100 SF of MT ceiling in Living Room, determine max. area of MT walls that can be exposed

Type IV-B Protection vs. Exposed

IV-B

Design Example: Mixing unprotected MT walls & ceilings

Credit: AWC

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

$$(100/160) + (U_{tw}/320) \leq 1.0$$

$$U_{tw} = 120 \text{ SF}$$

- **Can expose 120 SF of MT walls in dwelling unit in combination with exposing 100 SF of MT ceiling**

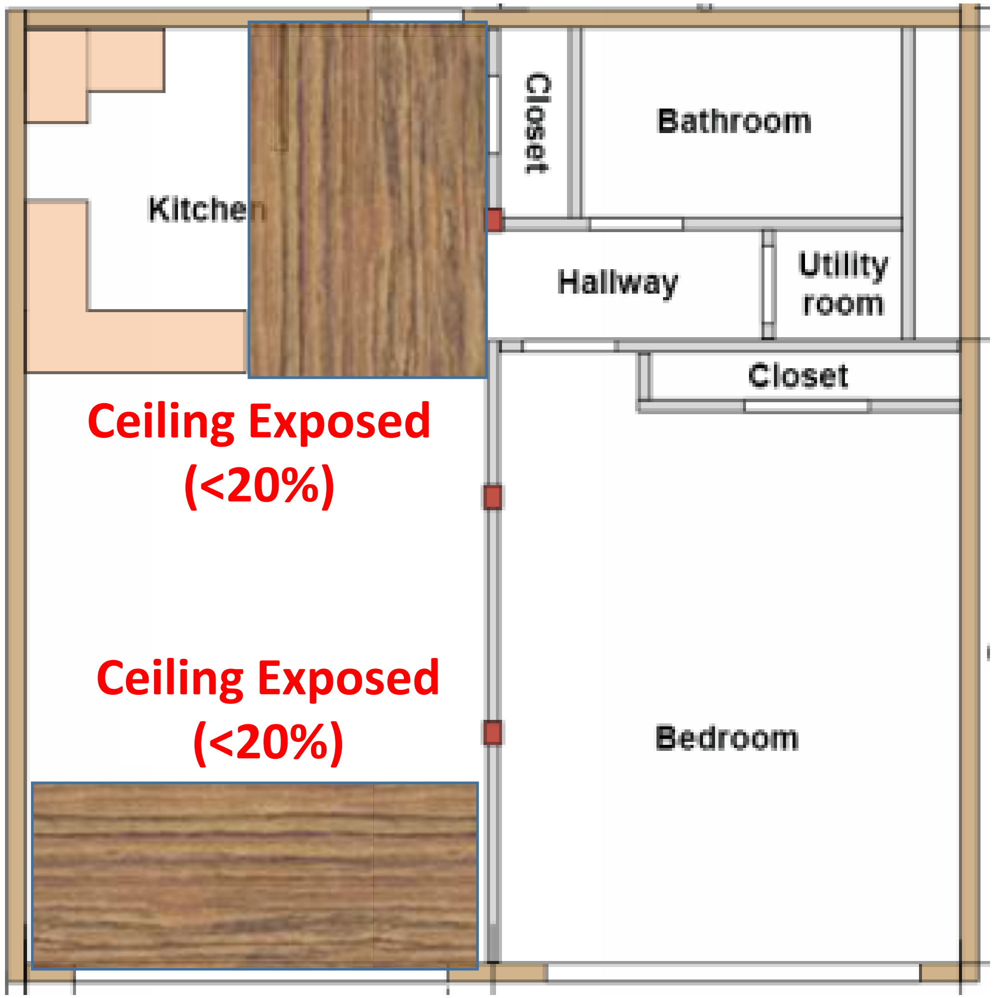
Type IV-B Protection vs. Exposed

IV-B

Credit: AWC

Type IV-B Protection vs. Exposed

IV-B



Credit: AWC

Type IV-B Protection vs. Exposed

IV-B

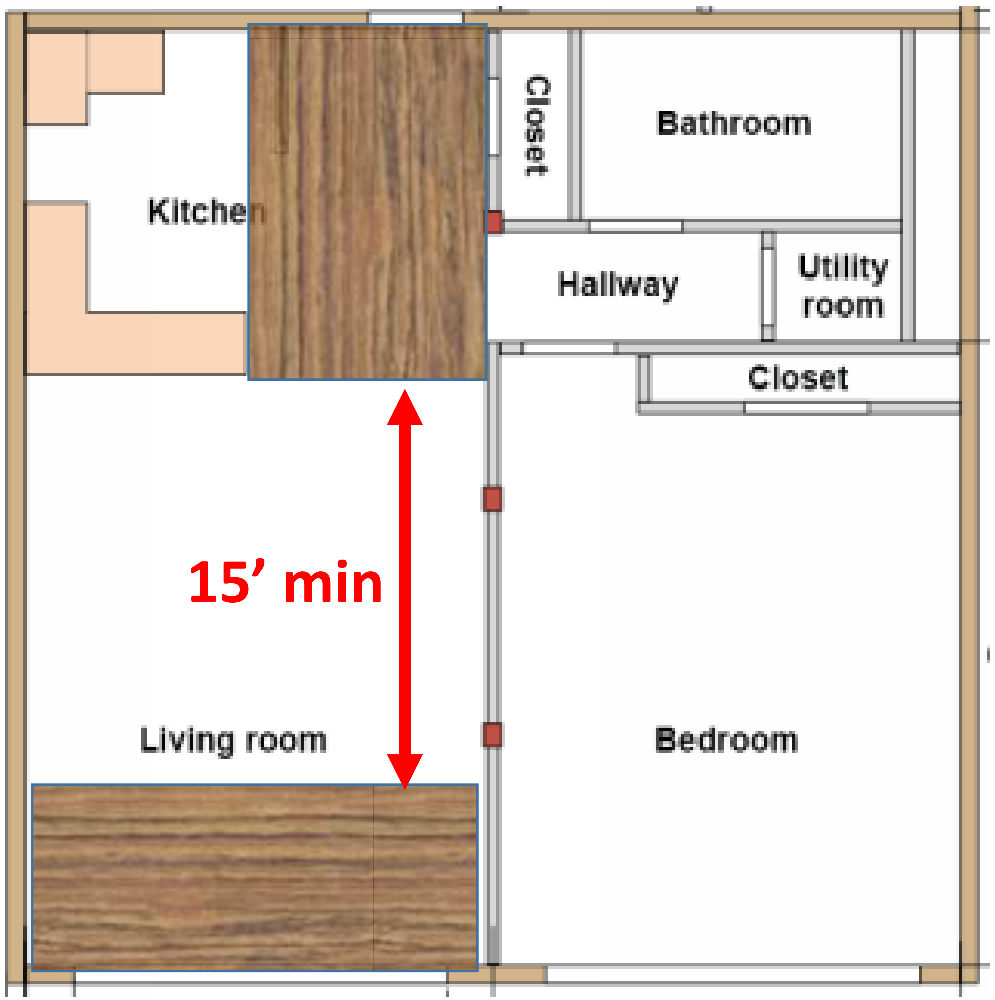
Horizontal separation of unprotected areas:

- 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

IV-B



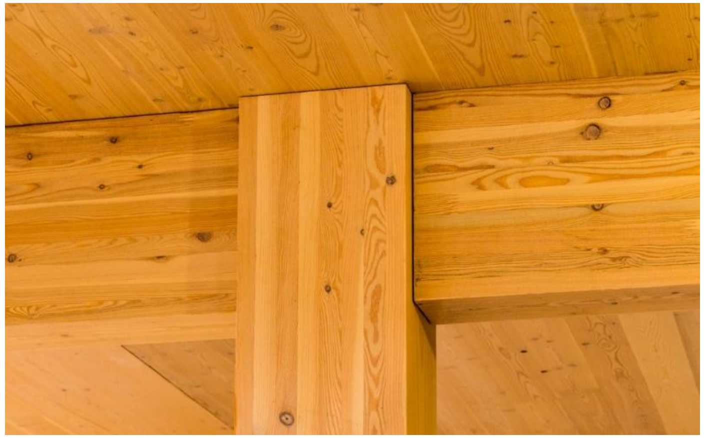
Credit: AWC

Type IV-C

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

TYPE IV-C

Credit: Susan Jones, atelierjones



Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman

Type IV-C Height and Area Limits

IV-C

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

TYPE IV-C

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	6	85 ft	56,250 SF	168,750 SF
B	9	85 ft	135,000 SF	405,000 SF
M	6	85 ft	76,875 SF	230,625 SF
R-2	8	85 ft	76,875 SF	230,625 SF

Areas exclude potential frontage increase

In most cases, Type IV-C height allowances = Type IV-HT height allowances, but add'l stories permitted due to enhanced FRR

Type IV-C area = 1.25 * Type IV-HT area

Credit: Susan Jones, atelierjones

Type IV-C Protection vs. Exposed

IV-C

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

TYPE IV-C

Credit: Susan Jones, atelierjones

Credit: Kaiser+Path, Ema Peter

All Mass Timber surfaces may be exposed

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

Type IV-C Fire Resistance Ratings (FRR)

IV-C

Primary Frame FRR	2 HR (1 HR at Roof)
Ext or Int Bearing Wall FRR	2 HR
Floor Construction FRR	2 HR
Roof Construction FRR	1 HR

Credit: Ema Peter

Same FRR as IV-B, but all MT in IV-C may be exposed*

Type IV-C Protection

IV-C

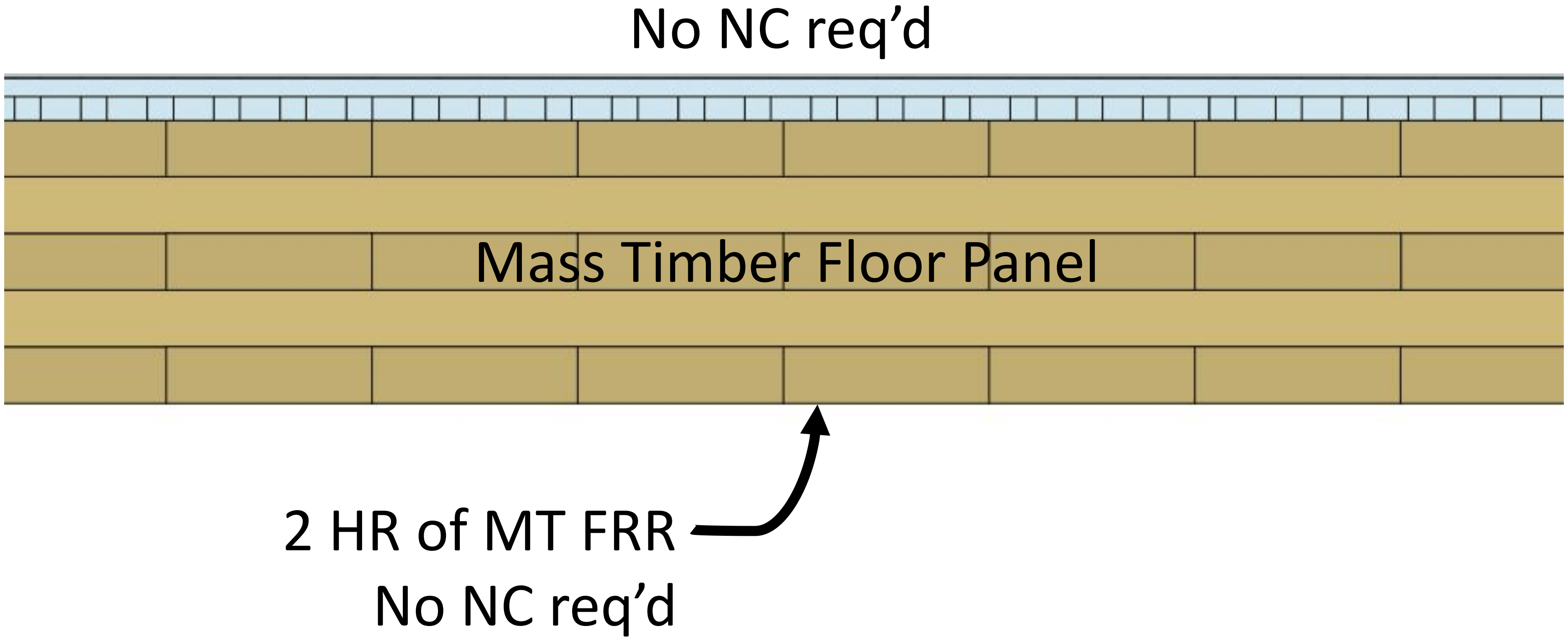
Floor Surface Protection	**None req'd**
Roof Construction Protection	**None req'd**
Ext Wall Protection	**Min. 1 layer 5/8" type X gyp on outside face** **None req'd on inside face**

Credit: Maxxon

Type IV-C Fire Resistance Ratings (FRR)

IV-C

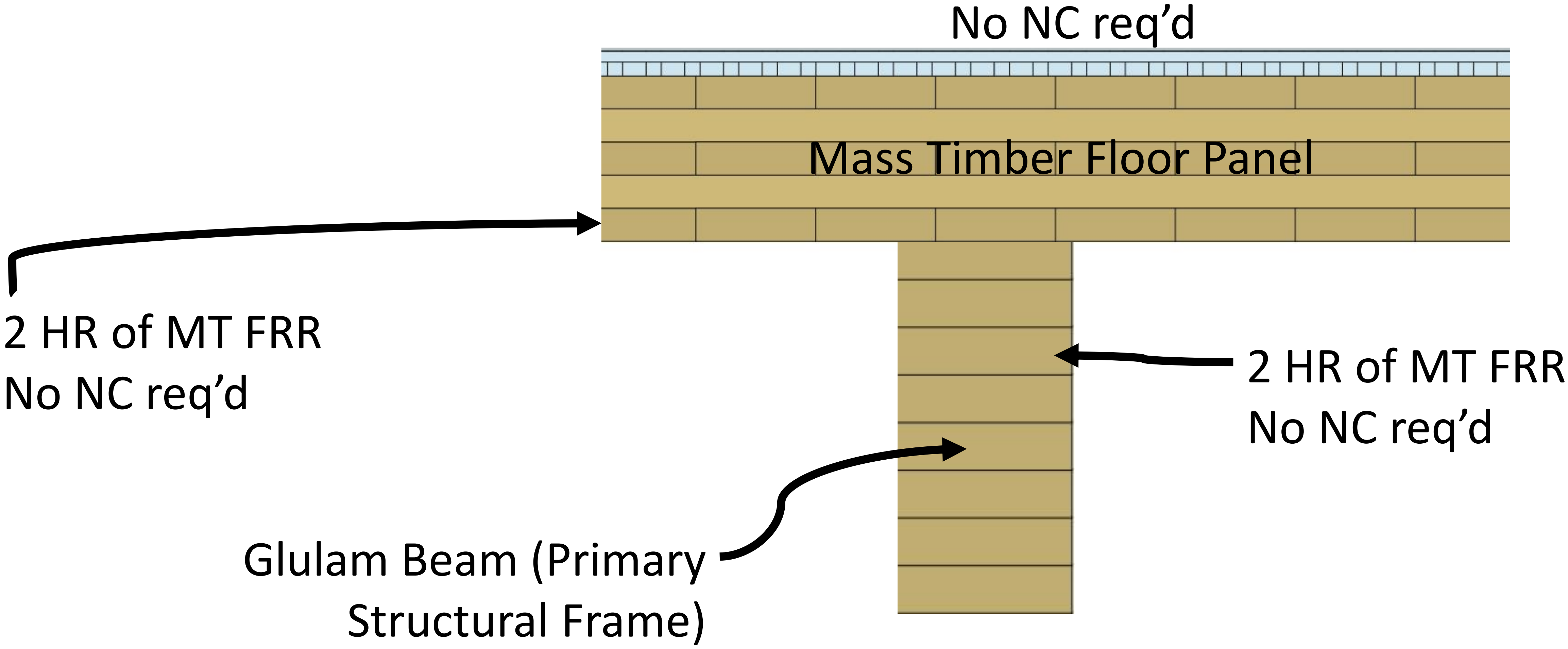
FRR & NC Floor Panel Example: 2 HR



Type IV-C Fire Resistance Ratings (FRR)

IV-C

Primary Frame (2 HR) + Floor Panel Example (2 HR):



Fire Resistance Ratings (FRR) Recap

	IV-A	IV-B	IV-C	IV-HT
Roof Construction	1.5	1	1	HT
Primary Frame @ Roof	2	1	1	HT
Floor Construction	2	2	2	HT
Primary Frame	3	2	2	HT
Exterior Bearing Walls	3	2	2	2
Interior Bearing Walls	3	2	2	1 or HT

Required Fire Resistance Rating in Hours (per Table 601 only)

Noncombustible Protection (NC) Recap

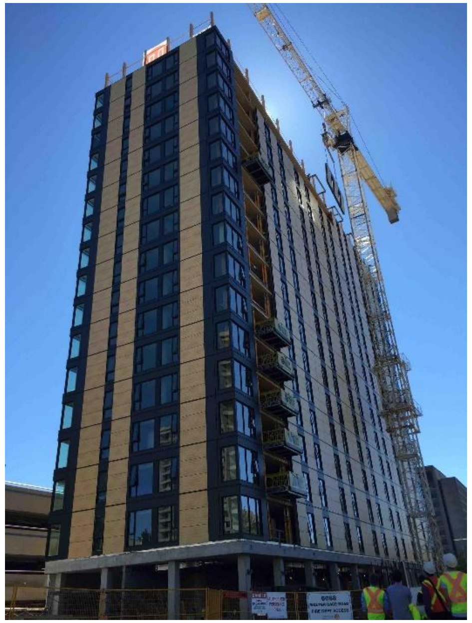
Noncombustible Protection Required

IV-A

IV-B

IV-C

IV-HT



Credit: LEVER Architecture

Credit: PATH Architecture

Photo: Blaine Brownell

Interior Wall Construction Recap

	IV-A	IV-B	IV-C	IV-HT
Fire Rating (bearing wall)	3 Hr	2 Hr	2 Hr	1 Hr or HT*
Construction – MT	Laminated construction 4” thick (CLT, NLT, etc) Solid wood construction min. 2 layers of 1” matched boards			
NC Protection	Per Interior Requirements			No
Noncombustible non-bearing wall	0 Hr			1 Hr
Wood Stud Wall	No			1 Hr

*IBC 2021 requires at least 1 Hr FRR for HT walls supporting 2 levels

Exterior Wall Construction Recap

	IV-A	IV-B	IV-C	IV-HT (IBC 2021)	IV-HT (IBC 2018)
Fire Rating (bearing wall)	3 Hr	2 Hr	2 Hr	2 Hr	2Hr
Mass Timber	Mass Timber/CLT			4" min thick CLT*	6" Wall*
Exterior NC Protection	40 Min NC & No Exterior Combustible Coverings			FRT Sheathing, Gyp or other NC	
Interior NC Protection	Per Interior Requirements			Not Required	
Light Frame FRTW	No			Yes*	6" Wall*

*Changes in IBC 2015, 2018, and 2021 editions

What's the 'Sweet Spot' for Tall Mass Timber?

Depends on many factors:

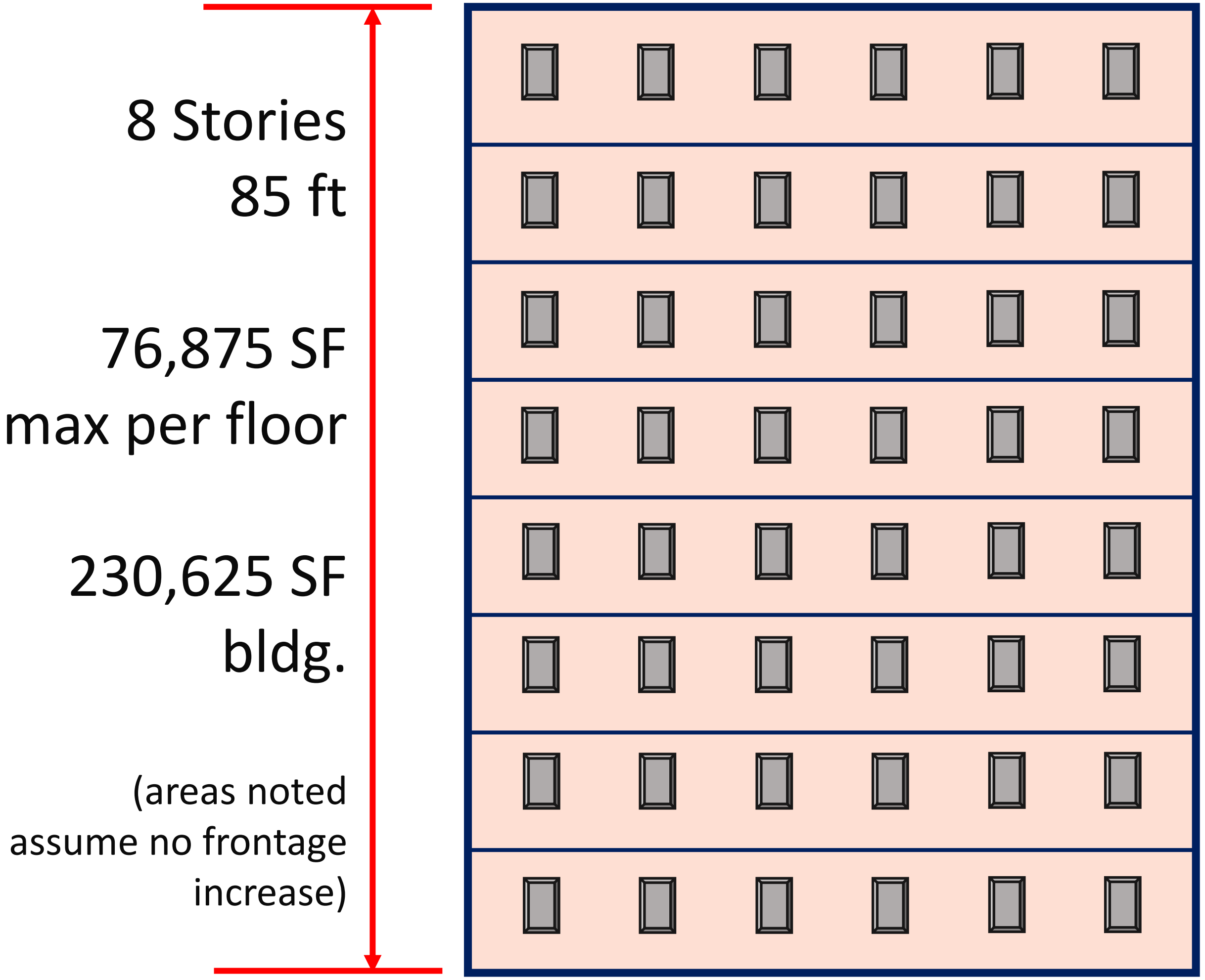
- **Project Use**
- **Site Constraints**
- **Local Zoning & FAR Limitations**
- **Budget**
- **Client Objectives for Sustainability, Exposed Timber**
- **And More…**

