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



Course Description

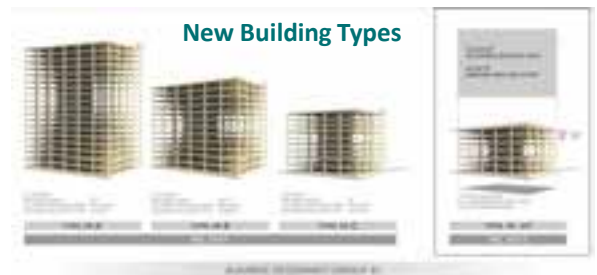
In January 2019, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (IBC). Based on these proposals, the 2021 IBC will include three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber 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. This presentation will take a detailed look at the new code provisions and methods of addressing the new requirements. Topics will include tall-wood specific high rise and sprinkler requirements, methods of demonstrating fire-resistance ratings, fire design for penetrations, connections and abutting panels, allowances for exposed timber, exterior walls, concealed spaces and more.

Learning Objectives

1. Explore the three new tall wood construction types and discuss related code provisions such as allowable heights and fire-resistance ratings.
2. Discuss code-compliant options for exposing mass timber, where up to 2-hour fire-resistance ratings are required, and demonstrate design methodologies for achieving these ratings.
3. Review code requirements unique to tall wood buildings, focusing on items such as sprinklers, shaft construction and concealed spaces.
4. Highlight design options for addressing topics such as fire stops at penetrations through mass timber assemblies and exterior walls fire-resistance in tall timber structures.



Credit: American Wood Council



Credit: Susan Jones, atellerjones

Tall Wood Building Size Limits

	Construction Type (All Sprinklered 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	180	270	180	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
B	Unlimited	12	18	12	6	6
R-2	Unlimited	12	18	12	8	5
	Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)					
A-2, A-3, A-4	Unlimited	Unlimited	135,000	90,000	56,250	45,000
B	Unlimited	Unlimited	324,000	216,000	135,000	108,000
R-2	Unlimited	Unlimited	184,500	123,000	76,875	61,500

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)

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

In almost all cases, sprinklers will be required

Non-Tall Opportunities – Large Area

	Construction Type (All Sprinklered 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	180	270	180	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
B	Unlimited	12	18	12	6	6
R-2	Unlimited	12	18	12	8	5
	Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)					
A-2, A-3, A-4	Unlimited	Unlimited	135,000	90,000	56,250	45,000
B	Unlimited	Unlimited	324,000	216,000	135,000	108,000
R-2	Unlimited	Unlimited	184,500	123,000	76,875	61,500

Type IV-A



Credit: Susan Jones, atelierjones



Photos: Structuram, naturallywood, Fast + Epp

Type IV-A Height and Area Limits

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



Credit: Susan Jones, atelierjones

Type IV-A Protection vs. Exposed



Credit: Susan Jones, atelierjones



100% NC protection on all surfaces of Mass Timber

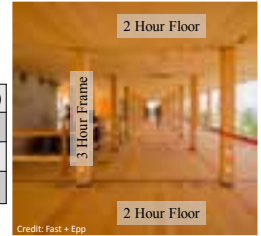
Credit: Action Outry Architects, Fast + Epp

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



Credit: Fast + Epp

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

1/2" Type X Gypsum = 25 min | 5/8" Type X Gypsum = 40 min



Credit: Urban One

Noncombustible Protection (NC)

TABLE 722.3.1(a) PROTECTION REQUIRED FROM NONCOMBUSTIBLE COVERING MATERIAL		
Required Fire Resistance Rating of Building Element, per Tables 602 and 603 (hours)	Minimum Protection Required 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

TABLE 722.3.1(b) PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL		
Noncombustible Protection	Protection Contribution (minutes)	
1/2 inch Type X Gypsum Board	25	
5/8 inch Type X Gypsum Board	40	

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 own fire-resistance rating (e.g., Mass Timber only) or have a fire resistance rating based on the fire resistance through a combination 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

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.



