Mass Timber Design

Presented by Bevan Jones, Parisa Nassiri
11/04/2021

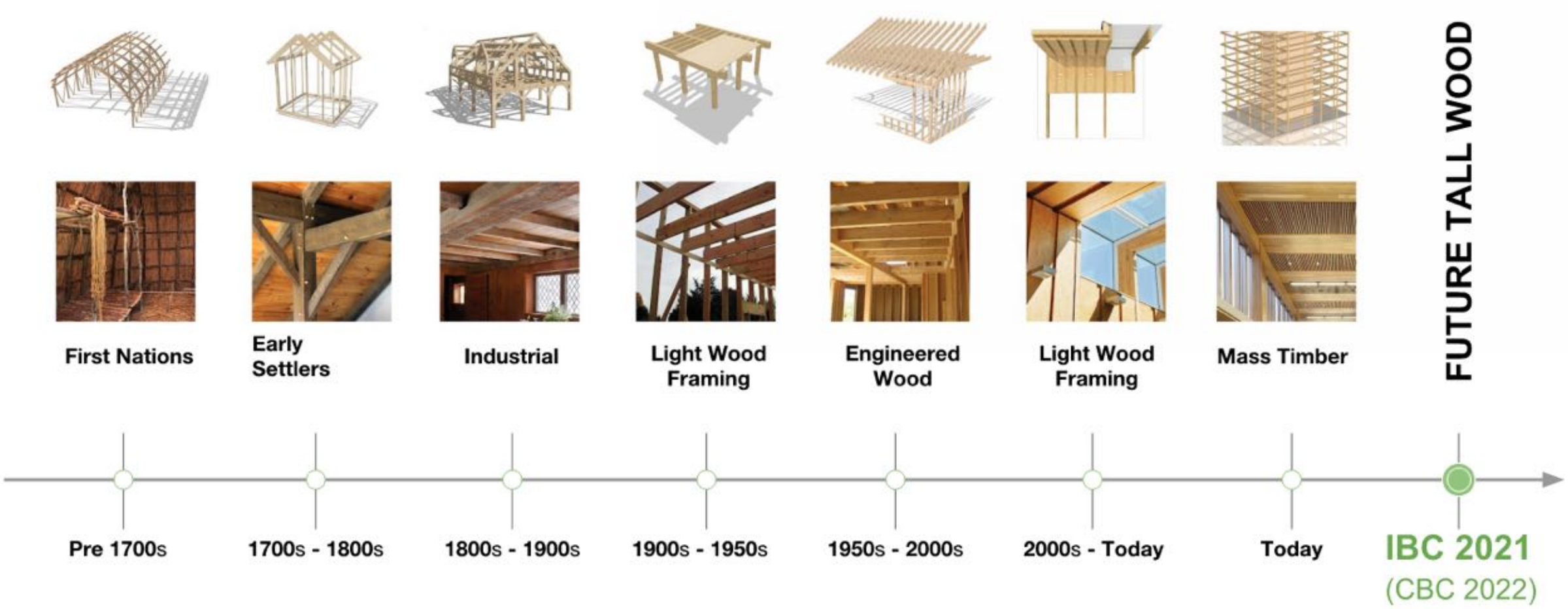
Disclaimer: This presentation was developed by a third party and is not funded by Woodworks or the or the Softwood Lumber Board.

Agenda

- What is mass timber?
- Construction types
- Mass timber design
- Noncombustible protection
- Testing opportunities
- Typical details
- Performance-based design
- Case studies

What is Mass Timber?

Mass Timber Evolution in North America



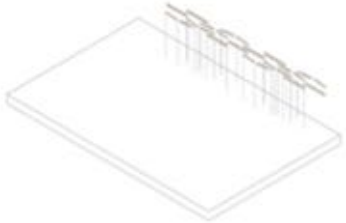
What is Mass Timber?

CLT

NLT

GLT

LSL



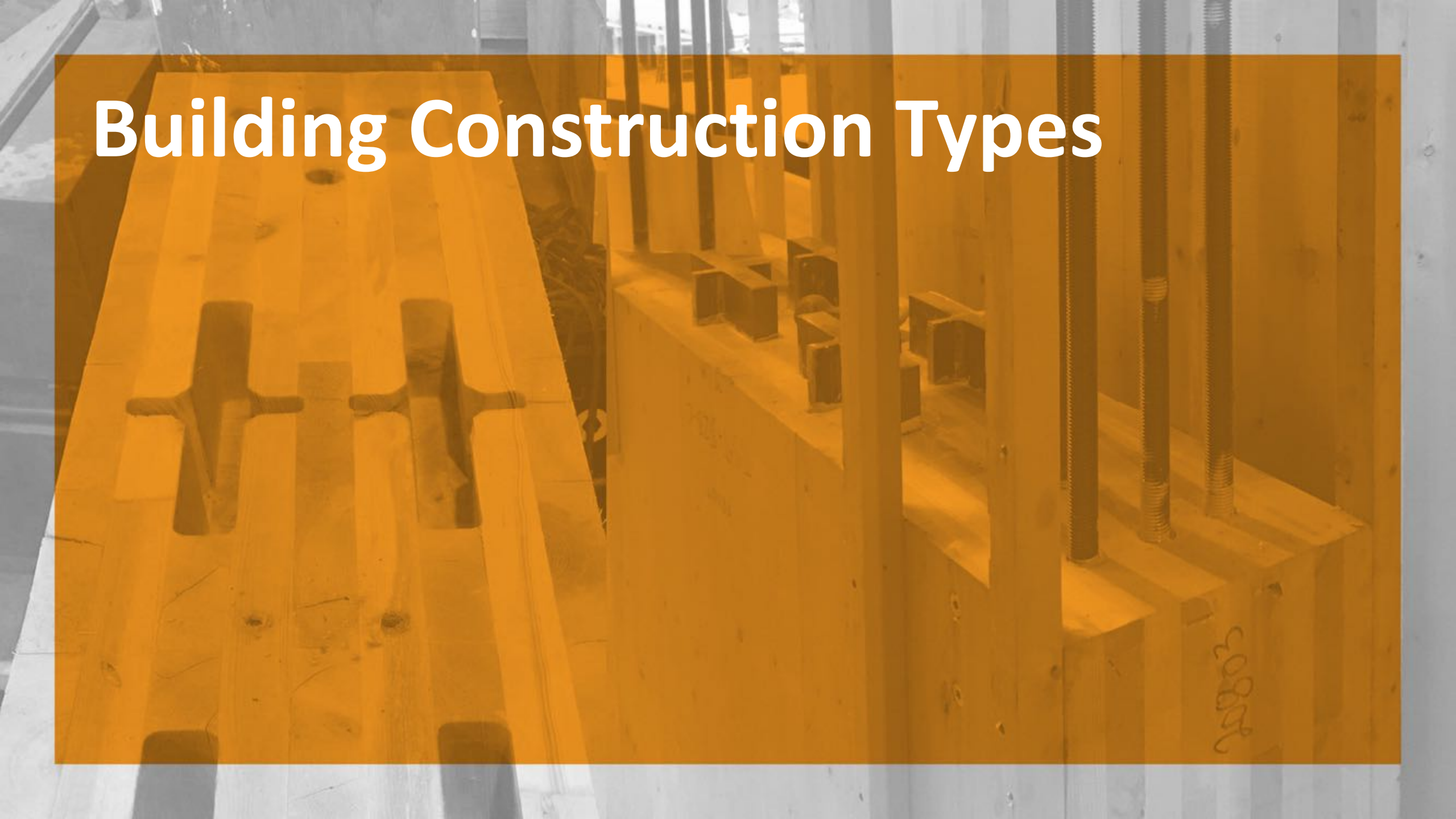
LVL

GLULAM

PSL

Mass Timber

Building Construction Types



Height and Story Limitations

Occupancy Group R-2

V, III & IV-HT

IV-C & IV-B

IV-A

Construction Type	Stories	Max Height	Mass Timber	Sprinklers	Primary Frame Fire Rating	Stair Tower	Concealed Spaces
V-B	4	60’	Exposed	Yes	0 HR	Mass Timber	Yes
V-A					1 HR		
III-B	4-5	75’- 85’			0 HR		
III-A					1 HR		
IV-HT					2 HR		No
IV-C	7-8						Yes
IV-B	11-12	180’	Partially Exposed				
IV-A	17-18	270’	Fully Protected		3 HR	Noncombustible	

Construction Type V (0-1 hr rated)

Type V construction is that type of construction in which the structural elements, exterior walls and interior walls are of any materials permitted by the Code.

BUILDING ELEMENT	TYPE V	
	A	B
Primary structural frame[f] (see Section 202)	1[b]	0
Bearing walls Exterior[e,f] Interior	 1 1	 0 0
Nonbearing walls and partitions Interior[d]	0	0
Floor construction and associated secondary members (see Section 202)	1	0
Roof construction and associated secondary members (see Section 202)	1[b,c]	0

Construction Type III (0-1 hr rated)

Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by the Code.

- TYPE III-A: Protected Combustible
- TYPE III-B: Unprotected Combustible

BUILDING ELEMENT	TYPE III	
	A	B
Primary structural frame[f] (see Section 202)	1[b]	0
Bearing walls Exterior[e, f] Interior	 2 1	 2 0
Nonbearing walls and partitions Interior[d]	0	0
Floor construction and associated secondary members (see Section 202)	1	0
Roof construction and associated secondary members (see Section 202)	1[b,c]	0

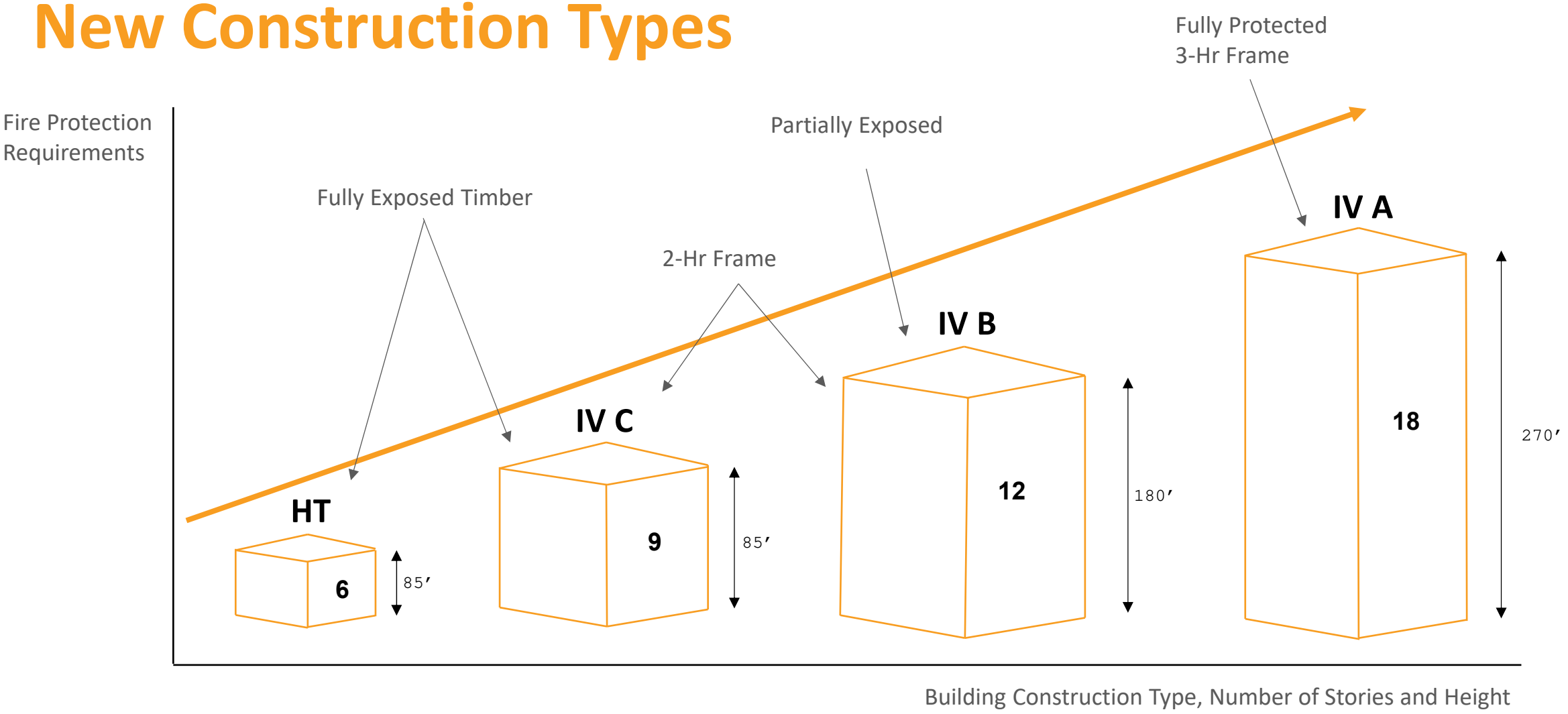
Construction Type IV (2-3 hr rated)

Type IV construction is that type of construction in which the building elements are mass timber or noncombustible materials

- Type IV-A: Fully protected mass timber
- Type IV-B: Partially exposed mass timber
  - **20% of the ceiling exposed; OR**
  - **40% of the walls exposed**
- Type IV-C: Fully exposed mass timber
- Type IV-HT: Exposed heavy timber, non combustible exterior walls

Building Element	Type IV			
	A	B	C	HT
Primary Structural Frame:	3-hour	2-hour	2-hour	HT
Exterior Bearing Walls:	3-hour	2-hour	2-hour	2-hour
Interior Bearing Walls:	3-hour	2-hour	2-hour	HT
Exterior Non-Bearing Walls:	TBD	TBD	TBD	TBD
Interior Non-Bearing Walls:	0-hour	0-hour	0-hour	Per CBC 2304.11.2
Floor:	2-hour	2-hour	2-hour	HT
Roof:	1-1/2 hour	1-hour	1-hour	HT

New Construction Types

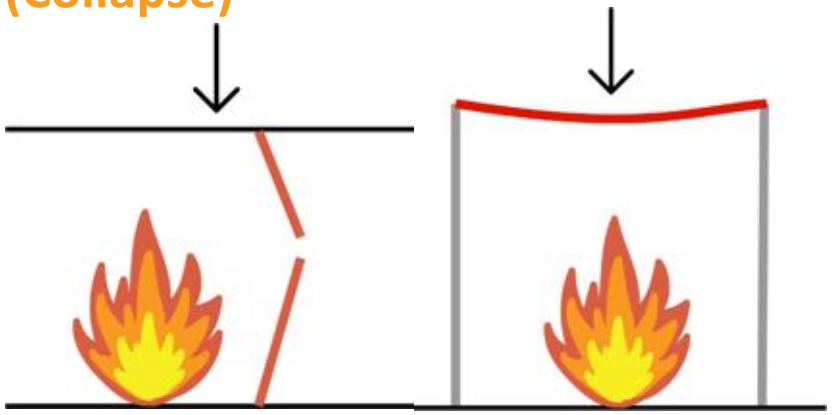


Mass Timber Design

Fire Resistance

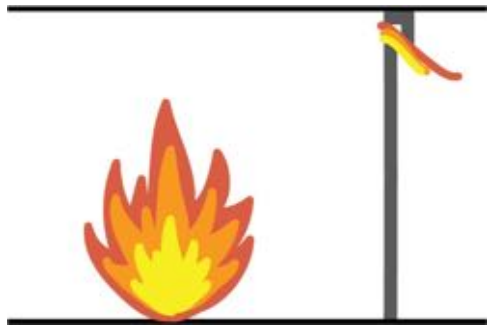
- **Building's ability to withstand exposure to fire in resistance of:**

Structural Stability (Collapse)



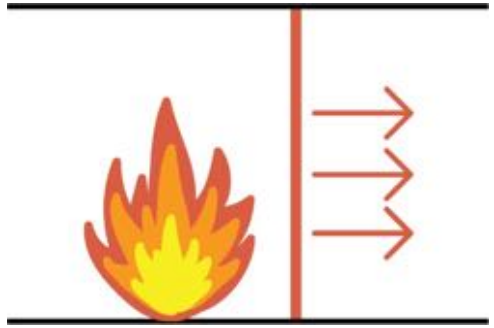
No collapse or excessive deflection

Integrity (Fire Penetration)



No gaps

Insulation (Transfer of excessive heat)



No excessive heat transfer

When mass timber needs a fire rating

- Generally, no FRR required for Type IV-HT, III-B and V-B construction
- 1-HR FRR:
  - **Type III-A and V-A construction (Table 601)**
  - **Fire barriers (and supporting construction), e.g.: occupancy separations, shaft enclosures, exit passageways, atrium separation, incidental uses, fire areas, etc (Section 707)**
- 2-HR FRR:
  - **Fire barriers, and supporting construction (Section 707)**
  - **2-HR exterior wall using FRTW lumber, or CLT (Section 602)**
- Other instances exist in the code, or possibly could be in support of an equivalency to Type I construction to achieve larger and/or higher mass timber higher buildings
- New IBC 2021 provisions will generally require HT elements to achieve 2-HR, or 3-HR fire-ratings (when exceeding 6 stories)


T3, Minneapolis, MN
Architecture MGA (Photo credit: StructureCraft Builders)

Determination of Fire-Resistance Rating

For Mass Timber Construction

IBC Table 601

Fire-resistance Rating Requirements For Building Elements

- The building elements shall have a fire-resistance rating not less than that specified in Table 601 and exterior walls shall have a fire-resistance rating not less than that specified in Table 602.
- The building elements shall comply with the applicable provisions of Section 703.2.