But Some General Trends Could Be:

80 M Street, SE, Washington, DC
Photo: Hickok Cole | Architect: Hickok Cole

Type IV-C Tall Mass Timber

Example R-2, Type IV-C Building



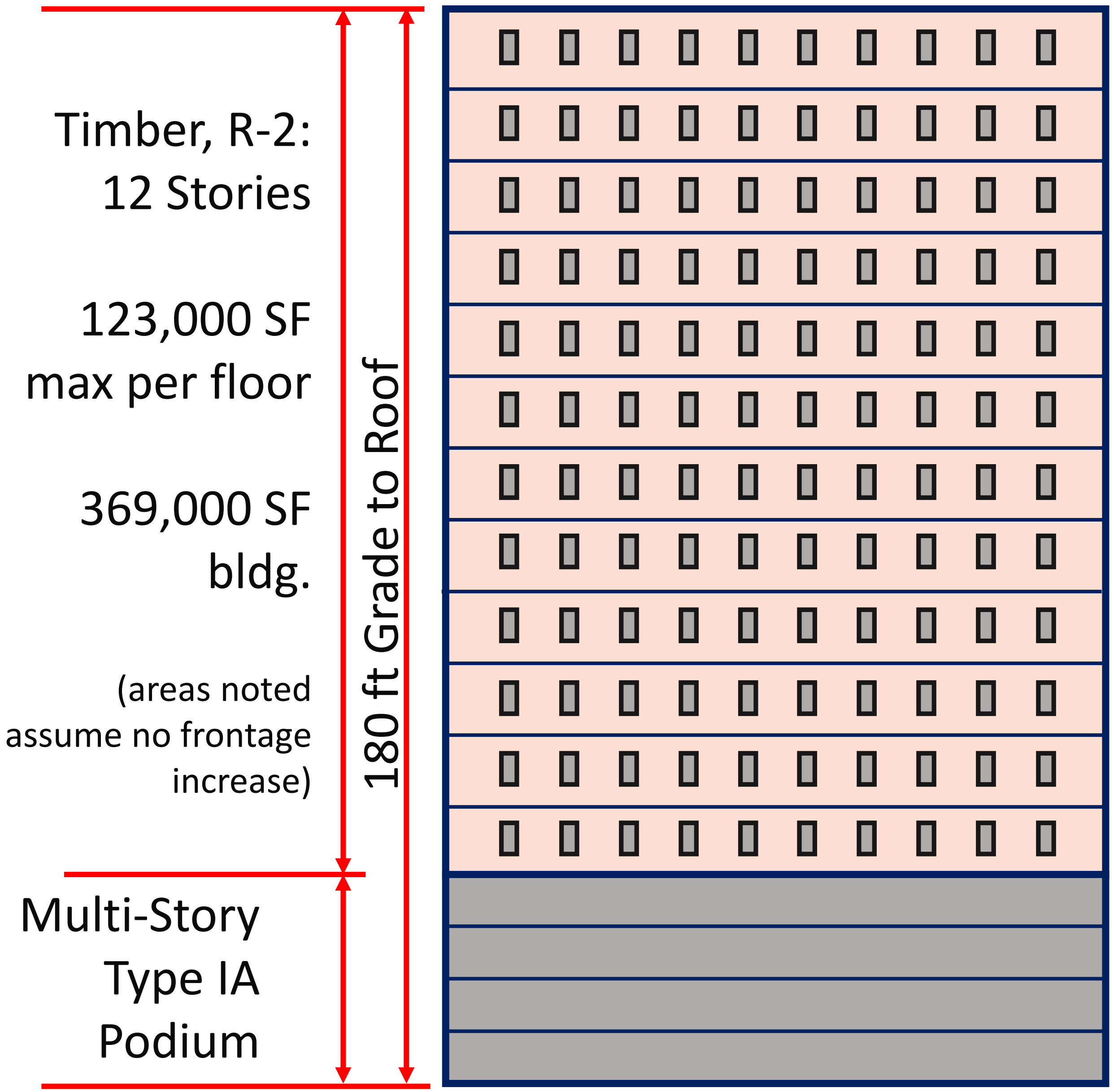
Not Likely to Utilize Podium Due to Overall Building Height Limit (85 ft) Relative to # of Timber Stories (8)

Same Overall Building Height Limit as IV-HT (85 ft) but higher Fire-Resistance Ratings Req'd

3 Additional Stories Permitted Compared to IV-HT

All Timber Exposed

Type IV-B Tall Mass Timber



Example Mixed-Use, Type IV-B Building

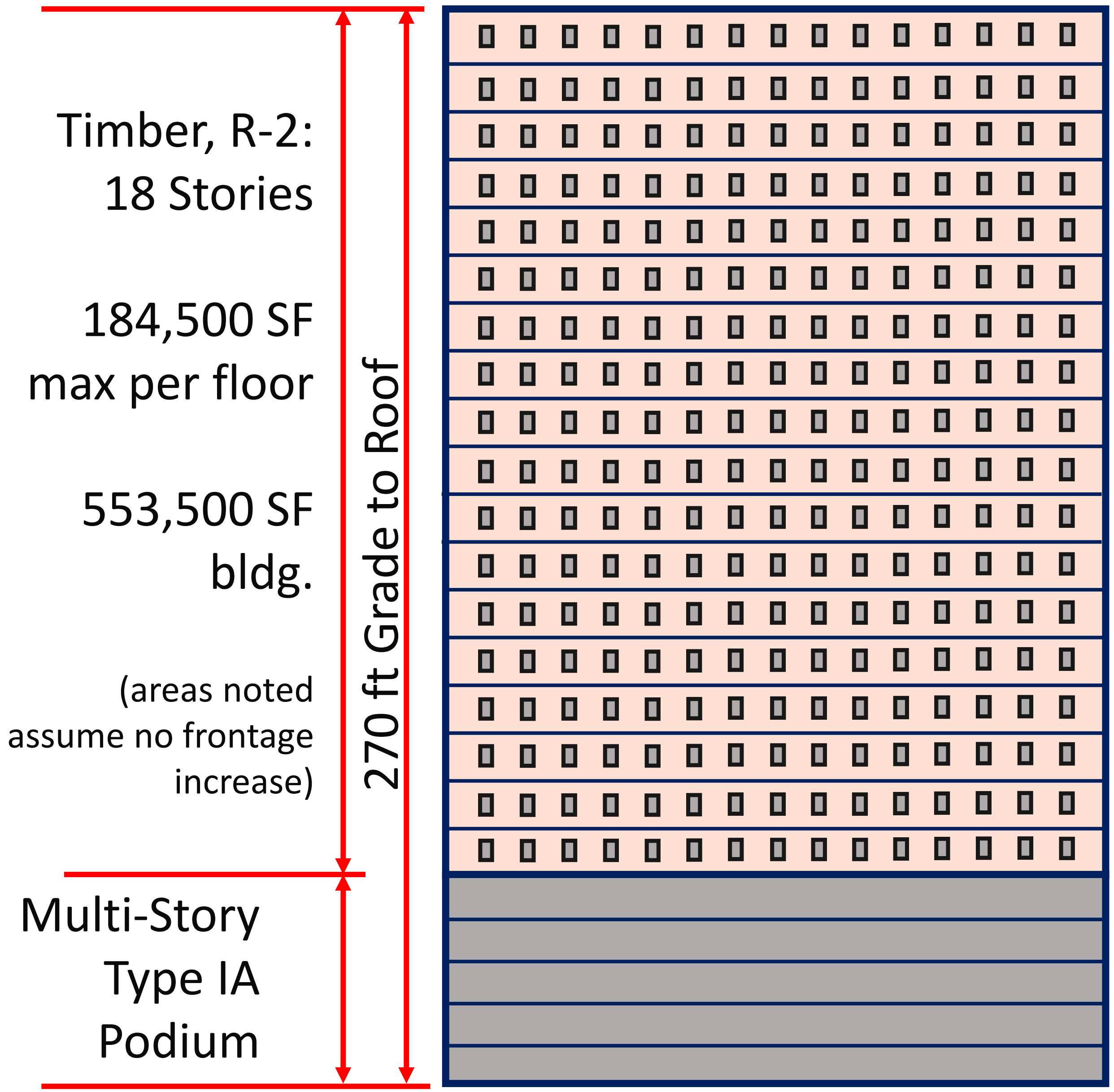
Likely to Utilize Podium Due to Overall Building Height Limit (180 ft) Relative to # of Timber Stories (12)

Same Fire-Resistance Ratings Req'd as IV-C But Limitations on Timber Exposed

4 Additional Stories Permitted Compared to IV-C

Limited Timber Exposed

Type IV-A Tall Mass Timber



Example Mixed-Use, Type IV-A Building

Likely to Utilize Podium Due to Overall Building Height Limit (270 ft) Relative to # of Timber Stories (18)

Higher Fire-Resistance Ratings Req'd than IV-B For Primary Frame

6 Additional Stories Permitted Compared to IV-B

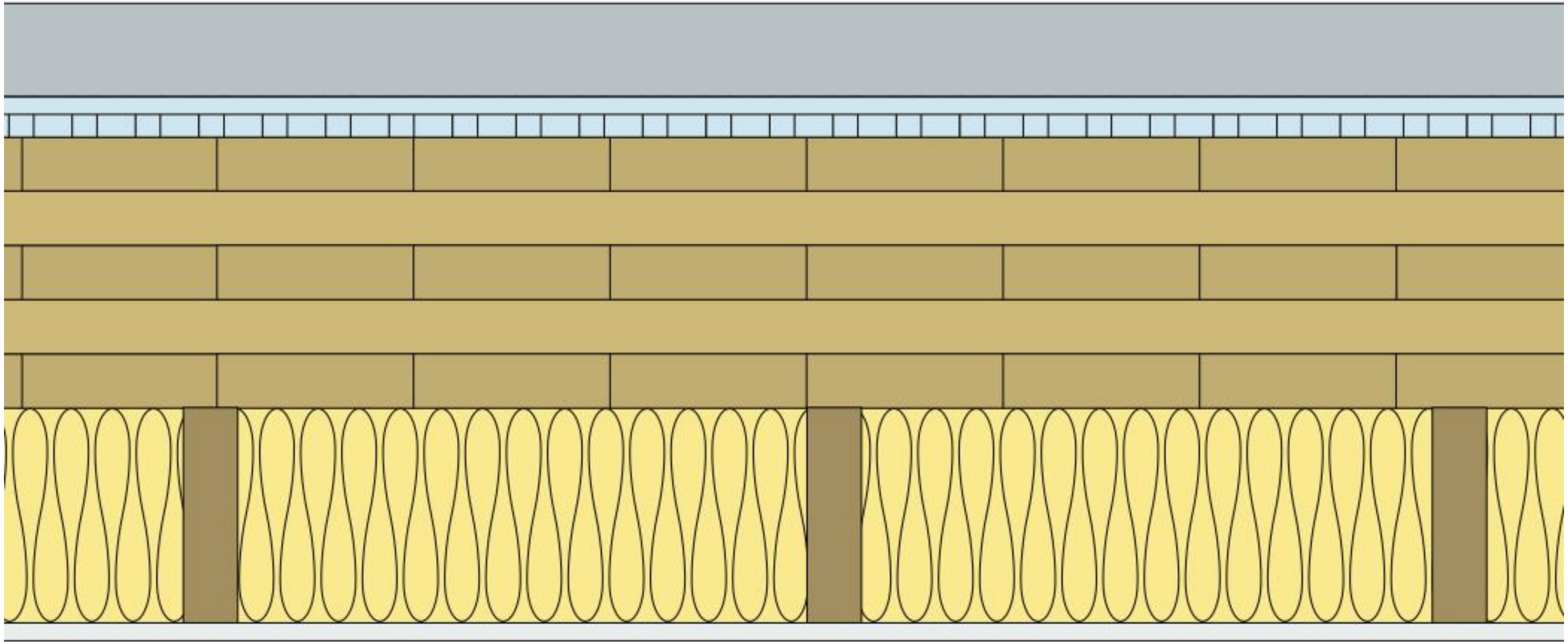
No Exposed Timber Permitted

CONCEALED SPACES IN TYPE IV

Concealed Spaces in Type IV

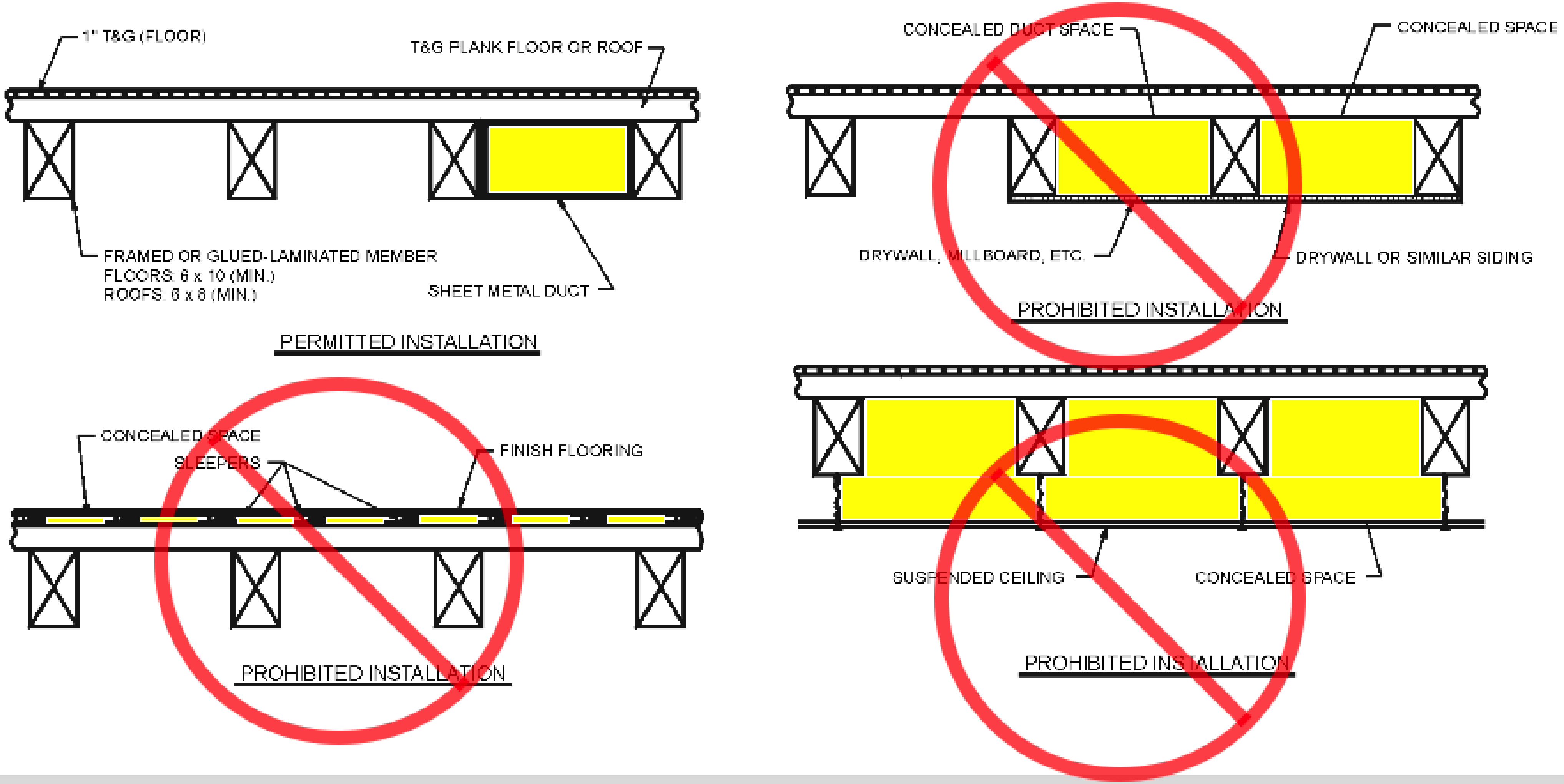
What if I have a dropped ceiling? Can I have a dropped ceiling?

- **Impact on FRR, NC placement, sprinkler requirements**



Concealed Spaces in Type IV

Previous Type IV (now IV-HT) provisions prohibited concealed spaces



Credit: IBC

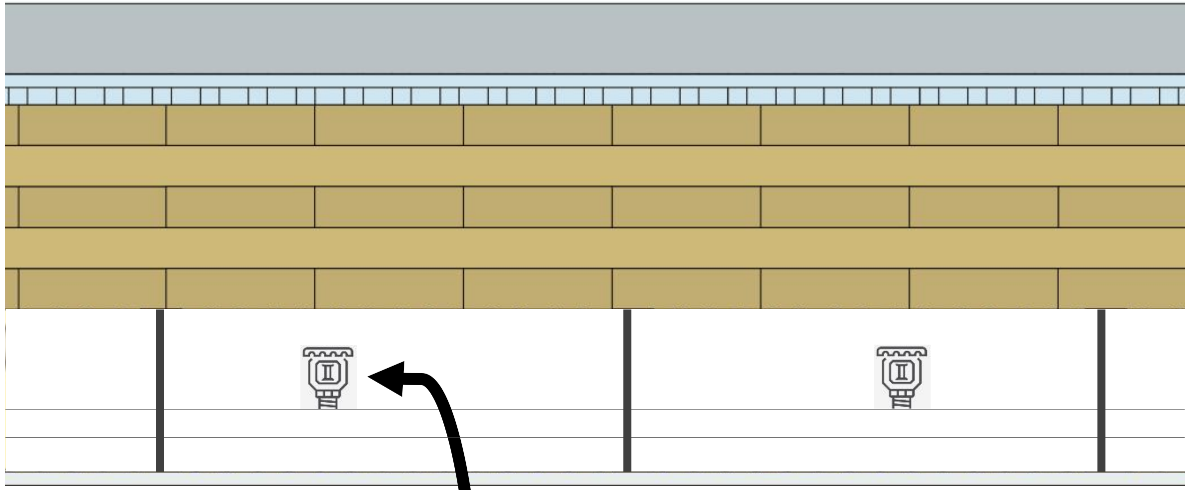
Concealed Spaces in Type IV-HT

Type IV-HT (IBC 2021) permits concealed spaces where one of the following conditions exists:

1. The building is sprinklered throughout with an NFPA 13 Sprinkler and automatic sprinklers are provided in the concealed space.
2. The concealed space is completely filled with noncombustible insulation.
3. Surfaces within the concealed space are fully sheathed with not less than 5/8” Type X gypsum.

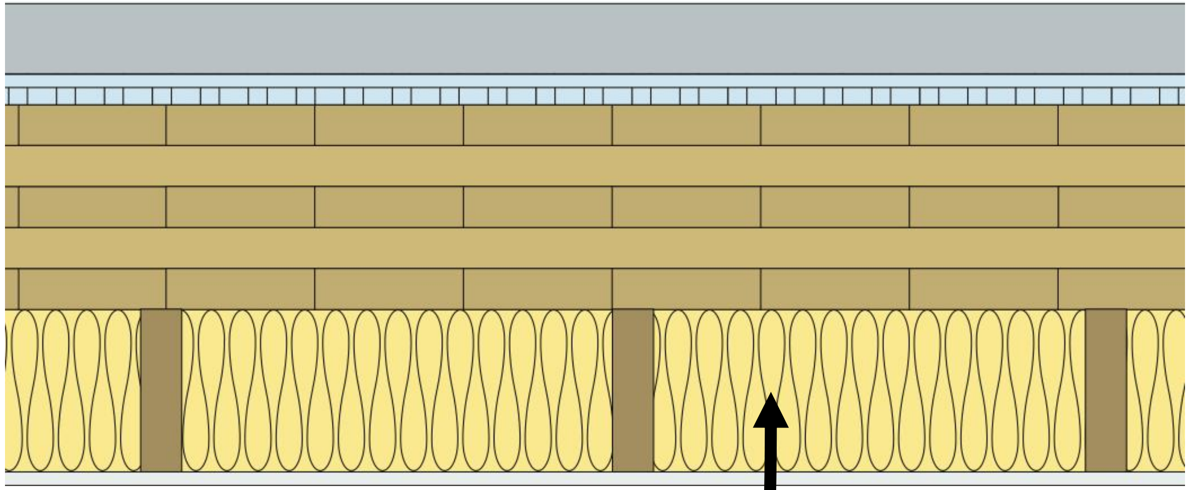
Concealed spaces within interior walls and partitions with a one hour or greater fire resistance rating complying Section 2304.11.2.2 do not require additional protection.