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:

MT



IBC 602.4

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

NC



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 minimum sizes also apply to MT used in new types IV-A, IV-B and IV-C

Contained in IBC 2304.11



Photo: Ring Riter

Type IV Minimum Sizes - Framing

Framing		Solid Sawn (nominal)	Glulam (actual)	SCL (actual)
Floor	Columns	8 x 8	6 ³ / ₄ x 8 ³ / ₄	7 x 7 ¹ / ₂
	Beams	6 x 10	5 x 10 ¹ / ₂	5 ¹ / ₂ x 9 ¹ / ₂
Roof	Columns	6 x 8	5 x 8 ³ / ₄	5 ¹ / ₂ x 7 ¹ / ₂
	Beams*	4 x 6	3 X 6 ⁷ / ₈	3 ¹ / ₂ X 5 ¹ / ₂

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 1/2" particleboard

Roof Panels/Decking:

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



Photo: StructuraCraft



Photo: 2020 architect / 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

MT Interior Walls in all Type IV:

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

Other Interior Walls in Type IV A,B,C

- Non-combustible (0 hr for nonbearing)

Other Interior Walls in Type IV HT

- 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:

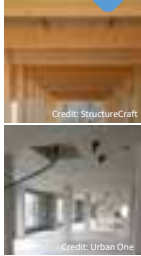
Primary Structural Frame (Beam, Column, Bearing Wall):

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

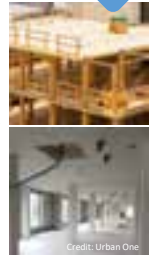
FRR Examples:

Floor Panels:

2 HR Required

NC Protection = at least 80 min

- Use 2 layers of 5/8" type X Gypsum = 80 min (1.33 HR), plus:
 - Mass Timber FRR req'd = 2 HR – 1.33 HR = 0.67 HR, or
- Use 3 layers of 5/8" Type X Gypsum = 120 min (2 HR) and no FRR from MT req'd



Type IV-A Protection



IV-A

- Floor Surface Protection
- Roof Construction Protection
- Ext Wall Protection

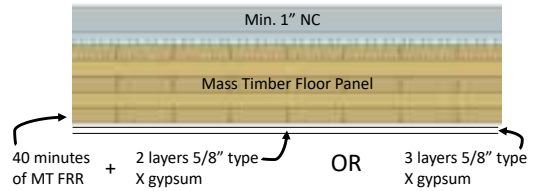
Min. 1 inch of NC protection
Min. 2 layers 5/8" type X gyp on inside face
Min. 1 layer 5/8" type X gyp on outside face
Min. 2 layers 5/8" type X gyp on inside face (non-brng)
Min. 3 layers 5/8" type X gyp on inside face (brng)



Type IV-A Fire Resistance Ratings (FRR)

IV-A

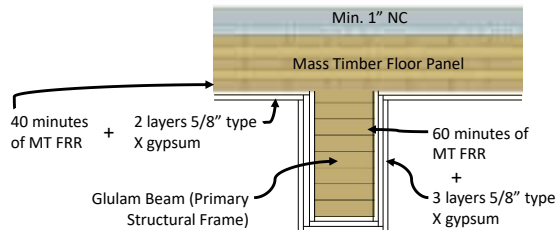
FRR & NC Floor Panel Example: 2 HR



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:

- Calculations in Accordance with IBC 722 → NDS Chapter 16
- Tests in Accordance with ASTM E119



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 Chpt 16 for exposed wood FRR

722.1 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 U.S. 263. The required fire resistance of a building element, component or assembly shall be permitted to be established by any of the following methods in precedence:

1. Calculations in accordance with Section 722.

722.2 General. The provisions of this section govern procedures by which the fire resistance of specific materials or combinations of materials is established by calculation. These provisions apply only to the information contained in this section and shall not be otherwise used. The calculated fire resistance of concrete, concrete masonry and other masonry assemblies shall be permitted to be determined with ACI 209.2-08 (TMS 602.4). The calculated fire resistance of steel assemblies shall be permitted to be determined with Chapter 16 of AISC 360-10 (Steel Design Manual) for structural steel assemblies.