IBC 703.2

Fire-resistance ratings

- Test procedures set forth in ASTM E119 or UL 263 or in accordance with Section 703.3.

IBC 703.3

Methods for determining fire resistance

- ITEM 3, Calculations in accordance with Section 722.

IBC 722

Calculated Fire Resistance

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

NDS Commentary Chapter 16

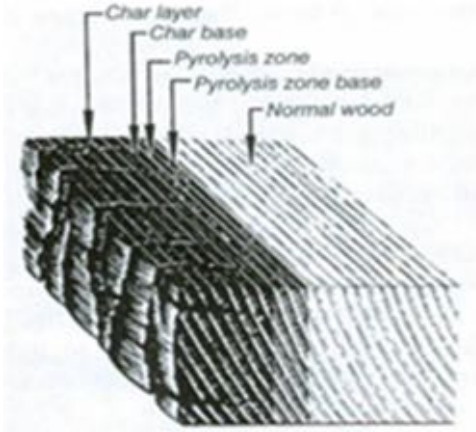
Fire Design of Wood Members

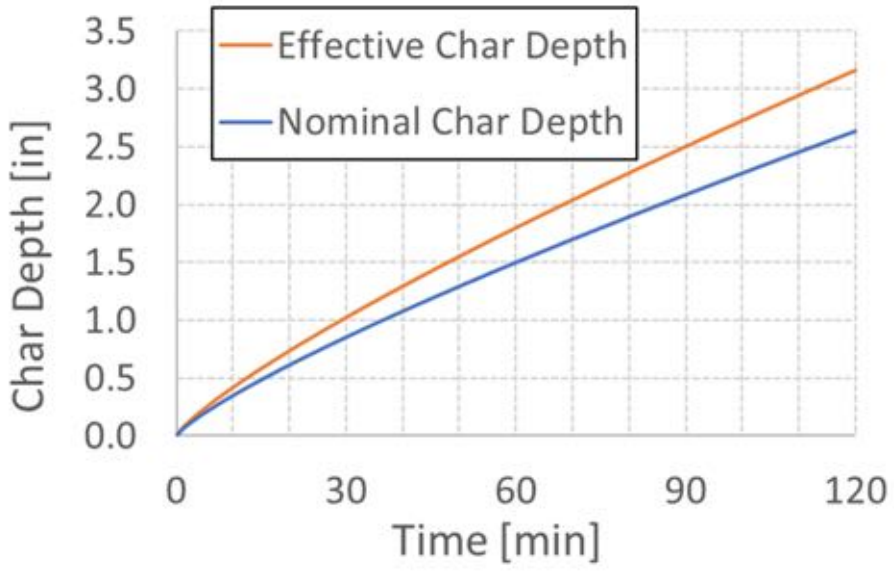
The design provisions in the NDS are intended for use in Allowable Stress Design (ASD).

- The mechanics-based design procedures in specification for exposed wood members are based on research described in AWC's Technical Report 10: Calculating the Fire Resistance of Wood Members.

Achieving Fire-Resistance for Timber

- Non-combustible protection (gypsum board)
- Sacrificial char layer (calculated)
- Alternative methods

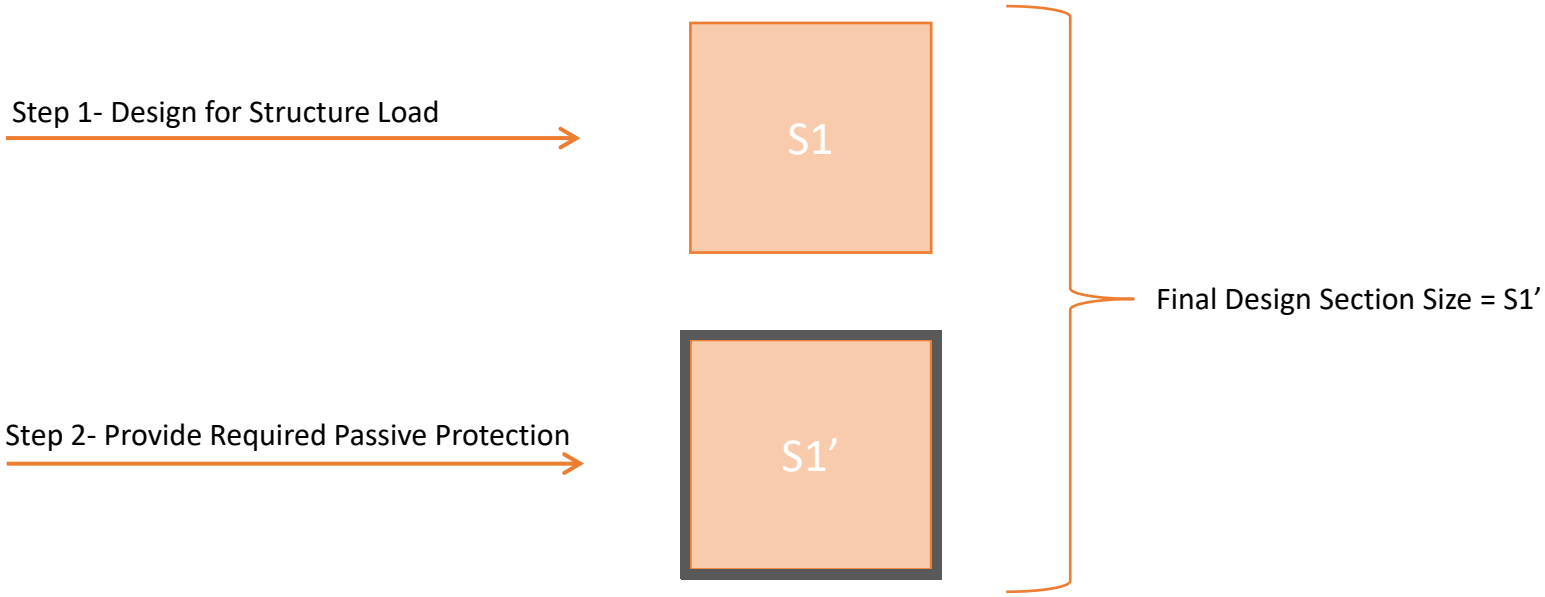




Noncombustible protection	Protection Contribution
½-inch Type X Gypsum Board	25 min
5/8-inch Type X Gypsum Board	40 min

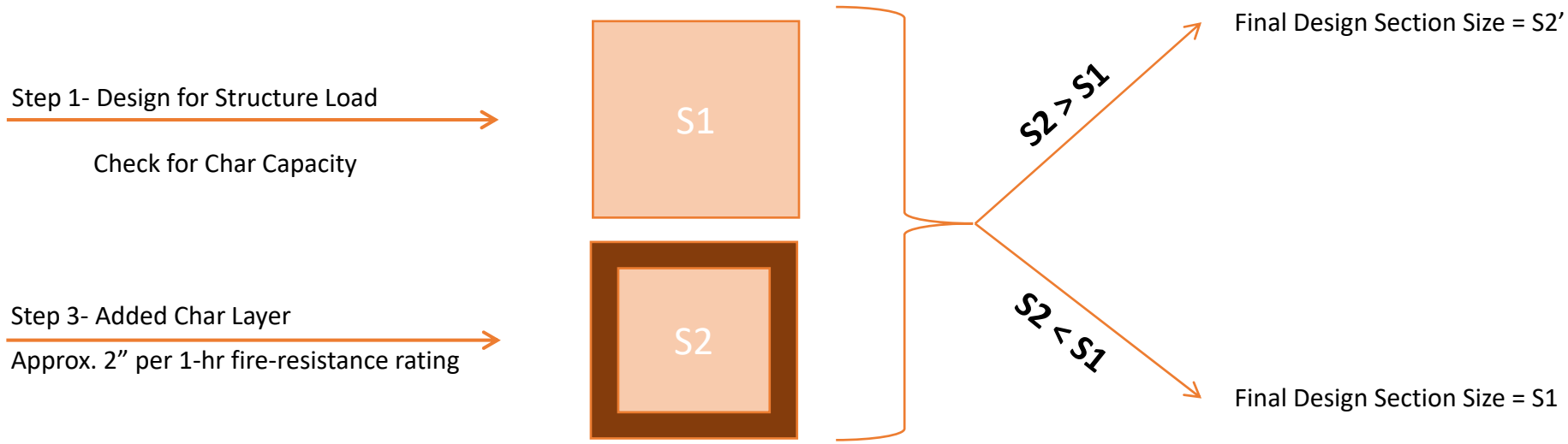
Protected Mass Timber Design

Columns



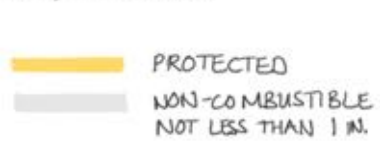
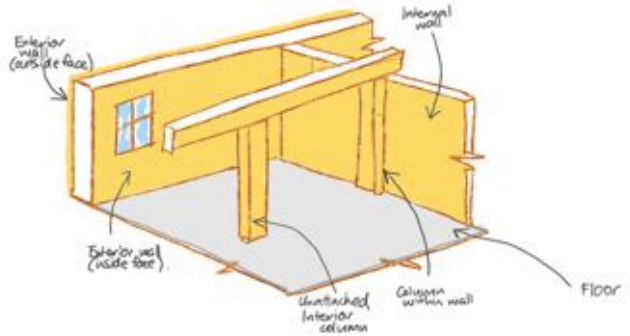
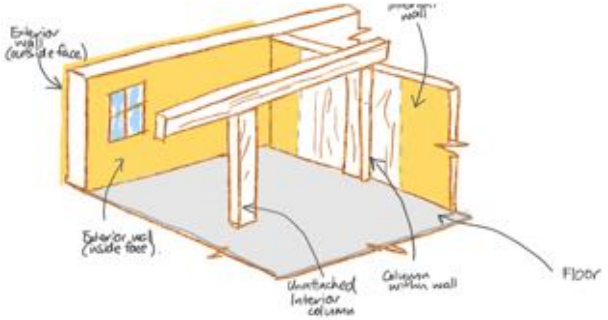
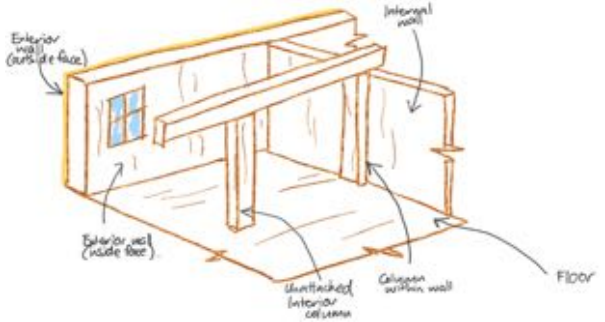
Exposed Mass Timber Design

Columns



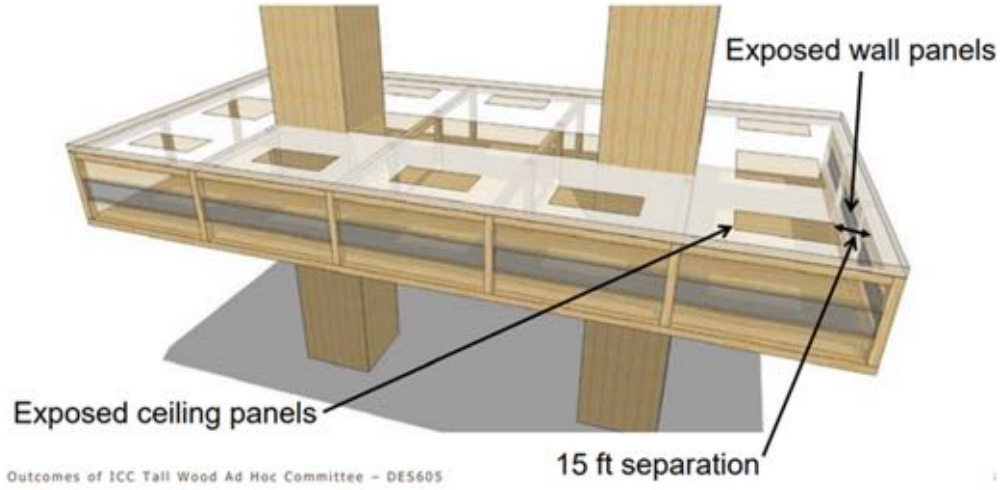
Noncombustible Protection

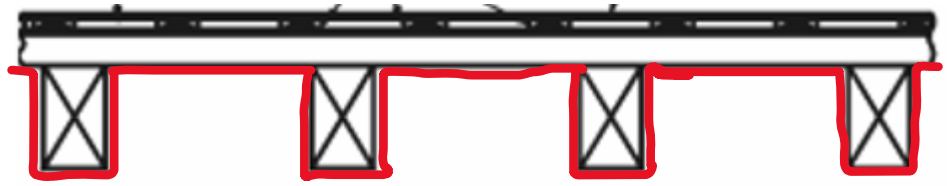
Mass Timber Construction Types, Fire Ratings (Code)

Construction Type	# Stories	Max Height	Mass Timber	Primary Frame Fire Rating
IV-A	18	250 - 270’	**Fully Protected**  	3 hour
IV-B	12	180’	**Partially Exposed** (20% of ceilings allowed to remain exposed) 	2 hour
IV-C	9	85’	**Fully Exposed** (Except outside of external walls, shafts and concealed spaces) 	2 hour

Exposed Mass Timber

- Partially exposed:
  - Ceiling: 20% of floor area of dwelling unit, or fire area (integral beams included)
  - Wall: 40% of floor area of dwelling unit, or fire area (integral columns included)
  - Wall + Ceiling: ratio < 1.0
  - Unprotected areas separated > 15’
- Rib-decks and similar system have increased surface area → reduced exposed ceiling area
- Directly attached to mass timber (furred construction?)
- AMM for increased exposed mass timber:
  - Testing of Gen. 2.0 panels (PRG320-2018)
  - Fire modelling
  - Improved fire protection (passive + active)





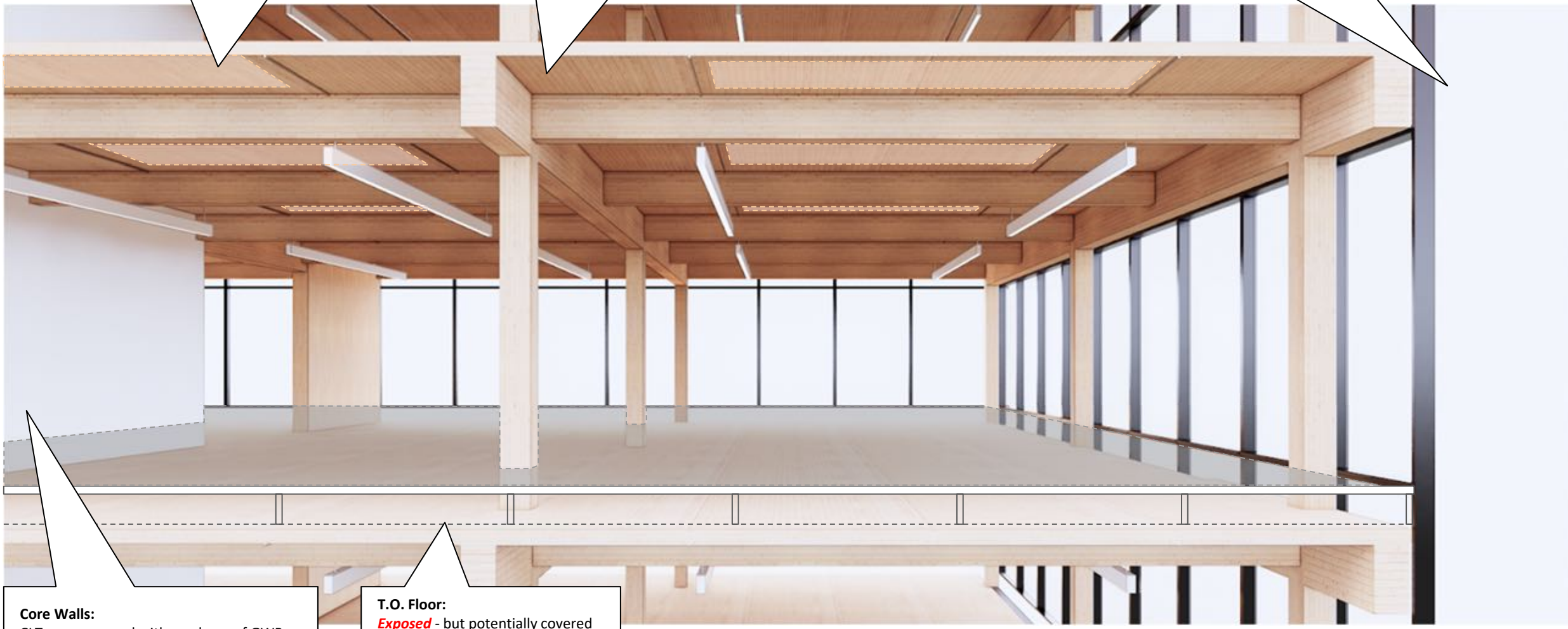
Massing x Construction Types- Visuals by SHoP