Concealed Spaces in Type IV-HT



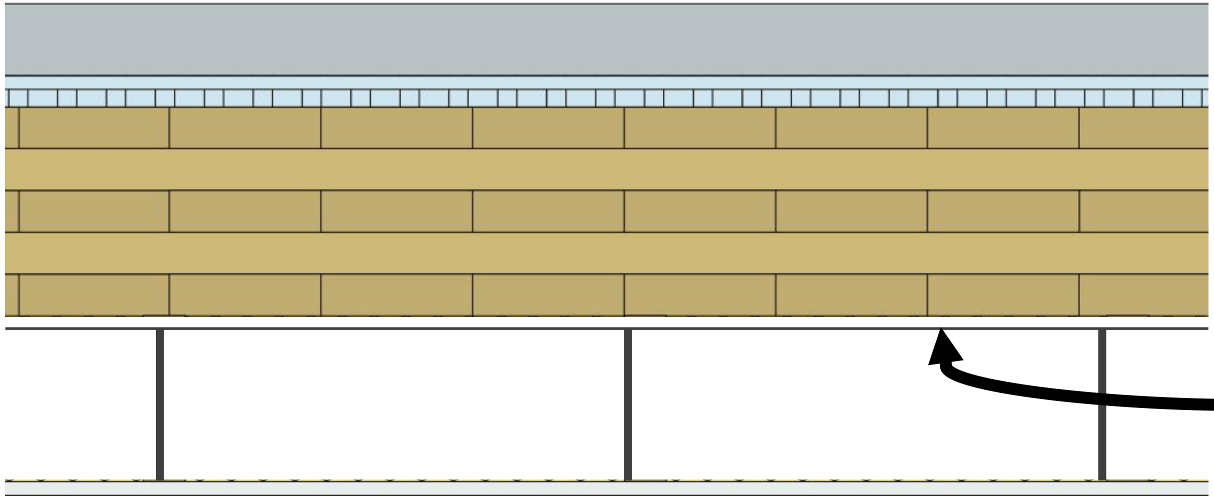
Option 1

Sprinklers in concealed spaces



Option 2

Noncombustible insulation



Option 3

5/8” Type X gypsum on all MT surfaces

Concealed Spaces in Type IV-A, IV-B, IV-C

New IV-HT concealed space provisions do not apply to IV-A, IV-B or IV-C

But, can still have concealed spaces in IV-A, IV-B, IV-C:

- **IV-A and IV-B:** Combustible construction forming concealed spaces protected with NC of 80 minutes (2 layers of 5/8" Type X Gypsum)
- **IV-C:** Combustible construction forming concealed spaces protected with NC of 40 minutes (1 layer of 5/8" Type X Gypsum)

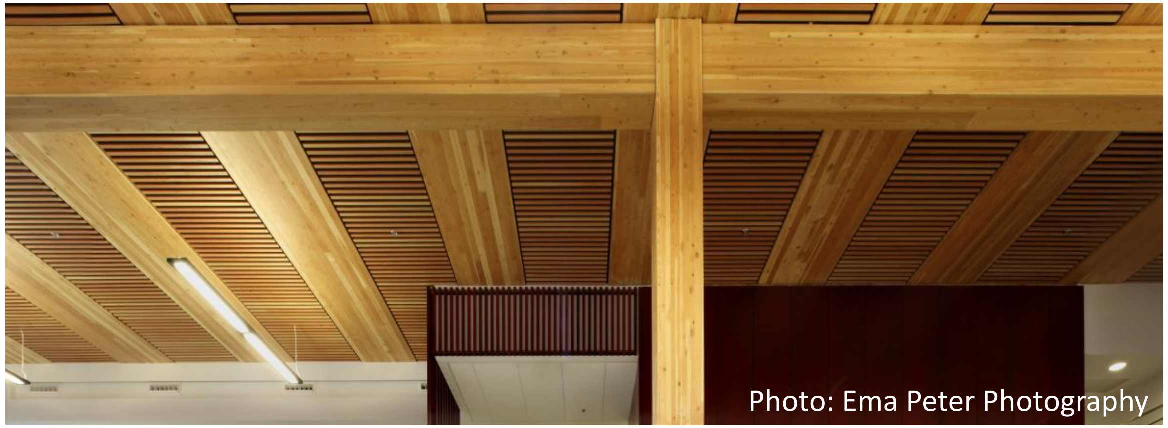


Photo: Ema Peter Photography

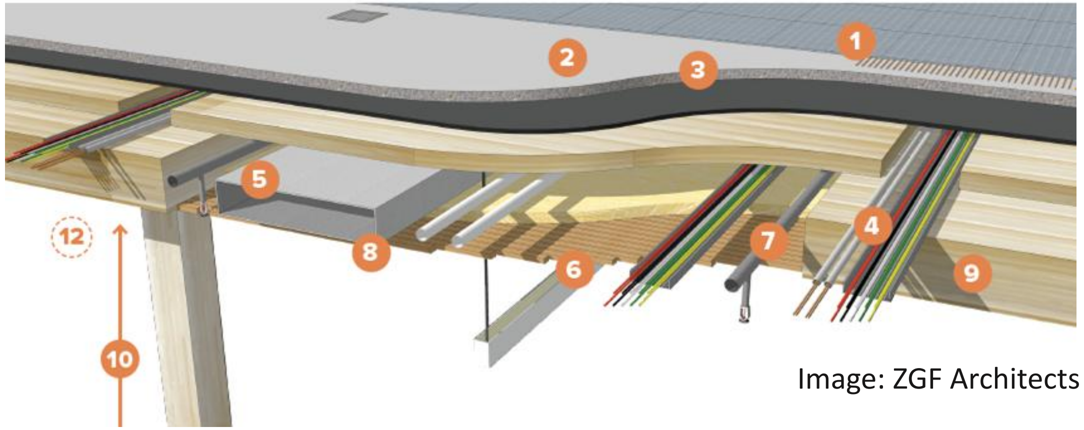
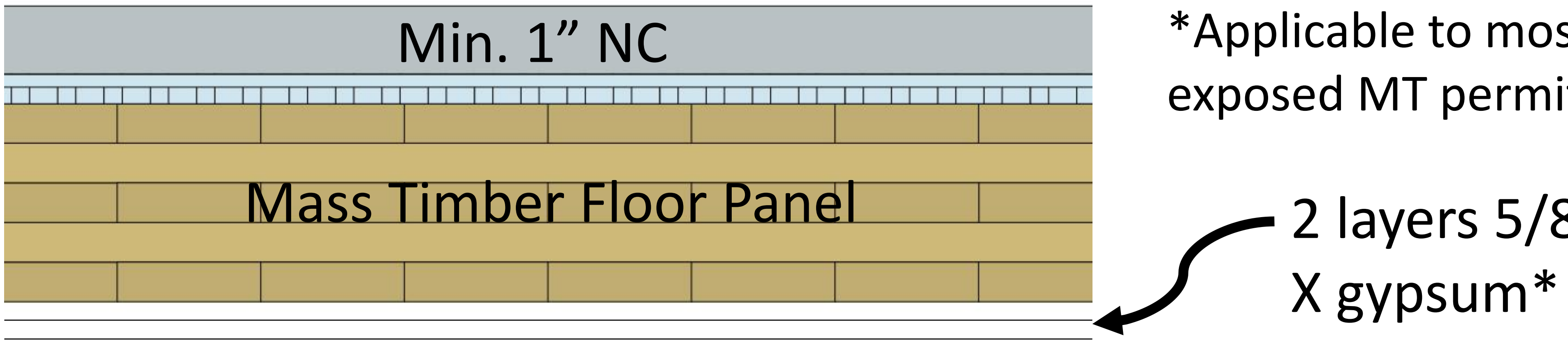


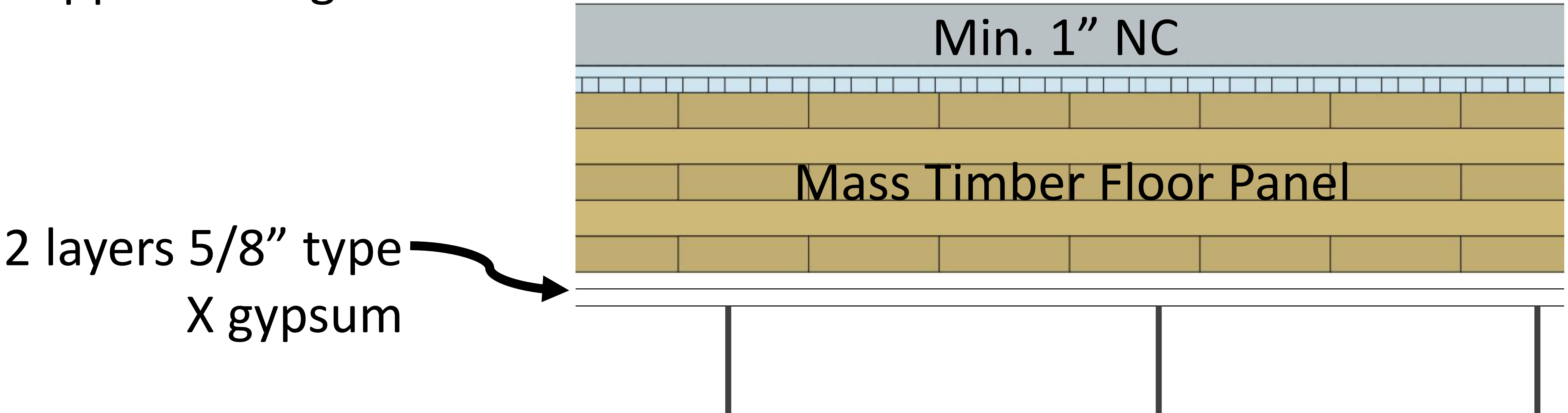
Image: ZGF Architects

Concealed Spaces in Type IV-A, IV-B

*Applicable to most locations. Limited exposed MT permitted in IV-B

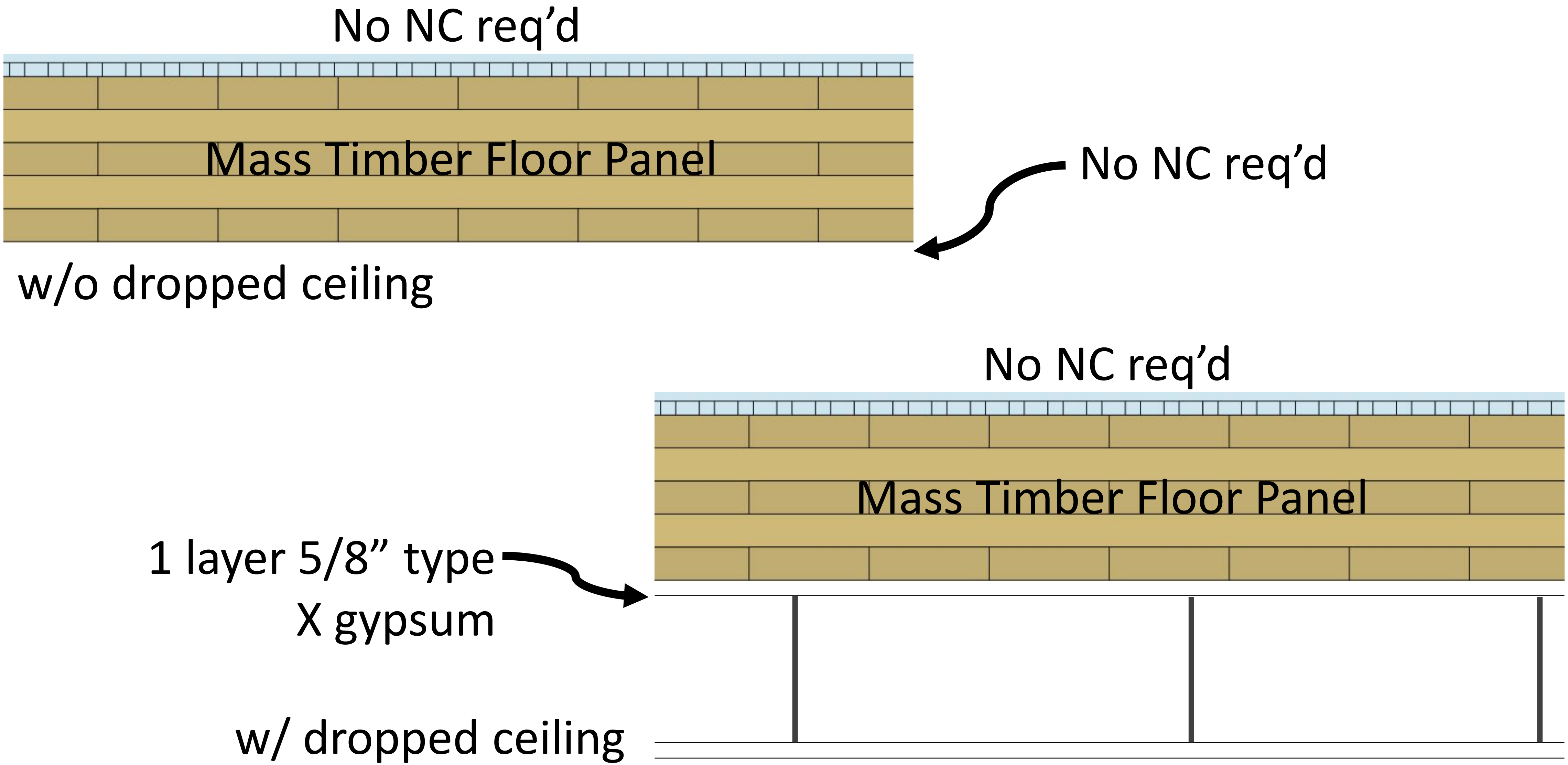


w/o dropped ceiling



w/ dropped ceiling

Concealed Spaces in Type IV-C



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Concealed Spaces in Mass Timber and Heavy Timber Structures

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

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

For mass timber building elements, the choice of construction type can have a significant impact on concealed space requirements. Because mass timber products such as cross-laminated timber (CLT) are prescriptively recognized for Type IV construction, there is a common misperception that exposed mass timber building elements cannot be used or exposed in other construction types. This is not the case. In addition to Type IV buildings, structural mass timber elements—including CLT, glued-laminated timber (glulam), nail-laminated timber (NLT), structural composite lumber (SCL), and tongue-and-groove (T&G) decking—can be utilized and exposed in the following construction types, whether or not a fire-resistance rating is required:

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

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

Rendering: Harbor Bay Real Estate Advisors, Image Fiction

Concealed Space Protection in Mass Timber

WoodWorks™
WOOD PRODUCTS COUNCIL

Tall Wood Buildings in the 2021 IBC
Up to 18 Stories of Mass Timber

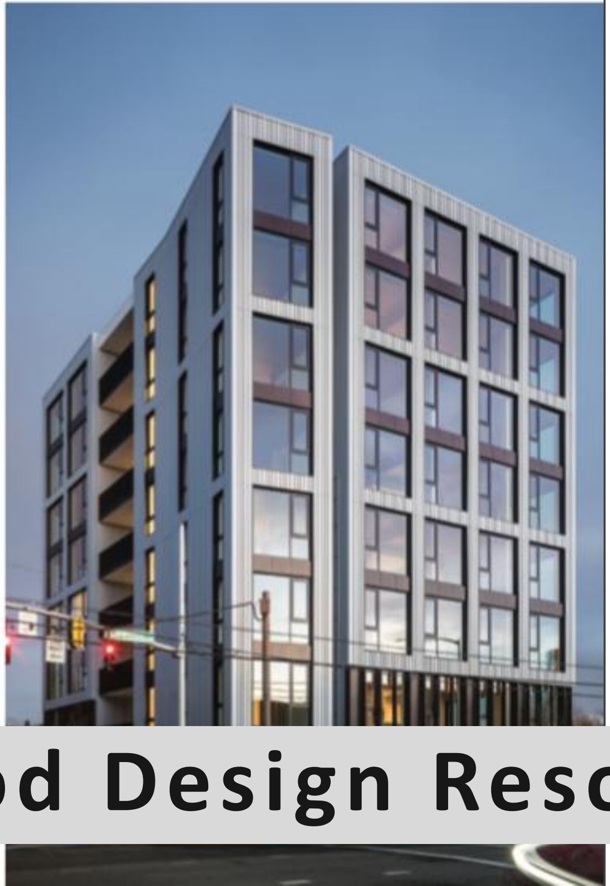
Scott Breneman, PhD, SE, WoodWorks – Wood Products Council • Matt Timmers, SE, John A. Martin & Associates • Dennis Richardson, PE, CBO, CASp, American Wood Council

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 will include 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 and levels of required noncombustible protection. The code will include 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:



WoodWorks Tall Wood Design Resource

Building Name	Location	Stories	Completion Date
Via Cenni	Milan, Italy	9	2013


BREAK
TIME!

Tall Wood Construction + Michigan State University STEM Facility Site Tour

June 13, 2025

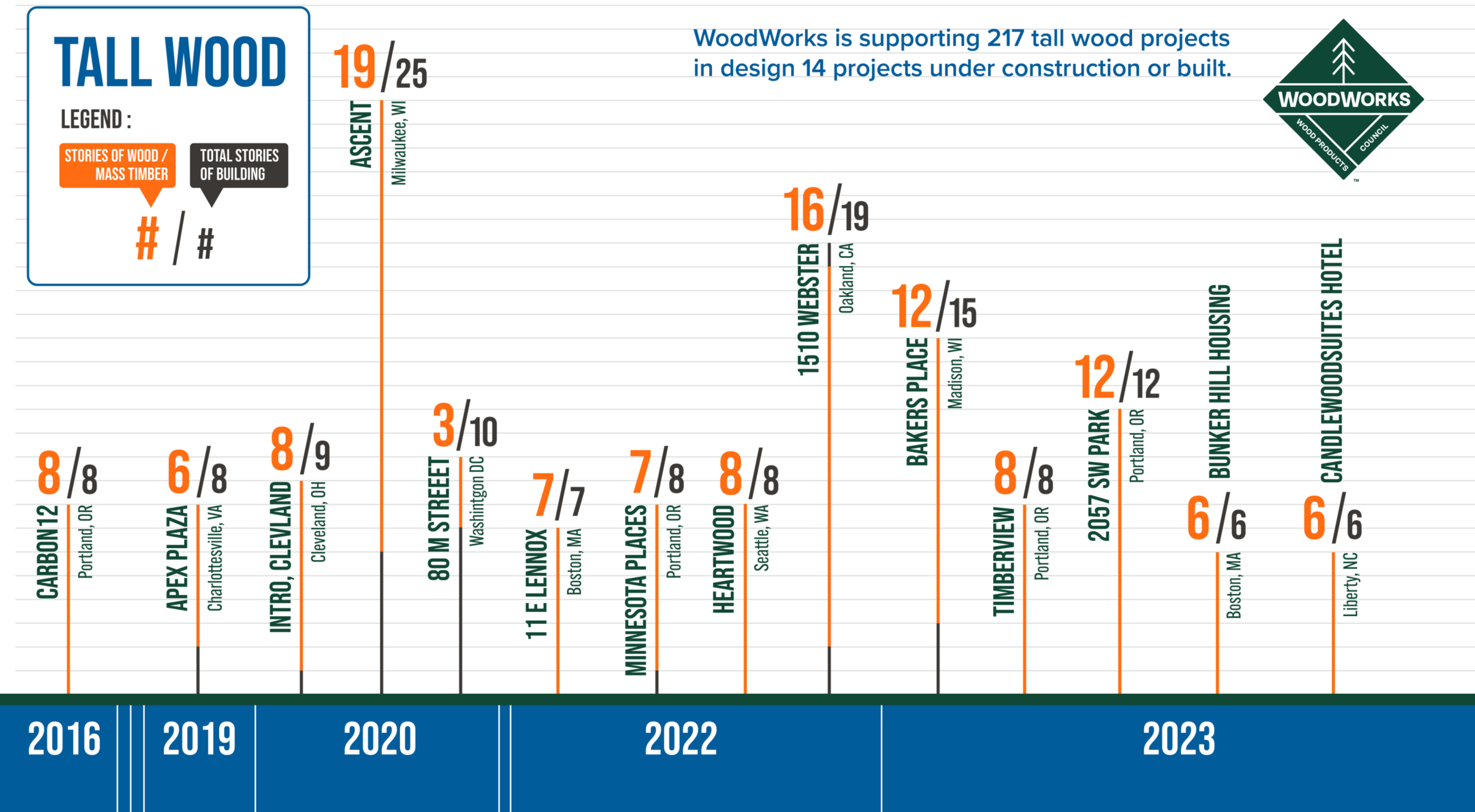
Presented by

Anthony Harvey, PE

MSU STEM Teaching and Learning Facility / Integrated Design Solutions / photo Christofer Lark

2022 AND BEYOND: PROJECTS RISING

Photo: Harbor Bay Real Estate Advisors, Image Fiction | Architect: Hartshorne Plunkard Architecture



TALL WOOD
LEGEND :
STORIES OF WOOD / MASS TIMBER
TOTAL STORIES OF BUILDING
/
WoodWorks is supporting 217 tall wood projects in design 14 projects under construction or built.
WOODWORKS WOOD PRODUCTS COUNCIL
8/8 CARBON12 Portland, OR
6/8 APEX PLAZA Charlottesville, VA
8/9 INTRO, CLEVLAND Cleveland, OH
19/25 ASCENT Milwaukee, WI
3/10 80 M STREEET Washintgon DC
7/7 11 E LENNOX Boston, MA
7/8 MINNESOTA PLACES Portland, OR
8/8 HEARTWOOD Seattle, WA
16/19 1510 WEBSTER Oakland, CA
12/15 BAKERS PLACE Madison, WI
8/8 TIMBERVIEW Portland, OR
12/12 2057 SW PARK Portland, OR
6/6 BUNKER HILL HOUSING Boston, MA
6/6 CANDLEWOODSUITES HOTEL Liberty, NC
2016
2019
2020
2022
2023

Carbon12

PORTLAND, OR

Kaiser + Path
Munzing Structural Engineering
Photo Andrew Pogue

CARBON12

PORTLAND, OR

First Modern Tall Mass Timber Building in the US

8 stories

42,000 sqft

1st floor retail, 7 stories of condos above

Completed in 2017

BUSINESS CASE STUDY

WN PROFILE

Kaiser + Path
Munzing Structural Engineering
Photo Andrew Pogue

INTRO

CLEVELAND, OH

Hartshorne Plunkard Architecture
Forefront Structural Engineers
Fast + Epp
Photo Nick Johnson, Tour D Space

INTRO

Cleveland, OH

Photo Nick Johnson, Tour D Space

Building Facts	115 ft tall, 9 stories total (8 mass timber) Type IV-B Multi-Family Mixed-Use Completed 2022
Developer	Harbor Bay Ventures
Architect	Hartshorne Plunkard Architecture
Engineer	Forefront Engineering, Fast + Epp
General Contractor	Panzica Construction

