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

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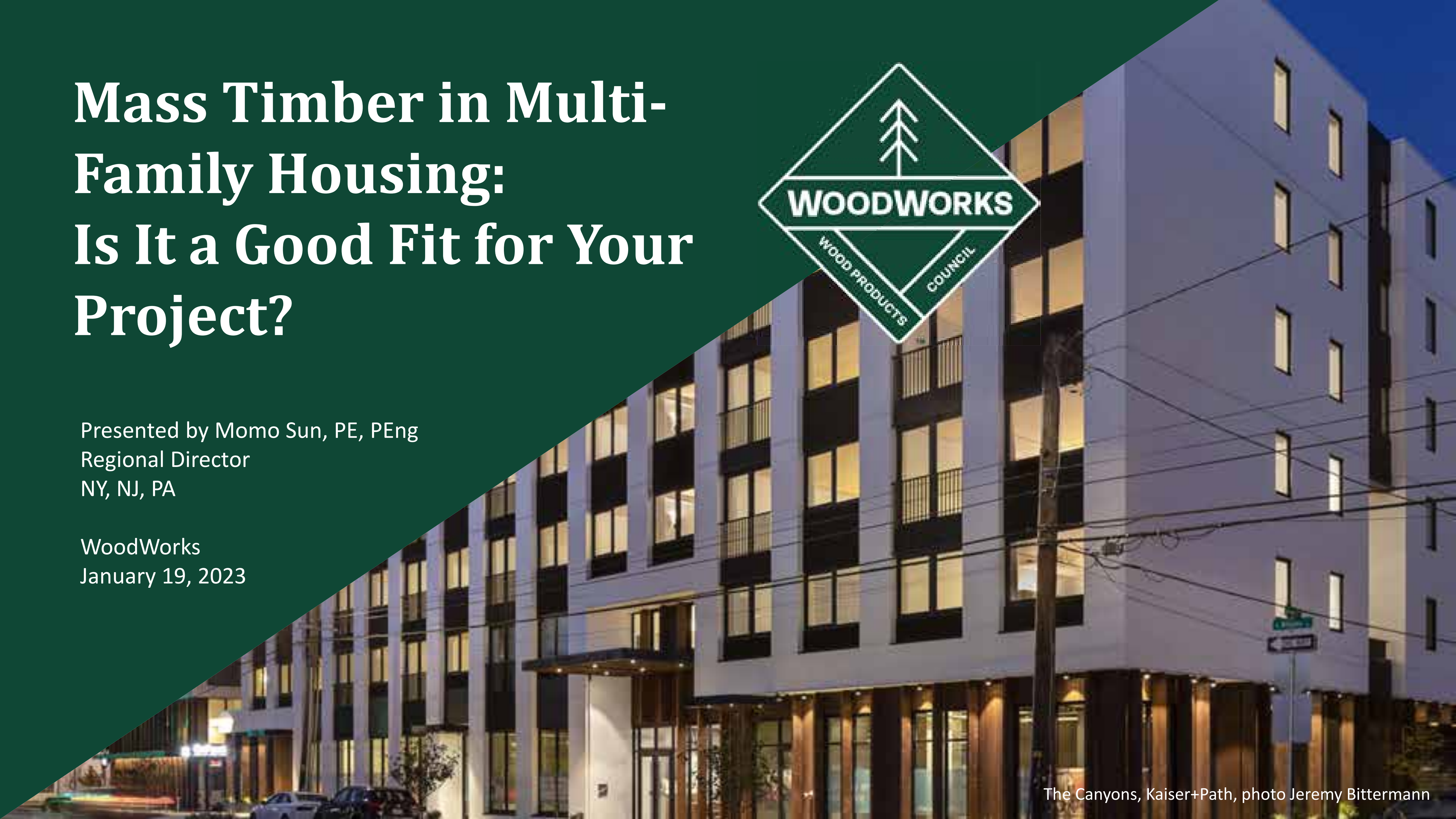
WoodWorks
January 19, 2023



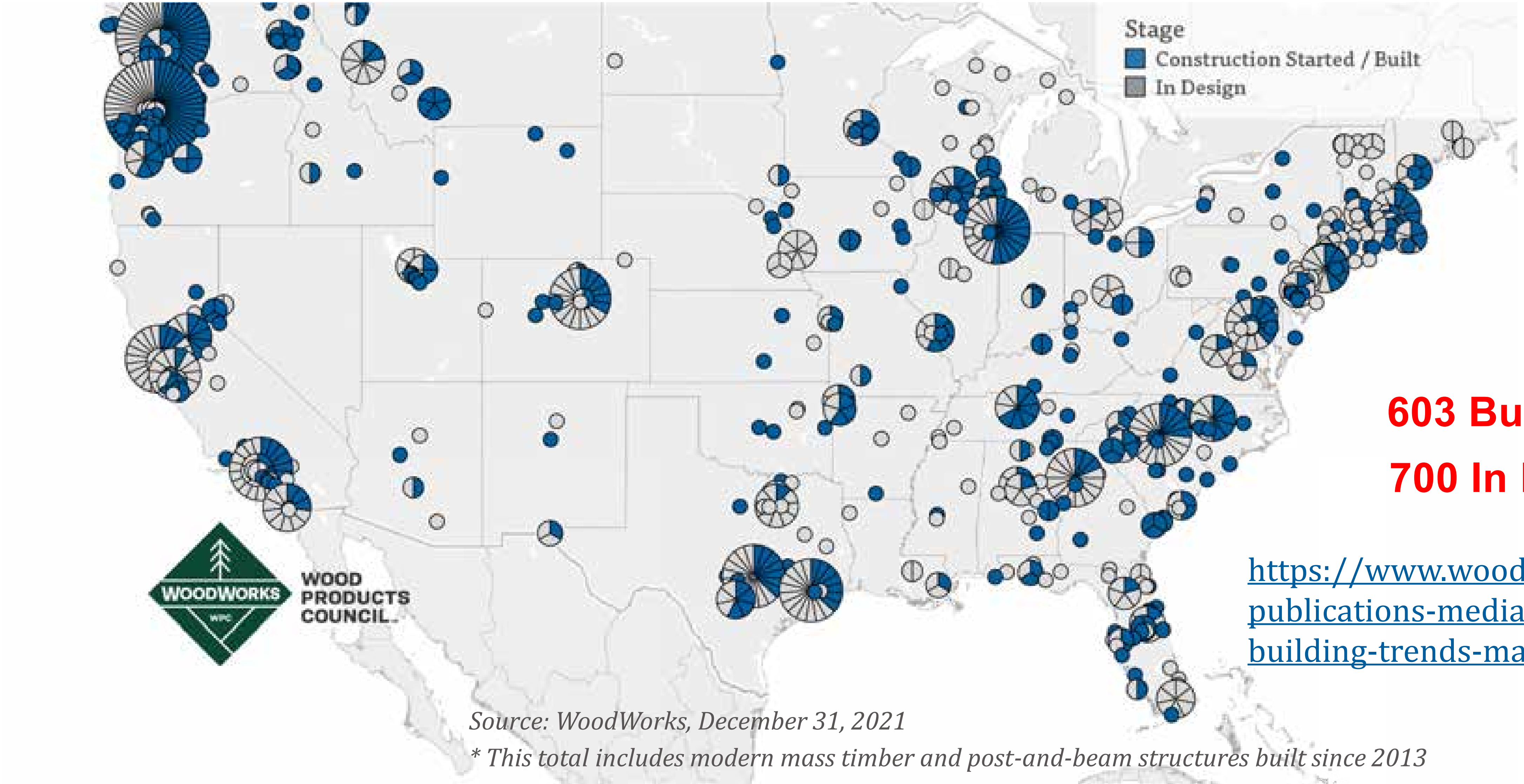
The Canyons, Kaiser+Path, photo Jeremy Bittermann

# 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.




*Source: WoodWorks, December 31, 2021*

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

**603 Built**

**700 In Design**

https://www.woodworks.org/publications-media/building-trends-mass-timber/

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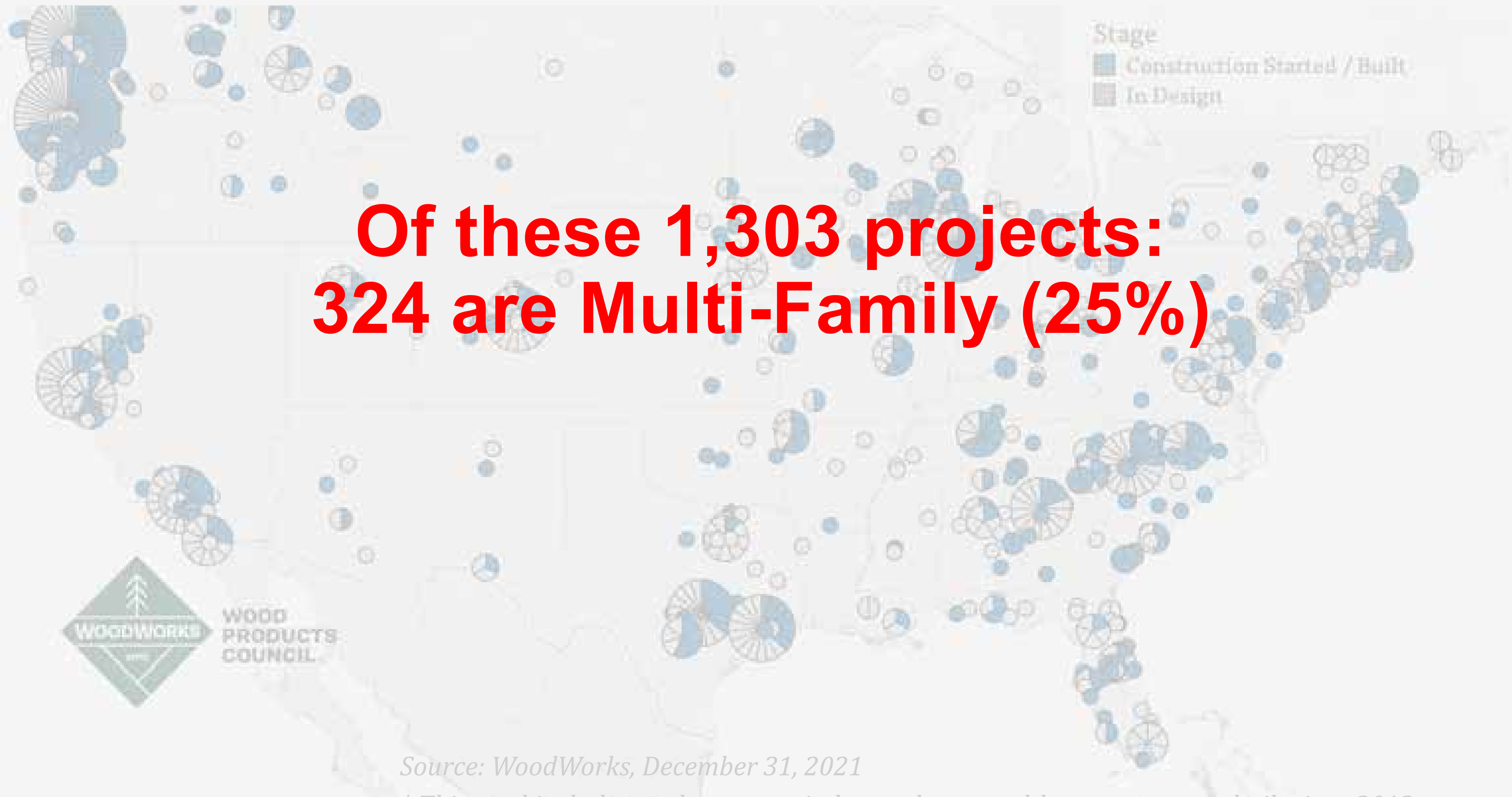


