

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

Presented by Jason Bahr, PE and
David Hanley, WoodWorks
April 5, 2022



*Photo Credit: The
Canyons, Kaiser+Path /
photo Jeremy Bittermann*



MULTI-FAMILY/MIXED-USE | EDUCATION | OFFICE | RETAIL | INDUSTRIAL | CIVIC | INSTITUTIONAL



Designing a wood building? Ask us anything.

FREE PROJECT SUPPORT / EDUCATION / RESOURCES

Nationwide support for the code-compliant design, engineering and construction of non-residential and multi-family wood buildings.

- Allowable Heights/Areas
- Construction Types
- Structural Detailing
- Wood-Framed & Hybrid Systems
- Fire/Acoustic Assemblies
- Lateral System Design
- Alternate Means of Compliance
- Energy-Efficient Detailing
- Building Systems & Technologies

woodworks.org/project-assistance | help@woodworks.org



John W. Oliver Design Building at UMass Amherst
Leers Weinzapfel Associates, Equilibrium Consulting
photo © Albert Vecerka / Esto

RESOURCES & UPCOMING EVENTS



New WOOD SOLUTION PAPER



**CLT Diaphragm Design for
Wind and Seismic Resistance**
Using SDPWS 2021 and ASCE 7-22

New CASE STUDIES

Adidas East Village Expansion
Innovative mass timber designs meet
ambitious construction timeline



Thomas Logan
Wood-frame urban podium project fills
need for affordable downtown housing



Visit woodworks.org/publications-media

INTERNATIONAL MASS TIMBER CONFERENCE

April 12 – April 14

Common Challenges in Wood Lateral System Layouts | **May 3**

1.5 AIA/CES HSW LUs, 1.5 PDH credits, 0.15 ICC credits

Lateral Design for Mass Timber Structures: How to Do It, How It's Been Done | **May 5**

1.5 AIA/CES HSW LUs, 1.5 PDH credits, 0.15 ICC credits

Virtual International Mass Timber Conference | **May 12**

Visit woodworks.org/events

New for GCs and installers: U.S. Mass Timber Construction Manual



PHOTO: MARCUS KAUFFMAN

U.S.
Mass Timber
Construction
Manual



Download free at
woodworks.org

Meet the **Help Desk**



Scott Breneman, PhD, PE, SE



Ashley Cagle, PE, SE



Karen Gesa, PE



Bruce Lindsey



Melissa Kroskey, AIA, SE



Terry Malone, PE, SE



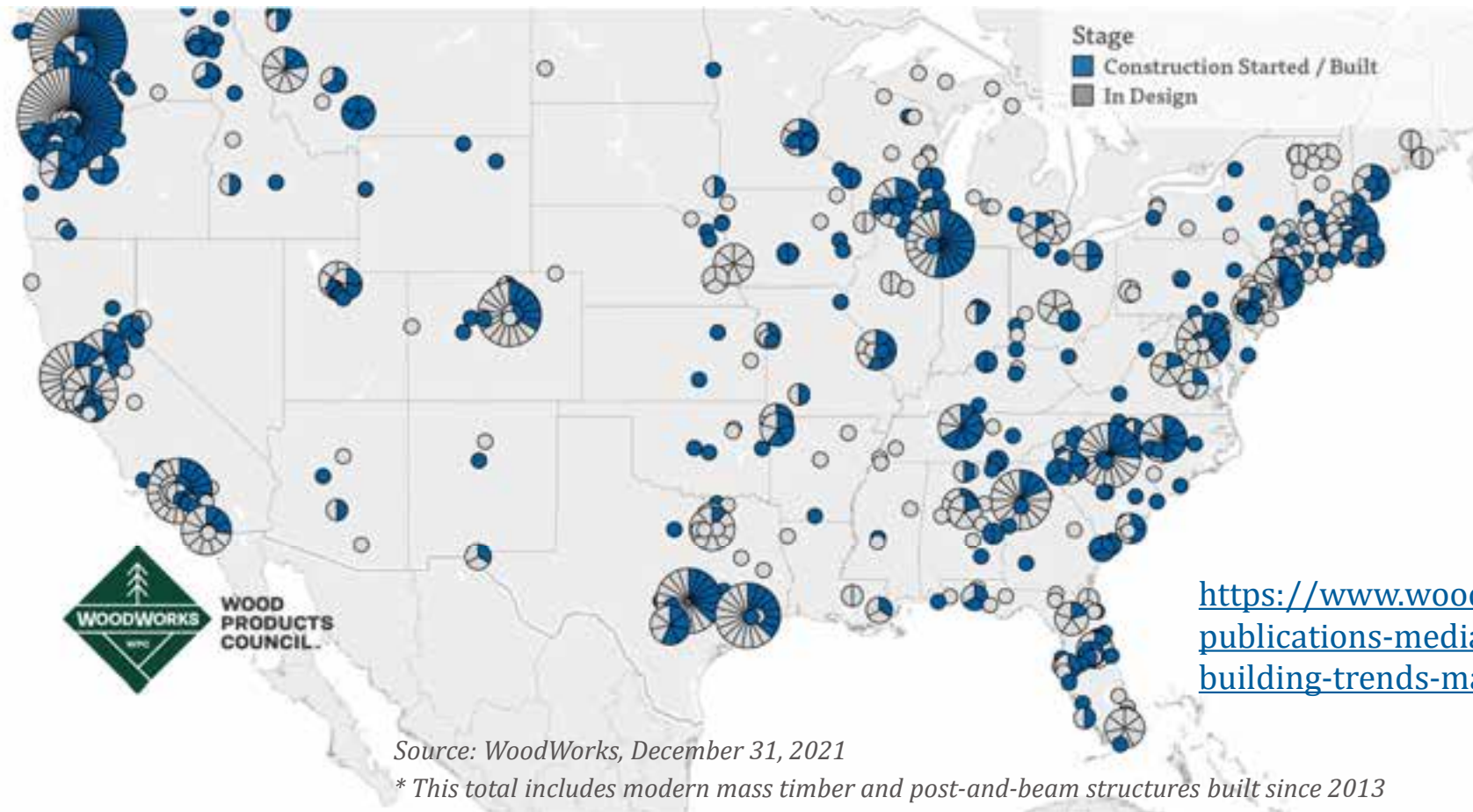
Ricky McLain, PE, SE

Need technical assistance on a project?

Email: help@woodworks.org

Current State of Mass Timber Projects

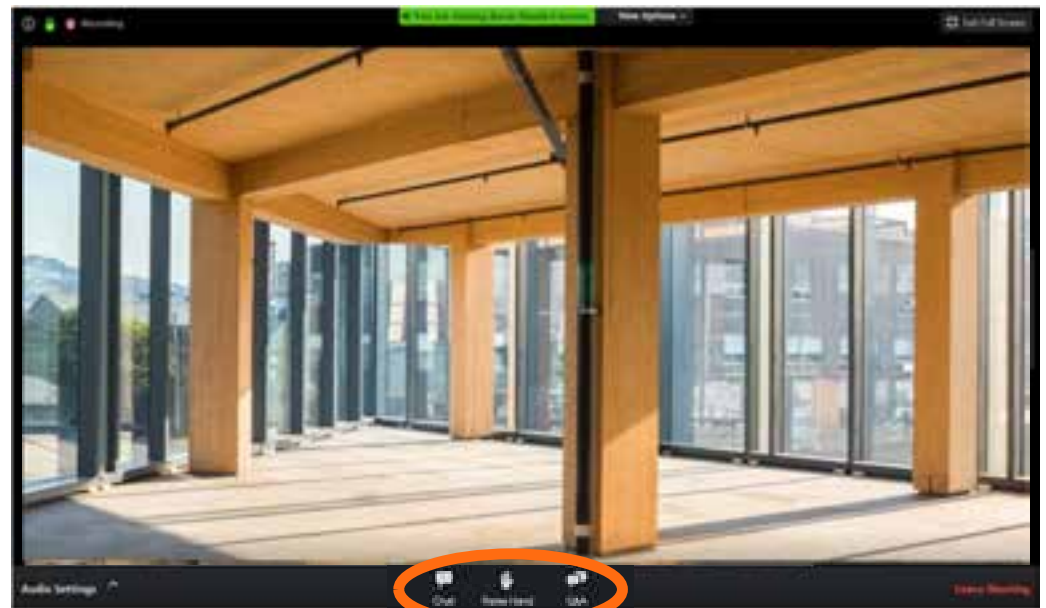
As of December 2021, in the US, **1,303** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.



Watch the Chat Window, Ask Questions through the Q&A Box



- » During today's event will be sending links, files and other pertinent information through the Chat window, located at the bottom of your screen.
- » Submit questions in the Q&A box at the bottom of your screen as they come up in the presentations. We will get to as many questions as possible.



Questions? Ask us anything.



Jason Bahr, PE

Regional Director | KS, AR, MO, OK
(913) 732-0075
jason.bahr@woodworks.org



David Hanley

Regional Director | CO, MT, NE, ND, SD, WY
(303) 570-8293
david.hanley@woodworks.org



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





Funding Partners

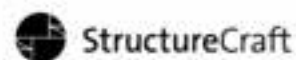




2022 Board Partners



2022 Market Development Partners



2022 Industry Advantage Partners



“The Wood Products Council” is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES), Provider #G516.

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

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

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



Course Description

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

Learning Objectives

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

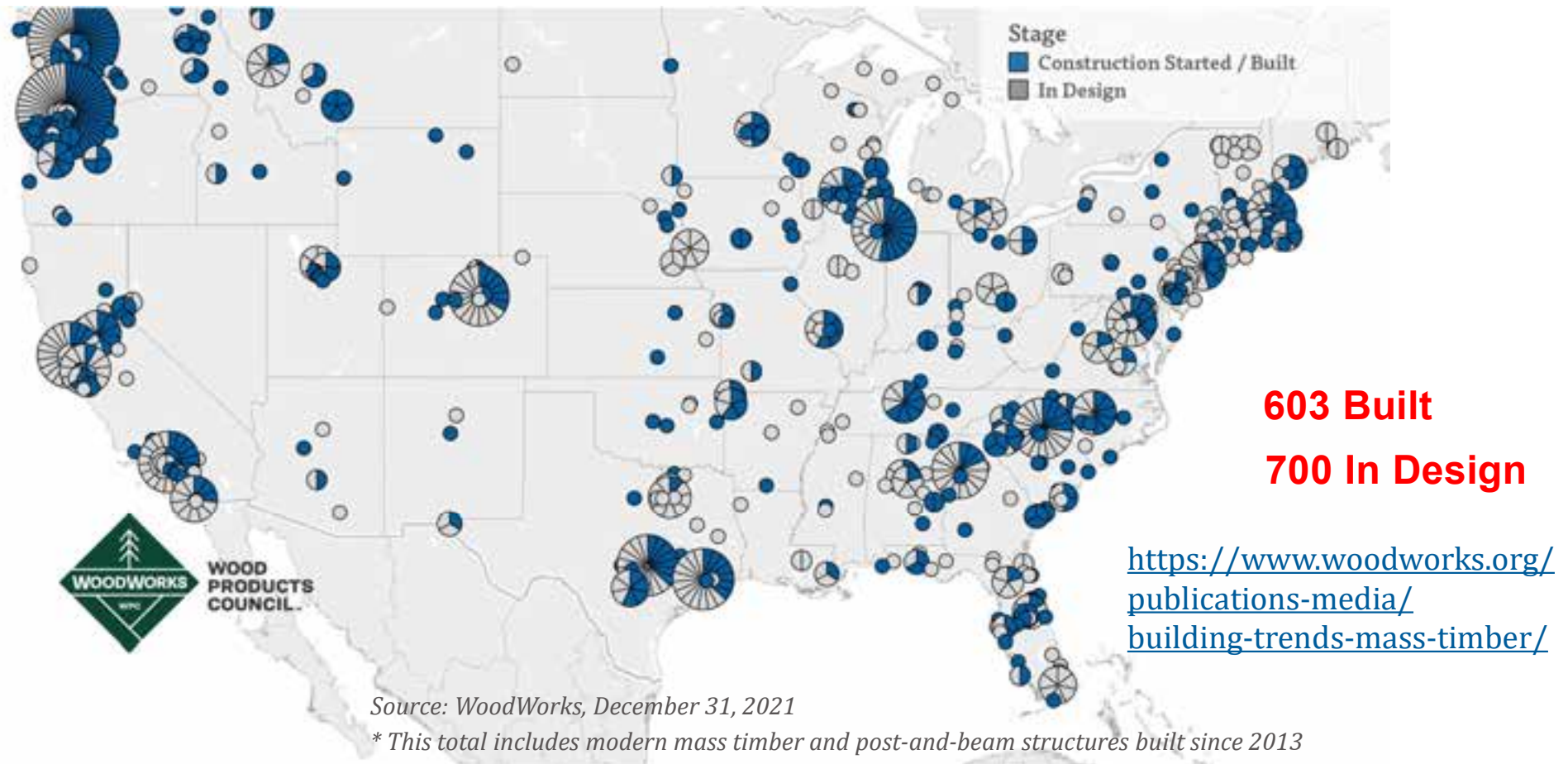
Is Mass Timber a Good Fit for Your Multi-Family Project?



Ascent, Milwaukee, WI
Source: Korb & Associates Architects

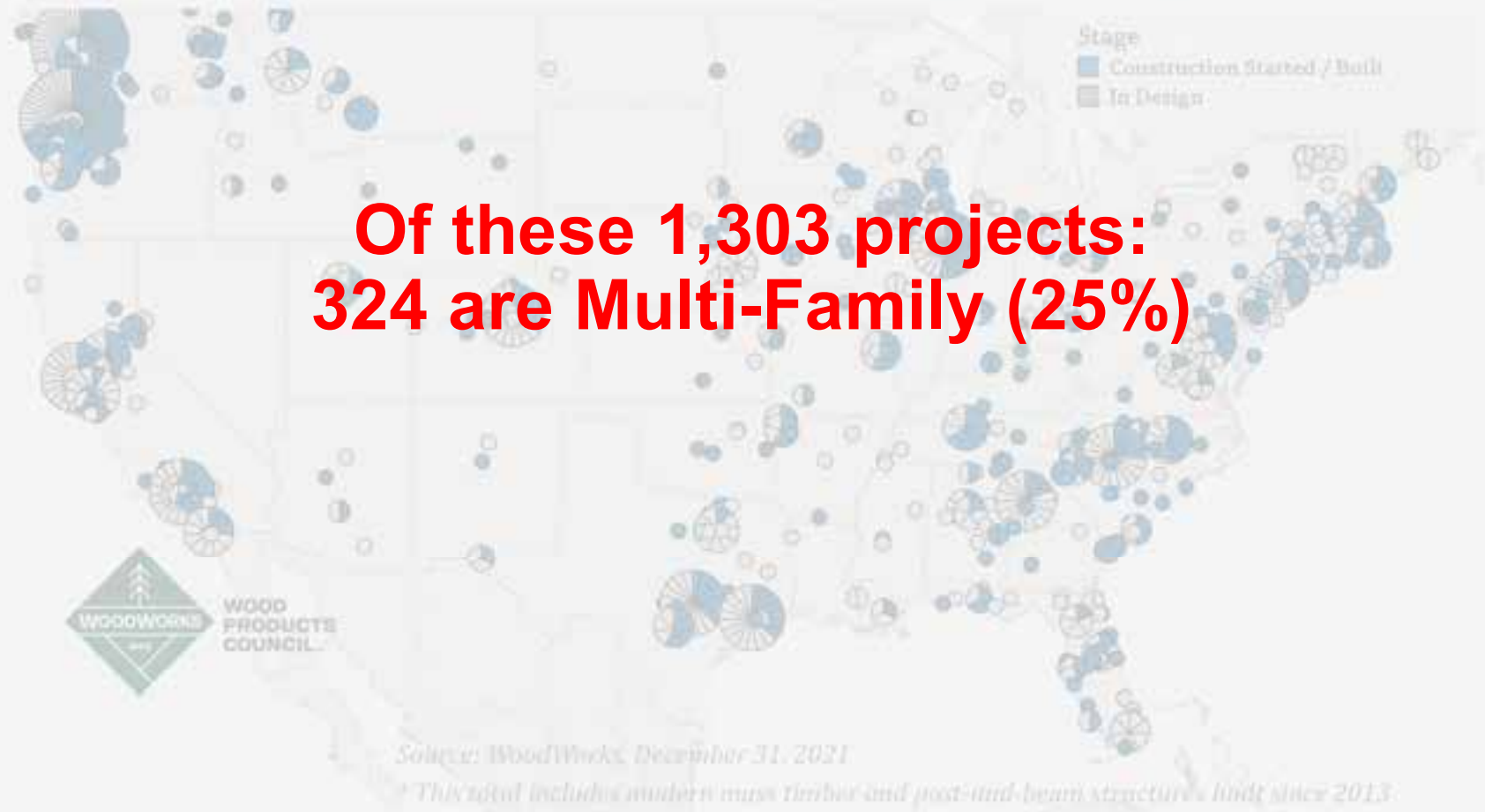
Current State of Mass Timber Projects

As of December 2021, in the US, **1,303** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.



Current State of Mass Timber Projects

As of December 2021, in the US, 1,303 multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.



**Of these 1,303 projects:
324 are Multi-Family (25%)**

Current State of Mass Timber Projects

As of December 2021, in the US, 1,303 multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.

It's NOT One Size Fits All:

Of these 324 Mass Timber Multi-Family Projects:

204 are 1-5 Stories (63%)

106 are 6-12 Stories (33%)

13 are 13+ Stories (4%)



Source: WoodWorks, December 31, 2021

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

MASS TIMBER IN MULTI-FAMILY

EVOLUTION

OR

REVOLUTION?