APEX PLAZA

CHARLOTTESVILLE, VA

William McDonough + Partners
Simpson Gumpertz & Heger
Photo Prakash Patel

APEX PLAZA

CHARLOTTESVILE, VA

Office building

CLT panels / glulam frame & braced frames

8 stories (6 mass timber), 187,000 sqft

WN PROFILE

William McDonough + Partners
Simpson Gumpertz & Heger
Photo Prakash Patel

11 E Lenox

Boston, MA

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

11 E Lenox

Boston, MA

43,000 sf, 7 stories wood

Type III-A with code modifications

Multi-Family

Completed 2023

WN PROFILE

WBLCA

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

80M

WASHINGTON, DC

Hickok Cole
Arup
Photo Ron Blunt

80M

WASHINGTON, DC

3 story MT vertical addition on top of existing 7 story building

CLT panels / glulam frame

108,000 sqft

16 ft floor to floor

Hickok Cole
Arup
Photo Maurice Harrington

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

Heartwood

Seattle, WA

atelierjones LLC
DCI Engineers
Image: atelierjones LLC

Heartwood

Seattle, WA

atelierjones LLC
DCI Engineers
Image: atelierjones LLC

66,000 sf, 8 stories

Type IV-C

Workforce Housing

MT / CLT

Wood construction: 1 day per floor

Completed 2023

MINNESOTA PLACES

PORTLAND, OR

Wright Architecture

8 stories total

7 stories of mass timber

Type IV-C

72 Affordable Housing Units

54,000 sqft

1510 Webster

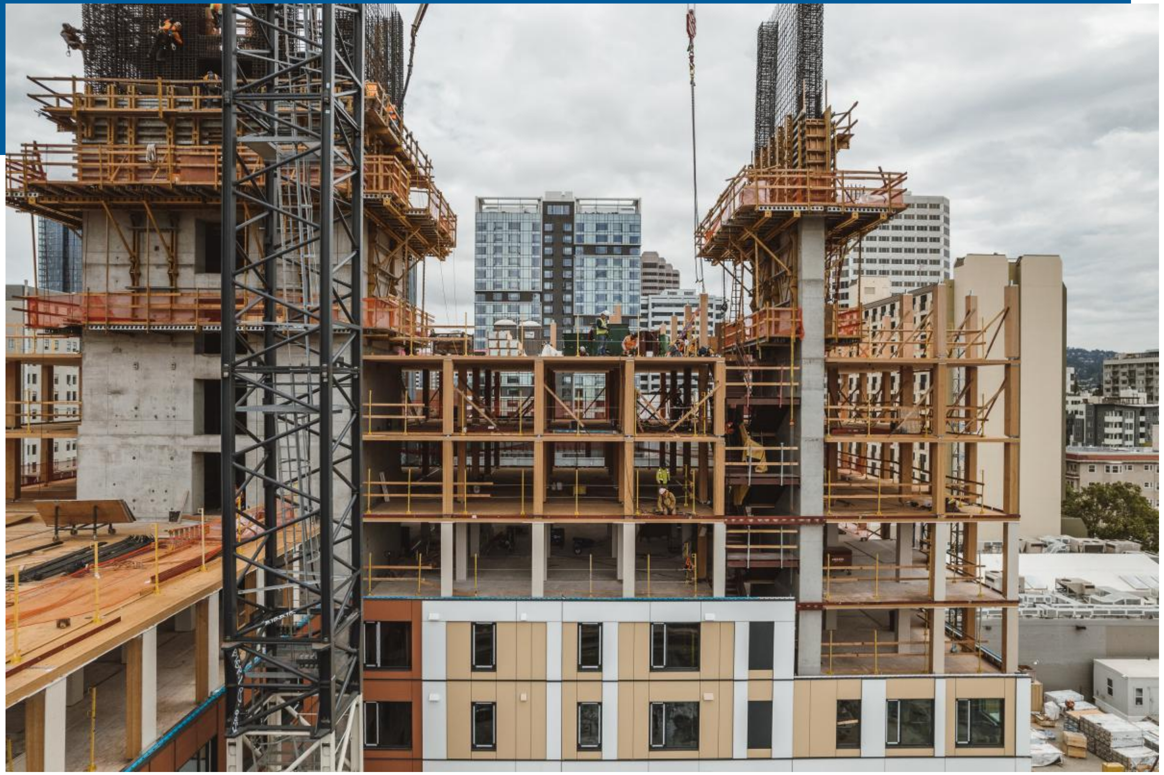
Oakland, CA

oWow
DCI Engineers
Photo: Flor Projects

1510 Webster

Oakland, CA

- 16 stories mass timber, 1 level steel over two-level concrete
- Designed with Tall Wood code provisions in the 2021 CBC
- Mass timber with concrete cores and staircases



Photos: Flor Projects

oWow
DCI Engineers

2057 SW PARK APARTMENTS

PORTLAND, OR

12 stories

Type IV-B

Affordable Housing

Tahran Architecture & Planning

BAKER'S PLACE

MADISON, WI

Angus-Young
Michael Green Architecture
Equilibrium Consulting
Photo Michael Green Architecture

Baker’s Place

Madison, WI

304,800 sf,

15 stories total (12 mass timber)

Type IV-B

Multi-Family

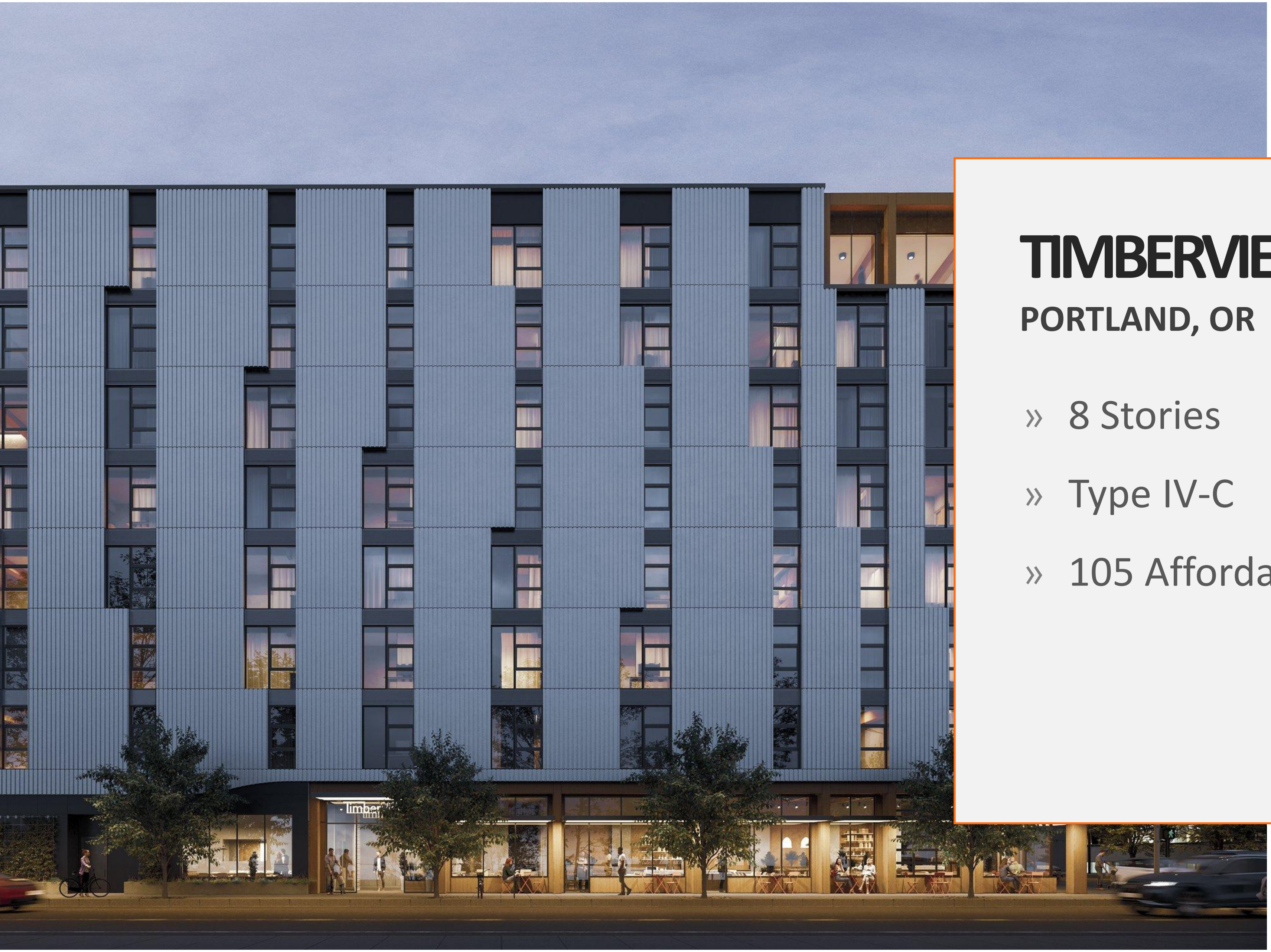
Passive House

WN PROFILE

Angus-Young
Michael Green Architecture
Equilibrium Consulting
Photo Michael Green Architecture

TIMBERVIEW
PORTLAND, OR

Access Architecture
DCI Engineers
Photo Access Architecture



TIMBERVIEW

PORTLAND, OR

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

Access Architecture
DCI Engineers
Photo Access Architecture

DOES TALL WOOD = HIGH RISE?

Photo: Ema Peter

Mid-Rise vs. High-Rise

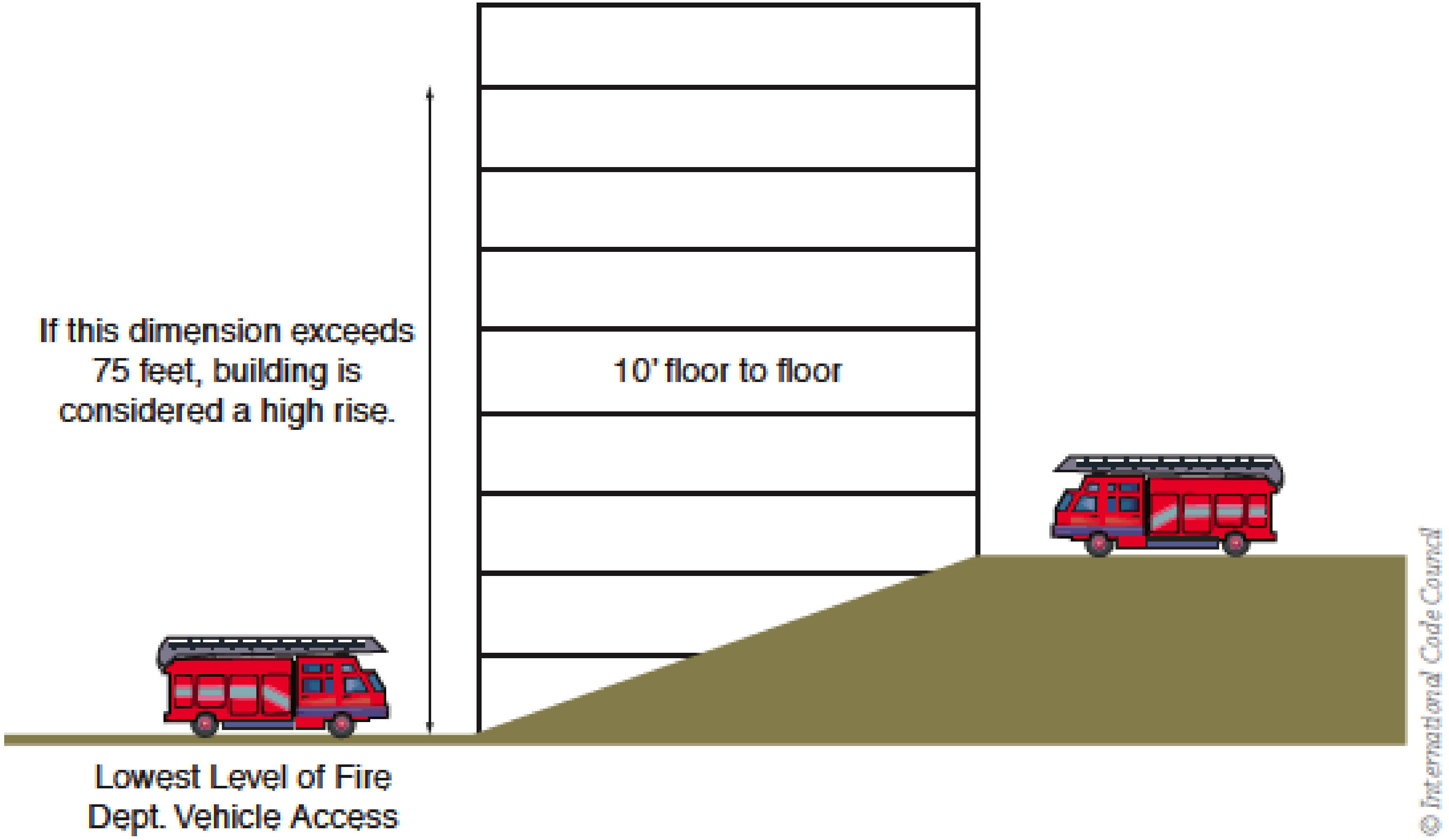


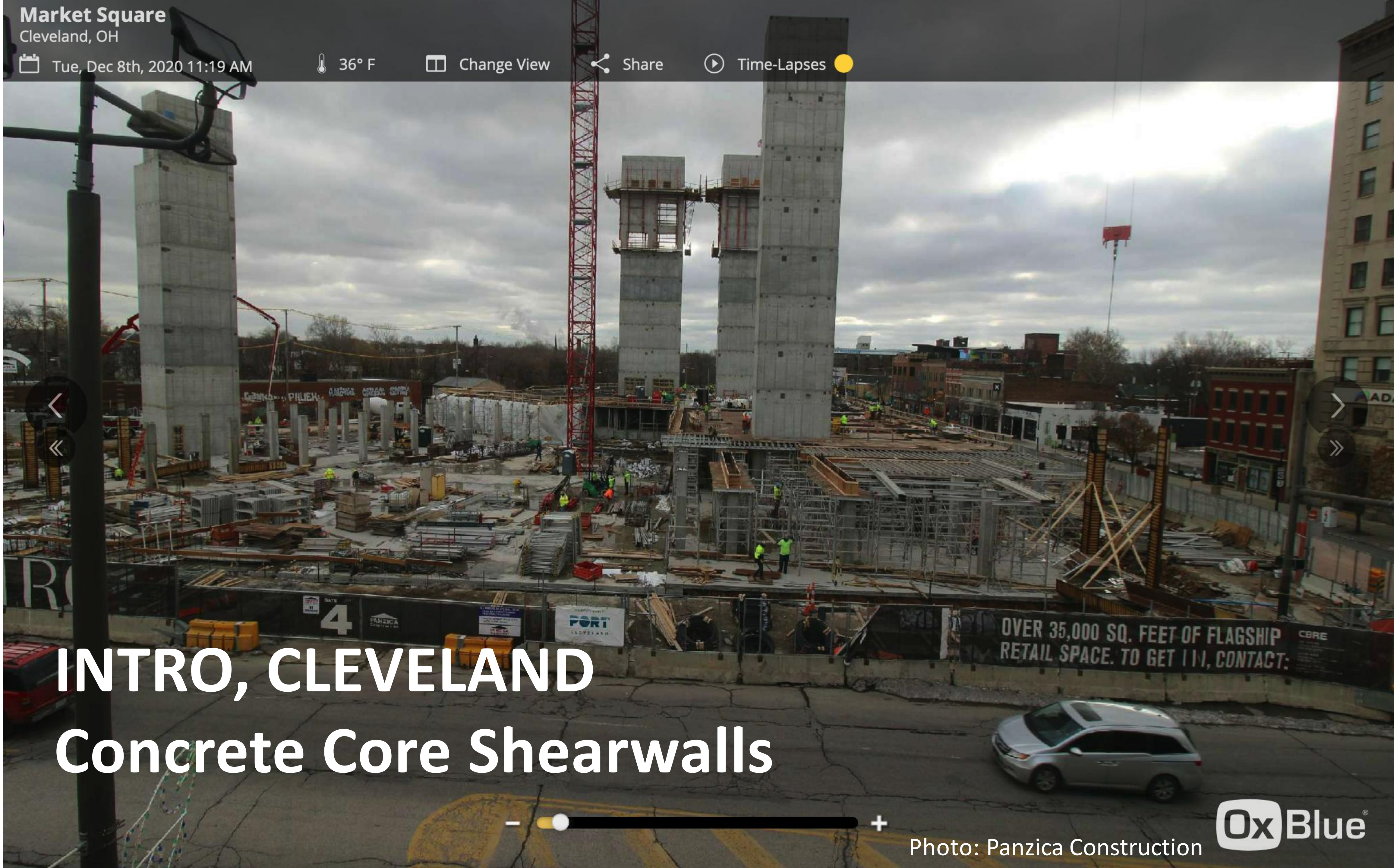
FIGURE 6-6 Determination of high-rise building

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

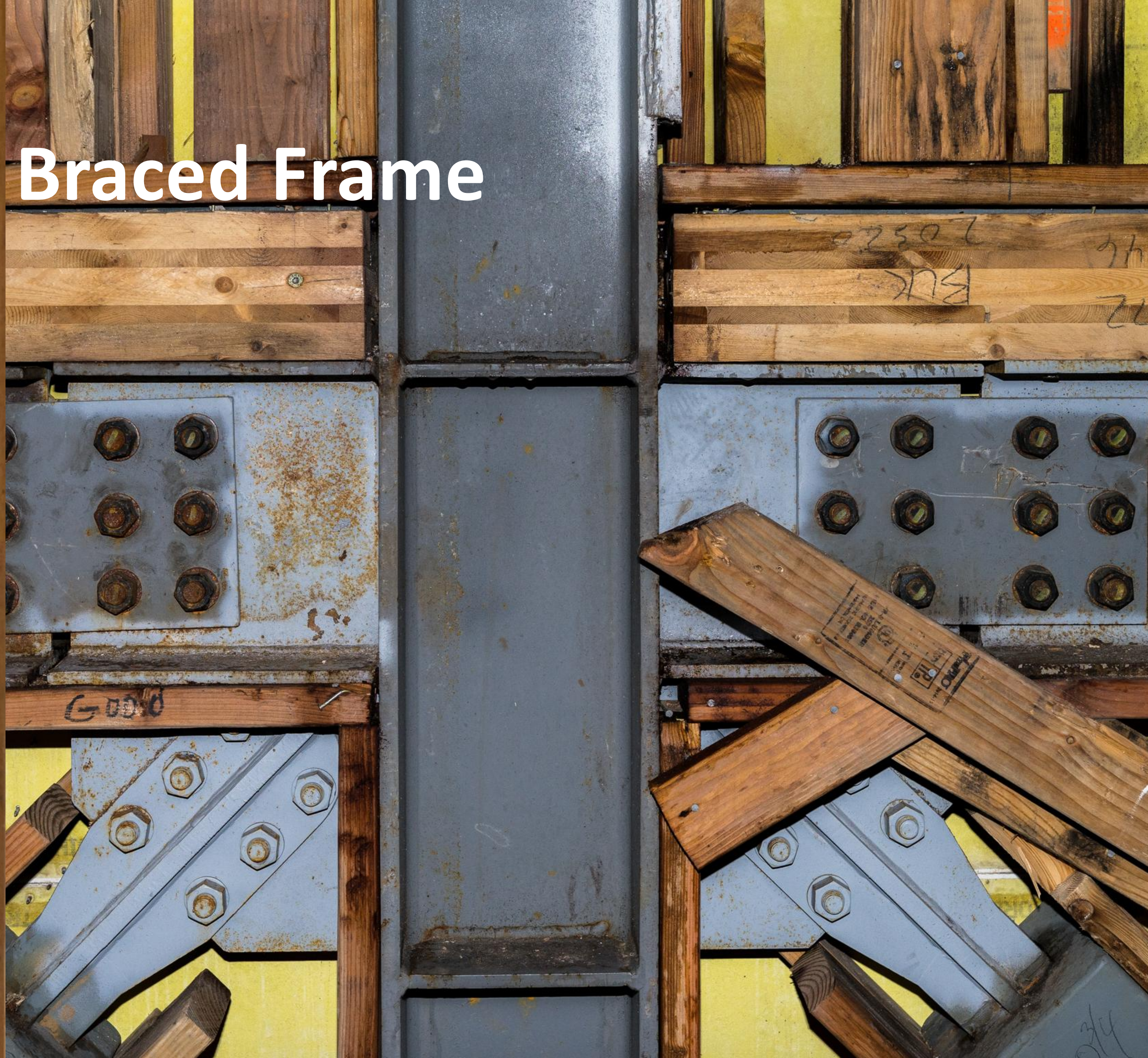
LATERAL SYSTEMS IN TALL WOOD



INTRO, CLEVELAND
Concrete Core Shearwalls

Photo: Panzica Construction

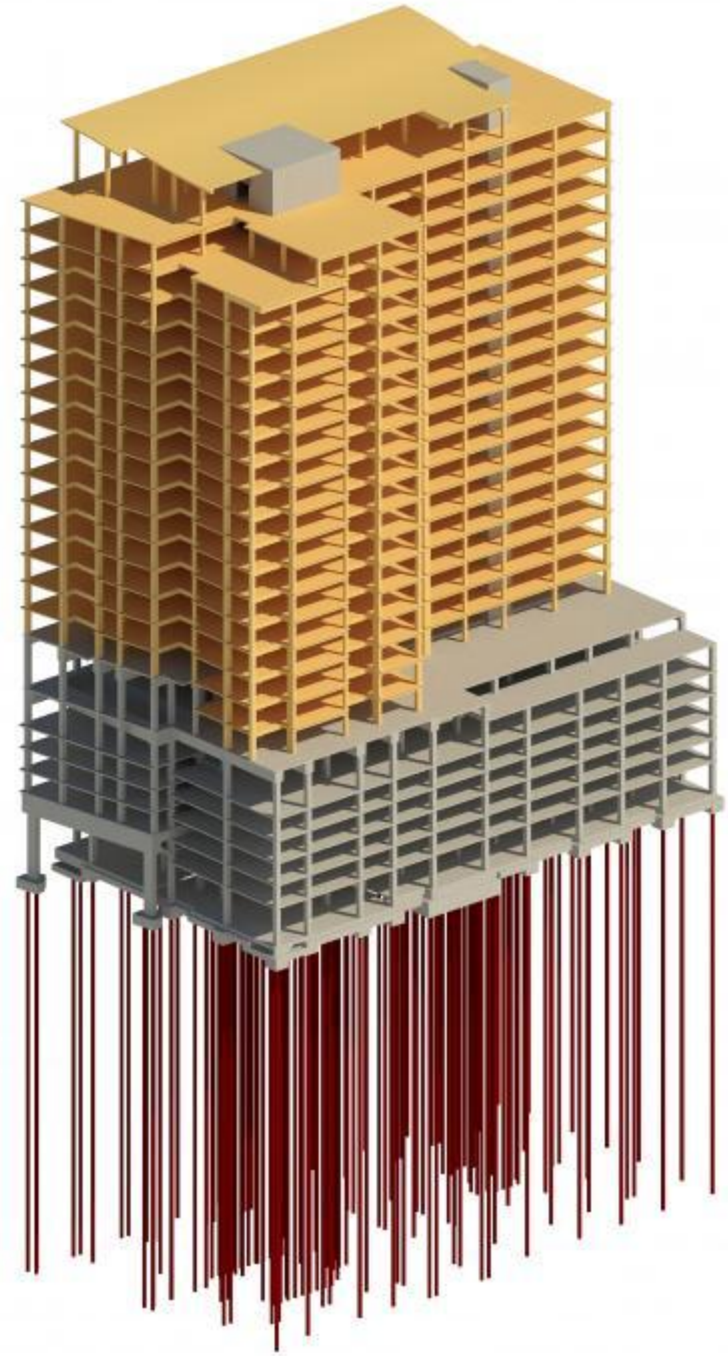
CARBON12, PORTLAND
Buckling-Restrained Braced Frame



