Sound Solutions + Mass Timber in Multi-Family Housing

October 19, 2023

Presented by
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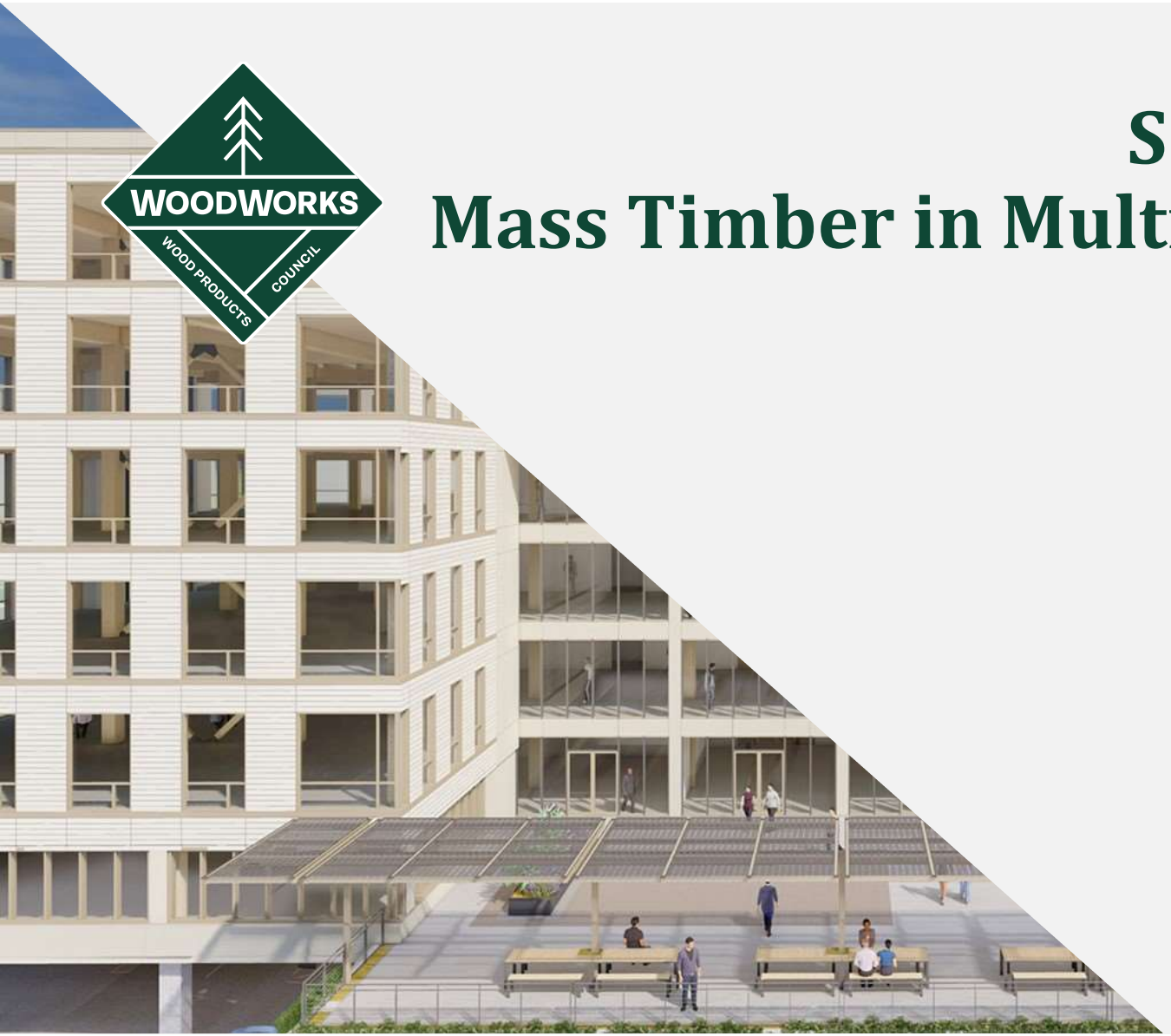
WoodWorks



Apex Plaza / Courtesy William McDonough + Partner

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

AIA Approved Continuing Education

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.