Type IV-C Construction

Ceiling :
Exposed - but potentially partially covered partially with acoustical panels

Interior surface of building elements (ceilings, walls, beams, columns):
Exposed

Exterior surface of building elements :
one layer of GWB on exterior face per fire code



Core Walls:
CLT core wrapped with one layer of GWB (Inside and outside)

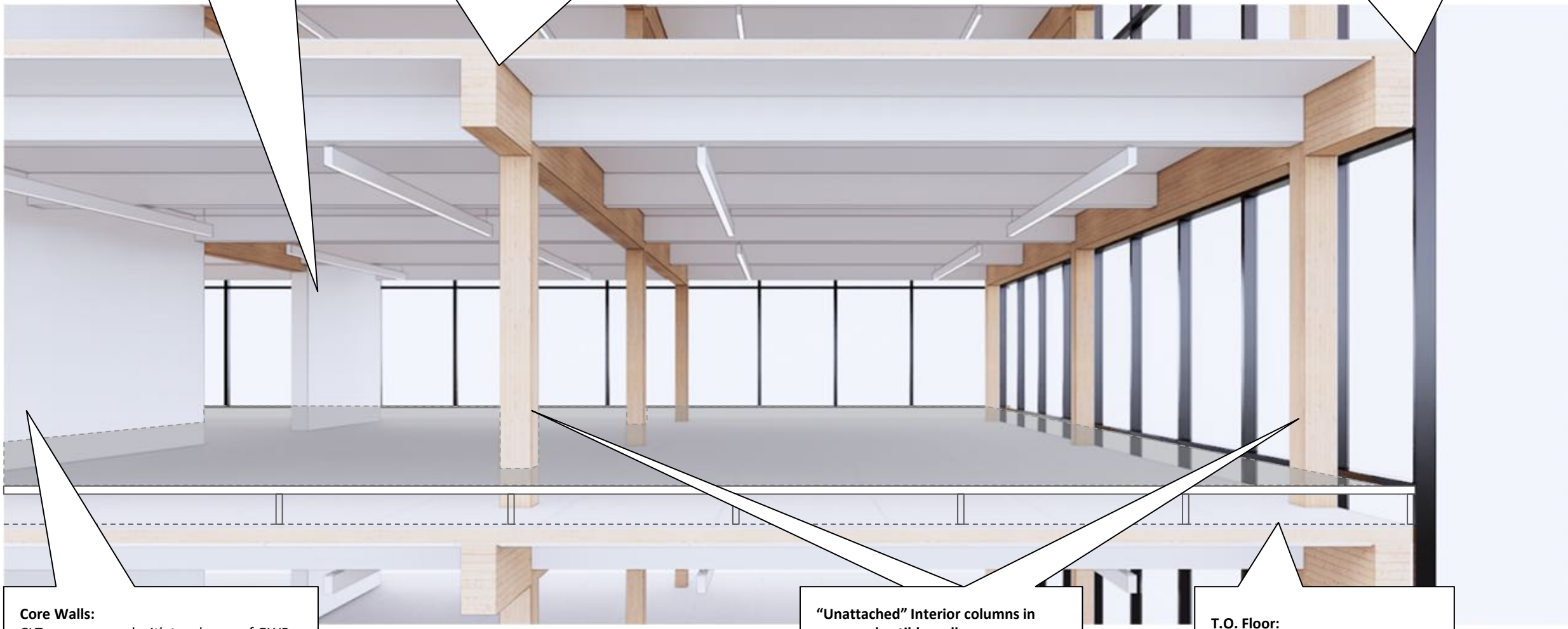
T.O. Floor:
Exposed - but potentially covered w/ acoustical layer and/or raised floor

Type IV-B Construction - Max Exposed Ceilings per Code Allowance

Mass timber column in mass timber wall:
Two layers of GWB with ***up to 40% floor area exposed***

Ceiling and Beams :
Two layers of GWB w/ ***up to 20% floor area Exposed Surface***
(note: a 2' deep beam is approx 19% of floor area @ 30' O.C.)

Exterior surface of building elements :
One layer of GWB on exterior face per fire code



Core Walls:
CLT core wrapped with two layers of GWB (Inside and outside)

"Unattached" Interior columns in non-combustible walls :
Exposed

T.O. Floor:
1" minimum topping

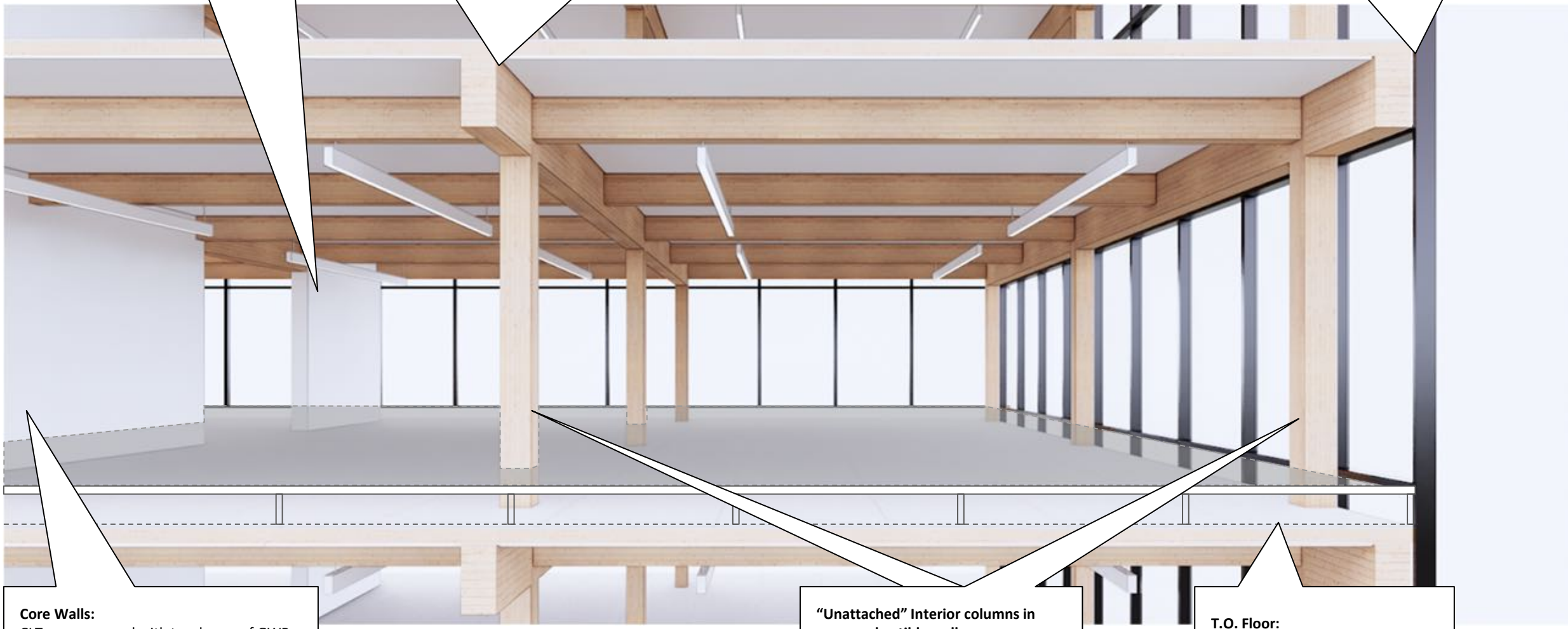
Massing x Construction Types - Visuals by SHoP

Type IV-B Construction - 50% Exposed Ceilings - Requires AHJ Approval

Mass timber column in mass timber wall:
Two layers of GWB with ***up to 40% floor area exposed***

Ceiling and Beams :
Two layers of GWB w/ ***up to 20% floor area Exposed Surface***
(note: a 2' deep beam is approx 45% of floor area @ 30' O.C.)

Exterior surface of building elements :
One layer of GWB on exterior face per fire code



Core Walls:
CLT core wrapped with two layers of GWB (Inside and outside)

"Unattached" Interior columns in non-combustible walls :
Exposed

T.O. Floor:
1" minimum topping

Type IV-B Construction - 50% Exposed Ceilings - Requires AHJ Approval

Mass timber column in mass timber wall:
Two layers of GWB with ***up to 40% floor area exposed***

Ceiling and Beams :
Two layers of GWB w/ ***up to 20% floor area Exposed Surface***
(note: a 2' deep beam is approx 20% of floor area @ 30' O.C.)

Exterior surface of building elements :
One layer of GWB on exterior face per fire code

Core Walls:
CLT core wrapped with two layers of GWB (Inside and outside)

"Unattached" Interior columns in non-combustible walls :
Exposed

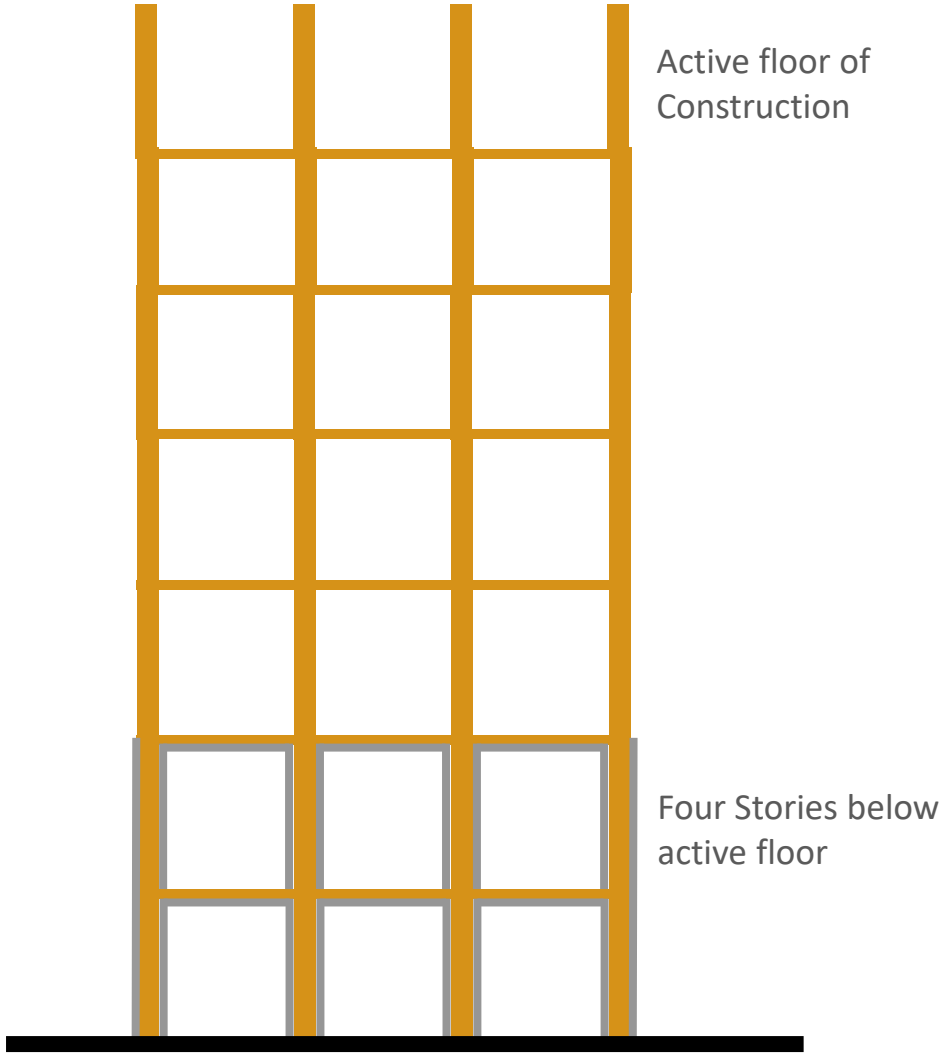
T.O. Floor:
1" minimum topping

Mass Timber Protection During Construction

During construction of a Type IV-A or IV-B building, when exceeding 6 stories, must provide the following protections during construction:

- Standpipes are provided during construction (installed prior to building reaching 40 feet in height and extend to within one floor of the highest floor with secured decking in place).
- A water supply approved by the fire code official shall be provided to the site (hydrants, standpipe, etc.)
- At least one layer of required non-combustible protection applied to building elements four stories below active floor of construction. Cannot build additional levels until non-comb layer is installed. (shafts not included) – Proposed code updates.
- Exterior wall non-combustible rating, if required, also must be installed four stories below active floor of construction before building an additional level. (shafts not included)

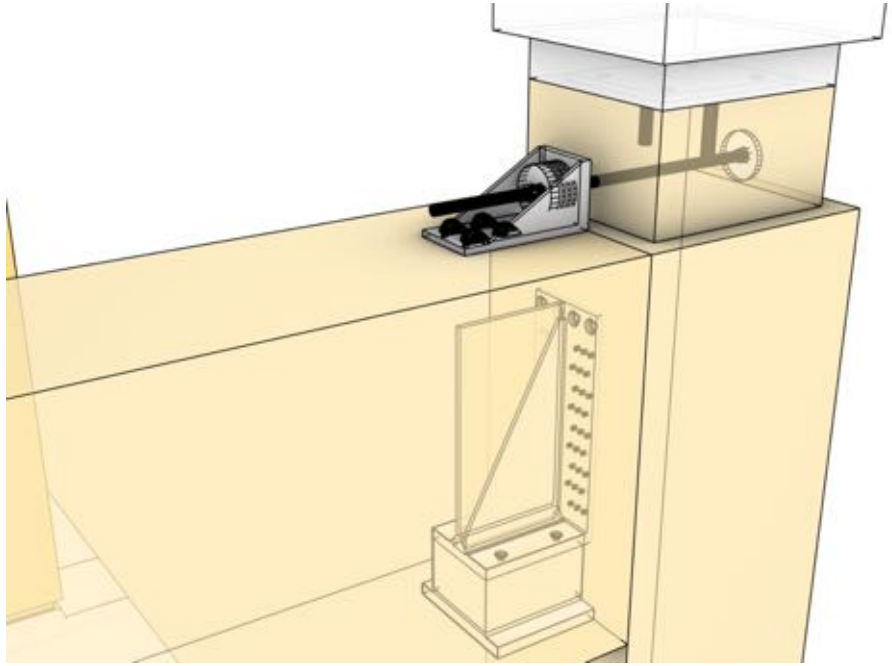
Possible Alternate Means of protection may be discussed with AHJ including providing Fire Watch, site hot work and waste management protocols to reduce likelihood of fire.