Photos: Marcus Kauffmann, ODF

ASCENT, MILWAUKEE

Concrete Core Shearwalls



Photos: Korb + Associates, Thornton Tomasetti

BROCK COMMONS, VANCOUVER
Concrete Core Shearwalls

Photos: Acton Ostry Architects

FUTURE POTENTIAL LATERAL SYSTEM FOR TALL WOOD

Photo: WoodWorks

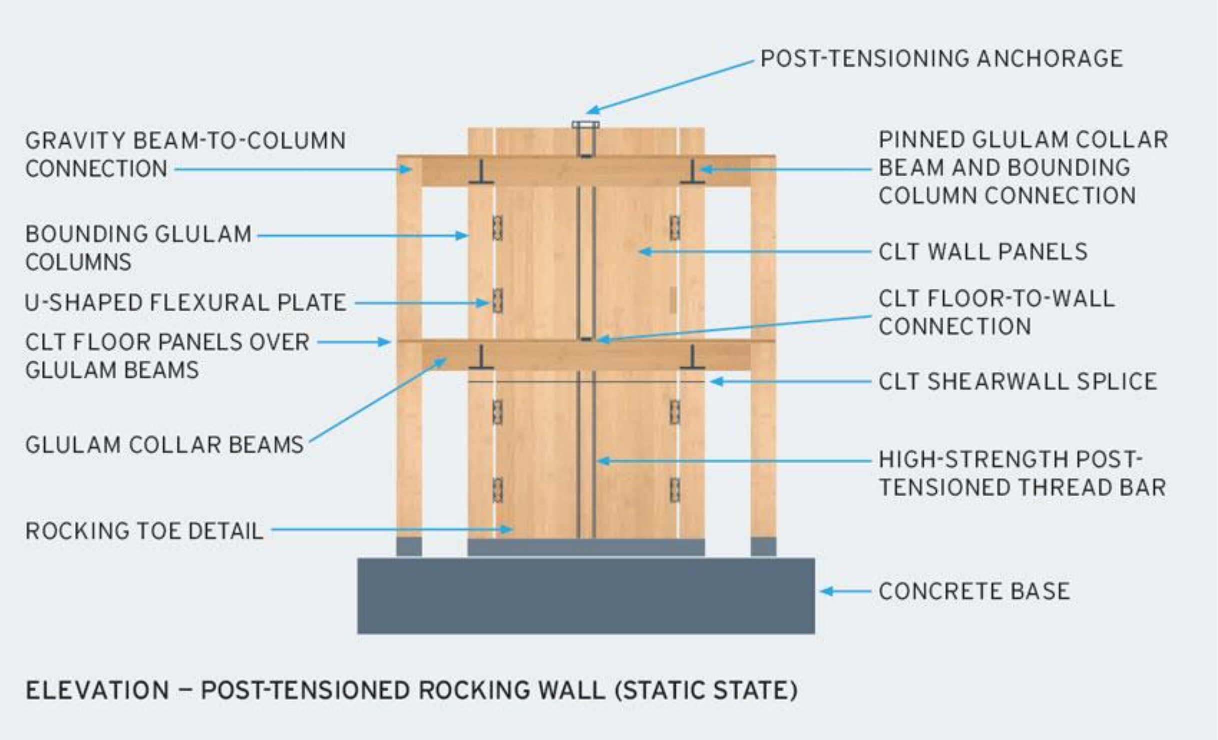


Image: KPFF

Mass Timber Rocking Shearwalls

CONSIDERATIONS FOR LATERAL SYSTEMS

<u>Prescriptive Code Compliance</u>

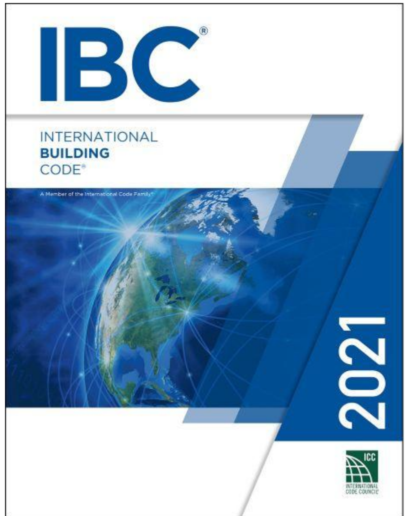
Concrete Shearwalls ✓

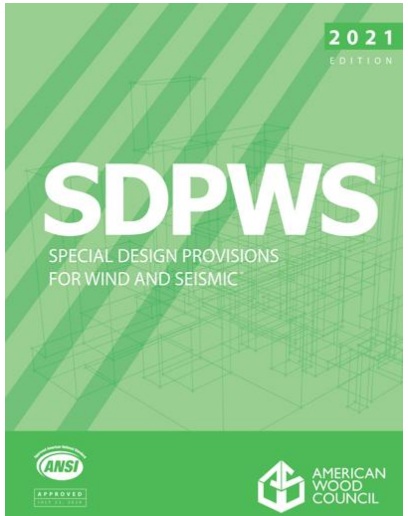
Steel Braced Frames ✓

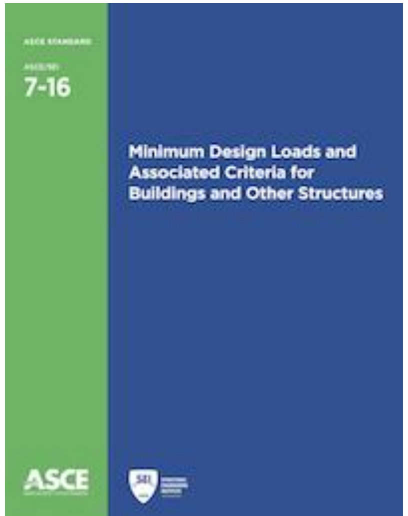
CLT Shearwalls (65 ft max) ✓

2021 SDPWS
ASCE 7-22

CLT Rocking Walls ✗



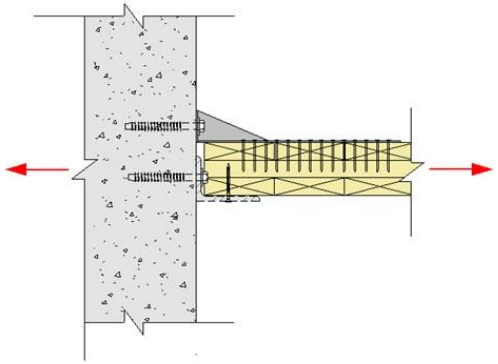


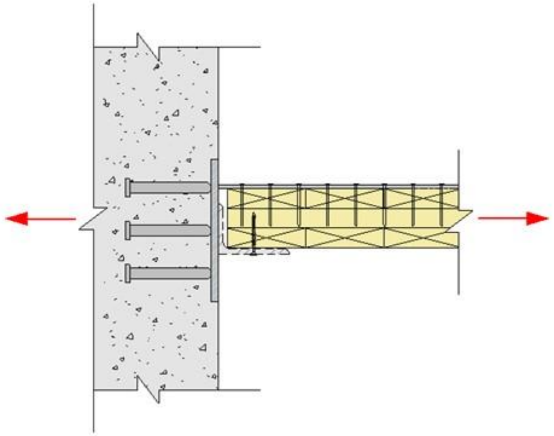


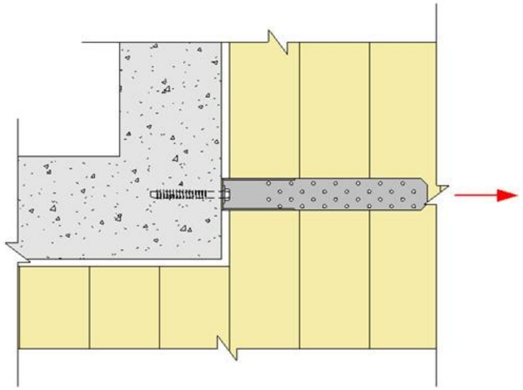
CONSIDERATIONS FOR LATERAL SYSTEMS

Connections to concrete core

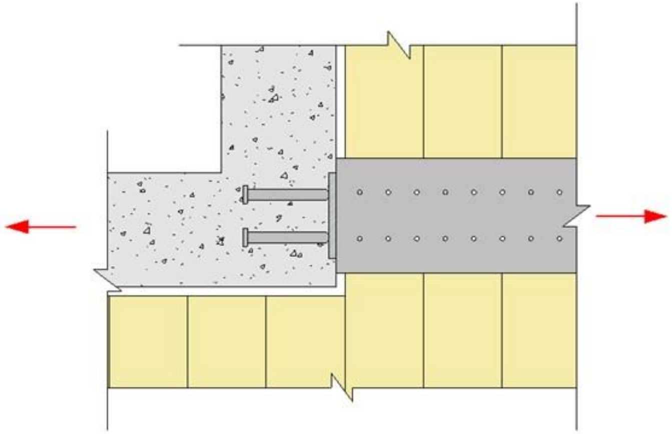
- Tolerances & adjustability
- Drag/collector forces



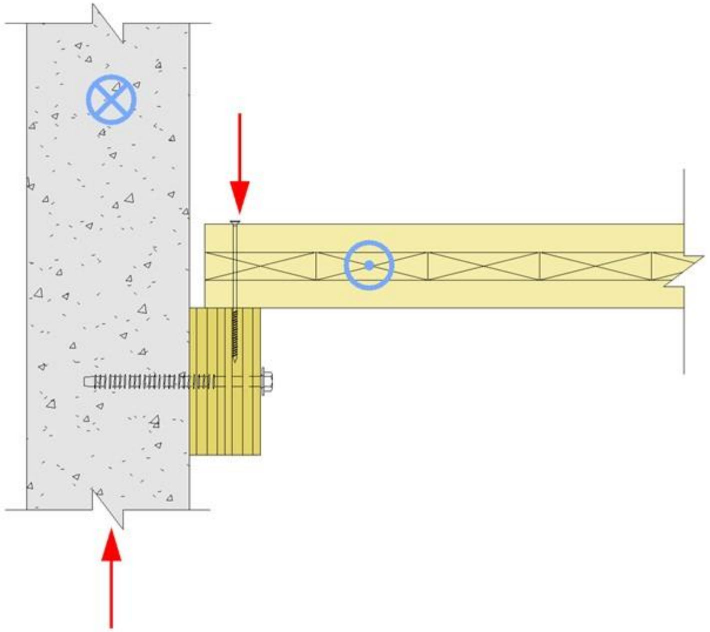




PLAN VIEW



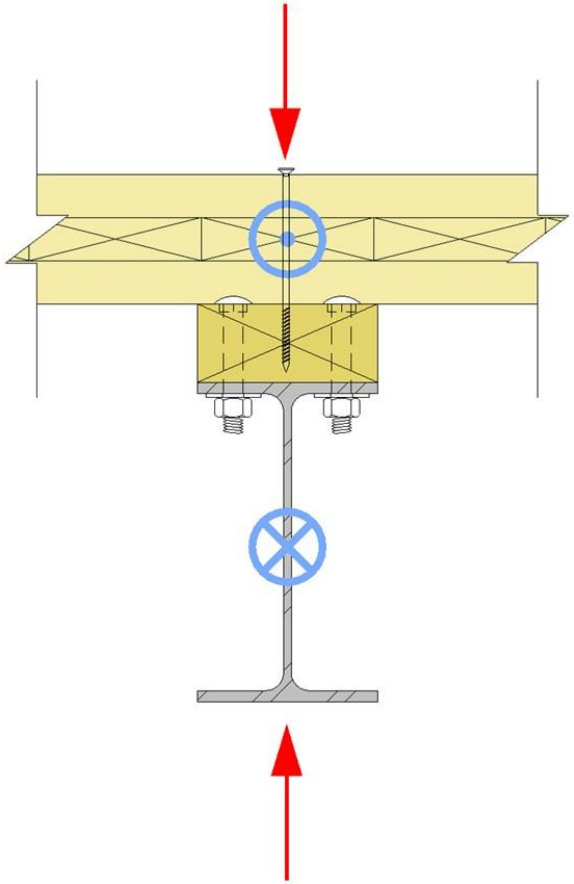
PLAN VIEW

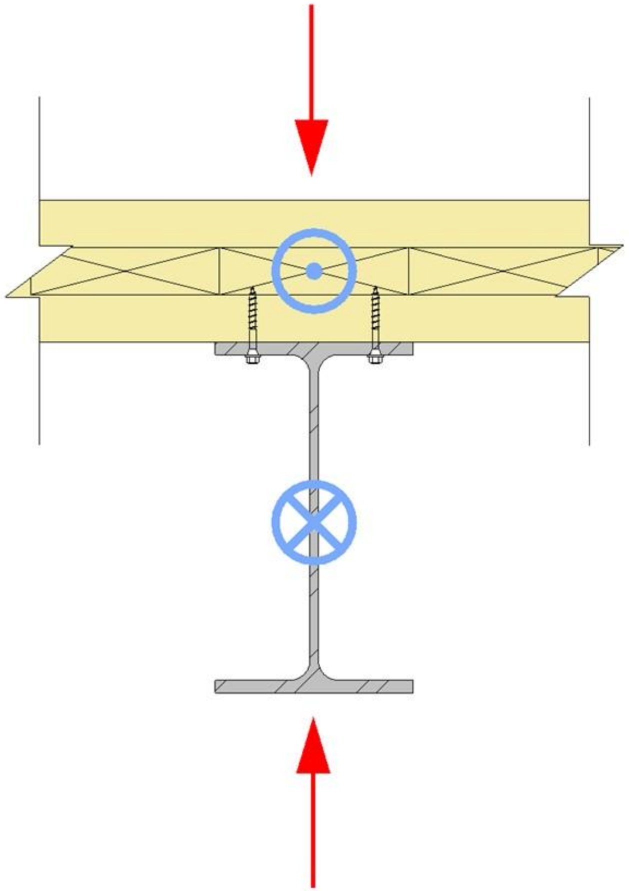


CONSIDERATIONS FOR LATERAL SYSTEMS

Connections to steel frame

- Tolerances & adjustability
- Ease of installation





Photos: Marcus Kauffmann, ODF

SHAFT ENCLOSURES

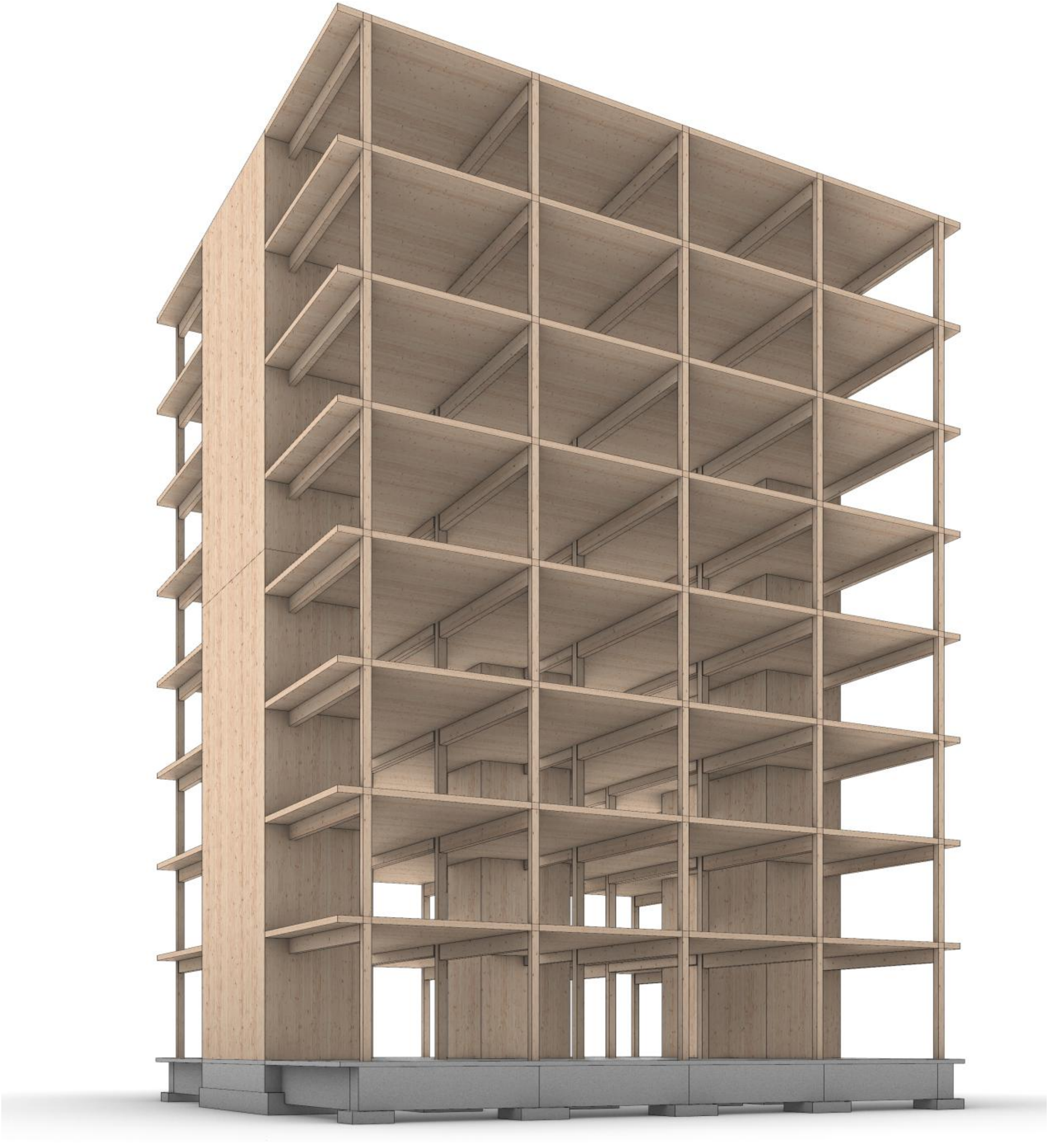


Image: Generate Architecture and Technologies + MIT – John Klein

Shaft Enclosures in Tall Timber…

- When can shaft enclosures be MT?
- What FRR requirements exist?
- If shaft enclosure is MT, is NC req'd?

Tall Wood Shaft Enclosures

	IV-A	IV-B	IV-C
Exit & Hoistway Enclosures	Up to 12 Stories or 180 ft: MT protected with 2 layers 5/8” type X gyp (if 2 HR req’d) <u>OR</u> 3 layers 5/8” type X gyp (if 3 HR req’d) both sides Above 12 Stories or 180 ft: Noncombustible shafts (IBC 2021 602.4)	NC or MT protected with 2 layers 5/8” type X gyp (IBC 2021 602.4.2.6) both sides	NC or MT protected with 1 layer 5/8” type X gyp (IBC 602.4.3.6) both sides
E&H Enclosures FRR	2 HR (not less than FRR of floor assembly penetrated, IBC 713.4)		

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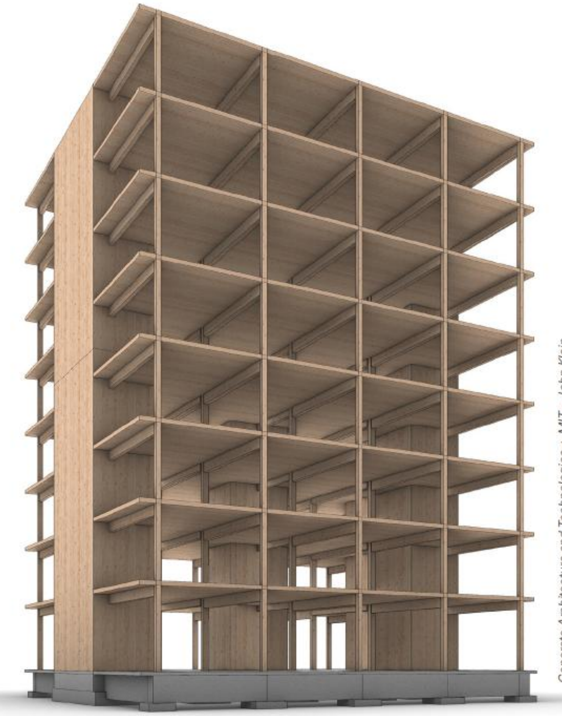
TECHNICAL BRIEF

Shaft Wall Requirements in Tall Mass Timber Buildings

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

The 2021 International Building Code (IBC) introduced three new construction types—Type IV-A, IV-B and IV-C—which allow tall mass timber buildings. For details on the new types and their requirements, see the WoodWorks paper, *Tall Wood Buildings in the 2021 IBC – Up to 18 Stories of Mass Timber.*[1] This paper builds on that document with an in-depth look at the requirements for shaft walls, including when and where wood can be used.



Generate Architecture and Technologies + MIT – John Klein

Shaft Enclosure Requirements in the 2021 IBC

A shaft is defined in Section 202 of the 2021 IBC as *"an enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and roof."* Therefore, shaft enclosure requirements apply to stairs, elevators, and mechanical/electrical/plumbing (MEP) chases in multi-story buildings. While these applications may be similar in their fire design requirements, they tend to differ in terms of their assemblies, detailing, and construction constraints.

Shaft enclosures are specifically addressed in IBC Section 713. However, because shaft enclosure walls must be constructed as fire barriers per Section 713.2, many shaft wall requirements reference provisions for fire barriers found in Section 707.

Allowable Shaft Wall Materials

Provisions addressing materials permitted in shaft wall

utilizing construction Types IV-A, IV-B, or IV-C is that they be constructed of either mass timber or noncombustible

A relatively new category of wood products, mass timber can

Structural elements of Type IV construction primarily of

Shaft Enclosure Design in Tall Timber

CONNECTIONS IN TALL WOOD

Photo: Structurlam

Connection Fire Protection

In Construction Types IV-A, IV-B & IV-C, building elements are required to be FRR as specified in IBC Tables 601 and 602. Connections between these building elements must be able to maintain FRR no less than that required of the connected members.