Course Description

Noise control in buildings such as apartments, schools, and offices plays an important role in tenant satisfaction. Selecting an effective wall or floor/ceiling assembly is important—and necessary for proper design—but it's just one of several considerations. Covering both light wood-frame and mass timber structures, this presentation will provide a top to bottom approach to achieving sound acoustical performance. Topics will include code requirements and owner expectations, tested assemblies vs. calculated performance, exterior noise, interior noise reverberation, structural and fire-resistance related components, detailing to avoid flanking paths, and installation best practices.

Learning Objectives

1. Consider code requirements for acoustical performance of building spaces compared to common owner expectations in occupancies such as multi-family.

2. Highlight best practice details to avoid noise flanking paths.

3. Explore options for minimizing exterior noise and interior reverberation issues in wood buildings including schools and offices.

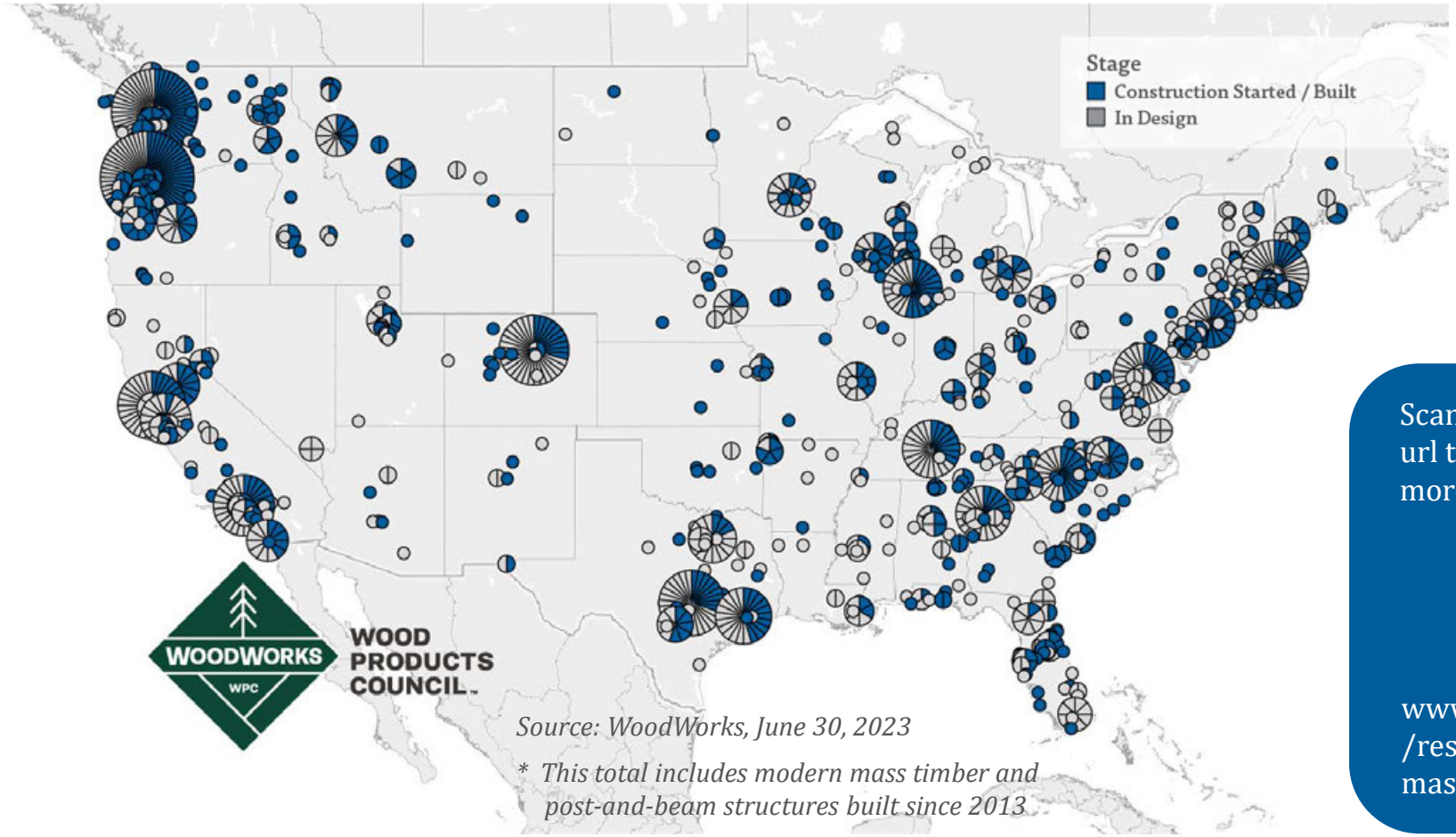
4. Discuss the difference between acoustical performance of light-frame wood and mass timber assemblies and highlight successful acoustical design approaches for each.