Multi-Housing Typologies



Credit: WGI

Multi-Housing Typologies

MT Floors & Roofs on
LWF Bearing Walls



Credit: KL&A Engineers & Builders

MT Floors & Roofs on
Post & Beam Framing



Credit: ADX Creative and Engberg Anderson

MT Floors & Roofs on
MT Bearing Walls



Credit: Grey Organschi Architecture and Spiritos Properties

EVOLUTION

INCREMENTAL CHANGE



REVOLUTION

TRANSFORMATIONAL CHANGE

Low- and Mid-Rise Multi-Family



Credit: ADX Creative and Engberg Anderson



Photo: John Klein

HYBRID LIGHT-FRAME + MASS TIMBER

THE KIND PROJECT, SACRAMENTO, CA



Credit: Kalesnikoff Mass Timber

CONDOS AT LOST RABBIT, MS



Lost Rabbit, MS
Credit: Everett Consulting Group

THE POSTMARK APARTMENTS, SHORELINE, WA



Credit: Kattera, Hans-Erik Blomgren

CIRRUS, DENVER, CO



Credit: KL&A Engineers & Builders

CANYONS, PORTLAND, OR



Credit: Jeremy Bittermann & Kaiser + Path

THE DUKE, AUSTIN, TX



Credit: WGI

PROJECT ONE, OAKLAND, CA



Credit: Gurnet Point

WESSEX WOODS, PORTLAND, ME



Credit: Avesta Housing



Photo: Ema Peter

POST, BEAM + PLATE

360 WYTHE AVENUE, BROOKLYN, NY



Credit: Flank



BARRACUDA CONDOS, MADISON, WI



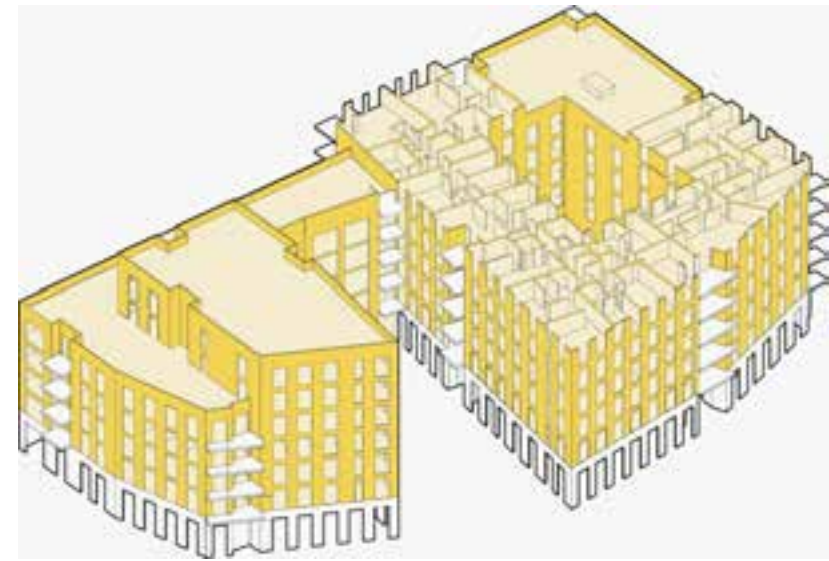
Credit: Populance Architecture and Development



Photo: Lendlease

MASS TIMBER BEARING WALLS

DALSTON WORKS, LONDON



Model C, Roxbury, MA



Credit: John Klein, Generate Architecture



Left: 69 A Street, Boston, MA Credit: Greg Folkins
Above: Timber Lofts, Milwaukee, WI
Credit: ADX Creative and Engberg Anderson Architects

VERTICAL ADDITIONS AND ADAPTIVE REUSE

BREWERY LOFTS, TACOMA, WA



Brewery Lofts, Flynn Architecture, Eclipse Engineering, photos: Brewery Blocks Tacoma, SmartLam



**TIMBER LOFTS
MILWAUKEE, WI**

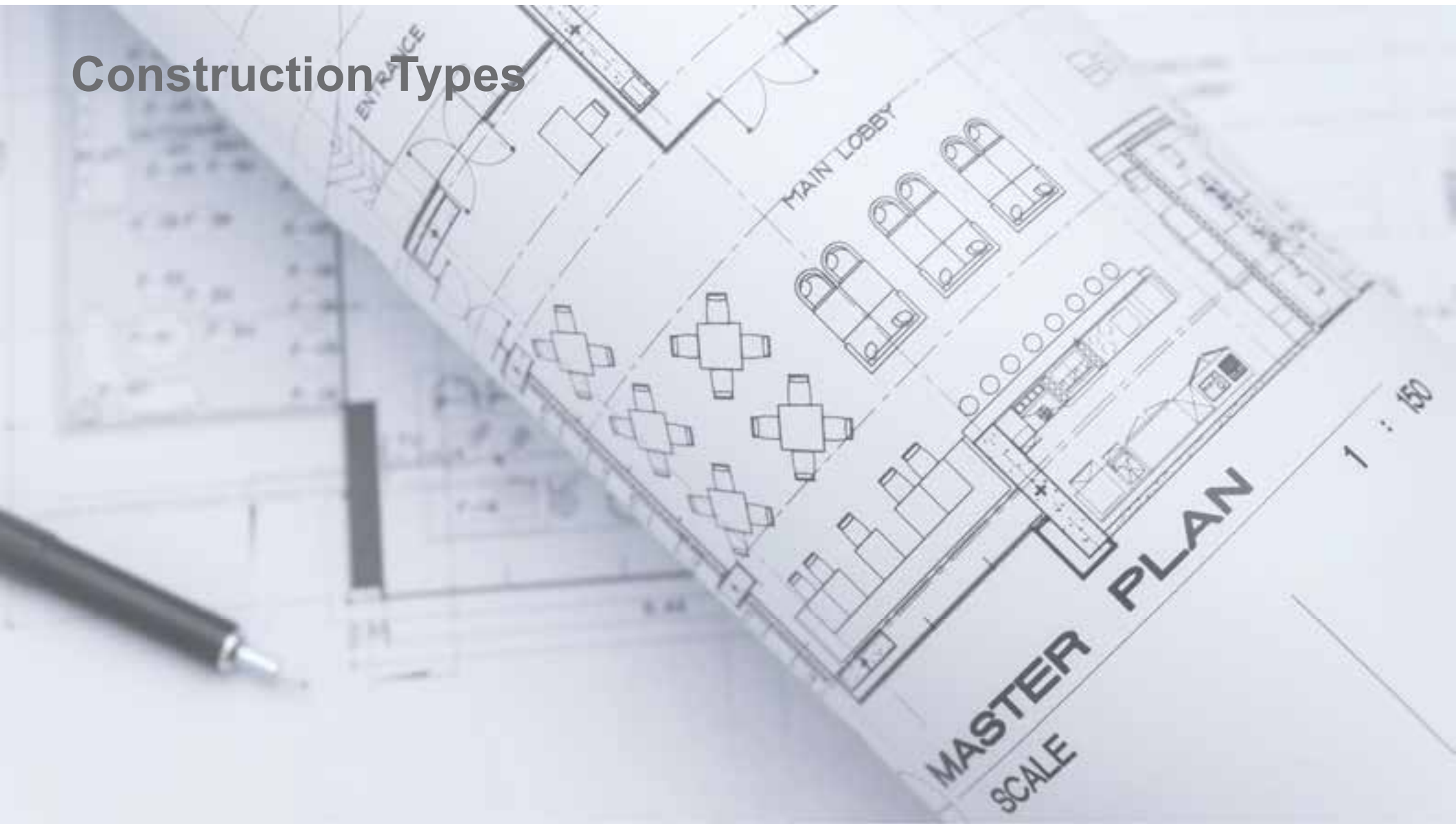
Source: ADX Creative and Engberg Anderson Architects

ANN PIEPER EISENBROWN
OWNER/PRESIDENT | PIPER PROPERTIES
TIMBER LOFTS

“Mass timber shaved 20% off our construction schedule. It's a renewable resource and also creates that warm look.”

Source: Think Wood

Construction Types



Construction Types

When does the code allow mass timber to be used in low- and mid-rise multi-family projects?

IBC defines mass timber systems in IBC Chapter 2 and notes their acceptance and manufacturing standards in IBC Chapter 23

Permitted anywhere that combustible materials and heavy timber are allowed, plus more



Construction Types

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

Construction Types I & II:
All elements required to be non-combustible materials

However, there are exceptions including several for mass timber

Construction Types

All wood framed building options:

Type III

Exterior walls non-combustible (may be FRTW)

Interior elements any allowed by code, including mass timber

Type V

All building elements are any allowed by code, including mass timber

Types III and V are subdivided to A (protected) and B (unprotected)

Type IV (Heavy Timber)

Exterior walls non-combustible (may be FRTW OR CLT)

Interior elements qualify as Heavy Timber (min. sizes, no concealed spaces except in 2021 IBC)

Photo Credit: Hacker Architects, Jeremy Bittermann

Construction Types

Where does the code allow MT to be used?

- Type III: Interior elements (floors, roofs, partitions/shafts) and exterior walls if FRT



ICE Block I, RMW Architecture & Interiors, Buehler Engineering, Bernard André Photography

Construction Types

Where does the code allow MT to be used?

- Type IV: Any exposed interior elements & roofs, must meet min. sizes; exterior walls if CLT or FRT. Concealed space limitations (varies by code version)

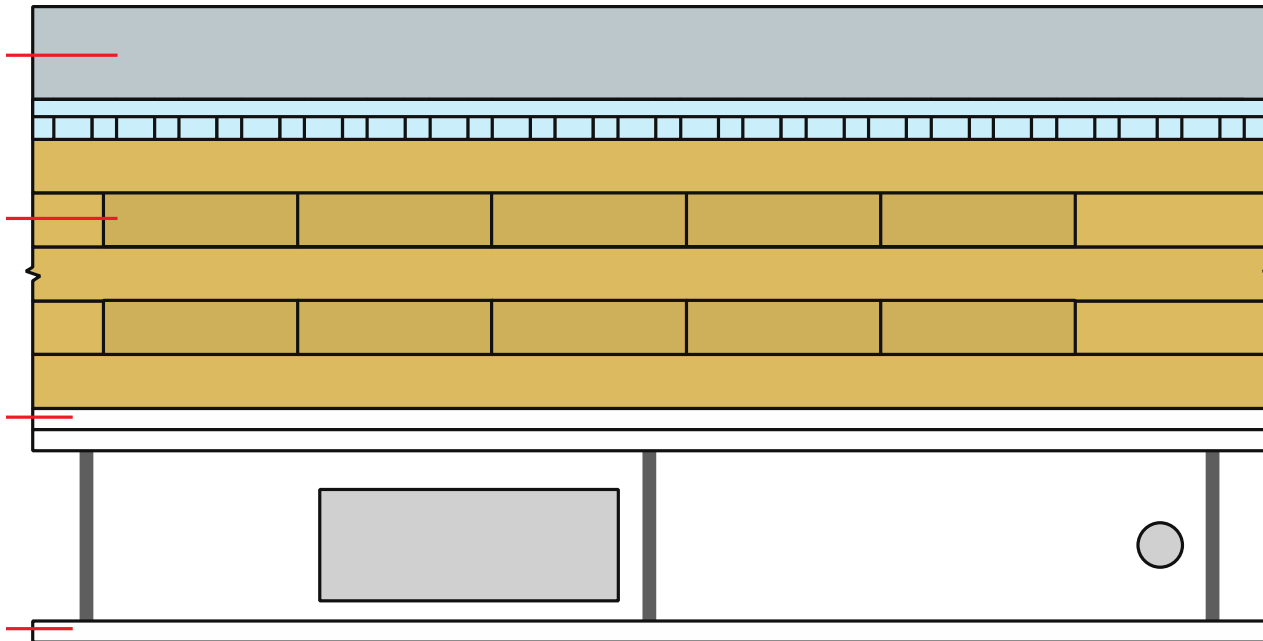


Image: Perkins + Will

Construction Types

Type IV concealed spaces

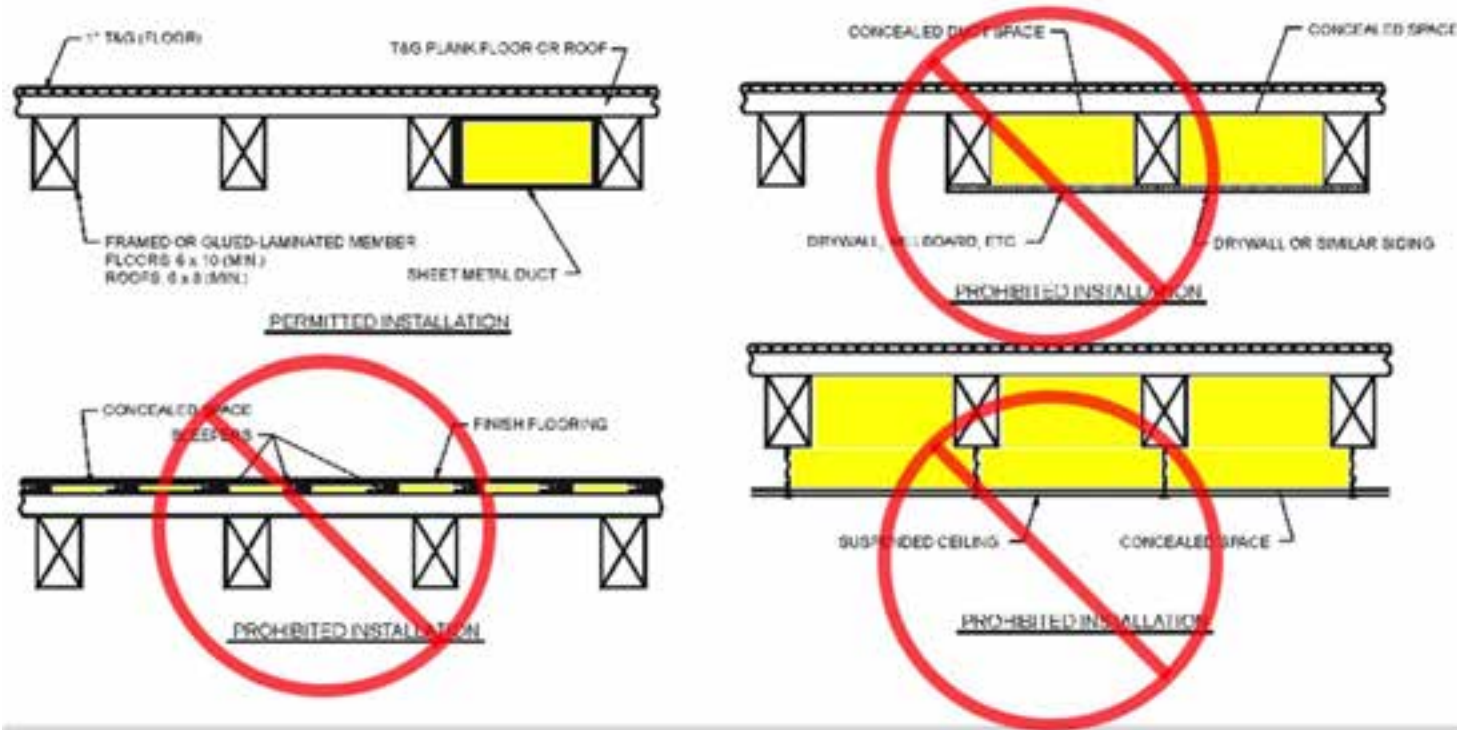
Can I have a dropped ceiling? Raised access floor?



Construction Types

Type IV concealed spaces

Until 2021 IBC, Type IV-HT provisions prohibited concealed spaces



Credit: IBC

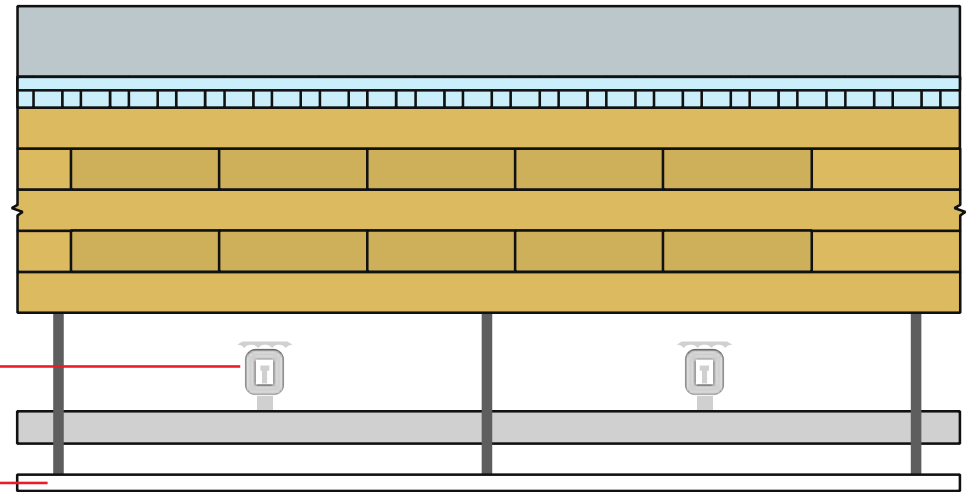
Construction Types

Type IV concealed space options within 2021 IBC

Option 1:

Sprinklers in concealed spaces

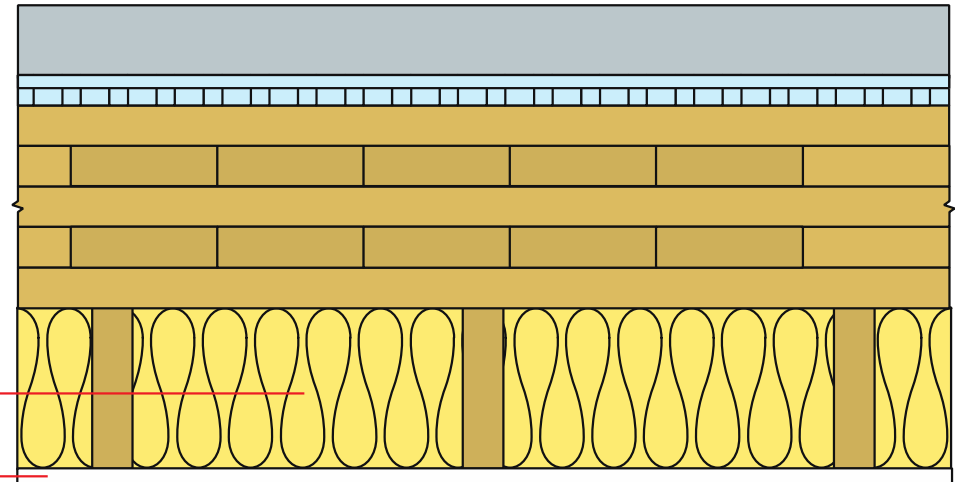
Dropped ceiling



Construction Types

Type IV concealed space options within 2021 IBC

Option 2:



Noncombustible insulation

Dropped ceiling

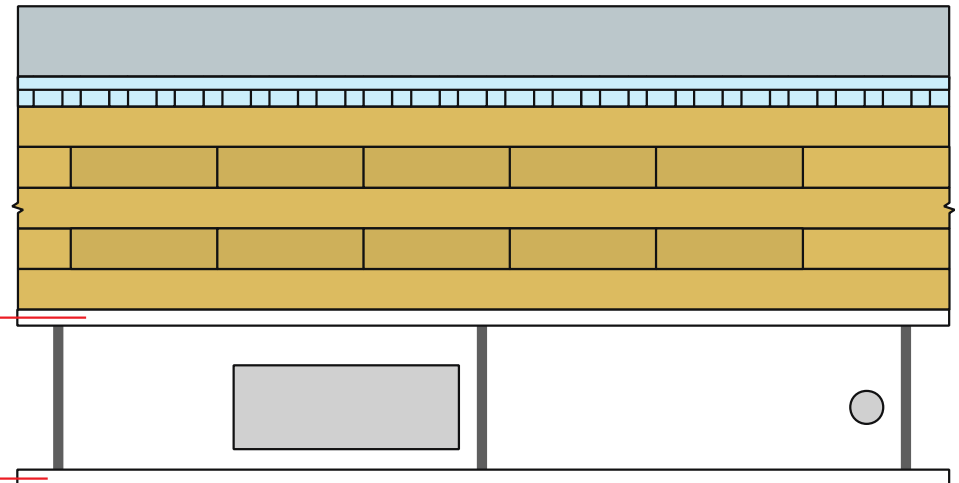
Construction Types

Type IV concealed space options within 2021 IBC

Option 3:

5/8" Type X gypsum on all mass timber surfaces within concealed space

Dropped ceiling



Construction Types

Concealed spaces solutions paper



https://www.woodworks.org/wp-content/uploads/wood_solution_paper-Concealed_Spaces_Timber_Structures.pdf

Construction Types

Where does the code allow MT to be used?

