Exploring Tall Timber Design & New Code Provisions

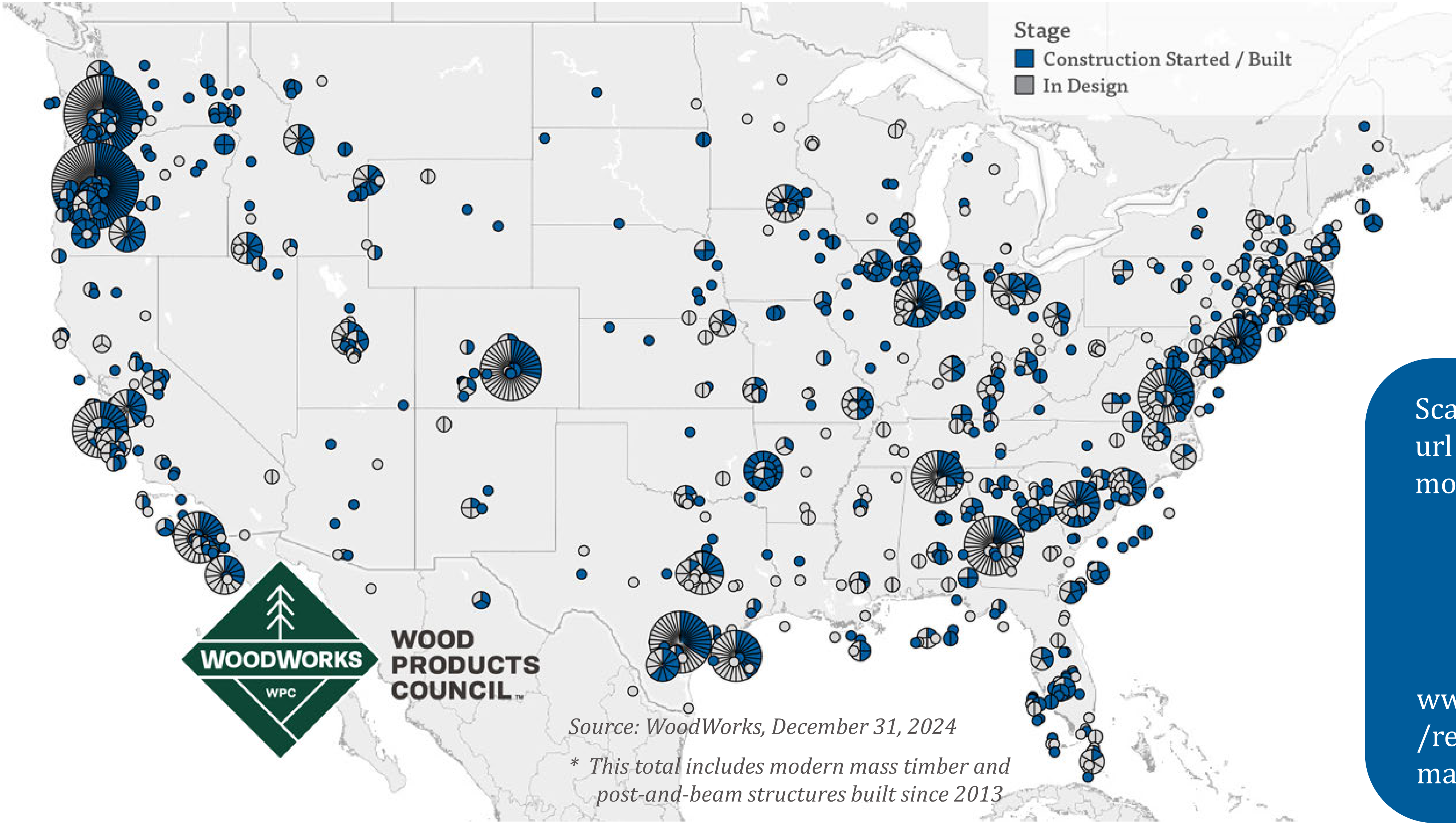
March 12 & 14, 2025

Presented by
John O’Donald II, WoodWorks

Rendering: CoStar Group

Current State of Mass Timber Projects

As of year-end 2024, in the US, **2,338** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.



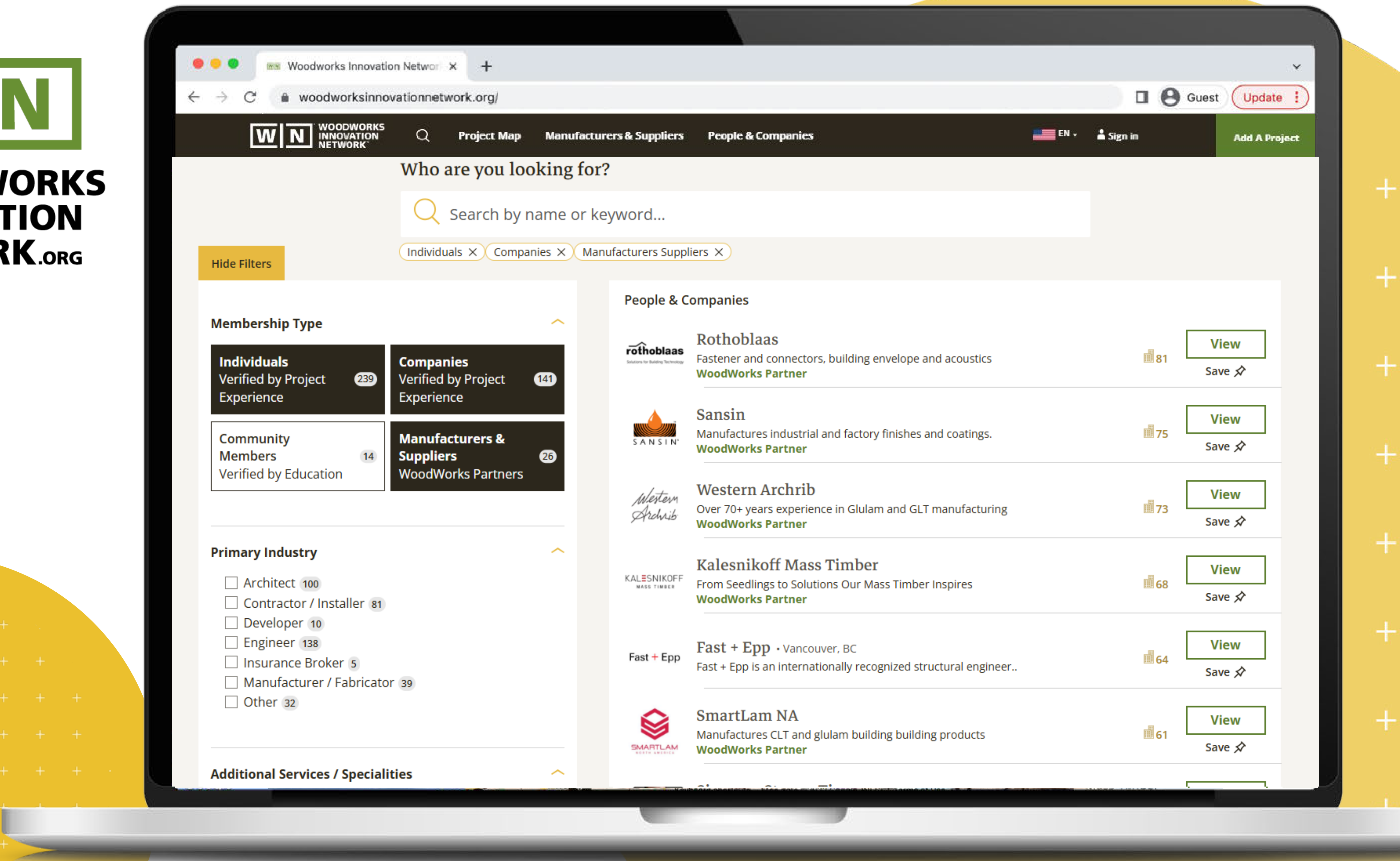
Source: WoodWorks, December 31, 2024

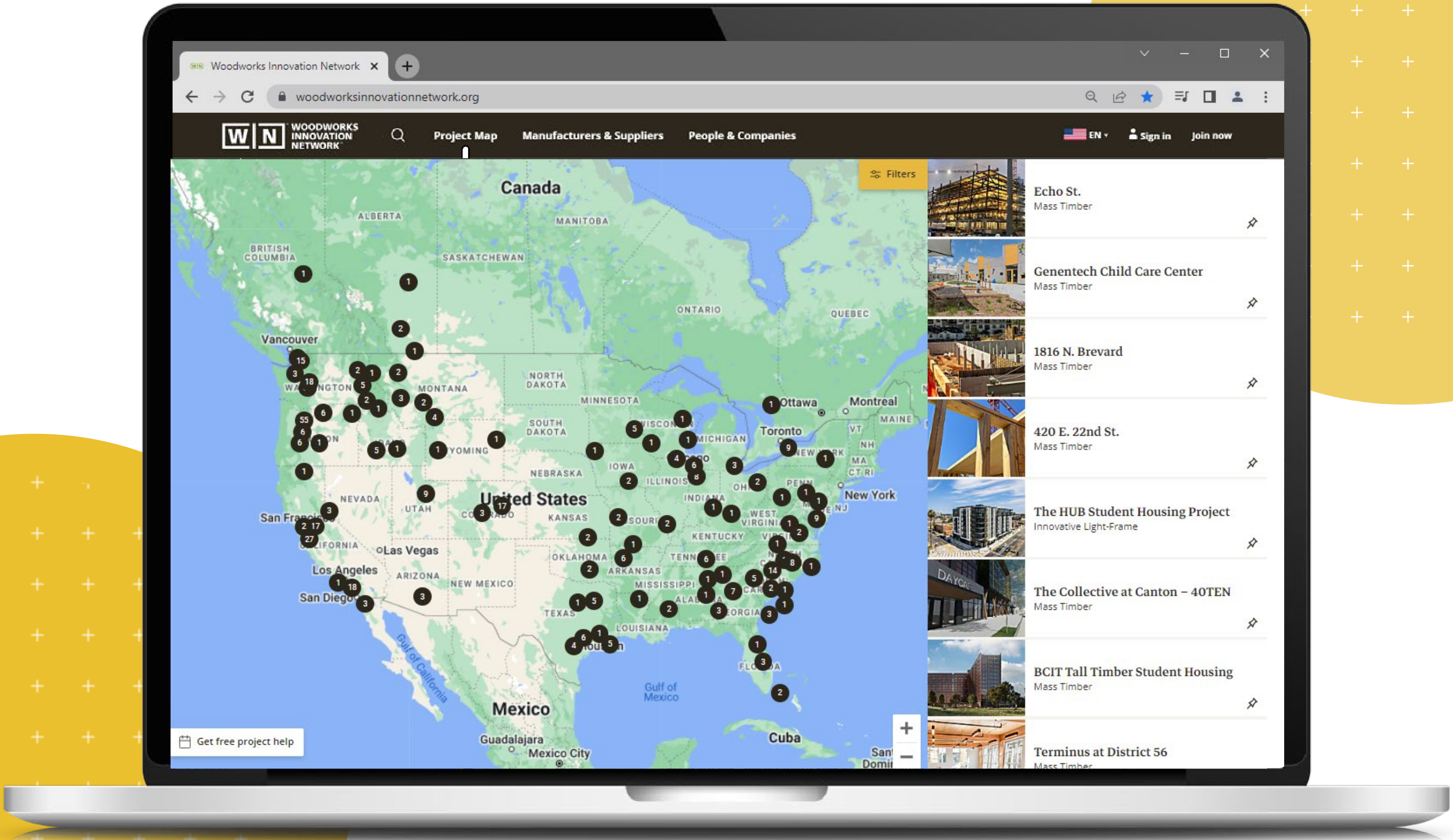
** This total includes modern mass timber and post-and-beam structures built since 2013*

Scan this code or use the url to find the map and more details online.

www.woodworks.org/resources/mapping-mass-timber/

WOODWORKS INNOVATION NETWORK.ORG




Woodworks Innovation Network
woodworksinnovationnetwork.org
WOODWORKS INNOVATION NETWORK
Project Map
Manufacturers & Suppliers
People & Companies
EN
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Filters
Canada
United States
Mexico
Cuba
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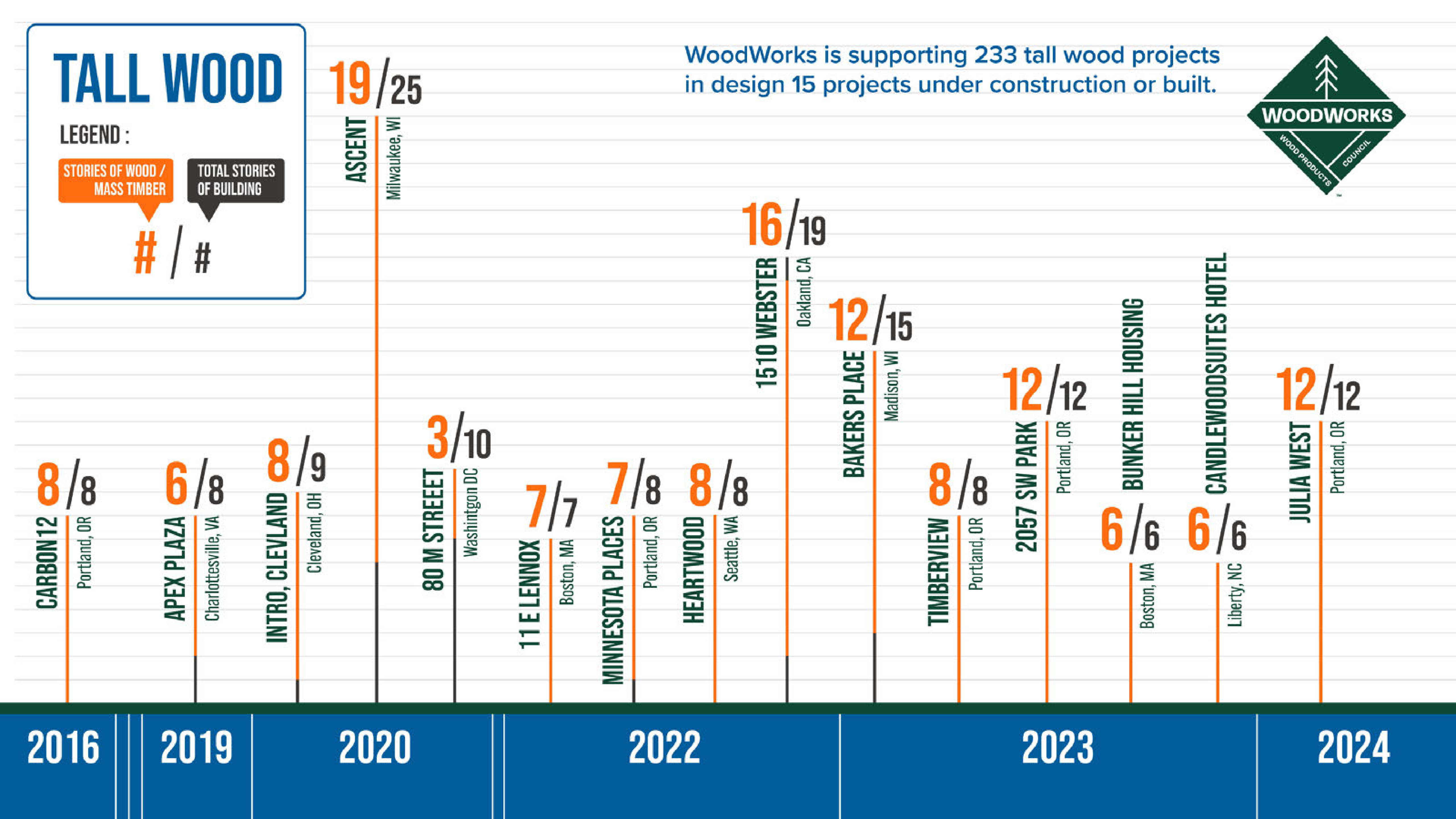
Echo St.
Mass Timber
Genentech Child Care Center
Mass Timber
1816 N. Brevard
Mass Timber
420 E. 22nd St.
Mass Timber
The HUB Student Housing Project
Innovative Light-Frame
The Collective at Canton – 40TEN
Mass Timber
BCIT Tall Timber Student Housing
Mass Timber
Terminus at District 56



TALL WOOD
LEGEND :
STORIES OF WOOD / MASS TIMBER
TOTAL STORIES OF BUILDING
/
WoodWorks is supporting 233 tall wood projects
in design 15 projects under construction or built.
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
12/12
JULIA WEST
Portland, OR
2016
2019
2020
2022
2023
2024

What is Tall Mass Timber?

Photo: WoodWorks
Architect/Developer: oWOW

Does Tall Wood = High Rise?

Mid-Rise vs. High-Rise

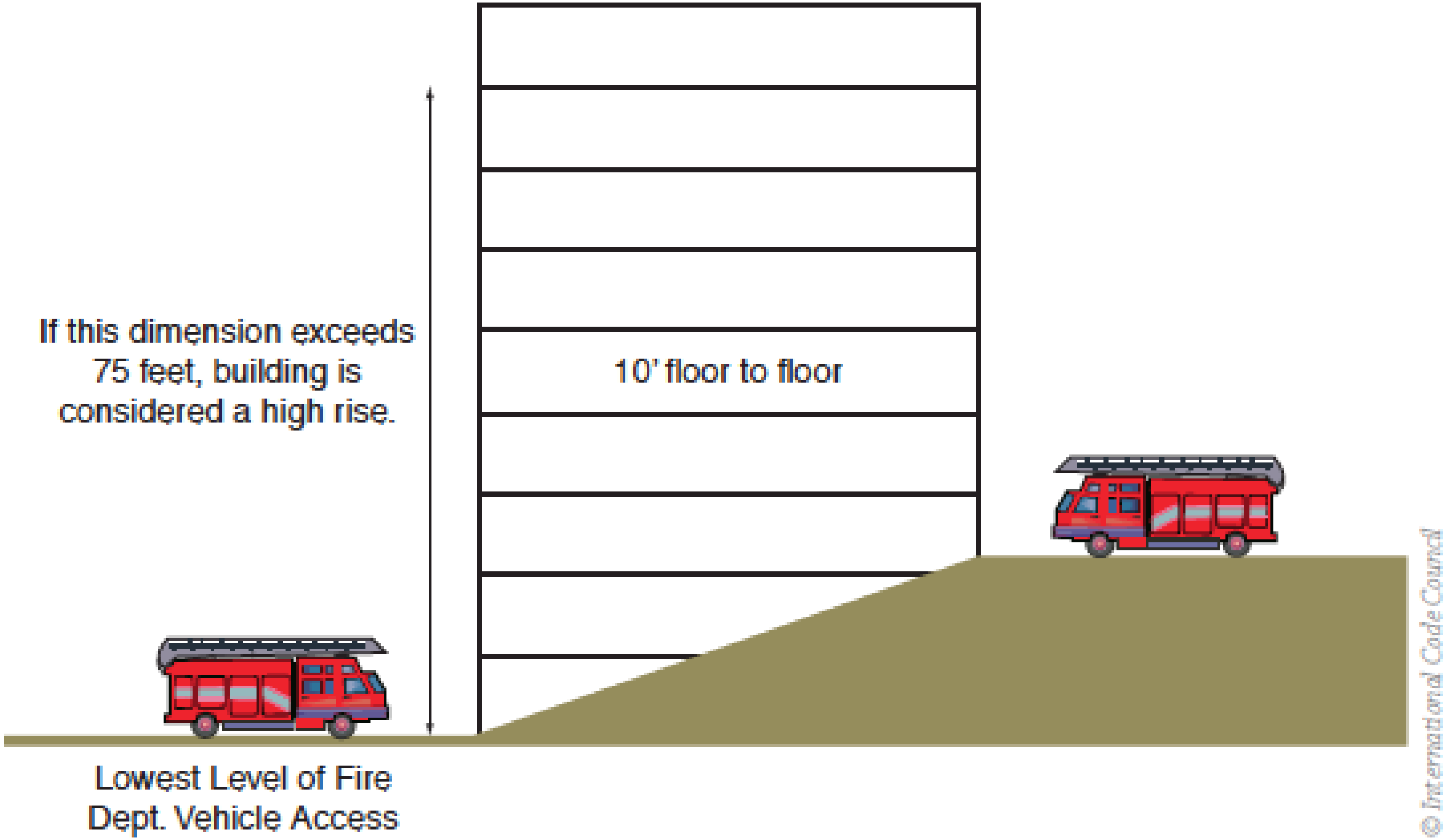
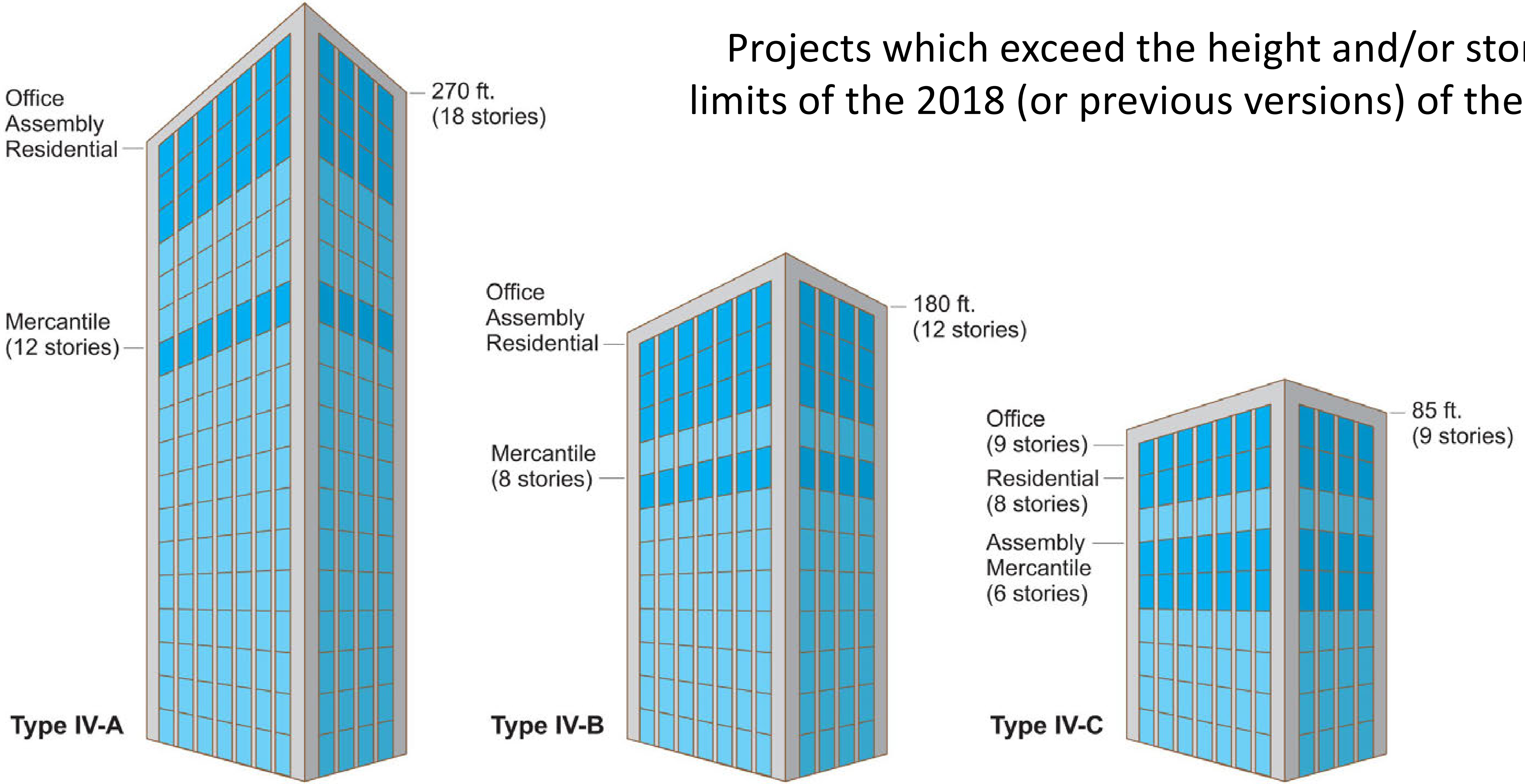


FIGURE 6-6 Determination of high-rise building

Tall Mass Timber

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



Tall Mass Timber

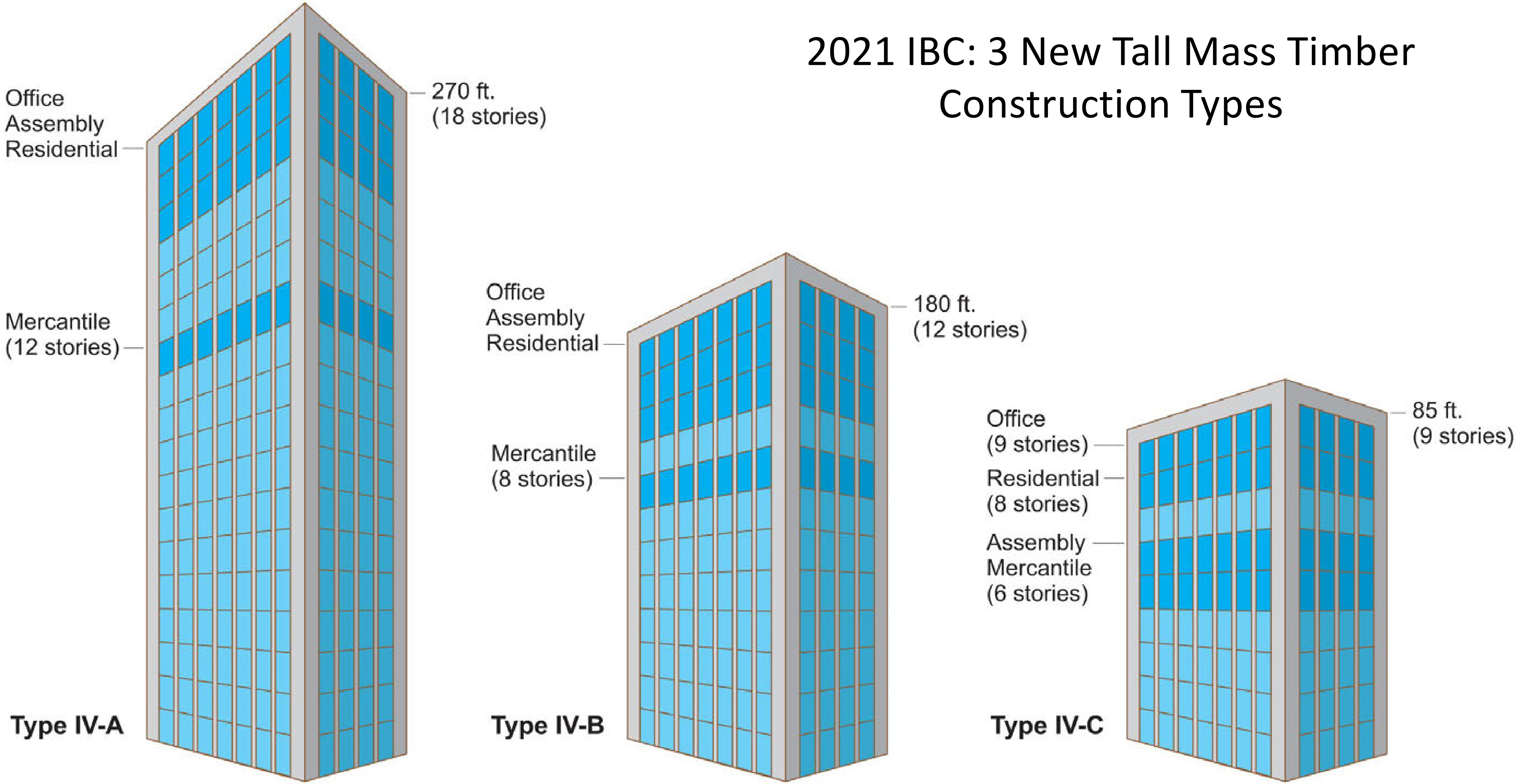
2021 IBC Introduces 3 new tall wood construction types:

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

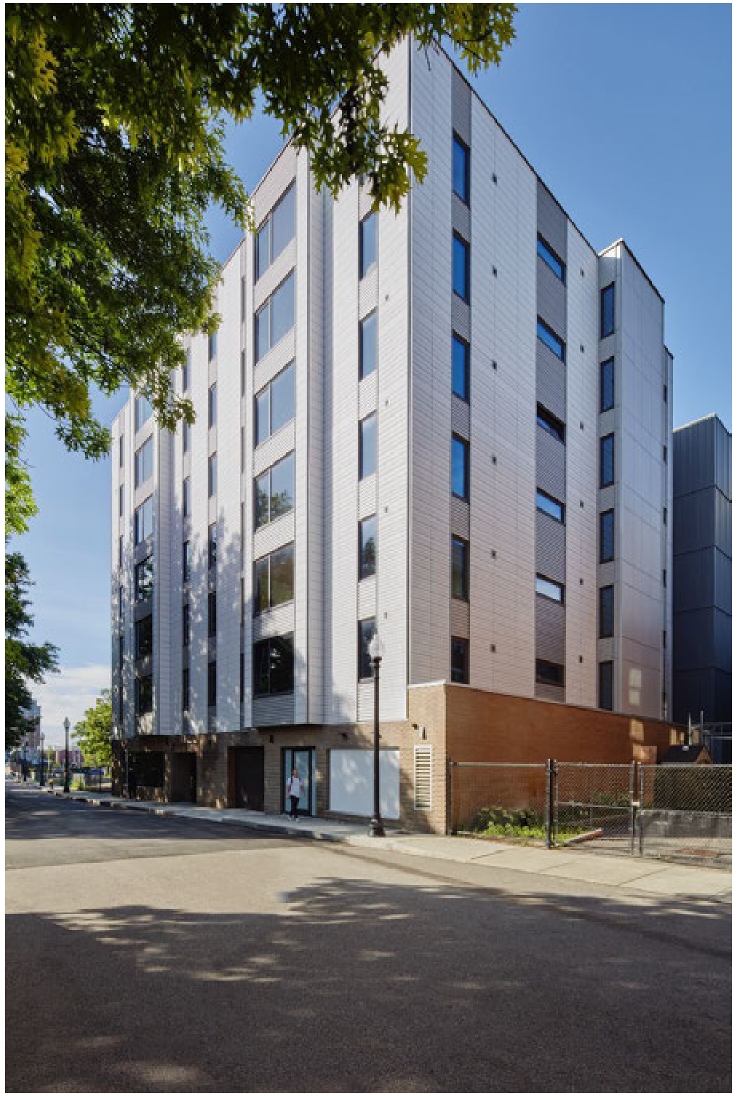
BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B