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 June 2023, in the US, **1,860** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.



Source: WoodWorks, June 30, 2023

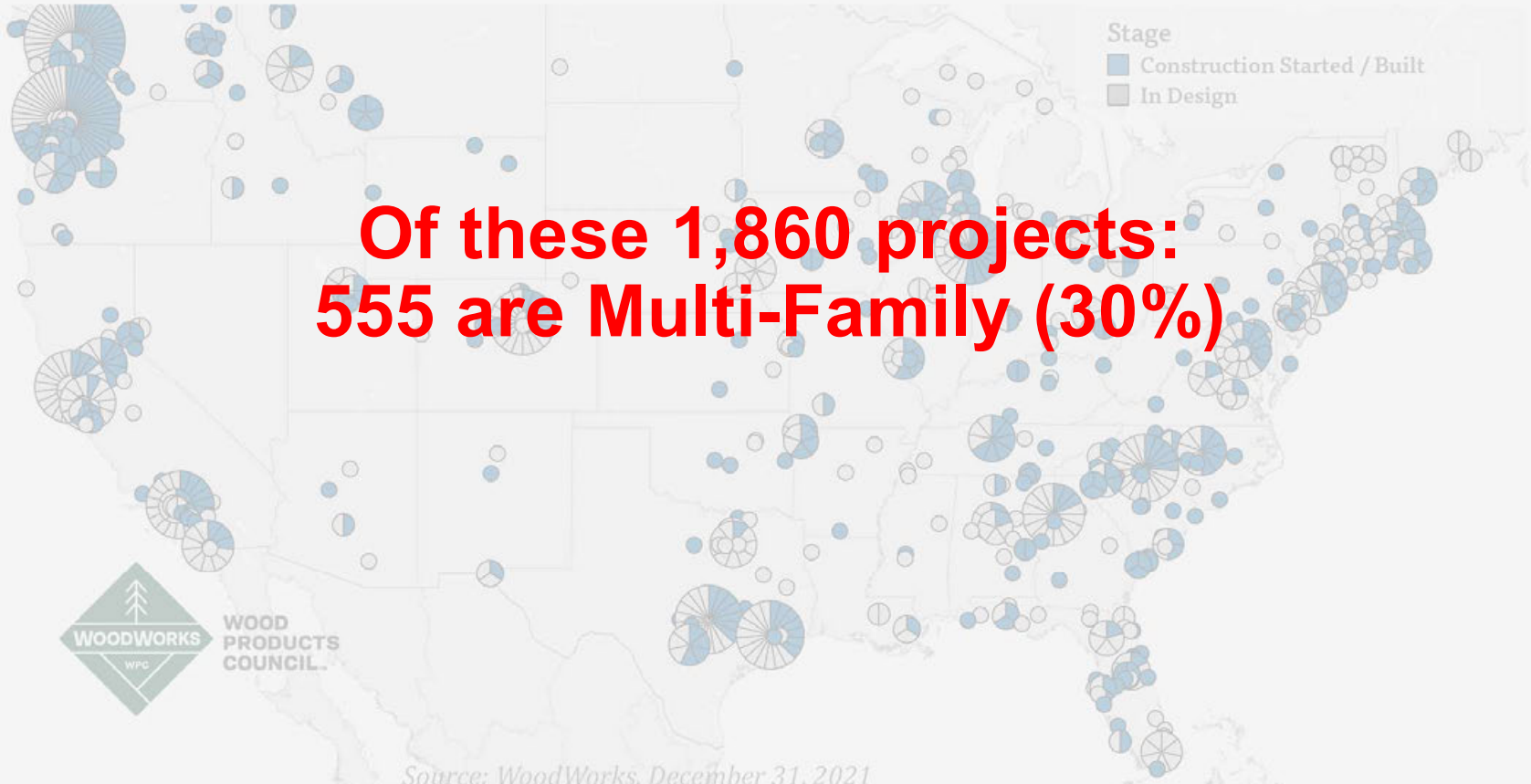
** This total includes modern mass timber and post-and-beam structures built since 2013*