- Type V: All interior elements, roofs & exterior walls



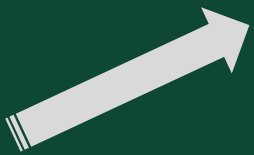
Image: Christian Columbres Photography

EVOLUTION

INCREMENTAL CHANGE

REVOLUTION

TRANSFORMATIONAL CHANGE



Tall Mass Timber Multi-Family



Credit: Harbor Bay Real Estate Advisors, Purple Film, INTRO, Cleveland, OH



CARBON 12, PORTLAND, OR



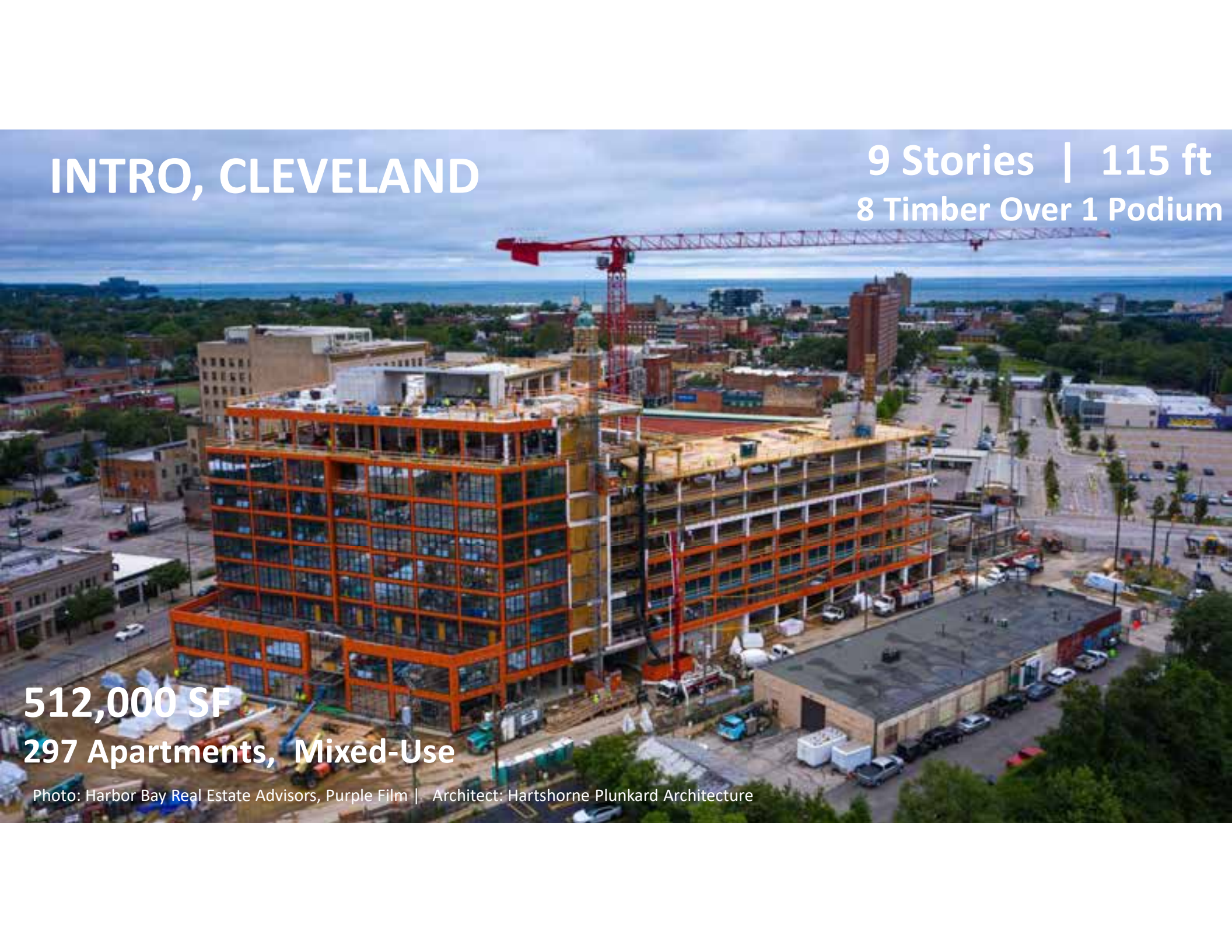
Credit: Baumberger Studio/PATH Architecture

INTRO, CLEVELAND

9 Stories | 115 ft
8 Timber Over 1 Podium

512,000 SF
297 Apartments, Mixed-Use

Photo: Harbor Bay Real Estate Advisors, Purple Film | Architect: Hartshorne Plunkard Architecture



INTRO, CLEVELAND

Type IV-B
Variance to expose ~50% ceilings

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

9 Stories | 115 ft
8 Timber Over 1 Podium



ASCENT, MILWAUKEE



Photo: Korb & Associates Architects |
Architect: Korb & Associates Architects



493,000 SF
259 APARTMENTS, MIXED-USE

ASCENT, MILWAUKEE

Tallest Mass Timber Building in the World



Photo: CD Smith Construction |
Architect: Korb & Associates Architects

ASCENT, MILWAUKEE

25 STORIES

19 TIMBER OVER 6 PODIUM, 284 FT

Photo: Korb & Associates Architects | Architect: Korb & Associates Architects



11 E LENOX, BOSTON, MA

7 STORIES

70 FT

**Passive House
Multi-Family**

Credit: H + O Structural Engineering

Credit: Monte French Design Studio



11 E LENOX, BOSTON, MA



Credit: H + O Structural Engineering

11 E LENOX, BOSTON, MA



Credit: H+O Structural Engineering



PRESCRIPTIVE BUILDING CODES

IBC Table 503: Base Height



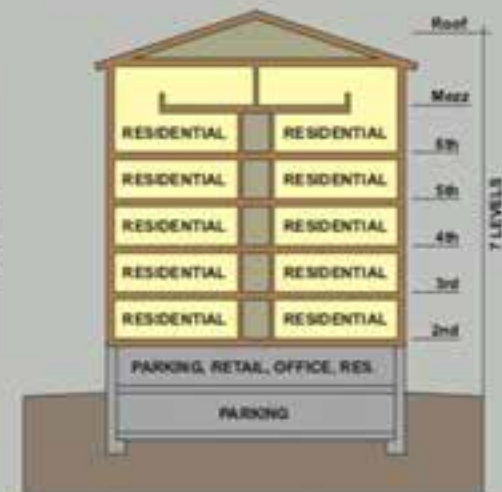
IBC Section 504: NFPA 13-Compliant Sprinkler System



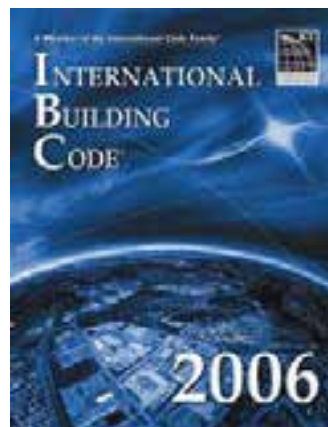
IBC Section 505: Mezzanine



IBC Section 510.2: Podium



3 YEAR CODE CYCLE



Source: ICC



ATF Lab Tests, 2017
Photo: LendLease



ATF Lab Tests, 2017
Photo: LendLease

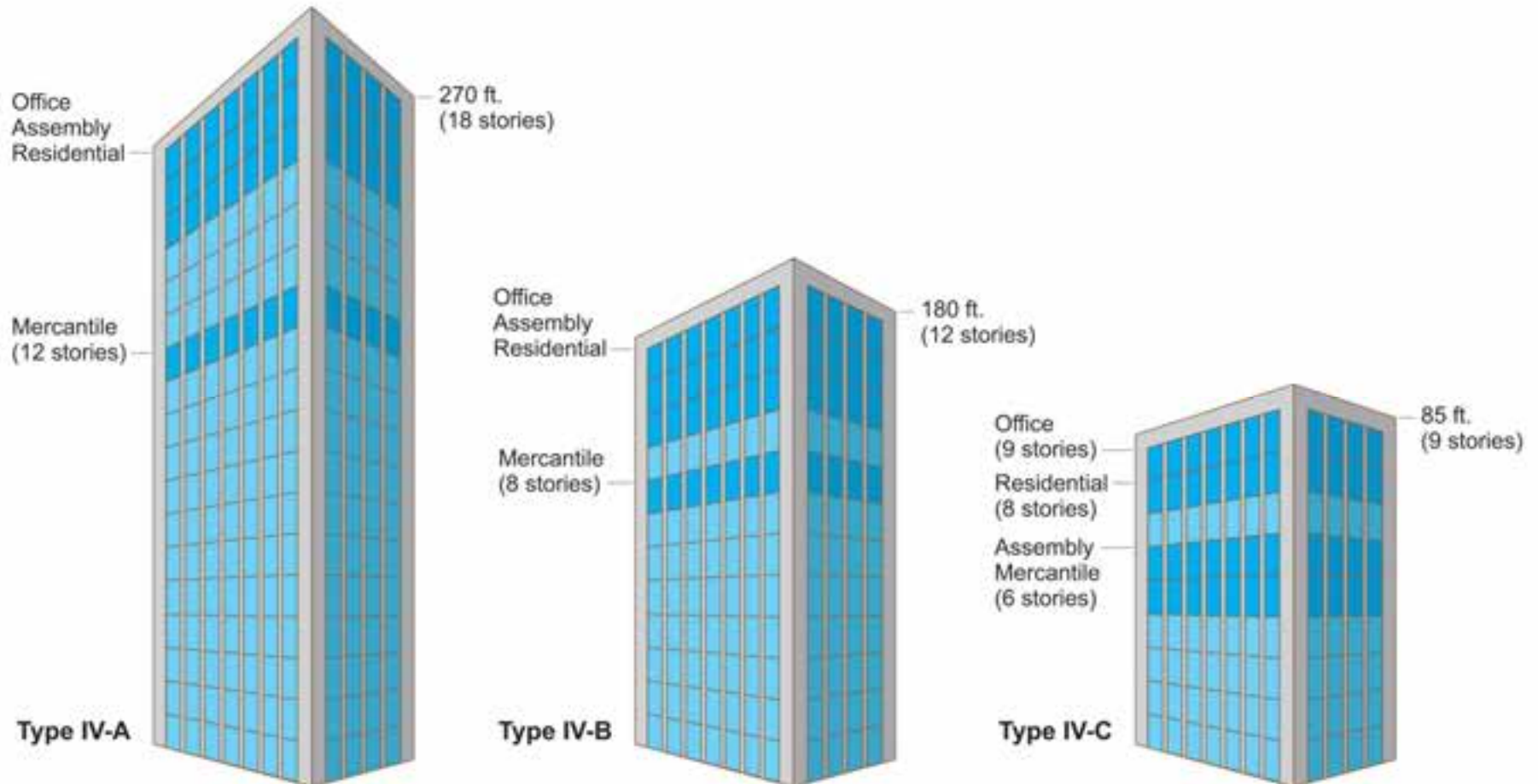


ATF Lab Tests, 2017
Photo: LendLease



ATF Lab Tests, 2017
Photo: LendLease

PRESCRIPTIVE BUILDING CODES



Type IV-C



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

TYPE IV-C

Credit: Susan Jones, atelierjones



Photos: Baumberger Studio/PATH
Architecture/Marcus Kauffman



IV-C

Type IV-C Height and Area Limits

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

Areas exclude potential frontage increase

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

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



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

TYPE IV-C

Credit: Susan Jones, atelierjones

IV-C

Type IV-C Protection vs. Exposed



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

TYPE IV-C

Credit: Susan Jones, atelierjones



Credit: Kaiser+Path, Ema Peter

All Mass Timber surfaces may be exposed

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

IV-C



IV-C



Type IV-B



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

TYPE IV-B

Credit: Susan Jones, atelierjones



Credit: LEVER Architecture



IV-B



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

TYPE IV-B

Credit: Susan Jones, atelierjones

Type IV-B Height and Area Limits

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

Areas exclude potential frontage increase

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

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

IV-B

Type IV-B Protection vs. Exposed



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

TYPE IV-B

Credit: Susan Jones, atelierjones



Credit: Kaiser+Path

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

Type IV-B Protection vs. Exposed

IV-B

Limited Exposed MT allowed in Type IV-B for:

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



Credit: Kaiser+Path

Type IV-B Protection vs. Exposed

IV-B

Mixed unprotected areas, exposing both ceilings and walls:

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

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

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



Credit: Kaiser+Path

Type IV-B Protection vs. Exposed

IV-B

Design Example: Mixing unprotected MT walls & ceilings



Credit: AWC

800 SF dwelling unit

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

Type IV-B Protection vs. Exposed

IV-B

Design Example: Mixing unprotected MT walls & ceilings



Credit: AWC

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

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

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

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

IV-B



IV-B



Type IV-A



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

TYPE IV-A

Credit: Susan Jones, atelierjones



Photos: Structurlam, naturally:wood,
Fast + Epp

IV-A



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

TYPE IV-A

Credit: Susan Jones, atelierjones

Type IV-A Height and Area Limits

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

Areas exclude potential frontage increase

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

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

IV-A

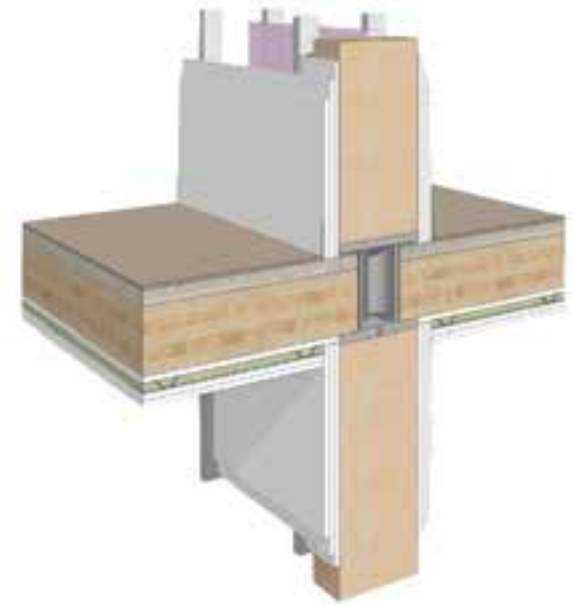
Type IV-A Protection vs. Exposed



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

TYPE IV-A

Credit: Susan Jones, atelierjones



**100% NC protection on all surfaces of
Mass Timber**

IV-A



2024 IBC Changes



RISE Tests, 2020
Photo: RISE



WoodWorks Online Event



Kendeda Building for Innovative Sustainable Design, The Miller Hull Partnership with Lord Aeck Sargent, photo Jonathan Hillier