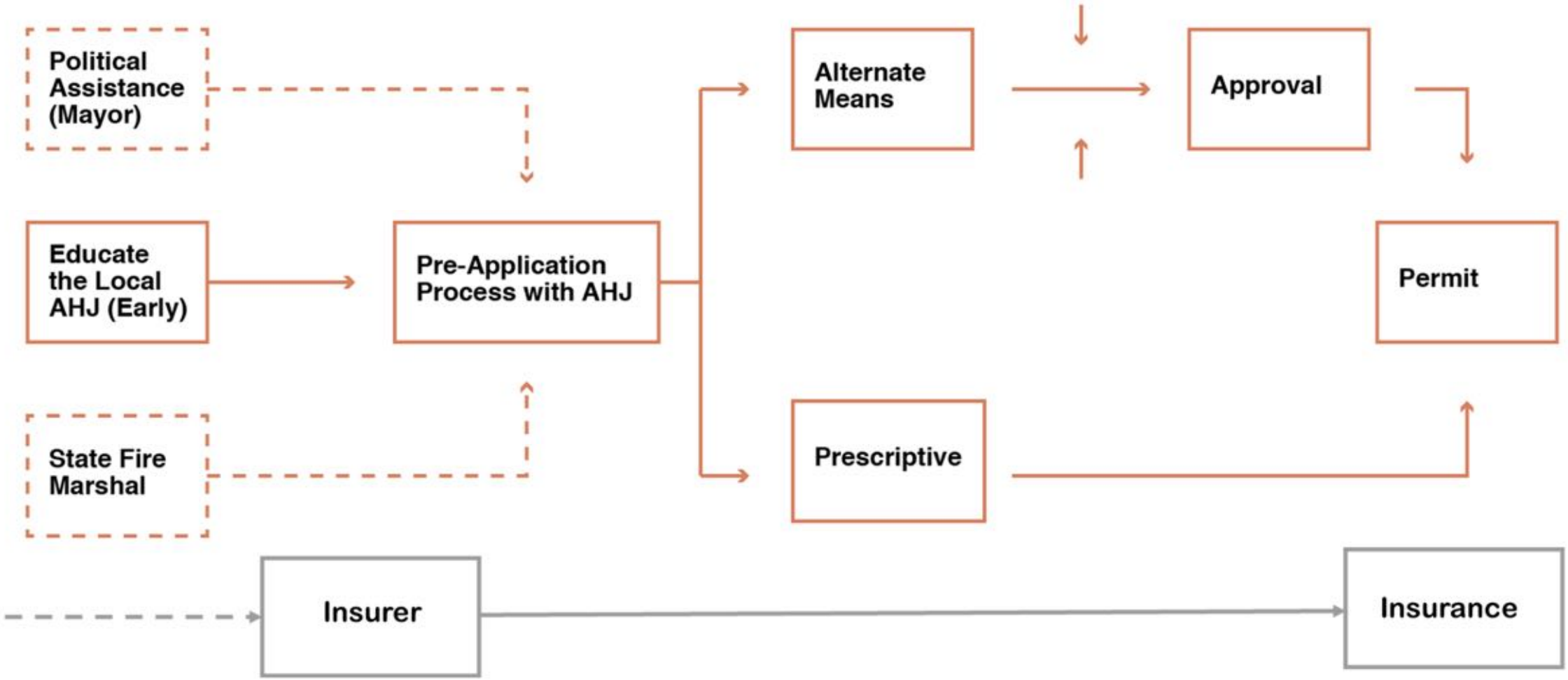
Testing Opportunities

Create Break Burn Solve

Furnace Testing



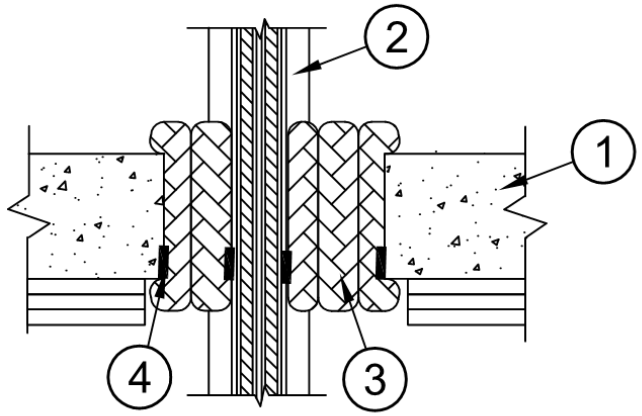
Approval Path



Typical Detailing

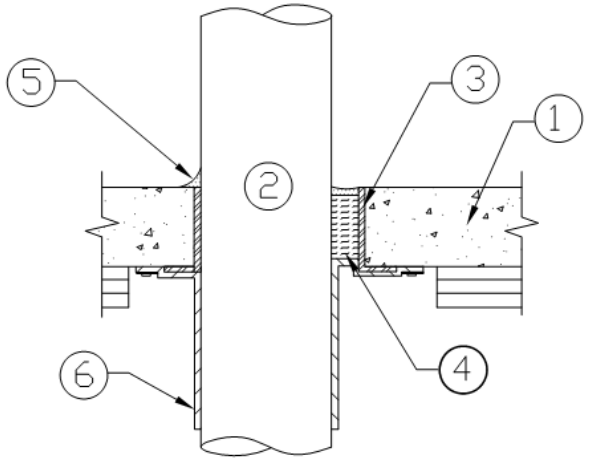
Floor Penetrations

3M ENGINEERING JUDGEMENT NO. 615658
MODIFIED SYSTEM NO. C-AJ-6041 DEPICTED
REQUESTED RATING - 1 HR / F
OBTAINABLE RATING: SEE BELOW*



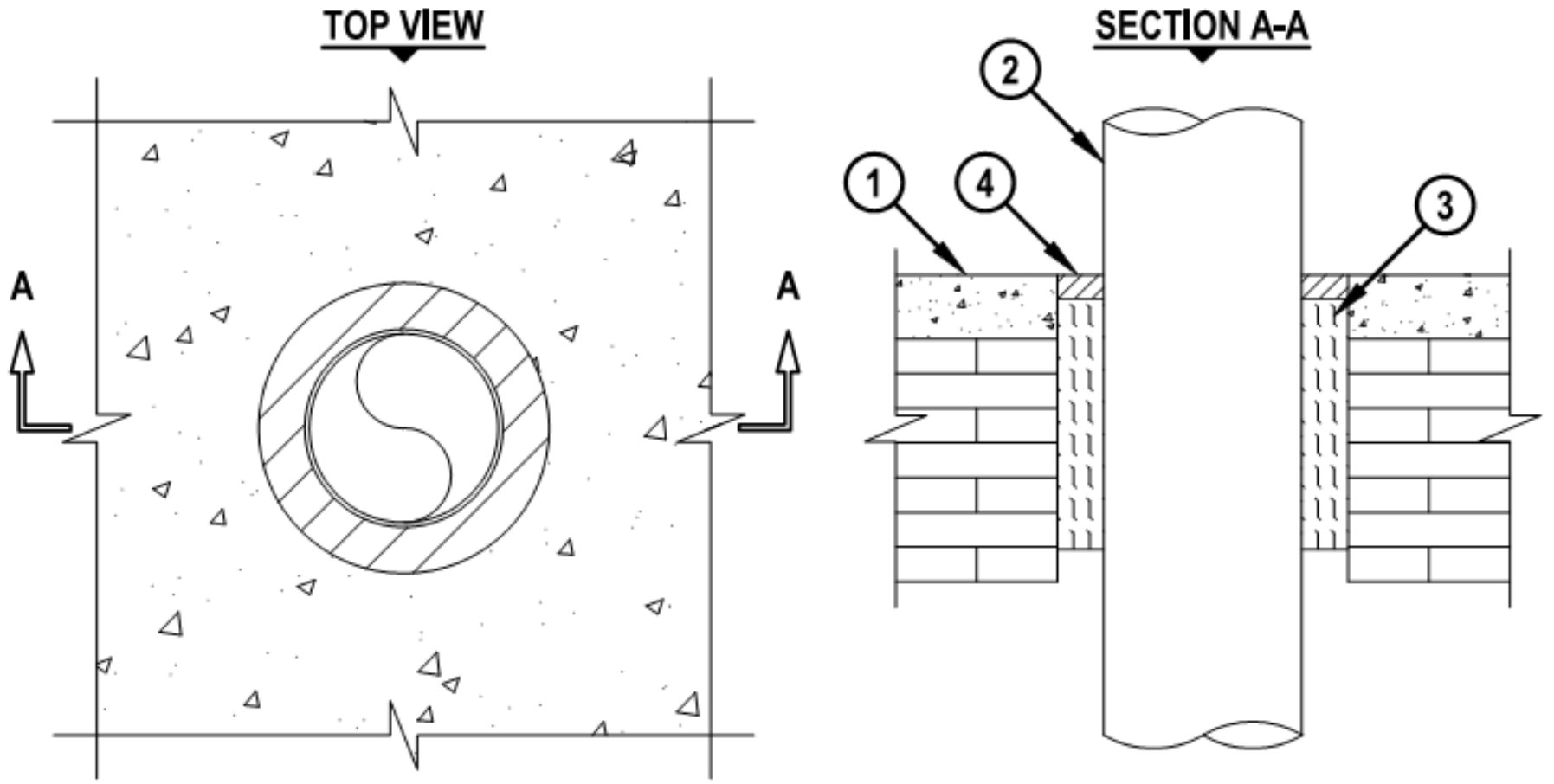
1. CONCRETE FLOOR/CROSS-LAMINATED TIMBER.
2. PENETRATING ITEM PER APPROPRIATE VERSION OF CORRESPONDING EJ.
3. 3M FIRE BARRIER PILLOWS/3M FIRE BARRIER SELF LOCKING PILLOWS.
4. MP+ MOLDABLE PUTTY

3M ENGINEERING JUDGEMENT NO. 607991 REV 3
MODIFIED SYSTEM NO. C-AJ-1427, F-A-1057
REQUESTED RATING - 1 HR / F AND T
OBTAINABLE RATING (*SEE BELOW)

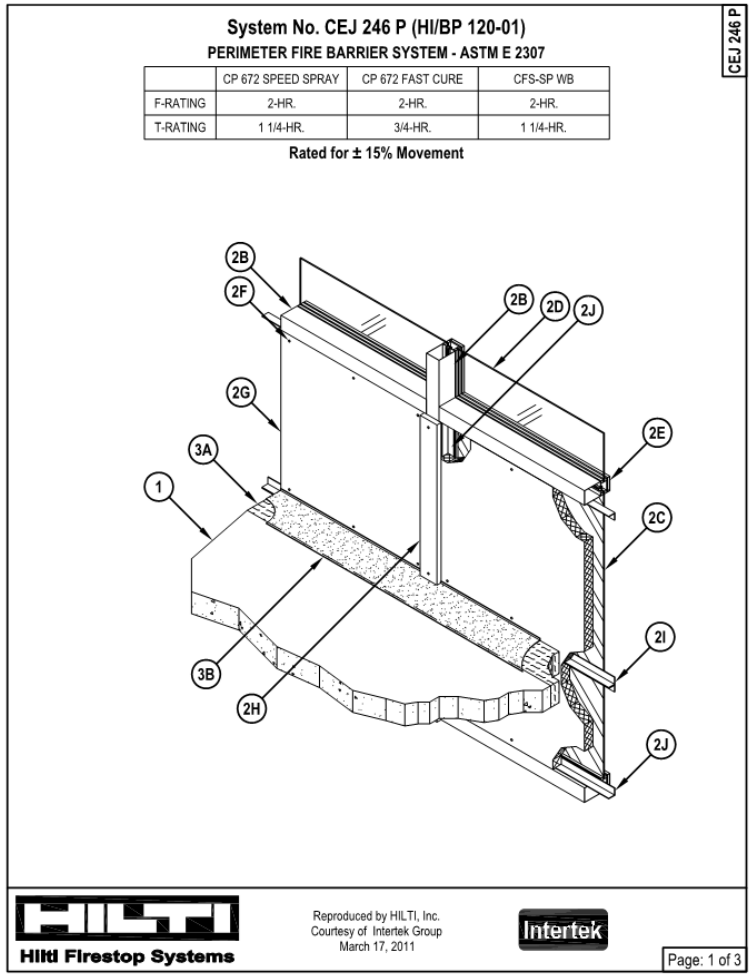


1. CONCRETE AND CROSS LAMINATED TIMBER FLOOR.
2. PENETRATING ITEM PER APPROPRIATE VERSION OF CORRESPONDING EJ.
3. STEEL SLEEVE. (WITH OPTIONAL SQUARE BASE)
4. 4 PCF MINERAL WOOL INSTALLED INTO ANNULAR SPACE AS OUTLINED IN APPROPRIATE VERSION OF CORRESPONDING EJ.
5. FIRESTOP SEALANT AS OUTLINED IN APPROPRIATE VERSION OF CORRESPONDING EJ.
6. 3M DUCT WRAP 615+

Penetrations



Edge of Slab Detailing



System No. CEJ 246 P (HI/BP 120-01)

PERIMETER FIRE BARRIER SYSTEM - ASTM E 2307

CEJ 246 P

	CP 672 SPEED SPRAY	CP 672 FAST CURE	CFS-SP WB
F-RATING	2-HR.	2-HR.	2-HR.
T-RATING	1 1/4-HR.	3/4-HR.	1 1/4-HR.

Rated for ± 15% Movement

Hilti Firestop Systems

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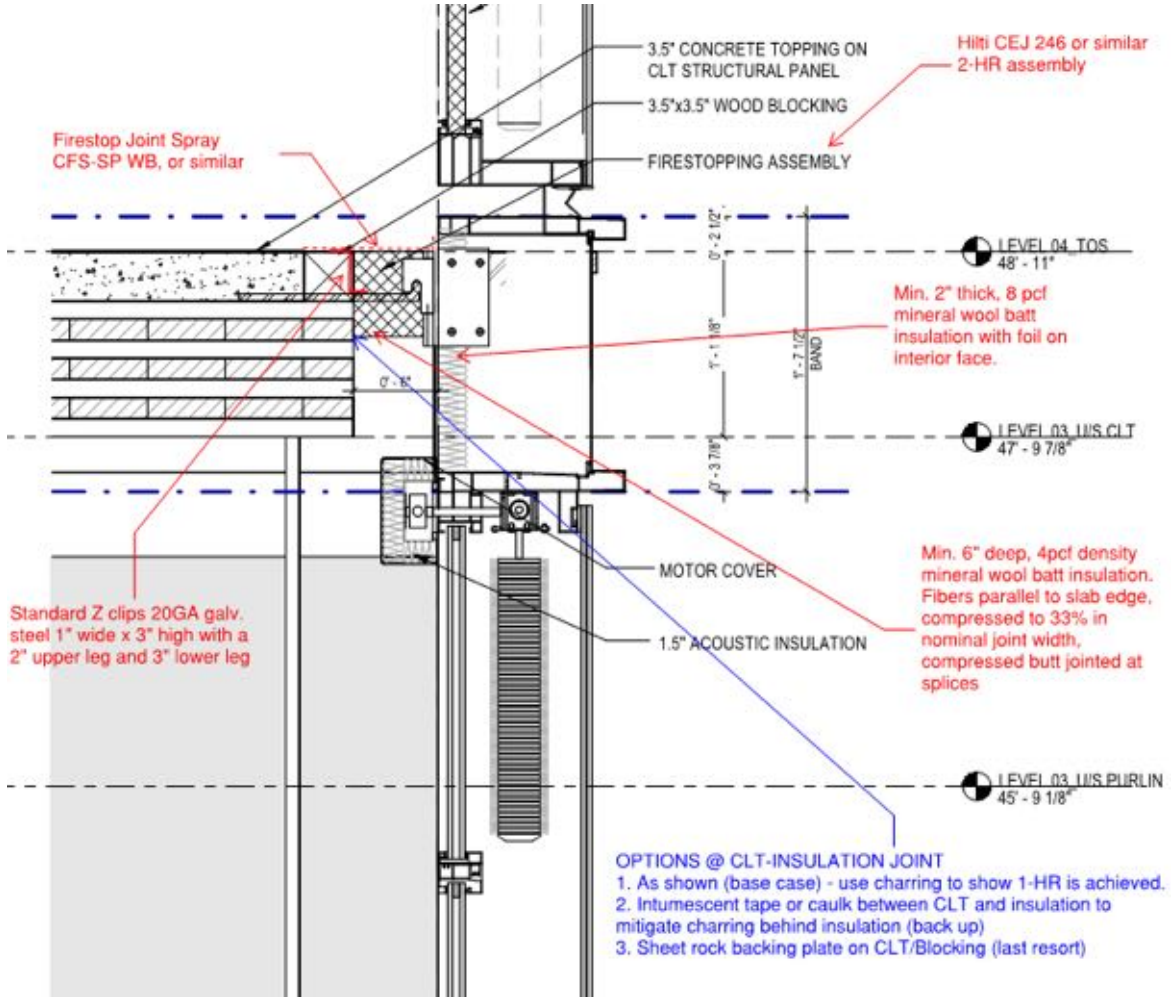
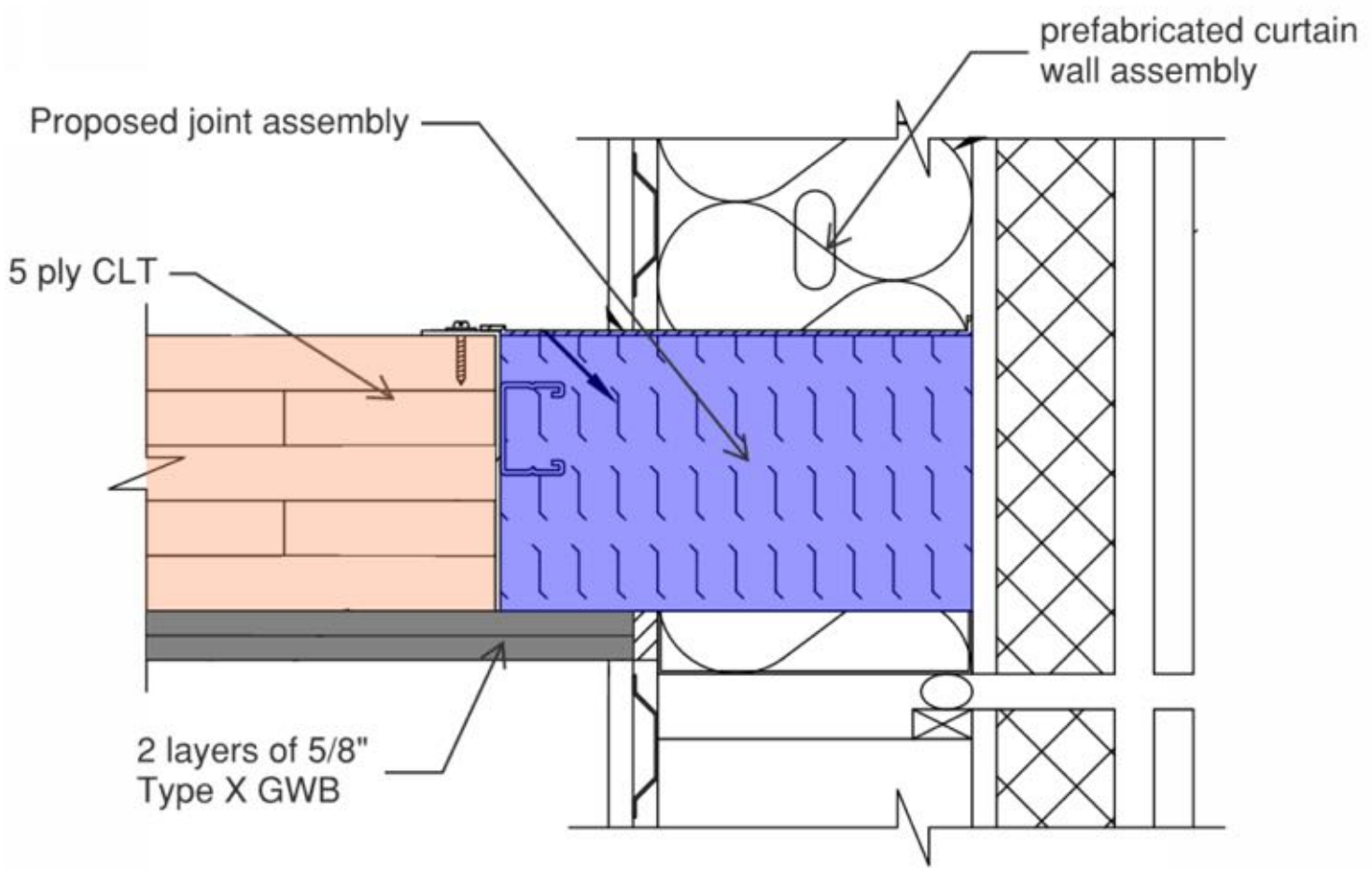
Intertek