Tall Mass Timber

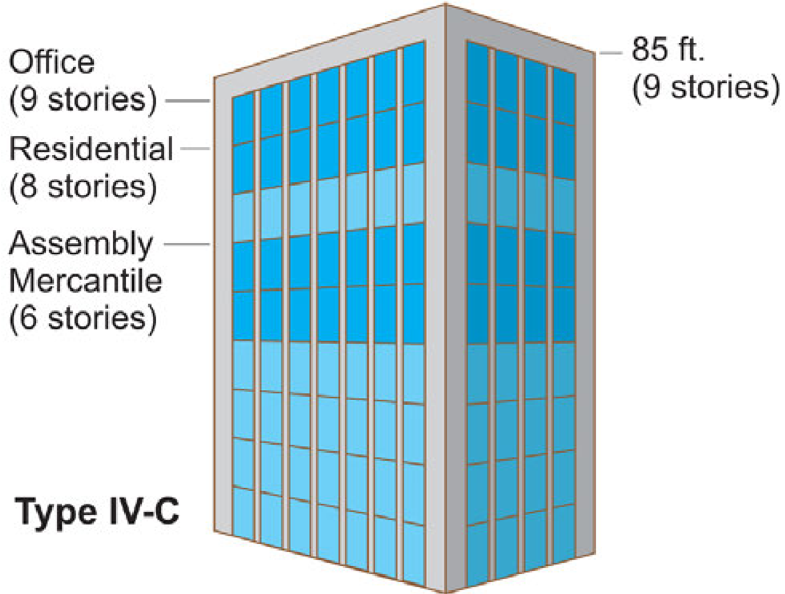
2021 IBC: 3 New Tall Mass Timber Construction Types



Type IV-C



Monte French Design Studio
Photos: Jane Messinger

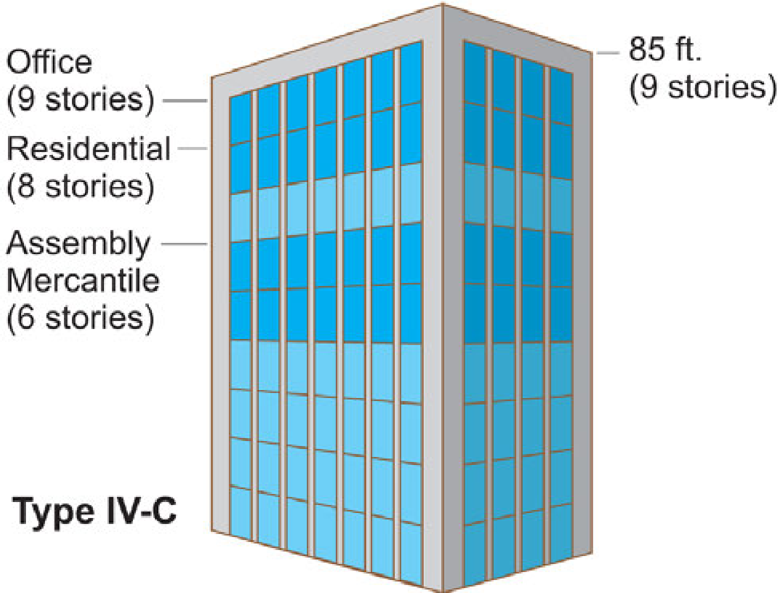


Type IV-C Exposure Limits

All Mass Timber surfaces may be exposed

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

Monte French Design Studio
Photo: Jane Messinger



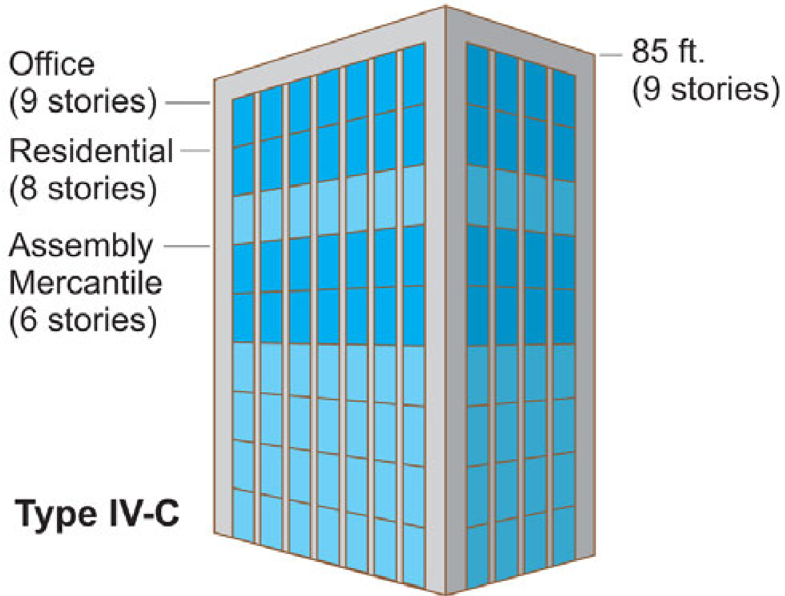
Type IV-C Building Size Limits

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

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

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



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

William McDonough + Partners
Simpson Gumpertz & Heger
Photo Prakash Patel

Type IV-B

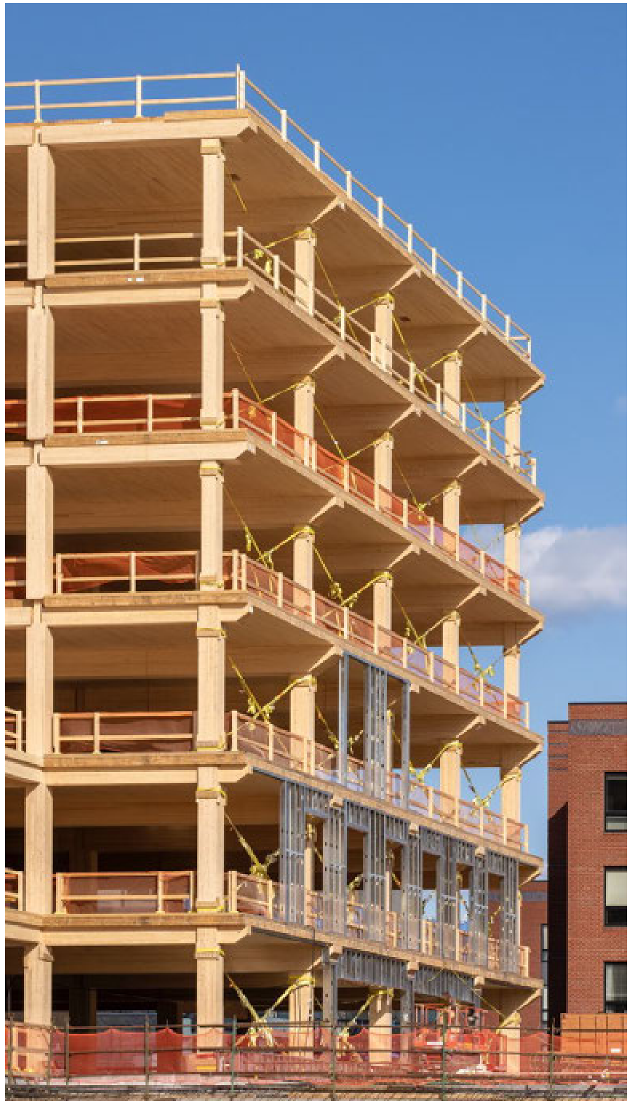
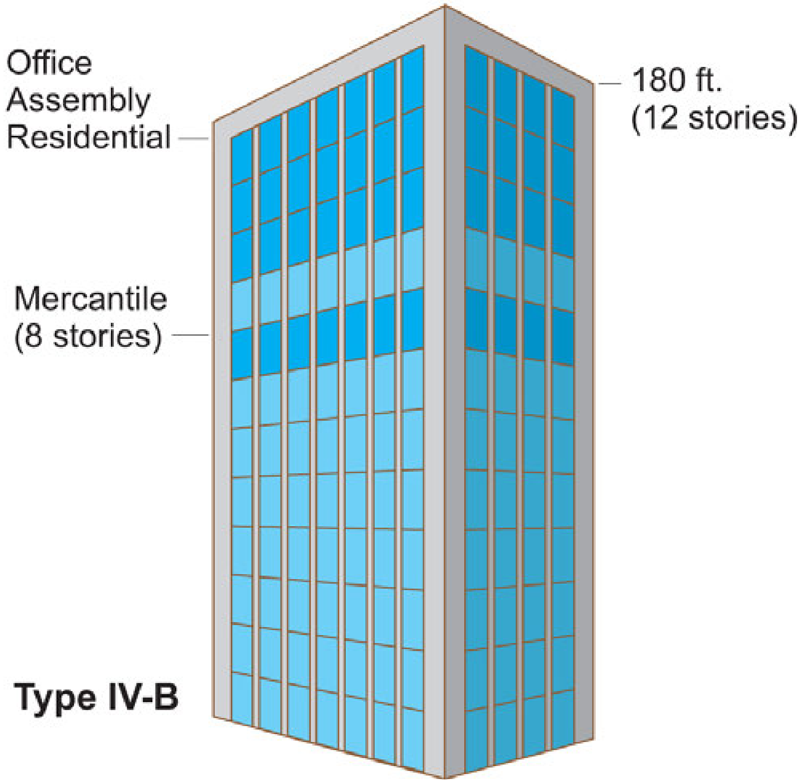


Photo: ©Prakash Patel

Photos: Nick Johnson, Tour D Space



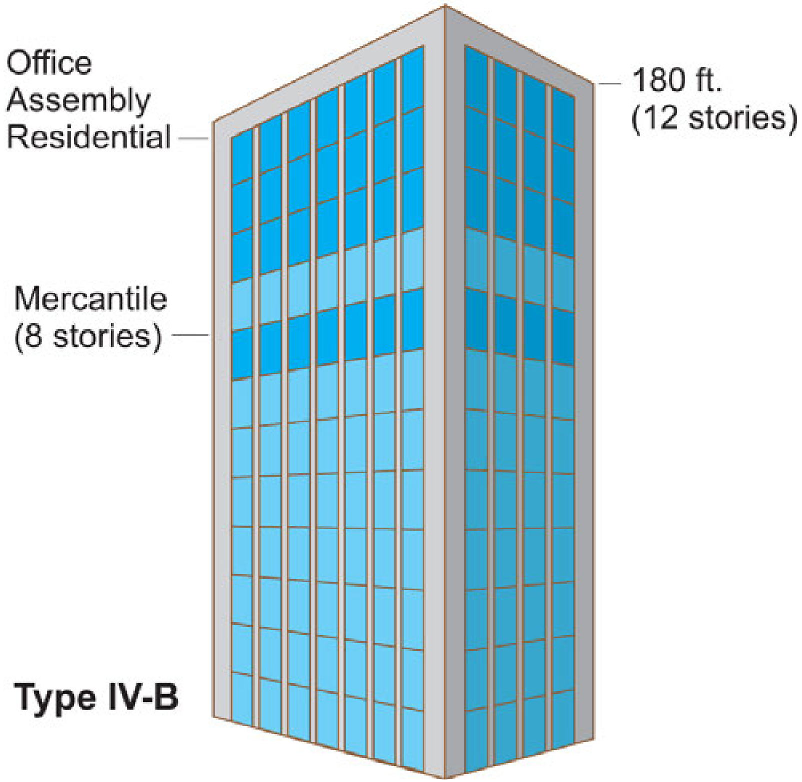
Type IV-B Exposure Limits

NC protection on some surfaces of Mass Timber

2021 IBC: 20% of ceilings or 40% of walls can be exposed

2024 IBC: 100% of ceilings or 40% of walls can be exposed

Photo: Nick Johnson, Tour D Space



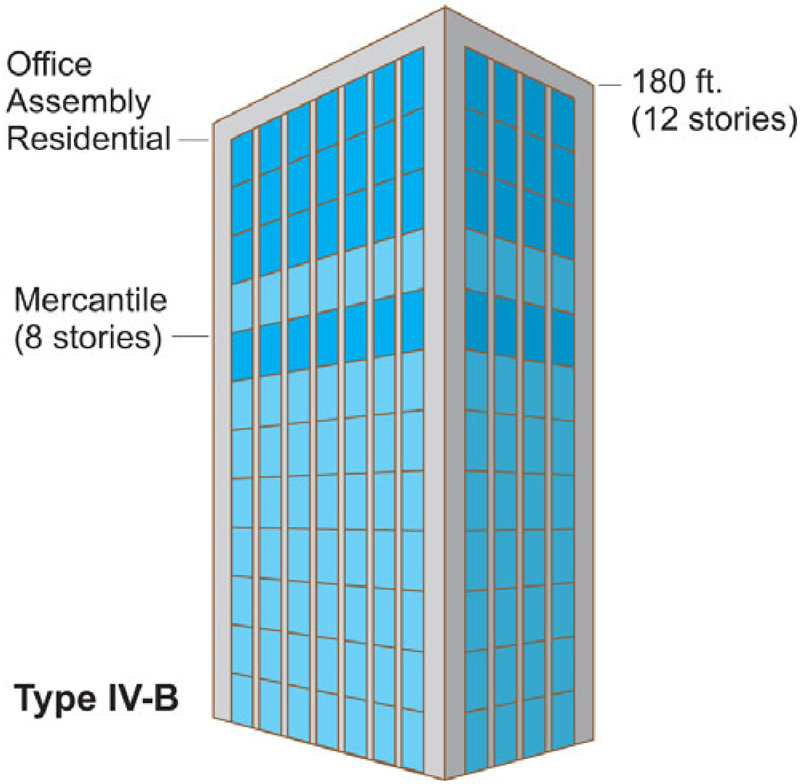
Type IV-B Building Size Limits

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

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

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



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

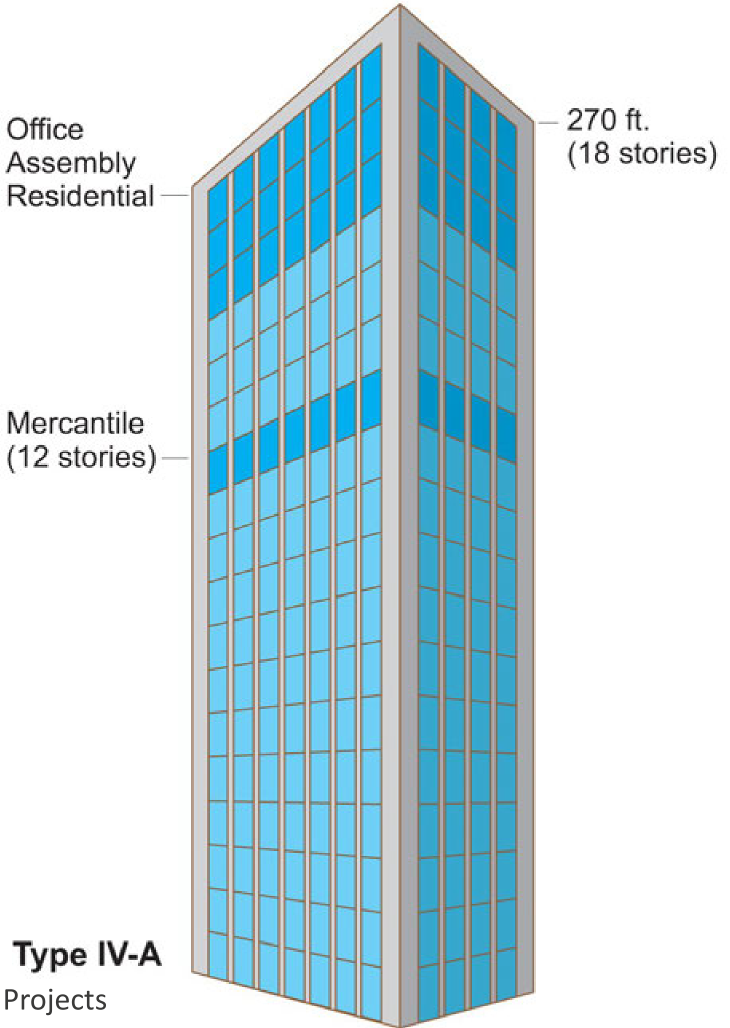
108,000 sqft

16 ft floor to floor

W|N PROFILE

Hickok Cole
Arup
Photo Maurice Harrington

Type IV-A

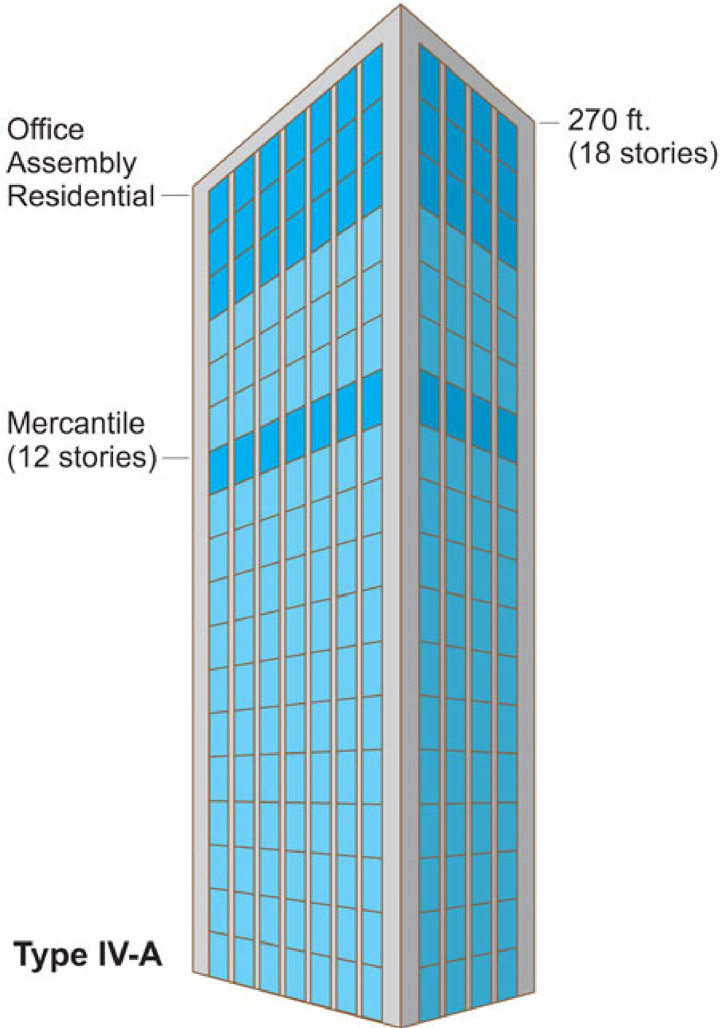


Photos: Flor Projects

Type IV-A Exposure Limits

100% NC protection on all surfaces of Mass Timber

Photo: Flor Projects



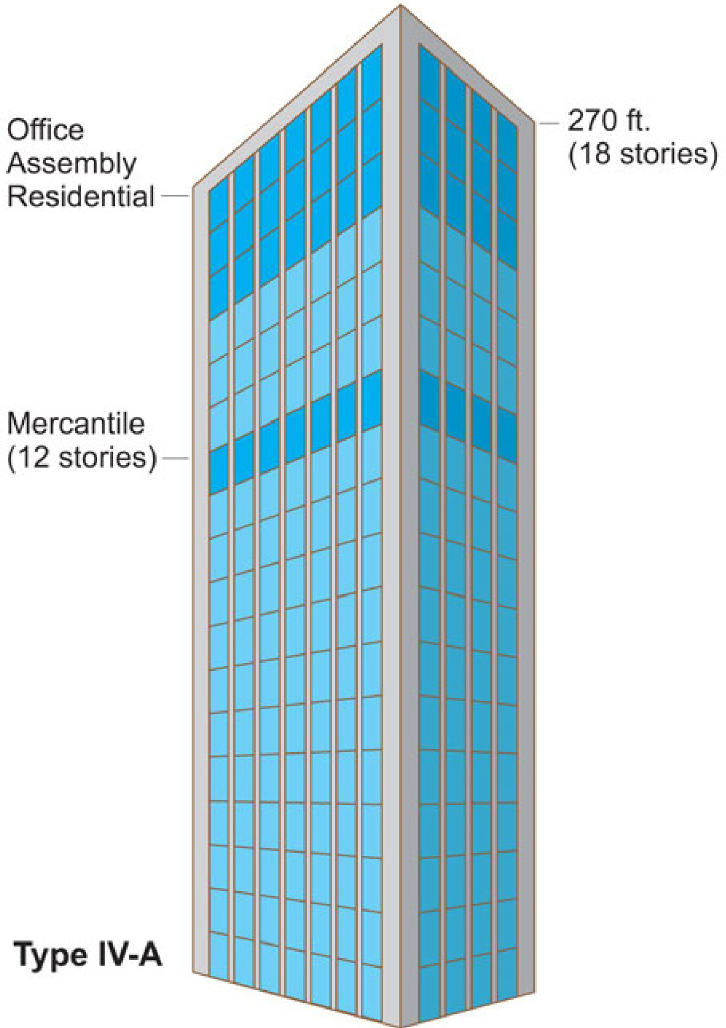
Type IV-A Building Size Limits

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

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

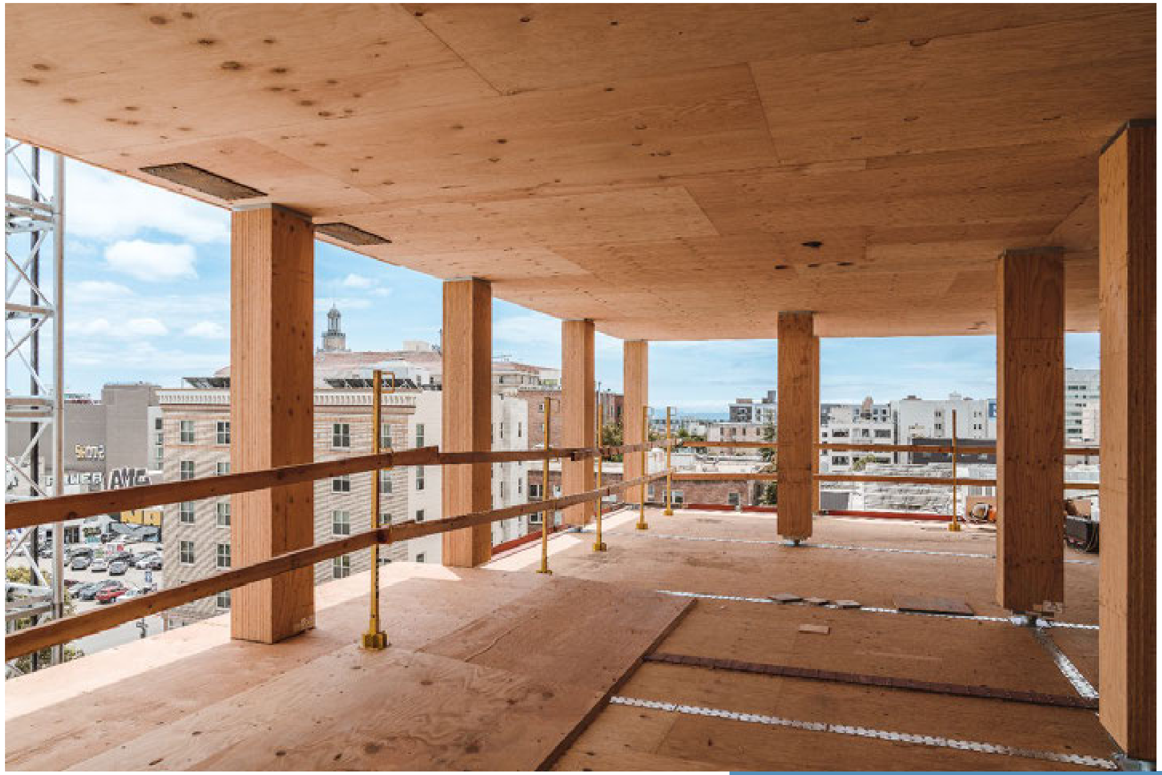



1510 Webster
Oakland, CA
oWow
DCI Engineers
Photo: Flor Projects

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

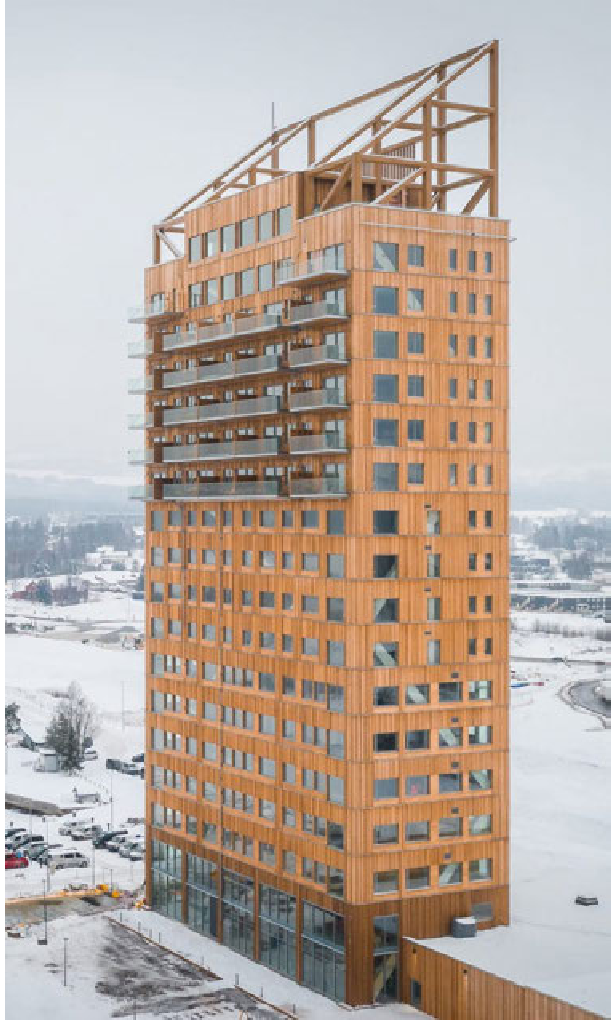
Tall Mass Timber in the U.S.

How Did We Arrive Here?