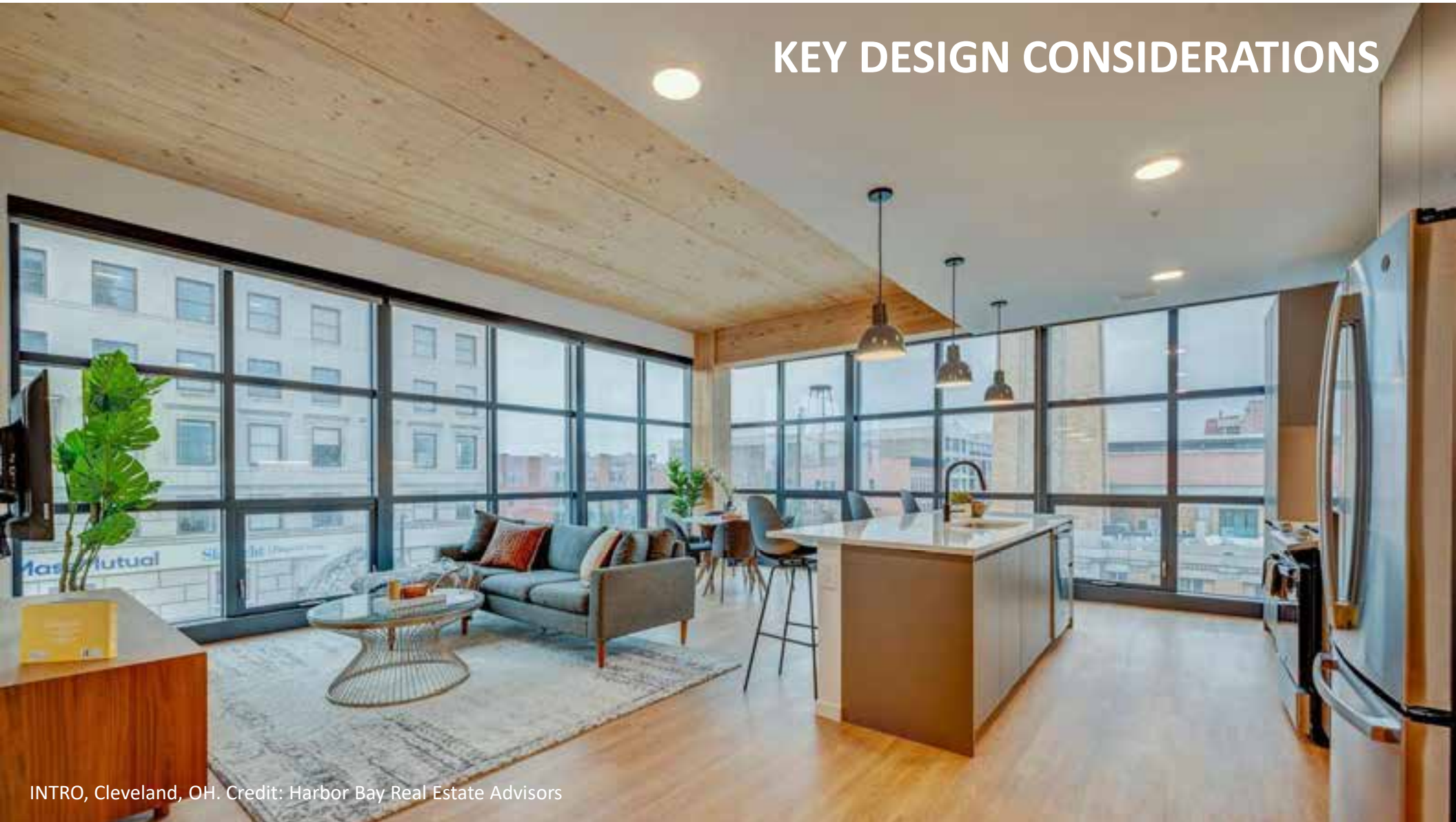


1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography



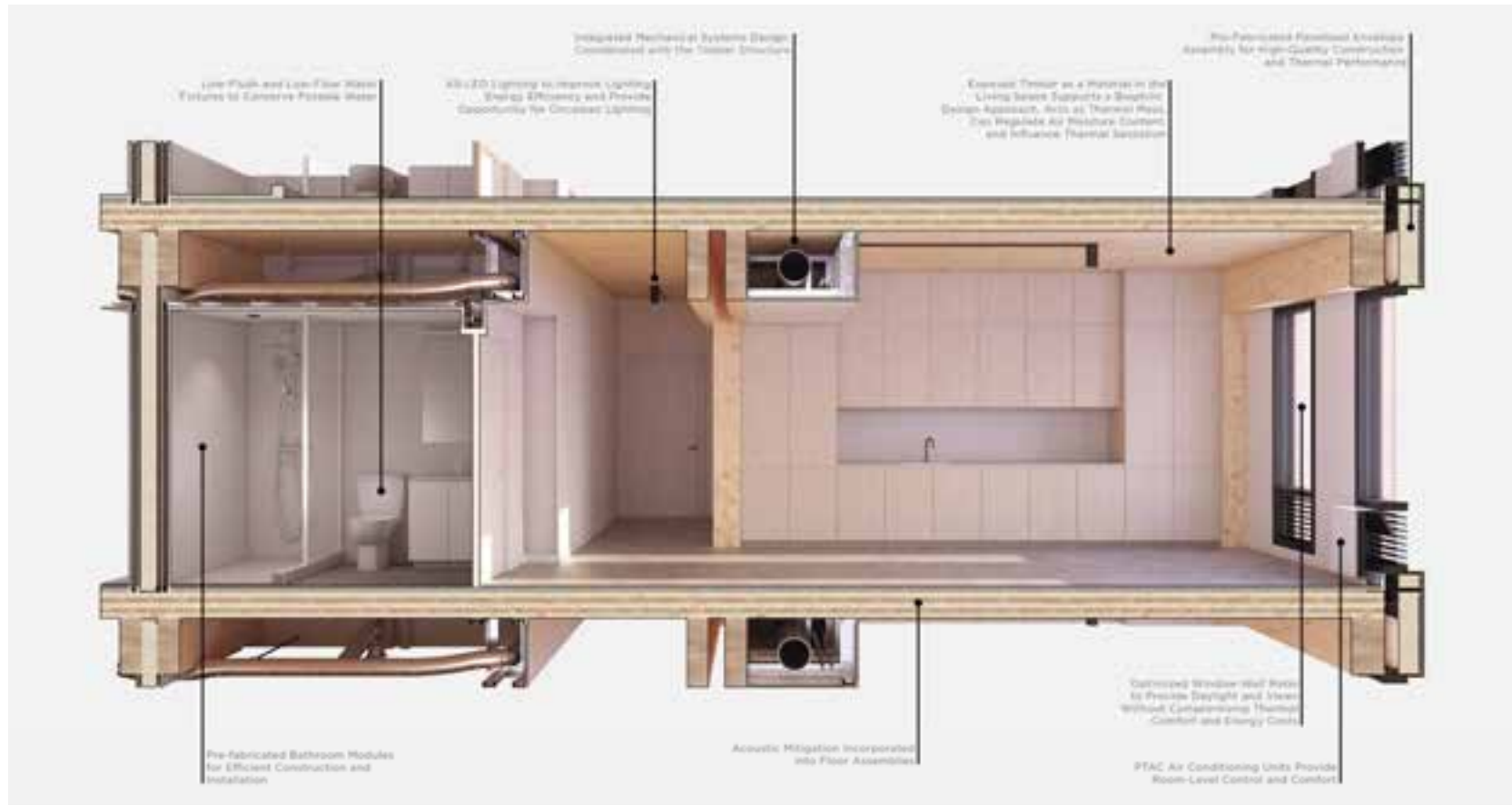
T3 Minneapolis, MGA, DLR Group, Magnusson Klemencic Associates, StructureCraft, photo Ema Peter

KEY DESIGN CONSIDERATIONS



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

MEP SYSTEMS, ROUTING, INTEGRATION



INTEGRATED SYSTEMS

Credit: John Klein, Generate Architecture

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

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

MEP Layout & Integration

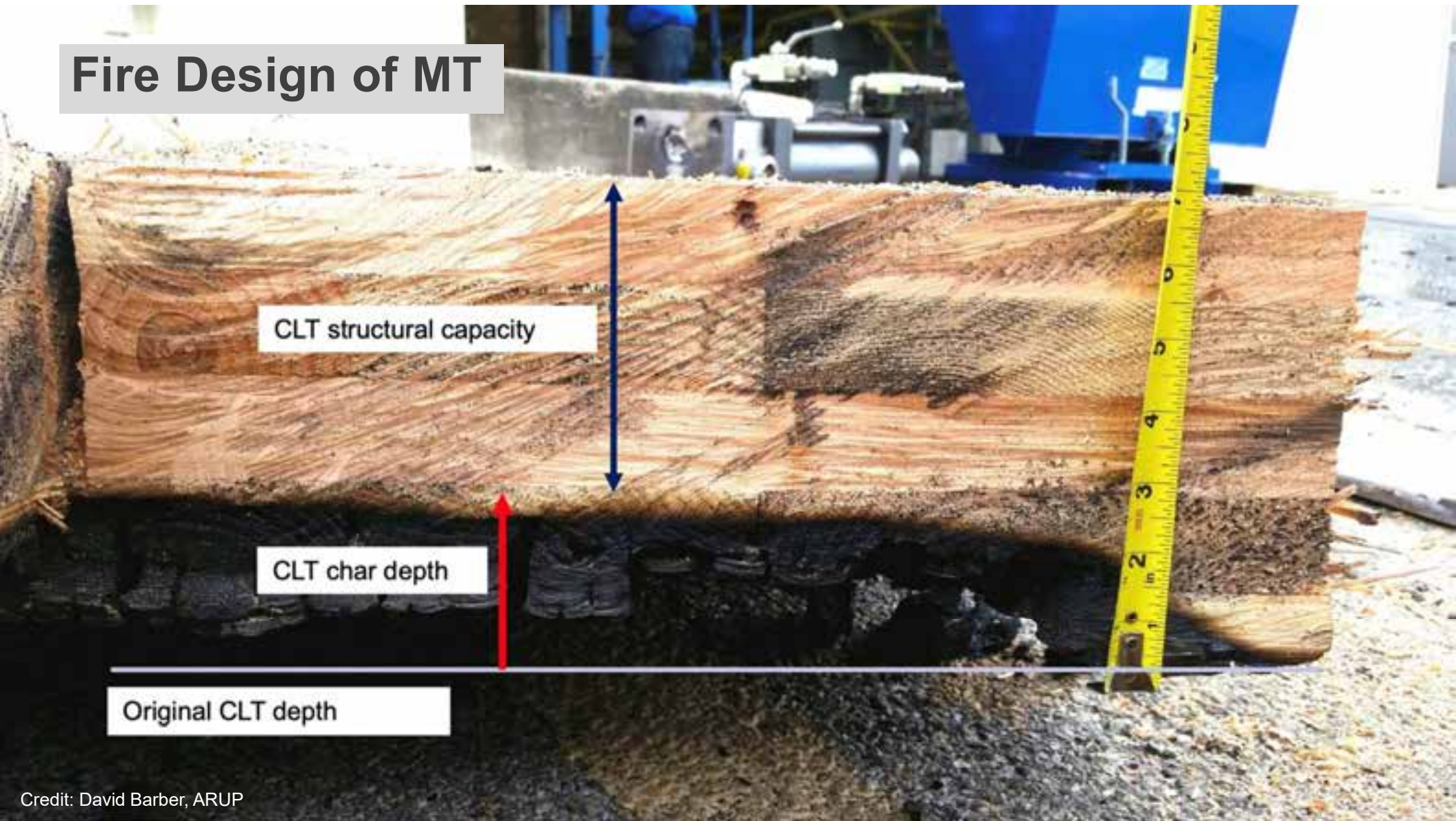
Key considerations:

- Level of exposure desired
- Floor to floor, structure depth & desired head height
- Building occupancy and configuration (i.e. central core vs. double loaded corridor)
- Grid layout and beam orientations
- Need for future tenant reconfiguration
- Impact on fire & structural design: concealed spaces, penetrations



Credit: WoodWorks

Fire Design of MT



Key Early Design Decisions

Fire-Resistance Ratings

- Driven primarily by construction type
- Rating achieved through timber alone or non-com protection required?

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

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

Key Early Design Decisions

Fire-Resistance Ratings (FRR)

- Thinner panels (i.e. 3-ply) generally difficult to achieve a 1+ hour FRR
- 5-ply CLT / 2x6 NLT & DLT panels can usually achieve a 1- or 2-hour FRR
- Construction Type | FRR | Member Size | Grid (or re-arrange that process but follow how one impacts the others)

Panel	Example Floor Span Ranges
3-ply CLT (4-1/8" thick)	Up to 12 ft
5-ply CLT (6-7/8" thick)	14 to 17 ft
7-ply CLT (9-5/8")	17 to 21 ft
2x4 NLT	Up to 12 ft
2x6 NLT	10 to 17 ft
2x8 NLT	14 to 21 ft
5" MPP	10 to 15 ft



Key Early Design Decisions

Construction type influences FRR

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

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A	B	A	B	HT	A	B
Primary structural frame ^f (see Section 202)	3 ^a	2 ^a	1	0	1	0	HT	1	0
Bearing walls									
Exterior ^{e, f}	3	2	1	0	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions	See Table 602								
Exterior									
Nonbearing walls and partitions							See		
Interior ^d	0	0	0	0	0	0	Section	0	0
							602.4.6		
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1½ ^b	1 ^{b, c}	1 ^{b, c}	0 ^c	1 ^{b, c}	0	HT	1 ^{b, c}	0

Source: 2018 IBC

Key Early Design Decisions

Construction type influences FRR

**TABLE 705.1
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)**

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

Source: 2021 IBC

Key Early Design Decisions

Construction type influences FRR

- Type IV-HT Construction (minimum sizes)
- **Other than type IV-HT**: Demonstrated fire resistance

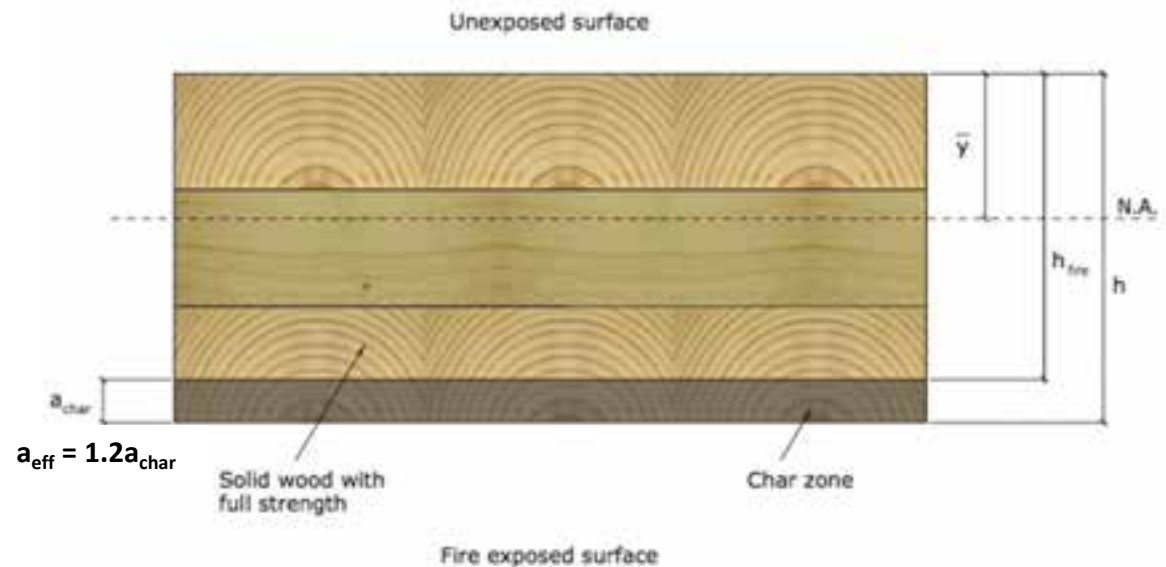
Method of demonstrating FRR (calculations or testing)
can impact member sizing



Key Early Design Decisions

Which Method of Demonstrating FRR of MT is Being Used?

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



FRR Design of MT

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



Code Path for Exposed Wood Fire-Resistance Calculations

IBC 703.3

Methods for determining fire resistance

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



IBC 722

Calculated Fire Resistance

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



NDS Chapter 16

Fire Design of Wood Members

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

FRR Design of MT



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

Table 16.2.1B Effective Char Depths (for CLT with $\beta_n=1.5\text{in./hr.}$)

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



Credit: FPInnovations

FRR Design of MT

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



Credit: ARUP

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

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

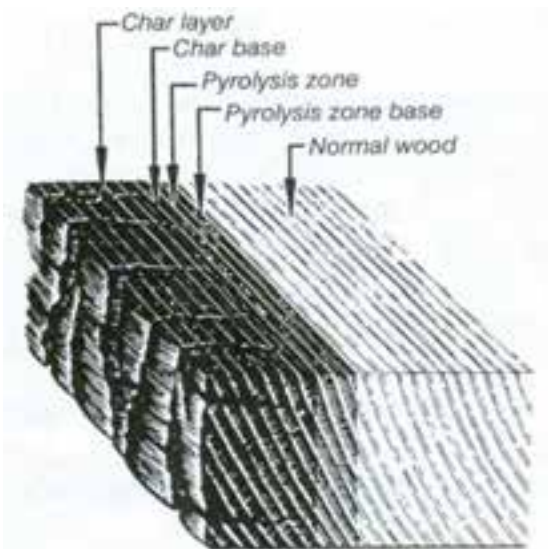
Table 16.2.1B Effective Char Depths (for CLT with $\beta_n=1.5$ in./hr.)