MT Fire Resistance Ratings (FRR)



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

Table 16.3.18 Effective Char Depths (for CLT with $\rho_{\text{eff}} \geq 0.85 \rho_{\text{ref}}$)

Exposure Time (hr)	Effective Char Depth, d_{eff} (in.)							
	1	2	3	4	5	6	7	8
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Credit: Innovations

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



Credit: ARUP

Table 16.3.18 Effective Char Depths (for CLT with $\rho_{\text{eff}} \geq 0.85 \rho_{\text{ref}}$)

Exposure Time (hr)	Effective Char Depth, d_{eff} (in.)	
	1	2
1.0	0.0	0.0
2.0	0.0	0.0
3.0	0.0	0.0

Table 16.3.18 Effective Char Depths (for CLT with $\rho_{\text{eff}} \geq 0.85 \rho_{\text{ref}}$)

Exposure Time (hr)	Effective Char Depth, d_{eff} (in.)							
	1	2	3	4	5	6	7	8
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

MT Fire Resistance Ratings (FRR)

Structural capacity check performed on remaining section, with stress increases



Credit: Forest Products Laboratory

Table 16.4.1 Adjustment Factors for Fire Design

Property	Factor	Fire Exposure Time (hr)							
		1	2	3	4	5	6	7	8
Bending Strength	F_b	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Roar Bending Strength	F_{br}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shear Strength	F_v	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Compression Strength	F_c	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Creep Strength	F_{cr}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

$$F_{b, \text{red}} = F_b \cdot C_{F, \text{red}}$$

$$F_{b, \text{red}} = F_b \cdot C_{F, \text{red}} + \beta \left(1 - F_{b, \text{red}} \right)^{0.85}$$

$$F_{b, \text{red}} = 1.2 F_{b, \text{red}}$$

Solid Sawn, Glulam, SCL

CLT

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



MT Fire Resistance Ratings (FRR)



Mass Timber Fire Design Resource

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

MT Fire Resistance Ratings (FRR)

Inventory of Fire Tested MT Assemblies

TABLE 602.4.1 - Inventory of Fire Tested Mass Timber Assemblies (FRR)

Assembly	Fire Resistance Rating (FRR)	Notes	Notes	Notes	Notes	Notes	Notes
1. 4" x 12" CLT Panel	2 HR						
2. 4" x 12" CLT Panel with 1/2" Gypsum Board	2 HR						
3. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool	2 HR						
4. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
5. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
6. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
7. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
8. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
9. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
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12. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
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15. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
16. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
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25. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
26. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
27. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
28. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
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31. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
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48. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
49. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						
50. 4" x 12" CLT Panel with 1/2" Gypsum Board and 1/2" Mineral Wool and 1/2" Mineral Wool	2 HR						

Materials Permitted

602.4 Type IV. Type IV construction is that type of construction in which the building elements are mass timber or noncombustible materials and have fire resistance ratings in accordance with Table 602. Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both and shall be determined in accordance with Section 703.2 or 703.3. The minimum dimensions and permitted materials for building elements shall comply with the provisions of this section and Section 2304.11. Mass timber

Exterior load bearing walls and nonload bearing walls shall be mass timber construction, or shall be of noncombustible construction.

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

The interior building elements, including nonload bearing walls and partitions, shall be of mass timber construction or of noncombustible construction.