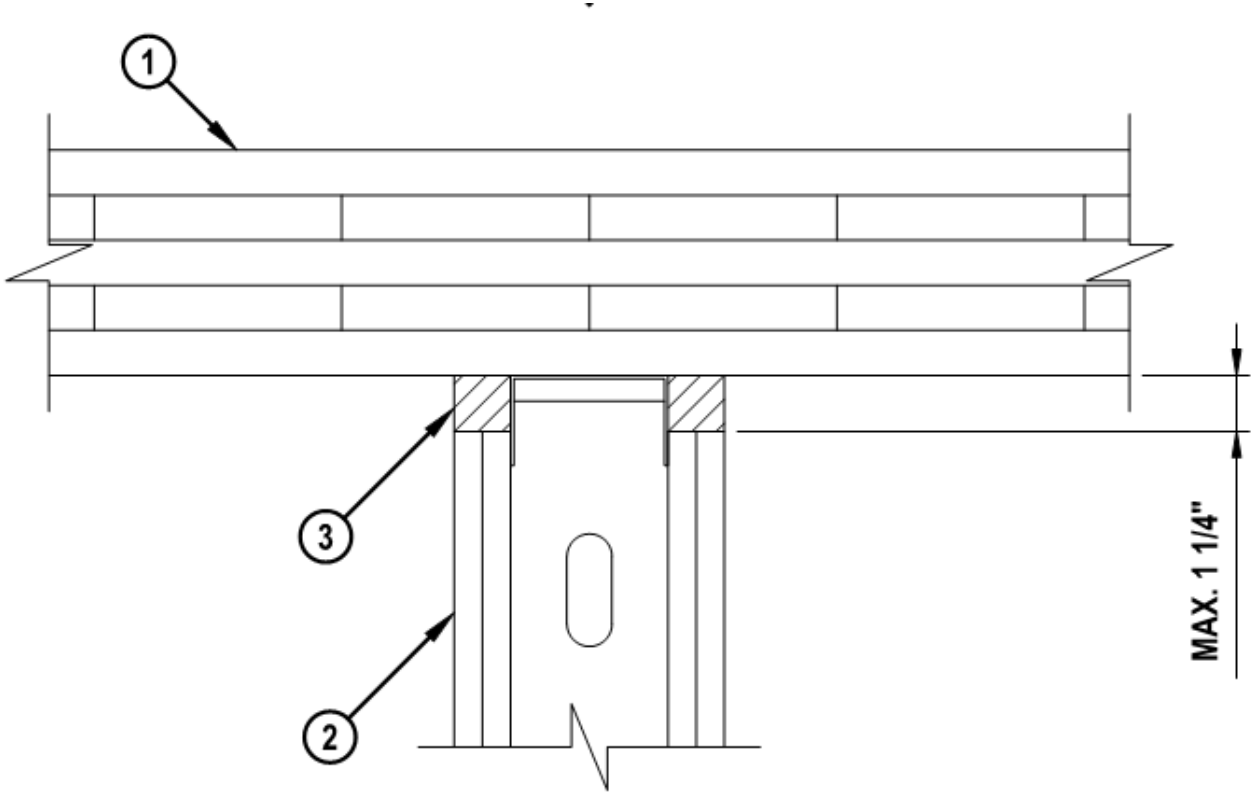
Page: 1 of 3

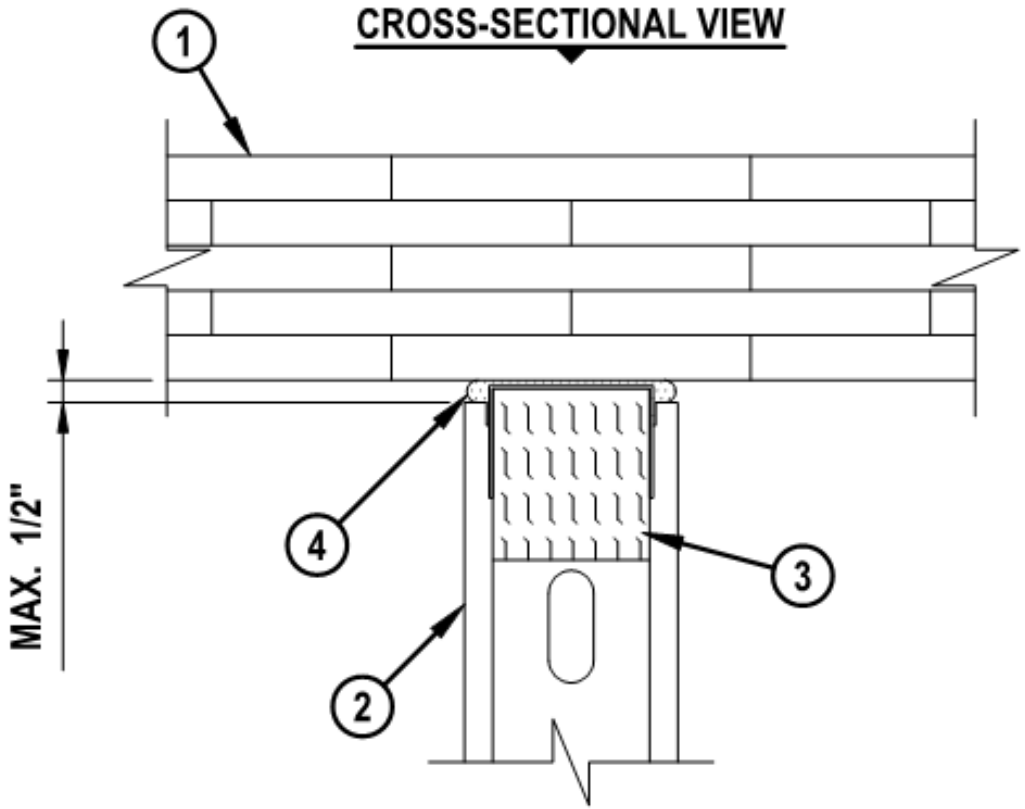


Edge of Slab Detailing

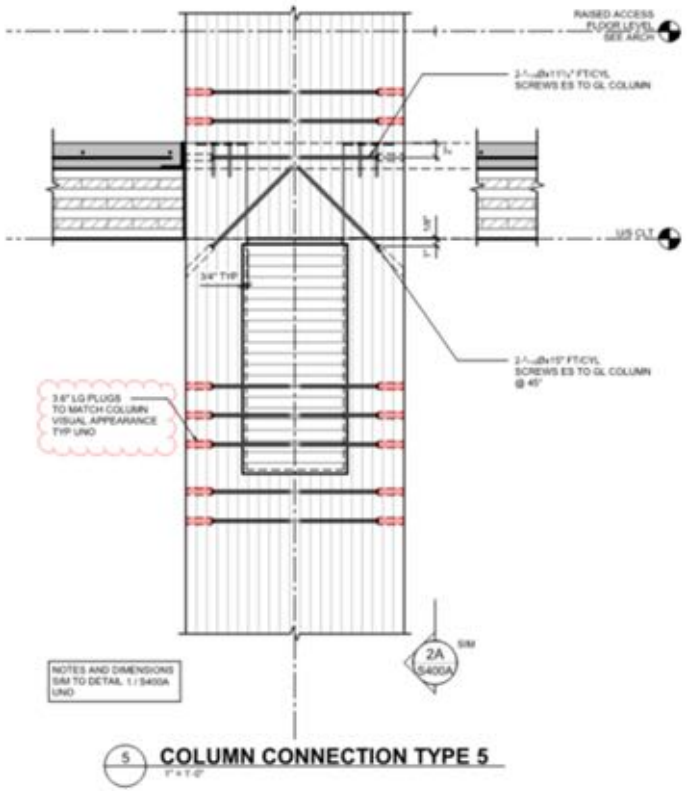


Head of the Walls





Beam-Column Joint



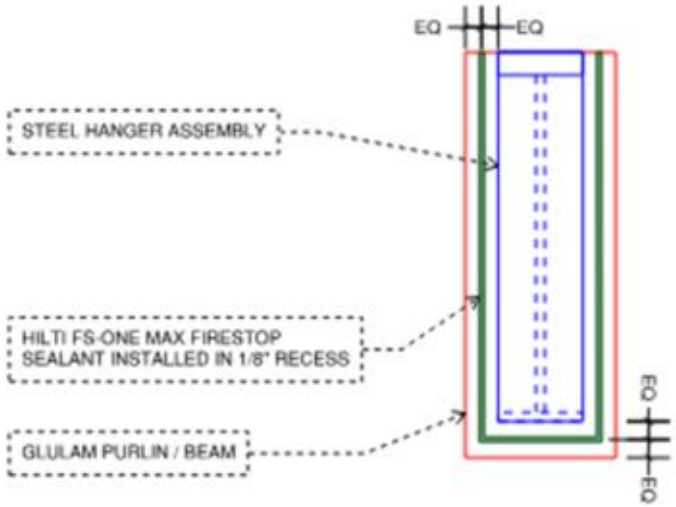


Figure A-3. Column Prepped.

Figure A-4. Column and Beam Connection.

Performance Based Design

Alternative Means and Methods

IBC 602.4

Type IV Construction (New Tall Wood Building Provisions)

- The time assigned to the noncombustible protection shall be determined in accordance with Section 703.8 and comply with 722.7.

IBC 703.8

Determination of Noncombustible Protection Time Contribution (New Tall Wood Building Provisions

- The noncombustible protection time contribution shall be established through a comparison of assemblies tested using procedures set forth in ASTM E 119 or UL 263.
  - Test Assembly 1 without protection
  - Test Assembly 2 includes the noncombustible protection.*

IBC 722.7

Fire Resistance Rating of Mass Timber (New Tall Wood Building Provisions)

- The required fire resistance of mass timber elements in section 602.4 shall be determined in accordance with Section 703.2 or Section 703.3.

IBC 703.2

Fire-Resistance Rating

- Test procedures set forth in ASTM E119 or UL 263 or in accordance with Section 703.3.

IBC 703.3

Methods of Determining Fire-Resistance Rating

- Item 4, Engineering analysis based on comparison of building element, component or assemblies designs having FRR as determined by the test procedures set forth in ASTM E119 or UL 263

OR

- Item 5 Alternative protection methods as allowed by Section 104.11.

IBC 104.11

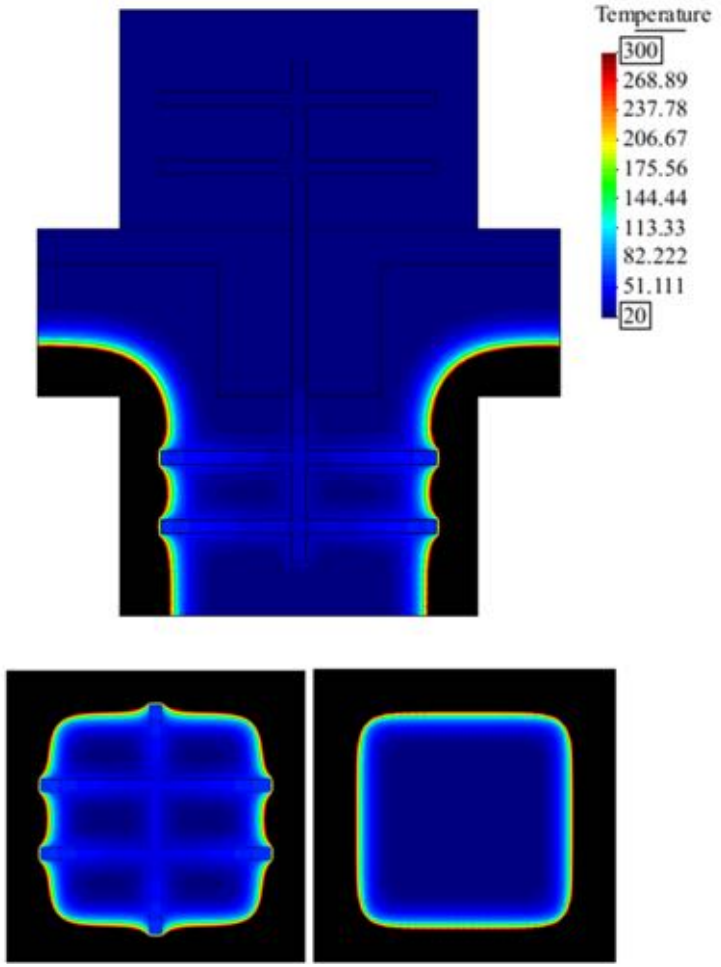
Alternative materials, design and methods of construction and equipment (AMM)

- AMM, shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material is, for the purpose intended, not less than the equivalent of that prescribed in this code in
  1) Quality,
  2) Strength
  3) Effectiveness
  4) Fire resistance
  5) Durability and
  6) Safety

*Noncombustible protection time contribution is determined by subtracting the fire resistance time of Test Assembly 1 from the fire resistance time of Test Assembly 2.

Performance Based Analysis

- Thermal-finite element assessment of assemblies
- Support engineering judgement of untested systems/assemblies
- Protection details for connections, exposure of mass timber
- Furnace and realistic building fires



Case Studies

Case Study 1

Corporate Campus, Mountain View

Architect: WRNS Studio

Contractor: Rudolph & Sletten

Location: Mountain View, CA

Project Description: Corporate campus predominately office use with assembly uses accessible green roof over all new building structure

Gross SF: 645,000 SF office + 505,000 SF structured parking

Construction Type: III-B-Sprinklered

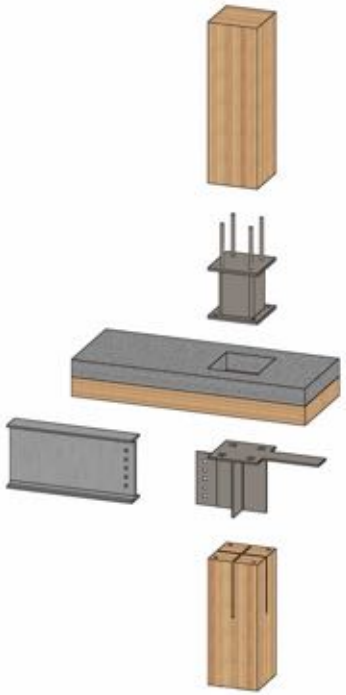
Structural System – Gravity: Composite CLT + conc. topping floor, steel beams w/glulam columns

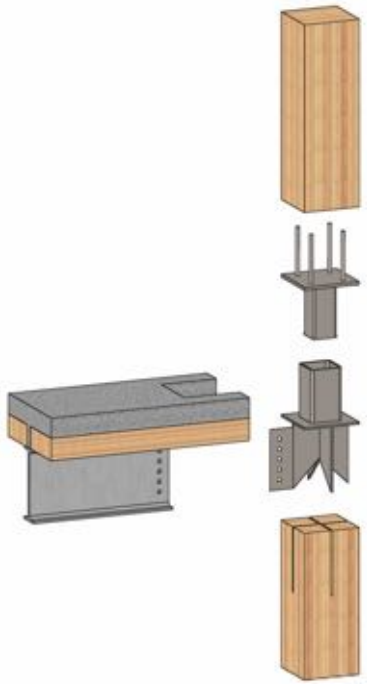
Structural System – Lateral: Concrete shear wall

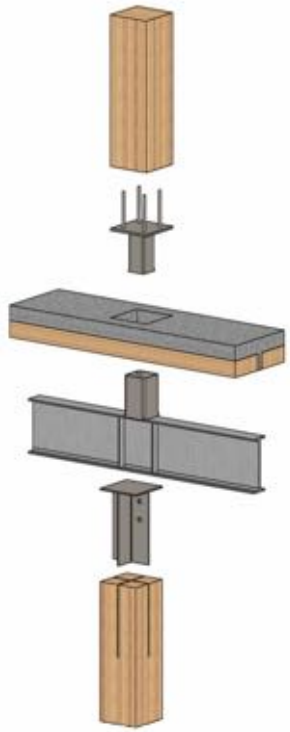
Largest (by S.F.) mass timber building in North America