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

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

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 1,860 projects:
555 are Multi-Family (30%)

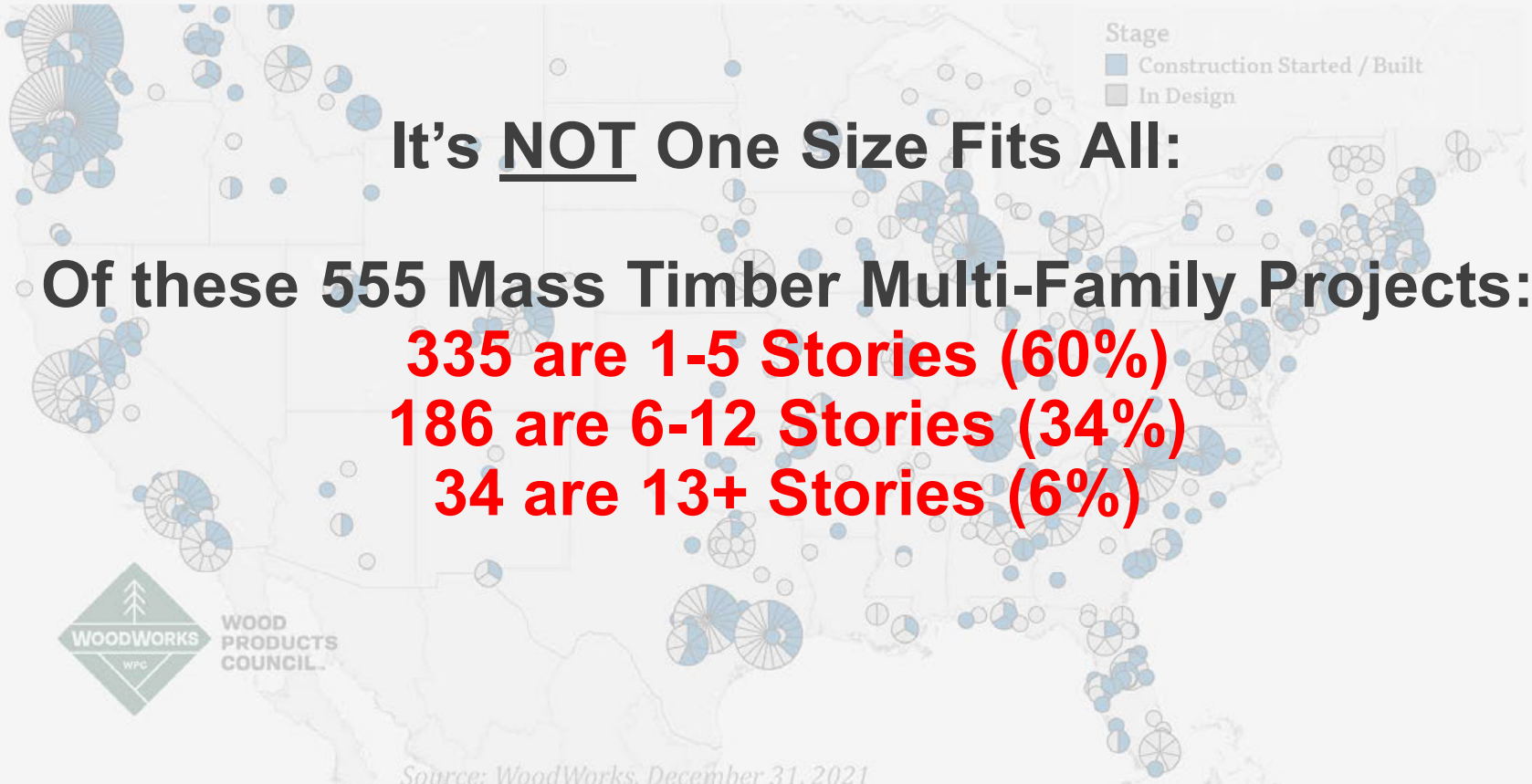
WOODWORKS
WPC
WOOD PRODUCTS COUNCIL

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 555 Mass Timber Multi-Family Projects:

335 are 1-5 Stories (60%)