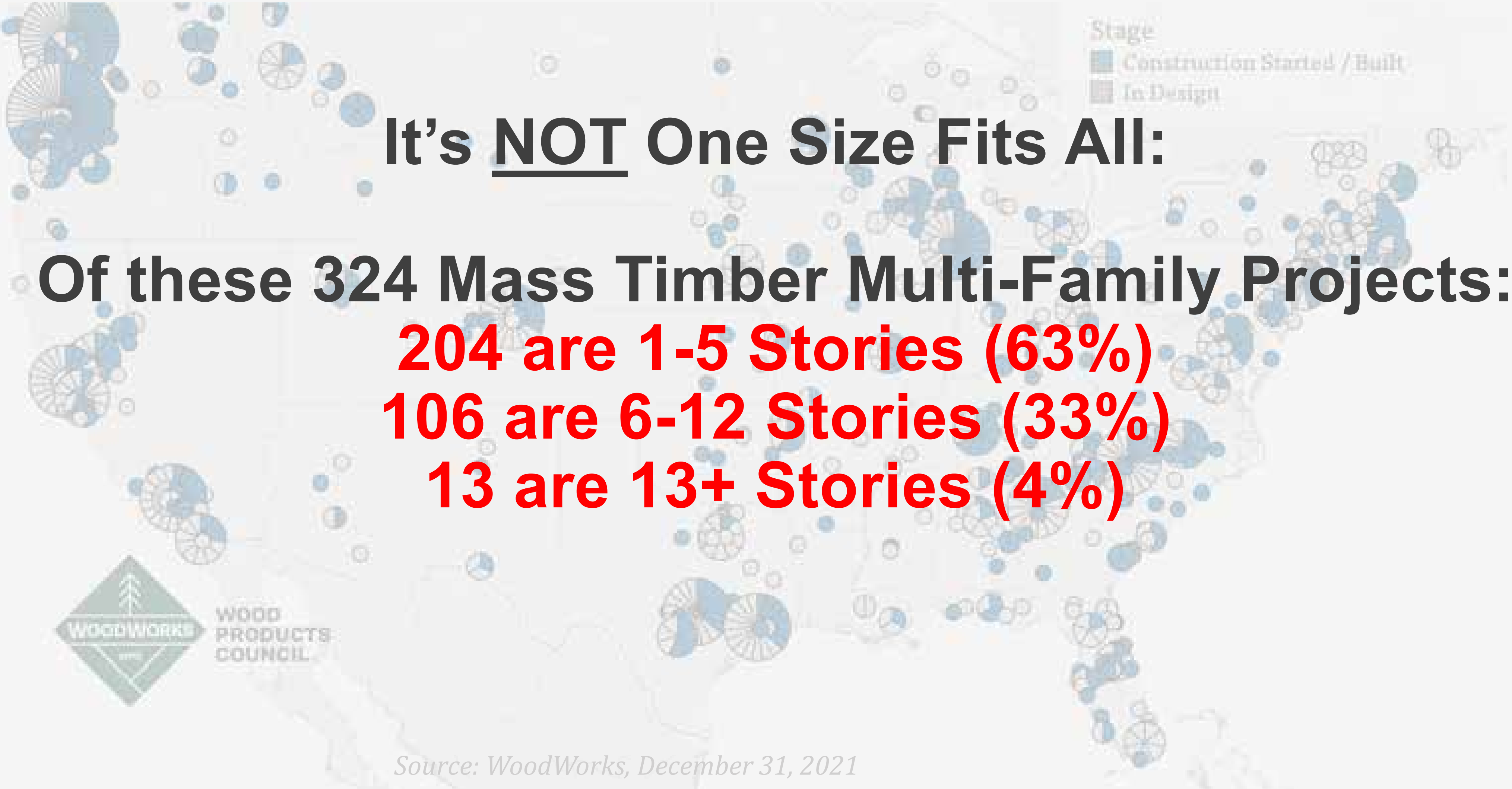

**Of these 1,303 projects:**
**324 are Multi-Family (25%)**

*Source: WoodWorks, December 31, 2021*

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

# 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%)**

WOOD PRODUCTS COUNCIL

*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


# HYBRID LIGHT-FRAME + MASS TIMBER

# THE KIND PROJECT, SACRAMENTO, CA

# CONDOS AT LOST RABBIT, MS

Lost Rabbit, MS
Credit: Everett Consulting Group

# THE POSTMARK APARTMENTS, SHORELINE, WA



Credit: Katerra, 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

# 320 AND 360 WYTHE AVENUE, BROOKLYN, NY

Credit: Flank

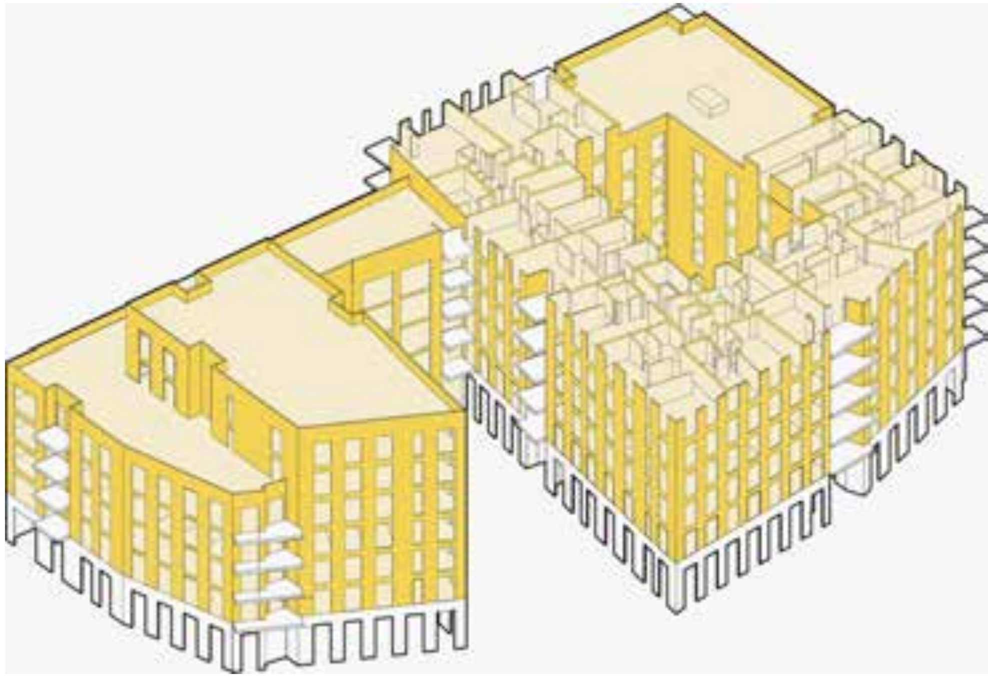
# BARRACUDA CONDOS, MADISON, WI

Credit: Populance Architecture and Development


## MASS TIMBER BEARING WALLS

# DALSTON WORKS, LONDON

Photos: Daniel Shearin | Waugh Thistleton Architects



# Model C, Roxbury, MA

Credit: John Klein, Generate Architecture

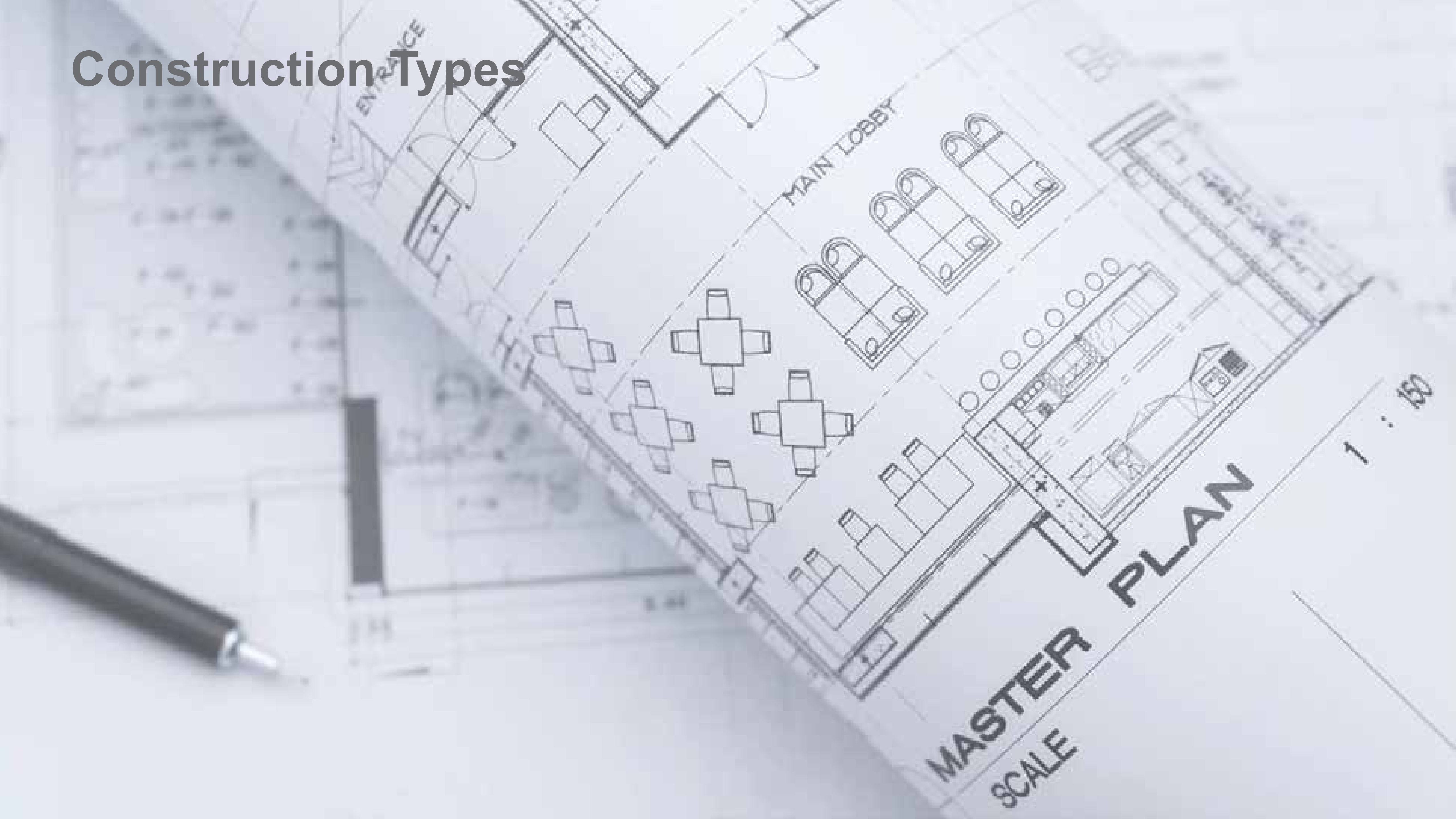
Left: 69 A Street, Boston, MA Credit: Greg Folkins
Above: Timber Lofts, Milwaukee, WI
Credit: ADX Creative and Engberg Anderson Architects

# VERTICAL ADDITIONS AND ADAPTIVE REUSE

# BREWERY LOFTS, TACOMA, WA

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

# 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:

**<u>Type III</u>**
Exterior walls non-combustible (may be FRTW)
Interior elements any allowed by code, including mass timber

**<u>Type V</u>**
All building elements are any allowed by code, including mass timber

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

**<u>Type IV (Heavy Timber)</u>**
Exterior walls non-combustible (may be FRTW OR CLT)
Interior elements qualify as Heavy Timber (min. sizes, no concealed spaces except in 2021 IBC)

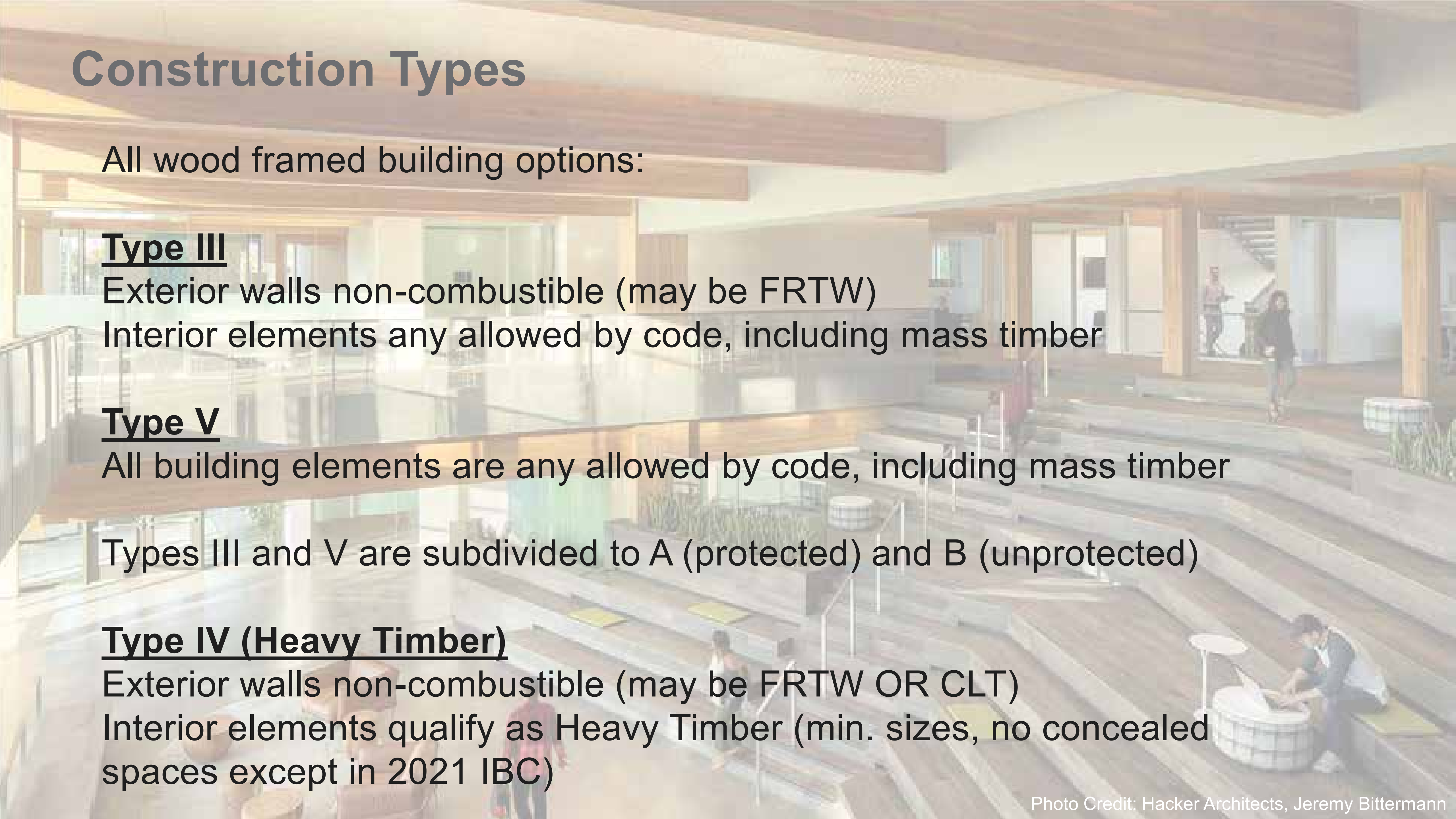


Photo Credit: Hacker Architects, Jeremy Bittermann

# 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?**

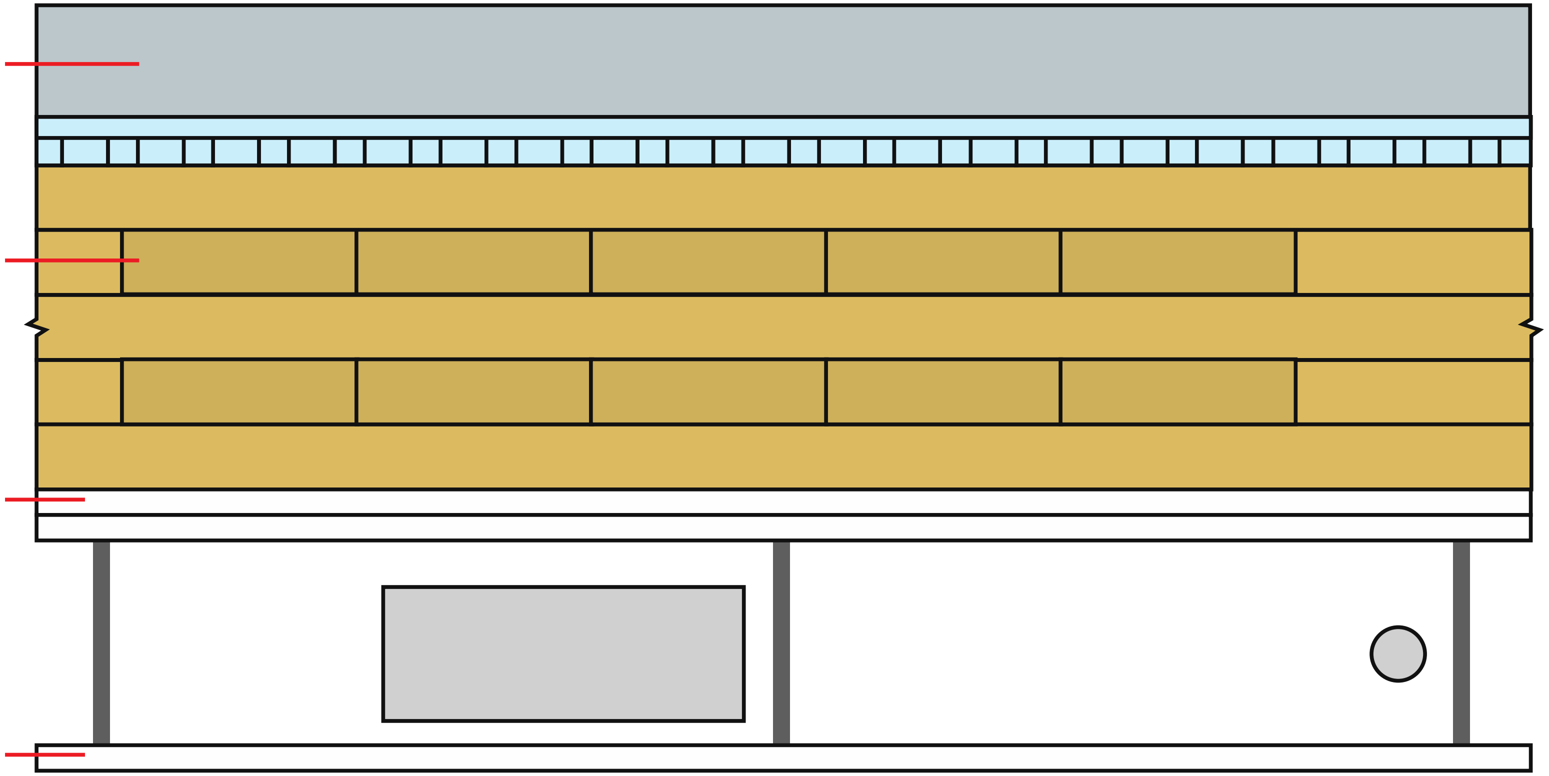
- Type IV: Any exposed interior elements & roofs, must meet min. sizes; exterior walls if CLT or FRT. Concealed space limitations (varies by code version)