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

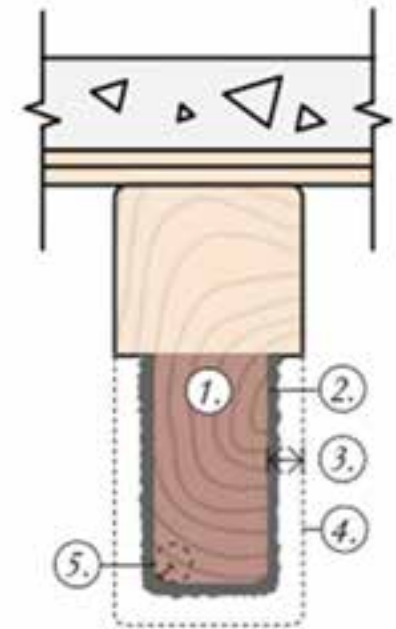
FRR Design of MT

Two structural capacity checks performed:

1. On entire cross section neglecting fire effects
2. On post-fire remaining section, with stress increases



Credit: Forest Products Laboratory



$$a_{\text{char}} = \beta_t t^{0.813}$$

Solid Sawn, Glulam, SCL

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

CLT

$$a_{\text{eff}} = 1.2 a_{\text{char}}$$

Effective Char Depth

FRR Design of MT

WoodWorks Inventory of Fire Tested MT Assemblies

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



CLT Panel	Manufacturer	CLT Grade or Major x Minor Grade	Ceiling Protection	Panel Connection in Test	Floor Topping	Load Rating	Fire Resistance Achieved (Hours)	Source	Testing Lab
3-ply CLT (118mm 4.644 in)	Nordic	SPF 1400 Fb L2EMR x SPF #1	2 layers 1/2" Type X gypsum	Half Lap	None	Reduced 14% Moment Capacity	1	1 (Test 1)	NRC Fire Laboratory
3-ply CLT (140mm 5.511 in)	Interstratum	SPF #1 #2 x SPF #1 #2	1 layer 1/2" Type X gypsum	Half Lap	None	Reduced 77% Moment Capacity	1	1 (Test 3)	NRC Fire Laboratory
3-ply CLT (175mm 6.875")	Nordic	E1	None	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	2	NRC Fire Laboratory March 2016
3-ply CLT (175mm 6.875")	Nordic	E1	1 layer of 1/2" Type X gypsum under 2" channels and furring strips with 3/8" Rhombus bars	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	3	NRC Fire Laboratory Nov 2014
3-ply CLT (175mm 6.875")	Nordic	E1	None	Topside Spline	3/4 in. proprietary gypsum over Maxon acoustical mat	Reduced 59% Moment Capacity	1.5	3	UL
3-ply CLT (175mm 6.875")	Nordic	E1	1 layer 1/2" normal gypsum	Topside Spline	3/4 in. proprietary gypsum over Maxon acoustical mat or proprietary sound board	Reduced 14% Moment Capacity	2	4	UL
3-ply CLT (175mm 6.875")	Nordic	E1	1 layer 3/8" Type X gypsum under Beuflex Channel under 7/8" furring strips with 1/2" Mineral Wool between furring	Half Lap	None	Loaded, See Manufacturer	2	21	Intertek 8/24/2012
3-ply CLT (175mm 6.875")	Interstratum	E1 M1 MFR 2100 x SPF #2	None	Topside Spline	1/2" Maxon Cyp-Glue 2000 or Maxon Reinforcing Mesh	Loaded, See Manufacturer	2.5	6	Intertek, 2/22/2016
3-ply CLT (175mm 6.875")	DR Johnson	V1	None	Half Lap & Topside Spline	2" gypsum topping	Loaded, See Manufacturer	2	7	SwRI (May 2016)
3-ply CLT (175mm 6.875")	Nordic	SPF 1400 Fb MDR x SPF #1	None	Half Lap	None	Reduced 59% Moment Capacity	1.5	1 (Test 3)	NRC Fire Laboratory
3-ply CLT (175mm 6.875")	Interstratum	SPF #1 #2 x SPF #1 #2	1 layer 1/2" Type X gypsum	Half Lap	None	Unreduced 100% Moment Capacity	2	1 (Test 6)	NRC Fire Laboratory
3-ply CLT (245mm 9.65")	Interstratum	SPF #1 #2 x SPF #1 #2	None	Half Lap	None	Unreduced 100% Moment Capacity	2.5	1 (Test 7)	NRC Fire Laboratory
3-ply CLT (175mm 6.875")	SmartLam	SL-V4	None	Half Lap	nominal 1/2" plywood with 5/8 nails	Loaded, See Manufacturer	2	12 (Test 4)	Western Fire Center 10/26/2016
3-ply CLT (175mm 6.875")	SmartLam	V1	None	Half Lap	nominal 1/2" plywood with 5/8 nails	Loaded, See Manufacturer	2	12 (Test 3)	Western Fire Center 10/26/2016
3-ply CLT (175mm 6.875")	DR Johnson	V1	None	Half Lap	nominal 1/2" plywood with 5/8 nails	Loaded, See Manufacturer	2	12 (Test 6)	Western Fire Center 11/01/2016
3-ply CLT (140mm 5.511 in)	KLT	CV3M1	None	Half Lap & Topside Spline	None	Loaded, See Manufacturer	1	14	SwRI

FRR Design of MT



Fire-Resistive Design of Mass Timber Members

Code Applications, Construction Types and Fire Ratings

Richard McCull, P.E., SE • Senior Technical Director • WoodWorks
David Starnes, P.E., SE • Senior Technical Director • WoodWorks

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

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

are leveraging to create innovative designs with a warm yet modern aesthetic, often for projects that go beyond traditional norms of wood design.

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

Mass Timber & Construction Type

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

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

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

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

Type IV IBC 602.4: Commonly referred to as "heavy timber" construction, this option



Colwell 1 Penthouse, Oregon
Floor Slab / 2nd Automobile
Machine Structural Engineering

Mass Timber Fire Design Resource

- Code compliance options for demonstrating FRR
- Free download at woodworks.org

Acoustics & Sound Control



Acoustics & Sound Control

Consider Impacts of:

- Timber & Topping Thickness
- Panel Layout
- Gapped Panels
- Connections & Penetrations
- MEP Layout & Type

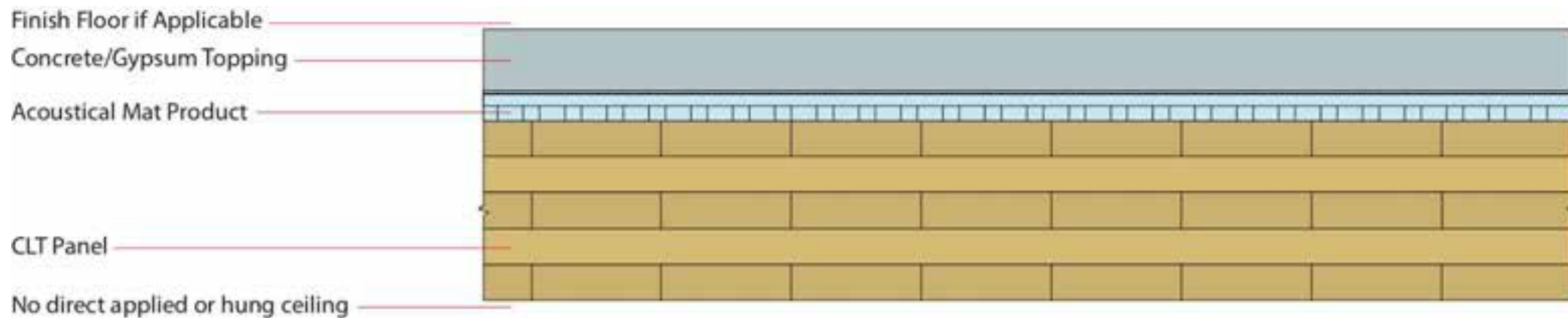


Credit: Rothoblaas

Acoustics & Sound Control



Images: Maxxon

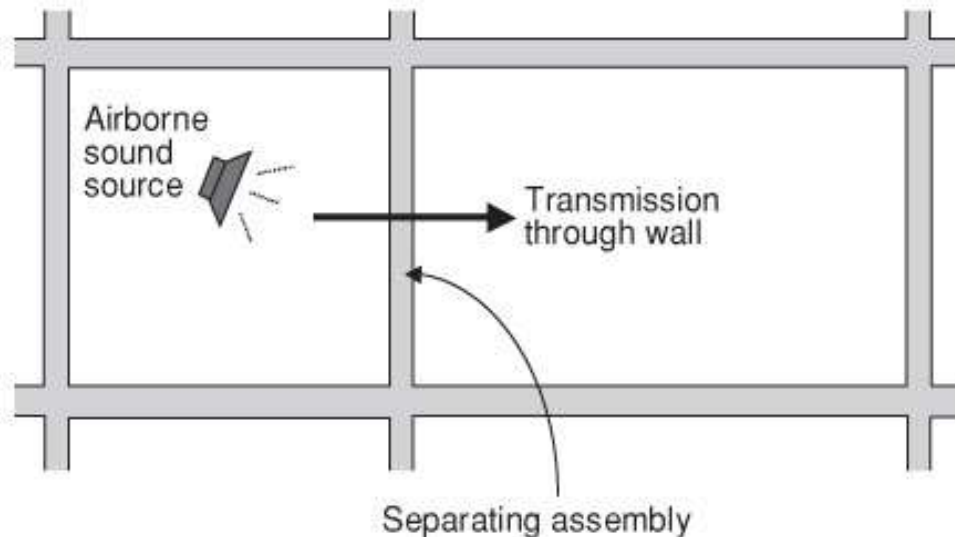


Acoustics & Sound Control

Air-Borne Sound:

Sound Transmission Class (STC)

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

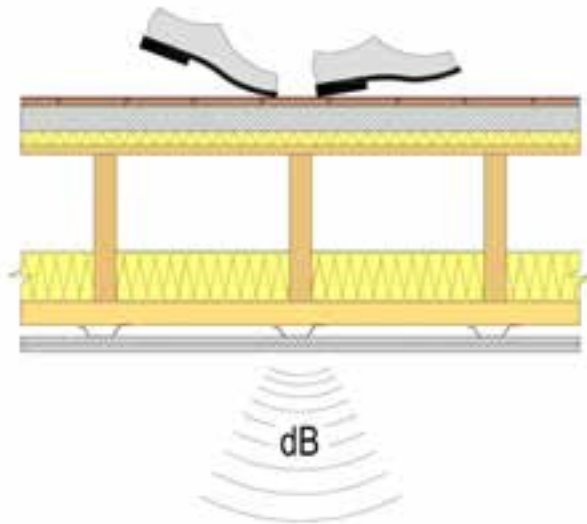


Acoustics & Sound Control

Structure-borne sound:

Impact Insulation Class (IIC)

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



Acoustics & Sound Control

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



Acoustics & Sound Control

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

Acoustics & Sound Control

MT: Structure Often is Finish



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

Acoustics & Sound Control

But by Itself, Not Adequate for Acoustics



Acoustics & Sound Control

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, WoodWorks⁷

Acoustics & Sound Control

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

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

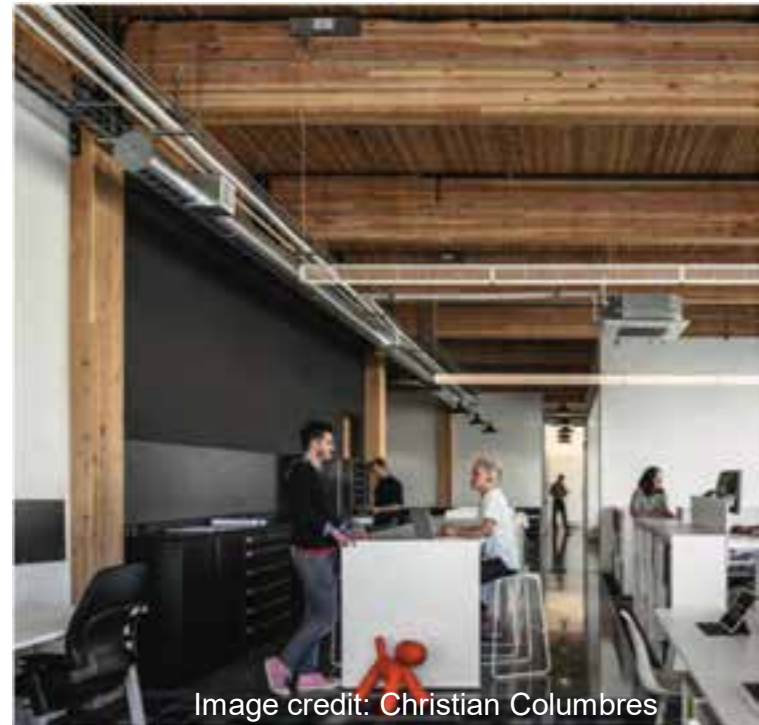
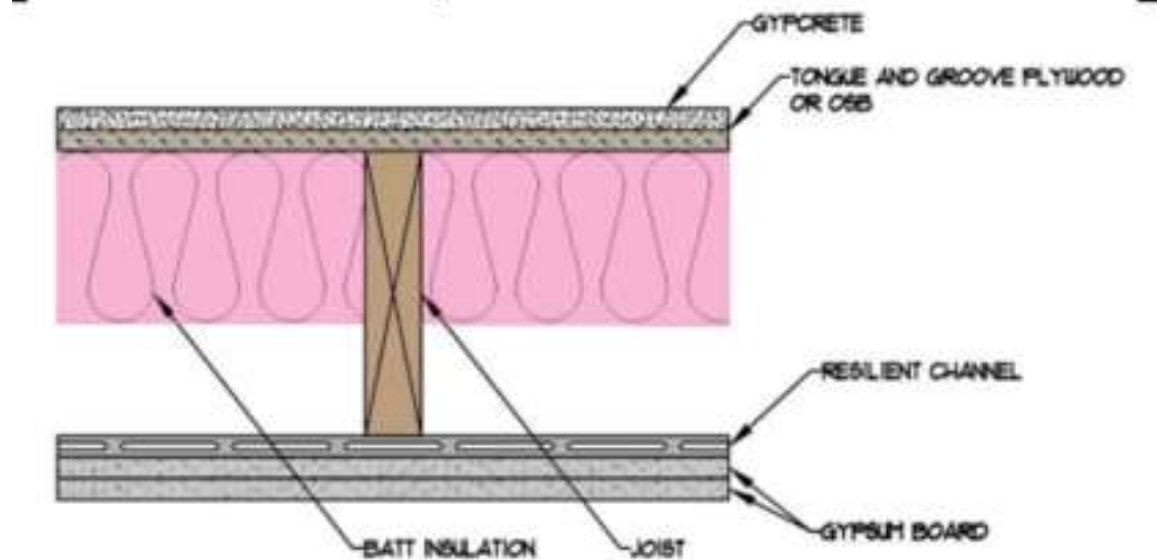


Image credit: Christian Columbres

Acoustics & Sound Control

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

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

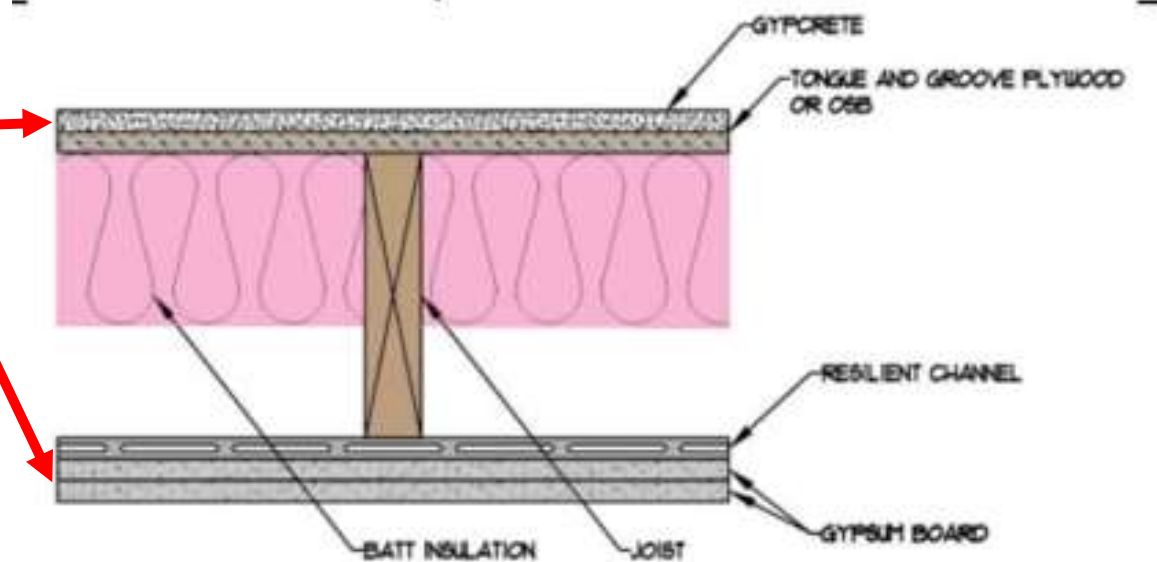


STC 62

Acoustics & Sound Control

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

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

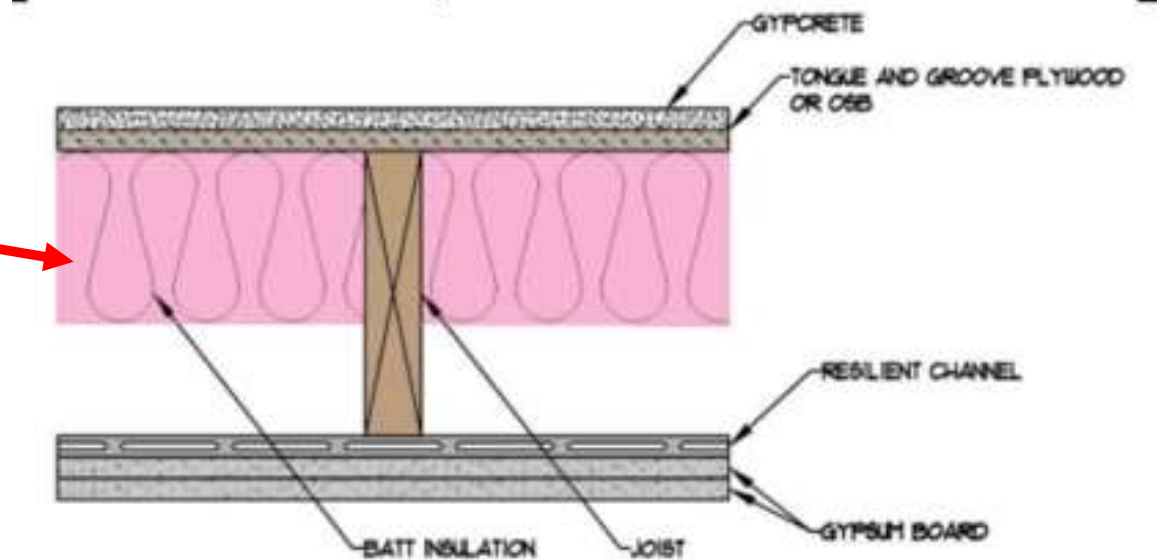


STC 62

Acoustics & Sound Control

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

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

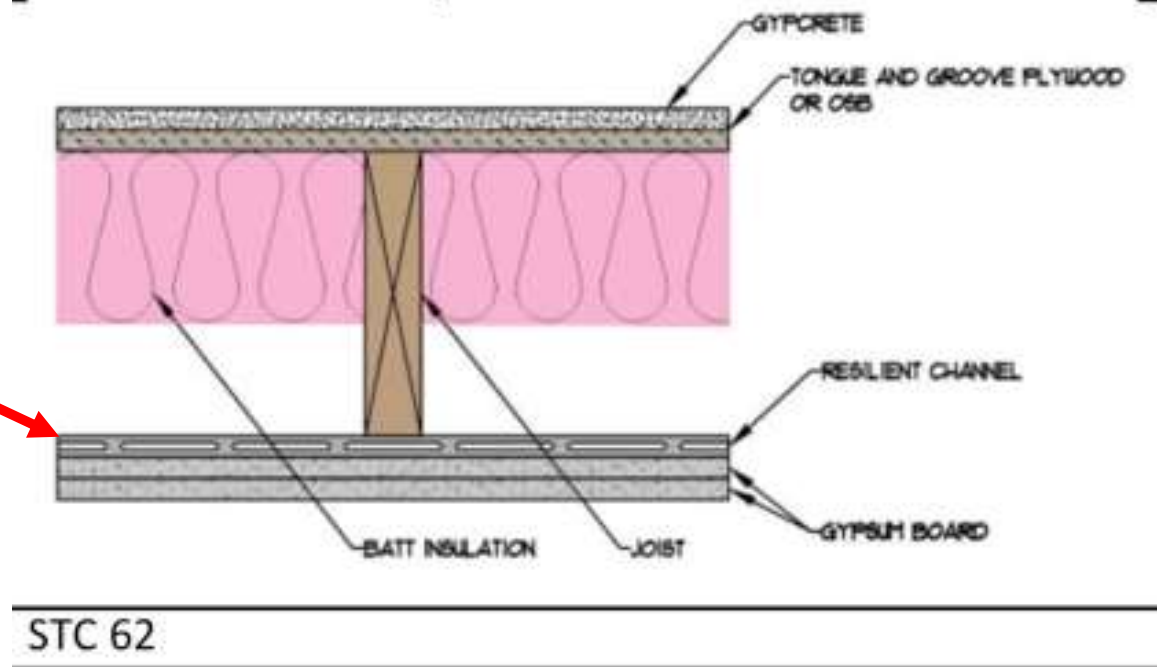


STC 62

Acoustics & Sound Control

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

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



Acoustics & Sound Control

Mass timber has relatively low “mass”