Photo: MyTiCon

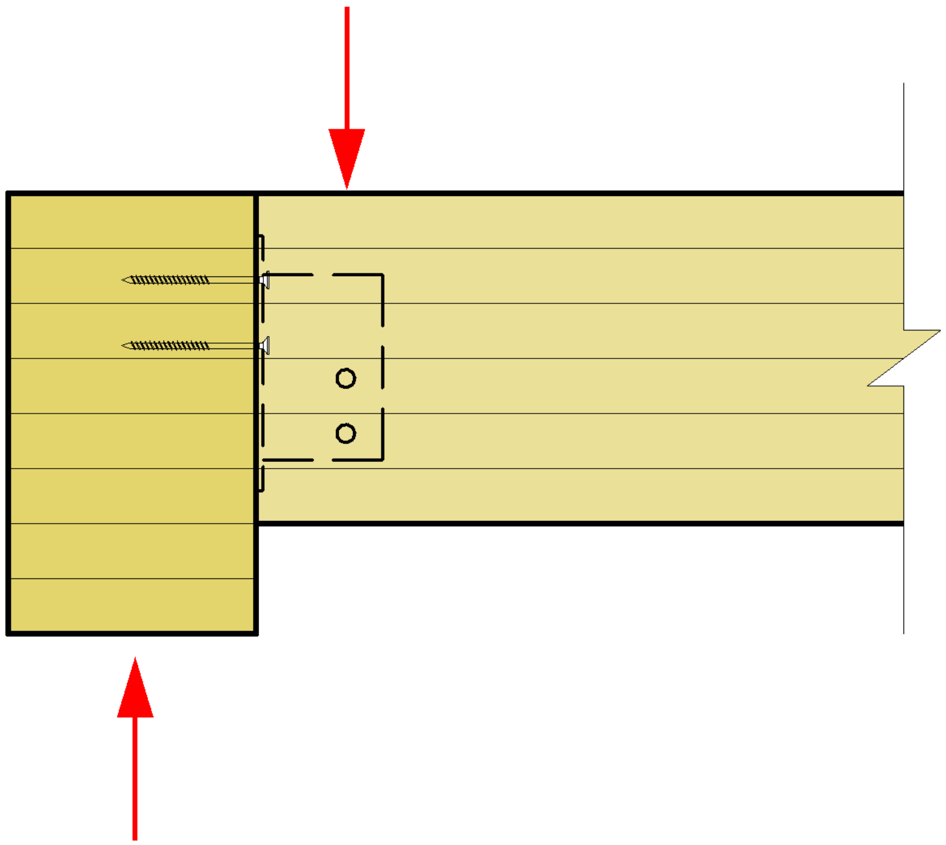
16.3 Wood Connections

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

Connection Fire Protection

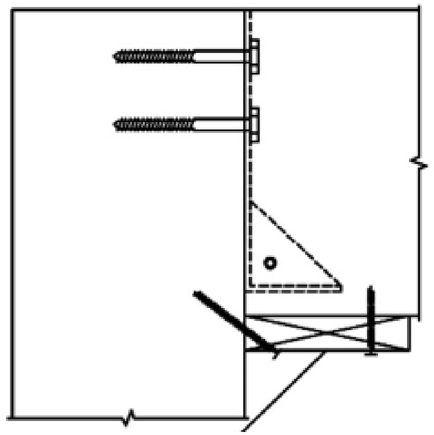
Steel hangers/hardware fully concealed within a timber to timber connection is a common method of fire protection



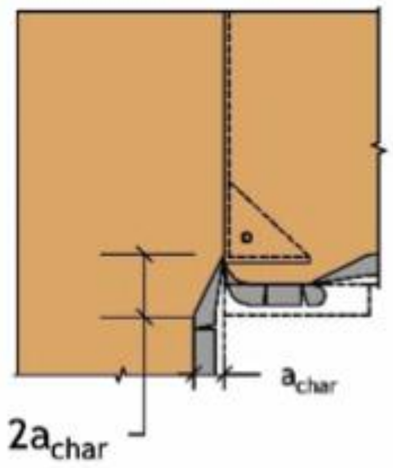
Fire Resistance of Connections

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.



Source: AWC's TR 10



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.

Connection Fire Protection

Many ways to demonstrate connection fire protection: calculations, prescriptive NC, test results, others as approved by AHJ


Photo: John Stamets


Photo: Josh Partee

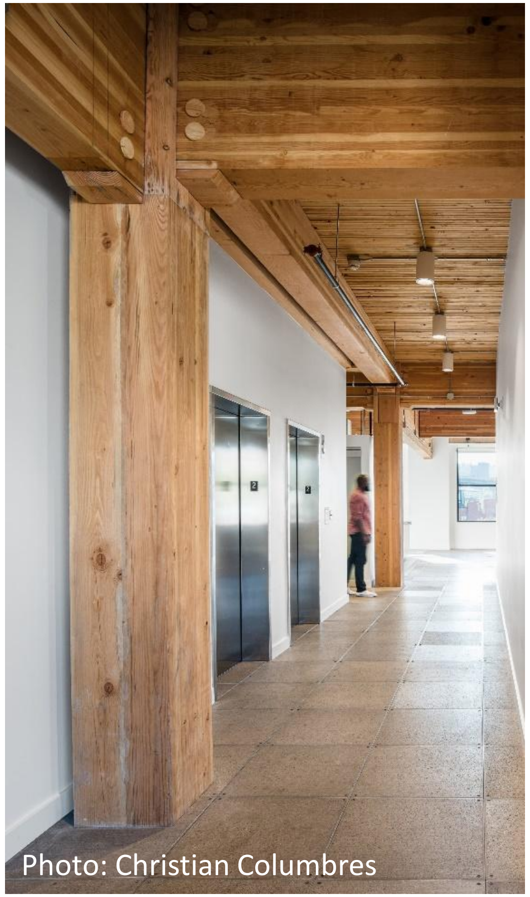


Photo: Christian Columbres

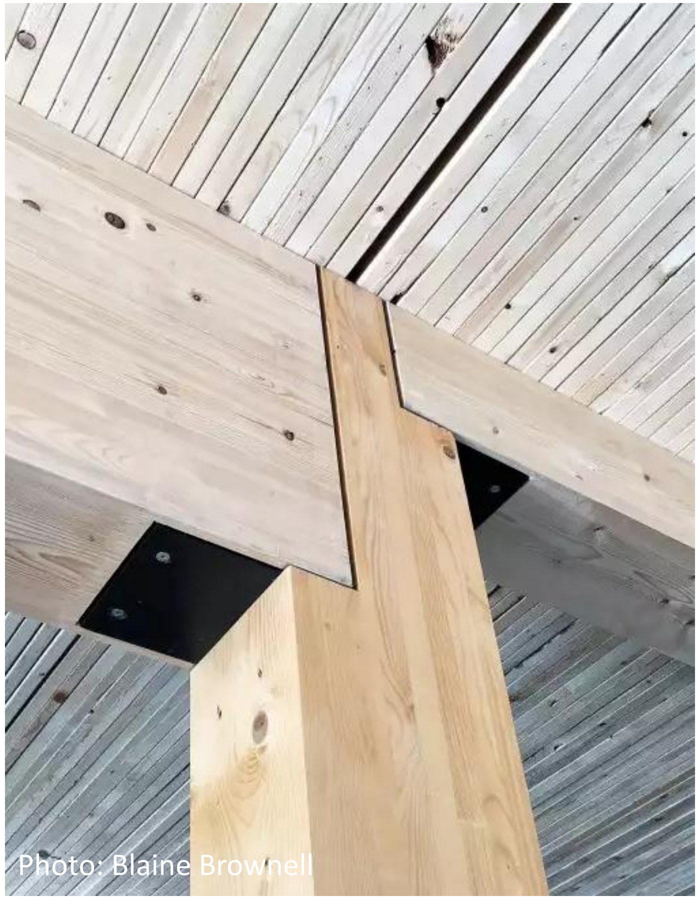


Photo: Blaine Brownell

Connection Fire Protection

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

Connection Fire Protection

Fire Test Results

Test	Beam	Connector	Applied Load	FRR
1	8.75" x 18" (222mm x 457mm)	1 x Ricon S VS 290x80	3,905lbs (17.4kN)	1hr
2	10.75" x 24" (273mm x 610mm)	Staggered double Ricon S VS 200x80	16,620lbs (73.9kN)	1.5hrs
3	10.75" x 24" (273mm x 610mm)	1 x Megant 430	16,620lbs (73.9kN)	1.5hrs

Connection Fire Protection

Softwood Lumber Board

Glulam Connection Fire Test

Summary Report

Issue | June 5, 2017

SOUTHWEST RESEARCH INSTITUTE

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CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

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

NSF

FIRE PERFORMANCE EVALUATION OF A LOAD BEARING GLULAM BEAM TO COLUMN CONNECTION, INCLUDING A CLT PANEL, TESTED IN GENERAL ACCORDANCE WITH ASTM E119-16a, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 32 Pages

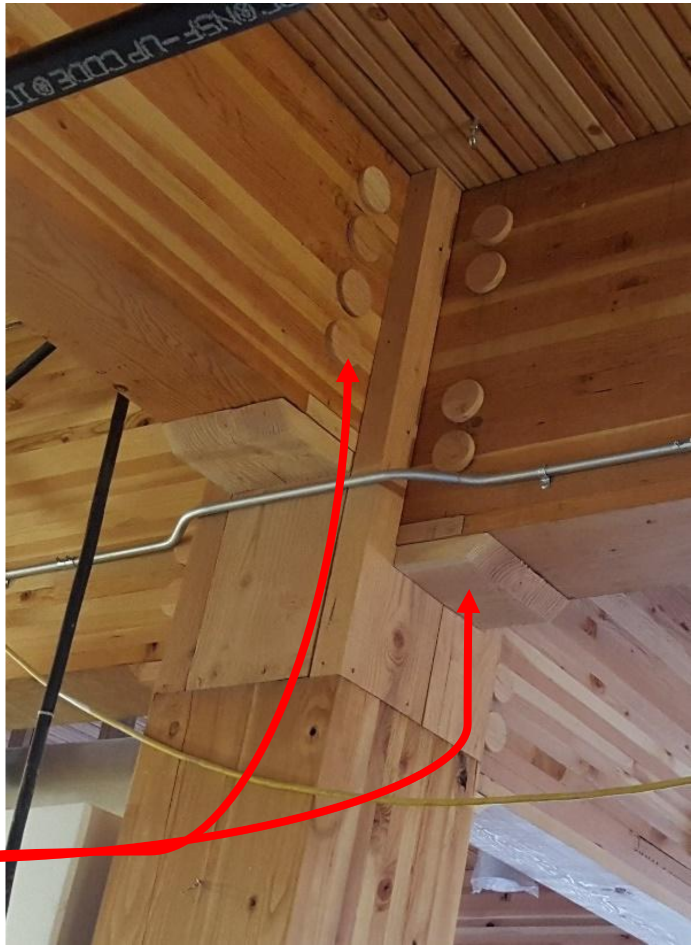
Full Report Available at:

https://www.thinkwood.com/wp-content/uploads/2018/01/reThink-Wood-Arup-SLB-Connection-Fire-Testing-Summary-web.pdf

Tall Mass Timber Inspections

Wood Connection Coverings for Fire-Resistance

110.3.5 <u>Type IV-A, IV-B, and IV-C</u> 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

Tall Mass Timber Special Inspections

TABLE 1705.5.3
REQUIRED SPECIAL INSPECTIONS OF MASS TIMBER CONSTRUCTION

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

Source: International Building Code

Table is only required for Type IV-A, IV-B, and IV-C

NEW MASS TIMBER CONNECTIONS INDEX

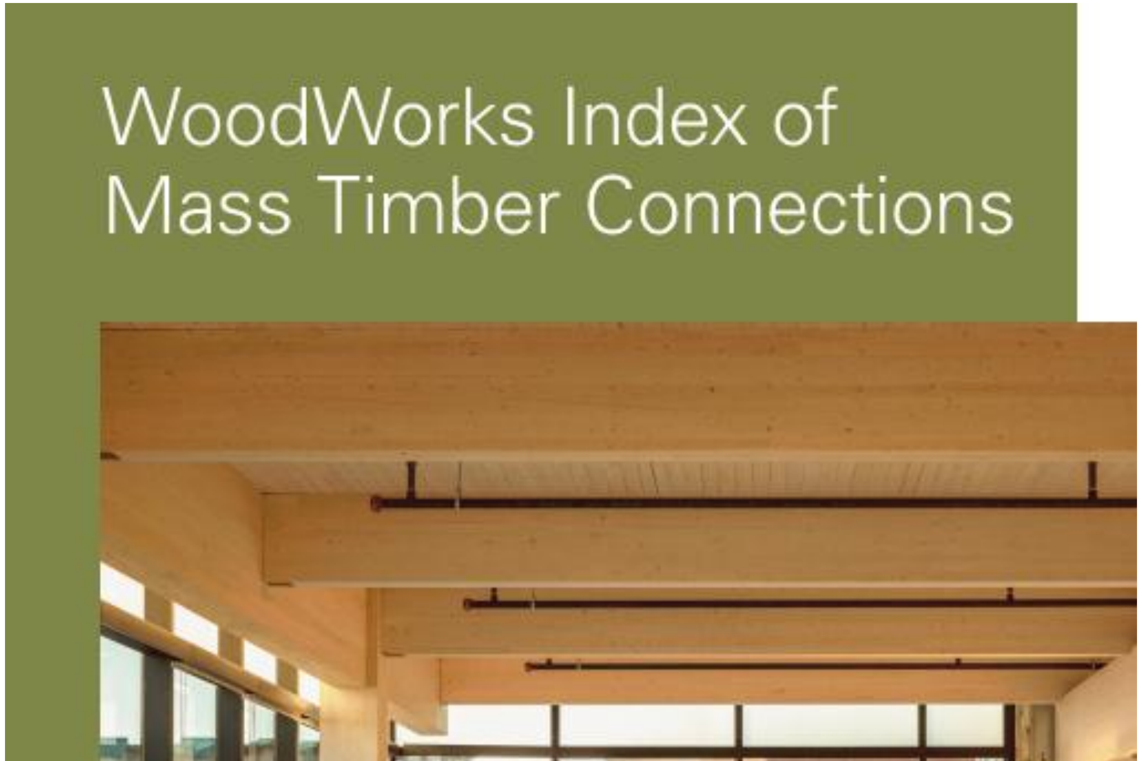
WOODWORKS™
WOOD PRODUCTS COUNCIL

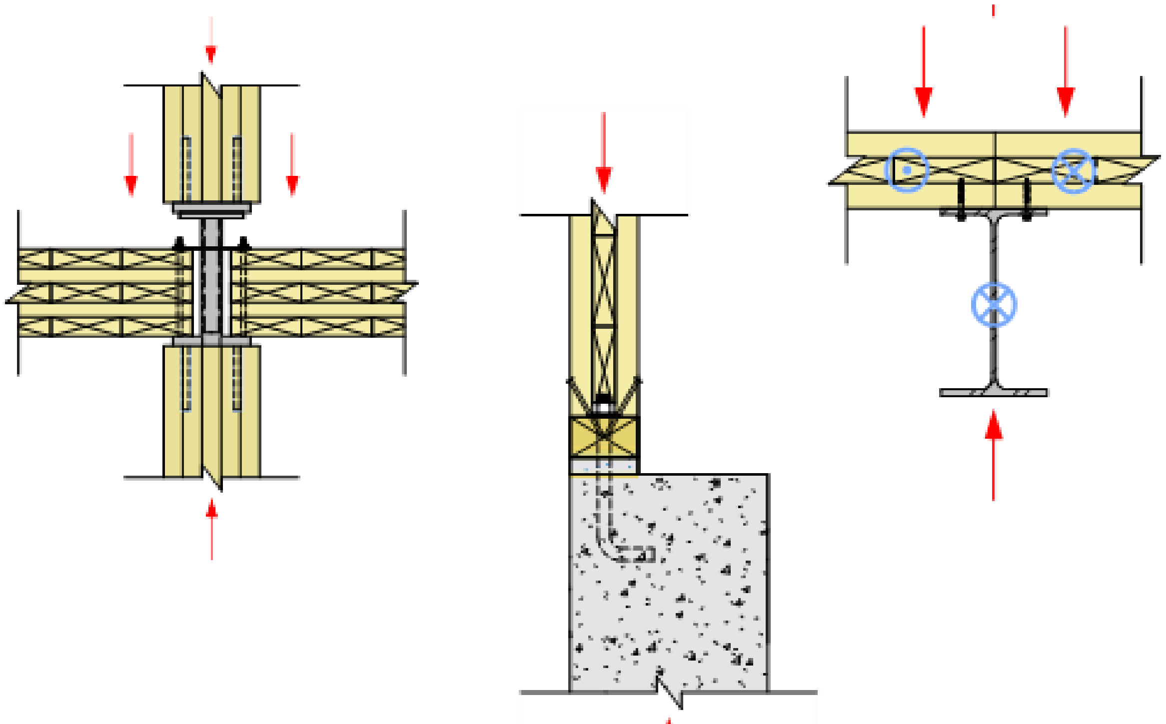
KL&A
Engineers & Builders

OZ
ARCHITECTURE
URBAN DESIGN
INTERIOR DESIGN

SWINERTON
MASS TIMBER

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





PENETRATIONS IN TALL WOOD

Photo: Alex Schreyer

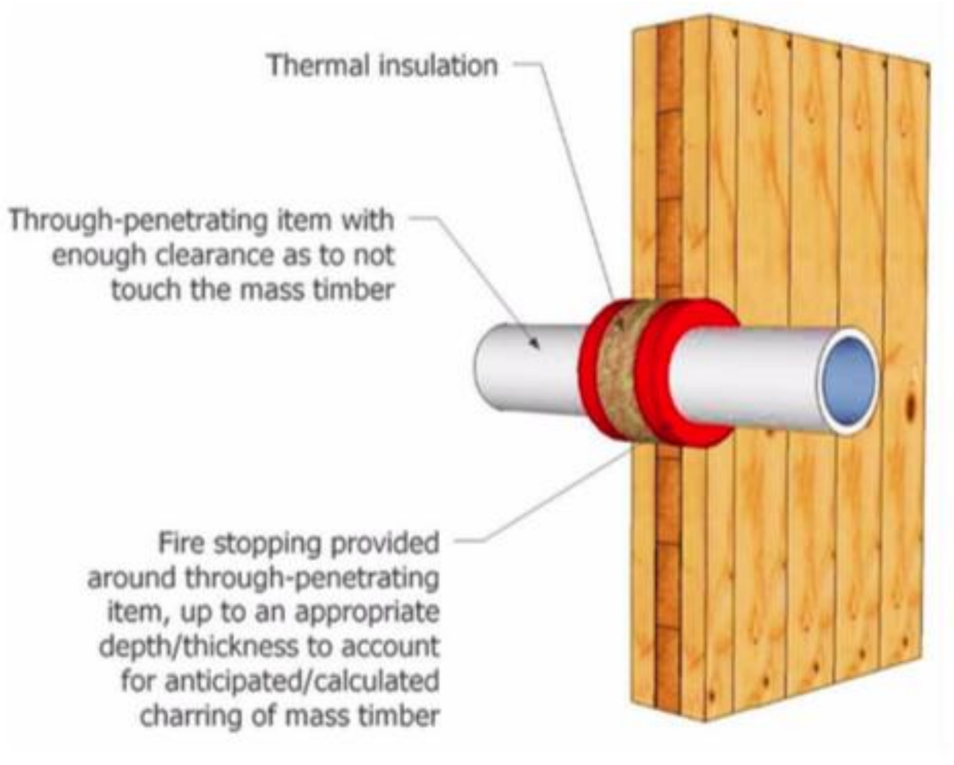
Penetration Fire Protection

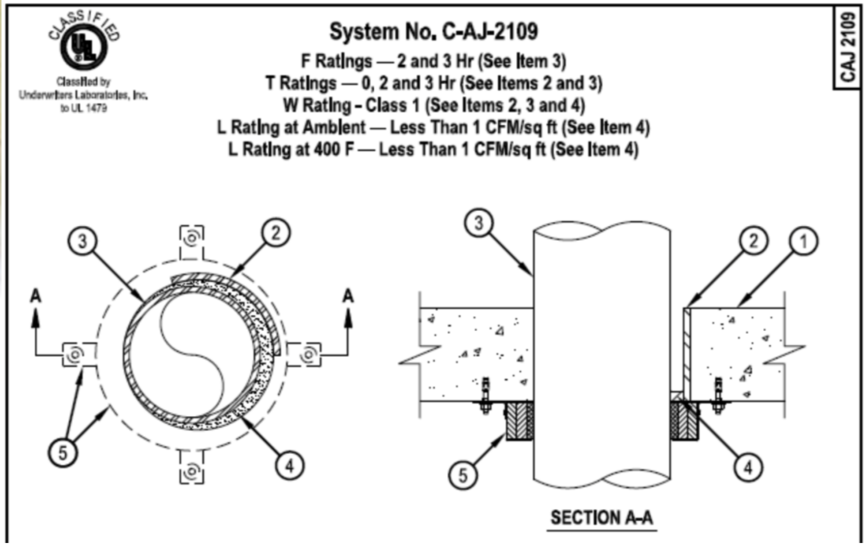
Although not a new code requirement or specific to tall wood, more testing & information is becoming available on firestopping of penetrations through MT assemblies

Photos: AWC/FPInnovations

Penetration Fire Protection

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





Photos: AWC/FPInnovations/Hilti

Penetration Fire Protection

Firestop systems tests on Mass Timber
Contact WoodWorks for information

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NSF

FIRE RESISTANCE PERFORMANCE EVALUATION OF A PENETRATION FIRESTOP SYSTEM TESTED IN ACCORDANCE WITH ASTM E814-13A, *STANDARD TEST METHOD FOR FIRE TESTS OF PENETRATION FIRESTOP SYSTEMS*

FINAL REPORT
Consisting of 18 Pages

SwRI® Project No. 01.21428.01.001a
Test Date: September 30, 2015
Report Date: October 22, 2015

Prepared for:

American Wood Council
222 Catoctin Circle SE
Leesburg, VA 20175

WCTE 2018
2018 World Conference on Timber Engineering
August 20 - 23, 2018 | Seoul, Republic of Korea

FIRE PERFORMANCE OF FIRESTOPS, PENETRATIONS, AND FIRE DOORS IN MASS TIMBER ASSEMBLIES

Lindsay Ranger [1], Christian Dagenais [1], Conroy Lum[1], Tony Thomas[1]

ABSTRACT: Integrity and continuity must be maintained for fire separations required to provide fi
prevent passage of hot gases or increased temperature on the unexposed side. Vulnerable locations, whe
are introduced into mass timber systems, are susceptible to fire spread. Service and closure penetrat
timber fire separation have been investigated. Many of the fire stop systems were able to achieve 1-½
accordance with CAN/ULC-S115, which would be required for 2-hr fire resistance rated assemblies, su
tall wood buildings. Construction details are outlined which ensure adequate fire performance of these p

KEYWORDS: Firestop, through-penetrations, fire rated door, mass timber, cross-laminated tim
buildings, fire resistance

1 INTRODUCTION

Many tall wood buildings using mass timber are planned or are currently being designed for construction around the world. A few have been built in Canada, including an 18 storey cross-laminated timber (CLT) and glulam building in British Columbia. The prescriptive requirements in the National Building Code of Canada (NBCC) [1] do not (yet) permit the construction of wood buildings taller than six stories, however an alternative

construction, as well as in several alter
building designs.