INTRO, Cleveland, OH | Architect: Hartshorne Plunkard Architecture | Image Courtesy Harbor Bay Real Estate Advisors, Image Fiction

2008 – 2015: International Inspiration

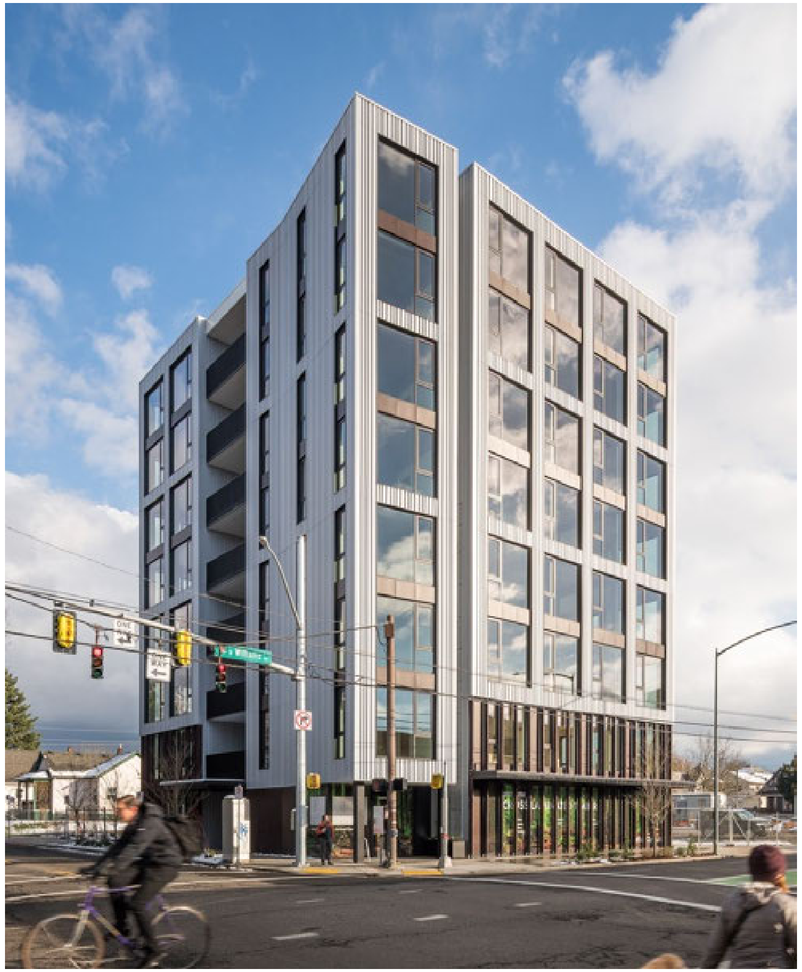
8-18-Story Projects in Europe, Canada, Australia



Photos: Waugh Thisleton Architects | Bygg Mesteren | Voll Arkitekter | Michael Elkan | Naturally Wood | UBC

2015-2018: Domestic Innovation

TALL WOOD BUILDING COMPETITION, 8-STORY CARBON 12 IN PORTLAND, OR



Photos: SHoP Architects | LEVER Architecture | Baumberger Studio/PATH Architecture

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

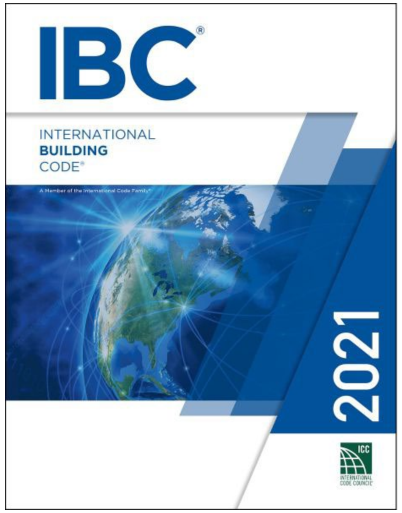
W N PROFILE

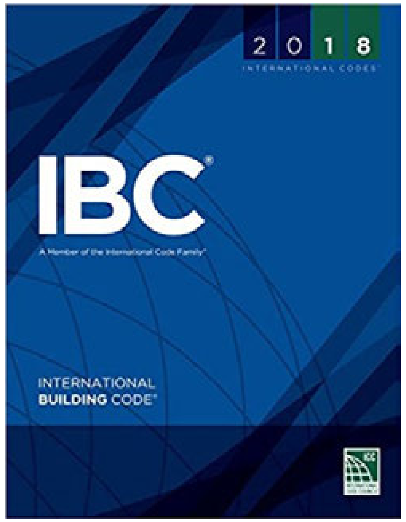
Kaiser + Path
Munzing Structural Engineering
Photo Andrew Pogue

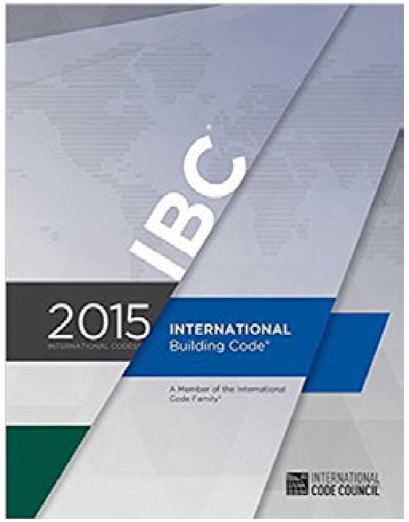
2015-2018: Building a Code Roadmap

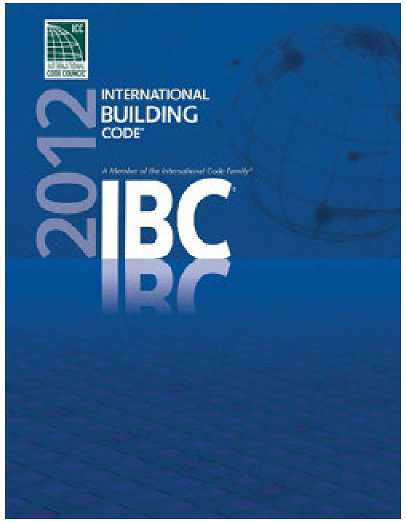
Photos: ICC

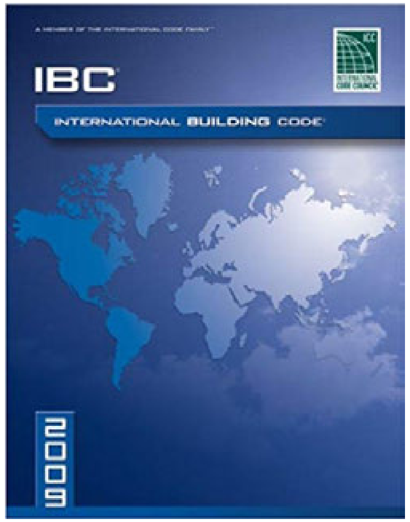
2015-2018: Building a Code Roadmap

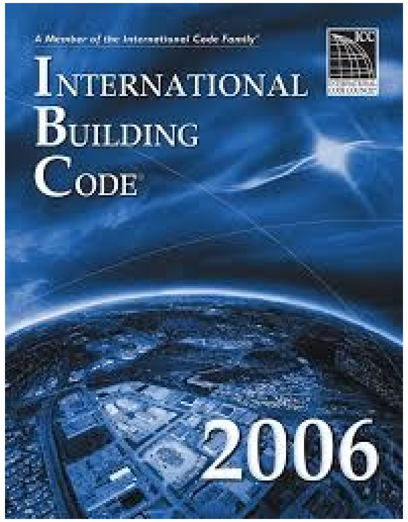


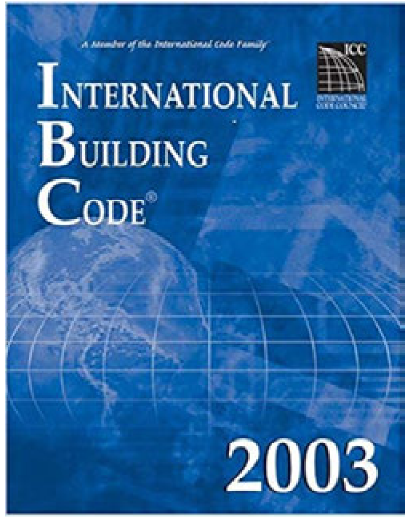


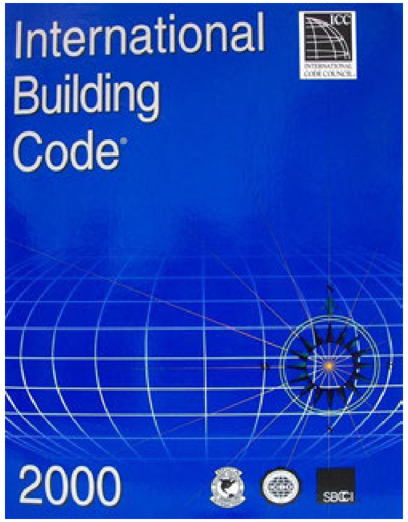












Images: ICC

2015-2018: Building a Code Roadmap

Photo: Lendlease

2015-2018: Building a Code Roadmap

Photo: Lendlease

2015-2018: Building a Code Roadmap

Photo: Lendlease

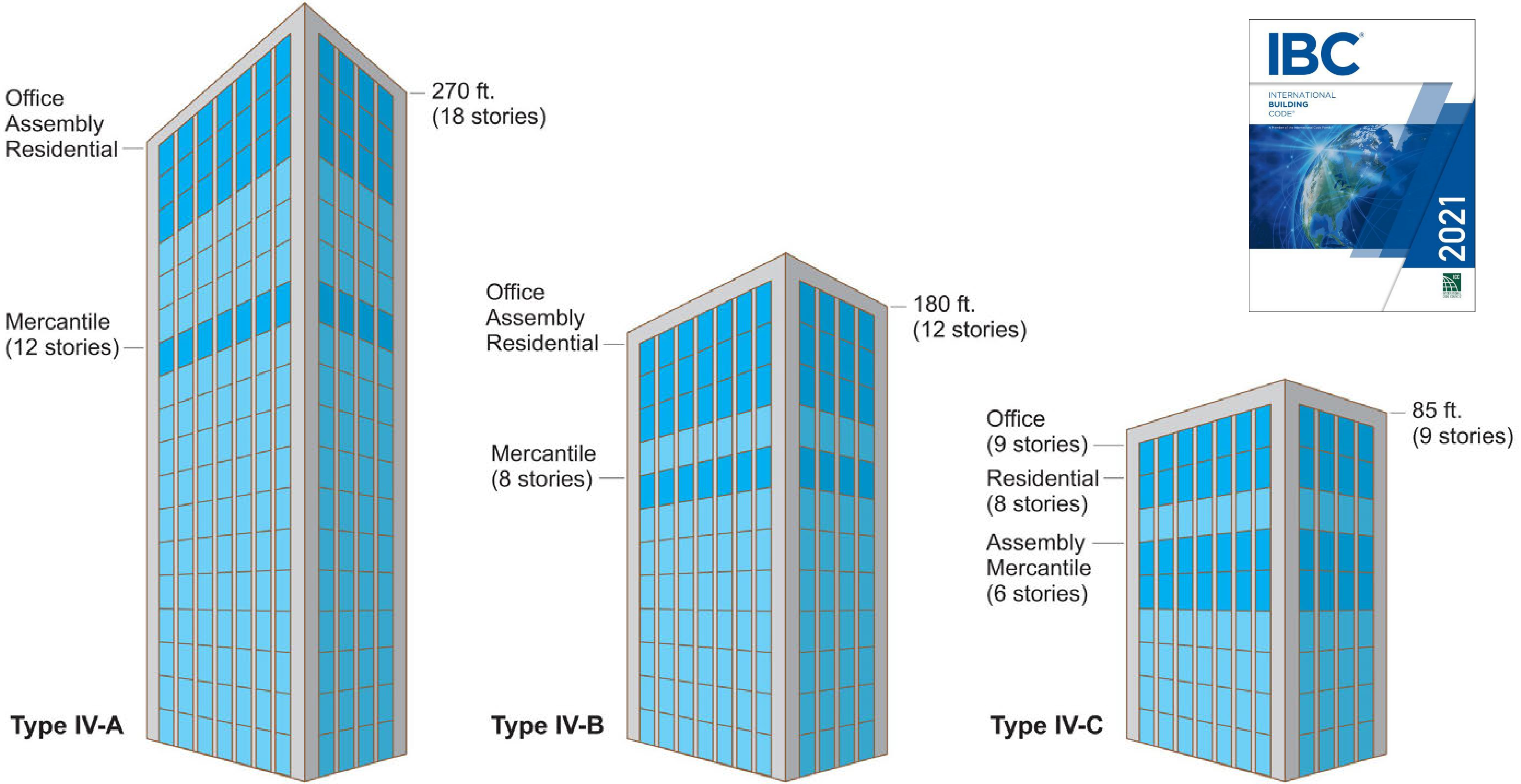
2015-2018: Building a Code Roadmap

Photo: Lendlease

2015-2018: Building a Code Roadmap

Photo: Lendlease

2018-2021: Rollout of a New Code Path



2021 IBC

2019-2022: REFINING THE CODE ROADMAP

RI.
SE

Fire Safe Implementation of Mass Timber In Tall Buildings

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

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

Source: RISE

2019-2022: REFINING THE CODE ROADMAP

USDA
United States Department of Agriculture

Compartment Fire Testing of a Two-Story Mass Timber Building

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

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

Conservatism: ATF lab tests based on older generation CLT adhesives

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

Source: RISE, USDA FS FPL & AWC

2019-2022: REFINING THE CODE ROADMAP

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.

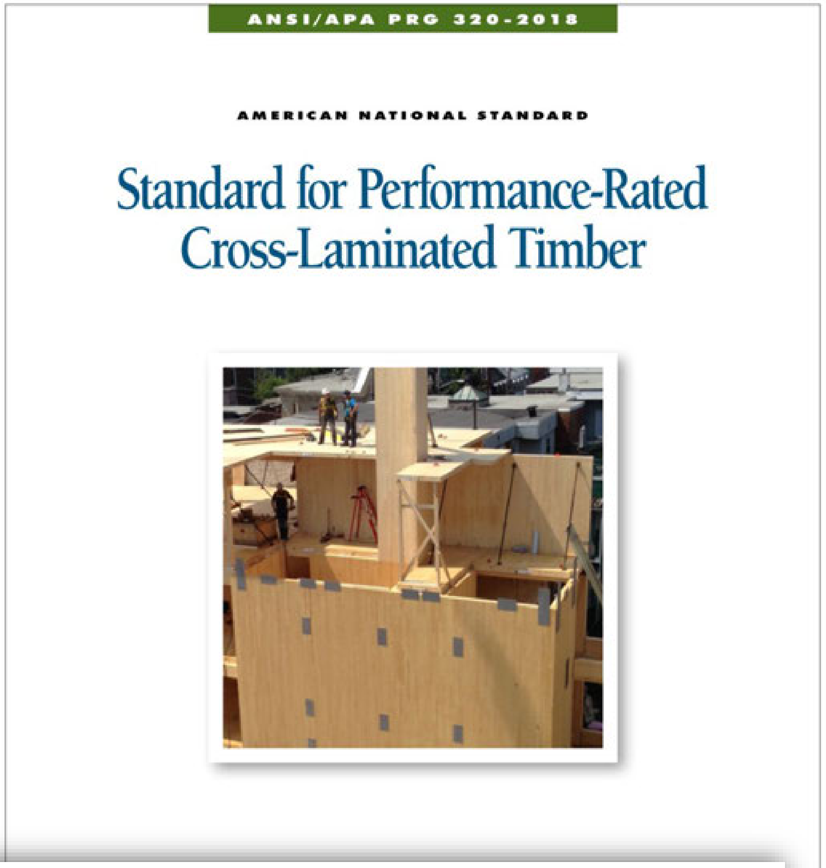

Photo: Urban One


Photo: ARUP

2019-2022: REFINING THE CODE ROADMAP

PRG 320 is manufacturing & performance standard for CLT

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



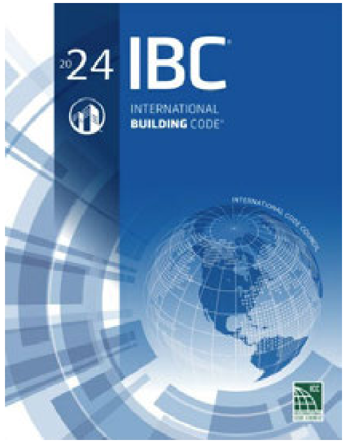
ANNEX B. PRACTICE FOR EVALUATING ELEVATED TEMPERATURE PERFORMANCE OF ADHESIVES USED IN CROSS-LAMINATED TIMBER (MANDATORY)

2019-2022: REFINING THE CODE ROADMAP

Photo: RISE

2019-2022: REFINING THE CODE ROADMAP

Change to 2024 IBC: IV-B Ceiling Exposure



602.4.2.2.2 Protected area.

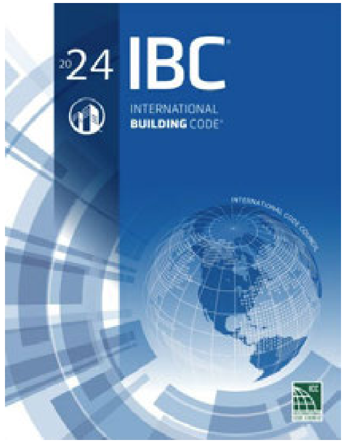
Interior faces of *mass timber* elements, including the inside face of exterior *mass timber walls* and *mass timber roofs*, shall be protected in accordance with Section 602.4.2.2.1.

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, limited to an area less than or equal to 100 percent of the floor area in any *dwelling unit* within a *story* or fire area within a *story*.
   1.2. Unprotected portions of *mass timber* walls, including attached columns, limited to an area less than or equal to 40 percent of the floor area in any *dwelling unit* within a *story* or fire area within a *story*.
   1.3. Unprotected portions of both walls and ceilings of *mass timber*, including attached columns and beams, in any *dwelling unit* or fire area and in compliance with Section 602.4.2.2.3.
2. *Mass timber* columns and beams that are not an integral portion of walls or ceilings, respectively, without restriction of either aggregate area or separation from one another.

2019-2022: REFINING THE CODE ROADMAP

Change to 2024 IBC: IV-B Exposure Separation



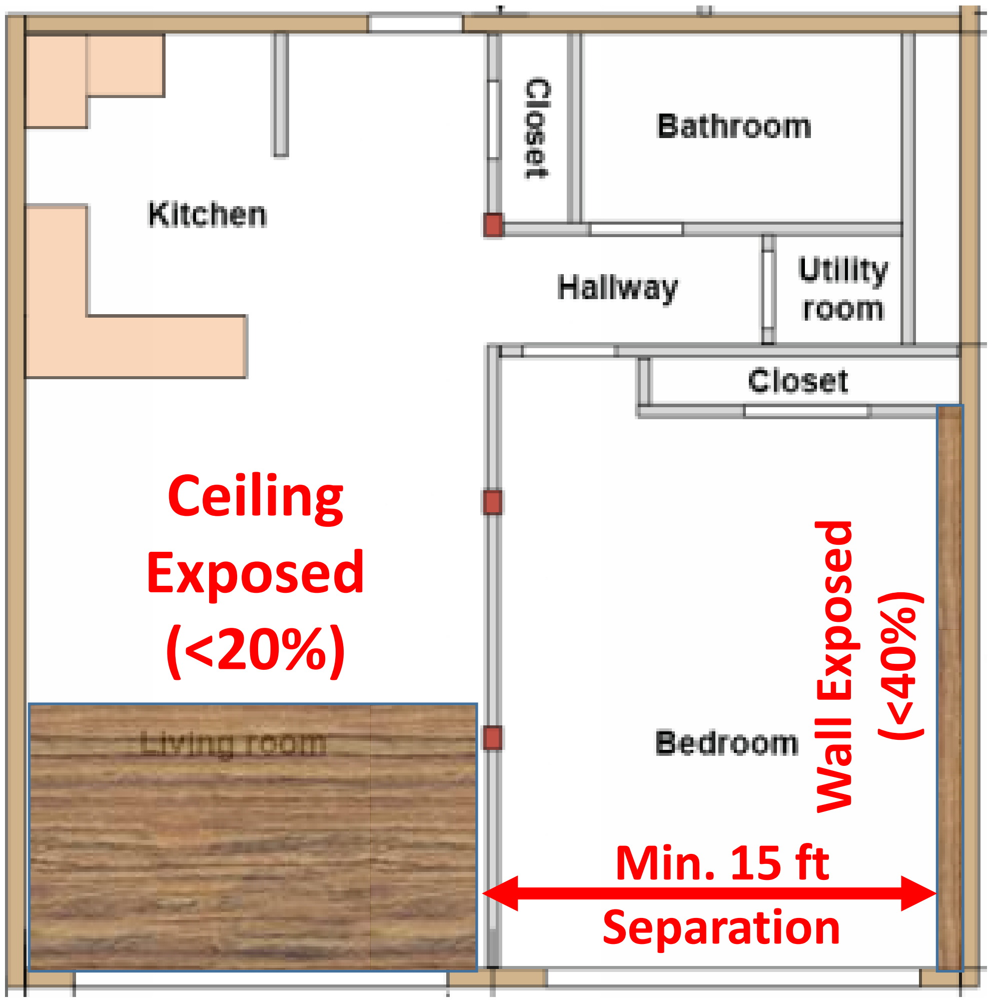
602.4.2.2.4 Separation distance between unprotected *mass timber* elements.

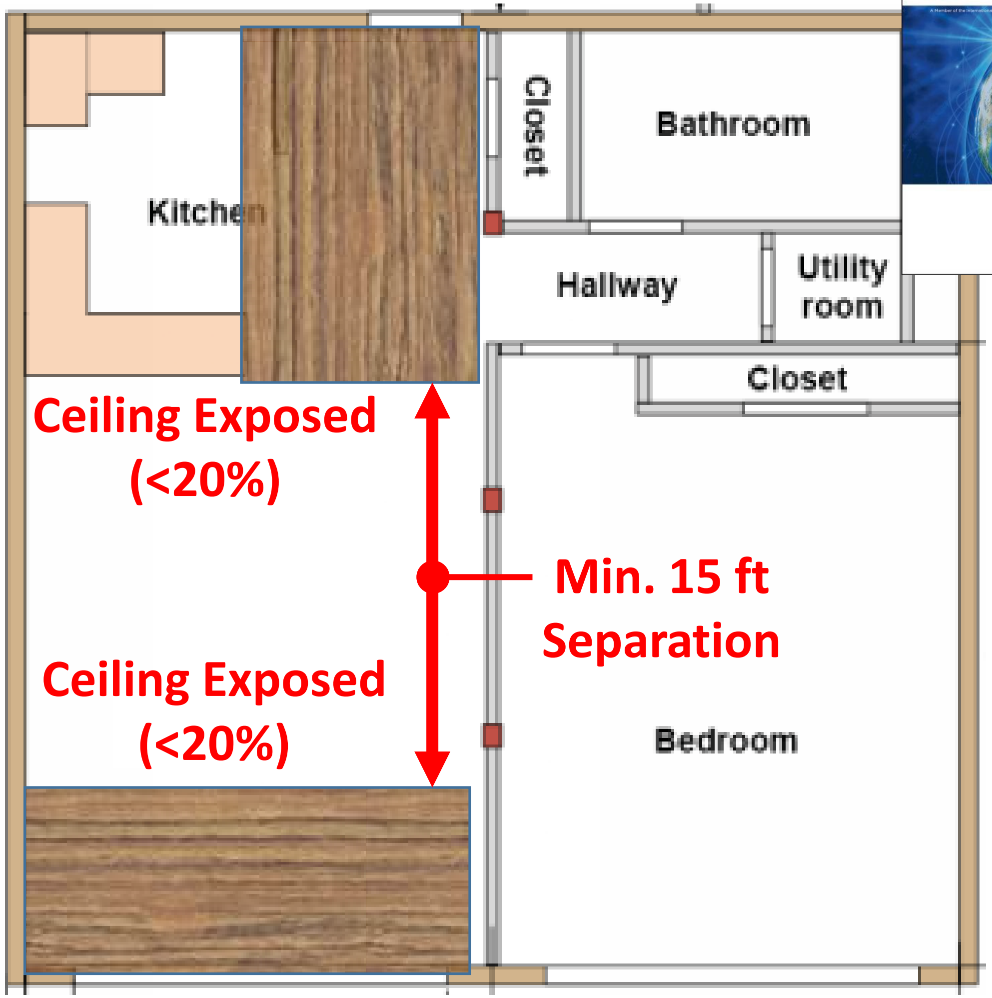
In each *dwelling unit* or *fire area*, unprotected portions of *mass timber* walls shall be not less than 15 feet (4572 mm) from unprotected portions of other walls measured horizontally along the floor.

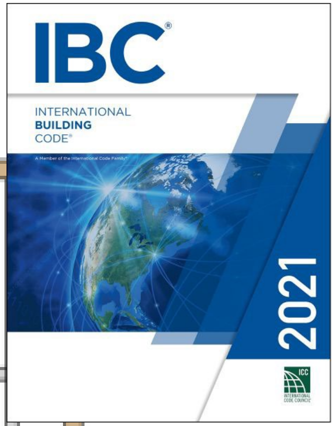
2024 IBC eliminates need for 15 ft separation between exposed walls and ceilings, and between portions of exposed ceilings

2019-2022: REFINING THE CODE ROADMAP

2021 IBC Allowances



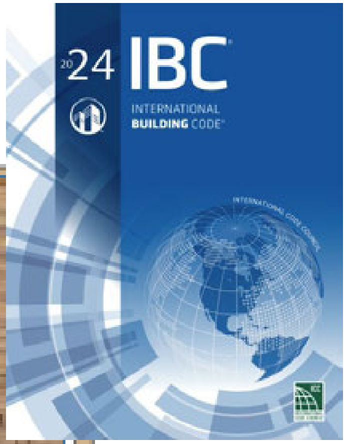


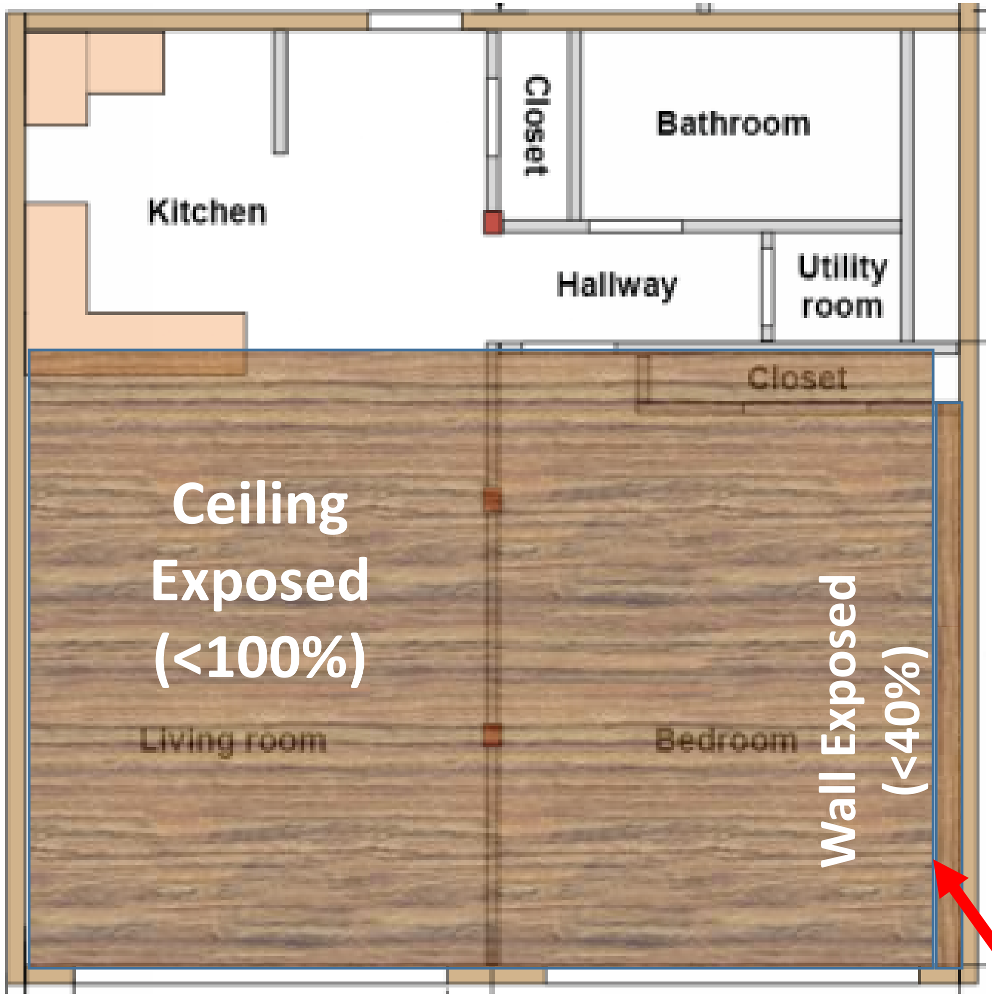


Credit: AWC

2019-2022: REFINING THE CODE ROADMAP

2024 IBC Allowances

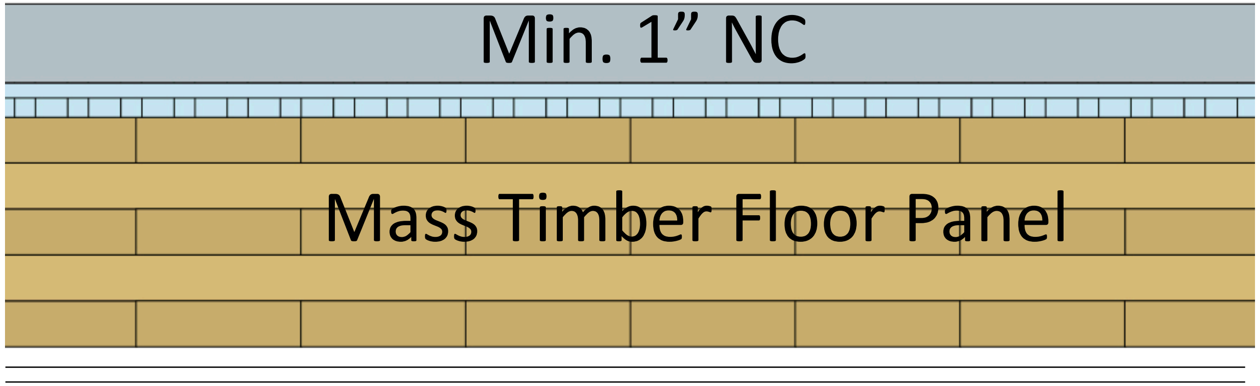




Credit: AWC

No separation req'd between wall & ceiling

2019-2022: REFINING THE CODE ROADMAP



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

2019-2022: REFINING THE CODE ROADMAP

Change to 2024 IBC: Sequencing of NC topping install

F174-21

IFC: 3303.5

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

2021 International Fire Code

Revise as follows:

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

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

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

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

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

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

Credit: ICC

2022 AND BEYOND: ADOPTING UPDATED CODES

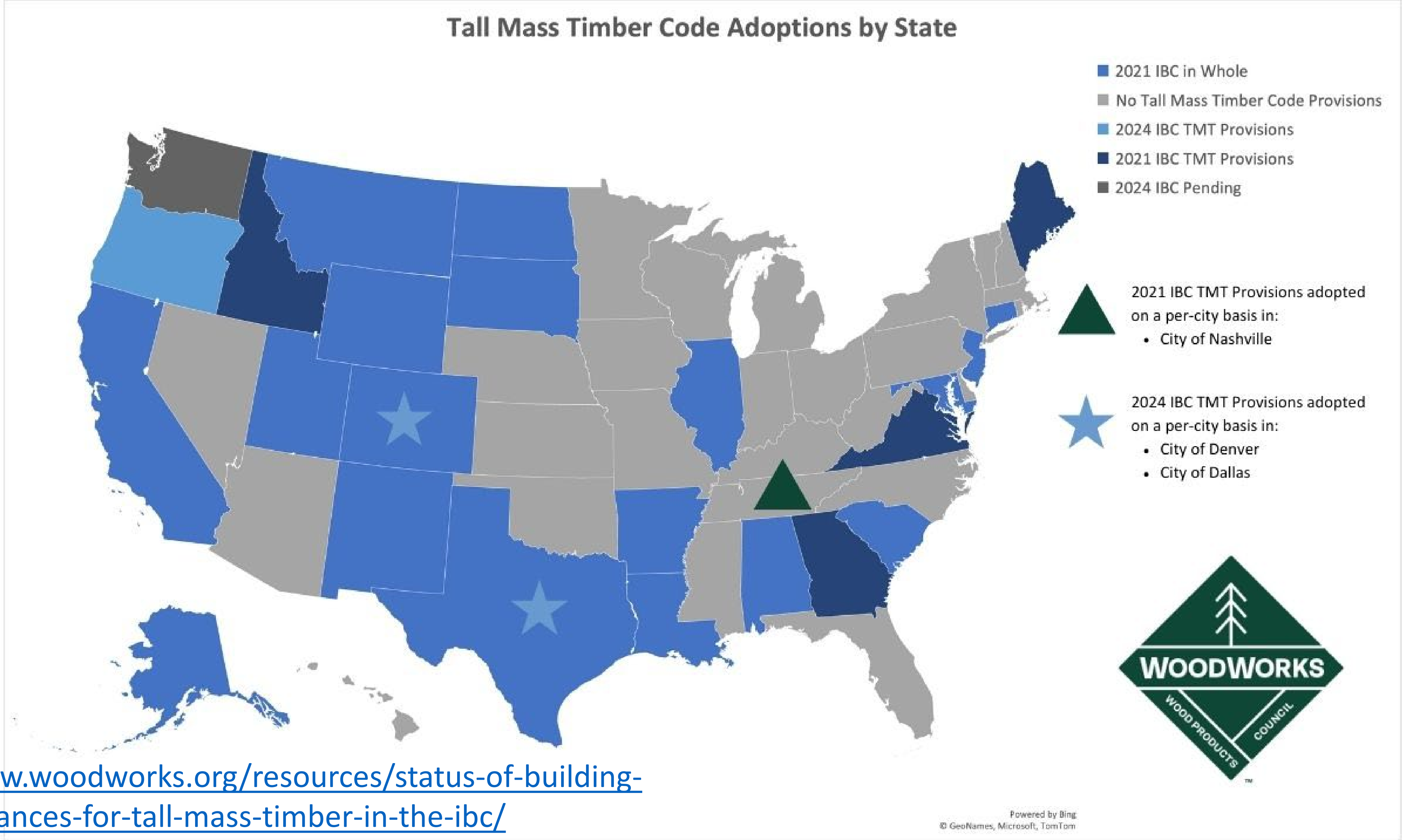
ORDINANCE NO. 32198

An ordinance amending Chapter 53, "Dallas Building Code," of the Dallas City Code by amending Sections 202, [F] 403.3.2, 406.5.2, 504.3, 504.4, 506.2.1, 506.2.3, 506.2.4, 507.3, 507.14,

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 100 percent of the floor area in any dwelling unit or fire area; or
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; or

Dallas
Denver
Oregon
Washington

TALL MASS TIMBER CODE ADOPTIONS



https://www.woodworks.org/resources/status-of-building-code-allowances-for-tall-mass-timber-in-the-ibc/

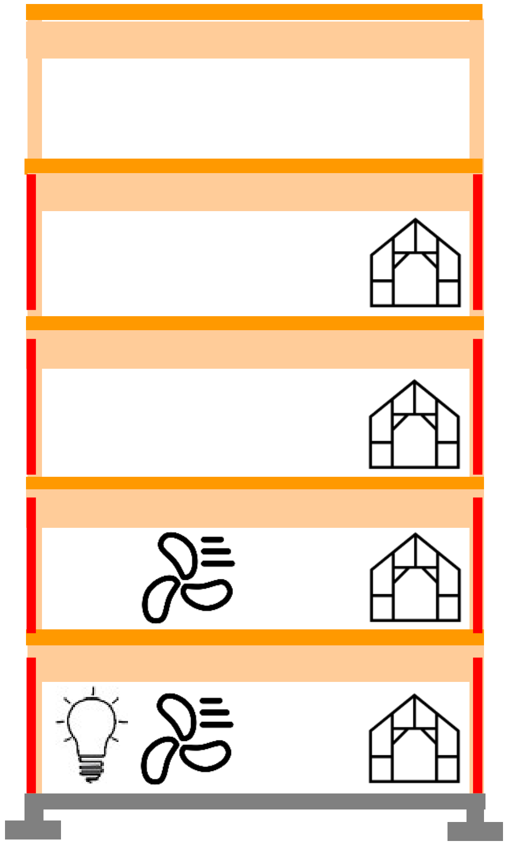
WHY ALL OF THE INTEREST?