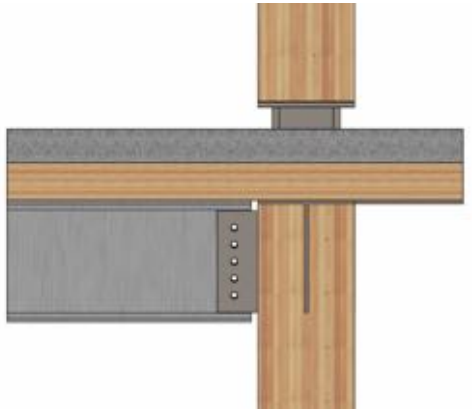

GEHL

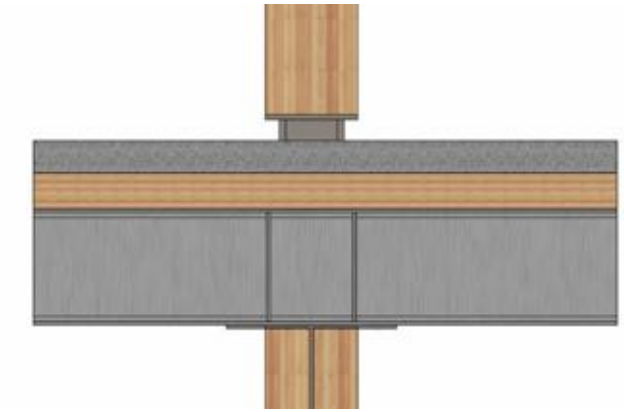
Connections



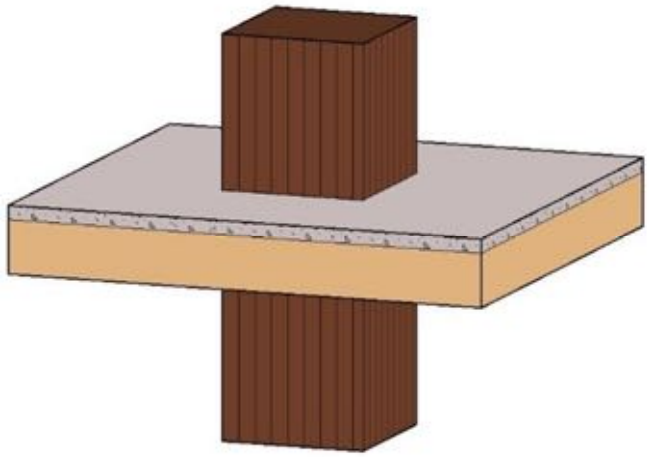




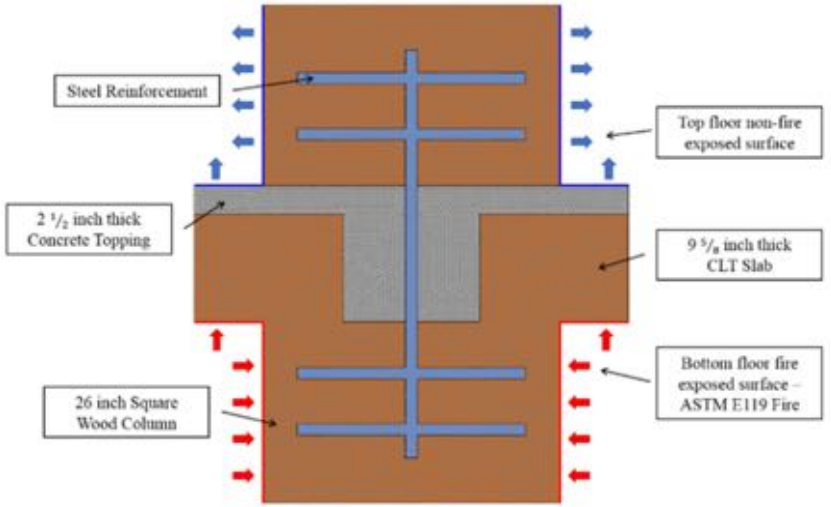




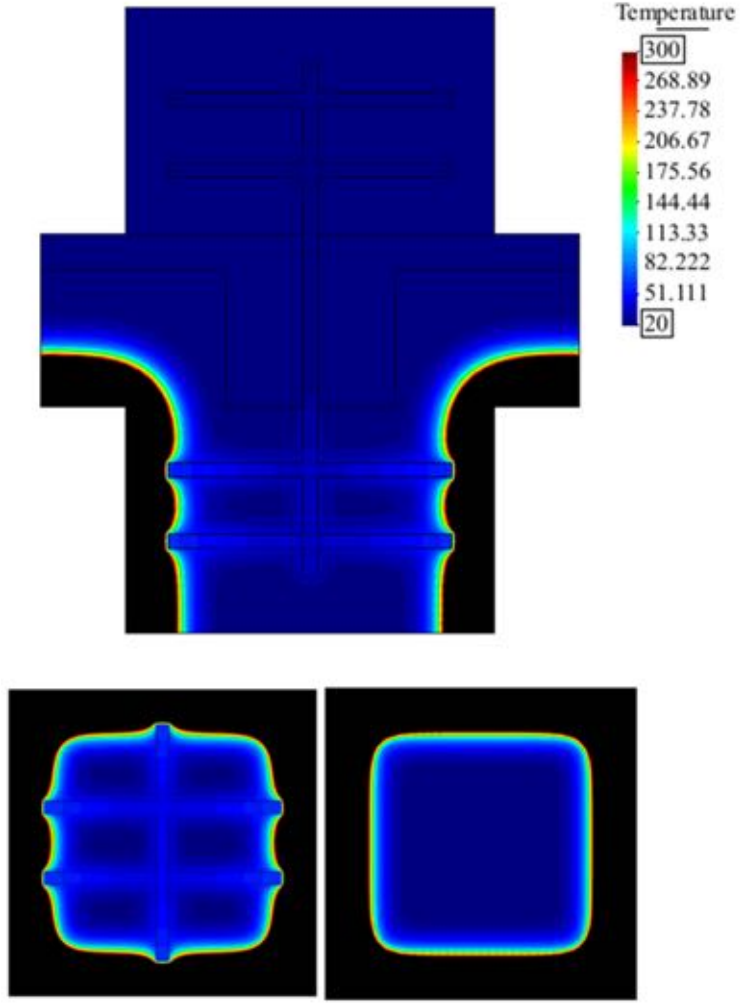
Fire Design



Assembly Selected for Fire Analysis



Square Column to Slab Connection



Case Study 2

Residential Building, San Jose

Architect: SERA

Owner: First Community Housing

Location: San Jose, CA

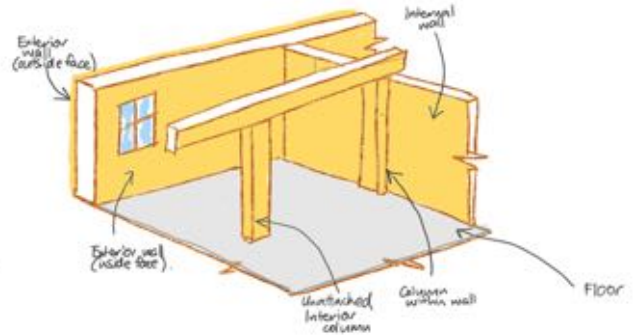
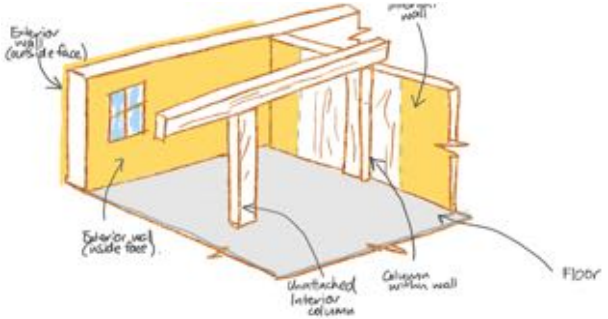
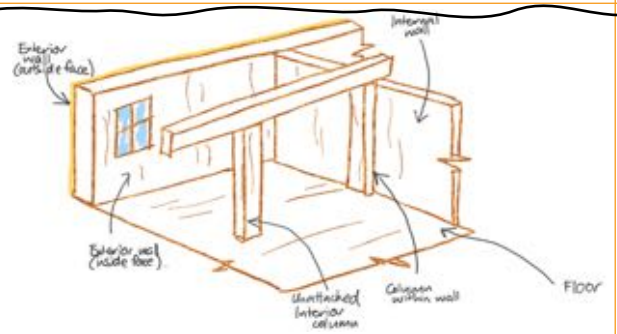
Project Description: 12-story residential buildings located on a shared podium

Gross SF: 260,000 SF

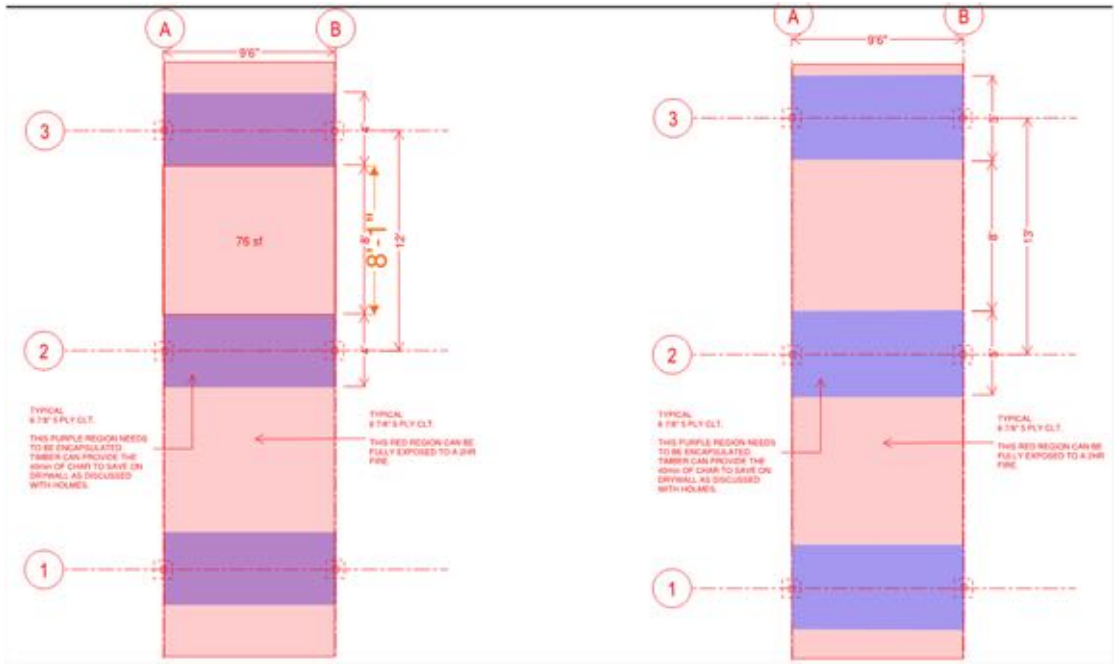
Construction Type: IV-B, Sprinklered

Structural System – Gravity: CLT + conc. topping floor, glulam columns

Mass Timber Construction Types, Fire Ratings (Code)

Construction Type	# Stories	Max Height	Mass Timber	Primary Frame Fire Rating
IV-A	18	250 - 270’	**Fully Protected** PROTECTED NON-COMBUSTIBLE NOT LESS THAN 1 IN. 	3 hour
IV-B	12	180’	**Partially Exposed** (20% of ceilings allowed to remain exposed Stand-alone columns can remain exposed) 	2 hour
IV-C	9	85’	**Fully Exposed** (Except outside of external walls, shafts and concealed spaces) 	2 hour

50% Exposed Mass Timber



Gypsum protection at column lines and weak axis of CLT span.

Upcoming Code Changes (G147-21)

Excerpt from G147-21:

602.4.2.2.2 Protected area. Interior faces of mass timber elements, including the inside face of exterior mass timber walls and mass timber roofs, shall be protected in accordance with Section 602.4.2.2.1.

Exceptions: Unprotected portions of mass timber ceilings and walls complying with Section 602.4.2.2.4 and the following:

1. Unprotected portions of mass timber ceilings and walls complying with one of the following:

   1.1. Unprotected portions of mass timber ceilings, including attached beams, shall be permitted and shall be limited to an area less than or equal to ~~20~~ 100 percent of the floor area in any dwelling unit or fire area.

   1.2. Unprotected portions of mass timber walls, including attached columns, shall be permitted and shall be limited to an area less than or equal to 40 percent of the floor area in any dwelling unit or fire area.

   1.3. Unprotected portions of both walls and ceilings of mass timber, including attached columns and beams, in any dwelling unit or fire area shall be permitted in accordance with Section 602.4.2.2.3.

2. Mass timber columns and beams that are not an integral portion of walls or ceilings, respectively, shall be permitted to be unprotected without restriction of either aggregate area or separation from one another.

Connection Fire-Resistance Rating

FRR for connections in Type IV-A IV-B, or IV-C construction shall be determined by one of the following:

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

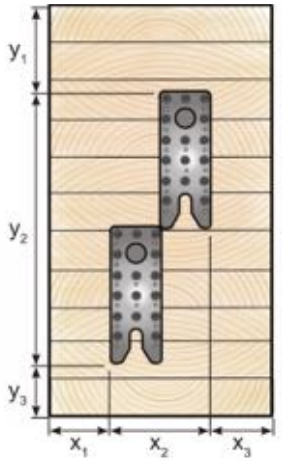
2. **Engineering analysis** that demonstrates that the temperature rise at any portion of the connection is limited to an average temperature rise of 250°F (139°C) and a maximum temperature rise of 325°F (181°C) for a time corresponding to the required fire resistance rating of the structural element being connected.

   For the purposes of this analysis the connection includes connectors fasteners and portions of wood members included in the structural design of the connection.

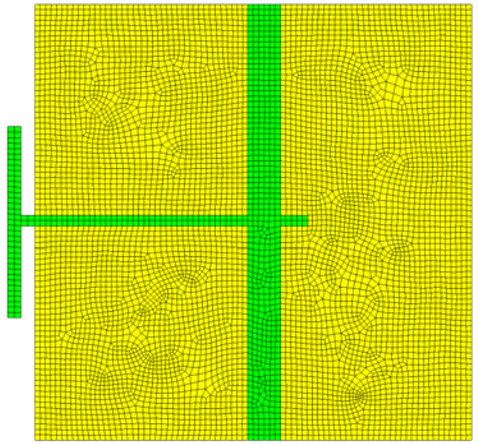
Concealed / exposed connections

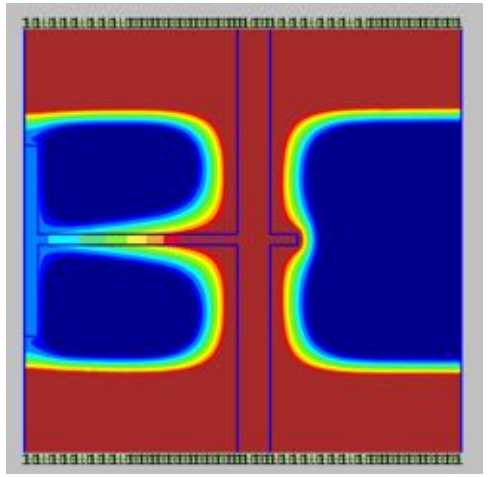
- New IBC criteria can be applied in simple calculations for concealed connections – (similar to char calculations)
- Engineering analysis of exposed connections are challenging – Finite Element Analysis / Alternative Means and Methods may be needed