Although the general fire performance
well documented, there are still seve
warrant further investigation to ensure
safety levels are met and a number
available for designers to use. Generating
generic assemblies will reduce the need f
completed on an individual construction

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FIRESTOPPING TEST WITNESS REPORT

for

NORDIC STRUCTURES

Penetration Fire Protection

Inventory of Fire Tested Penetrations in MT Assemblies

WoodWorks WOOD PRODUCTS COUNCIL

Table 3: North American Fire Tests of Penetrations and Fire Stops in CLT Assemblies

CLT Panel	Exposed Side Protection	Penetrating Item	Penetrant Centered or Offset in Hole	Firestopping System Description	F Rating	T Rating	Stated Test Protocal	Source	Testing Lab
3-ply (78mm 3.07")	None	1.5" diameter data cable bunch	Centered	3.5 in diameter hole. Mineral wool was installed in the 1in. annular space around the data cables to a total depth of approximately 2 – 5/64in. The remaining 1in. annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	0.5 hour	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	2" copper pipe	Centered	4.375 in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 2 – 5/64in. The remaining 1in. annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	N.A.	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	2.5" sched. 40 pipe	Centered	4.92 in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 2 – 5/64in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	N.A.	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	6" cast iron pipe	Centered	8.35 in diameter hole. Mineral wool was installed in the 1in. annular space around the cast iron pipe to a total depth of approximately 2 – 5/64in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	N.A.	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07")	None	Hilti 6 in drop in device. System No.: F-B-2049	Centered	9.01" diameter hole. Mineral wool was installed in the 1 – 1/4in. annular space around the drop-in device to a total depth of approximately 1 – 7/64in and the remaining 1in. annular space from the top of the mineral wool to the top edge of the 9 – 1/64in. hole in the CLT was filled with Hilti FS-One Max caulking.	1 hour	0.75 hour	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	1.5" diameter data cable bunch	Centered	3.5" diameter hole. Mineral wool was installed in the 1in. annular space around the data cables to a total depth of approximately 4 – 5/32 in. The remaining 1in. annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	1.5 hours	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	2" copper pipe	Centered	4.375 in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 4 – 5/32 in. The remaining 1in. annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	N.A.	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	2.5" sched. 40 pipe	Centered	4.92 in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 4 – 5/32 in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	0.5 hour	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	6" cast iron pipe	Centered	8.35 in diameter hole. Mineral wool was installed in the 1in. annular space around the cast iron pipe to a total depth of approximately 4 – 5/32 in. The remaining 1in. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	N.A.	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131mm 5.16")	None	Hilti 6 in drop in device. System No.: F-B-2049	Centered	9.01" diameter hole. Mineral wool was installed in the 1 – 1/4in. annular space around the drop-in device to a total depth of approximately 1 – 7/64in and the remaining 1in. annular space from the top of the mineral wool to the top edge of the 9 – 1/64in. hole in the CLT was filled with Hilti FS-One Max caulking.	2 hours	1.5 hours	CANULC S115	26	Intertek March 30, 2016
5-ply (175mm 6.875")	None	1" nominal PVC pipe	Centered	4.21 in diameter with a 3/4 in plywood reducer flush with the top of the slab reducing the opening to 2.28 in. Two wraps of Hilti CP 648-E W45/1-3/4" Firestop wrap strip at two locations with a 30 gauge steel sleeve which extended from the top of the slab to 1 in below the slab. The first location was with the bottom of the wrap strip flush with the bottom of the steel sleeve and the second was with the bottom of the wrap strip 3 in. from the bottom of the slab. The void between the steel sleeve and the CLT and between the steel sleeve and pipe at the top was filled with Roxul Safe mineral wool leaving a 3/4 in deep void at the top of the assembly. Hilti FS-One Max Intumescent Firestop Sealant was applied to a depth of 3/4 in on the top of the assembly between the plywood and steel sleeve as well as the steel sleeve and pipe.	2 hours	2 hours	ASTM E814	24	QAI Laboratories March 3, 2017

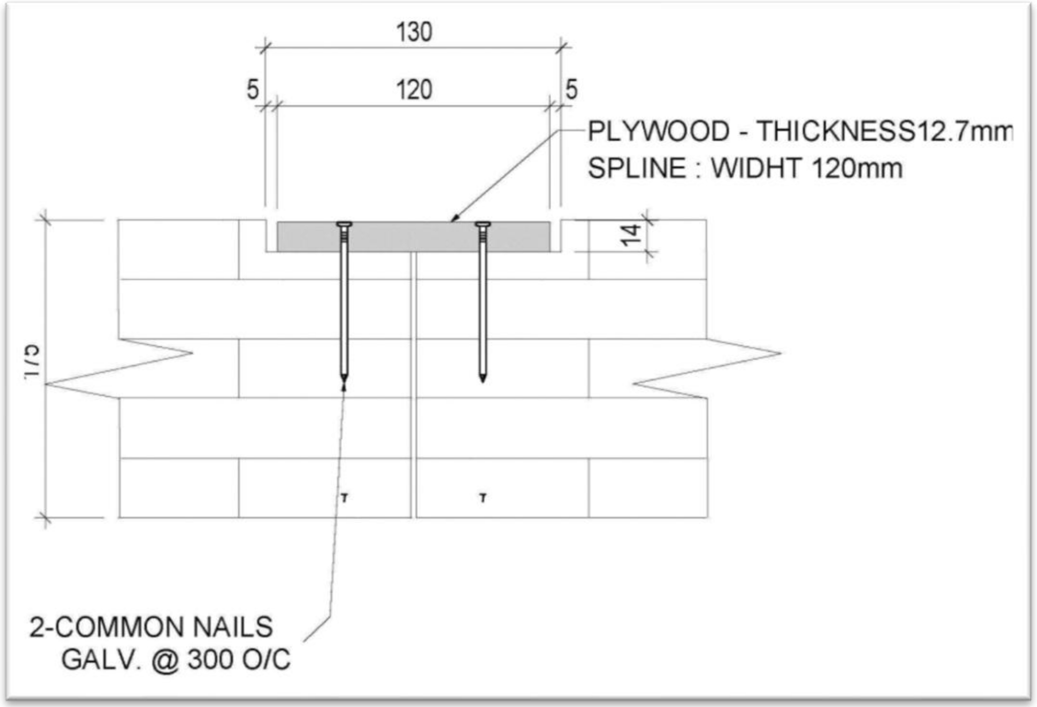
SEALANTS AT MT PANEL EDGES

Photos: ARUP

Sealants at MT Panel Edges

703.9 Sealing of adjacent mass timber elements. In buildings of Type IV-A, IV-B, and IV-C 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 Judd


Photo: ARUP

Sealants at MT Panel Edges

Several MT fire tested assemblies have successfully been completed w/o adhesives/sealants at abutting panel edges

2021 IBC will require periodic special inspections of adhesive/sealant installation (when required to be installed)

FIRE SAFETY DURING CONSTRUCTION

Fire Safety During Construction

New code provisions in International Fire Code (IFC) address construction fire safety of tall wood buildings

3308.4 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 <u>greater than six stories above grade plane</u> shall meet 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 chief.

Photo: Structurlam

Fire Safety During Construction

IFC 3313 Standpipe Requirements

SECTION 3313
STANDPIPES

3313.1 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 standpipe shall be provided with fire department hose connections at accessible locations adjacent to usable stairways. Such standpipes shall be extended as construction progresses to within one floor of the highest point of construction having secured decking or flooring.

3313.2 Buildings being demolished.

Where a building is being demolished and a standpipe is existing within such a building, such standpipe shall be maintained in an operable condition so as to be available for use by the fire department. Such standpipe shall be demolished with the building but shall not be demolished more than one floor below the floor being demolished.

3313.3 Detailed requirements.

Standpipes shall be installed in accordance with the provisions of Section 905.

> **Exception:** Standpipes shall be either temporary or permanent in nature, and with or without a water supply, provided that such standpipes comply with the requirements of Section 905 as to capacity, outlets and materials.

Credit: IFC

Fire Safety During Construction

IFC 3308.4 Cont'd

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

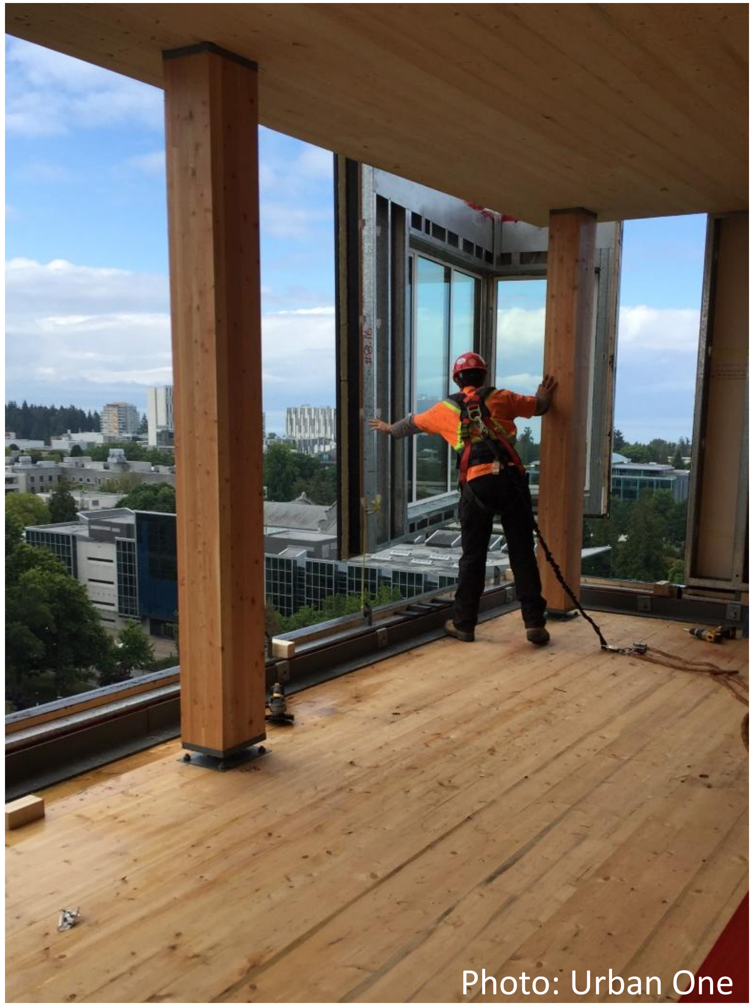
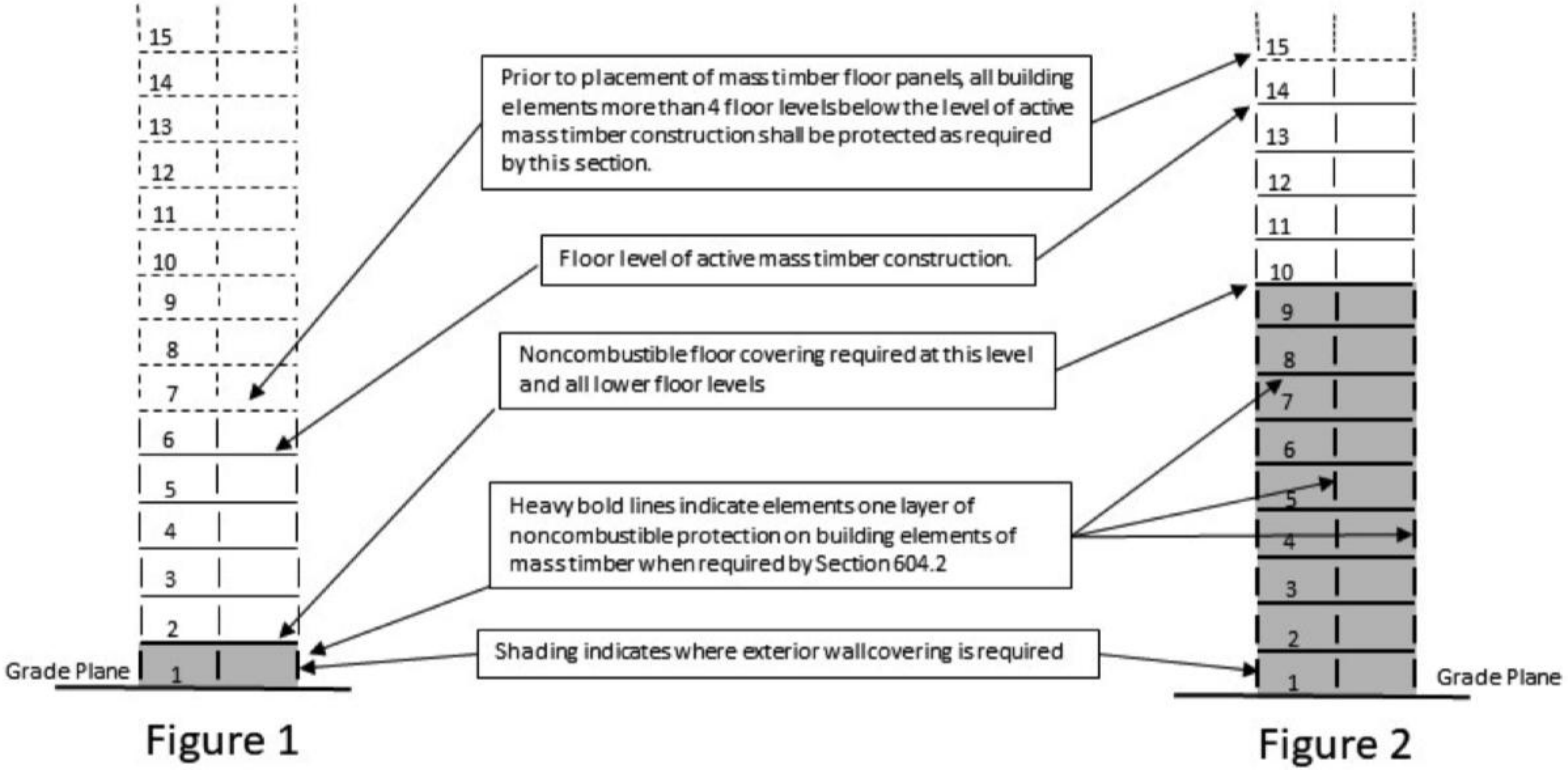


Photo: Urban One

Exception: Shafts and vertical exit enclosures

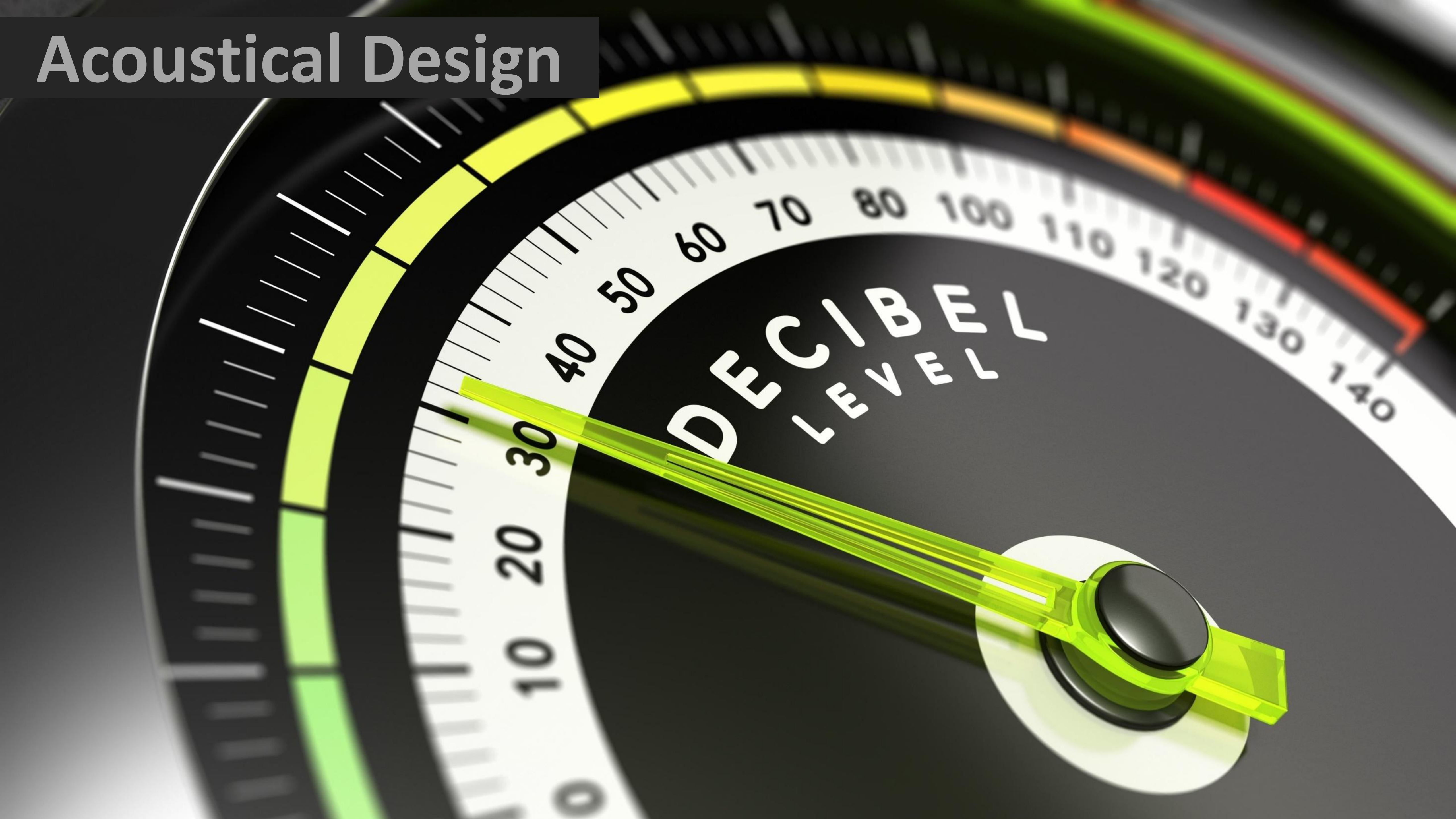
Fire Safety During Construction



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

Credit: ICC

Acoustical Design

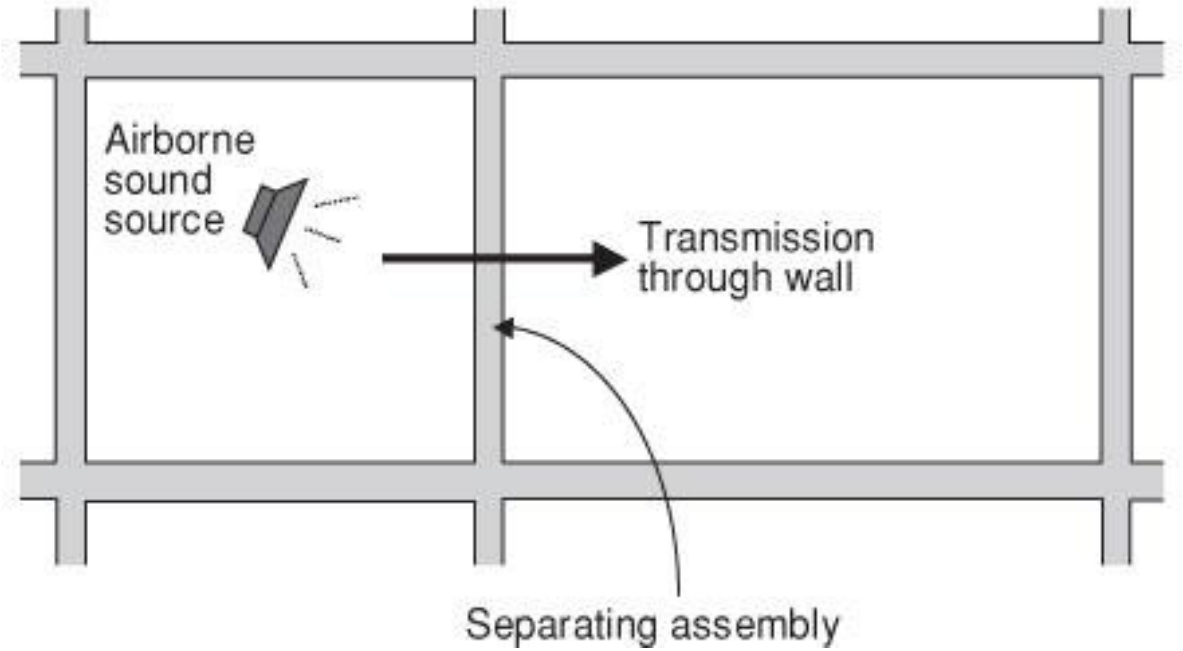


Acoustical Design

Air-Borne Sound:

Sound Transmission Class (STC)

- Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other
- Applies to walls and floor/ceiling assemblies