Image: Perkins + Will

# Construction Types

## Type IV concealed spaces

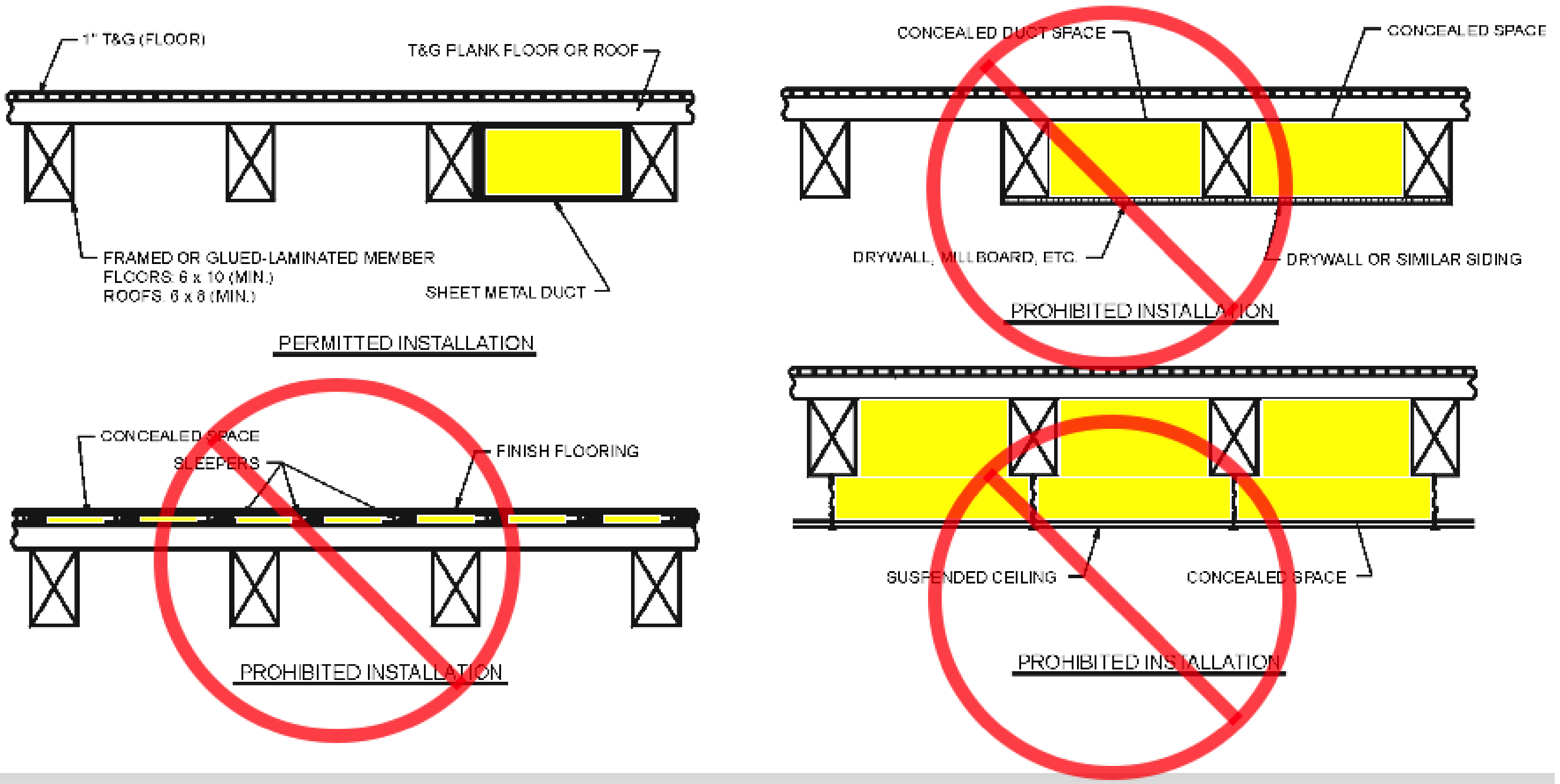
Can I have a dropped ceiling? Raised access floor?



# Construction Types

## Type IV concealed spaces

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

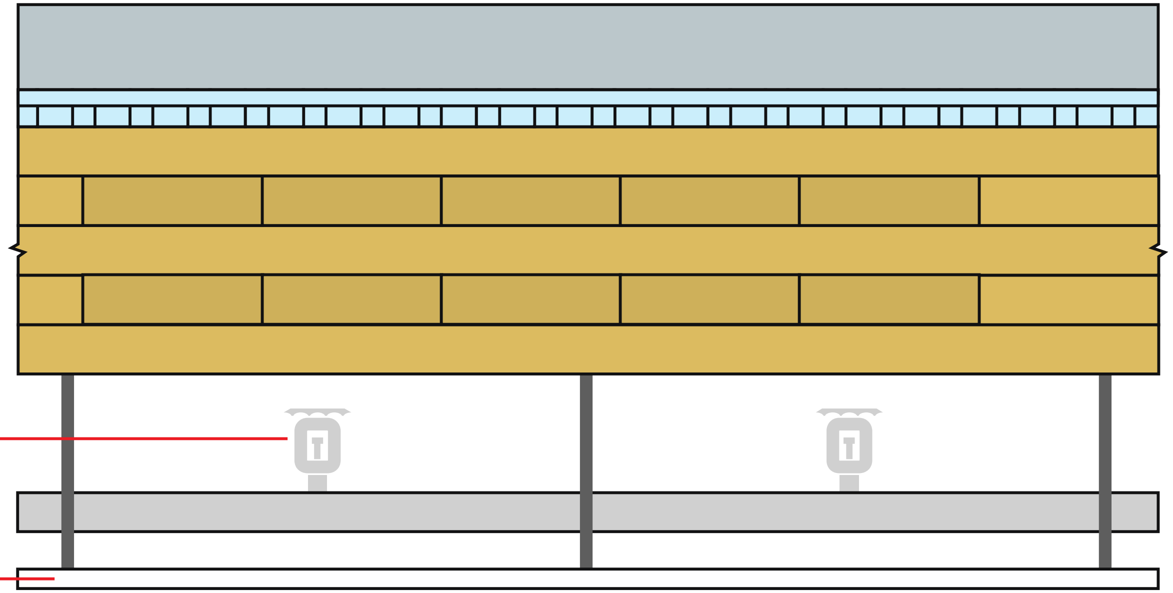



Credit: IBC

# Construction Types

## Type IV concealed space options within 2021 IBC

**Option 1:**



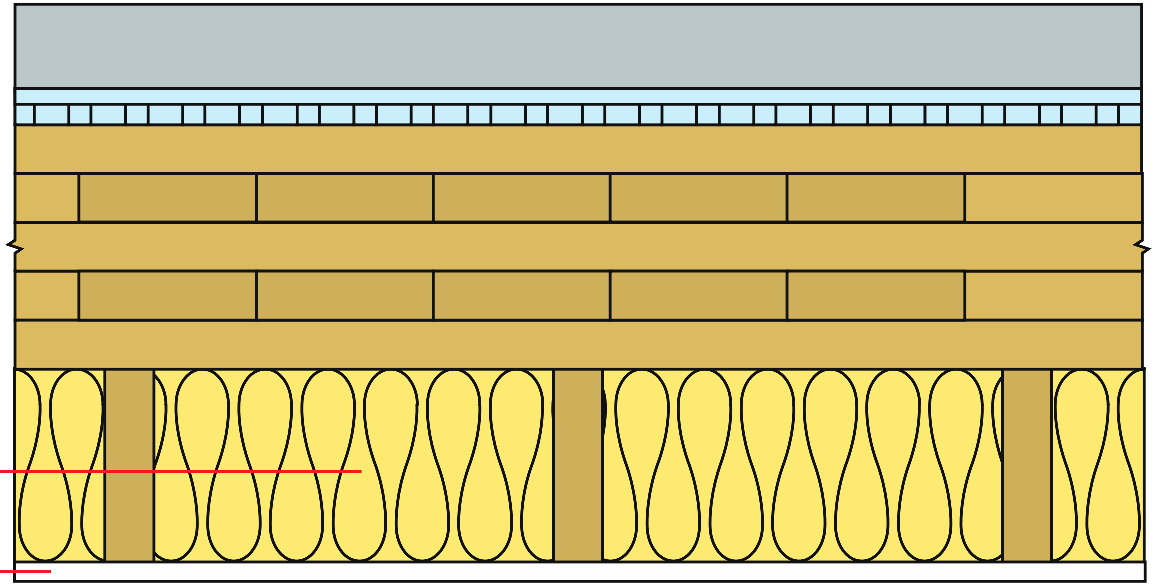
Sprinklers in concealed spaces

Dropped ceiling

# Construction Types

## Type IV concealed space options within 2021 IBC

**Option 2:**



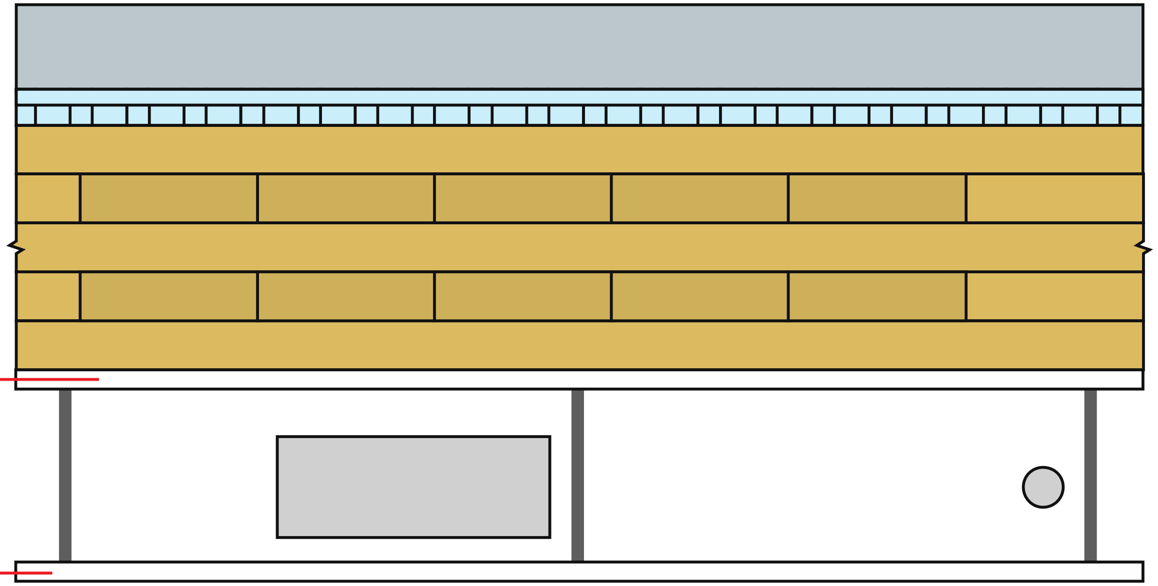
Noncombustible insulation

Dropped ceiling

# Construction Types

## Type IV concealed space options within 2021 IBC

**Option 3:**

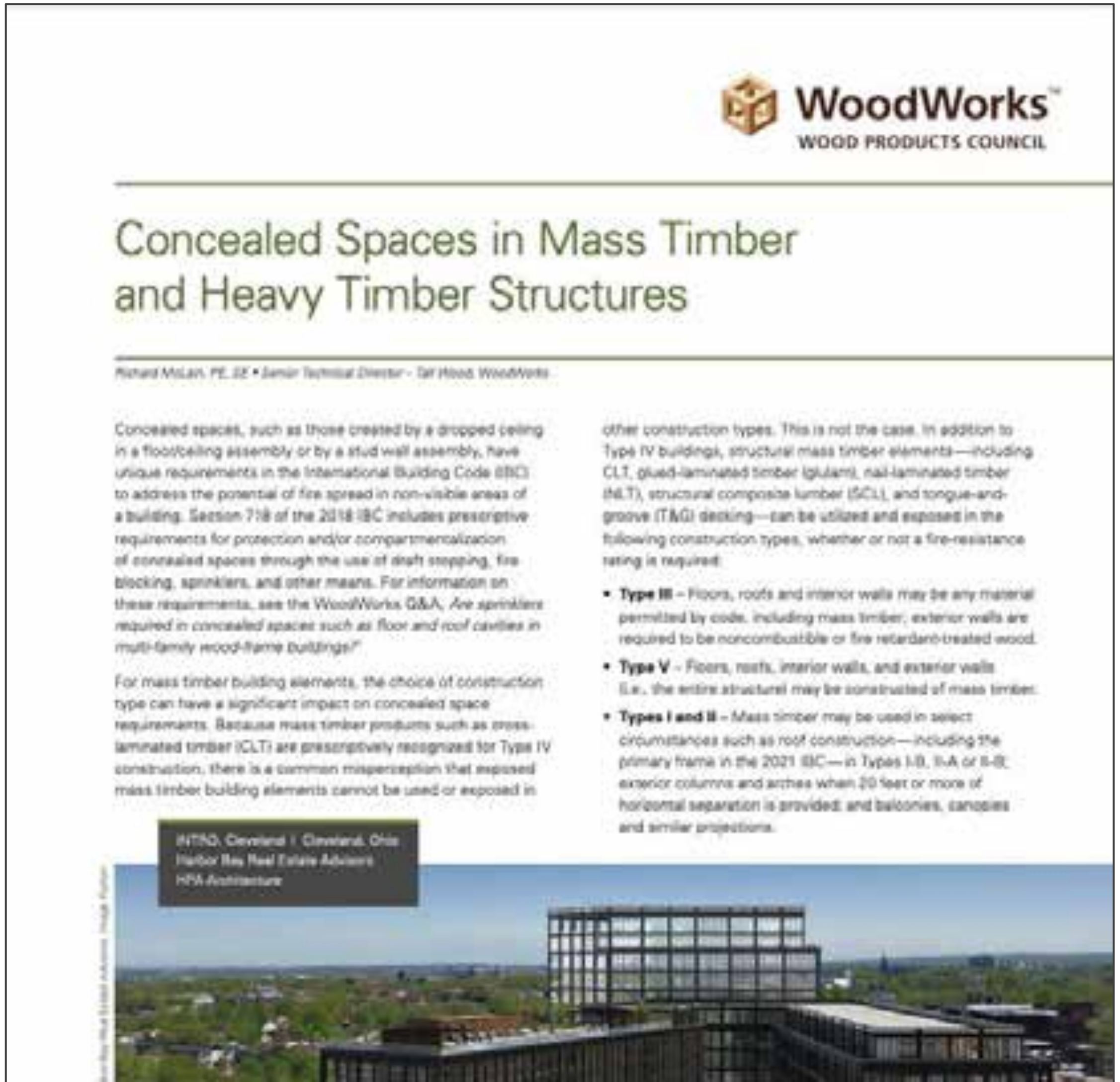


5/8" Type X gypsum on all mass timber surfaces within concealed space

Dropped ceiling

# Construction Types

## Concealed spaces solutions paper



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# Concealed Spaces in Mass Timber and Heavy Timber Structures