Recall the three ways to increase acoustical performance:

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



Credit: Christian Columbres

Acoustics & Sound Control



Concrete Slab:

6" Thick

80 PSF

STC 53



CLT Slab:

6-7/8" Thick

18 PSF

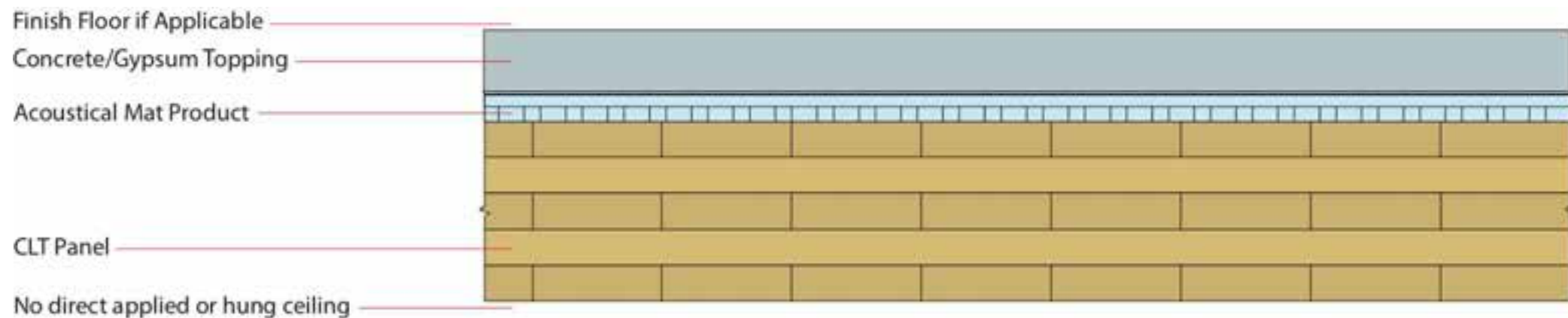
STC 41



Acoustics & Sound Control

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

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



Acoustics & Sound Control

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 $\frac{1}{4}$ " to 1"+



Credit: Maxxon

Acoustics & Sound Control

Acoustical floor underlayments



Photo: AcoustiTECH™



Photo: Kinetics Noise Control, Inc.™



Photo: Maxxon Corporation



Photo: Pileq Inc.™

Acoustics & Sound Control

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

Acoustics & Sound Control

Solutions Paper



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

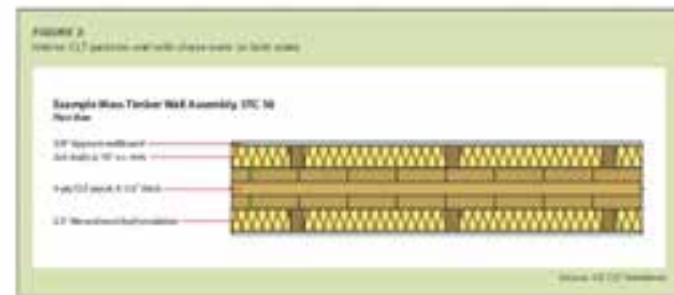
Richard Kline, PE, SE • Senior Technical Advisor • WoodWorks



Photo courtesy of WoodWorks. Interior view of a modern office space with mass timber walls and ceiling.

The growing availability and wide acceptance of mass timber—i.e., large solid wood panel products such as engineered timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof control has long been designed as a structural 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 at times, 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.



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 on top of the mass timber wall or installing gypsum wallboard on resilient channels that are attached to the mass timber wall. As with some mass timber floor panels, bare mass timber walls don't typically provide adequate noise control, and chase walls also function as sound bar improvements. For example, a 3-ply CLT wall panel with a thickness of 5.0" has an STC rating of 51.¹ In contrast, Figure 2 shows an interior CLT partition wall with chase walls on both sides. This assembly achieves an STC rating of 58, exceeding the IBC's acoustic requirements for multi-family construction.² 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, gaps have also been done on other mass timber panel options such as NLT and glued-laminated timber (GLT), 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-grain 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 compares 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 acoustic performance objectives.

One way to minimize flanking paths at these connections and interfaces is to use resilient connection joints and resilient strips. These products are capable of reducing structure-borne or structure-borne vibrations between structural members and connections while providing isolation and breaking hard direct connections between members. In the context of this three-methods for improving acoustic performance noted above, these strips act as decouplers. With air-gaps, connections, interfaces and penetrations, there is a much greater chance that the acoustic performance of a mass timber building will meet expectations.



Resilient connection strips

Photo: WoodWorks

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

Acoustics & Sound Control

Inventory of Tested Assemblies



Acoustically-Tested Mass Timber Assemblies

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

Contents:

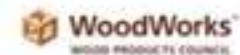
Table 1: CLT Floor Assemblies with Concrete/Gypsum Topping, Ceiling Side Exposed	2
Table 2: CLT Floor Assemblies without Concrete/Gypsum Topping, Ceiling Side Exposed.....	7
Table 3: CLT Floor Assemblies without Concrete/Gypsum Topping, with Wood Sleepers, Ceiling Side Exposed	9
Table 4: NLT, GLT & T&G Decking Floor Assemblies, Ceiling Side Exposed.....	11
Table 5: Mass Timber Floor Assemblies with Ceiling Side Concealed	14
Table 6: Single CLT Wall	21
Table 7: Single NLT Wall.....	26
Table 8: Double CLT Wall	29
Sources.....	32
Disclaimer	34

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

Acoustics & Sound Control

Inventory of Tested Assemblies

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



CLT Panel	Concrete/Gypsum Topping	Acoustical Mat Product Between CLT and Topping	Finish Floor	STC ^a	IIC ^a	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	
			None	49 ² ASTC	45 ² AIIC	
	1-1/2" Levelrock*	Maxxon Acousti-Mat® 1/2 Premium	LVT	-	47 ² AIIC	
			LVT on Acousti-Top*	-	49 ² AIIC	
		USG SAM N25 Ultra	None	45 ^a	39 ^a	15
			LVT	48 ^a	47 ^a	16
			LVT Plus	48 ^a	49 ^a	58
			Eng Wood	47 ^a	47 ^a	59
			Carpet + Pad	45 ^a	67 ^a	60
			Ceramic Tile	50 ^a	46 ^a	61
		None	None	45 ^a	42 ^a	15
			LVT	48 ^a	44 ^a	16

Mass Timber in Multi-Family

Early Design Decision Example

7-story, 84 ft tall multi-family building

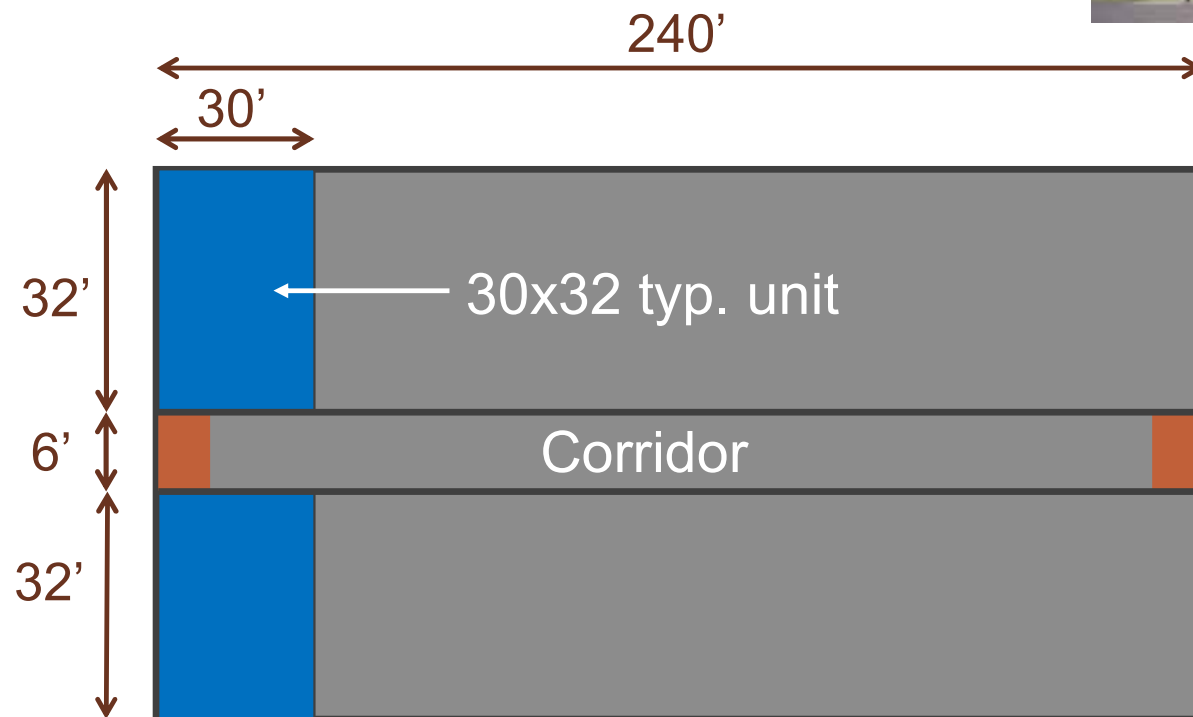
- Parking & Retail on 1st floor, residential units on floors 2-7
- NFPA 13 sprinklers throughout
- Floor plate = 18,000 SF
- Total Building Area = 126,000 SF



Key Early Design Decisions

Early Design Decision Example

7-story, multi-family building, typ. floor plan:

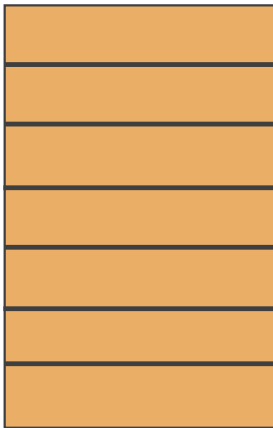


Key Early Design Decisions

Early Design Decision Example

MT Construction Type Options:

- 7 stories of IV-C
- 5 stories of IIIA over 2 stories of IA podium
- 5 stories of IV-HT over 2 stories of IA podium



Credit: Monte French Design Studio

Key Early Design Decisions

Early Design Decision Example

MT Construction Type Options:

- 7 stories of IV-C
- 5 stories of IIIA over 2 stories of IA podium
- 5 stories of IV-HT over 2 stories of IA podium

Implications of Type IV-C:

- 2 hr FRR, all exposed floor panels, beams, columns
- Likely will need at least 5-ply CLT / 2x6 NLT/DLT
- Efficient spans in the 14-17 ft range
- Efficient grids of that or multiples of that (i.e. 30x25, etc)
- No podium required
- CLT exterior walls permitted