186 are 6-12 Stories (34%)
34 are 13+ Stories (6%)

WOODWORKS WPC
WOOD PRODUCTS COUNCIL

Source: WoodWorks, December 31, 2021
** This total includes modern mass timber and post-and-beam structures built since 2013*

Multi-Housing Typologies

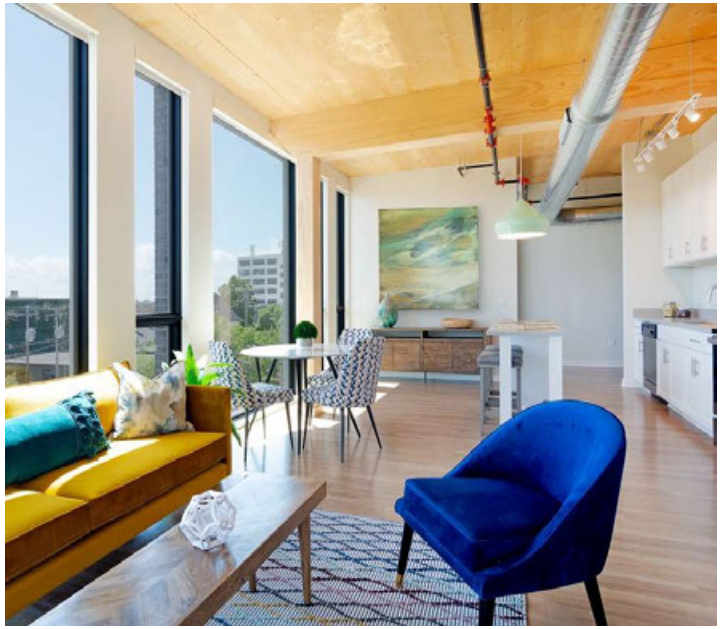
Credit: WGI

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: A2X Creative and Engberg Anderson