Concealed connection



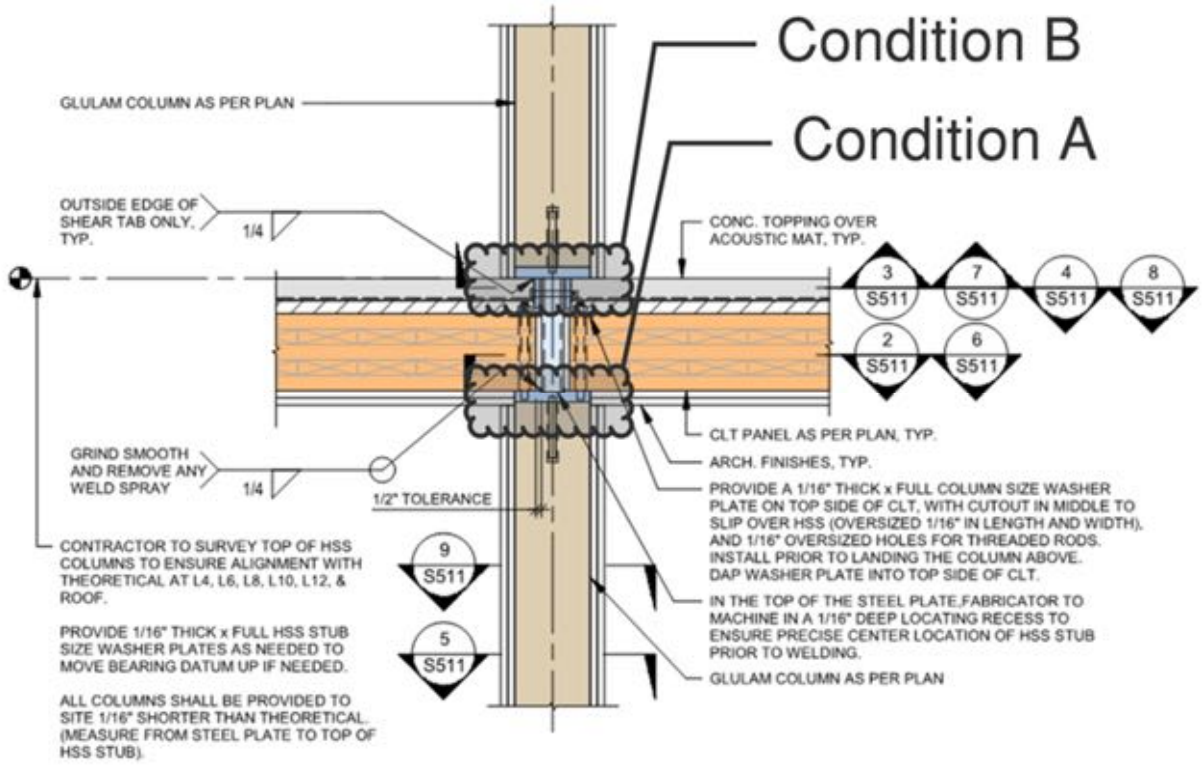
Connection with exposed steel





Connection Protection

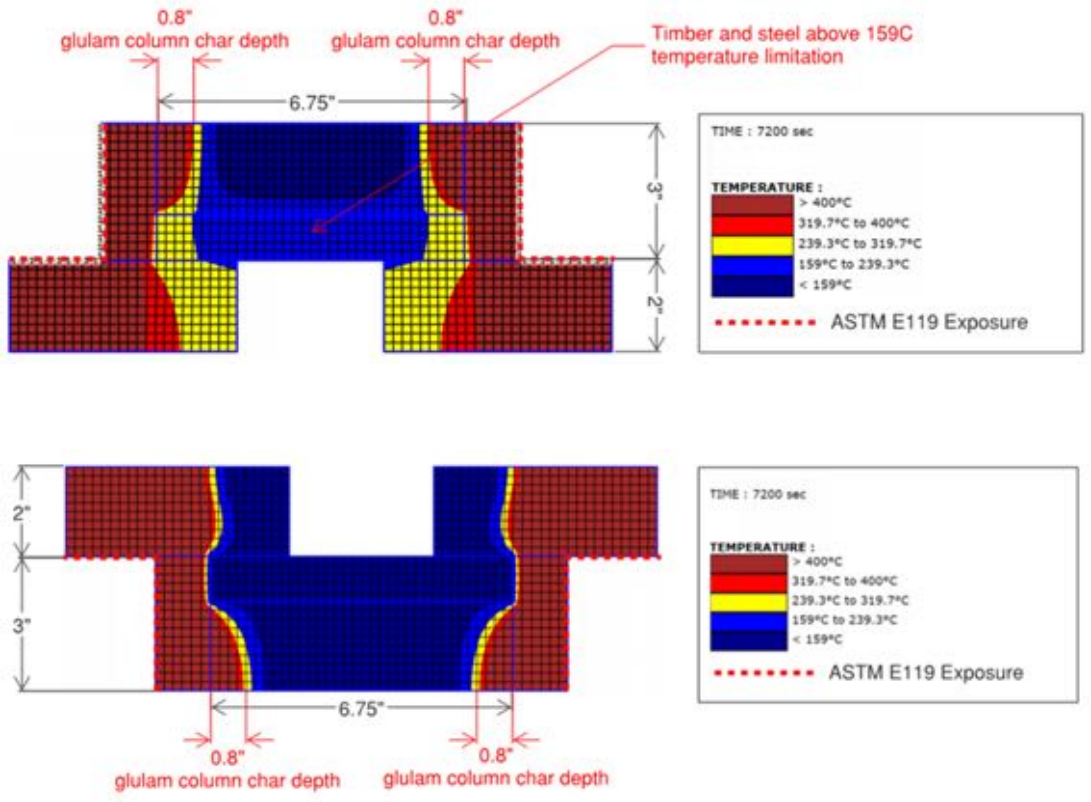
Appling new connection criteria of IBC



Finite Element Assessment

- Thermal-finite element assessment to ASTM E119 temperature curve for 2-hour duration.

- Indicated additional protection was required to bottom bearing plate to mitigate accelerated charring at bottom of column.



TOP and BOTTOM sections of column-floor-column joint (thermal analysis)

Case Study 3

Commercial Building, San Jose

Architect: Studio Gang

Owner: West Bank

Location: San Jose, CA

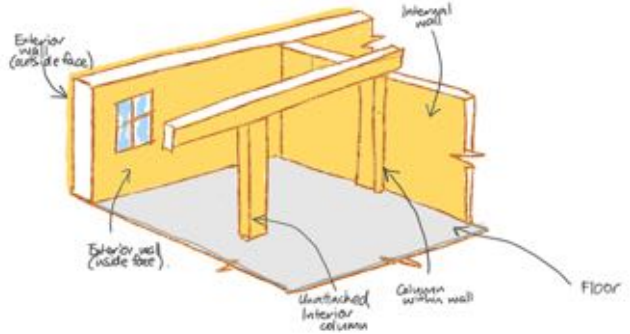
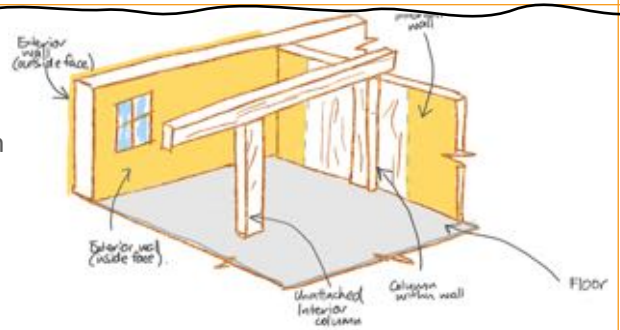
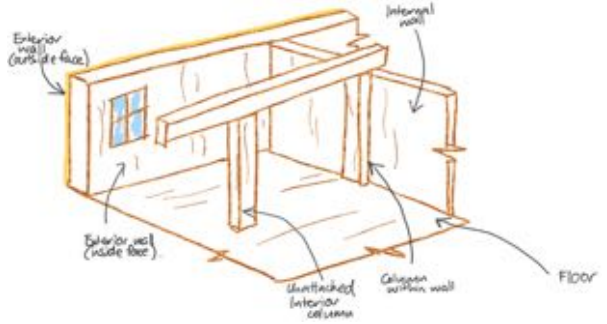
Project Description: 14-story Commercial building predominately office use with assembly uses.

Gross SF: 240,000 SF

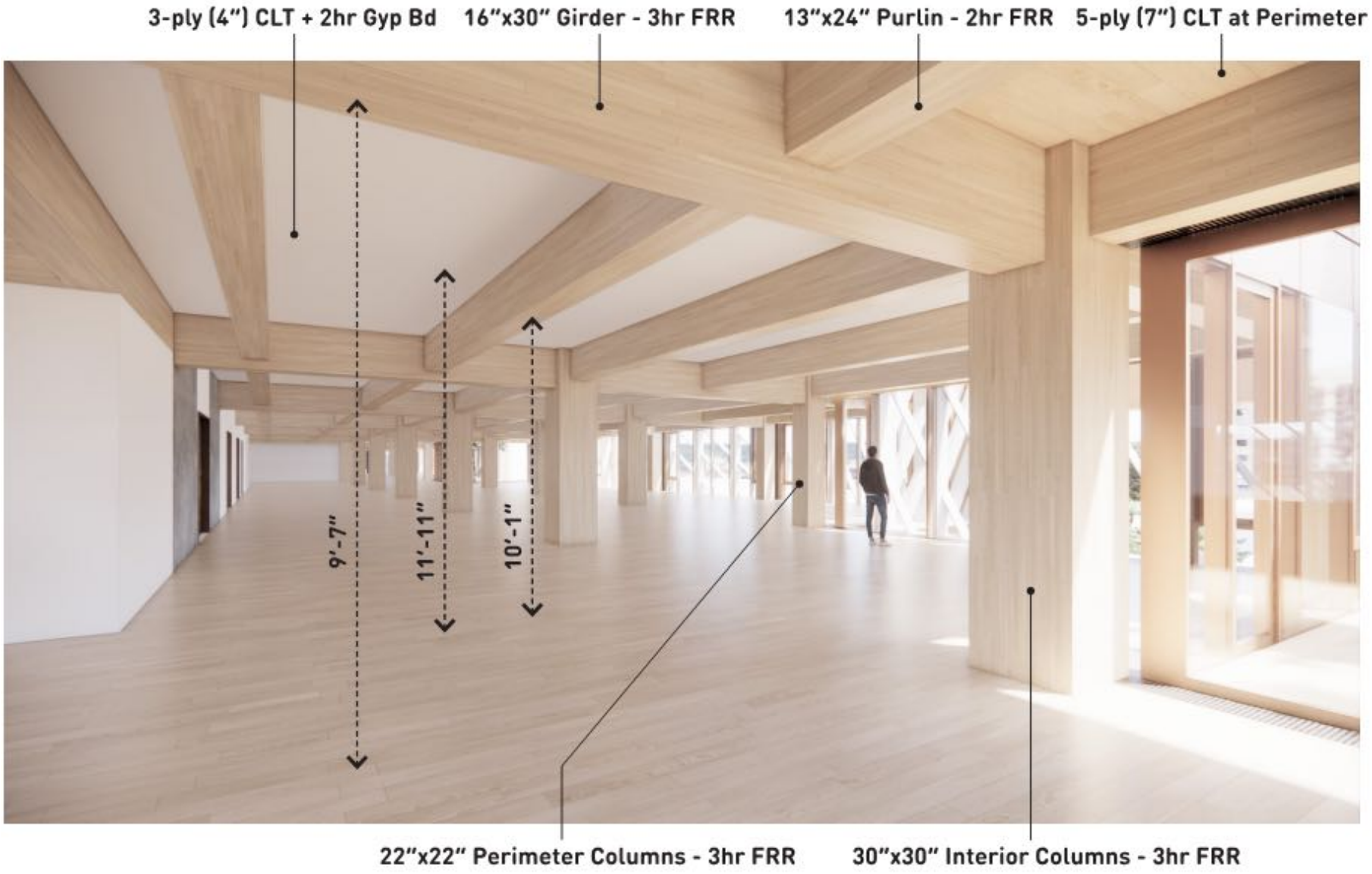
Construction Type: IV-A, Sprinklered

Structural System – Gravity: Composite CLT + conc. topping floor, glulam beams w/glulam columns

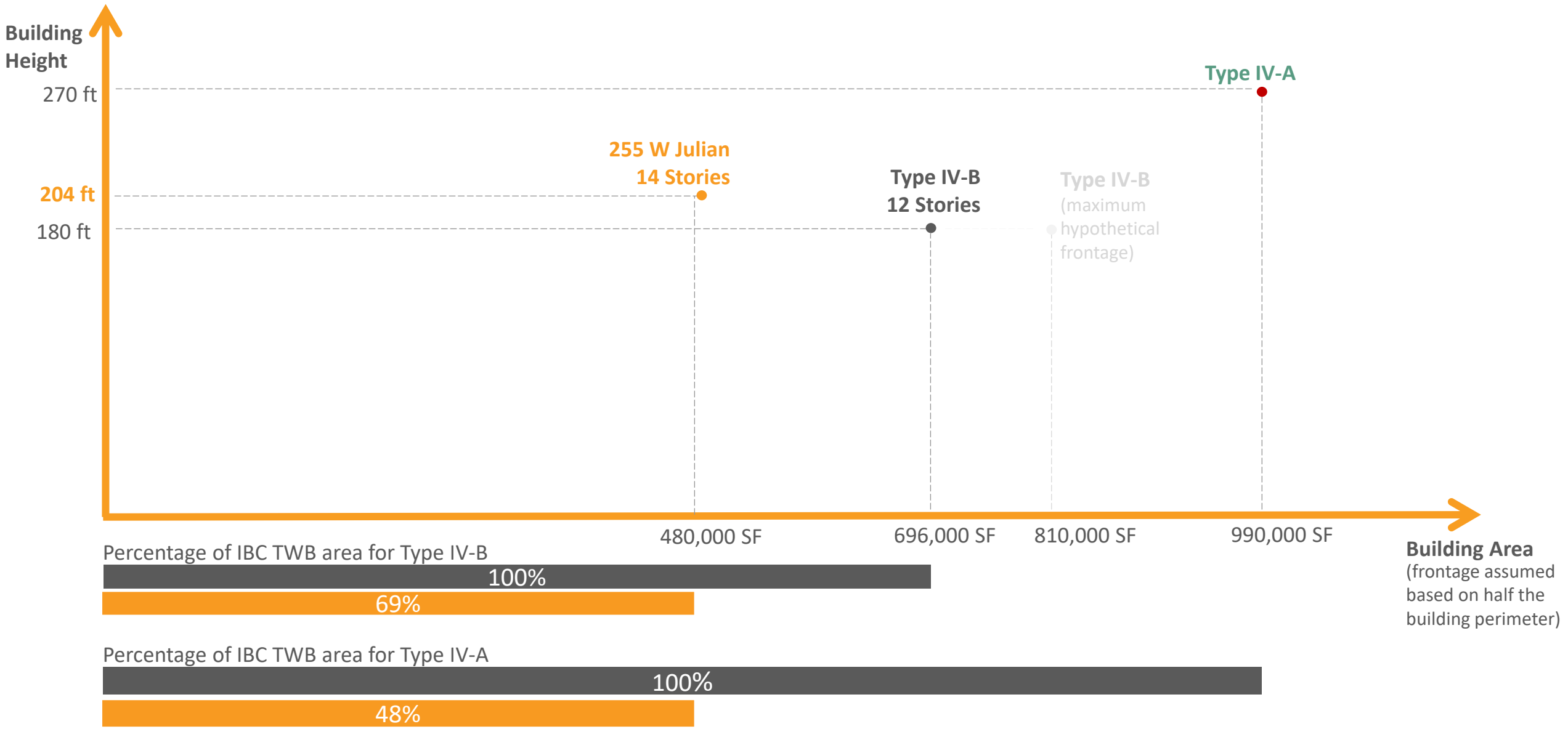
Mass Timber Construction Types, Fire Ratings (Code)

Construction Type	# Stories	Max Height	Mass Timber	Primary Frame Fire Rating
IV-A	18	270’	**Fully Protected** PROTECTED NON-COMBUSTIBLE NOT LESS THAN 1 IN. 	3 hour
IV-B	12	180’	**Partially Exposed** (20% of ceilings allowed to remain exposed Stand-alone columns can remain exposed) 	2 hour
IV-C	9	85’	**Fully Exposed** (Except outside of external walls, shafts and concealed spaces) 	2 hour

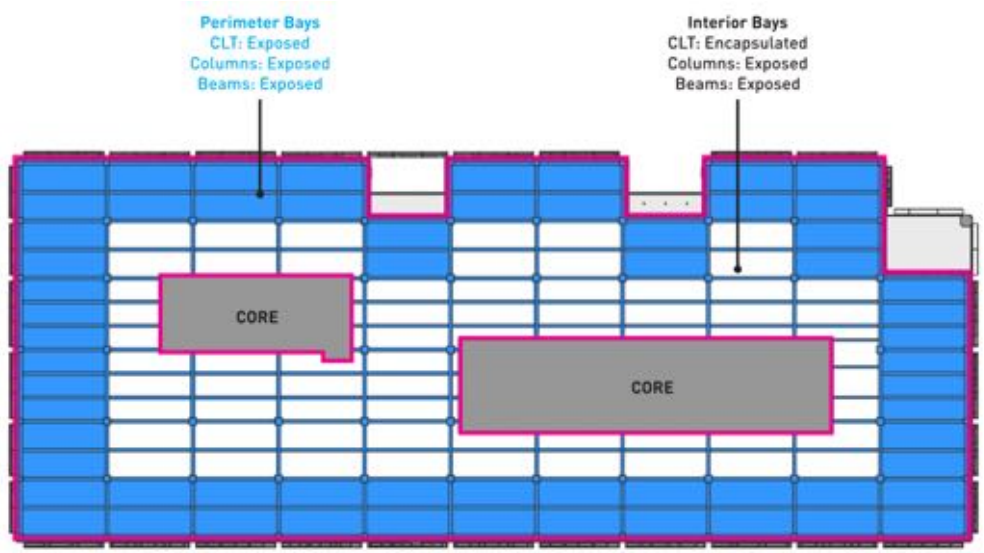
255 W Julian – Project Vision



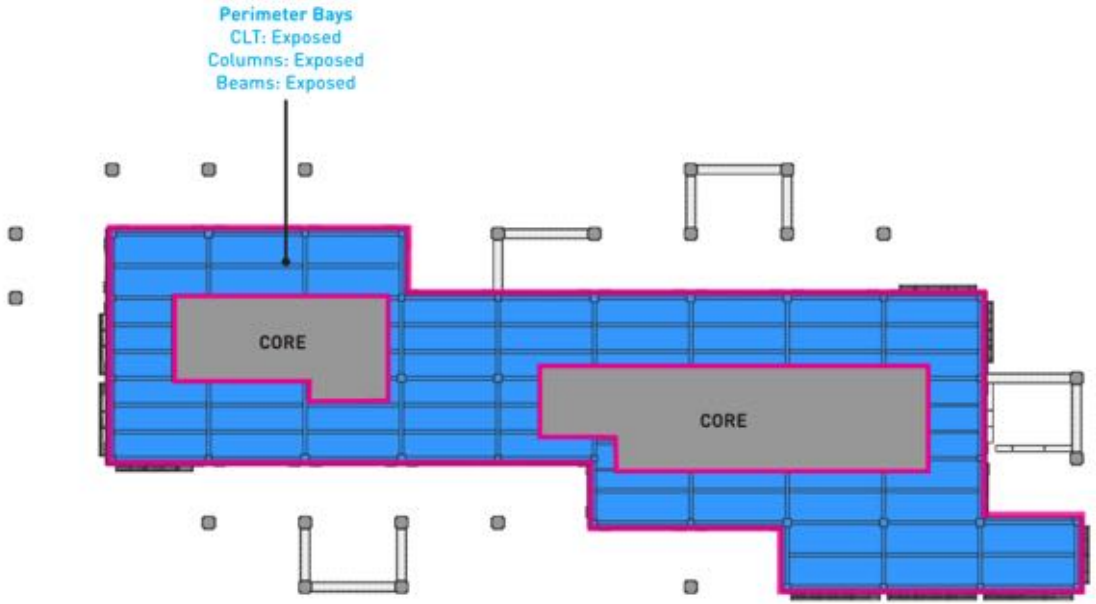
Height / Area Comparisons



Project Vision



Typical Floor (Level 2 shown)



Level 14

Item	Code Allowance	Proposed Approach
Exposed Mass timber- Columns	None	14% to 16% of fire area (i.e., floor area)
Exposed Mass timber- Beams*	None	70% to 100% of fire area (i.e., floor area)
Exposed Mass timber- CLT Ceiling	None	40% to 100% of fire area (i.e., floor area)

* Area of the exposed mass timber within the beam accounts for all exposed surfaces of the beam within the fire area.