Photo: WoodWorks
Architect/Developer: oWOW

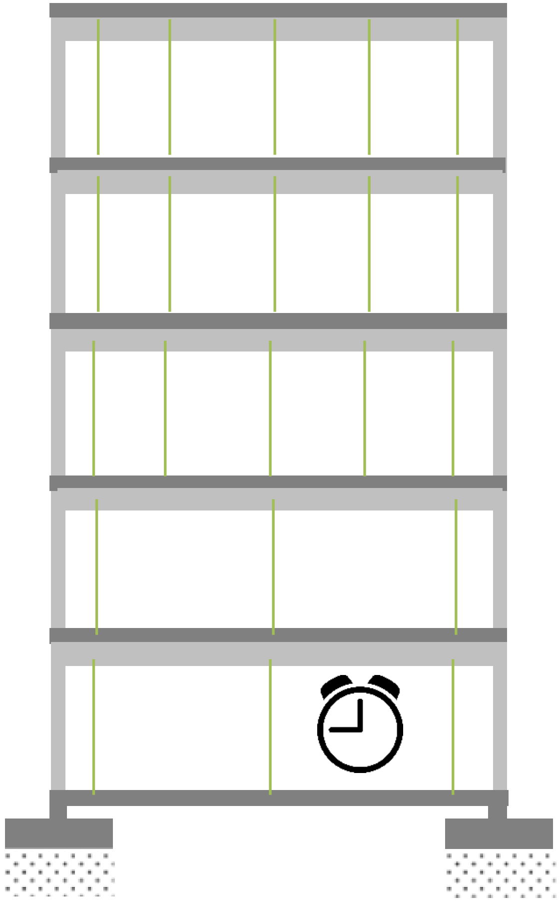
Mass Timber: Structural Warmth is a Value-Add

Schedule Savings for Rough-In Trades

Fast Construction



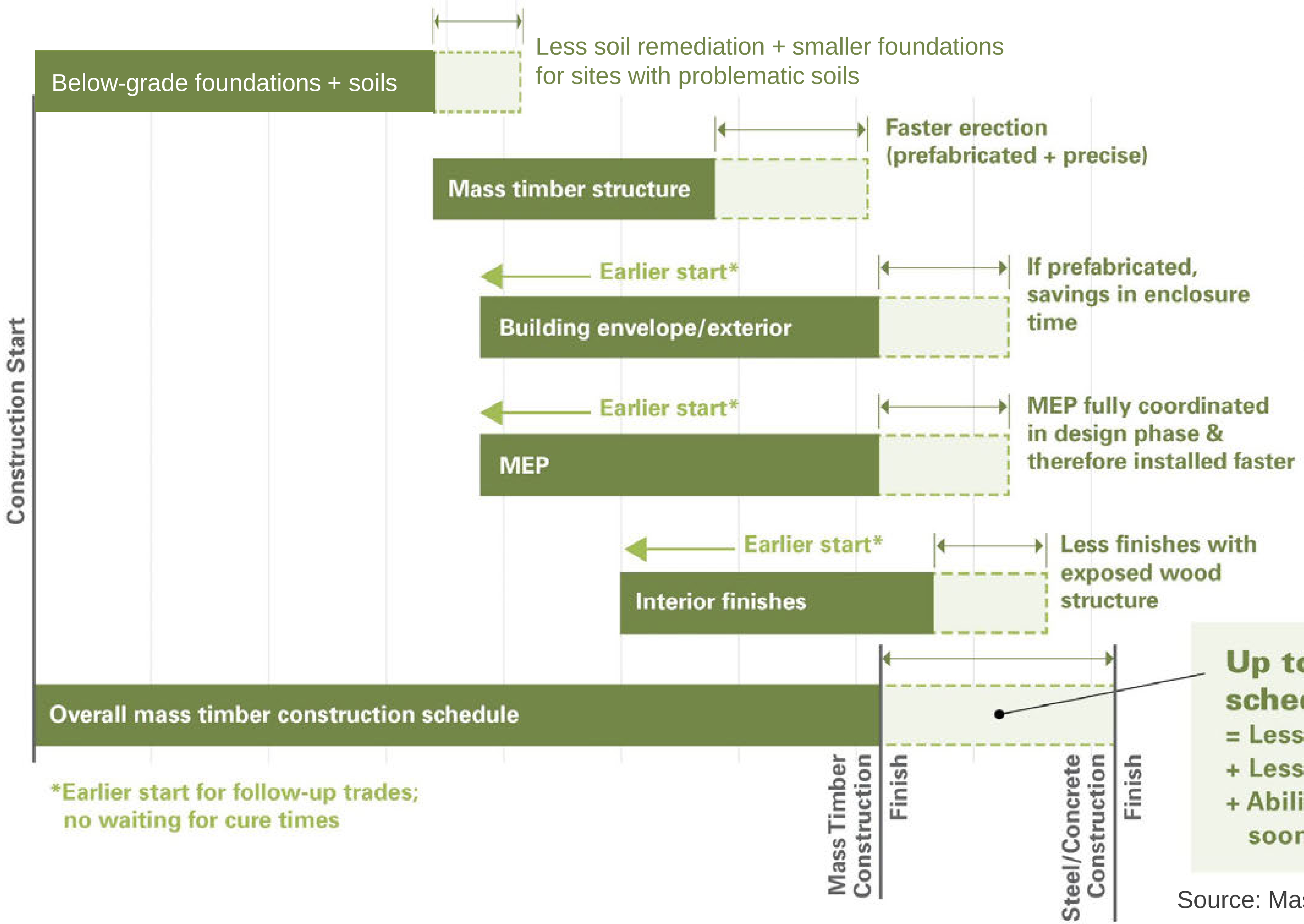
NO curing
(mass timber)



Curing & maze of
shores (concrete)

Compressing the Typical Schedule

Fast Construction



Look for these potential $$ schedule savings with mass timber in comparison to steel and concrete.

Up to 25% schedule savings
= Less carrying costs
+ Less GC overhead
+ Ability to lease/occupy sooner

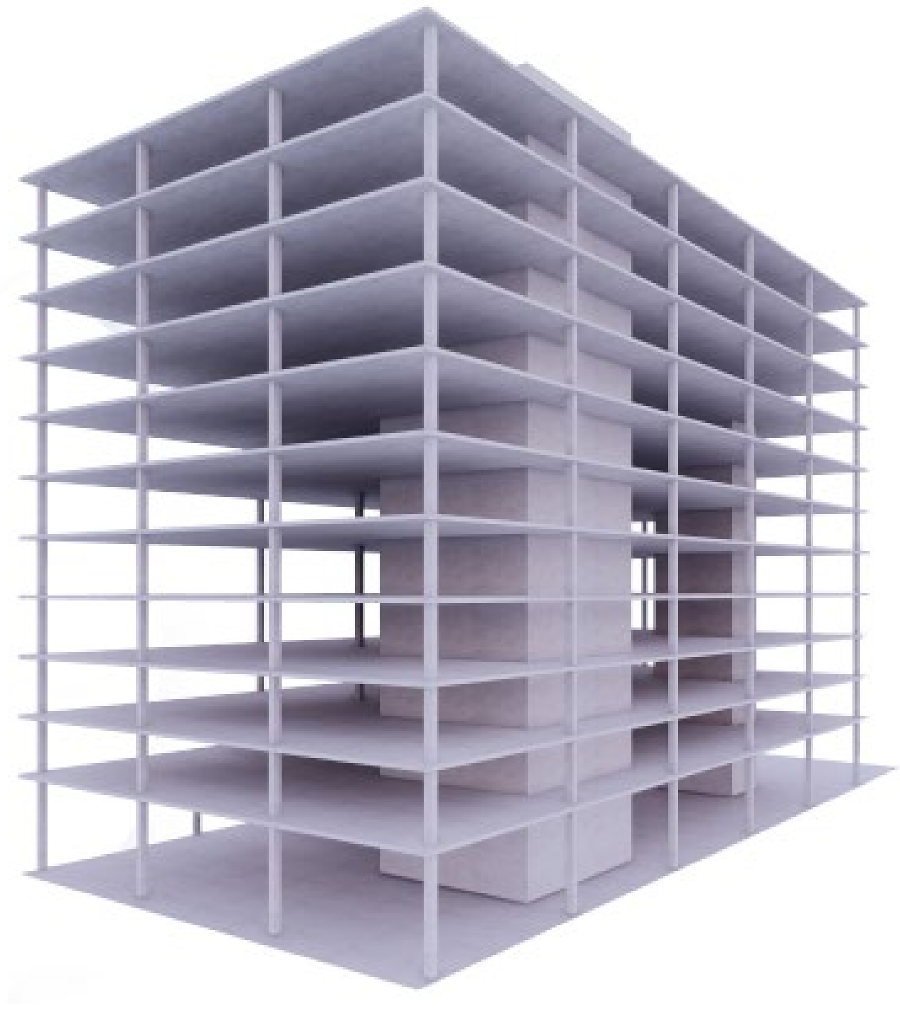
Source: Mass Timber Cost & Design Optimization, WoodWorks[2]

Construction Impacts: Labor Availability

Photo: Lendlease

But is it cost competitive?

Need to Consider Holistic Costs, Not Structure Only



$/SF

$/SF

Image: GBD Architects

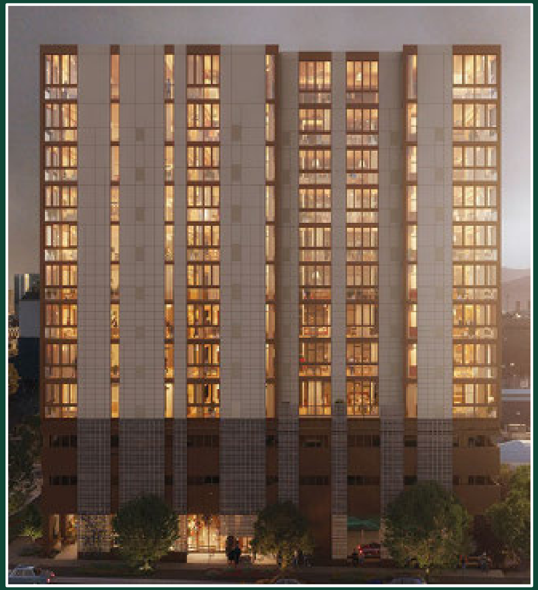
Risk Mitigation: Total Project Cost Analysis

CONSIDERATIONS:

- Ceiling Treatment
- Floor Topping
- HVAC System & Route
- Foundation Size
- Soil Improvements
- Exterior Skin Coordination
- Value of Time

Credit: Hacker Architects

Mass Timber Comparative Life Cycle Assessment Series

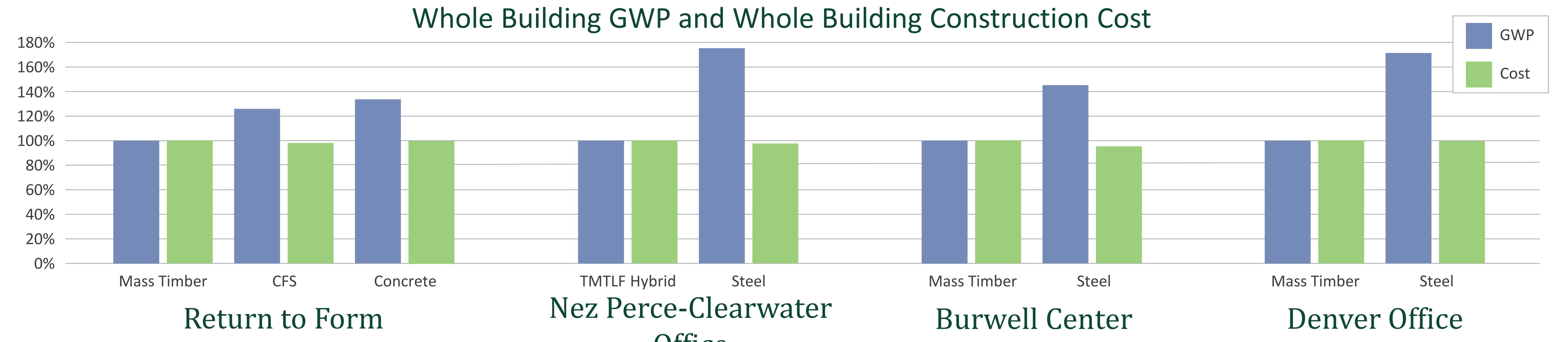


Rendering tres birds

Mosaic Architecture / Morrison-Maierle / Photo Heidi Long, Longview Studios

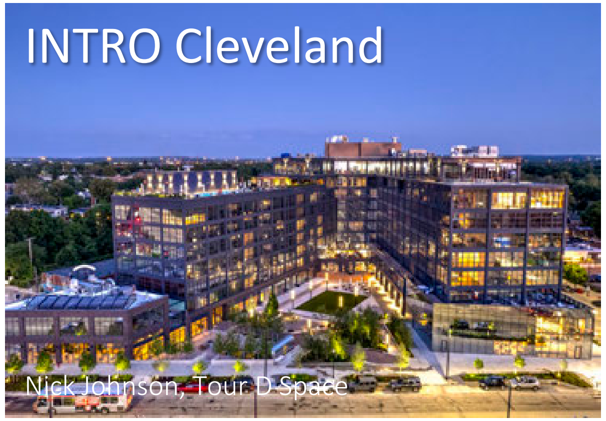
University of Denver Burwell Center for Career Achievement / Lake|Flato Architects / Shears Adkins Rockmore / KL&A Engineers and Builders / Photo © Frank Ooms

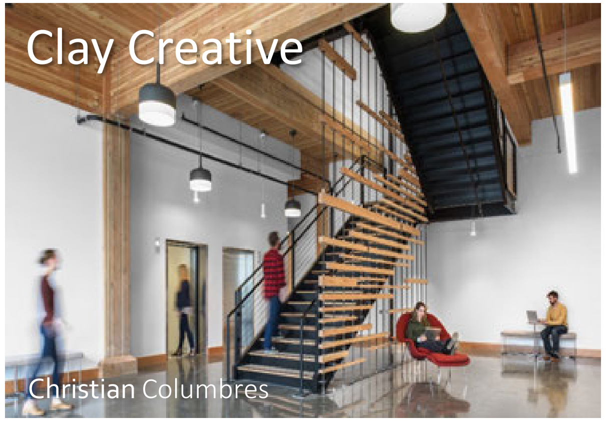
Rendering Shears Adkins Rockmore

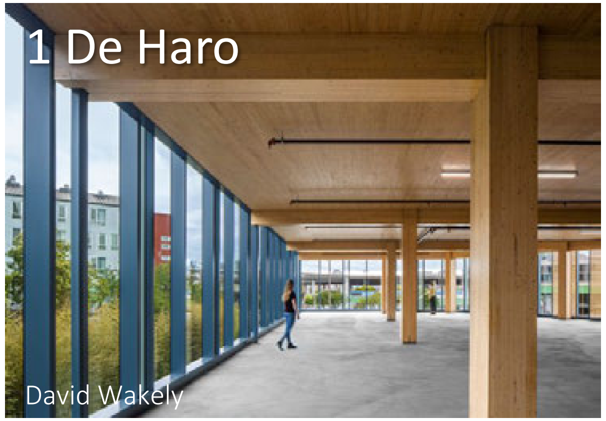


Source: https://www.woodworks.org/resources/mass-timber-comparative-lca-series/

Mass Timber Business Case Studies







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WOOD PRODUCTS COUNCIL

$ Costs + $ Returns
Challenges,
Lessons Learned, Successes

Scan code here to download the current package

INTRO, Cleveland

CLEVELAND, OH

Nick Johnson, Tour D Space

WOODWORKS™ WOOD PRODUCTS COUNCIL

Mass Timber Business Case Study

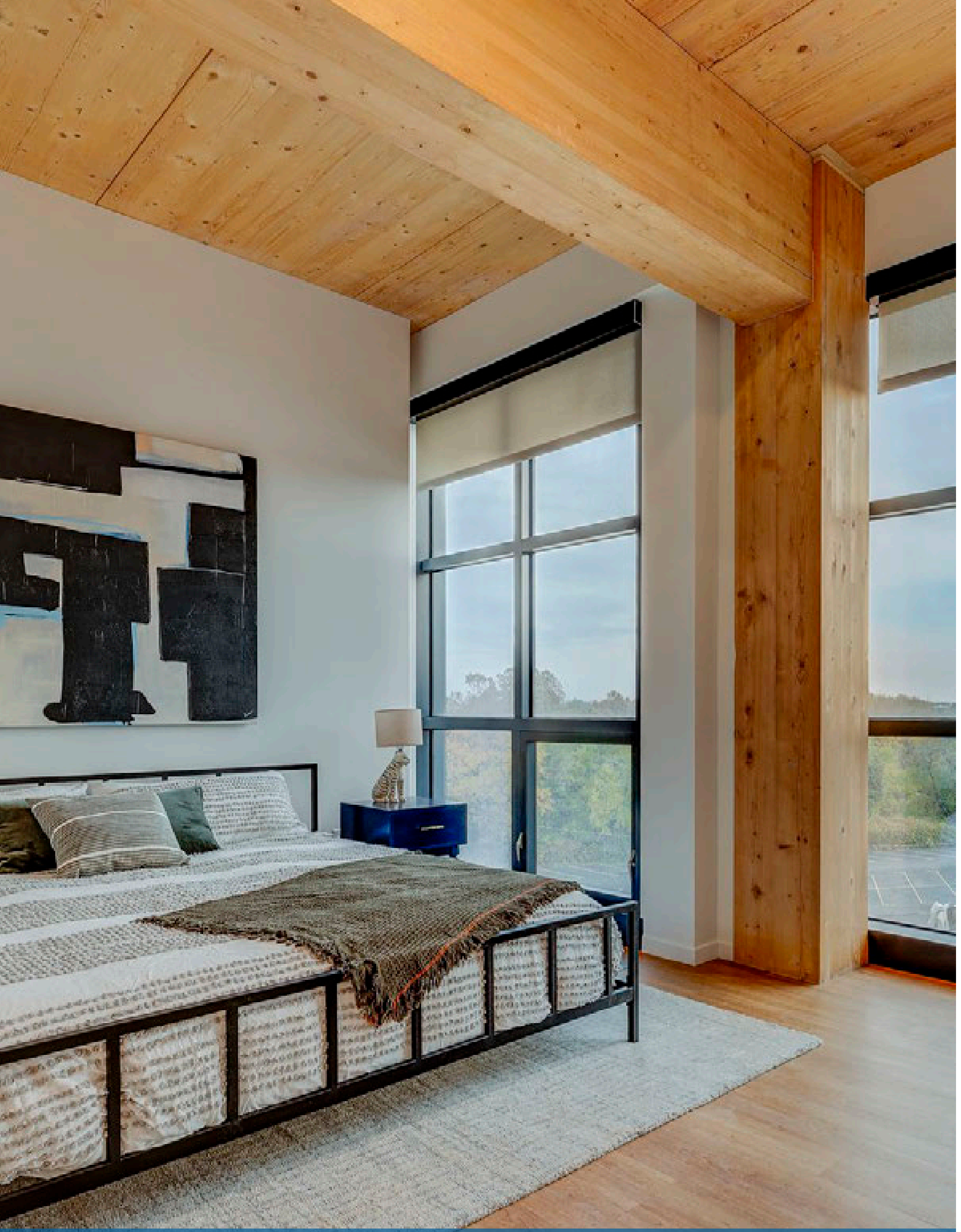


Photo Nick Johnson, Tour D Space

INTRO

Cleveland, OH

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

Development Overview

- 9-story, 115’ tall building
- 8 stories of CLT & glulam construction over a podium
- Strategy:
    - Create Cleveland's best, most distinctive urban living experience; a new level and bespoke brand
    - Combine best-in-city amenity package and contemporary interiors to appeal to health/ wellness & entertainment-focused young professionals

Property Information	
Property timing	Completed Feb 2022
Submarket	Cleveland’s Ohio City neighborhood
Construction Type	4-B over 1-A retail & parking
Site size	2.1 acres (FAR 5.5)
Gross building area	512,000 SF
Net rentable area (total)	279,000 SF

Nick Johnson, Tour D Space

Quantitative Overview

Costs			
Total project cost	$147,000,000		
	$494,950/ unit		
Land Cost	$10,450,000	@ appraised value	
	Market Standard*	**Pro Forma**	**Realized****
Construction costs	$212 / GSF	$200 / GSF	$215 / GSF

NOI

Apartment		Market	Realized	
Rental rates				
	Studio	$1,279	$1,500 -$1,750 (P.H. $2,000)	~26% higher
	1-BR	$1,631	$1,675 -$2,500 (P.H. $5,700)	~28% higher
	2-BR	$2,301	$2,500 -$5,200 (P.H. $7,800)	~67% higher
	3-BR	$3,334	$8,800 -$19,500 P.H.	~324% higher
Occupancy at stabilization		91%	98%	~7% higher

Parking Revenue	Market	Pro Forma	Realized**
Included or in addition to lease?	Additional	Additional	Additional
Rate	$175 / lot / month	$185 -$200 / lot / month	$225 -$375 / lot / month

Retail	Market	Pro Forma	Realized**
Retail rental rates	$30 -$40 / RSF/YR	$45 / RSF/YR	$45 / RSF/YR
Rent type (e.g., NNN)	NNN & Gross	NNN	NNN
Expenses	$7 -$10 / RSF/YR	$8 / RSF/YR	$8 / RSF/YR
Tenant improvement allowance	$40 -$50 / RSF	$150 / RSF	$150 / RSF
Occupancy after 12 months	60% -70%	90%	75%

**Market standard costs refer to normal cost to build for subject's use, irrespective of structural approach.*
***Realized metrics at stabilization*
****Conversations with local building officials were held concurrent to land use entitlement approvals processes such that the overall building code review process was only slightly longer. This concurrent approach was essential given that Ohio was not adopting the 2021 IBC, so the Type 4 code path was performance-based, albeit a mirror of what other states have adopted.*

Return Performance

	Market	Pro Forma	Realized**	
Yield on cost – untrended	6.25%	7.00%	7.35%	Higher
Cap rate	4.75%	4.50%	TBD	
Value/rentable SF	$550 / RSF	$717 / RSF	TBD ($800+ / RSF)	Higher
Leverage	65%	65%	N/A	

Timeline

	Date	Context/Comment
Date of conception (first dollar spent)	Mid 2018	Mid-cycle
Date underwriting finalized (go/no-go decision)	Mid 2019	Mid-cycle
Date equity capital secured	N/A	Developer is equity
Permitting duration***	3 + 6 mo.	Demolition permit first, then building permit
GMP in place	Feb/March 2020	COVID
Construction start	April 2020	
Duration of construction	24 months	Faster by about 2 months
Construction completed	April 2022	Early-cycle
Date stabilized (80% occupancy, NOI, or at pro forma or refinanced)	June 2022	Faster

Project Context

Unparalleled leasing velocities at significant premiums

- The project was 90% leased 4 months after completion
- The premium product drives both velocity and rates with rents significantly higher than market counterparts
- Leasing velocity allowed refinancing activities to start 3 months after completion

Unparalleled leasing velocities at significant premiums

Exceptional Leasing Velocity and Premiums

Lessons Learned
- **Schedule Savings:** Anticipated schedule savings not fully achieved - subcontractors had not shifted approaches
- **Critical paths:** Exterior cladding system required multiple subcontractors & erection did not keep up w/ speed of timber structure; faster (unitized) skin would be better

Challenges
- **International shipping**: Issues during COVID delayed delivery; assurances compromised by lowest cost bid
- **Moisture Protection:** Laborious repairs required due to insufficient water management

Successes
- **Fast lease-up**: 60% pre-leased & stabilized after 4 months
- **Premiums**: Achieved rent premiums in market

Nick Johnson, Tour D Space

Quantitative Overview

Costs			
Total project cost	$130,000,000		
	$501,930/ unit		
Land	$6,250,000	@ appraised value	
	Market Standard*	**Pro Forma****	**Realized*****
Construction costs (normalized wo/COVID)	$200 / GSF	$190 / GSF	$190 / GSF****

NOI			
Apartment	**Market**	**Realized*****	
Rental rates			
1-BR	$1,850	$2,046	~11%% higher
2-BR	$3,500	$3,956	~13% higher
3-BR	$5,500	$8,551	~55% higher
Occupancy at stabilization	95%	54%	Property still in lease up
Parking Revenue	**Market**	**Pro Forma****	**Realized*****
In addition to lease	$175	$185	$175

Retail	Market	Pro Forma**	Realized***
Retail rental rates	$25 / RSF/YR	$21 / RSF/YR	$TBD/ COVID
Rent type (e.g., NNN)	Modified Gross	NNN	TBD
Tenant improvement allowance	Varies	$86 / SF	$TBD / SF
Occupancy after 12 months	Varies	100%	TBD%

Market rental rates for apartments sourced from a CoStar report dated September 2022

**Market standard costs refer to normal cost to build for subject's use, irrespective of structural approach*
***Pro forma dated early 2020*
****Realized metrics as of October 2022*
*****Average unit size is larger than the market contributing to lower cost per square foot. Mass timber was a slight premium. A longer iterative design process proved beneficial in maximizing efficiencies, thereby driving down costs to make mass timber competitive.*

Return Performance	Market	Pro Forma**	Realized***
Yield on cost – untrended	6.00%	5.85%	TBD / on track
Cap rate (mkt vs. appraisal subject conclusion)	5.00%	4.70%	TBD
Value per unit	$500,000	$594,000	TBD / on track
Leverage	65%	70%	50%
Mezzanine leverage	15%	15%	20%

Timeline	Date	Context/Comment
Date of conception (first dollar spent)	April 2018	Mid cycle
Date underwriting finalized (go/no-go decision)	May 2020	Mid cycle
Date equity capital secured	June 2020	Late cycle
Permitting duration	6 months	Longer (started early & ran concurrent w/design)
GMP in place	July 2020	
Construction start	Aug 2020	
Duration of construction (anticipated without delays)	22 months	Faster (by 4 months)
Duration of construction (realized w/ delays)	24 months	Delays due to COVID + Suez Canal obstruction
Construction completed	Aug 2022	Two phases of completion: July 15 & Aug 31
Date stabilized (80% occupancy, NOI, or at pro forma or refinanced)	TBD	Projected June 2023

Project Context

Economic case made by demand

- Lease up velocity averaging 20 units/month is better than the market's typical average of 14 units/month (per the appraisal) and better than the pro forma expectations
- Superior luxury product with minimal comps in Milwaukee market

Above-market absorption


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

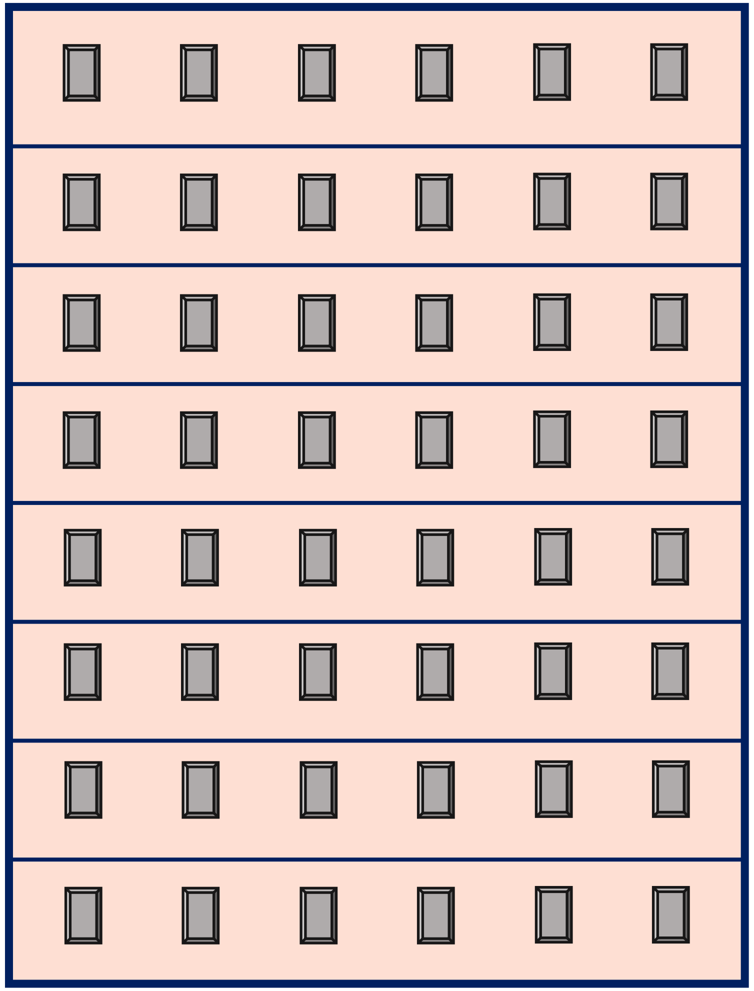
Example R-2, Type IV-C Building

8 Stories
85 ft

76,875 SF
max per floor

230,625 SF
bldg.