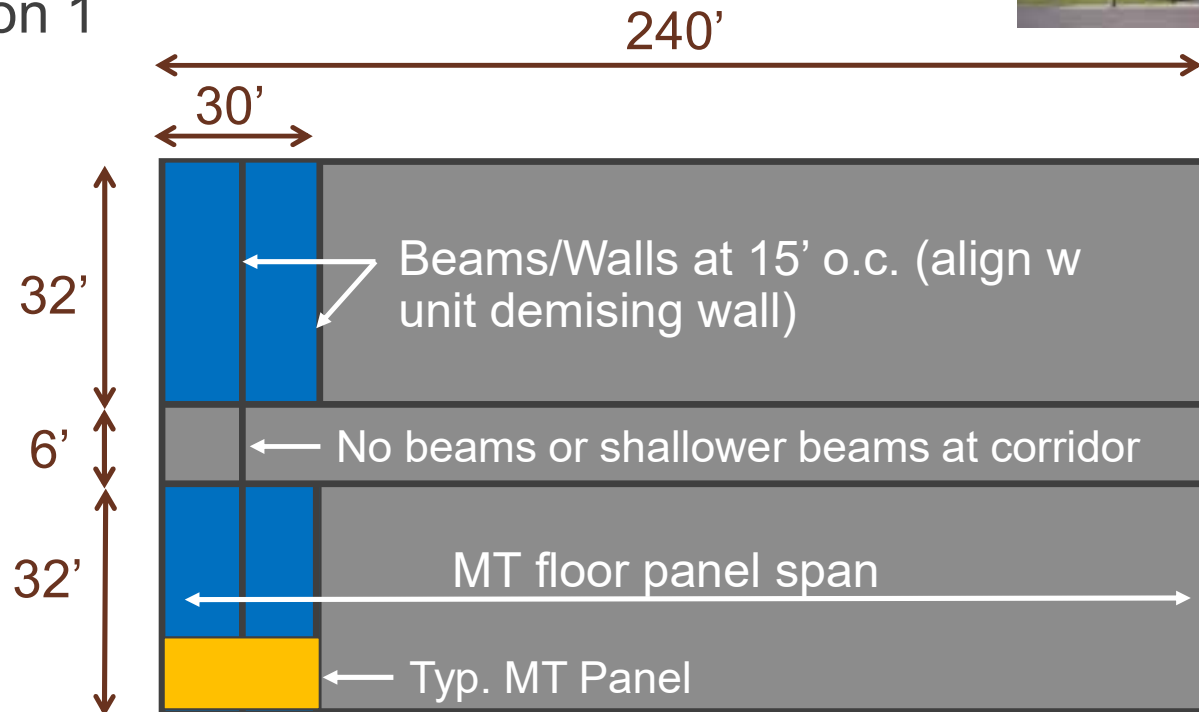


Key Early Design Decisions

Early Design Decision Example

Type IV-C Grid Options

- Option 1

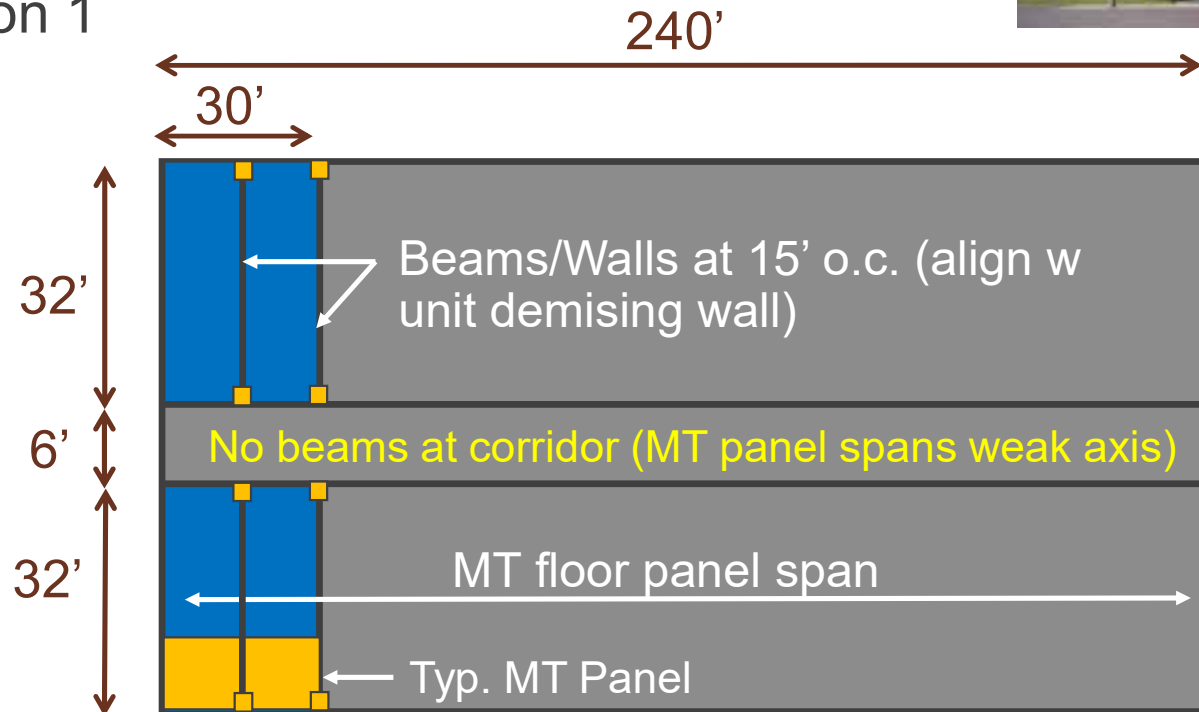


Key Early Design Decisions

Early Design Decision Example

Type IV-C Grid Options

- Option 1

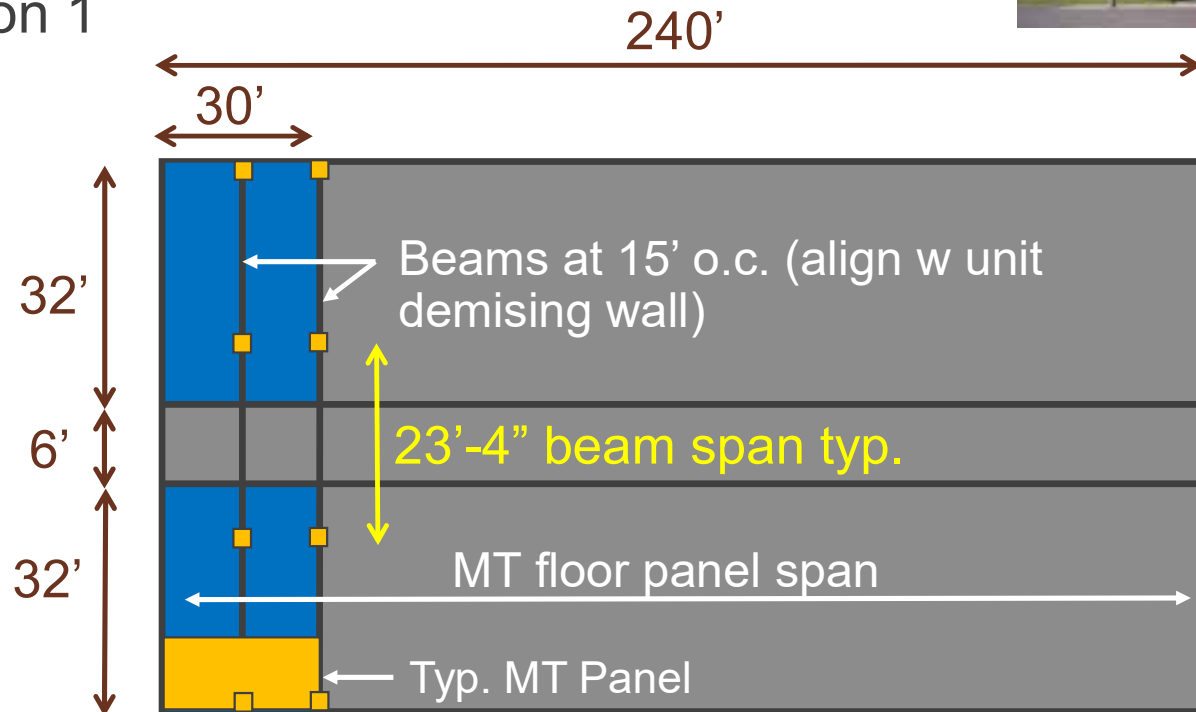


Key Early Design Decisions

Early Design Decision Example

Type IV-C Grid Options

- Option 1

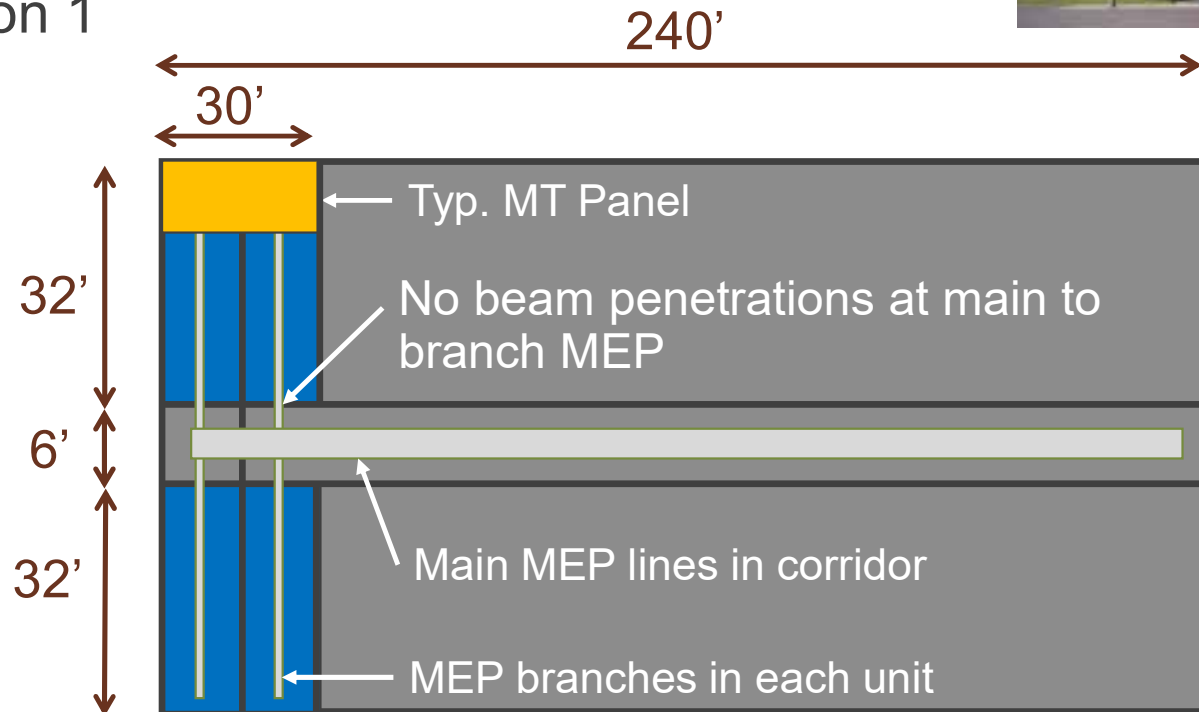


Key Early Design Decisions

Early Design Decision Example

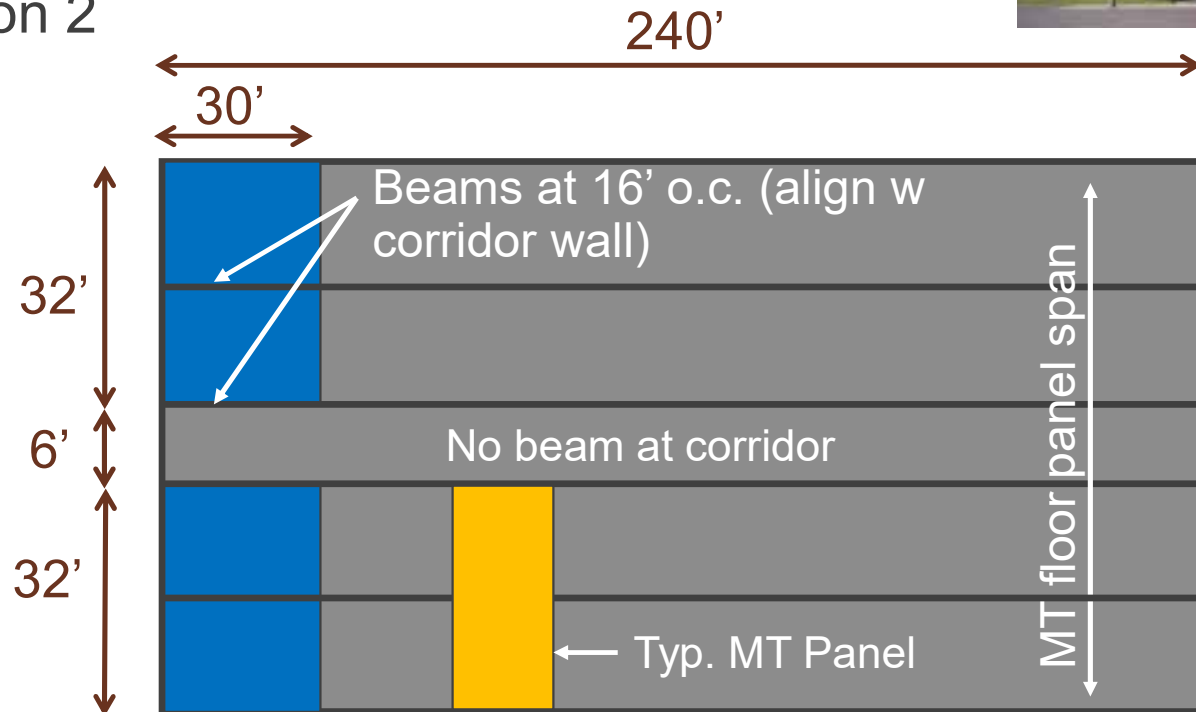
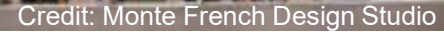
Type IV-C Grid Options

- Option 1



Early Design Decision Example

- Option 2

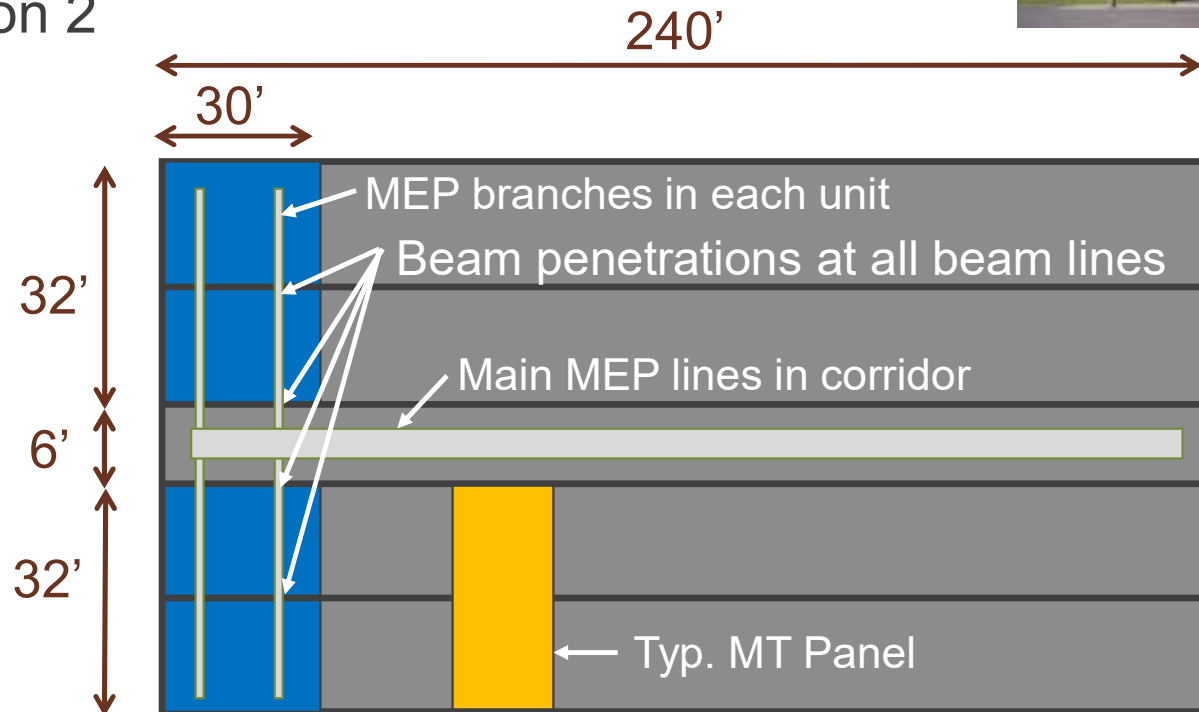


Key Early Design Decisions

Early Design Decision Example

Type IV-C Grid Options

- Option 2



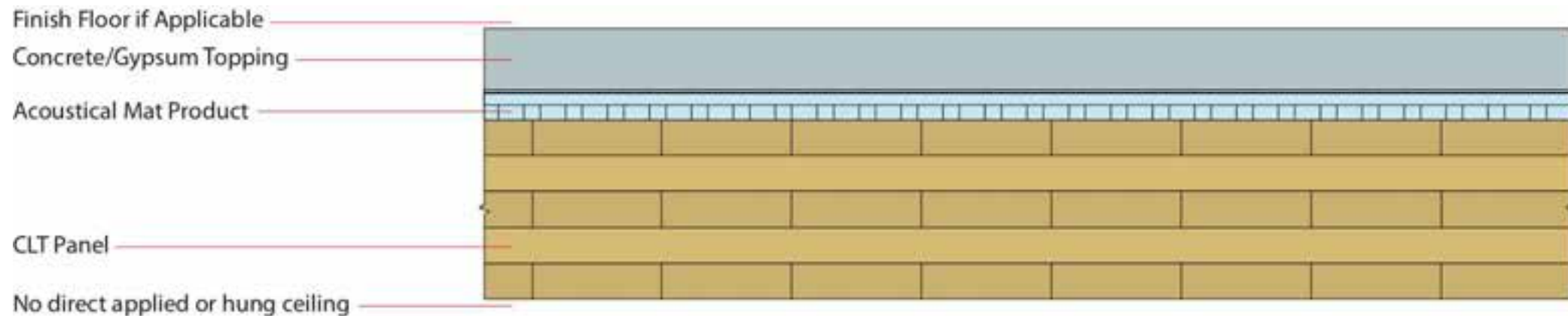
Key Early Design Decisions

Early Design Decision Example

Type IV-C Floor Assembly Options



Credit: Monte French Design Studio



- 2-hr FRR: 5-ply CLT (tested assembly) or 7-ply CLT (char calculations)
- STC & IIC 50 min: 2" topping (5-ply CLT) or 1.5" topping (7-ply CLT)

Note: many other acoustic mat and topping options exist, one example shown here

Note: 5-ply is most efficient for the 15-16 ft panel spans shown

Key Early Design Decisions

Early Design Decision Example

MT Construction Type Options:

- 7 stories of IV-C
- 5 stories of IIIA over 2 stories of IA podium
- 5 stories of IV-HT over 2 stories of IA podium

Implications of Type IIIA:

- 1 hr FRR
- Potential to use 3-ply or thin 5-ply CLT
- Efficient spans vary with panel thickness
- Efficient grids of that or multiples of that (i.e. 20x25, etc)
- 1 story Type IA podium required
- CLT exterior walls not permitted

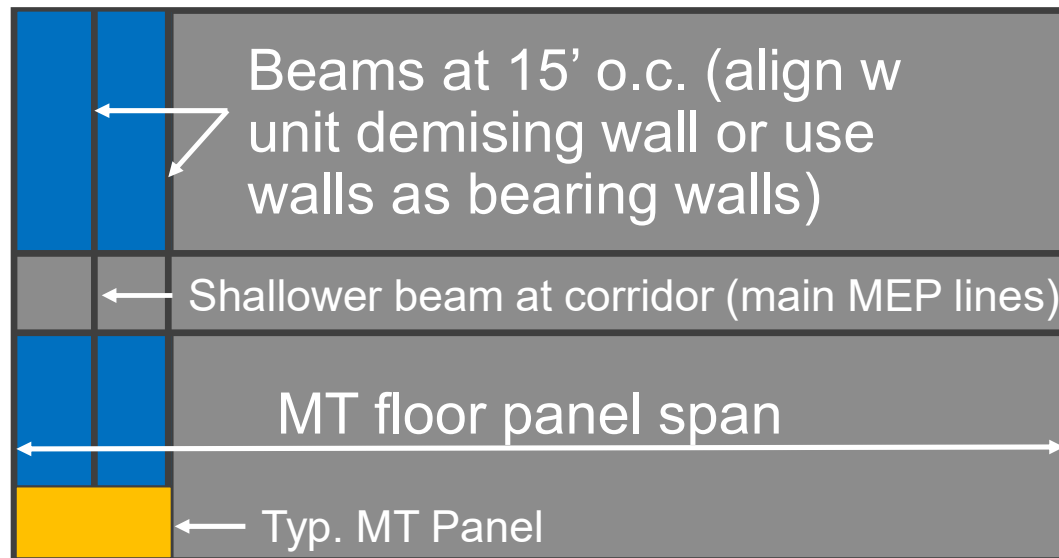


Key Early Design Decisions

Early Design Decision Example

Type IIIA Grid Options

- Option 1

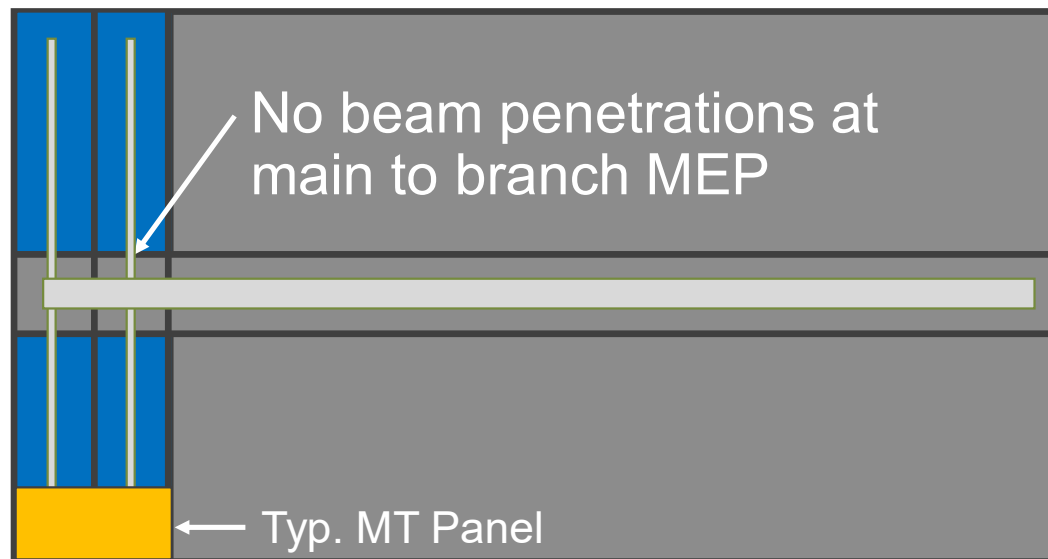


Key Early Design Decisions

Early Design Decision Example

Type IIIA Grid Options

- Option 1

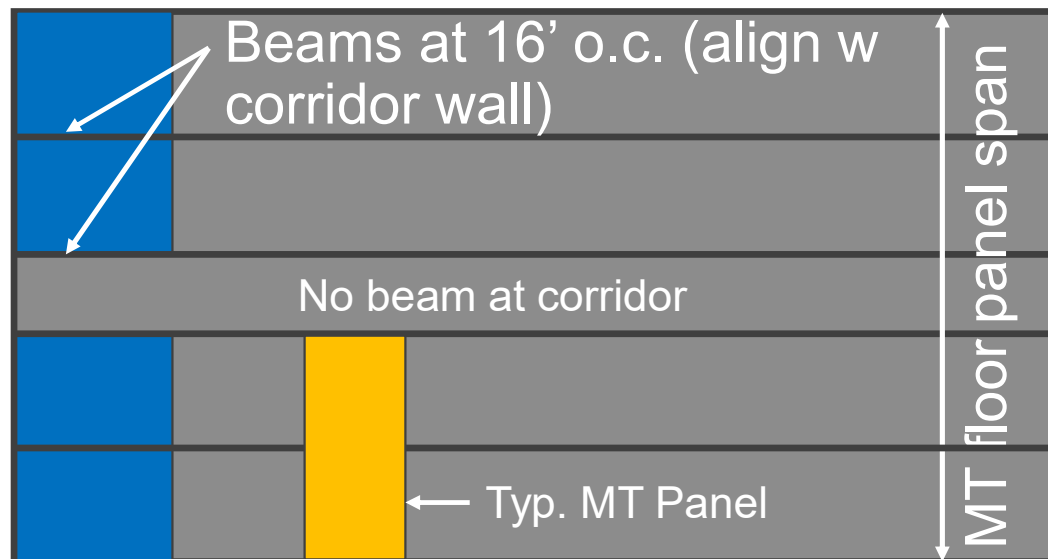


Key Early Design Decisions

Early Design Decision Example

Type IIIA Grid Options

- Option 2

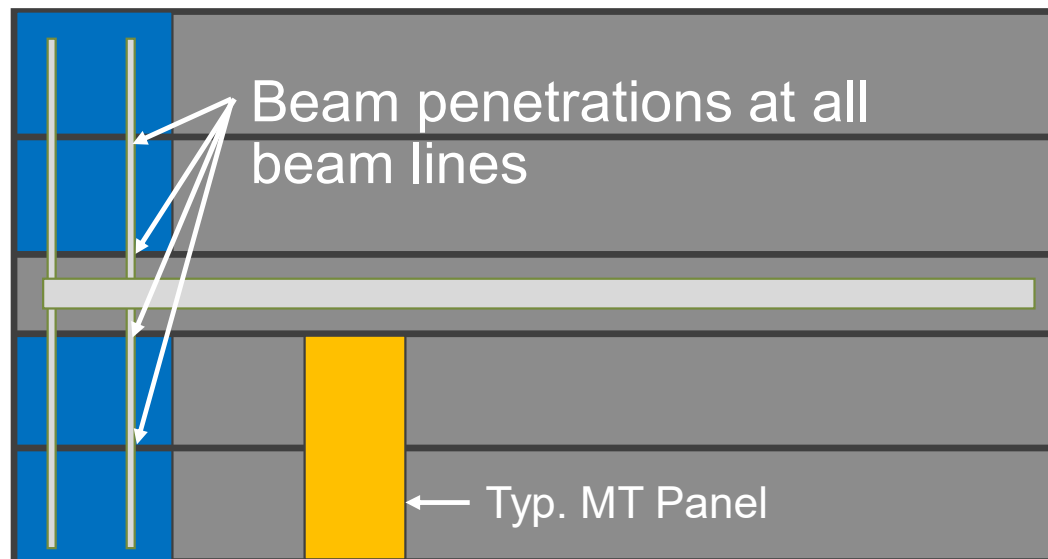


Key Early Design Decisions

Early Design Decision Example

Type IIIA Grid Options

- Option 2



Key Early Design Decisions

Early Design Decision Example

MT Construction Type Options:

- 7 stories of IV-C
- 5 stories of IIIA over 2 stories of IA podium
- 5 stories of IV-HT over 2 stories of IA podium

Type IV-HT in Group R Occupancy:

- Separation walls (fire partitions) and horizontal separation (horizontal assemblies) between dwelling units require a 1-hour rating.
- Floor panels require a 1-hour rating in addition to minimum sizes
- Essentially the same panel and grid options as IIIA

Ref. IBC 420.2, 420.3, 708.3, 711.2.4.3



Speed of Construction

Market Distinction

KNOW
YOUR
WHY

Sustainability

Lightweight

Leasing Velocity

Cost

Urban Density

Seattle Mass Timber Tower: Detailed Cost Comparison

Fast Construction



- Textbook example done by industry experts
- Mass timber vs. PT conc
- Detailed cost, material takeoff & schedule comparisons

“The initial advantage of Mass Timber office projects in Seattle will come through the

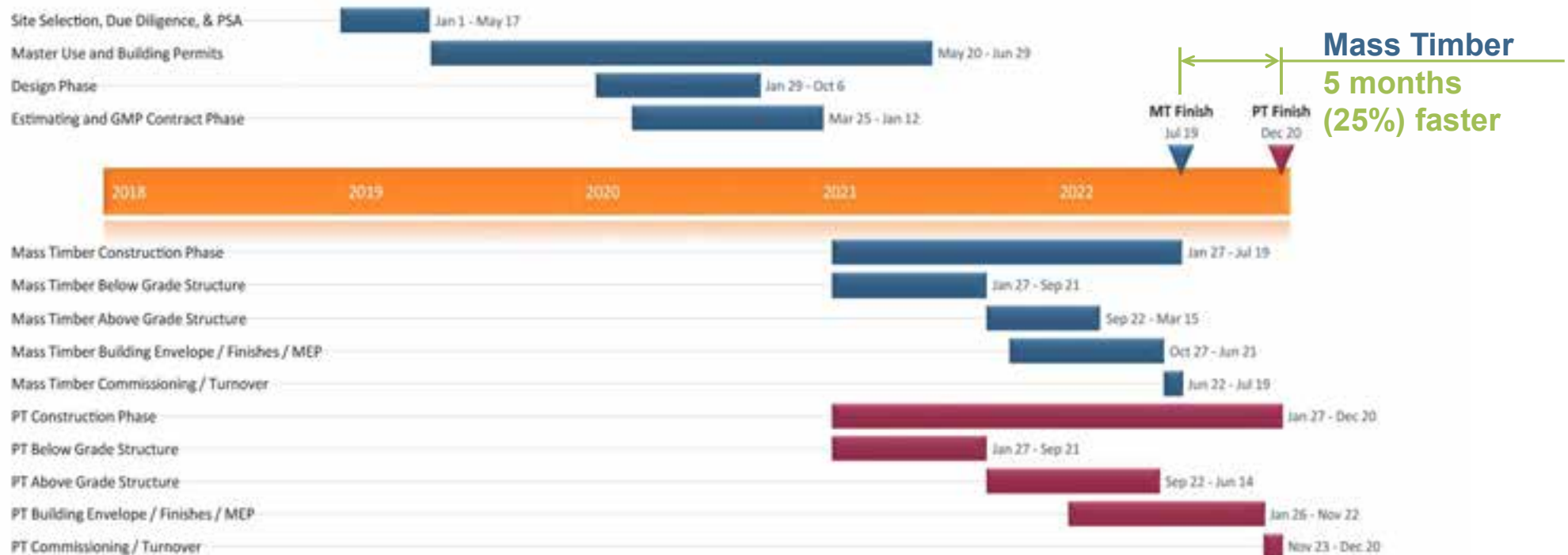
leasing velocity

that developers will experience.”

- Connor McClain, Colliers

Seattle Mass Timber Tower Fast Construction

Construction Schedule:

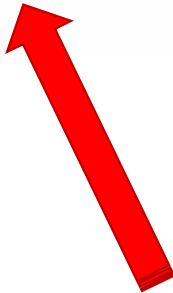


Source: Tall With Timber
A Seattle Mass Timber Tower Case Study by DLR Group¹

Seattle Mass Timber Tower

Faster Construction + Higher Material Costs = Cost Competitive

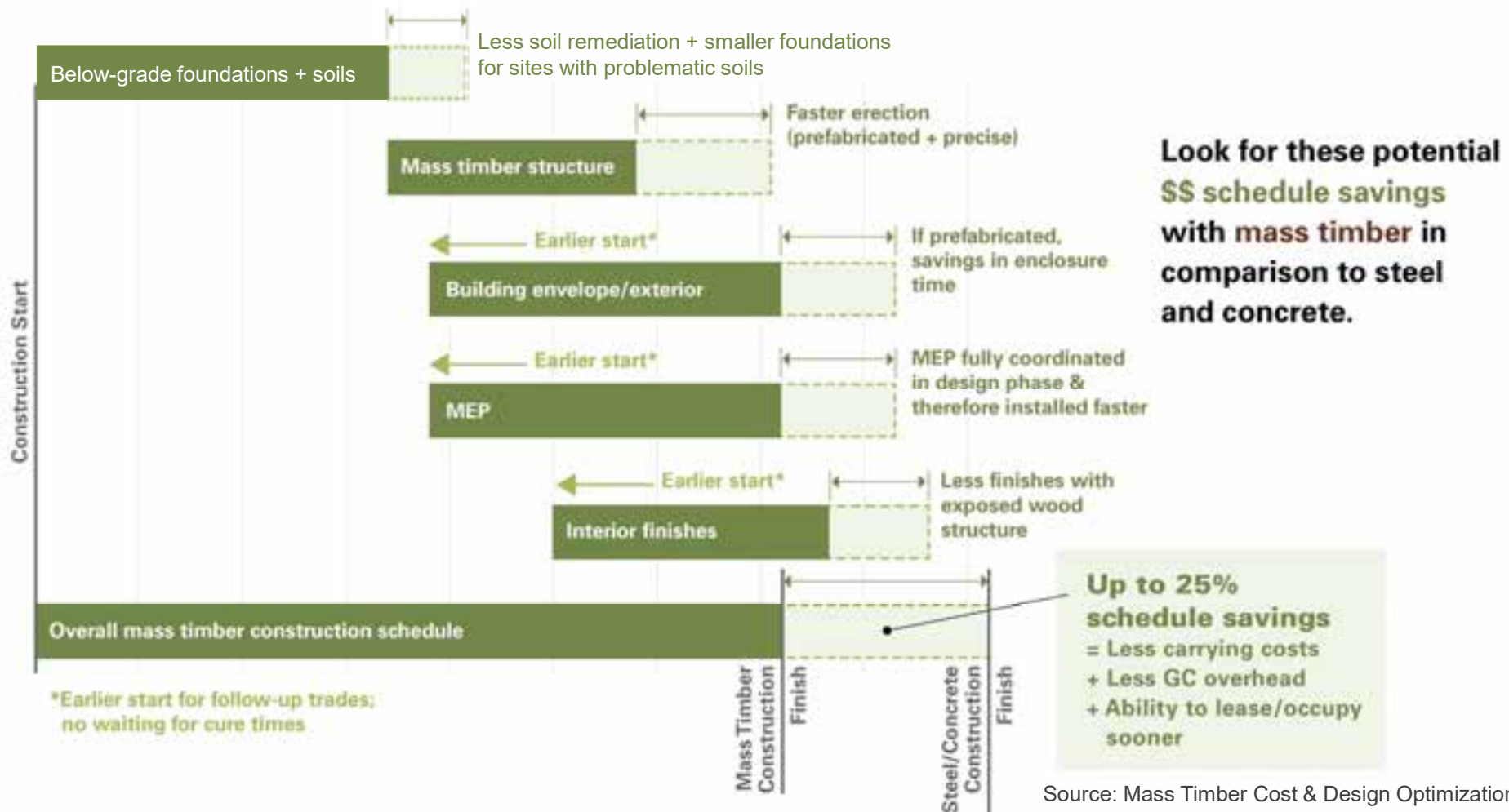
System	Mass Timber Design	PT Concrete Design	Mass Timber Savings
Direct Cost of Work	\$86,997,136	\$85,105,091	2.2%
Project Overhead	\$ 9,393,750	\$11,768,750	-20.2%
Add-Ons	\$ 8,387,345	\$ 8,429,368	-0.5%
Total	\$104,778,231	\$105,303,209	-0.5%



Source: DLR Group | Fast + Epp | Swinerton Builders

Compressing the Typical Schedule

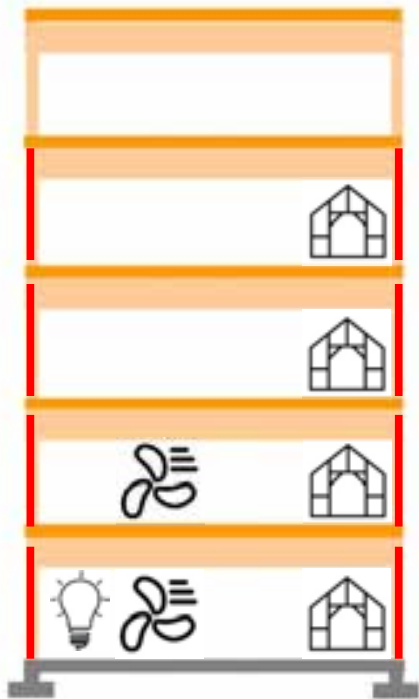
Fast Construction



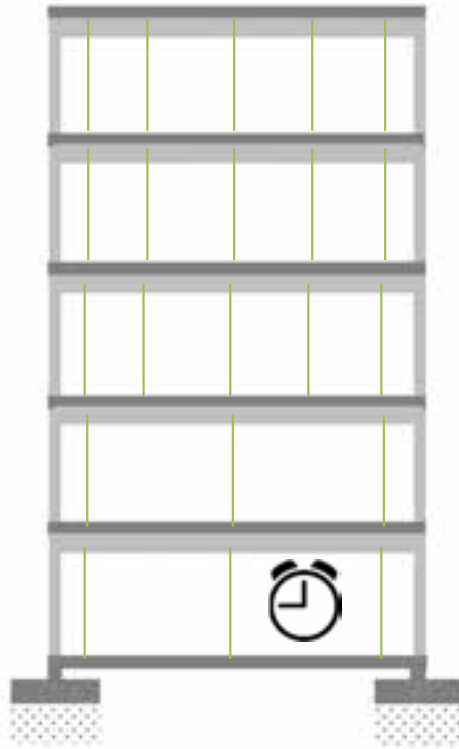
Source: Mass Timber Cost & Design Optimization, WoodWorks²

Schedule Savings for Rough-In Trades

Fast Construction



NO curing
(mass timber)



Curing & maze of
shores (concrete)



Photo: WoodWorks



Source: Generate Architecture + Technologies

Holistic Cost Assessment



Reference 1
Concrete Slabs on Steel Deck;
Steel Frame; Concrete Cores



Reference 2
Concrete Flat Slab;
Concrete Cores



Timber Use 1
Timber Floors; Steel Frame;
Concrete Cores



Timber Use 2
Timber Post, Beam, & Plate;
Concrete Cores



Timber Use 3
Timber Floors; LGM Framing;
Steel Frame Podium



Timber Use 4
Timber Floors & Shear Walls;
Steel Frame Podium

Source: Generate Architecture
+ Technologies

Sustainability Impacts



GLOBAL WARMING POTENTIAL & MATERIAL MASS
(PER BUILDING ASSEMBLY)

The total global warming potential (GWP) of each option is shown with a breakdown by building assembly. The Concrete With Steel Frame and Concrete Flat Slab options have the highest GWP, with the bulk of the impact embedded in the floor slabs. The Timber Use 1 (Floor Slabs, Steel Frame) option offers a slight reduction in GWP, with the most of the savings also embedded in the floor slabs. The Timber Use 2 (Post, Beam, and Floor) option offers a relatively typical approach to building with timber, showing savings in floor slabs, beams, and columns. Since Timber Use 3 and 4 are hybrid approaches with steel-bearing walls, these options include steel columns to accommodate the ground floor program. Timber Use 3 shows how a hybrid approach with light gauge metal yields GWP savings in structural walls and exterior walls, despite the addition of the podium slabs. Timber Use 4 emphasizes how a completely cellular CLT timber approach yields massive reductions in nearly every category.

Source: Generate Architecture + Technologies

Reduce Risk

Optimize Costs

- For the entire project team, not just builders
- Lots of reference documents

Download Checklists at
www.woodworks.org

www.woodworks.org/wp-content/uploads/wood_solution_paper-Mass-Timber-Design-Cost-Optimization-Checklists.pdf



Mass Timber Cost and Design Optimization Checklists

WoodWorks has developed the following checklists to assist in the design and cost optimization of mass timber projects. The design optimization checklists are intended for building designers (architects and engineers), but many of the topics should also be discussed with the fabricators and builders. The cost optimization checklists will help guide coordination between designers and builders (general contractors, construction managers, estimators, fabricators, installers, etc.) as they are estimating and making cost-related decisions on a mass timber project.

Most resources listed in this paper can be found on the WoodWorks website. Please see the end notes for URLs.

First Tech Federal Credit Union
Hickory, NC
Architect:
Builder:
General Contractor:
Interior Designer:
Structural Engineer:
Mechanical Engineer:
Electrical Engineer:
Civil Engineer:
Landscape Architect:
Architectural Photographer:
Construction Manager:
Construction Inspector:
Construction Worker:
Construction Supervisor:
Construction Safety Officer:
Construction Quality Control:
Construction Cost Estimator:
Construction Scheduler:
Construction Project Manager:
Construction Superintendent:
Construction Foreman:
Construction Laborer:
Construction Helper:
Construction Apprentice:
Construction Trainee:
Construction Intern:
Construction Student:
Construction Volunteer:
Construction Consultant:
Construction Analyst:
Construction Researcher:
Construction Writer:
Construction Editor:
Construction Publisher:
Construction Distributor:
Construction Retailer:
Construction Wholesaler:
Construction Manufacturer:
Construction Supplier:
Construction Vendor:
Construction Contractor:
Construction Subcontractor:
Construction Joint Venture:
Construction Partnership:
Construction Corporation:
Construction LLC:
Construction S-Corp:
Construction Sole Proprietorship:
Construction Partnership:
Construction Corporation:
Construction LLC:
Construction S-Corp:
Construction Sole Proprietorship:





Keys to Mass Timber Success:

Know Your WHY

Design it as Mass Timber From the Start

Leverage Manufacturer Capabilities

Understand Supply Chain

Optimize Grid

Take Advantage of Prefabrication & Coordination

Expose the Timber

Discuss Early with AHJ

Work with Experienced People

Let WoodWorks Help for Free

Create Your Market Distinction

The challenge is not in learning how to accept change, but in how to orchestrate the most efficient change



Carbon12, Portland, OR Credit: Kaiser + Path

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

There's a good chance it is...Let's talk about it!



Credit: D/O Architects

Questions?

Speaker Name

Title

Phone

email



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



Copyright Materials

This presentation is protected by US
and International Copyright laws.
Reproduction, distribution, display and use of
the presentation without written permission
of the speaker is prohibited.

© The Wood Products Council 2022

Disclaimer: The information in this presentation, including, without limitation, references to information contained in other publications or made available by other sources (collectively “information”) should not be used or relied upon for any application without competent professional examination and verification of its accuracy, suitability, code compliance and applicability by a licensed engineer, architect or other professional. Neither the Wood Products Council nor its employees, consultants, nor any other individuals or entities who contributed to the information make any warranty, representative or guarantee, expressed or implied, that the information is suitable for any general or particular use, that it is compliant with applicable law, codes or ordinances, or that it is free from infringement of any patent(s), nor do they assume any legal liability or responsibility for the use, application of and/or reference to the information. Anyone making use of the information in any manner assumes all liability arising from such use.