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

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

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

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

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

The John W. Olver Design Building at UMass Amherst includes exposed wood structure in some areas and dropped ceilings in others. Architect: Leers Weinzapfel Associates

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?**

- <u>Type V</u>: 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

**9 Stories | 115 ft**

**8 Timber Over 1 Podium**


**Type IV-B**

**Variance to expose ~50% ceilings**

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

# 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

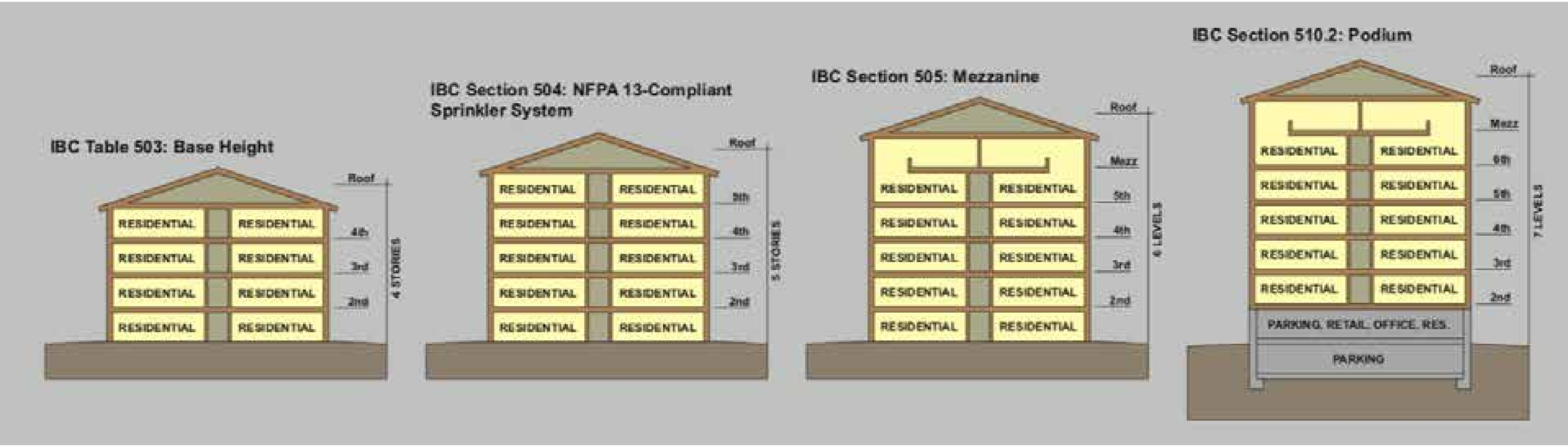
# 11 E LENOX, BOSTON, MA

Credit: H + O Structural Engineering

# 11 E LENOX, BOSTON, MA

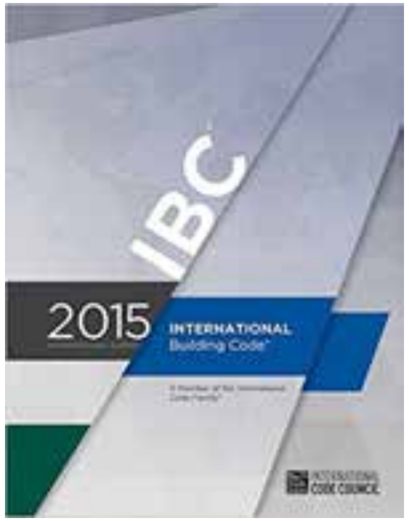
Credit: H+O Structural Engineering

# PRESCRIPTIVE BUILDING CODES

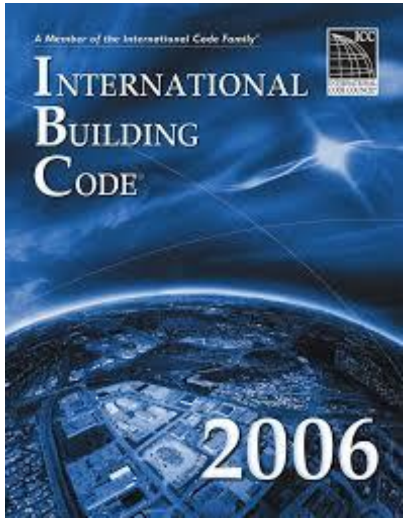


# 3 YEAR CODE CYCLE

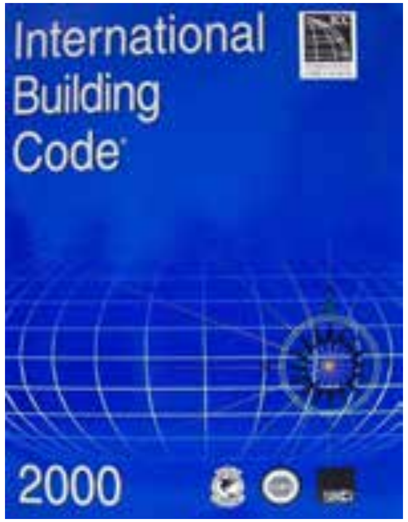











Source: ICC

# WoodWorks Online Event

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

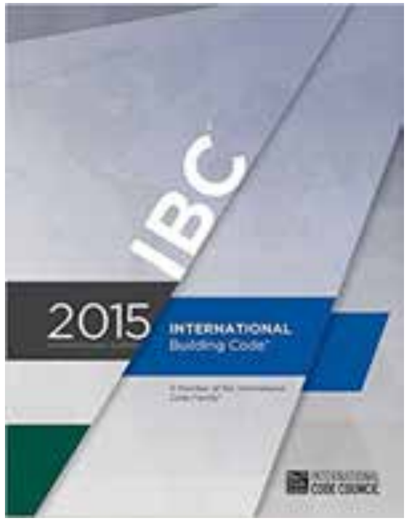
1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

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

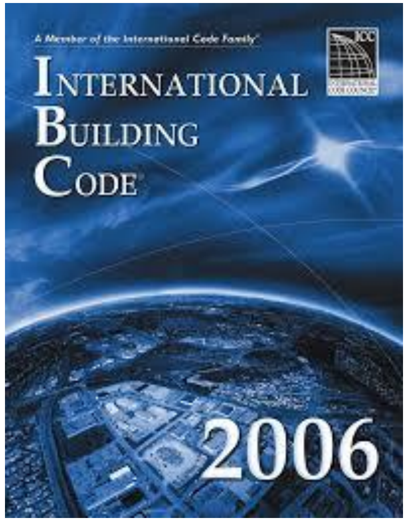
ICC INTERNATIONAL CODE COUNCIL®

# 3 YEAR CODE CYCLE

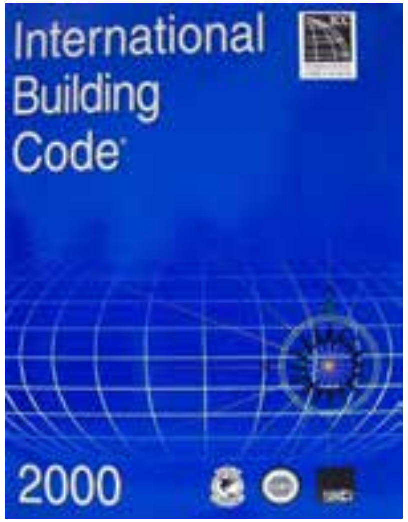











Source: ICC

ATF Lab Tests, 2017
Photo: LendLease

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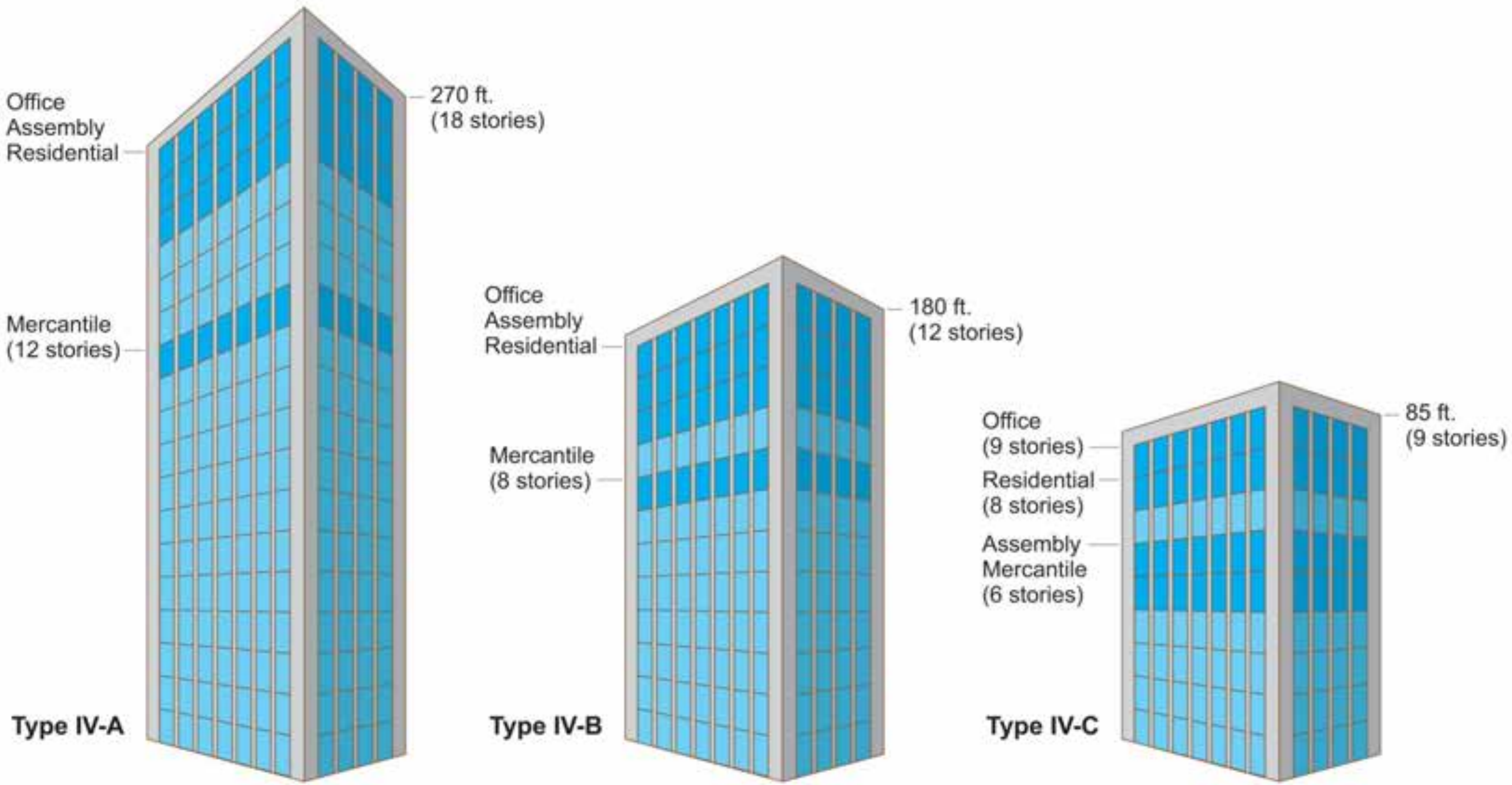
Photo: LendLease

ATF Lab Tests, 2017
Photo: LendLease

# PRESCRIPTIVE BUILDING CODES



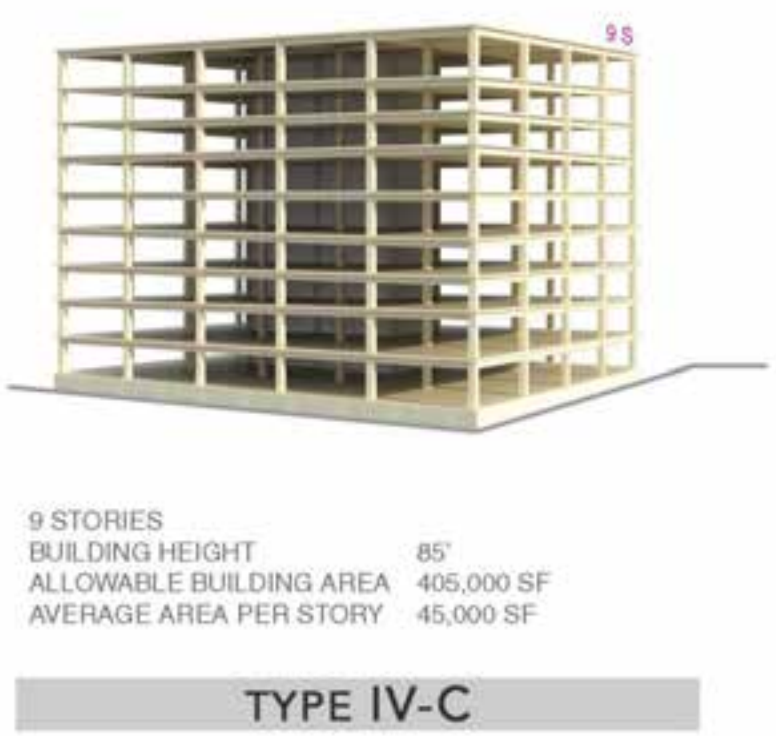
# Type IV-C


Credit: Susan Jones, atelierjones

Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman

# Type IV-C Height and Area Limits

IV-C




Credit: Susan Jones, atelierjones

| 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**

# Type IV-C Protection vs. Exposed

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


Credit: Susan Jones, atelierjones

Credit: LEVER Architecture

IV-B

# Type IV-B Height and Area Limits


Credit: Susan Jones, atelierjones

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

Areas exclude potential frontage increase

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

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

# Type IV-B Protection vs. Exposed

IV-B


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 SF)*(0.20) = 160 SF
- $U_{aw}$ = (800 SF)*(0.40) = 320 SF
- Could expose 160 SF of MT ceiling, <u>OR</u> 320 SF of MT Wall, <u>OR</u>
- 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