(areas noted
assume no frontage
increase)



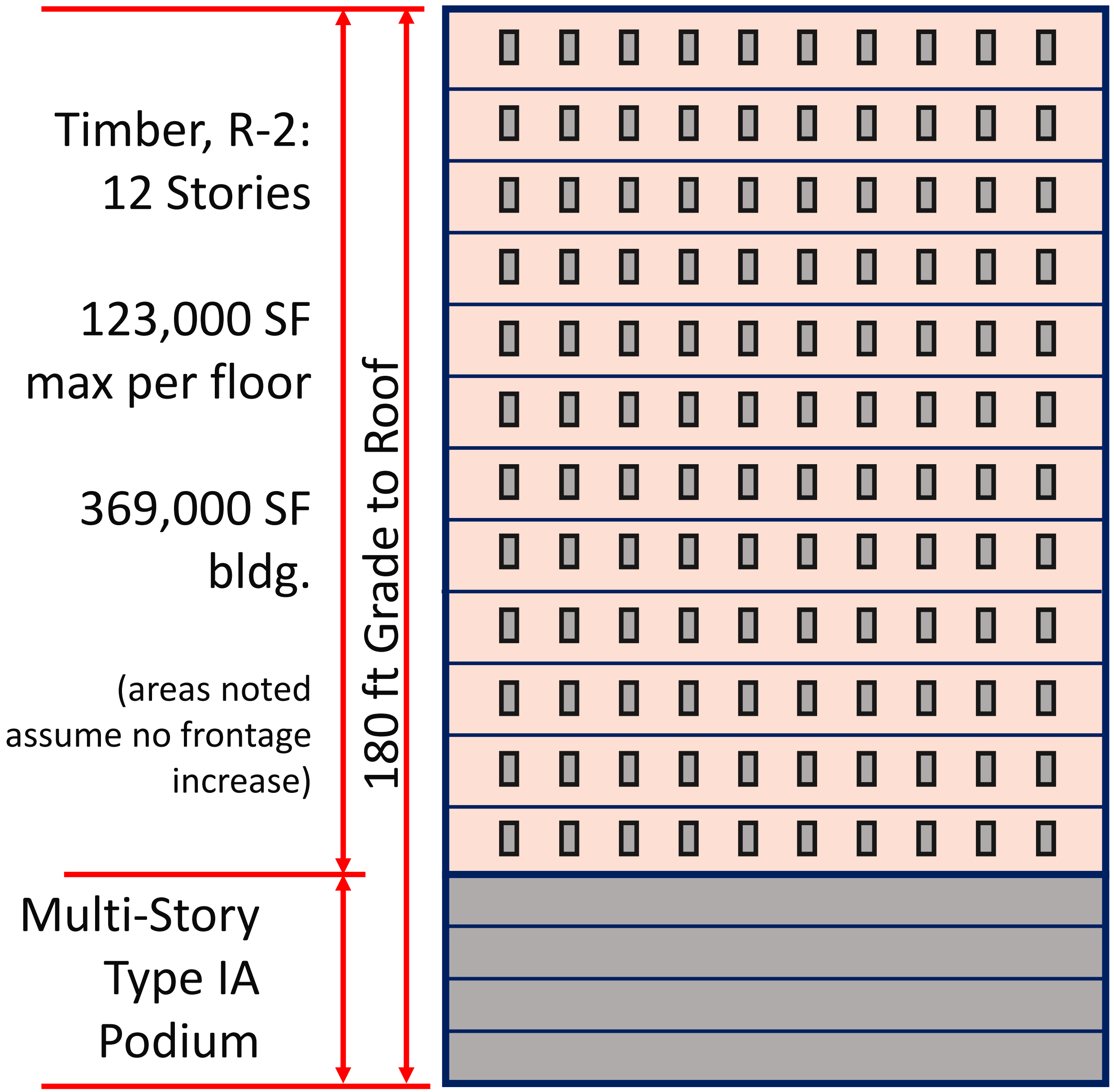
Not Likely to Utilize Podium Due to Overall Building Height Limit (85 ft) Relative to # of Timber Stories (8)

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

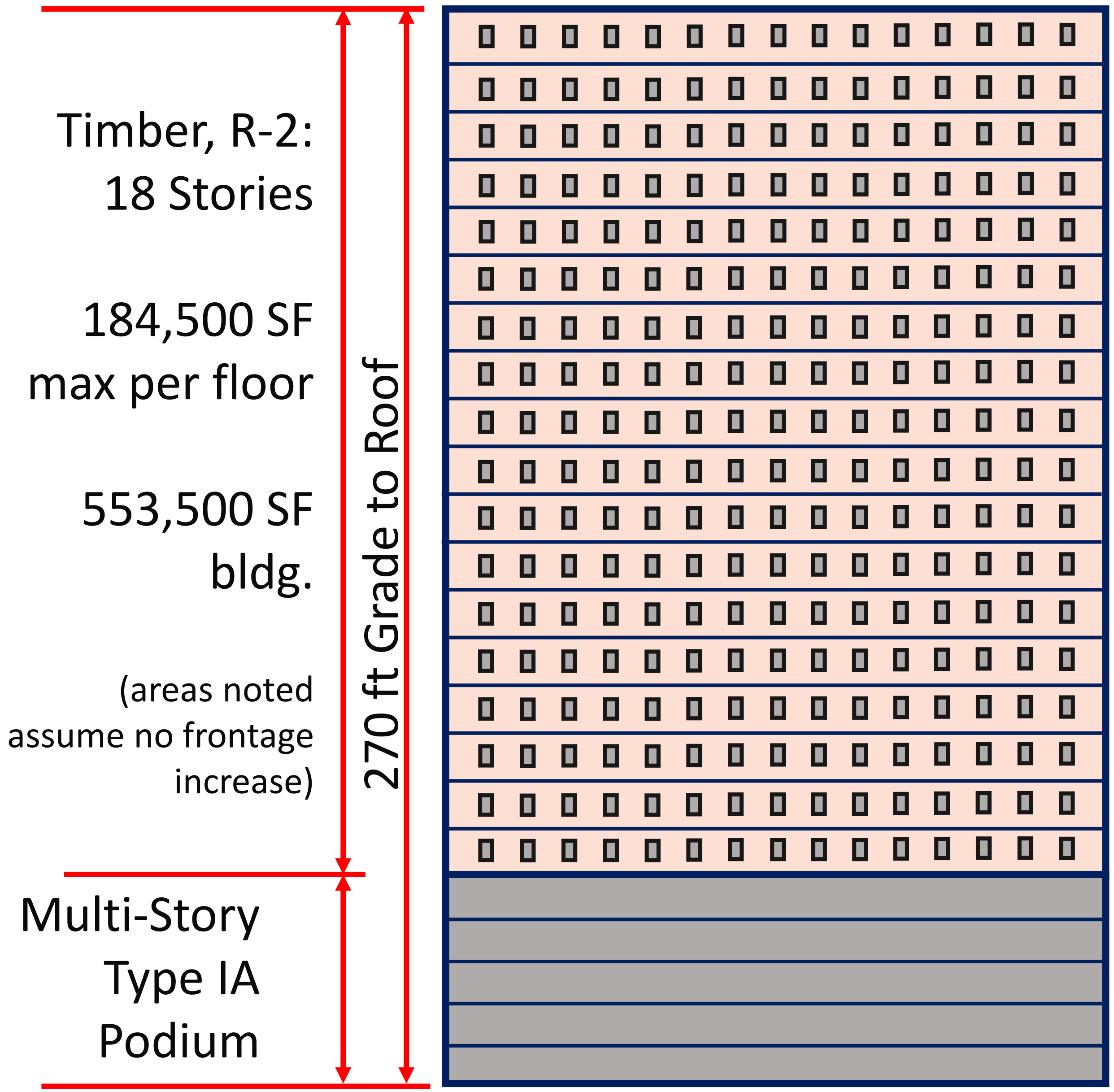
Likely to Utilize Podium Due to Overall Building Height Limit (180 ft) Relative to # of Timber Stories (12)

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

2022 AND BEYOND: PROJECTS RISING

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

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

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

WN PROFILE

MINNESOTA PLACES

PORTLAND, OR

Wright Architecture

8 stories total

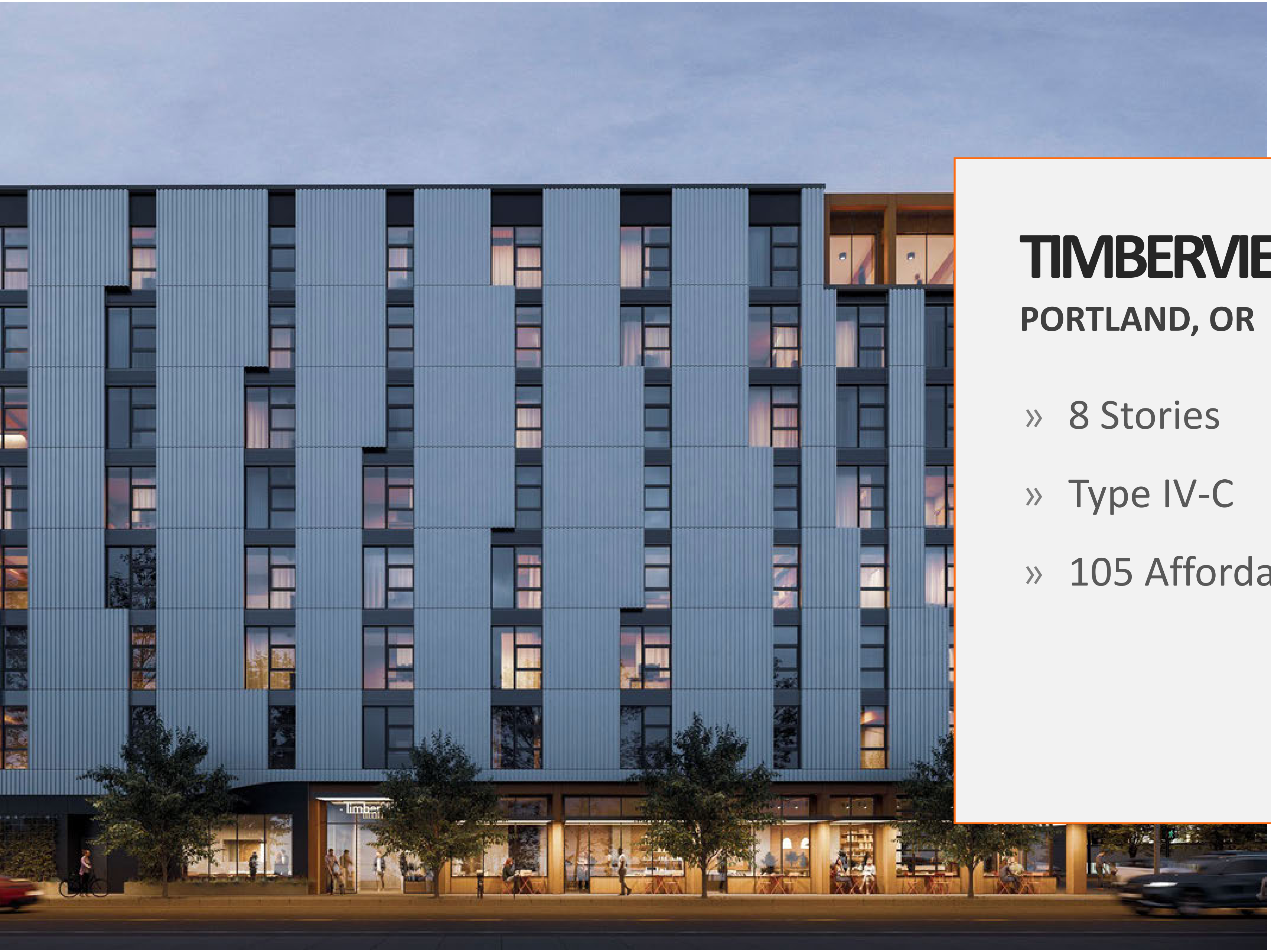
7 stories of mass timber

Type IV-C

72 Affordable Housing Units

54,000 sqft


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

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

W|N PROFILE

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

Ascent

Milwaukee, WI

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

Ascent

Milwaukee, WI

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

Type IV-HT with code modifications

Multi-Family

Completed 2022

WN PROFILE

BUSINESS CASE STUDY

WOOD DESIGN AWARD WINNER

Korb + Associates Architects
Thronton Tomasetti
Photo: VRX Media Group

Outline

- Tall Wood Introduction
- Lateral Systems in Tall Wood
- Connections in Tall Wood
- Penetrations in Tall Wood
- Sealants at Mass Timber Panel Edges
- Joints and Intersecting Elements
- Fire Safety During Construction
- Acoustical Design

INTRO – Cleveland, OH

Concrete Core Shear Walls

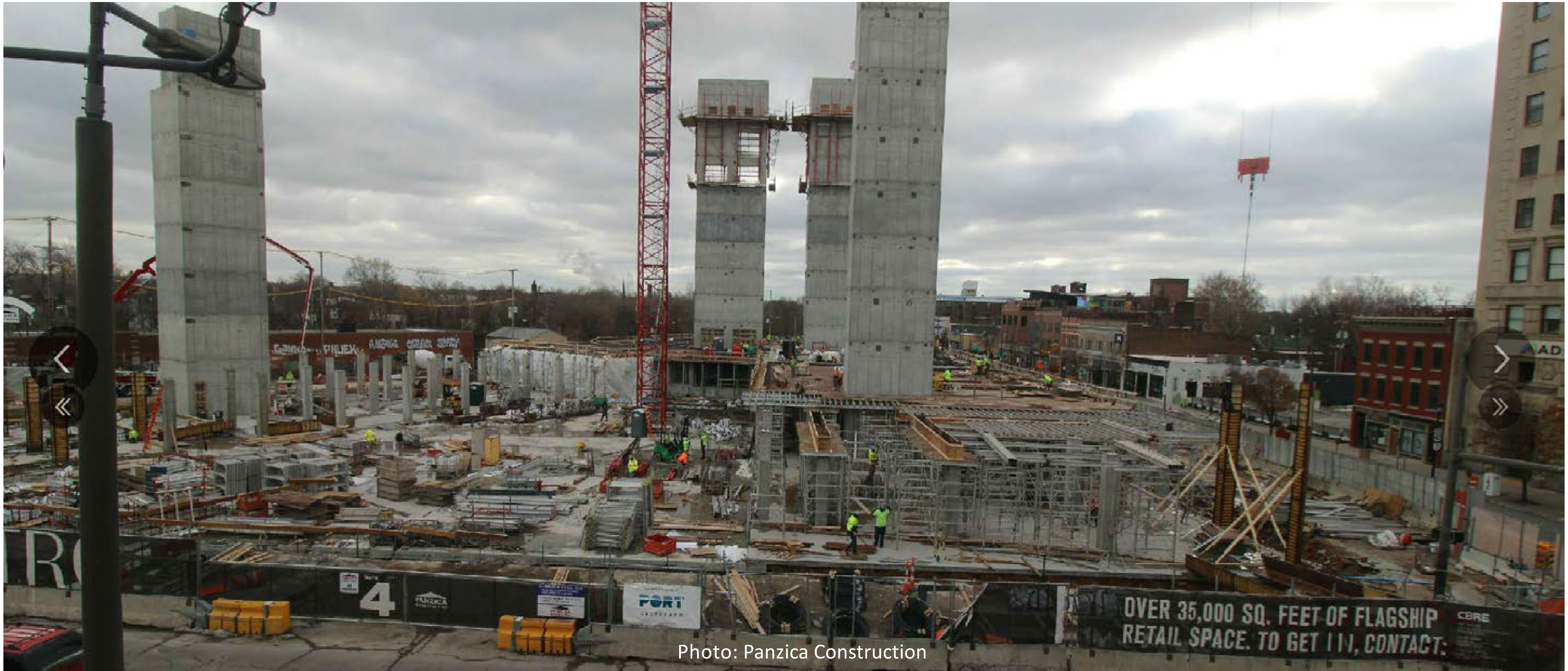
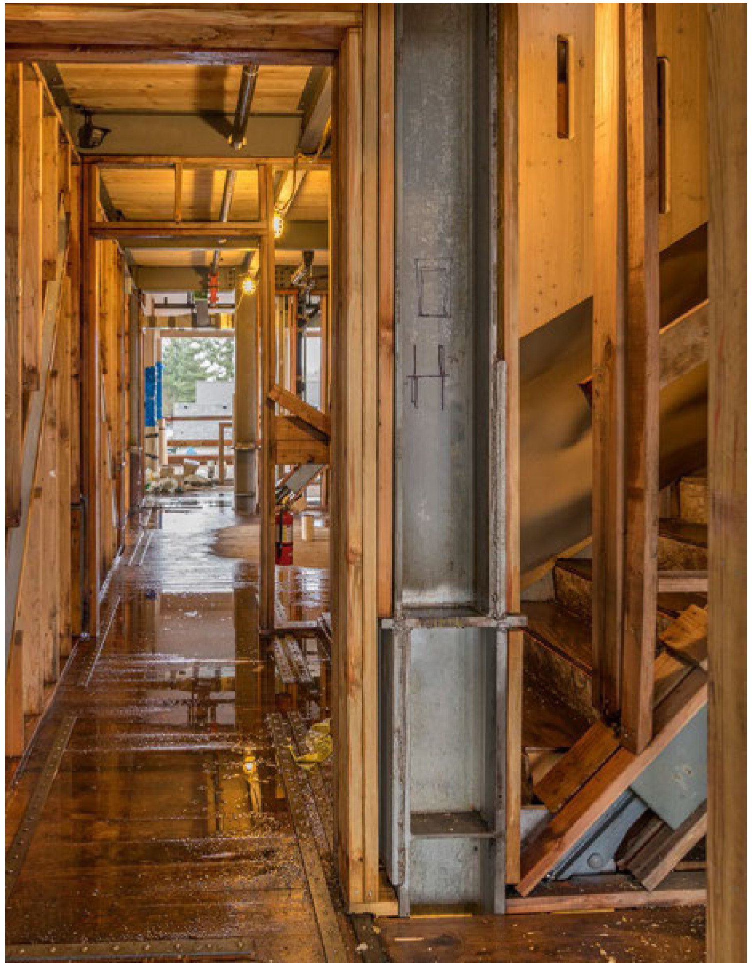


Photo: Panzica Construction

Carbon12 – Portland, OR

Buckling-Restrained Braced Frame

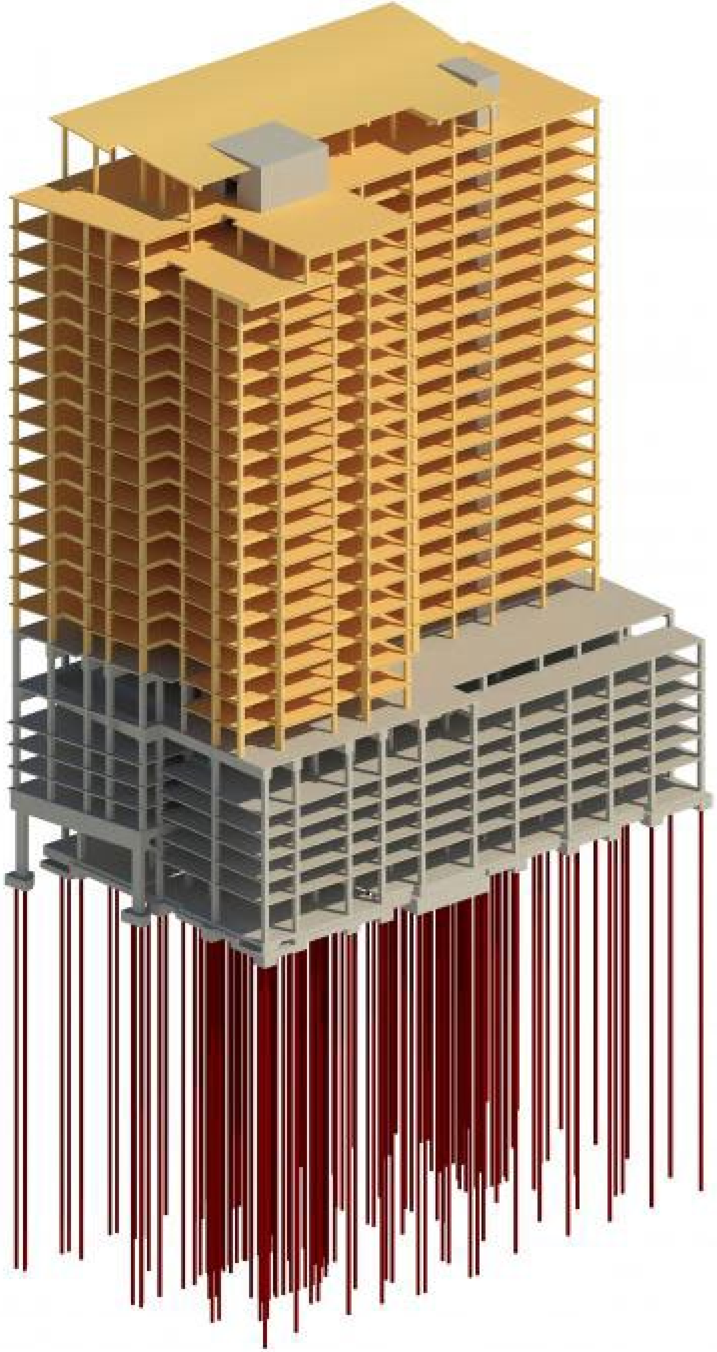


Photos: Marcus Kauffmann, ODF

Ascent – Milwaukee, WI

Concrete Core Shear Walls

Photos: Korb + Associates, Thornton Tomasetti



Brock Commons – Vancouver, BC

Concrete Core Shear Walls

Photos: Acton Ostry Architects

Future Potential Lateral System for Tall Wood

Mass Timber Rocking Shear Walls

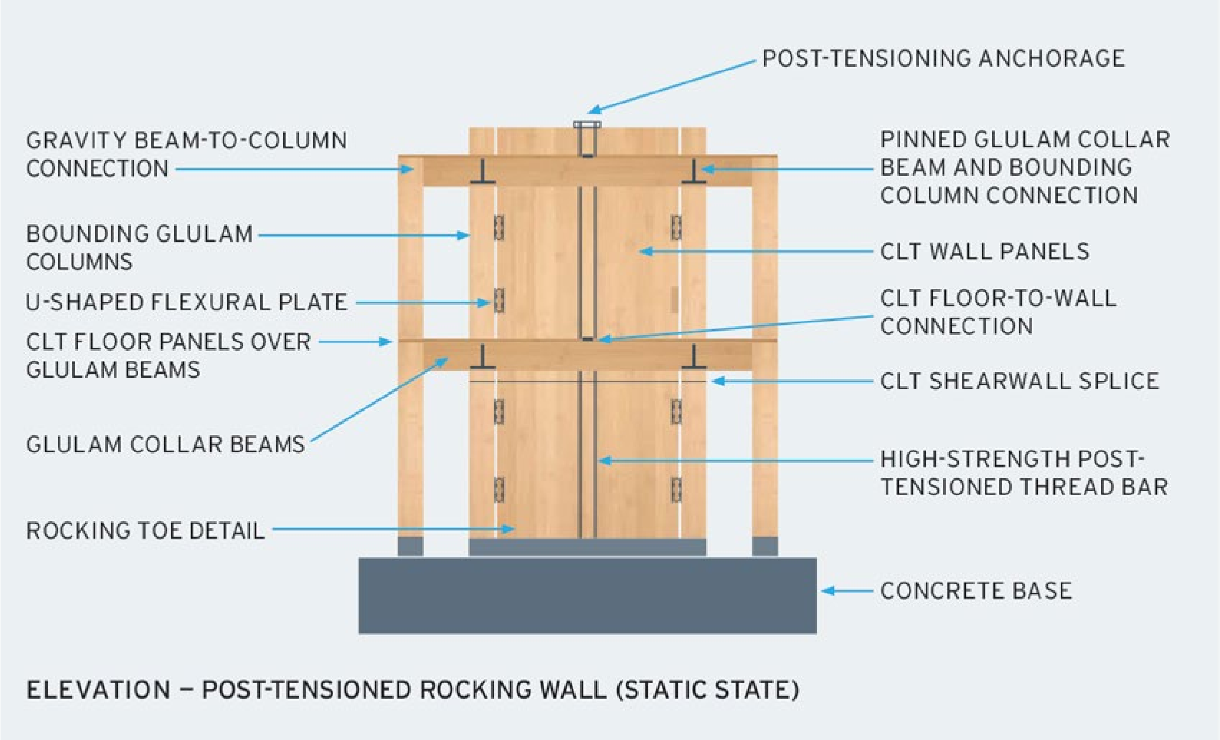


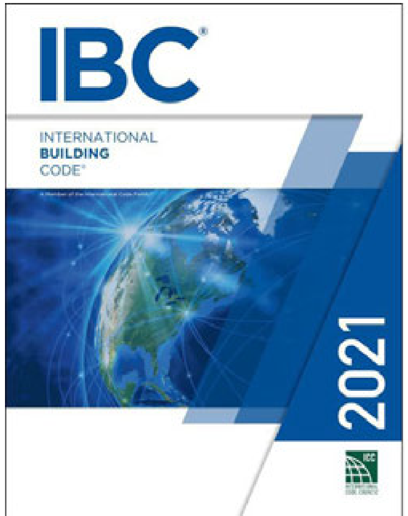
Image: KPFF

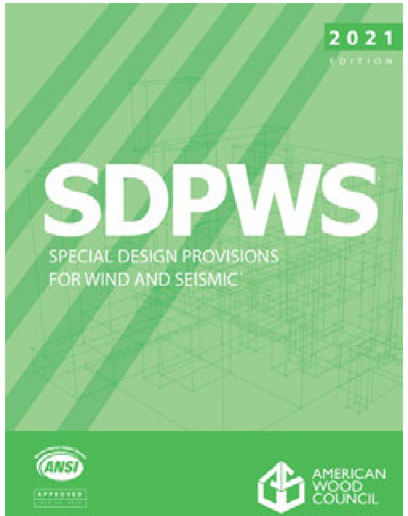
Considerations for Lateral Systems

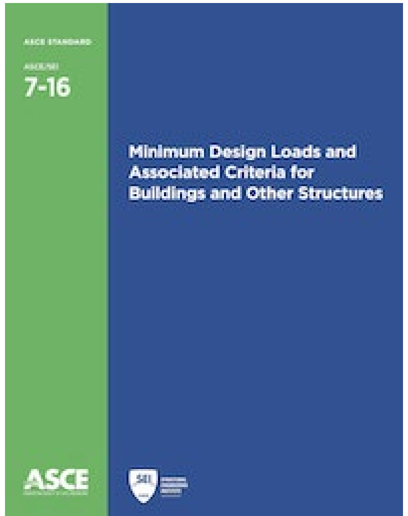
<u>Prescriptive Code Compliance</u>

Concrete Shear Walls	✓
Steel Braced Frames	✓
CLT Shear Walls (65 ft max)	✓
CLT Rocking Walls	✗