HYBRID LIGHT-FRAME + MASS TIMBER

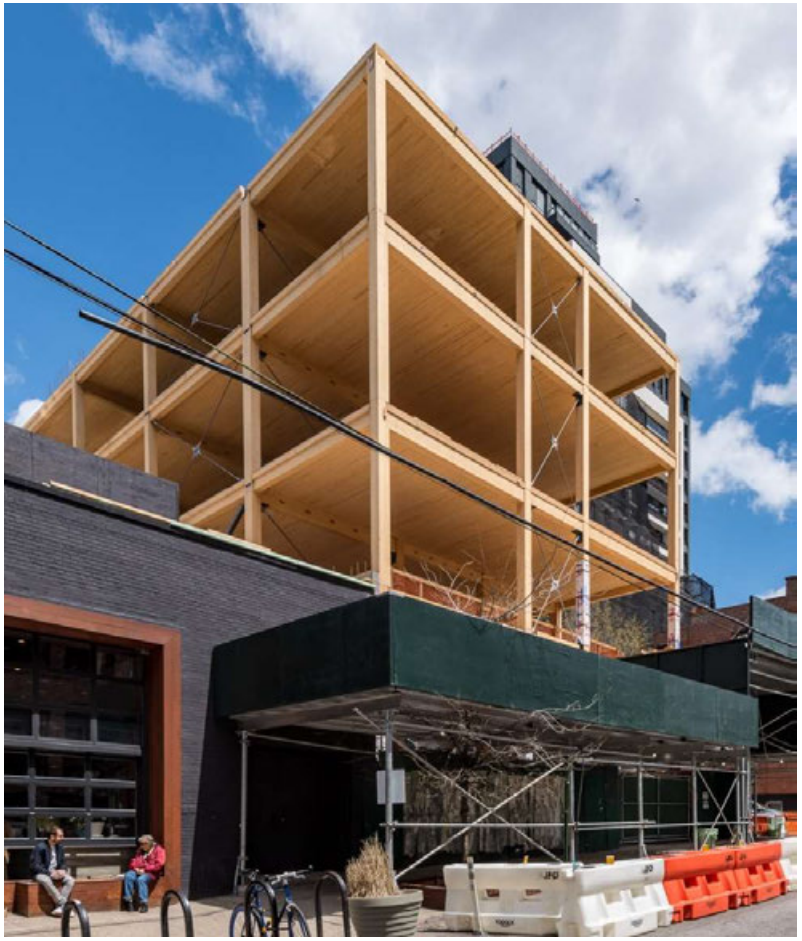
CONDOS AT LOST RABBIT, MS

Lost Rabbit, MS
Credit: Everett Consulting Group

Photo: Ema Peter

POST, BEAM + PLATE

360 WYTHE AVENUE, BROOKLYN, NY

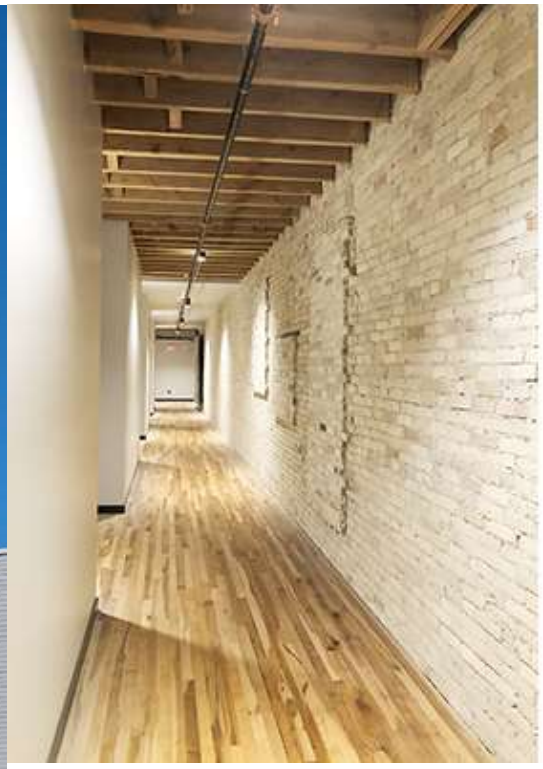


Credit: Flank

MASS TIMBER BEARING WALLS

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