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

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

$U_{tw} = 120$ 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


Credit: Susan Jones, atelierjones


Photos: Structurlam, naturally:wood, Fast + Epp

IV-A

# Type IV-A Height and Area Limits


Credit: Susan Jones, atelierjones

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

Areas exclude potential frontage increase

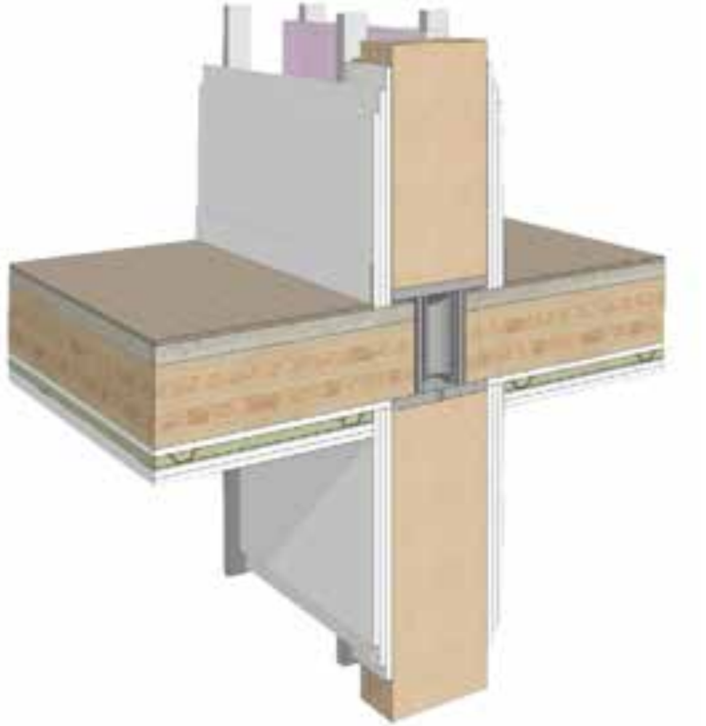
**In most cases, Type IV-A height & story allowances = 1.5 * Type I-B height & story allowances**

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

IV-A

# Type IV-A Protection vs. Exposed


Credit: Susan Jones, atelierjones



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

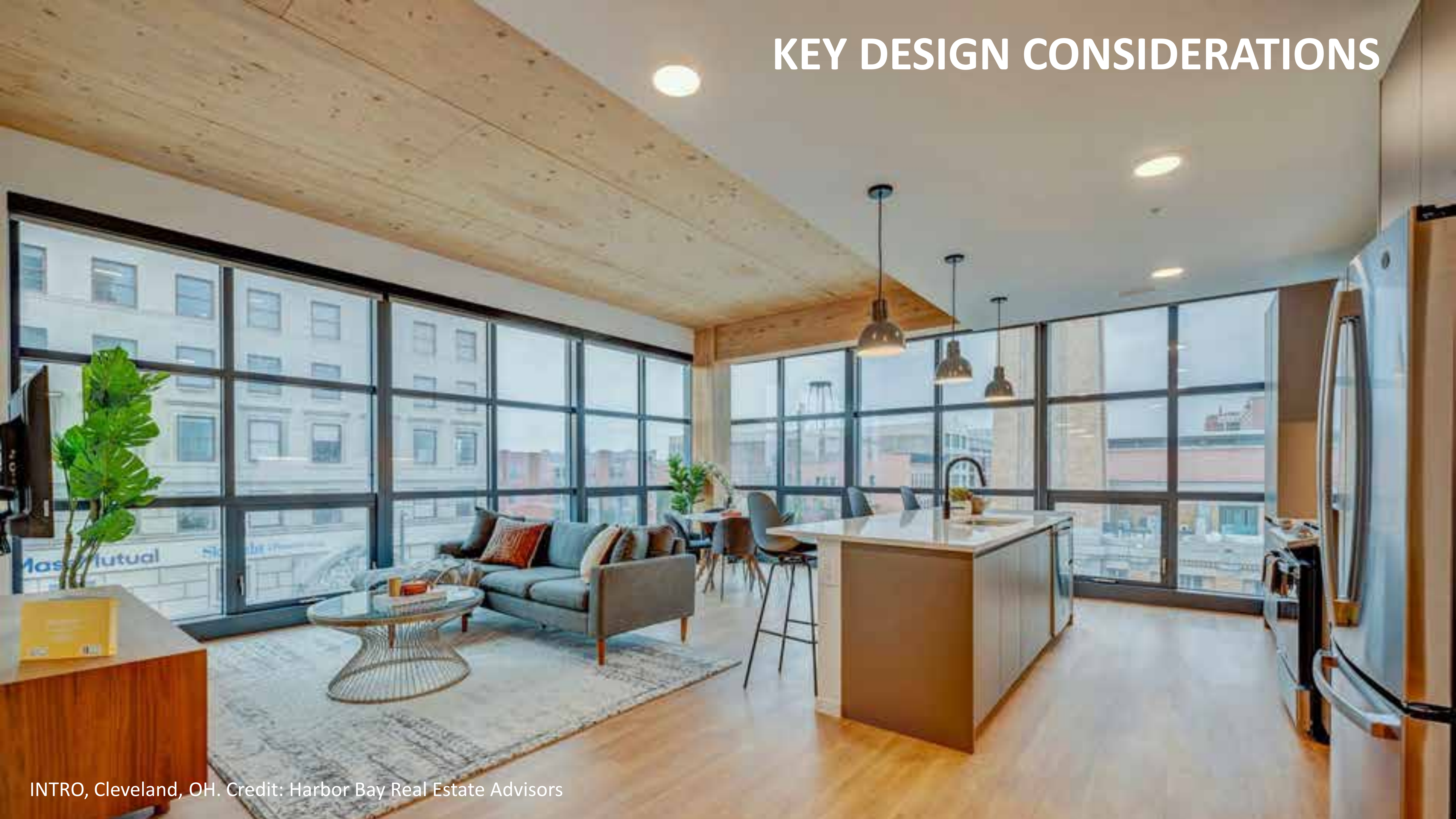
Credit: Acton Ostry Architects, Fast + Epp

IV-A

# 2024 IBC Changes

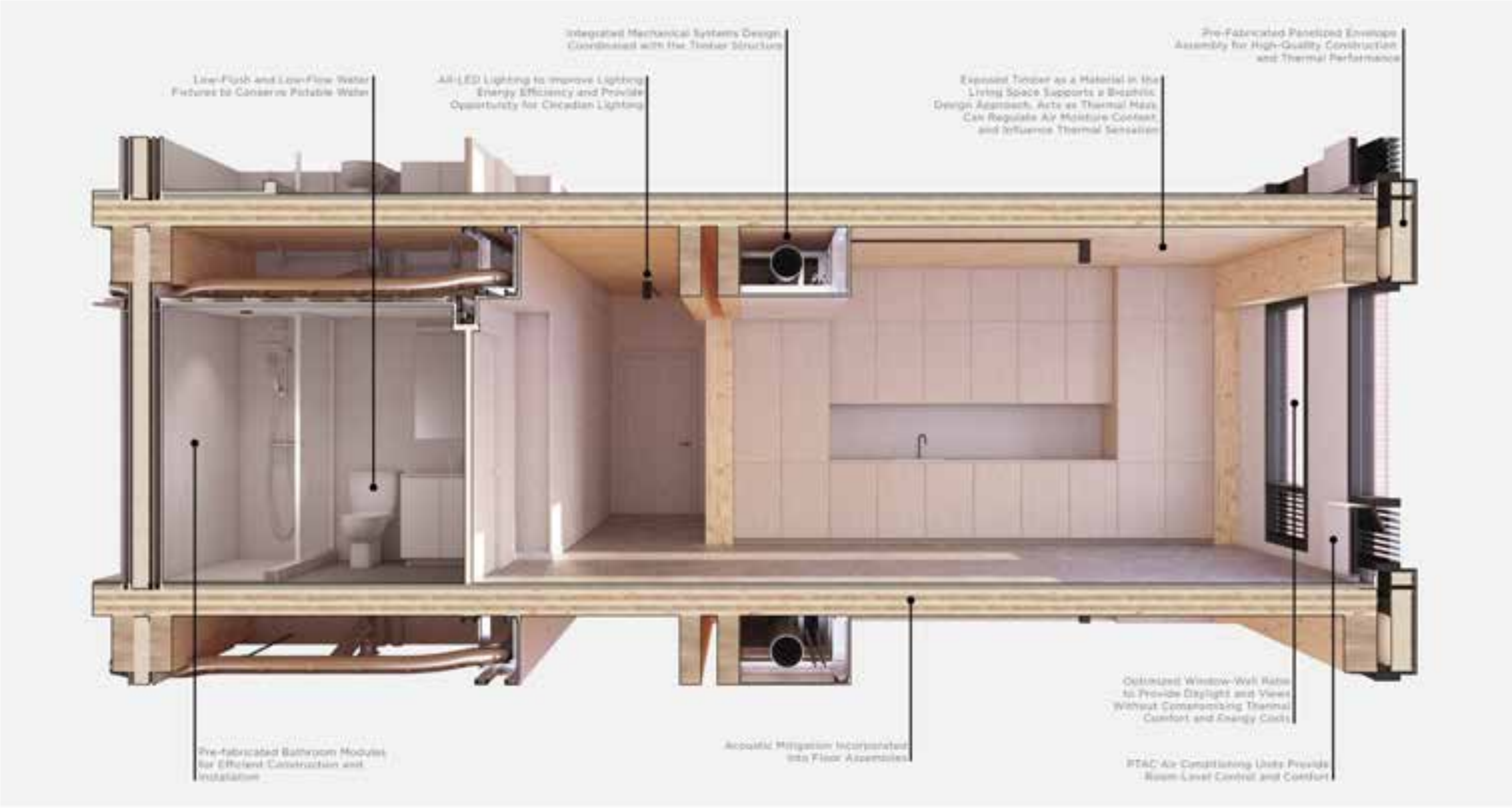

RISE Tests, 2020
Photo: RISE

# KEY DESIGN CONSIDERATIONS



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

# MEP SYSTEMS, ROUTING, INTEGRATION




**INTEGRATED SYSTEMS**

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.

Credit: John Klein, Generate Architecture

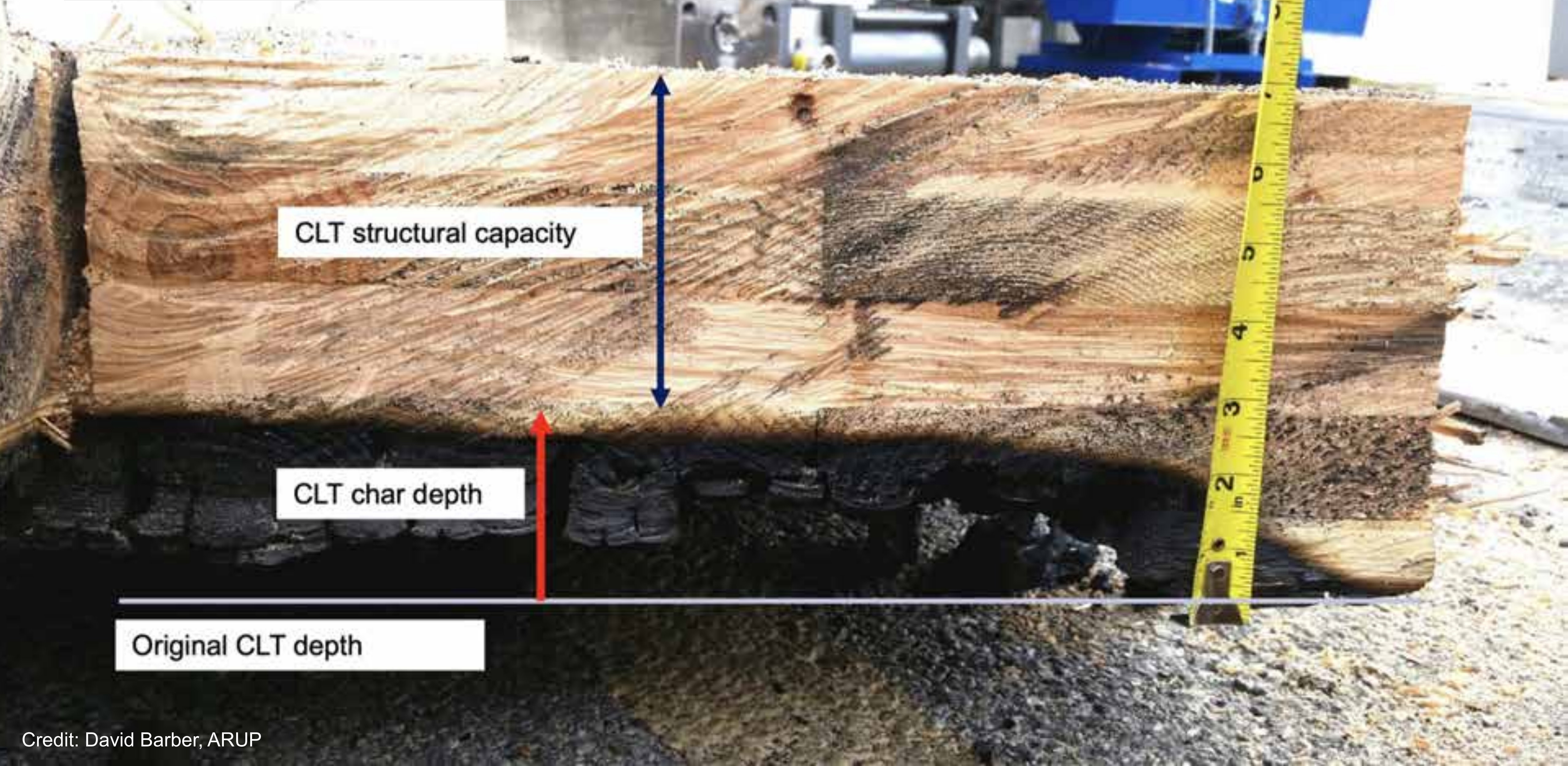
# MEP Layout & Integration

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




Credit: David Barber, ARUP

# 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[e, 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 |


Credit: David Barber, ARUP

# 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<br>Exterior[e, f]<br>Interior | <br>3<br>3[a] | <br>2<br>2[a] | <br>1<br>1 | <br>0<br>0 | <br>2<br>1 | <br>2<br>0 | <br>2<br>1/HT | <br>1<br>1 | <br>0<br>0 |
| Nonbearing walls and partitions<br>Exterior | See Table 602 | | | | | | | | |
| Nonbearing walls and partitions<br>Interior[d] | 0 | 0 | 0 | 0 | 0 | 0 | See Section 602.4.6 | 0 | 0 |
| 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) | $1^1/_2$[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 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[e, 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 |