2021 SDPWS
ASCE 7-22



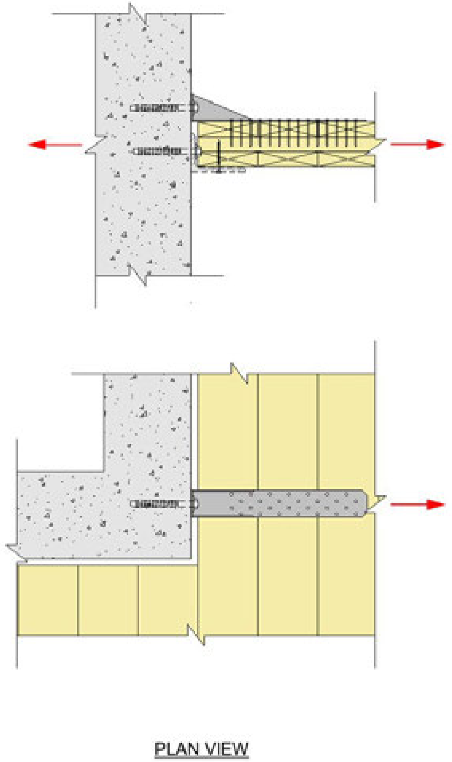


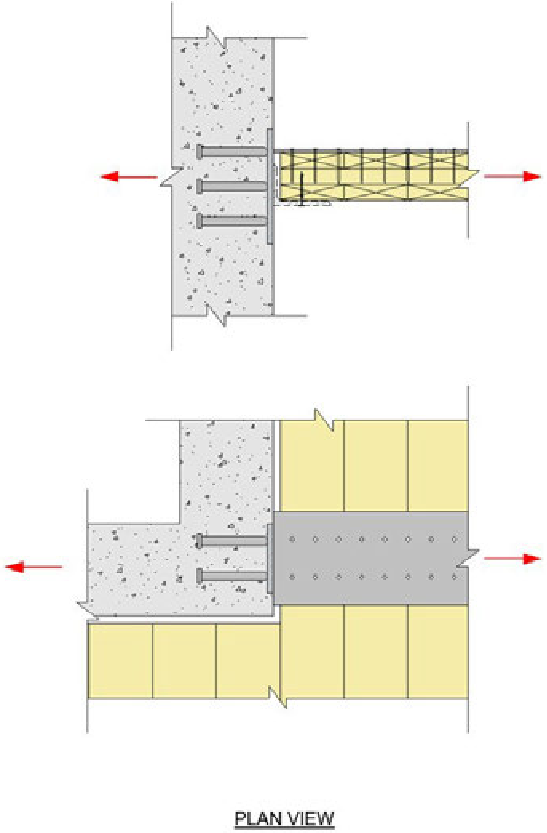


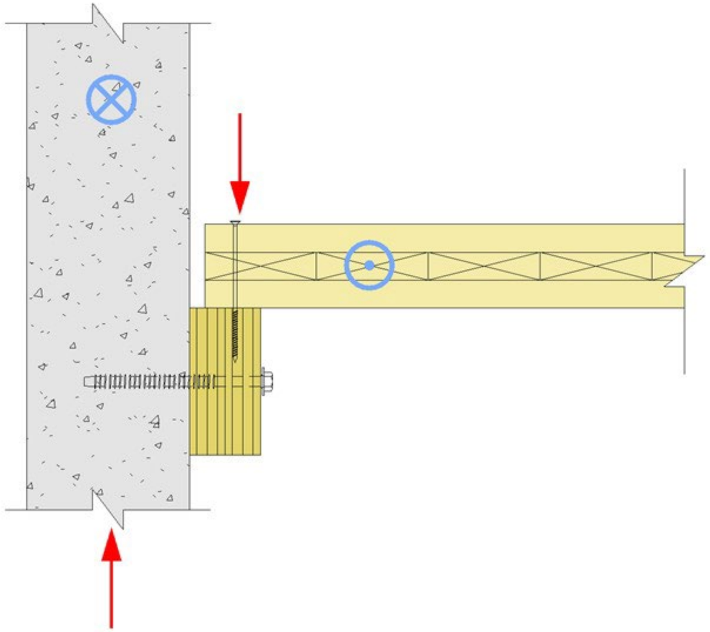
Considerations for Lateral Systems

Connections to concrete core

- » Tolerances & adjustability
- » Drag/collector forces







Considerations for Lateral Systems

Connections to steel frame

» Tolerances & adjustability

» Ease of installation

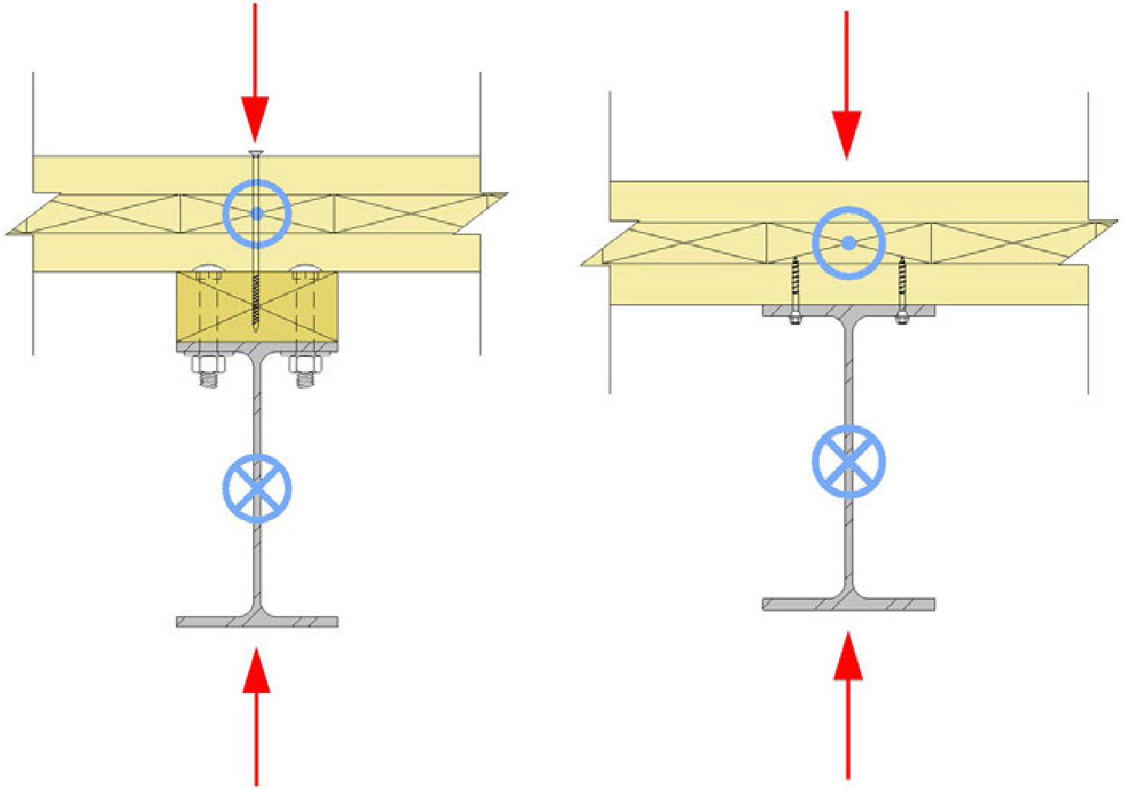



Photo: Marcus Kauffmann, ODF

Shaft Enclosures in Tall Timber

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

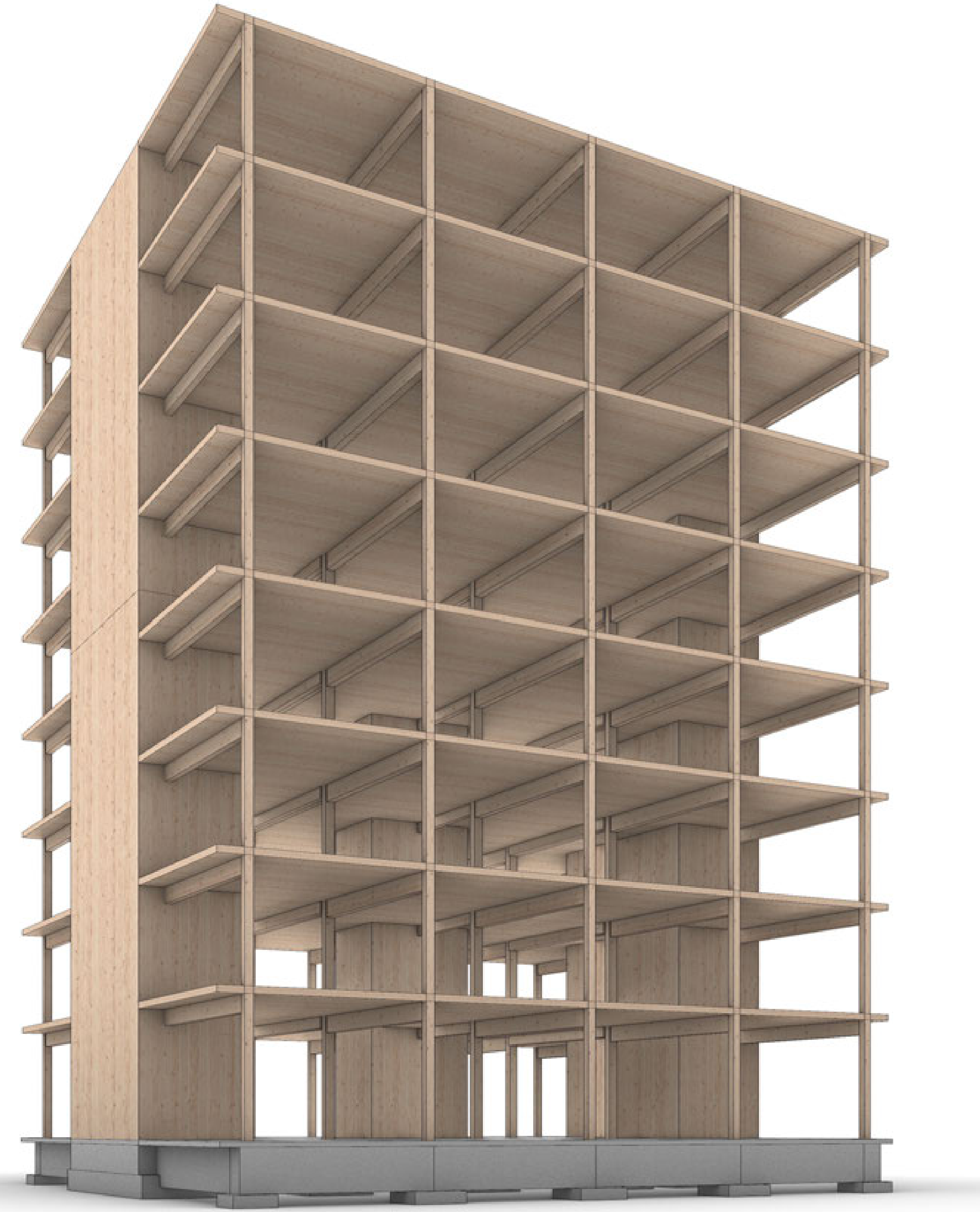


Image: Generate Architecture and Technologies + MIT – John Klein

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) 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
E&H Enclosures FRR	2 HR (not less than FRR of floor assembly penetrated, IBC 713.4)		

Shaft Enclosure Design in Tall Timber

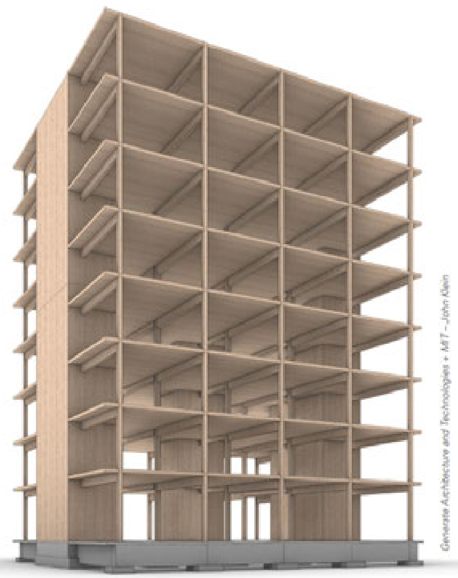
WoodWorks™
WOOD PRODUCTS COUNCIL

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 construction can be found in both the shaft enclosures section (713.3) and fire barriers section (707.2) of the code. These sections state that fire barriers can be constructed of any material permitted by the building's type of construction. One of the baseline requirements for tall wood structures utilizing construction Types IV-A, IV-B, or IV-C is that they be constructed of either mass timber or noncombustible materials (or a combination thereof).

A relatively new category of wood products, mass timber can encompass well known and widely used products such as glued-laminated timber (glulam) and nail-laminated timber (NLT), as well as newer panelized products such as cross-laminated timber (CLT). The definition of mass timber adopted for the 2021 IBC is:

> *Structural elements of Type IV construction primarily of solid, built-up, panelized or engineered wood products*

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- Joints and Intersecting Elements
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- Acoustical Design

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

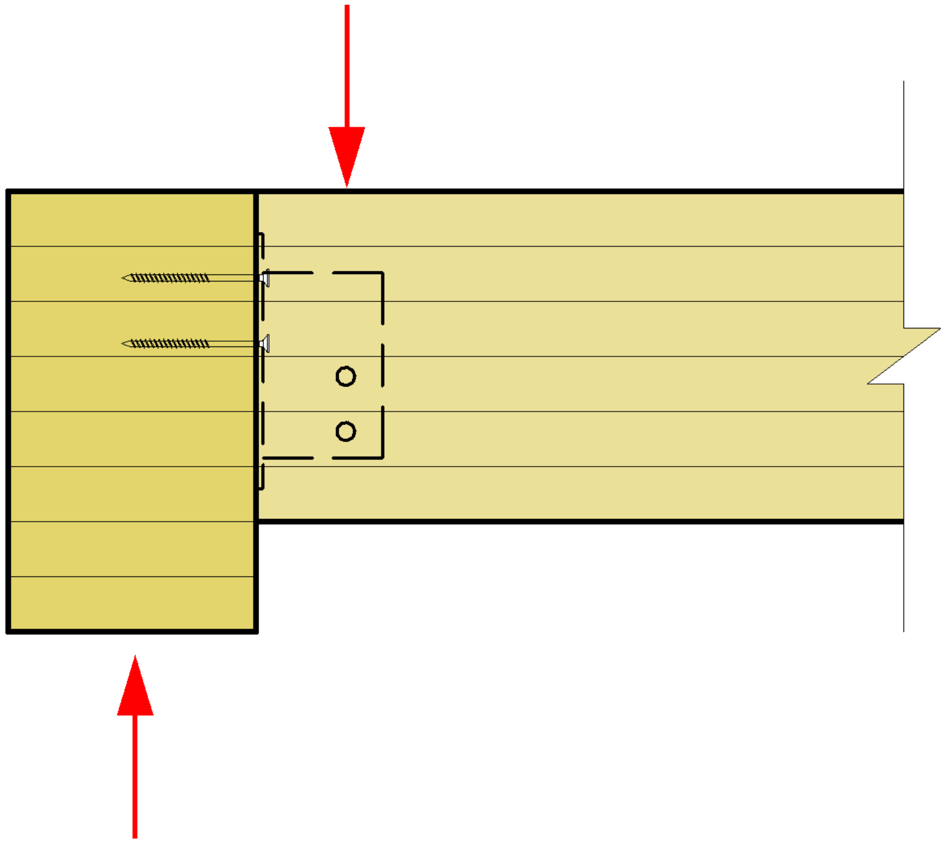
16.3 Wood Connections

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

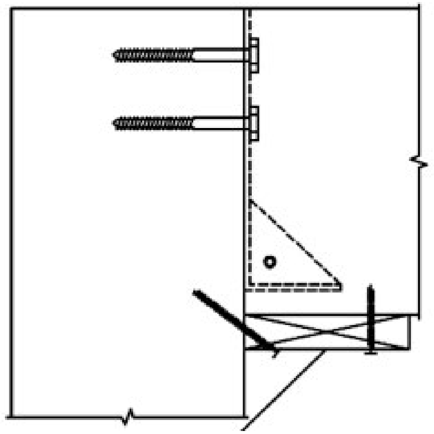
Steel hangers/hardware fully concealed within a timber-to-timber connection is a common method of fire protection

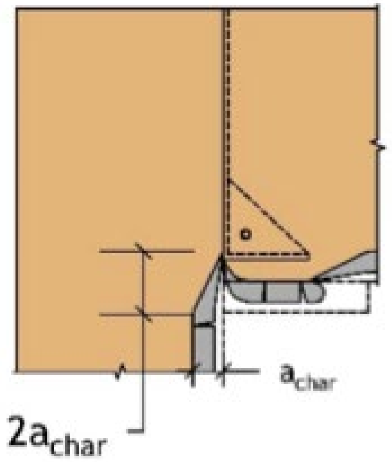


Fire Resistance of Connections

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.
2. Engineering analysis that demonstrates that the temperature rise at any portion of the connection is limited to an average temperature rise of 250o F (139o C), and a maximum temperature rise of 325o F (181o C), for a time corresponding to the required fire resistance rating of the structural element being connected. For the purposes of this analysis, the connection includes connectors, fasteners, and portions of wood members included in the structural design of the connection.





Source: AWC’s TR 10

Connection Fire Protection

Many ways to demonstrate connection fire protection:

calculations, prescriptive NC, test results, others as approved by AHJ


Photo: John Stamets


Photo: Josh Partee

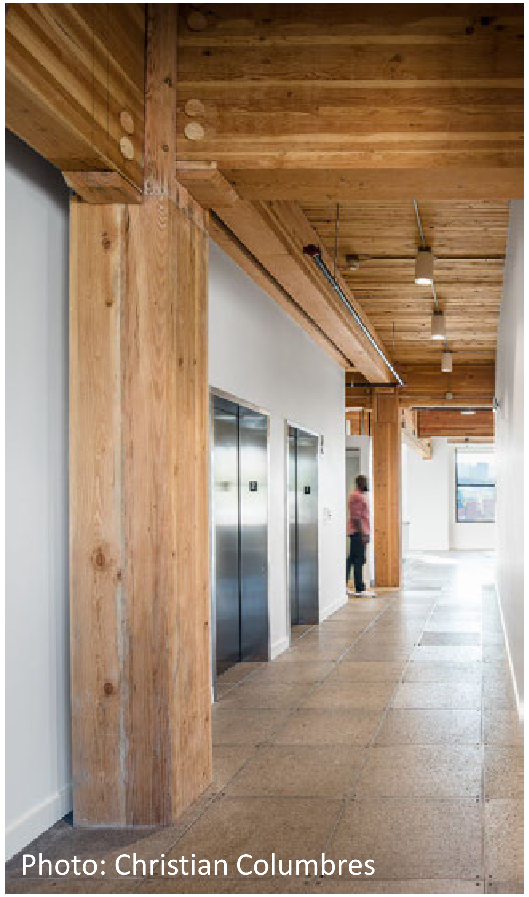


Photo: Christian Columbres

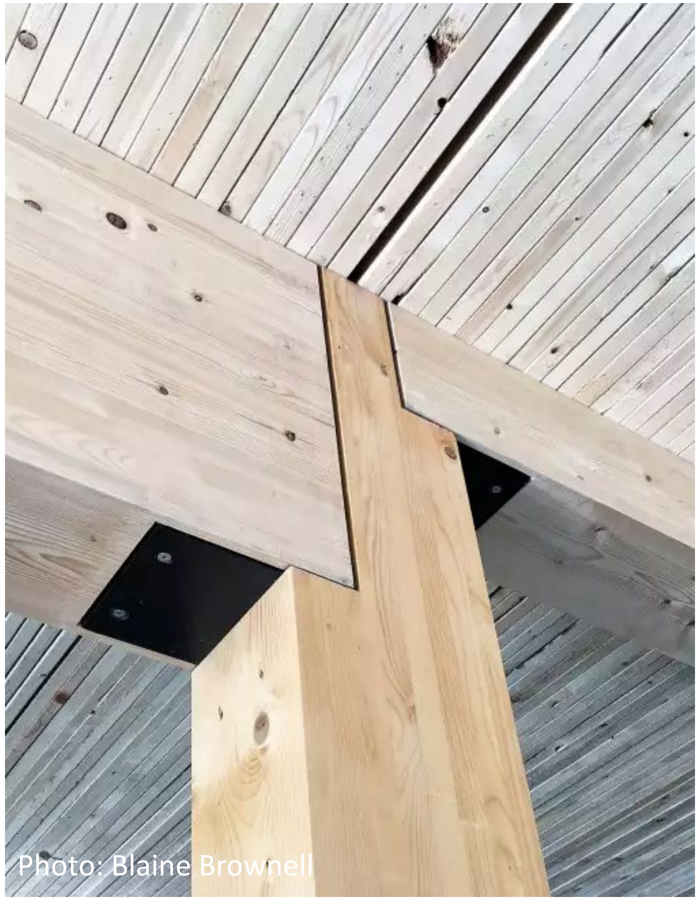


Photo: Blaine Brownell

Connection Fire Protection

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



Photo: ARUP/SLB

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

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

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

Outline

- » Tall Wood Introduction
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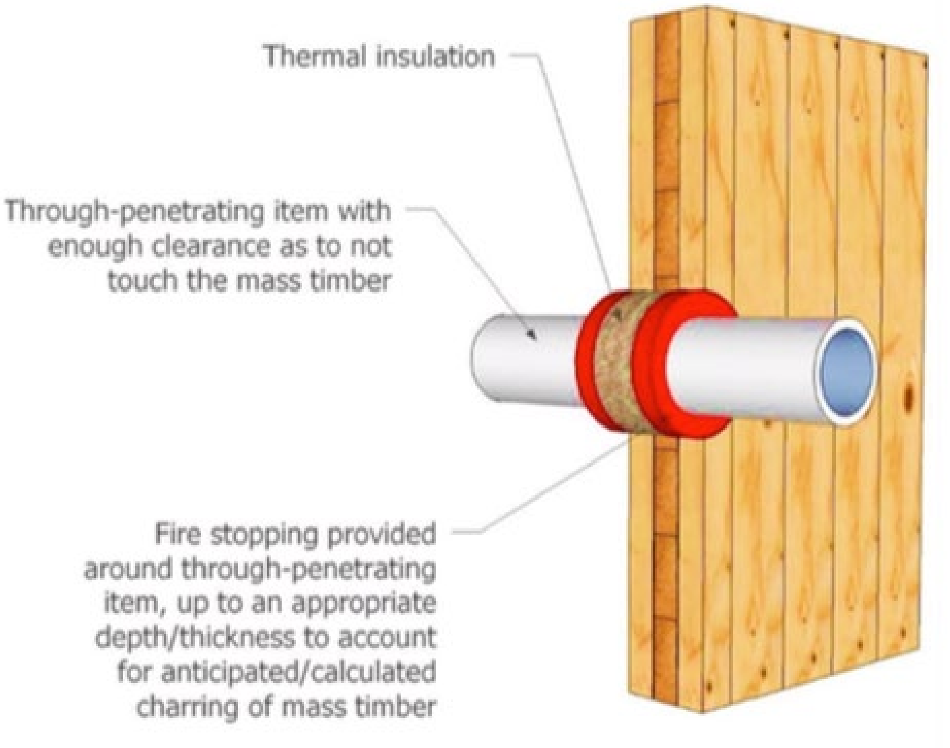
Penetration Fire Protection

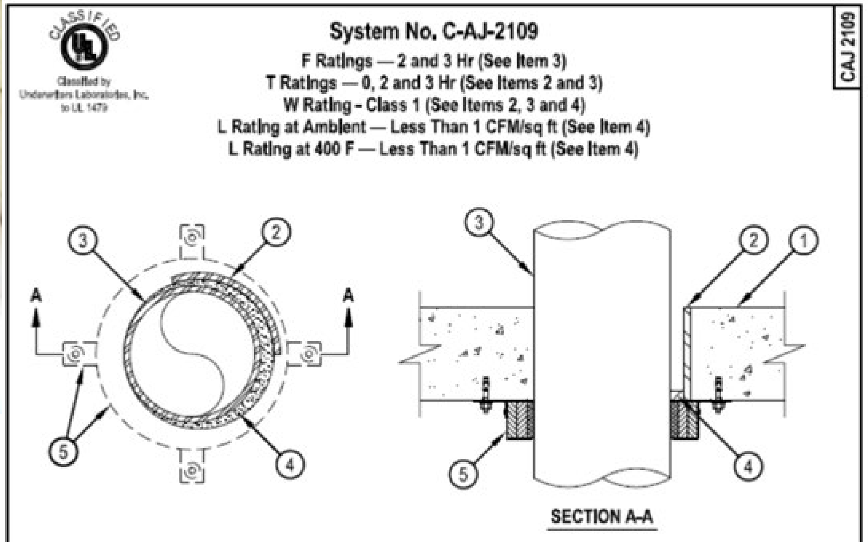
Although not a new code requirement or specific to tall wood, more testing & information is becoming available on firestopping of penetrations through MT assemblies

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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WWW.FIRE.SWRI.ORG
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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 fire resistance to prevent passage of hot gases or increased temperature on the unexposed side. Vulnerable locations, where gaps or holes are introduced into mass timber systems, are susceptible to fire spread. Service and closure penetrations in a mass timber fire separation have been investigated. Many of the fire stop systems were able to achieve 1-½ hr F-ratings, in accordance with CAN/ULC-S115, which would be required for 2-hr fire resistance rated assemblies, such as for use in tall wood buildings. Construction details are outlined which ensure adequate fire performance of these penetrations.

KEYWORDS: Firestop, through-penetrations, fire rated door, mass timber, cross-laminated timber, tall wood 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 solutions approach can be used to demonstrate equivalent performance to prescriptive acceptable solutions requiring noncombustible construction. The

construction, as well as in several alternative solution building designs.

Although the general fire performance of CLT is now well documented, there are still several details that warrant further investigation to ensure adequate fire safety levels are met and a number of options are available for designers to use. Generating test results for generic assemblies will reduce the need for testing to be completed on an individual construction project basis which will help ease the approvals process, and expedite widespread adoption of tall wood buildings.

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409 GRANVILLE STREET, SUITE 950
VANCOUVER, BC V6C 1T2 CANADA
P 604 689 4449
F 604 689 4419
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FIRESTOPPING TEST WITNESS REPORT

for

NORDIC STRUCTURES

Prepared for

Nordic Structures
1100 av des Canadiens-de-Montreal
Montreal, QC
H3B 2S2

Penetration Fire Protection

Inventory of Fire Tested Penetrations in MT Assemblies

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

WoodWorks™
WOOD PRODUCTS COUNCIL

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

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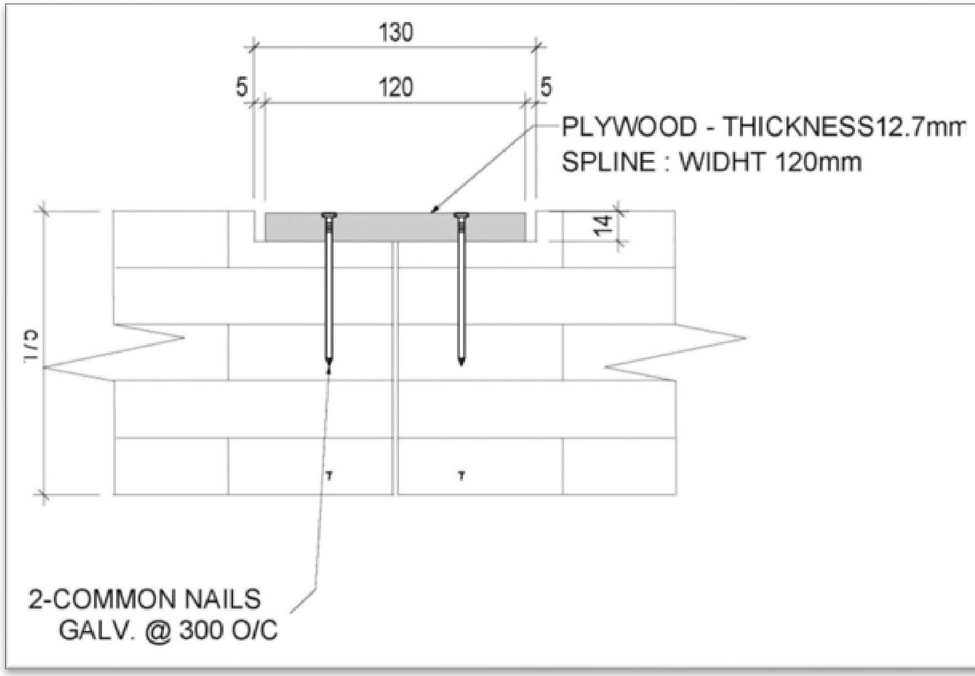
Sealants at MT Panel Edges

Photos: ARUP

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)

Photo: NRCAN

Photo: Fast + Epp

Photo: ARUP

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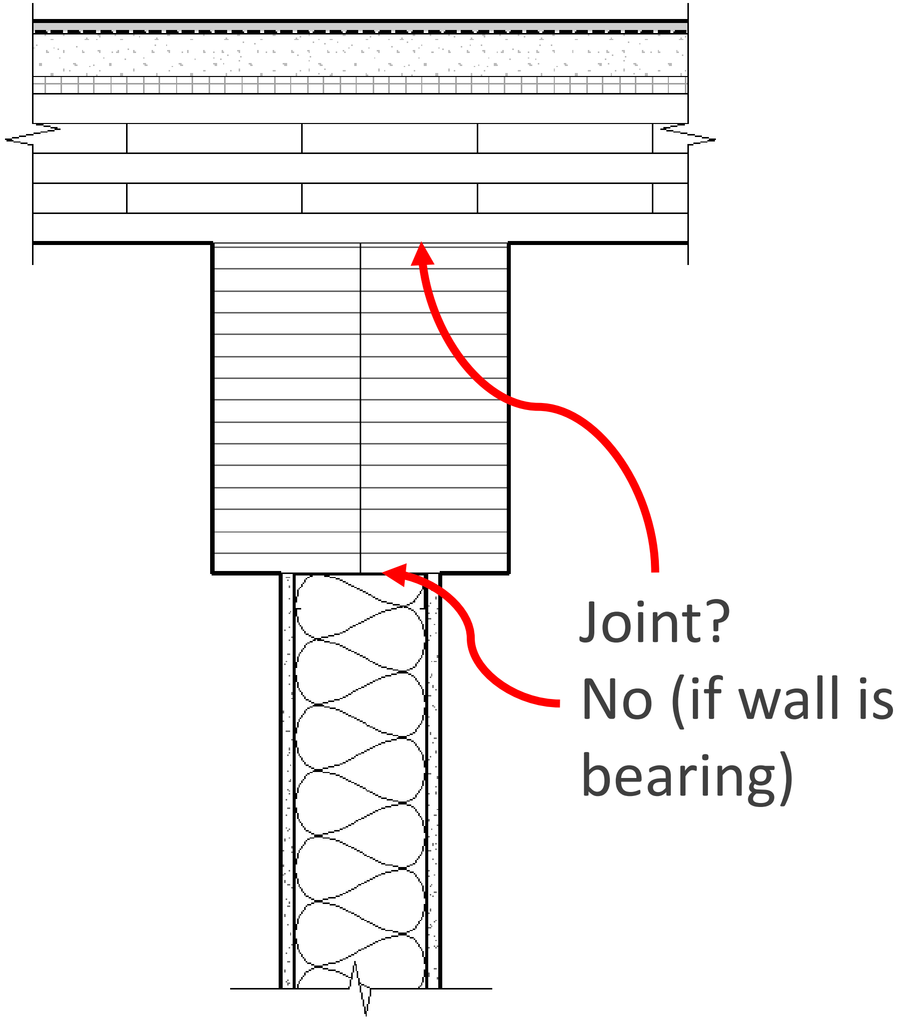
Joints & Intersecting Elements

Section 202 Definitions

Joint. The opening in or between adjacent assemblies that is created due to building tolerances, or is designed to allow independent movement of the building in any plane caused by thermal, seismic, wind or any other loading.