TIMBER LOFTS
MILWAUKEE, WI

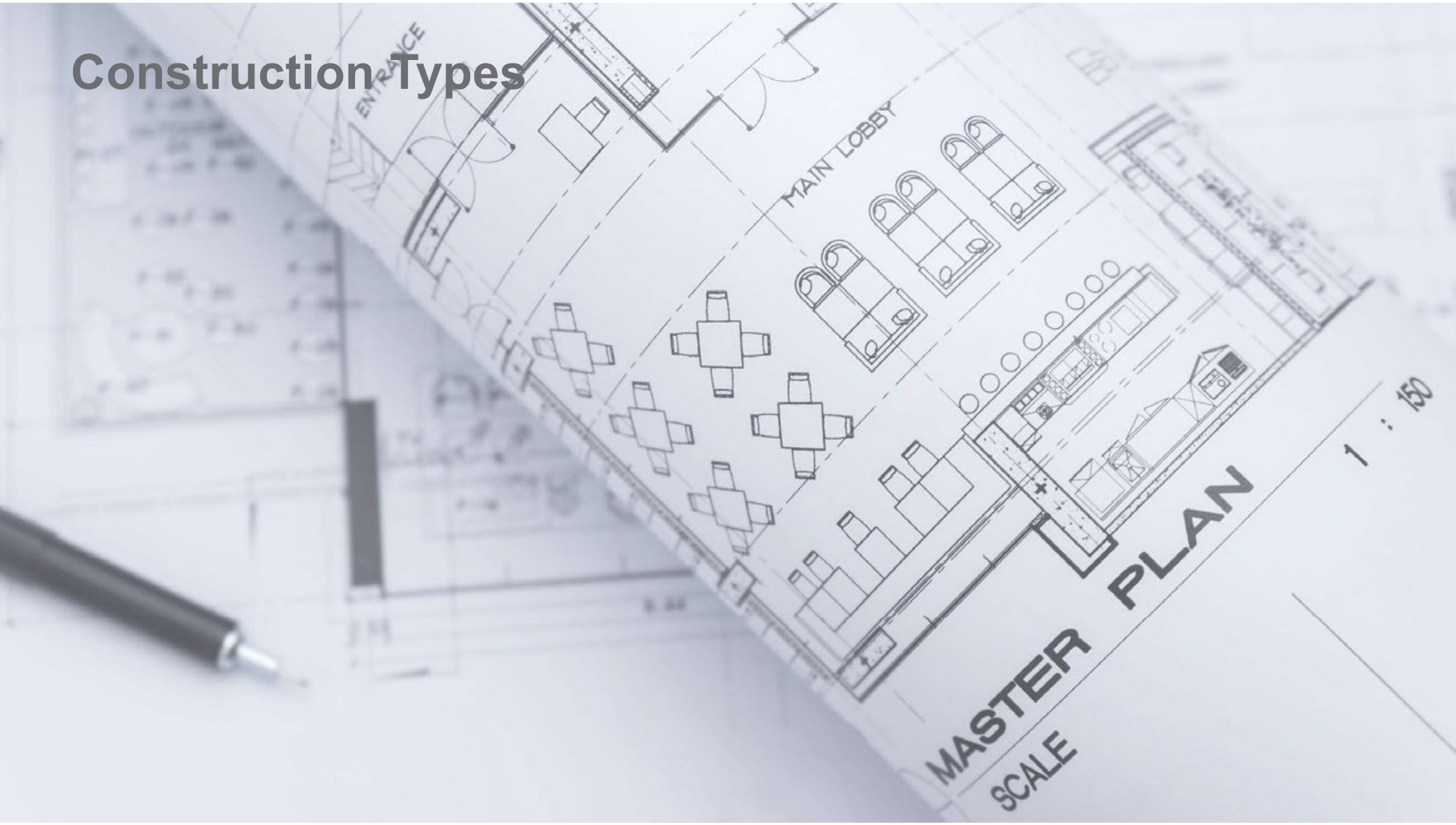
ANN PIEPER EISENBROWN
OWNER/PRESIDENT | PIPER PROPERTIES
TIMBER LOFTS

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

Source: Think Wood

Source: ADX Creative and Engberg Anderson Architects

Construction Types

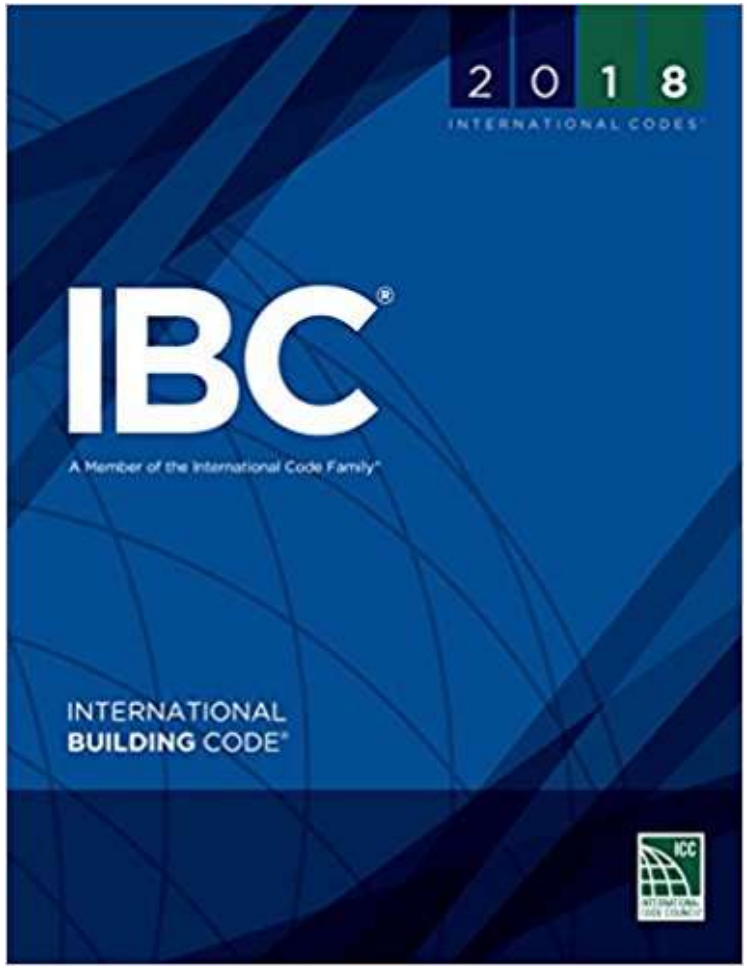


Construction Types