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

Type IV-B



Credit: Susan Jones, atellerjones



Credit: LEVER Architecture



IV-B



Credit: Susan Jones, atellerjones

Type IV-B Height and Area Limits

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



Credit: Susan Jones, atellerjones



NC protection on all surfaces of Mass Timber except limited exposed areas
~20% of Ceiling or ~40% of Wall can be exposed



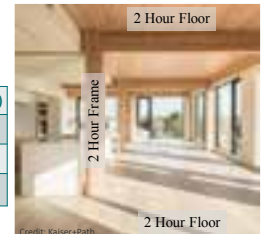
Credit: Kaiser+Path

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



Credit: Kaiser+Path

Type IV-B Fire Resistance Ratings (FRR)

IV-B



*Applicable to most locations. Limited exposed MT permitted

FRR	Min. NC Protection
2 HR (1 HR at Roof)	80 min* (40 min* at Roof)
2 HR	80 min*
2 HR	80 min*
1 HR	40 min*

Primary Frame FRR

Ext or Int Bearing Wall FRR

Floor Construction FRR

Roof Construction FRR

1/2" Type X Gypsum = 25 min | 5/8" Type X Gypsum = 40 min



Credit: Urban One

Type IV-B Protection

IV-B



Floor Surface Protection

Roof Construction Protection

Ext Wall Protection

Min. 1 inch of NC protection
Min. 1 layer 5/8" type X gyp on inside face*
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

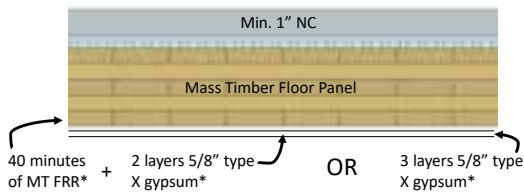


Credit: Maxon

Type IV-B Fire Resistance Ratings (FRR)

IV-B

FRR & NC Floor Panel Example: 2 HR



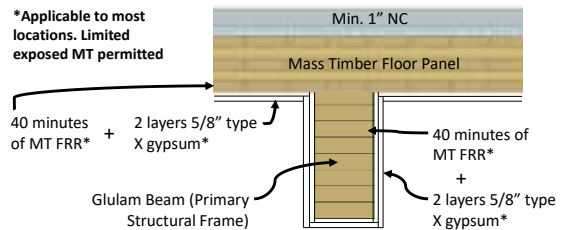
*Applicable to most locations. Limited exposed MT permitted

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, or
- MT walls and columns up to 40% of floor area in dwelling unit or fire area, or
- 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

- $U_{ac} = (800 \text{ SF}) * (0.20) = 160 \text{ SF}$
- $U_{aw} = (800 \text{ SF}) * (0.40) = 320 \text{ SF}$
- 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

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.

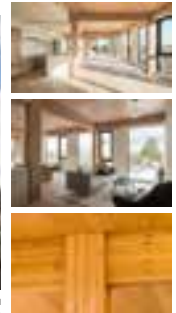


Credit: Kaiser+Patt

Type IV-C



Credit: Susan Jones, atellerjones

Photos: Baumberger Studio/PATW
Architecture/Marcus Kauffman

Type IV-C Height and Area Limits

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 'I stories permitted due to enhanced FRR

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



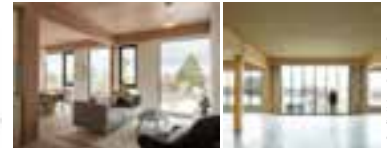
Credit: Susan Jones, atellerjones

Type IV-C Protection vs. Exposed

IV-C



Credit: Susan Jones, atellerjones



Credit: Kaiser+Patt, Emma 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

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



Type IV-C Protection



IV-C

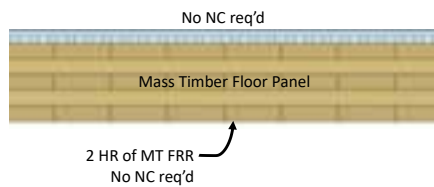
Floor Surface Protection	None req'd
Roof Construction Protection	None req'd
Ext Wall Protection	Min. 1 layer 5/8" type X gyp on outside face None req'd on inside face