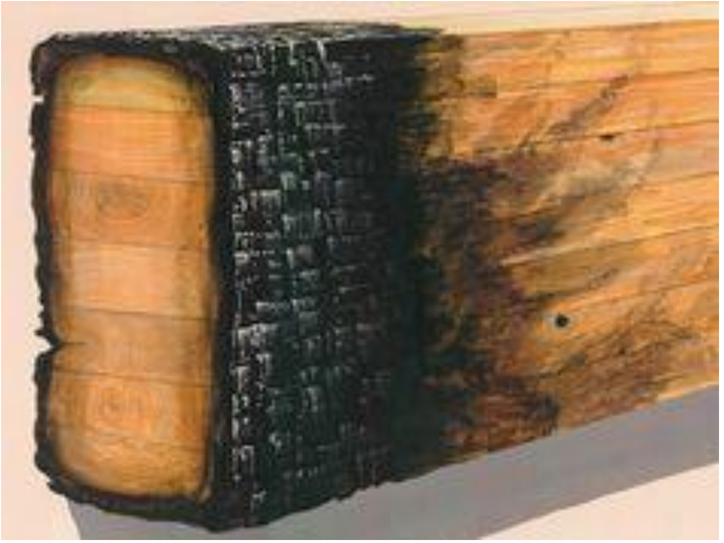
Source: 2021 IBC

# Key Early Design Decisions

Construction type influences FRR

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

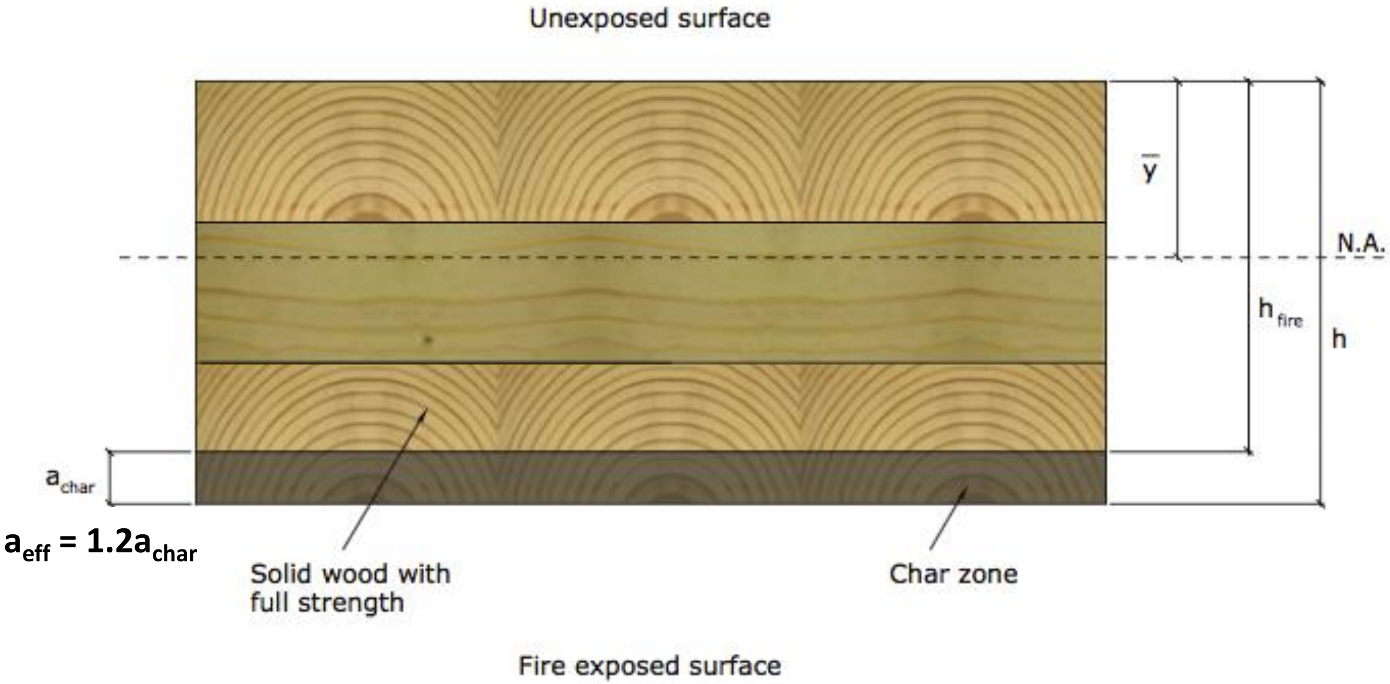
Method of demonstrating FRR (calculations or testing) can impact member sizing

# 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

## WoodWorks Inventory of Fire Tested MT Assemblies

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

WoodWorks
WOOD PRODUCTS COUNCIL

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

# FRR Design of MT

WoodWorks™
WOOD PRODUCTS COUNCIL

Fire-Resistive Design of Mass Timber Members

Code Applications, Construction Types and Fire Ratings

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

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

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

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

Mass Timber & Construction Type

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

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

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

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

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

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

**Mass Timber Fire Design Resource**

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

# Acoustics & Sound Control

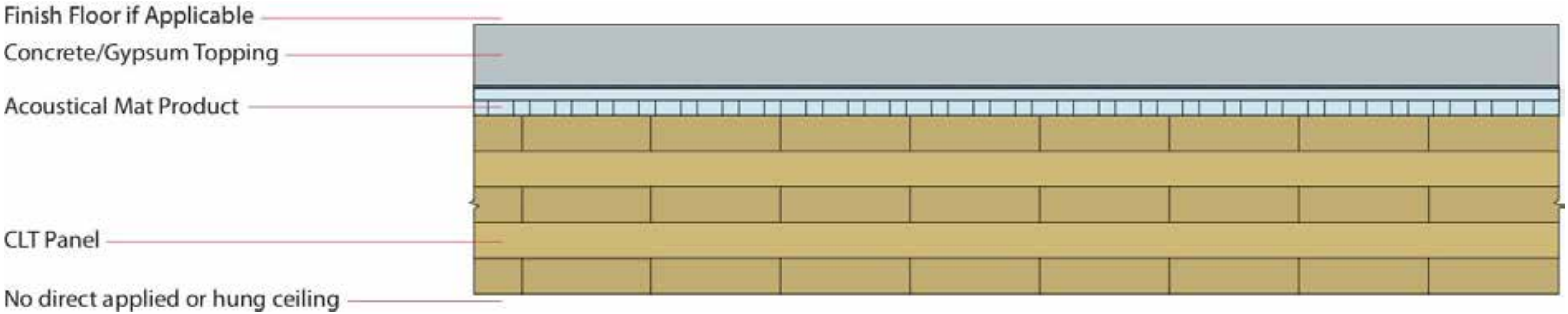
# Acoustics & Sound Control

Consider Impacts of:

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

# Acoustics & Sound Control

Images: Maxxon

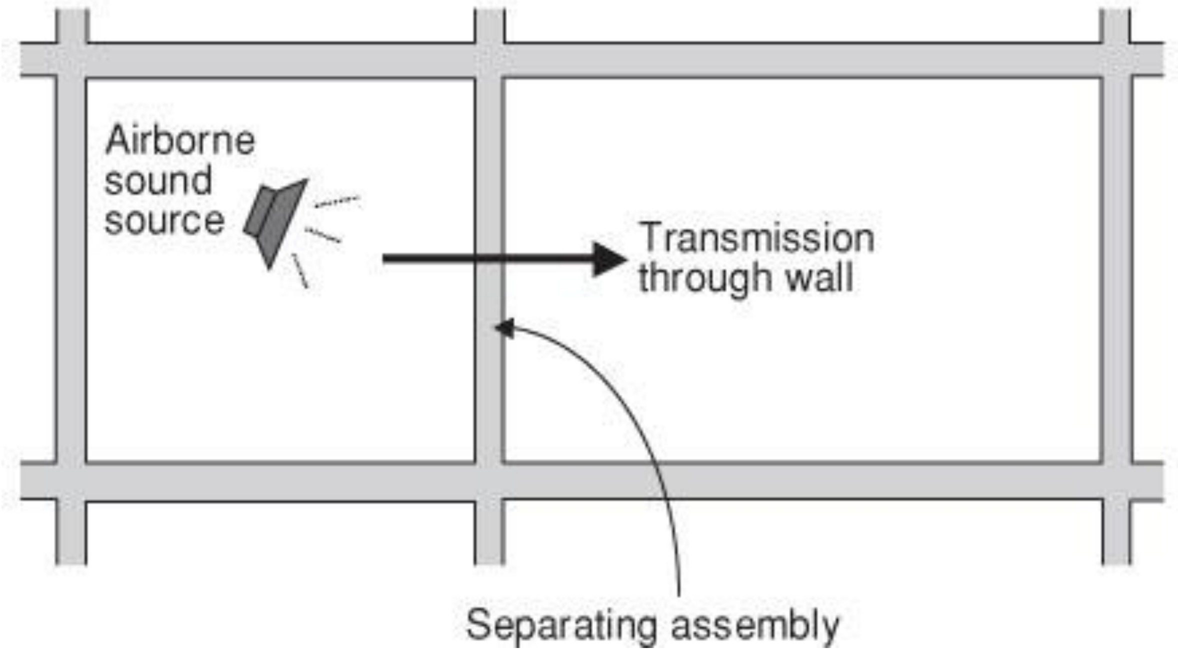


# Acoustics & Sound Control

**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

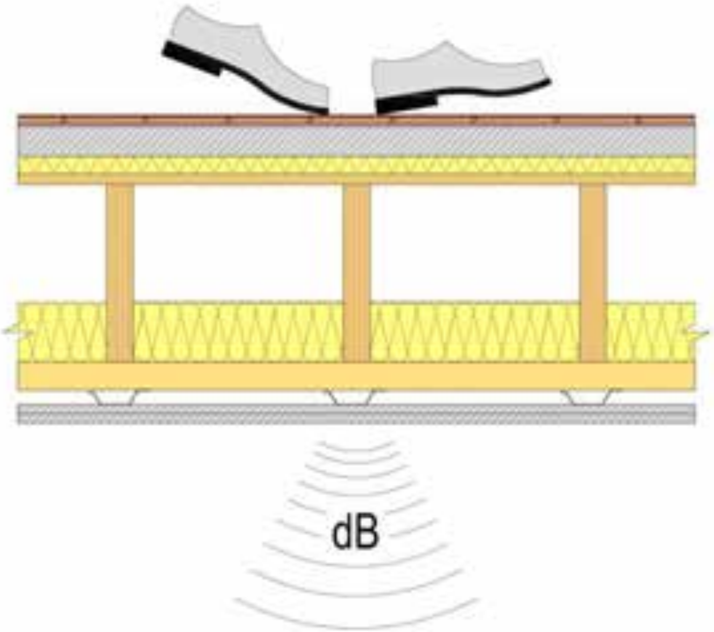



# Acoustics & Sound Control

**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<br>4-1/4" with 3/4" plywood | 24 bare NLT<br>29 with 3/4" plywood | N/A |
| 2x6 NLT wall[6] | 5-1/2" bare NLT<br>6-1/4" with 3/4" plywood | 22 bare NLT<br>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]*

# 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:**

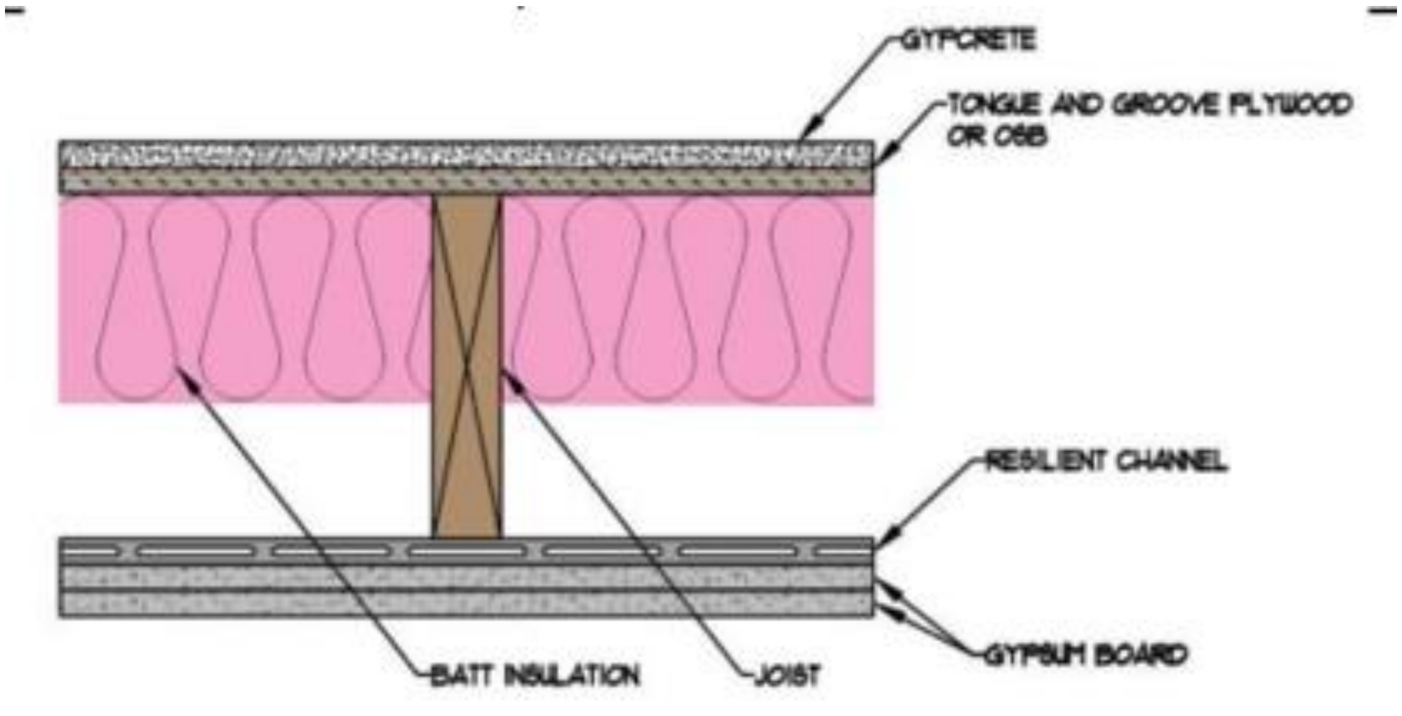
1. Add mass
2. Add noise barriers
3. Add decouplers