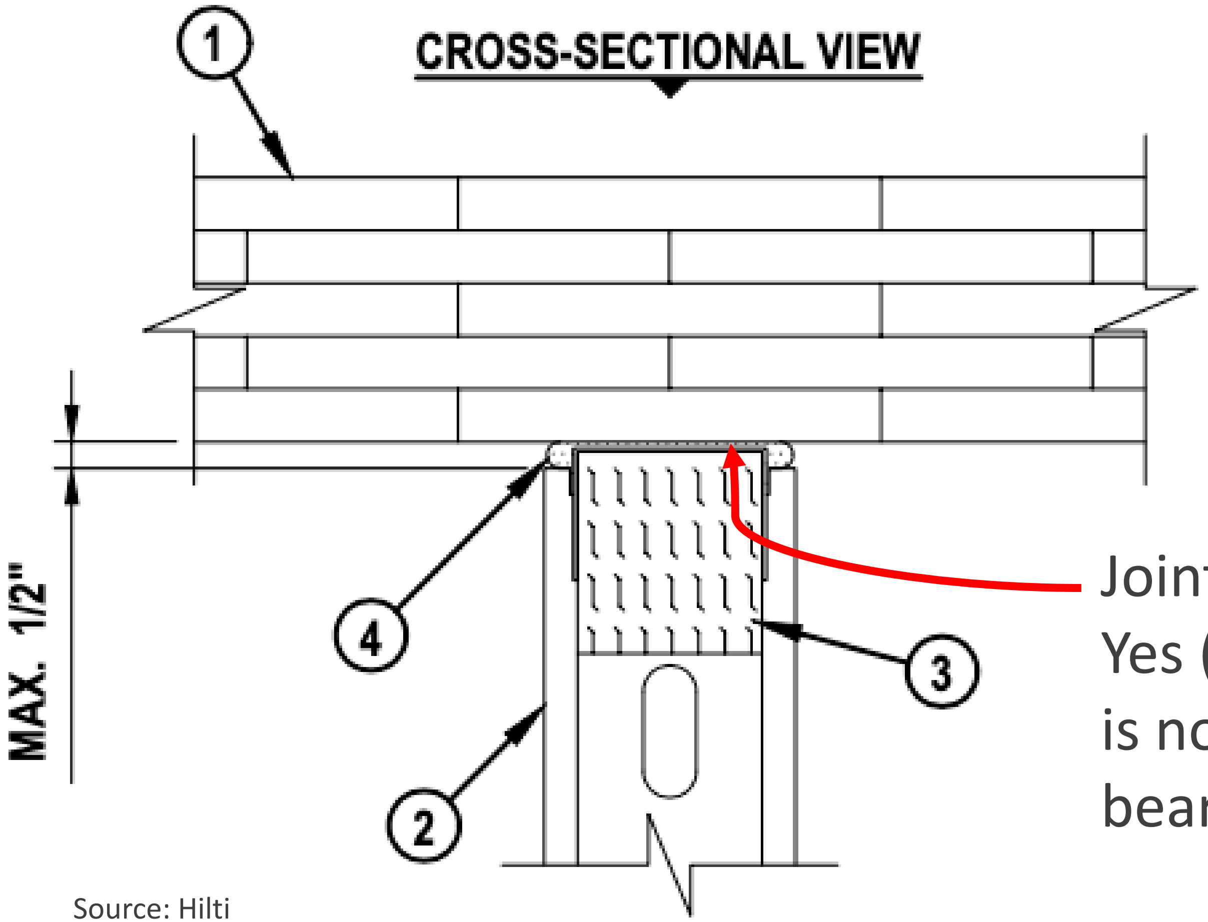
Considerations:

- Is wall, beam and slab rated?
- Required to prevent smoke passage?
- Not a tall timber specific item, applicable to all mass timber construction



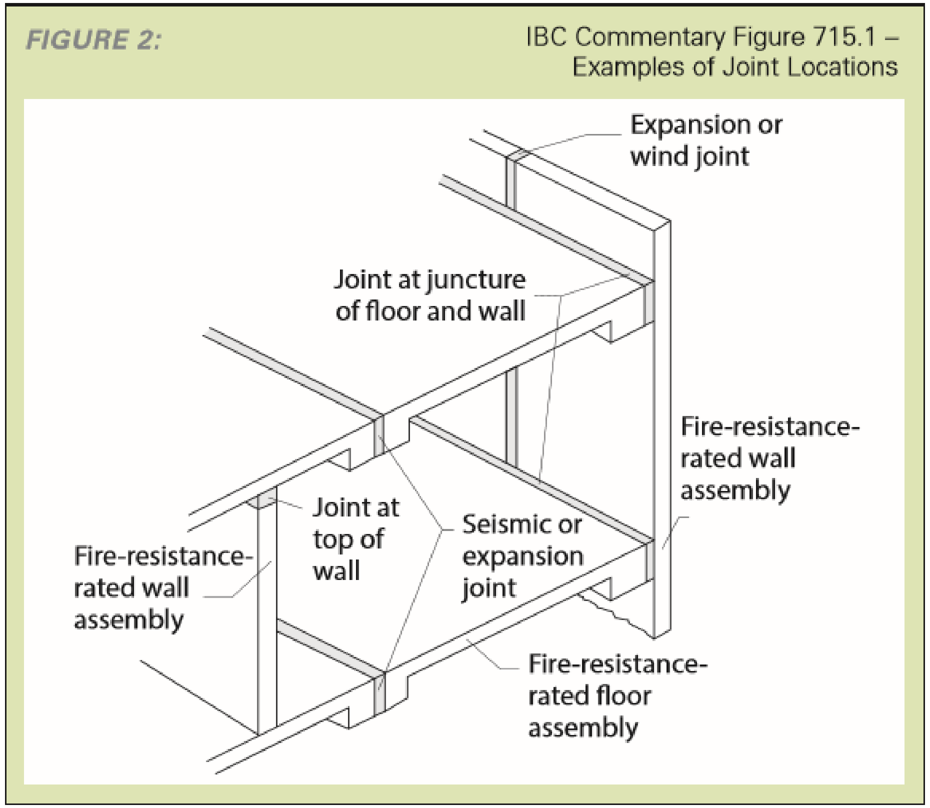
Joints & Intersecting Elements

Not a tall timber specific item, applicable to all mass timber construction



Joint?
Yes (if wall is non-bearng)

Source: Hilti



Source: International Building Code

Joints & Intersecting Elements

Section 715 Joints and Voids

715.3 Fire-resistance-rated assembly intersections.

Joints installed in or between fire-resistance-rated walls, floors or floor/ceiling assemblies and roofs or roof/ceiling assemblies shall be protected by an approved fire-resistant joint system designed to resist the passage of fire for a time period not less than the required fire-resistance rating of the wall, floor or roof in or between which the system is installed.

715.3.1 Fire test criteria.

Fire-resistant joint systems shall be tested in accordance with the requirements of either ASTM E1966 or UL 2079.

<u>Not a tall timber specific item, applicable to all mass timber construction. Firestop manufacturers should be consulted for specific solutions.</u>

Source: International Building Code

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 ½" gypsum board or a noncombustible equivalent.

Photo: MIT | John Klein

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

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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: 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.

Exception: Shafts and vertical exit enclosures

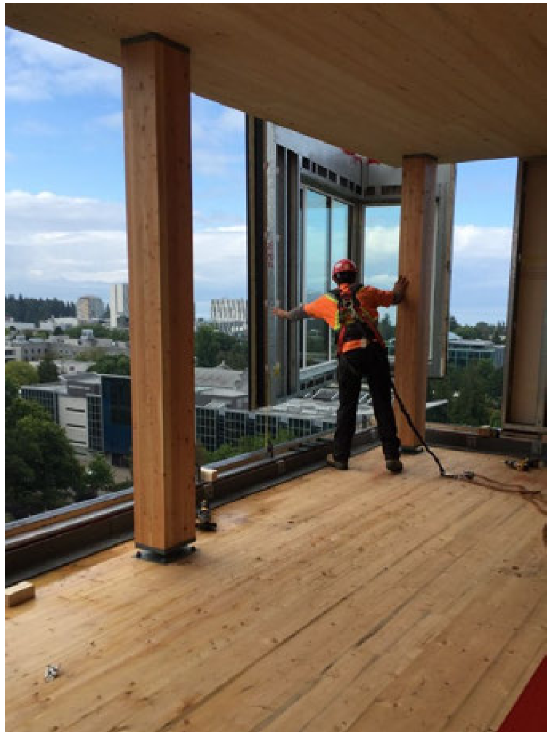
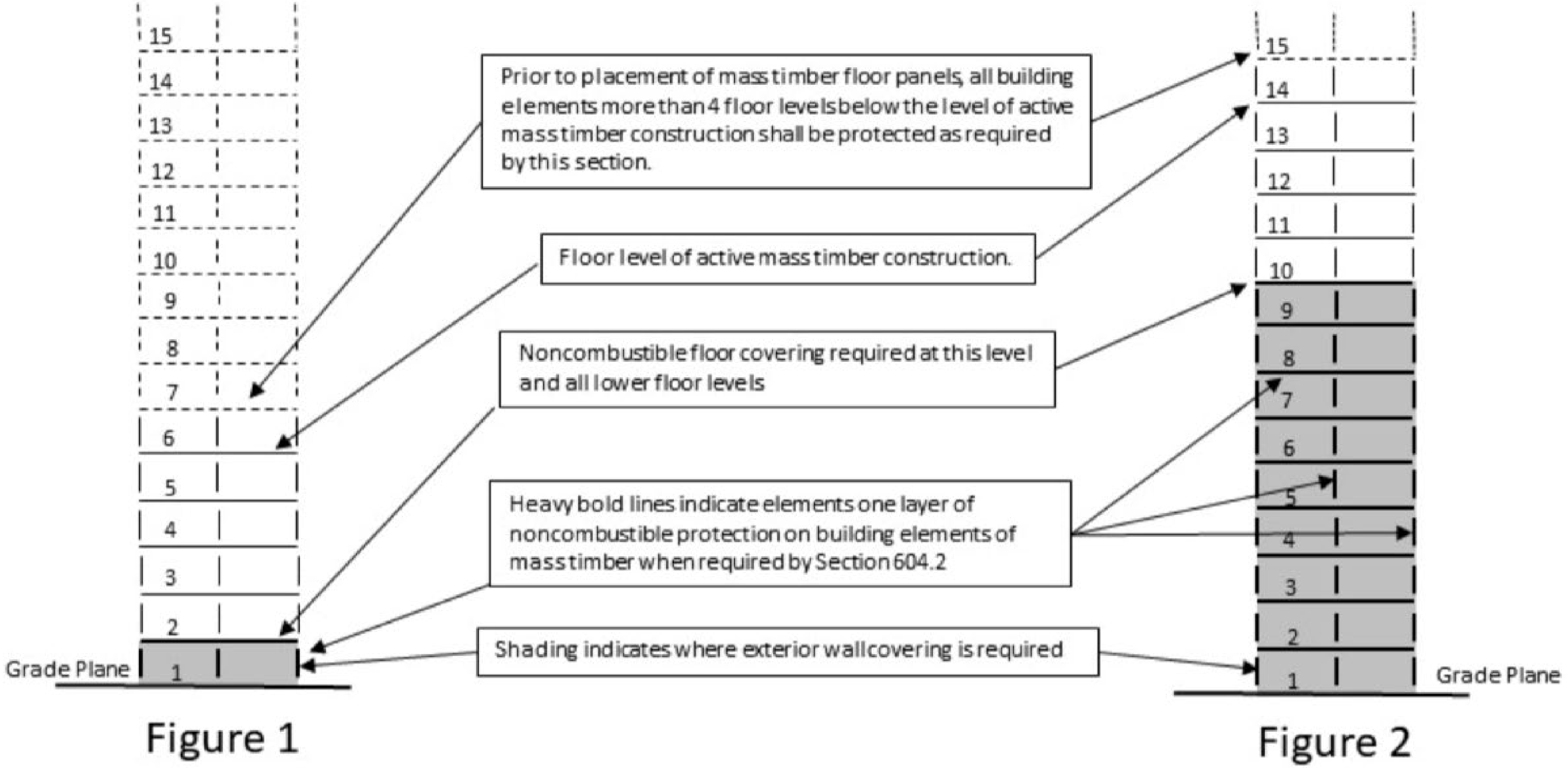


Photo: Urban One

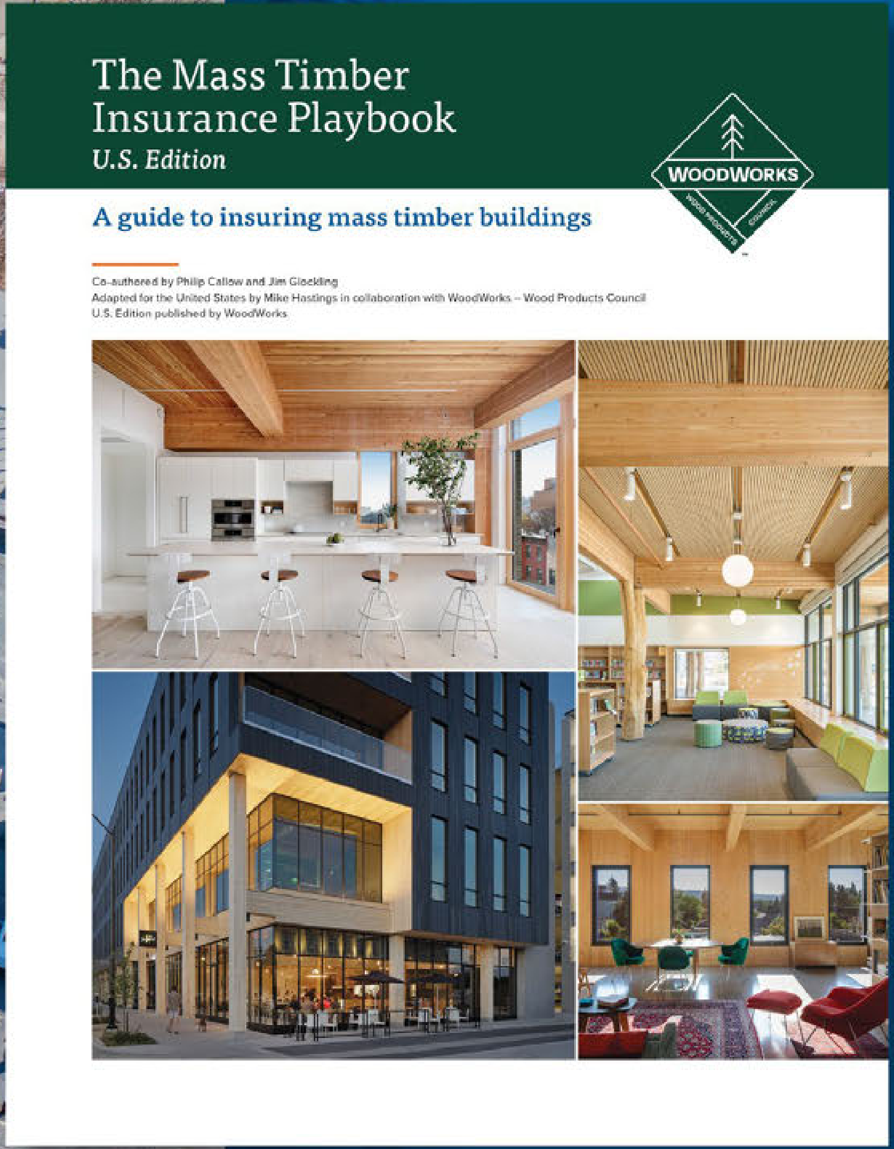
Fire Safety During Construction



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

Credit: ICC

11 E Lenox / Monte French Design Studio / H+O Structural Engineering
Photo H+O Structural Engineering



The Mass Timber Insurance Playbook
U.S. Edition

A guide to insuring mass timber buildings

Co-authored by Philip Callow and Jim Glockling
Adapted for the United States by Mike Hastings in collaboration with WoodWorks – Wood Products Council
U.S. Edition published by WoodWorks

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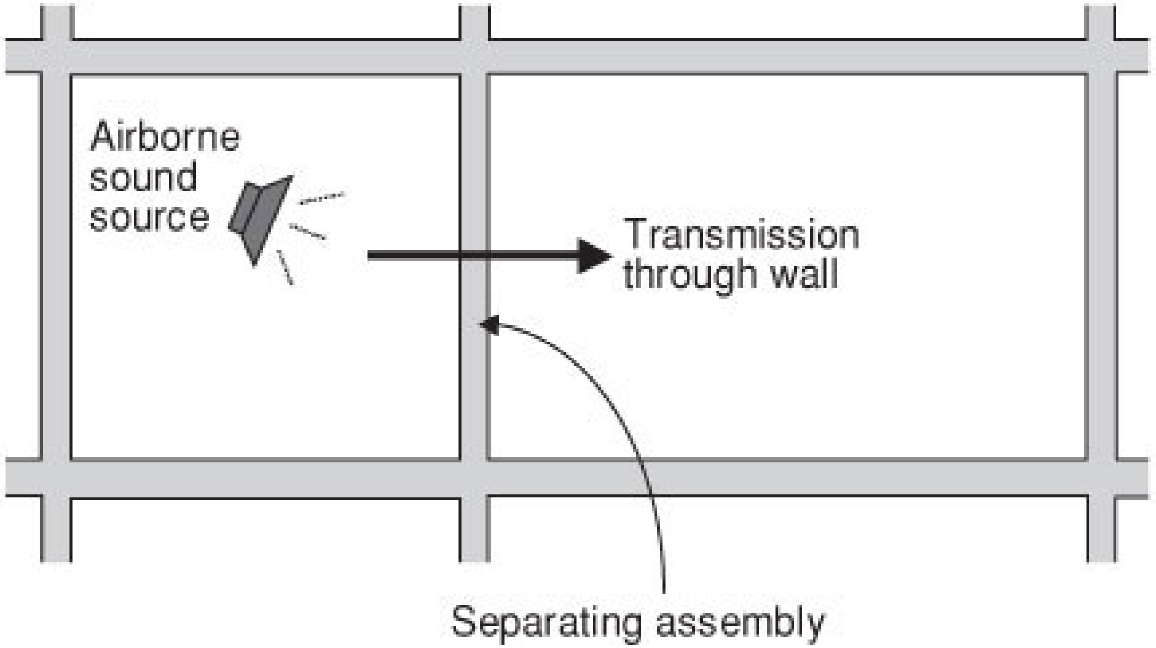
- › Acoustical Design

Acoustical Design

<u>Air-Borne Sound:</u>

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

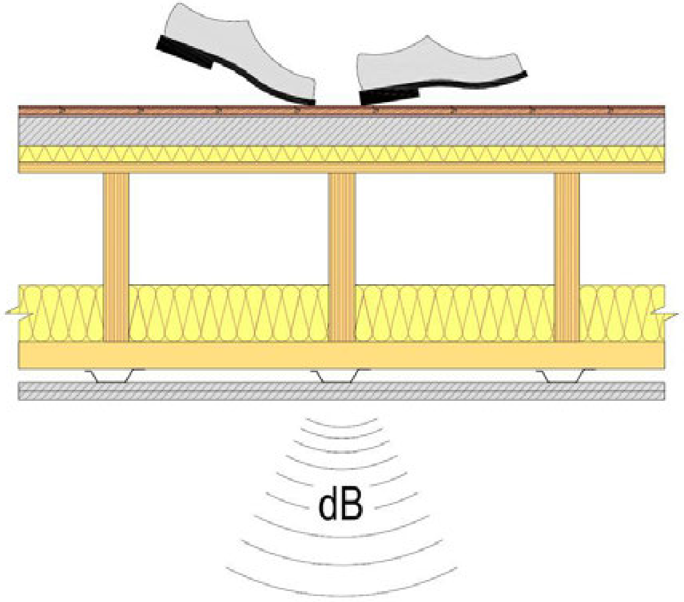


Acoustical Design

<u>Structure-Borne Sound:</u>

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:

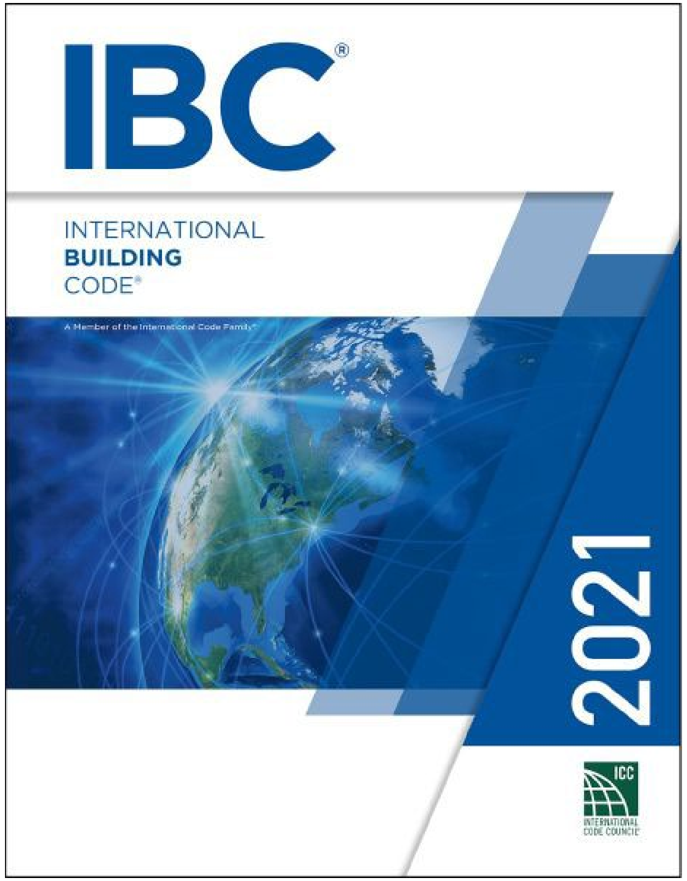
For unit to unit or unit to public or service areas:

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

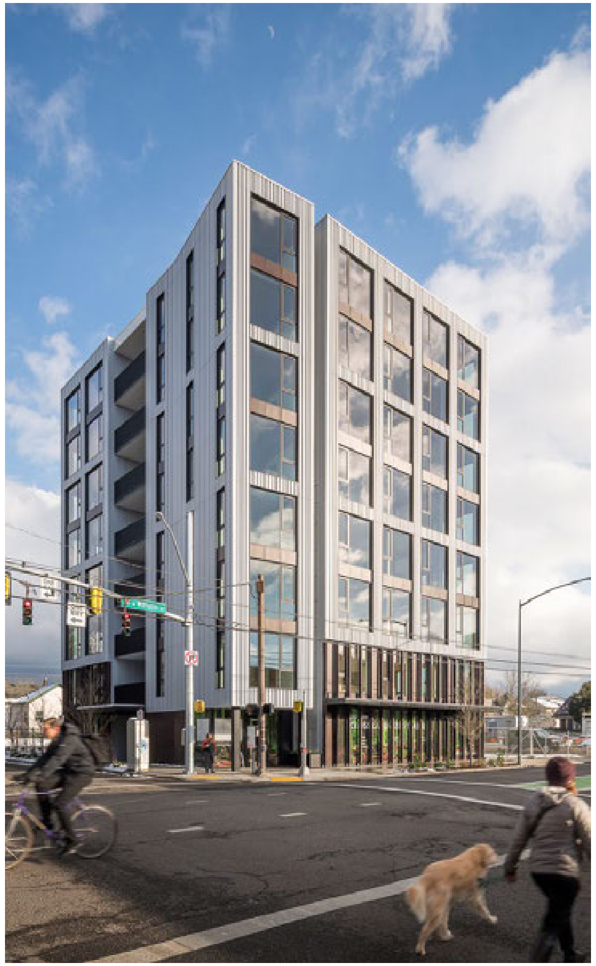


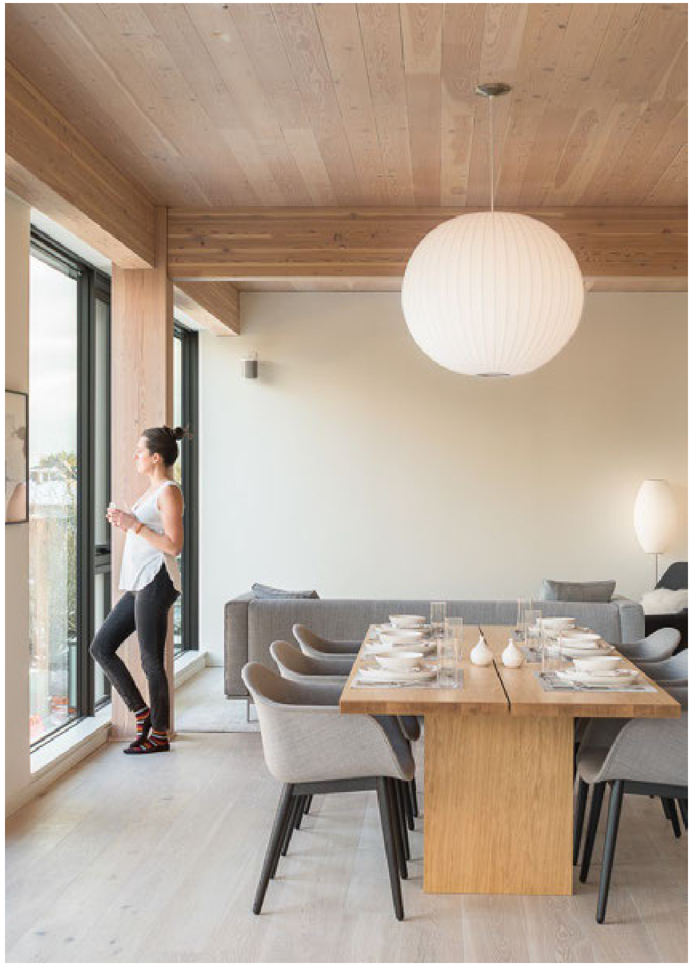
Acoustical Design

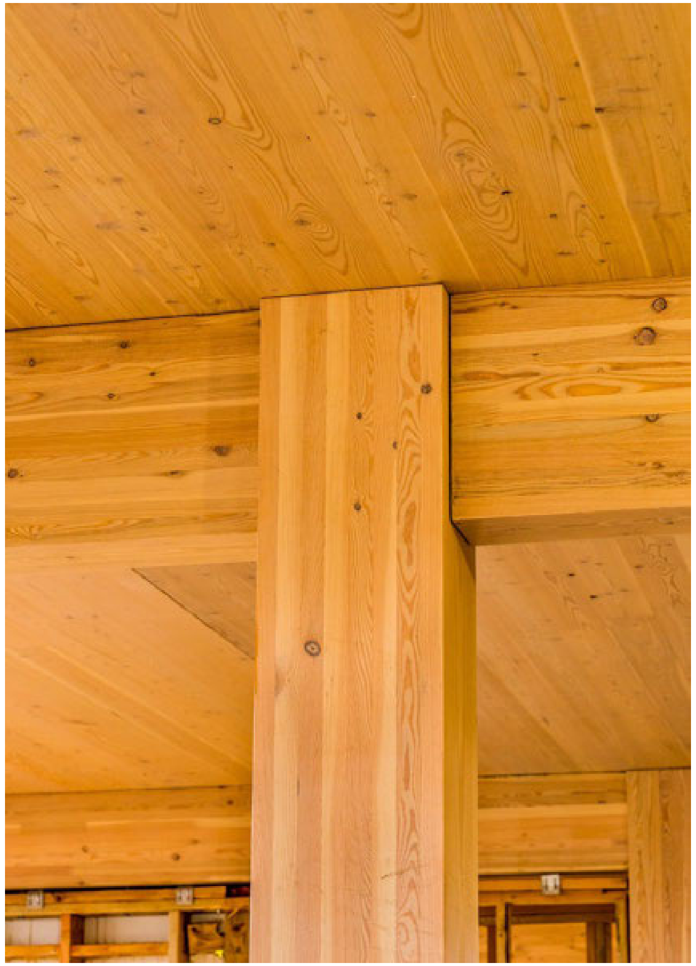
STC	What can be heard
25	Normal speech can be understood quite easily and distinctly through wall
30	Loud speech can be understood fairly well, normal speech heard but not understood
35	Loud speech audible but not intelligible
40	Onset of "privacy"
42	Loud speech audible as a murmur
45	Loud speech not 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