Type IV-C Fire Resistance Ratings (FRR)

IV-C

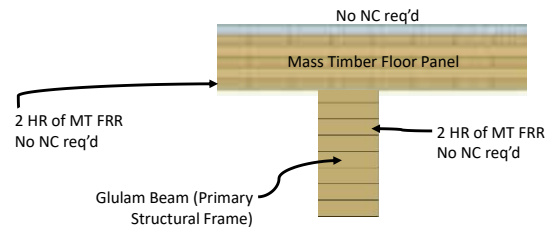
FRR & NC Floor Panel Example: 2 HR



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

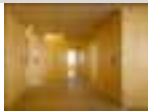


Credit: PATH Architecture



Photo: Blaine Brownell

Interior Wall Construction Recap



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



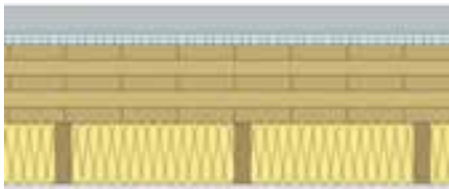
Fire Rating (bearing wall)	3 Hr	2 Hr	2 Hr	2 Hr	2 Hr
Mass Timber	Mass Timber/CLT		4" min thick CLT*		6" Wall*
Exterior NC Protection	40 Min NC & No Exterior Combustible Coverings		FRT Sheathing, Gyp or other NC		
Interior NC Protection	Per Interior Requirements		Not Required		
Light Frame FRTW	No		Yes*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

*Changes in IBC 2015, 2018, and 2021 editions

Concealed Spaces in Type IV

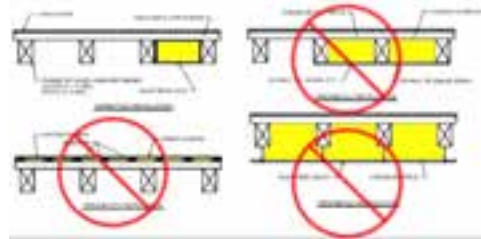
What if I have a dropped ceiling? Can I have a dropped ceiling?

- Impact on FRR, NC placement, sprinkler requirements



Concealed Spaces in Type IV

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



Credit: IBC

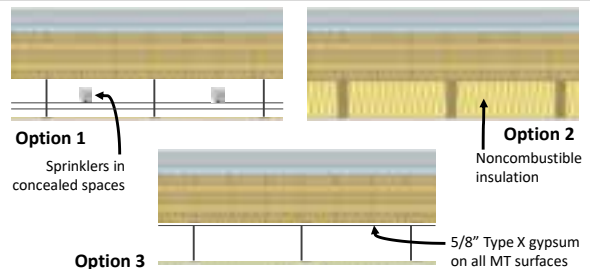
Concealed Spaces in Type IV

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

- The building is sprinklered throughout with an NFPA 13 Sprinkler and automatic sprinklers are provided in the concealed space.
- The concealed space is completely filled with noncombustible insulation.
- 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



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

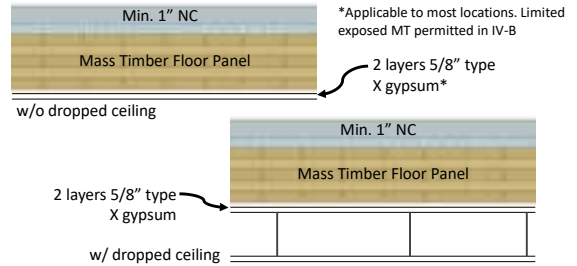
New IV-HT concealed space provisions do not apply to IV-A, IV-B or IV-C