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

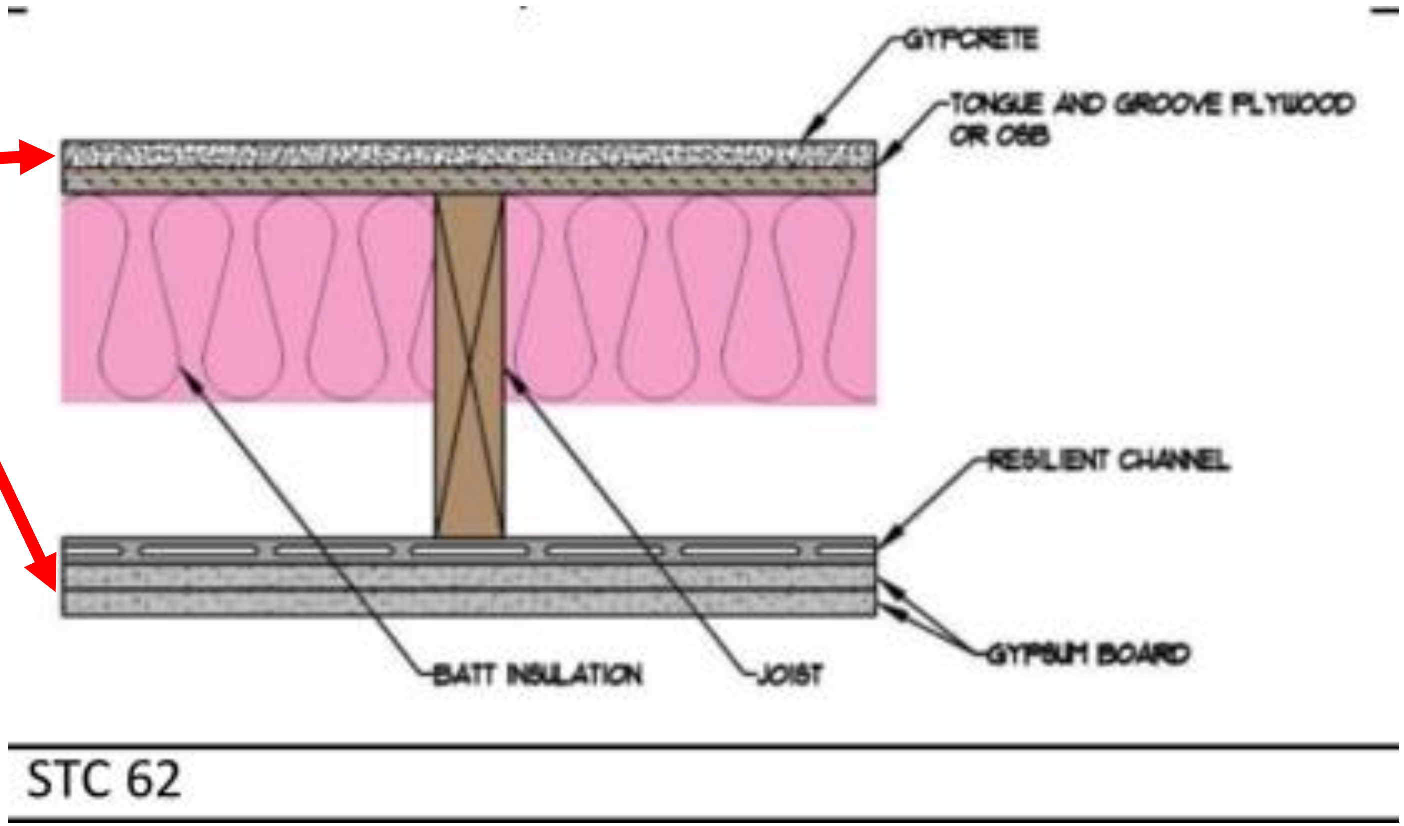



STC 62

# Acoustics & Sound Control

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

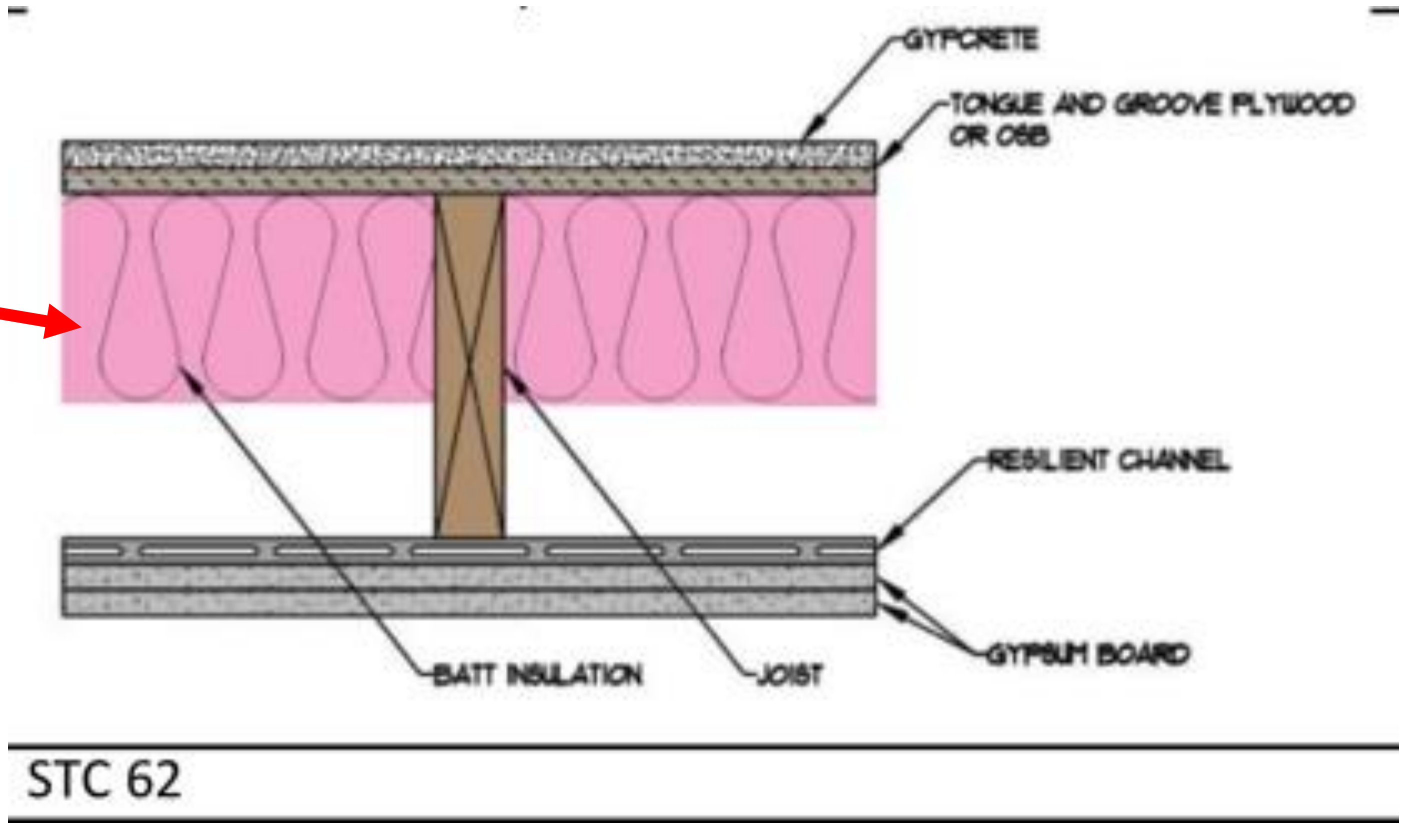
1. Add mass
2. Add noise barriers
3. Add decouplers



# 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

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

1. Add mass
2. Add noise barriers
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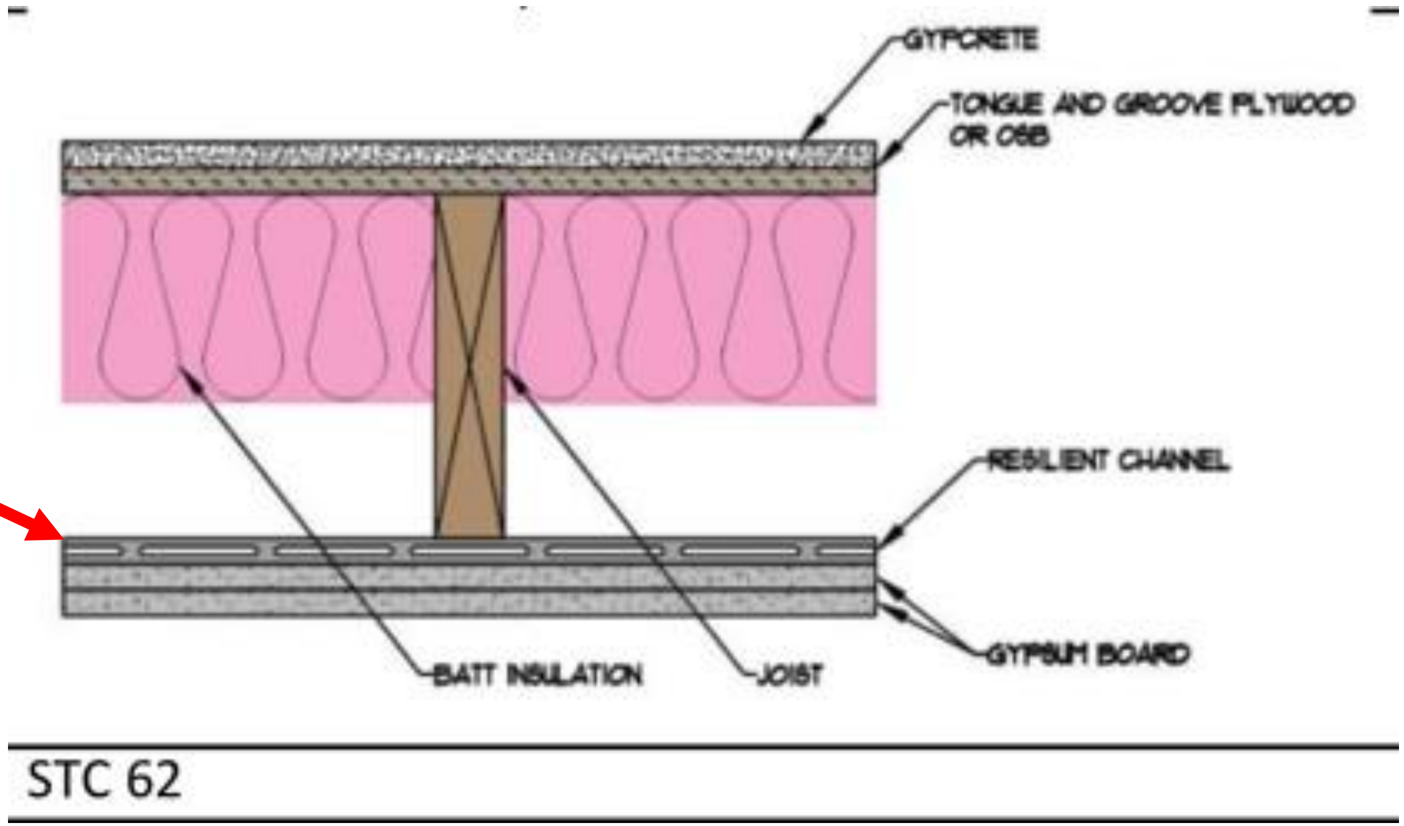


# Acoustics & Sound Control

**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

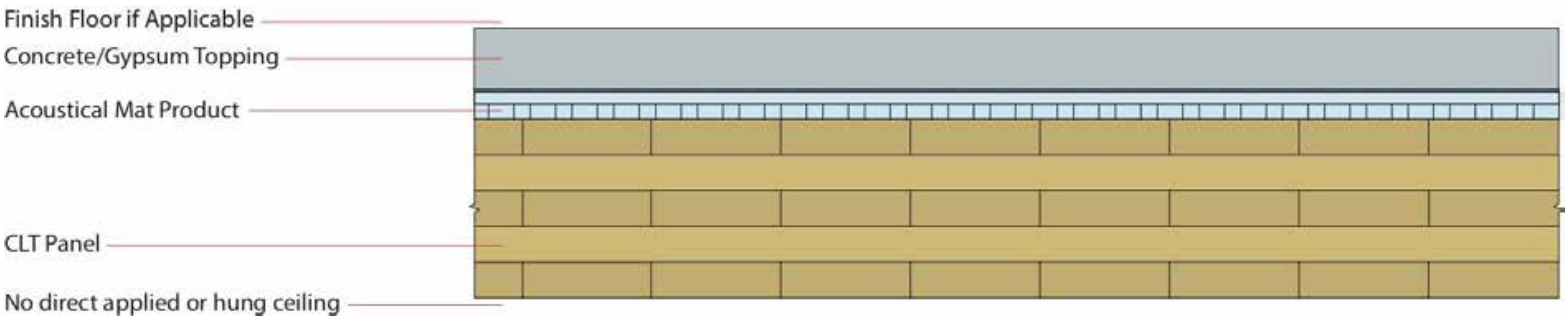
<u>Concrete Slab:</u>
6” Thick
80 PSF
STC 53

<u>CLT Slab:</u>
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 ¼" to 1"+

Credit: Maxxon

# Acoustics & Sound Control

Acoustical floor underlayments

Photo: AcoustiTECH [10]

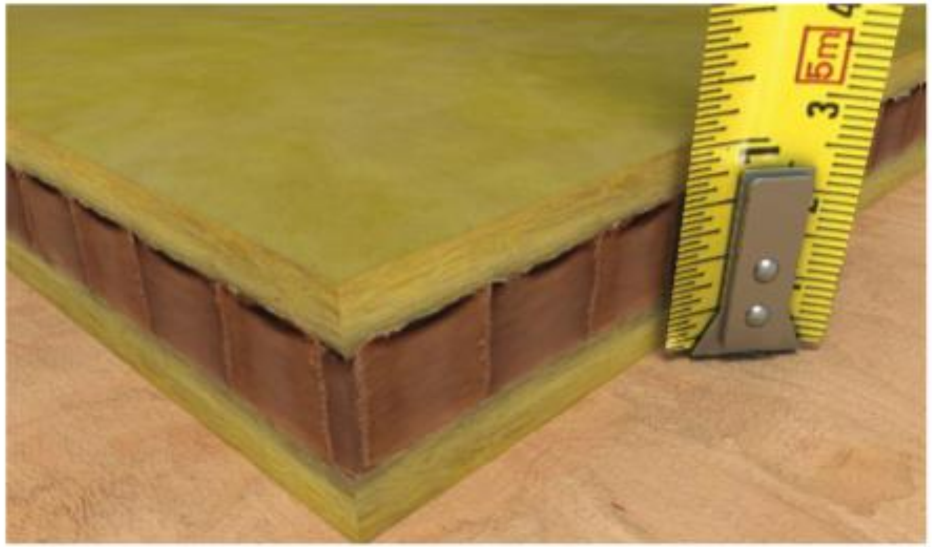


Photo: Kinetics Noise Control, Inc.,[11]

Photo: Maxxon Corporation

Photo: Pliteq Inc.,[12]

# 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



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 Regional Director nearest you: http://www.woodworks.org/project-assistance

**Contents:**



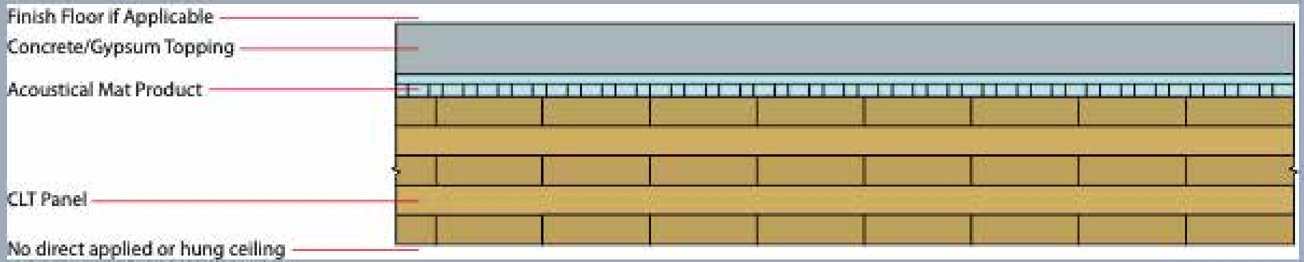
http://bit.ly/mass-timber-assemblies

# Acoustics & Sound Control

## Inventory of Tested Assemblies

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

WoodWorks™ WOOD PRODUCTS COUNCIL




| CLT Panel | Concrete/Gypsum Topping | Acoustical Mat Product Between CLT and Topping | Finish Floor | STC[1] | IIC[1] | Source |
|---|---|---|---|---|---|---|
| CLT 5-ply (6.875") | 1-1/2" Gyp-Crete® | Maxxon Acousti-Mat® 3/4 | None | 47[2] ASTC | 47[2] AIIC | 1 |
| | | | LVT | - | 49[2] AIIC | |
| | | | Carpet + Pad | - | 75[2] AIIC | |
| | | | LVT on Acousti-Top® | - | 52[2] AIIC | |
| | | | Eng Wood on Acousti-Top® | - | 51[2] AIIC | |
| | | Maxxon Acousti-Mat® ¾ Premium | None | 49[2] ASTC | 45[2] AIIC | |
| | | | LVT | - | 47[2] AIIC | |
| | | | LVT on Acousti-Top® | - | 49[2] AIIC | |
| | | | | | | |
| | 1-1/2" Levelrock® | 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 |
| | | | None | 45[6] | 42[6] | 15 |
| | | | LVT | 48[6] | 44[6] | 16 |