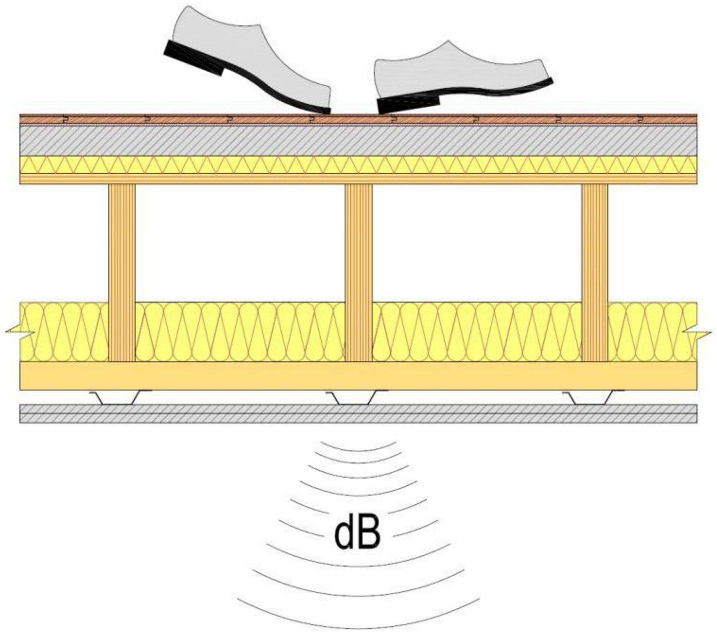


Acoustical Design

Structure-borne sound:

Impact Insulation Class (IIC)

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



Acoustical Design

Code requirements only address residential occupancies:

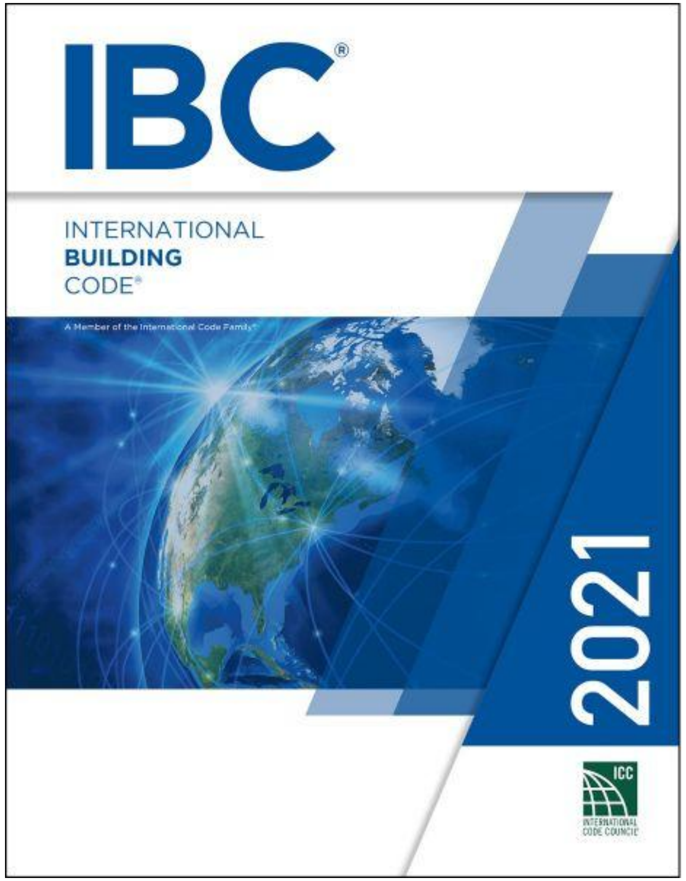
For unit to unit or unit to public or service areas:

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

- Walls, Partitions, and Floor/Ceiling Assemblies

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

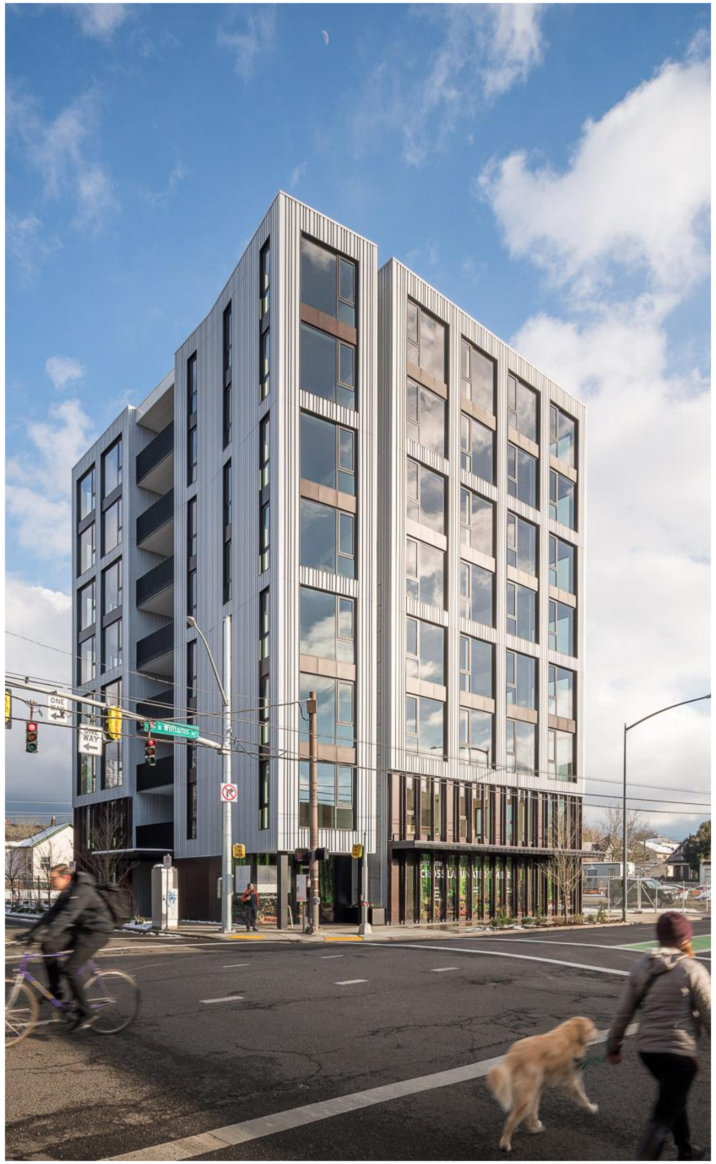
- Floor/Ceiling Assemblies

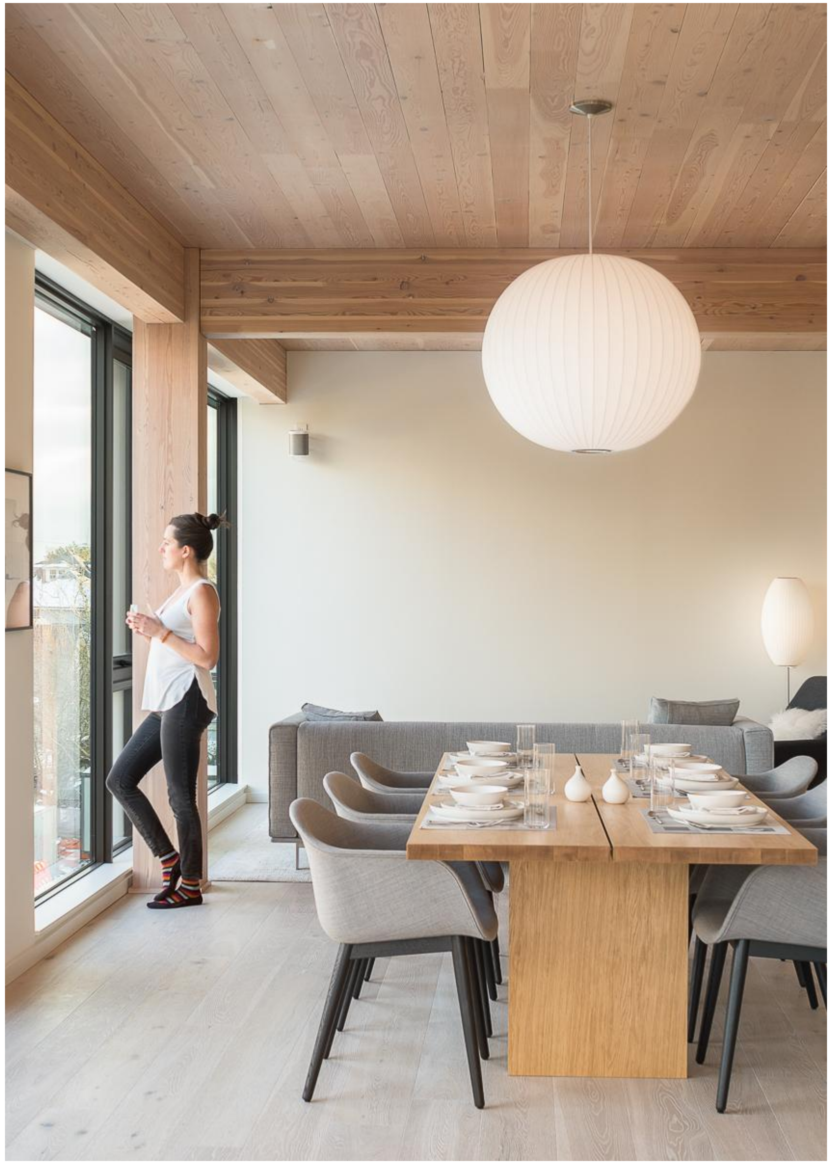


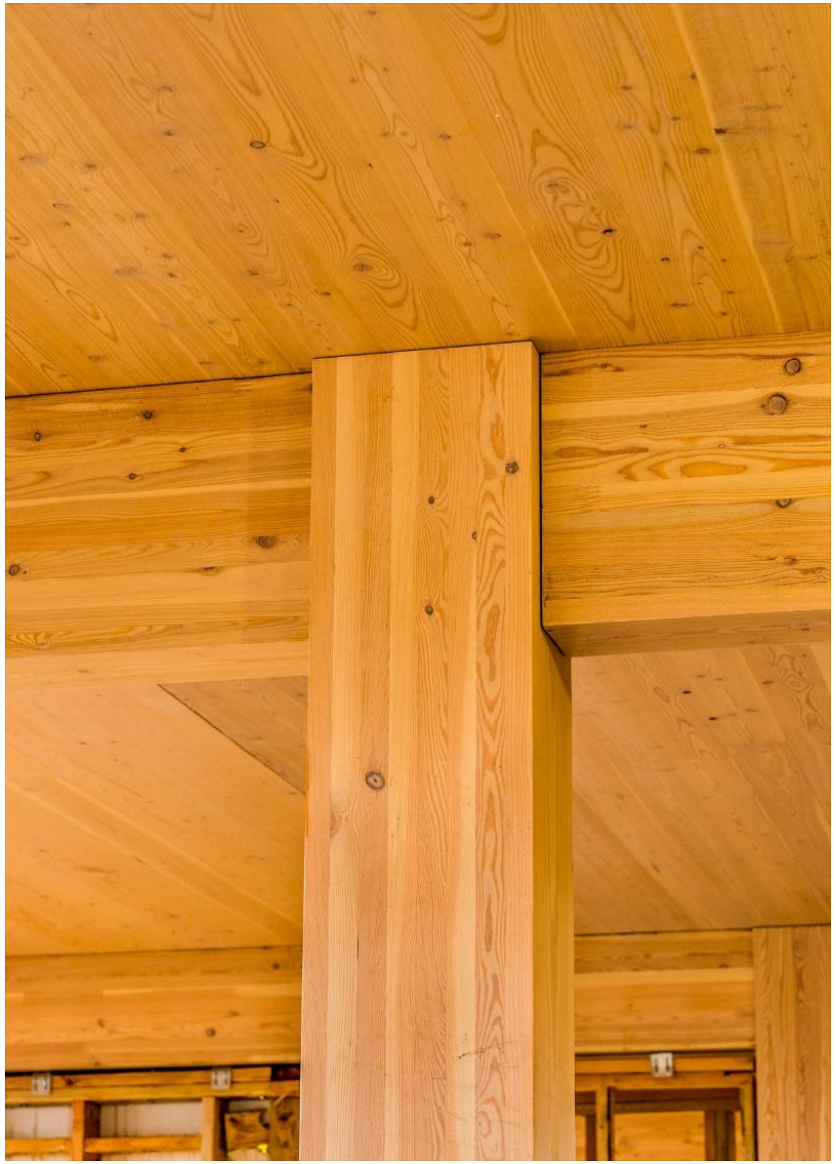
Acoustical Design

STC	What can be heard
25	Normal speech can be understood quite easily and distinctly through wall
30	Loud speech can be understood fairly well, normal speech heard but not understood
35	Loud speech audible but not intelligible
40	Onset of "privacy"
42	Loud speech audible as a murmur
45	Loud speech not audible; 90% of statistical population not annoyed
50	Very loud sounds such as musical instruments or a stereo can be faintly heard; 99% of population not annoyed.
60+	Superior soundproofing; most sounds inaudible

Tall Timber: Structure Often is Finish







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

But by Itself, Not Adequate for Acoustics

Photo: Corey Gaffer courtesy Perkins + Will

Mass Timber Acoustics

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]

Acoustical Detailing

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

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

Image credit: AcoustiTECH

Mass Timber Acoustics

Solutions Paper

WoodWorks™ WOOD PRODUCTS COUNCIL

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

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

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

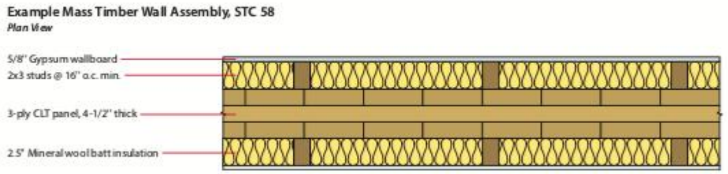
Photo: Corey Gaffer courtesy Perkins + Will

The growing availability and code acceptance of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction has given designers a low-carbon alternative to steel, concrete, and masonry for many applications. However, the use of mass timber in multi-family and commercial buildings presents unique acoustic challenges.

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

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

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



Source: US CLT Handbook

Mass Timber Assembly Options: Walls

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

Acoustical Differences between Mass Timber Panel Options

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

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

Improving Performance by Minimizing Flanking

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

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

Acoustical isolation strips

Photos: Rothoblaas

Mass Timber Acoustics

Inventory of Tested Assemblies

Acoustically-Tested Mass Timber Assemblies

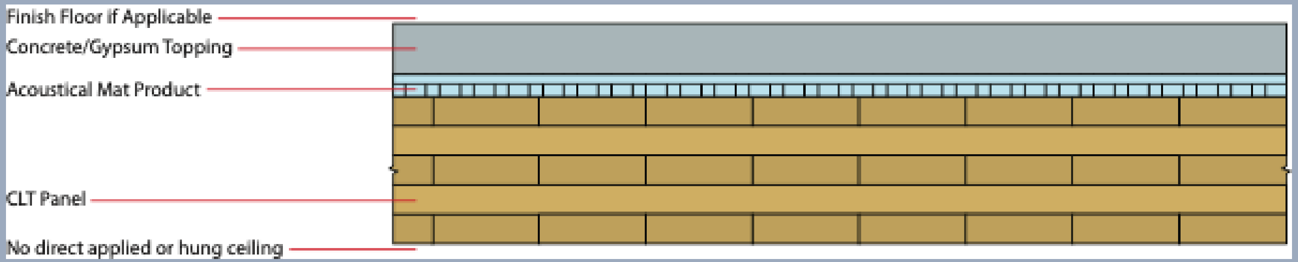
Following is a list of mass timber assemblies that have been acoustically tested as of January 23, 2019. Sources are noted at the end of this document. For free technical assistance on any questions related to the acoustical design of mass timber assemblies, or free technical assistance related to any aspect of the design, engineering or construction of a commercial or multi-family wood building in the U.S., email help@woodworks.org or contact the WoodWorks Regional Director nearest you: http://www.woodworks.org/project-assistance

Contents:

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

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

WoodWorks WOOD PRODUCTS COUNCIL



CLT Panel	Concrete/Gypsum Topping	Acoustical Mat Product Between CLT and Topping	Finish Floor	STC[1]	IIC[1]	Source
CLT 5-ply (6.875")	1-1/2" Gyp-Crete®	Maxxon Acousti-Mat® 3/4	None	47[2] ASTC	47[2] AIIC	1
			LVT	-	49[2] AIIC	
			Carpet + Pad	-	75[2] AIIC	
			LVT on Acousti-Top®	-	52[2] AIIC	
			Eng Wood on Acousti-Top®	-	51[2] AIIC	
		Maxxon Acousti-Mat® ¾ Premium	None	49[2] ASTC	45[2] AIIC	
			LVT	-	47[2] AIIC	
			LVT on Acousti-Top®	-	49[2] AIIC	
	1-1/2" Levelrock® Brand 2500	USG SAM N25 Ultra	None	45[6]	39[6]	15
			LVT	48[6]	47[6]	16
			LVT Plus	48[6]	49[6]	58
			Eng Wood	47[6]	47[6]	59
			Carpet + Pad	45[6]	67[6]	60
			Ceramic Tile	50[6]	46[6]	61
		Soprema® Insonomat	None	45[6]	42[6]	15
			LVT	48[6]	44[6]	16
			LVT Plus	48[6]	47[6]	58
			Eng Wood	47[6]	45[6]	59
			Carpet + Pad	45[6]	71[6]	60
			Ceramic Tile	50[6]	46[6]	61
		USG SAM N75 Ultra	None	45[6]	38[6]	15
			LVT	48[6]	47[6]	16
			LVT Plus	48[6]	49[6]	58
			Eng Wood	47[6]	49[6]	59

Tall Mass Timber Acoustics

Table 2: Impact of Direct Applied Ceiling Gypsum and Dropped Ceiling on Mass Timber Floor Panels[7]

Base Assembly (top to bottom)		Base assembly plus 2 layers direct applied 5/8" gyp on underside of mass timber	Base assembly plus 2 layers direct applied gyp plus dropped ceiling
1" poured gypsum, acoustical mat, 5-ply CLT	STC 50 IIC 40	STC 52 IIC 46	STC 63 IIC 60
LVT, 1" poured gypsum, acoustical mat, 5-ply CLT	STC 51 IIC 43	STC 52 IIC 48	STC 63 IIC 63
2" concrete, acoustical mat, 5-ply CLT	STC 52 IIC 46	STC 59 IIC 52	Not tested
LVT, 2" concrete, acoustical mat, 5-ply CLT	STC 53 IIC 52	STC 58 IIC 55	Not tested

Base Assembly Exposed Timber

With Direct Applied Ceiling Gyp

With Direct Applied Ceiling Gyp & Dropped Ceiling

NEW MASS TIMBER DESIGN MANUAL

80+ pages of mass timber technical resources, case studies and more. Links directly to many additional resources.

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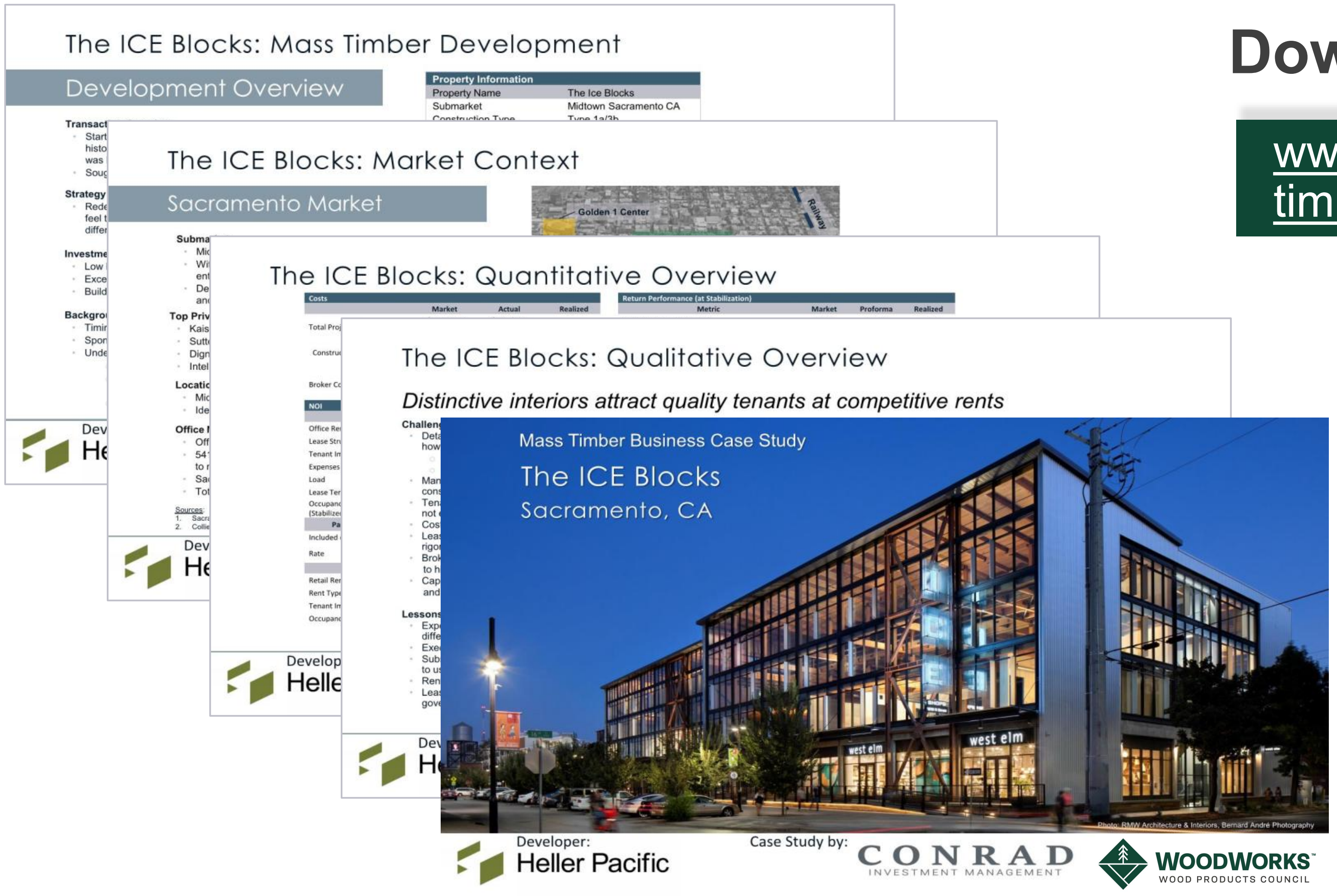
https://info.thinkwood.com/masstimberdesignmanual

NEW MASS TIMBER BUSINESS CASE STUDIES



Download online at

www.woodworks.org/mass-timber-business-case-studies

- Includes financial return performance data on mass timber projects
- Developers share lessons learned, challenges and successes

Questions? Ask us anything.

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