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

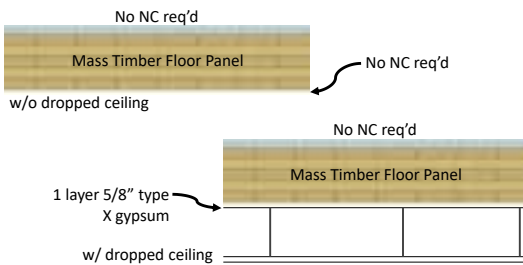
- **IV-A and IV-B:** Combustible construction forming concealed spaces protected with NC of 80 minutes (2 layers of 5/8" Type X Gypsum)
- **IV-C:** Combustible construction forming concealed spaces protected with NC of 40 minutes (1 layer of 5/8" Type X Gypsum)



Concealed Spaces in Type IV-A, IV-B



Concealed Spaces in Type IV-C



Tall Wood Shaft Enclosures

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



Tall Wood Shaft Enclosures



Exit & Hoistway Enclosures

E&H Enclosures FRR

Up to 12 Stories or 180 ft: MT protected with 2 layers 5/8" type X gyp (if 2 HR req'd) or 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)

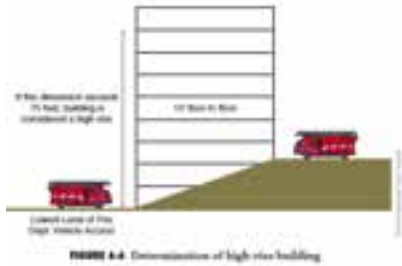
NC or MT protected with 2 layers 5/8" type X gyp (IBC 2021 602.4.2.6) both sides

NC or MT protected with 1 layer 5/8" type X gyp (IBC 602.4.3.6) both sides

2 HR (not less than FRR of floor assembly penetrated, IBC 713.4)



Mid-Rise vs. High-Rise



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



CLT Fire Performance – Char Fall Off

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



CLT Fire Performance – Fire Re-Growth

In tall buildings, preventing fire re-growth is key. Fire re-growth is a phenomenon in which the heat-release rate of a fire intensifies following a decay phase. Fire re-growth can be initiated when delamination occurs, as this exposes un-charred wood surfaces, thereby resulting in an influx of fuel available for consumption by the fire.



CLT Fire Performance – Char Fall Off

Facts about CLT char fall off:

- Only an item to consider in tall buildings. Important to avoid in high-rise construction where required performance is containment of fire within compartment of origin with no sprinkler or fire service suppression
- Not applicable when discussing mid-rise mass timber (or any building under types II, III, IV-HT or V)
- Largely a function of adhesive performance under high temps
- Has been addressed in PRG 320-18 (required for all CLT under 2021 IBC, not just tall wood)



CLT Fire Performance – PRG 320

2021 IBC Section 602.4 added:

Cross-laminated timber shall be labeled as conforming to PRG 320 - 18 as referenced in Section 2303.1.4.



CLT Fire Performance – PRG 320

PRG 320 is manufacturing & performance standard for CLT.

2018 edition (referenced in 2021 IBC) added new elevated temperature adhesive performance requirements validated by full-scale and medium-scale qualification testing to ensure CLT does not exhibit fire re-growth

When designing tall wood – specify CLT per PRG 320-18 (req'd in IBC 2021 for all CLT)



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



CONNECTIONS IN TALL WOOD

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.

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

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



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	Exposure
1	8.75" x 18" (222mm x 457mm)	1 x Ricon S V/S 290x80	3,905lbs (17.4kN)	1hr
2	10.75" x 24" (273mm x 610mm)	Staggered double Ricon S V/S 200x80	16,620lbs (73.9kN)	1.5hrs
3	10.75" x 24" (273mm x 610mm)	1 x Meguet 430	16,620lbs (73.9kN)	1.5hrs

Connection Fire Protection

Softwood Lumber Board Glulam Connection Fire Test Summary Report

Issue 1 June 1, 2017



Full Report Available at:

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



PENETRATIONS IN TALL WOOD

Photo: Alex Schmitt

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



Photo: AWG/Innovation



Penetration Fire Protection

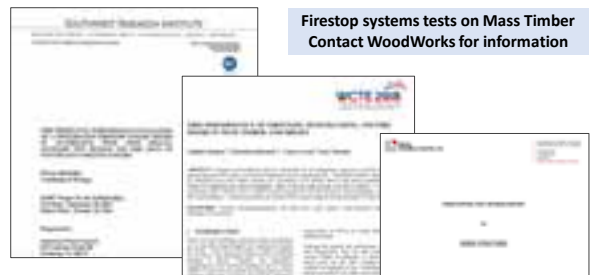
Most firestopping systems include combination of fire safing (eg. noncombustible materials such as mineral wool insulation) plus fire caulk



Photo: AWG/Innovation/HRI

Penetration Fire Protection

Firestop systems tests on Mass Timber
Contact WoodWorks for information



Penetration Fire Protection

Inventory of Fire Tested Penetrations in MT Assemblies

Table 4.4.4.4.1. Inventory of Fire Tested Penetrations in MT Assemblies

Penetration	Fire Test	Fire Resistance Rating	Notes
1. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
2. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
3. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
4. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
5. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
6. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
7. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
8. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
9. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
10. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
11. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
12. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
13. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
14. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
15. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
16. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
17. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
18. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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21. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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24. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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27. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
28. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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35. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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51. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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54. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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63. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
64. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
65. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
66. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
67. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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69. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
70. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
71. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
72. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
73. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
74. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
75. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
76. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
77. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
78. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
79. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
80. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
81. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
82. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
83. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
84. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
85. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
86. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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89. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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95. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required
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100. 2" x 4" x 8" Stud	ASTM E 119	1.0 hr	Sealant required

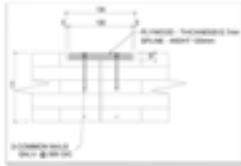
SEALANTS AT MT PANEL EDGES



Sealants at MT Panel Edges

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

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



Sealants at MT Panel Edges

Sealants shall meet the requirements of ASTM C920 (elastomeric joint sealants). Adhesives shall meet the requirements of ASTM D3498 (gap filling construction adhesives, i.e. not fire caulk).

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



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)



Occupancy Separation

Protection of MT used for occupancy separation

Addition to IBC 508.4.4.1 requires: Mass timber elements serving as fire barriers or horizontal assemblies to separate occupancies in Type IV-B or IV-C construction shall be separated from the interior of the building with a minimum of 1/2" gypsum board or a noncombustible equivalent.



Incidental Use Separation

Protection of MT used for incidental use separation

New section 509.4.1.1 requires:

Where Table 509 specifies a fire-resistance-rated separation, mass timber elements serving as fire barriers or a horizontal assembly in Type IV-B or IV-C construction shall be separated from the interior of the incidental use with a minimum of ½" gypsum board or a noncombustible equivalent.



Photo: MIT | John Klein

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

1. Standpipes shall be provided in accordance with Section 3313.
2. A water supply for fire department operations, as approved by the fire chief.



Photo: Directium

Fire Safety During Construction

IFC 3313 Standpipe Requirements



Credit: IFC

Fire Safety During Construction

IFC 3308.4 Cont'd

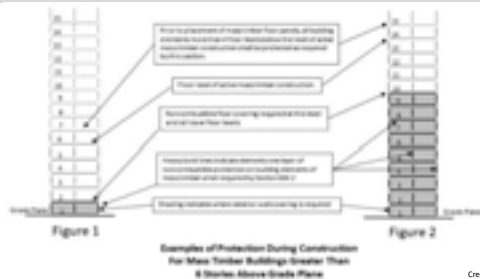
3. Where building construction exceeds six stories above grade plane, at least one layer of noncombustible protection where required by Section 602.4 of the International Building Code shall be installed on all building elements more than 4 floor levels, including mezzanines, below active mass timber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

Exception: Shafts and vertical exit enclosures



Photo: Urban One

Fire Safety During Construction



Credit: ICC

QUESTIONS?

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