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**

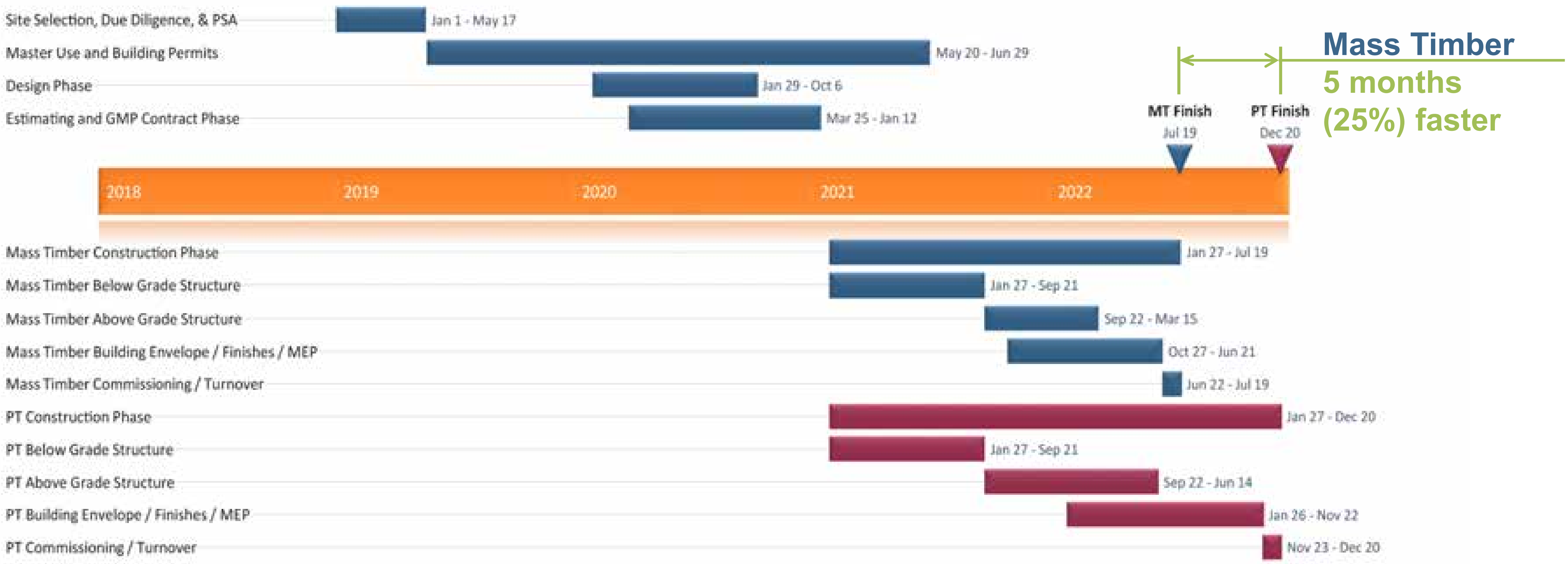
**that developers will experience."**

- Connor Mclain, Colliers

# Seattle Mass Timber Tower

## Fast Construction

Construction Schedule:




Source: Tall With Timber
A Seattle Mass Timber Tower Case Study by DLR Group[1]

# Seattle Mass Timber Tower

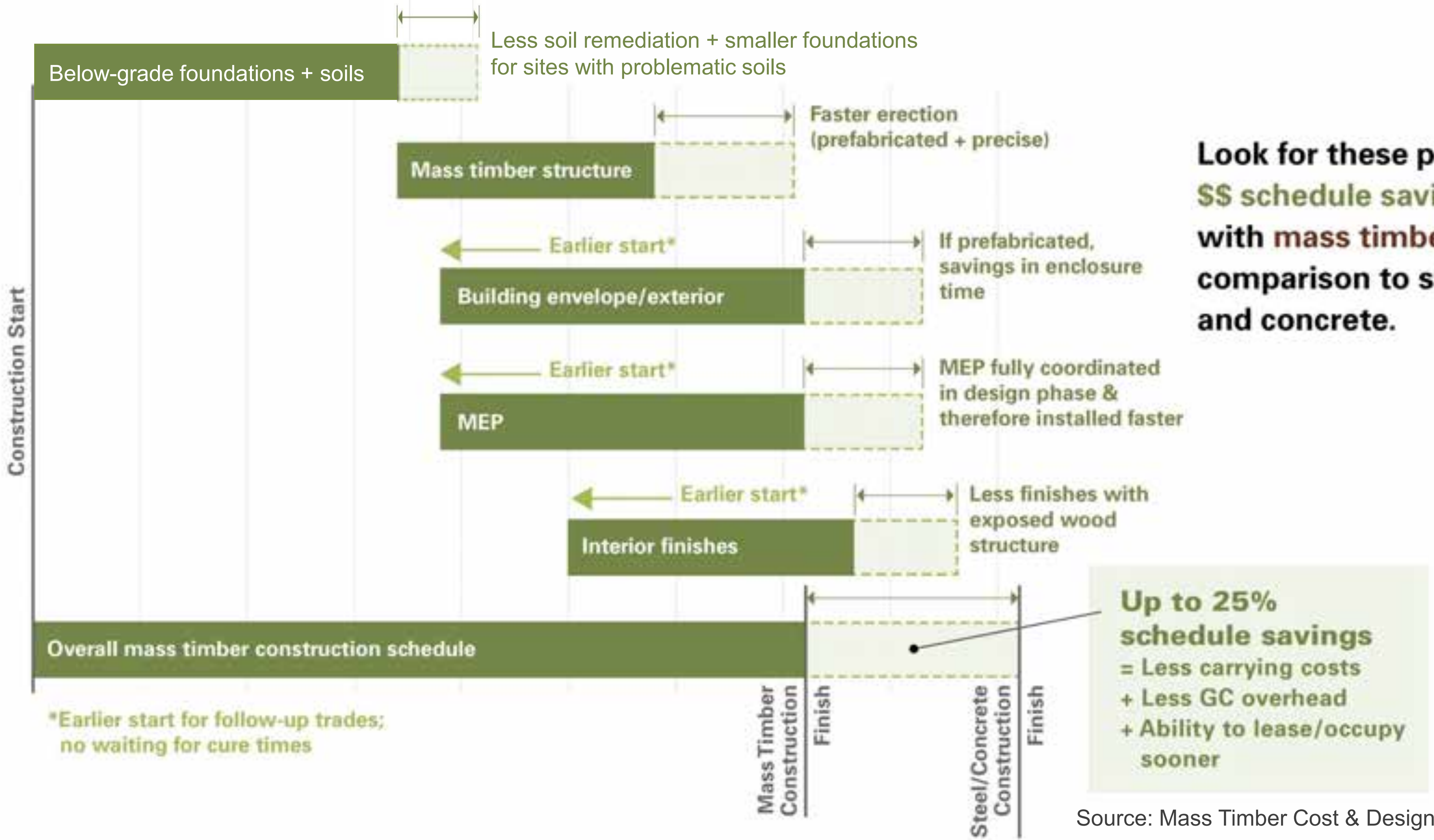
## Faster Construction + Higher Material Costs = Cost Competitive

| 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

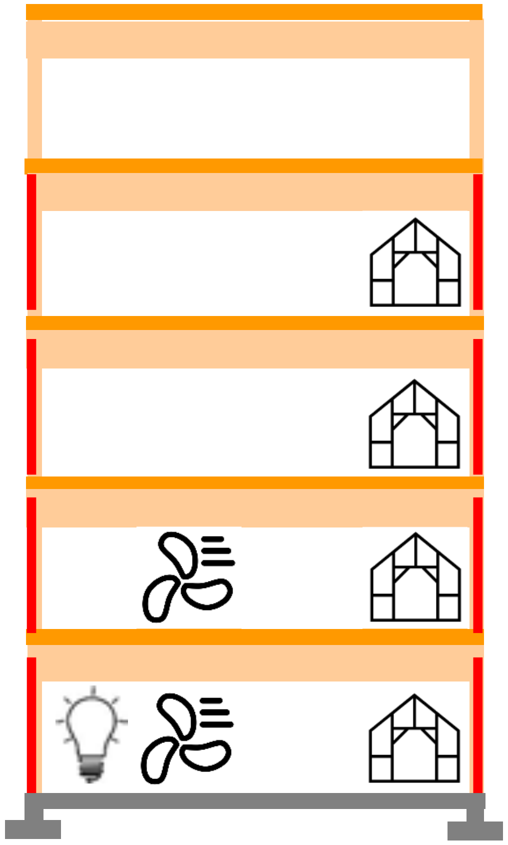



**Look for these potential $$ schedule savings with mass timber in comparison to steel and concrete.**

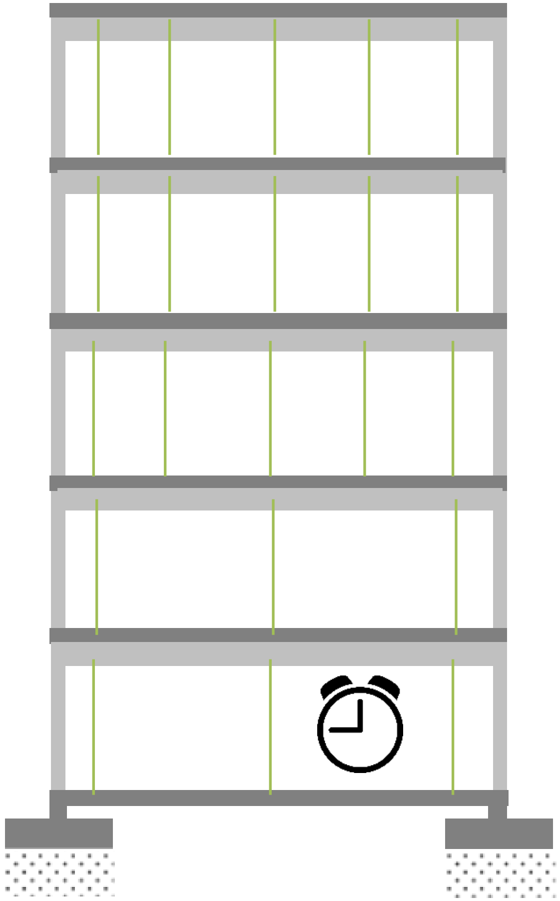
Source: Mass Timber Cost & Design Optimization, WoodWorks[2]

# Schedule Savings for Rough-In Trades

## Fast Construction



NO curing
(mass timber)

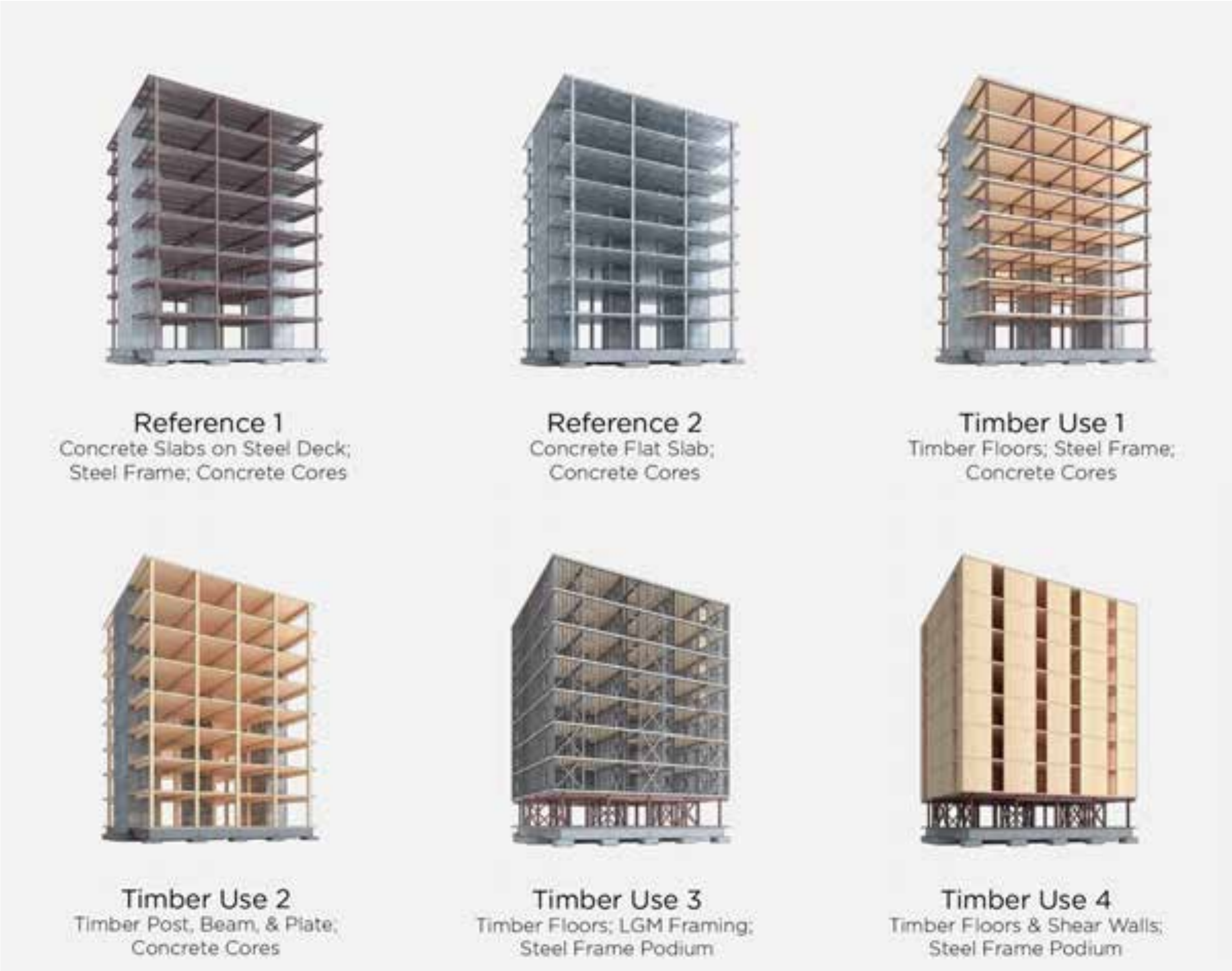


Curing & maze of shores (concrete)

Photo: WoodWorks

Source: Generate Architecture + Technologies

# Holistic Cost Assessment




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 Plate) 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 cellular approaches with load-bearing walls, these options included steel podiums 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. Lastly, Timber Use 4 emphasizes how a completely cellular CLT timber approach yields impressive 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


WoodWorks
WOOD PRODUCTS COUNCIL

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.

## **Keys to Mass Timber Success:**

Know Your <u>WHY</u>

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

Images: Korb & Associates

# 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? Ask us anything.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Leap!Structures, photo Casey Dunn

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