Why Exposed Mass Timber?

Exposed Mass Timber
(Analysis and Justification)

Mitigation Measures

Recent Testing

Performance Based Engineering

Proposed Mitigation Measures

1. Sprinkler upgrade from LH to OH1
   - Increased sprinkler density (from 225 SF to 130 SF coverage area)
   - Increased water flow per sprinkler design area (150 gpm to > 300 gpm)
   - Reduced fire size at time of sprinkler activation (from 1.4 MW to 1.1 MW)

2. Smoke detection throughout the building
   - Quicker occupant notification
   - Quicker fire department response
   - Accurate addressability of the fire location

Previous Test Series

- Series of full-scale compartment tests
- Multi-story compartment used for the test series, consisted CLT walls and floors
- Complete burnout of the fuel load without contribution of the mass timber elements
- No automatic fire sprinklers

Mass Timber Material Testing Developments

ICC Tall Wood Building provisions based on testing to PRG-320 (2015)

- Adhesives not thermally resistant
- Resulted in CLT delamination

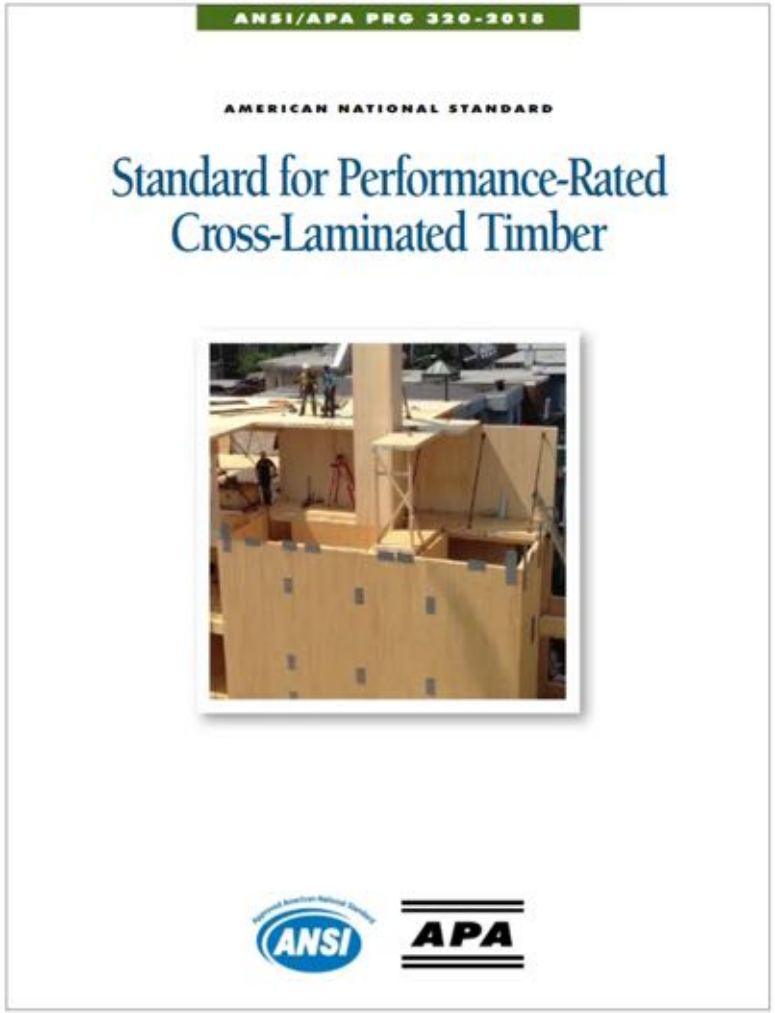
Current panels manufactured to PRG-320 (2018)

- Thermally resistant PUR (Polyurethane Reactive) adhesives
- No delamination expected
- Additional testing (AWC) just completed

Self-extinguishment is expected to improve within Commercial spaces (compared to residential configuration):

- Reduced re-radiation effects
- Increased ventilation (reduced fire severity)
- Glulam Columns tested > 3hr FRR

High rise commercial projects approved within Canada and US with increased exposed mass timber: INTRO Market Square residential building, ASCENT residential project



FPL Test Results

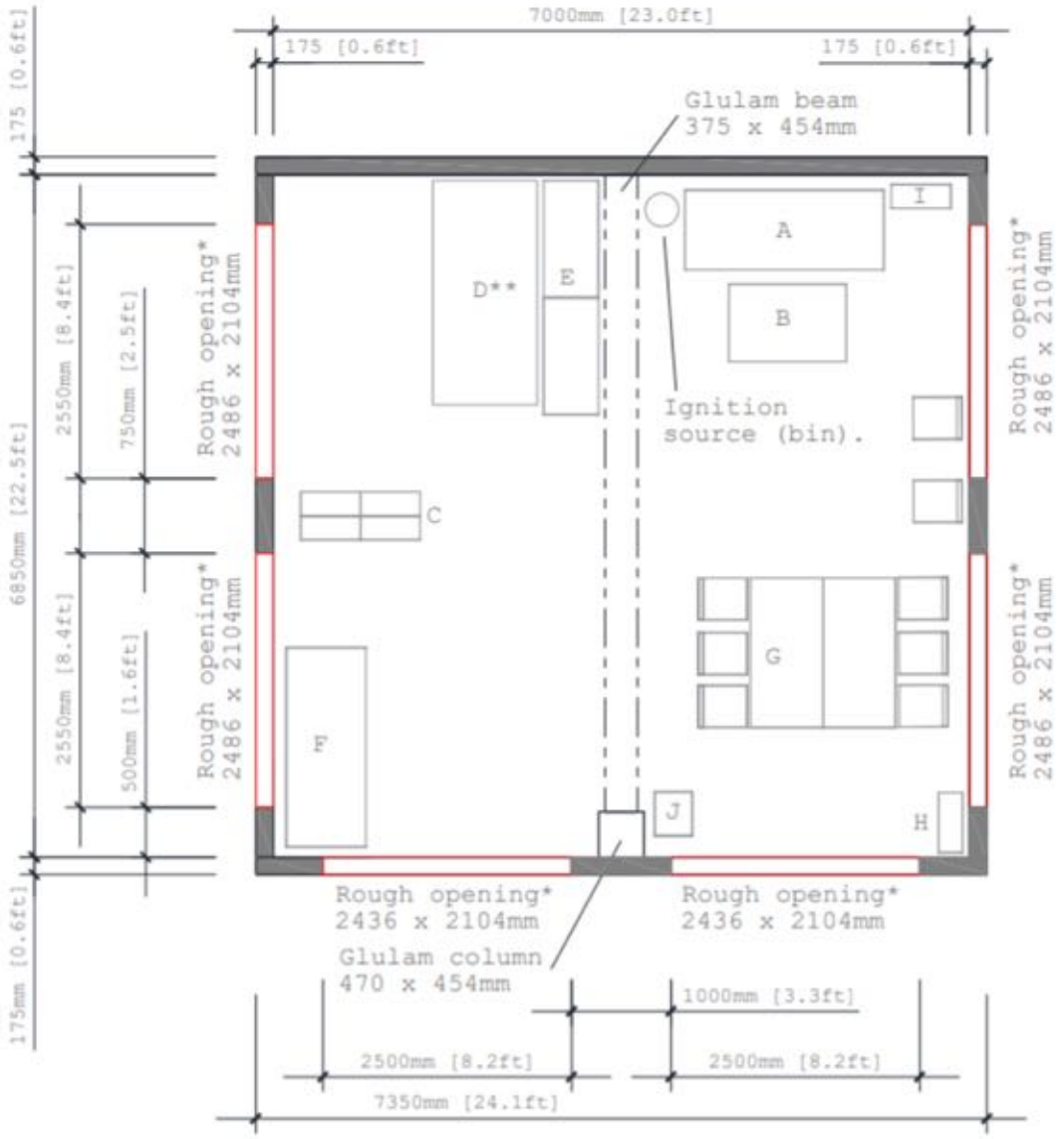
- Series of 4 compartment tests (residential compartment and fuel load).

- In all tests with exposed mass timber, the peak room temperatures were similar to fully encapsulated test. The fully developed fire stages were longer than the baseline as the exposed timber added more fuel load to the rooms.
- Glulam columns sized to 3-HR FRR per NDS 16, achieved > 4-hrs FRR.

https://www.iccsafe.org/wp-content/uploads/Fire-Tests-of-Encapsulated-MT-Rooms-with-Exposed-Wood.pdf

RISE Test Results

- Five compartment fire experiments were performed for this study.
- One of the tests were undertaken with six larger openings, resulting in an opening factor of 0.25 m1/2 (0.453 ft1/2), which is approximately equal to the **midrange of opening factors** for **office compartments**.
- ANSI/APA PRG 320, 2018 compliant panels.
- Only back wall protected (2xType X GWB).

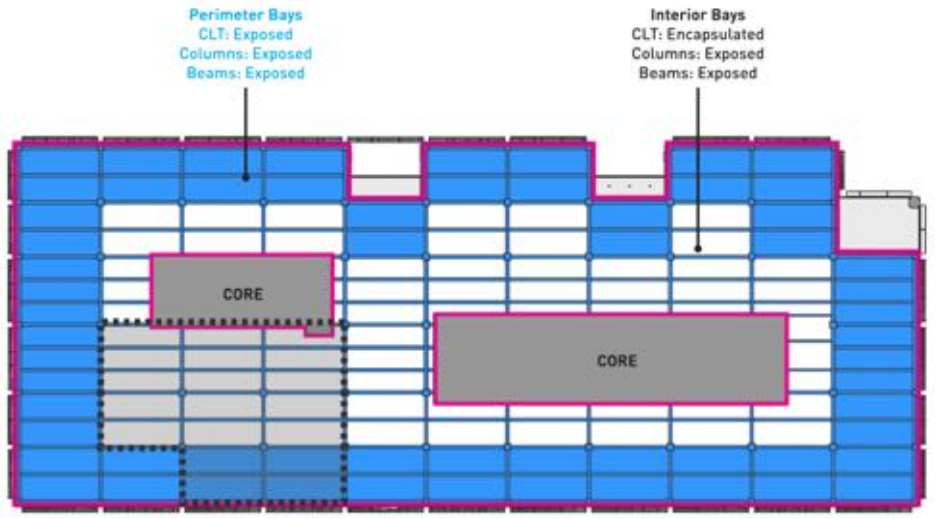


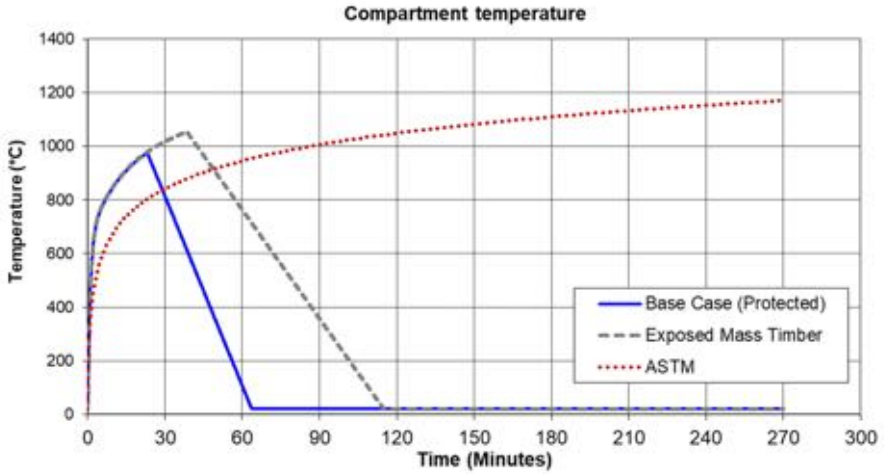
Egress Time Calculation

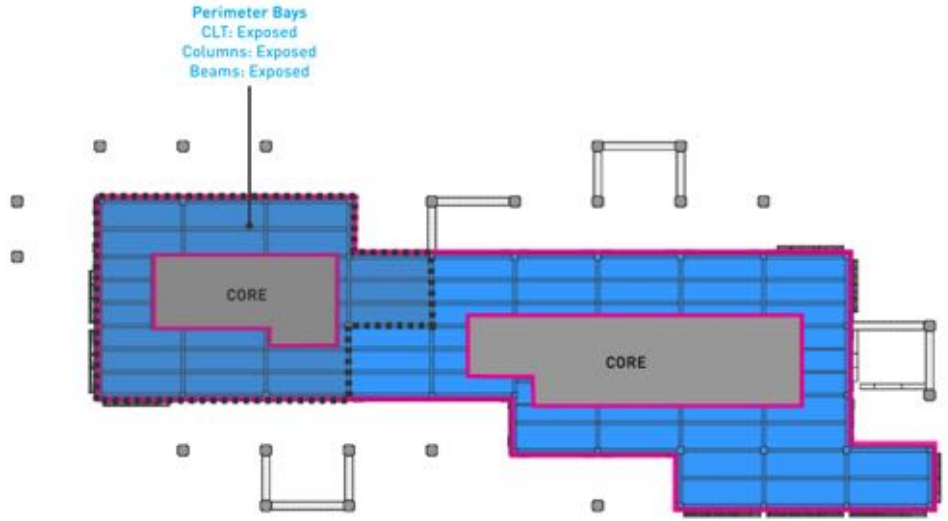
Egress traveling time includes the following:

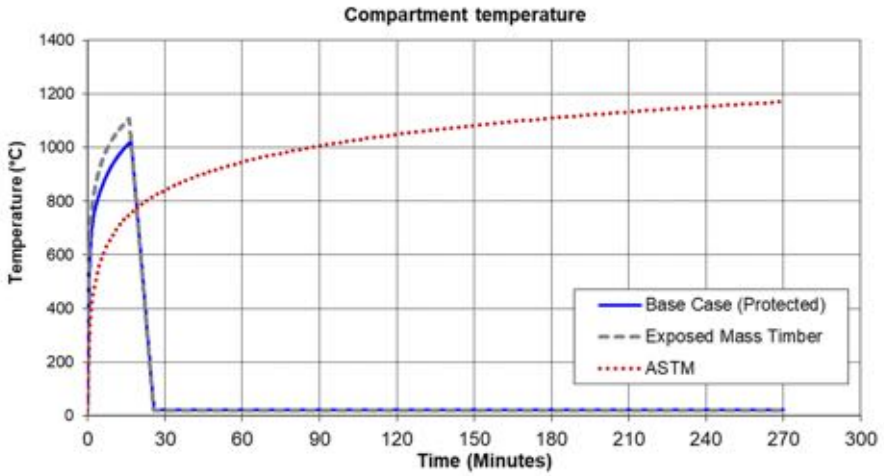
- Time for the first occupant to reach the interior exit stair door; and
- Time for the occupants to wait at the stair before entering; and
- Time for the last person to enter the stair door; and
- Time for the last person to reach safety from the controlling component (i.e., relocation to 4 stories below)

Fire Load Energy Density Assessment (FLED)









Summary

Exposed Mass Timber (Analysis and Justification)

Mitigation Measures		Recent Testing		Performance Based Engineering		
Full smoke detection	Sprinkler upgrade	FPL test results	RISE test results	Detection Time	Egress Time	FLED Assessment
Detection time decreased by more than 2 minutes	Smaller fire (from 1.4 MW to 1.1 MW)	Performance of the columns under fire conditions	Fully exposed mass timber proposed in office layout	Detection time decreased by more than 2 minutes	Detection time decreased by more than 2 minutes compared to a code compliant option	Short hot fire is expected. The peak temperature to be achieved within the first hour

Let’s Talk!

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