Mass Timber Acoustical Design

Mass Timber: Structure Often is Finish







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

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

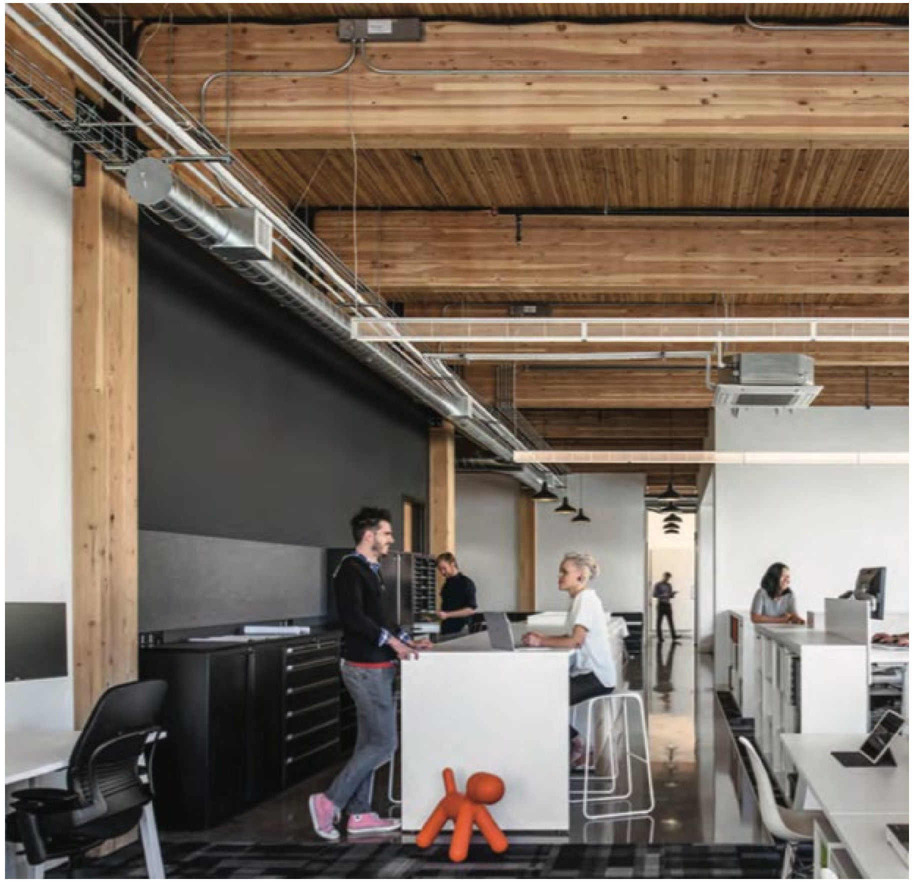
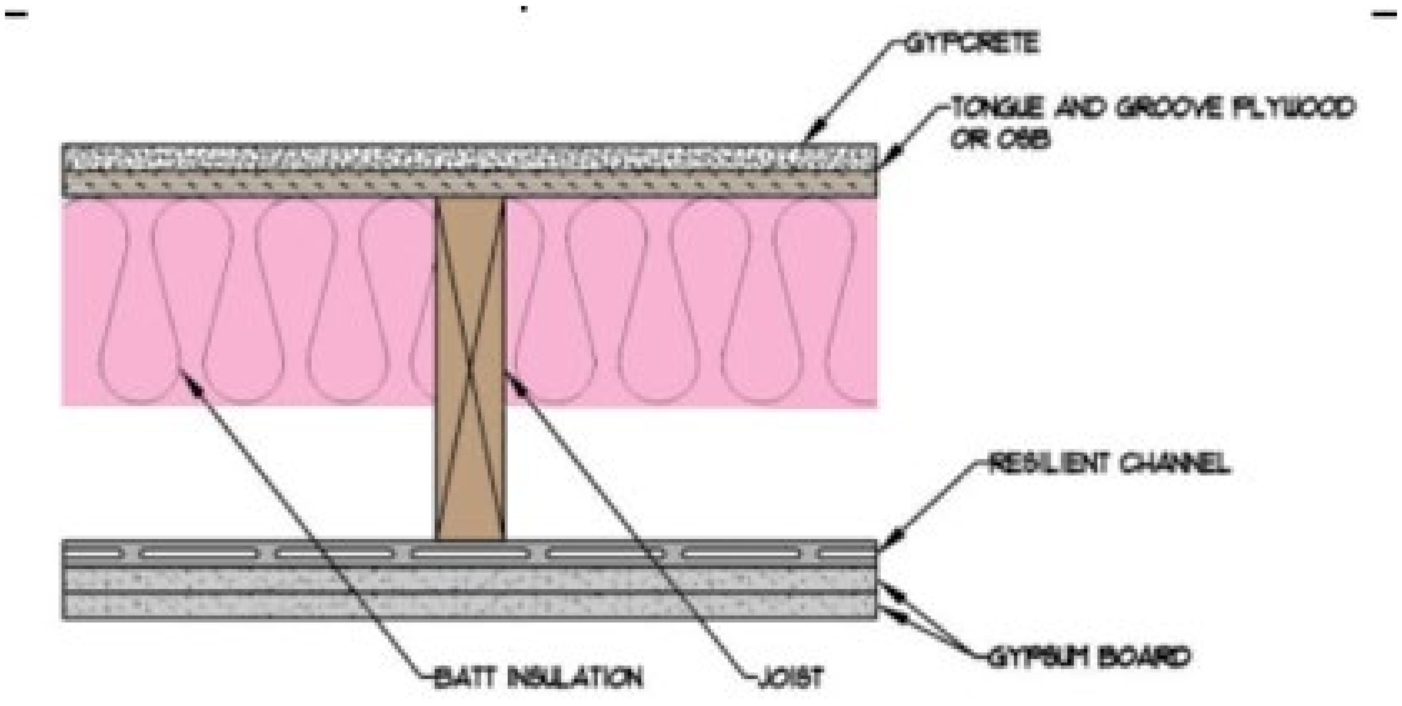


Image credit: Christian Columbres

Acoustical Detailing

What does this look like in typical wood-frame construction:

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



STC 62

Mass Timber Acoustics

Mass timber has relatively low “mass”

Recall the three ways to increase acoustical performance:

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

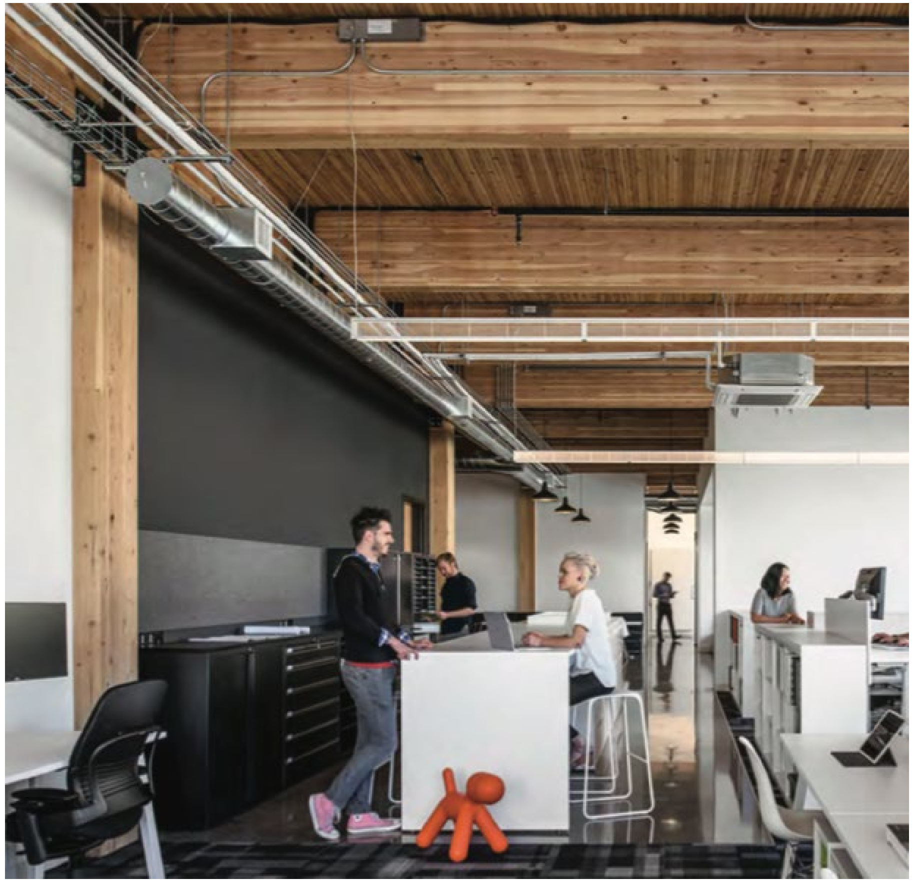


Image credit: Christian Columbres

Mass Timber Acoustics

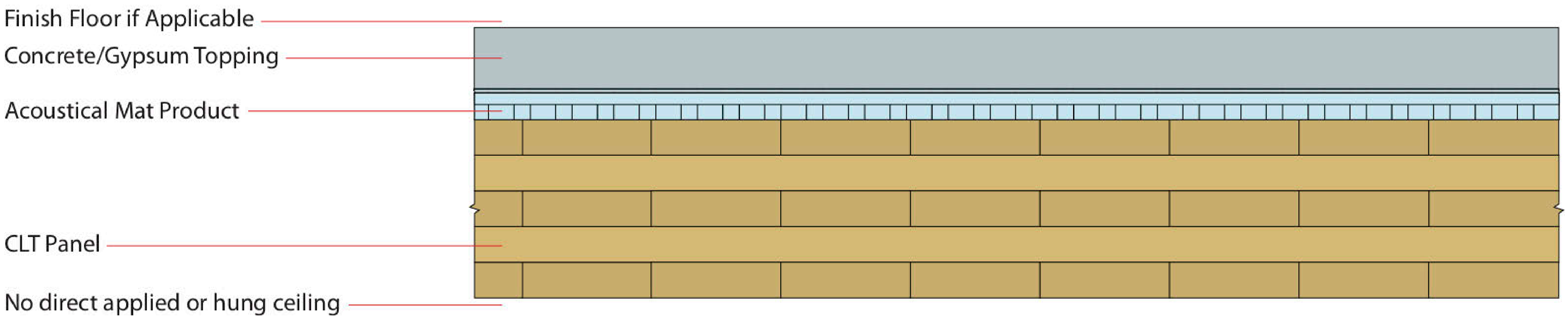
<u>Concrete Slab:</u>
6” Thick
80 PSF
STC 53

<u>CLT Slab:</u>
6-7/8” Thick
18 PSF
STC 41

Mass Timber Acoustics

There are three main ways to improve an assembly's acoustical performance:

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



Mass Timber Acoustics

There are three main ways to improve an assembly's acoustical performance:

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

Acoustical Mat:

» Typically roll out or board products
» Thicknesses vary: Usually ¼" to 1"+

Credit: Maxxon

Mass Timber Acoustics

Acoustical floor underlayments

Photo: AcoustiTECH [10]

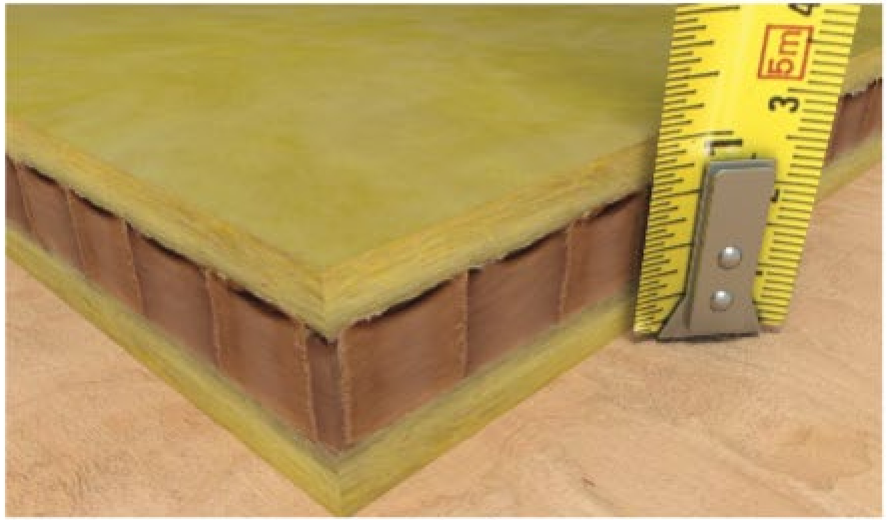


Photo: Kinetics Noise Control, Inc.,[11]

Photo: Maxxon Corporation

Photo: Pliteq Inc.,[12]

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

Credit: AcoustiTECH

Mass Timber Acoustics

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

Photo: Corey Gaffer courtesy Perkins + Will

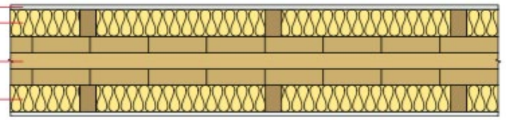
T3 Minneapolis
Architect: MGA | Michael Green Architecture, DLR Group
Structural Engineer: Magnusson Klemencic Associates
Design Assist + Build: StructureCraft

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.

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

Example Mass Timber Wall Assembly, STC 58
Plan View



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

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

Mass Timber Acoustics

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

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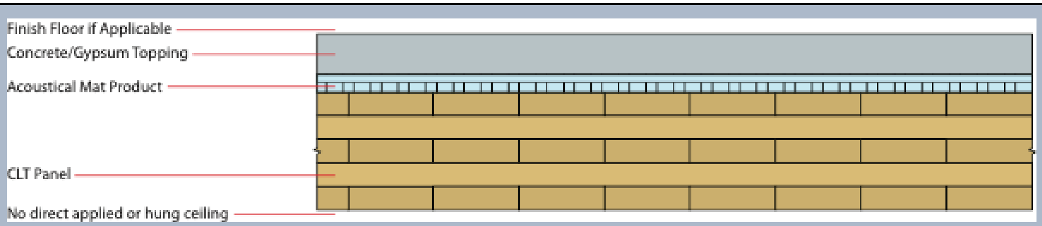


CLT Panel	Concrete/Gypsum Topping	Acoustical Mat Product Between CLT and Topping	Finish Floor	STC[1]	IIC[1]	Source
CLT 5-ply (6.875")	1-1/2" Gyp-Crete®	Maxxon Acousti-Mat® 3/4	None	47[2] ASTC	47[2] AIIC	1
			LVT	-	49[2] AIIC	
			Carpet + Pad	-	75[2] AIIC	
			LVT on Acousti-Top®	-	52[2] AIIC	
			Eng Wood 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]

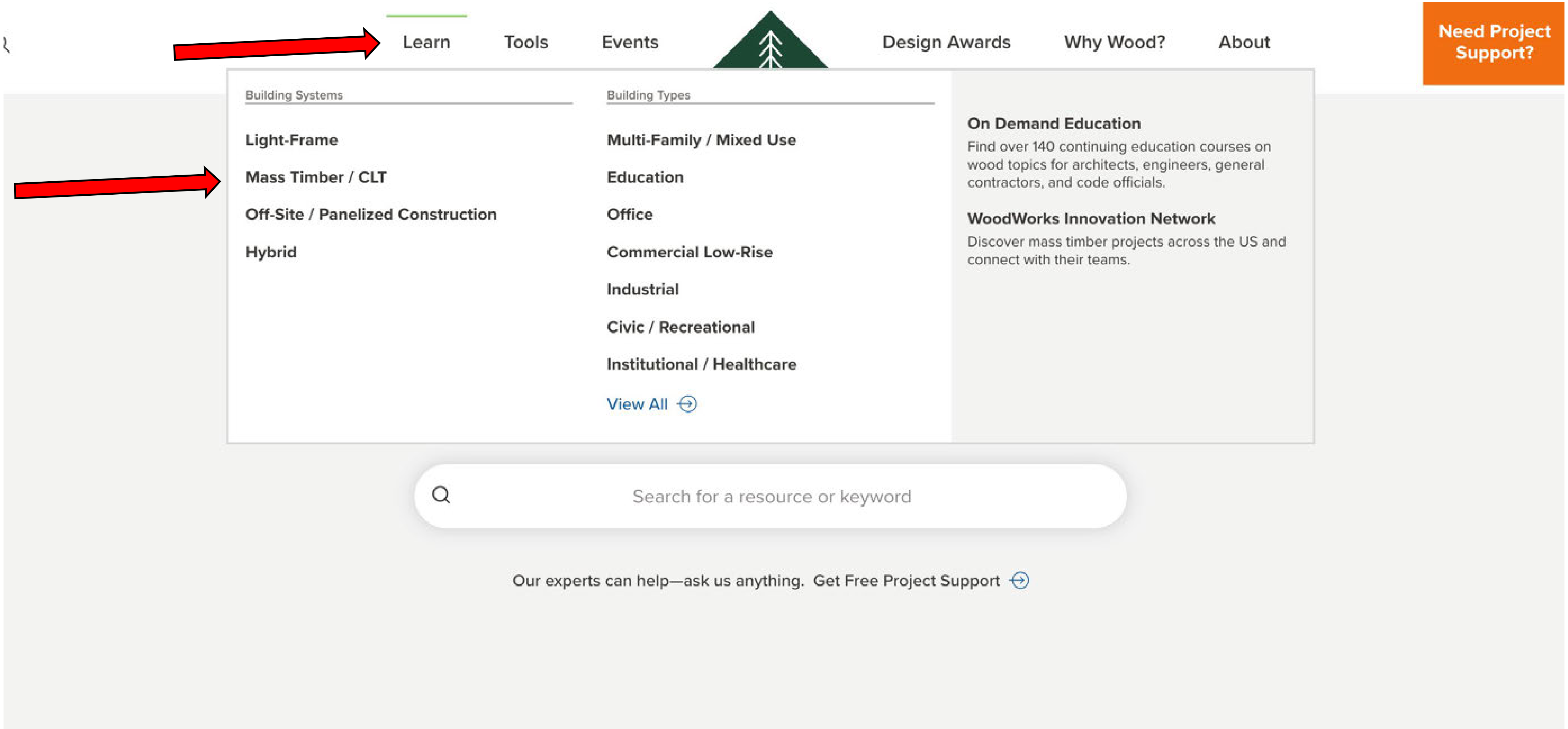
Base Assembly (top to bottom)		Base assembly plus 2 layers direct applied 5/8" gyp on underside of mass timber	Base assembly plus 2 layers direct applied gyp plus dropped ceiling
1" poured gypsum, acoustical mat, 5-ply CLT	STC 50 IIC 40	STC 52 IIC 46	STC 63 IIC 60
LVT, 1" poured gypsum, acoustical mat, 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

TALL MASS TIMBER RESOURCES



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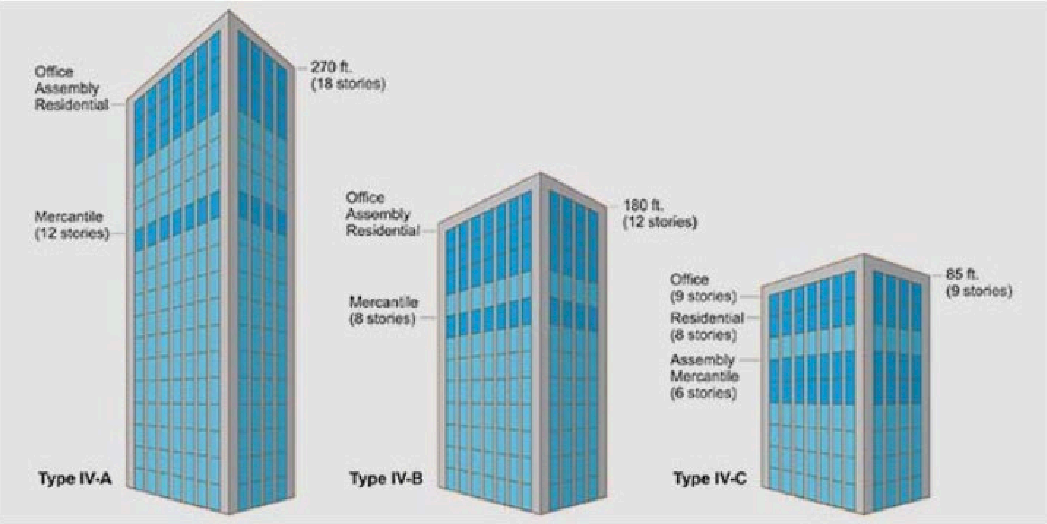
TALL MASS TIMBER RESOURCES



Tall Mass Timber

Code opportunities and requirements, FAQs, project examples and resources for teams interested in tall timber projects.

Learn More →

www.woodworks.org/learn/mass-timber-clt/tall-mass-timber/

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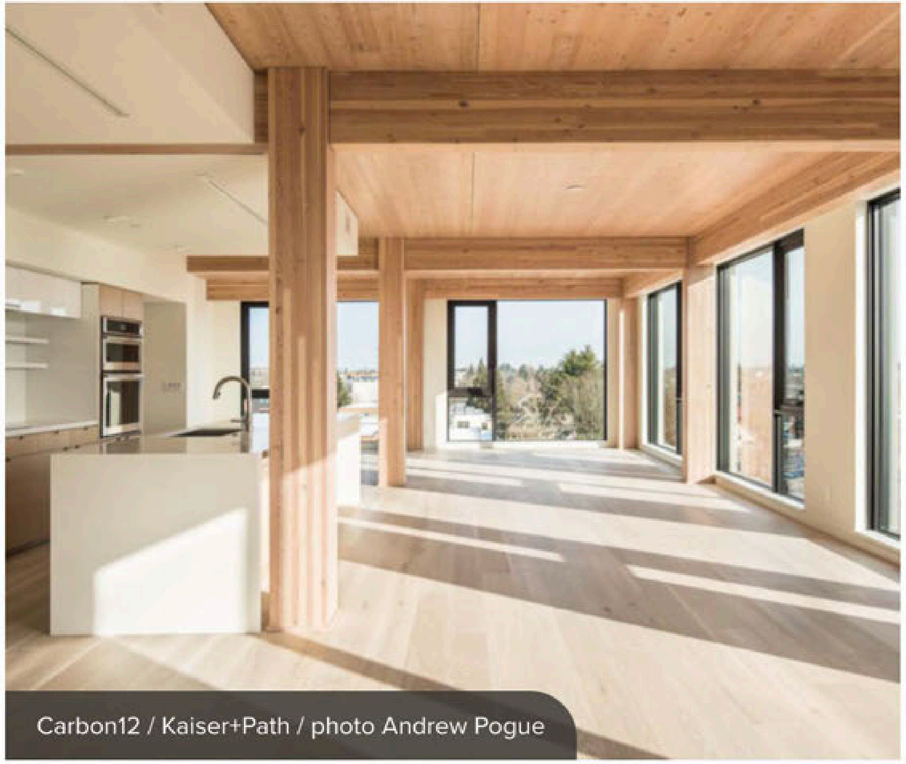
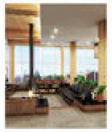
Technical Design Guidance from WoodWorks



Solution Papers

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

Looking for information on the tall wood provisions in the 2021 International Building Code? This paper summarizes the provisions as well as the background and research that supported their adoption.



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

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Shaft Wall Requirements in Tall Mass Timber Buildings

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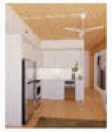

Concealed Spaces in Mass Timber and Heavy Timber Structures

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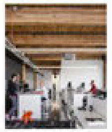

Acoustics and Mass Timber: Room-to-Room Noise Control

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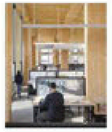

Fire Design of Mass Timber Members: Code Applications, Construction Types and Fire Ratings

Solution Papers

TALL MASS TIMBER RESOURCES

Answers to Tall Mass Timber FAQs

5. How are design teams leveraging tall mas timber code provisions to maximize the amount of timber exposure?

Follow this link for an article that discusses how teams are utilizing the new code provisions to enhance the appearance of their tall mas timber structures with exposed timber framing.

6. I've heard that the 2024 IBC will allow 100% timber ceiling exposure in type IV-B, up to 12 stories tall. Is that code language finalized?

Yes, the 2024 IBC will include new code changes, which have been approved and will be incorporated, which allow timber ceiling exposure in Type IV-B construction up to 100%. The new code language as it will read in the 2024 IBC is available here. Several jurisdictions such as the City of Denver, City of Dallas, State of Oregon and State of Washington are already in the process of incorporating these new timber exposure limits in their building codes, and several design teams are looking to utilize the new limits in project-specific discussions with their local building officials. Reach out to your local WoodWorks Regional Director to see how projects in your area can approach these design topics.

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Expert Tips

Tall Mass Timber Trends and Exposed Timber Allowances

Recent code changes and jurisdictional approvals provide for greater areas of exposed mass timber.

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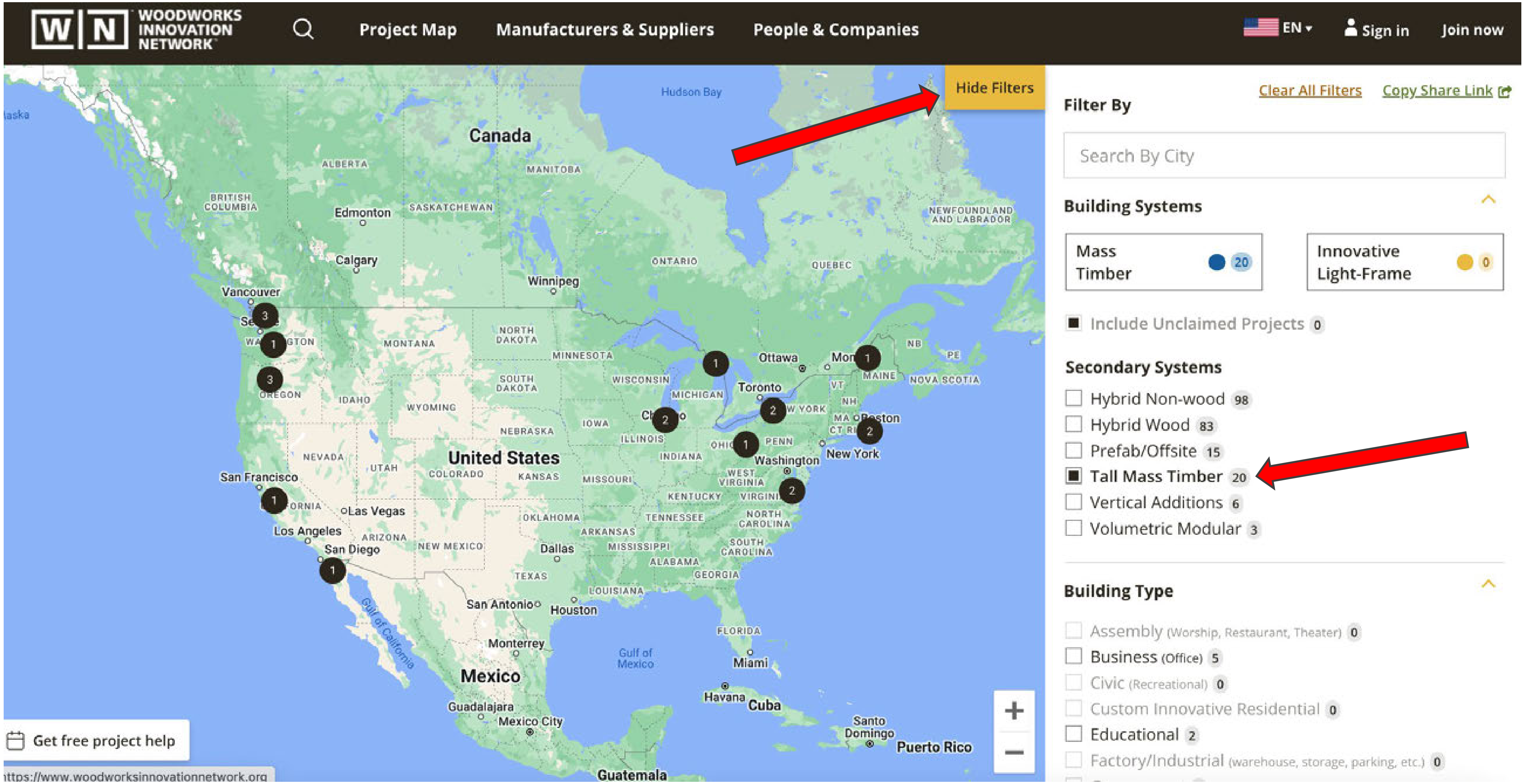

Questions? Ask us anything.

John O'Donald II, PE
Regional Director | VA, DC, DE, MD, WV
(814) 880-5636
john.odonald@woodworks.org

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