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

Where does the code allow MT to be used?

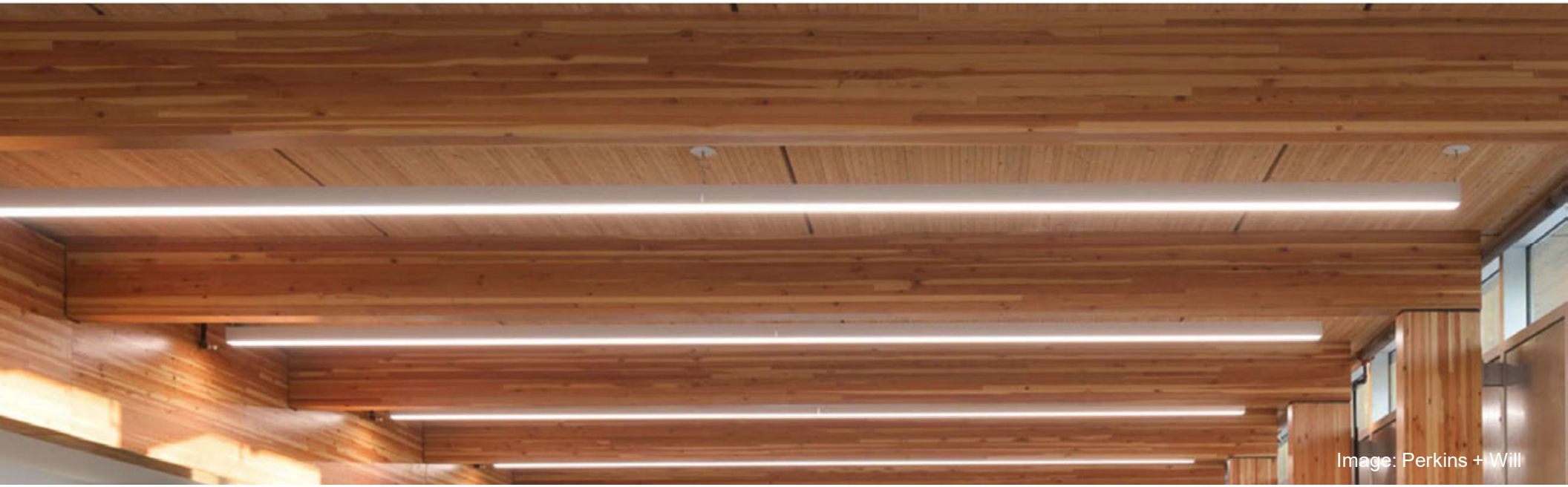
- Type III: Interior elements (floors, roofs, partitions/shafts) and exterior walls if FRT

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

Construction Types

Where does the code allow MT to be used?

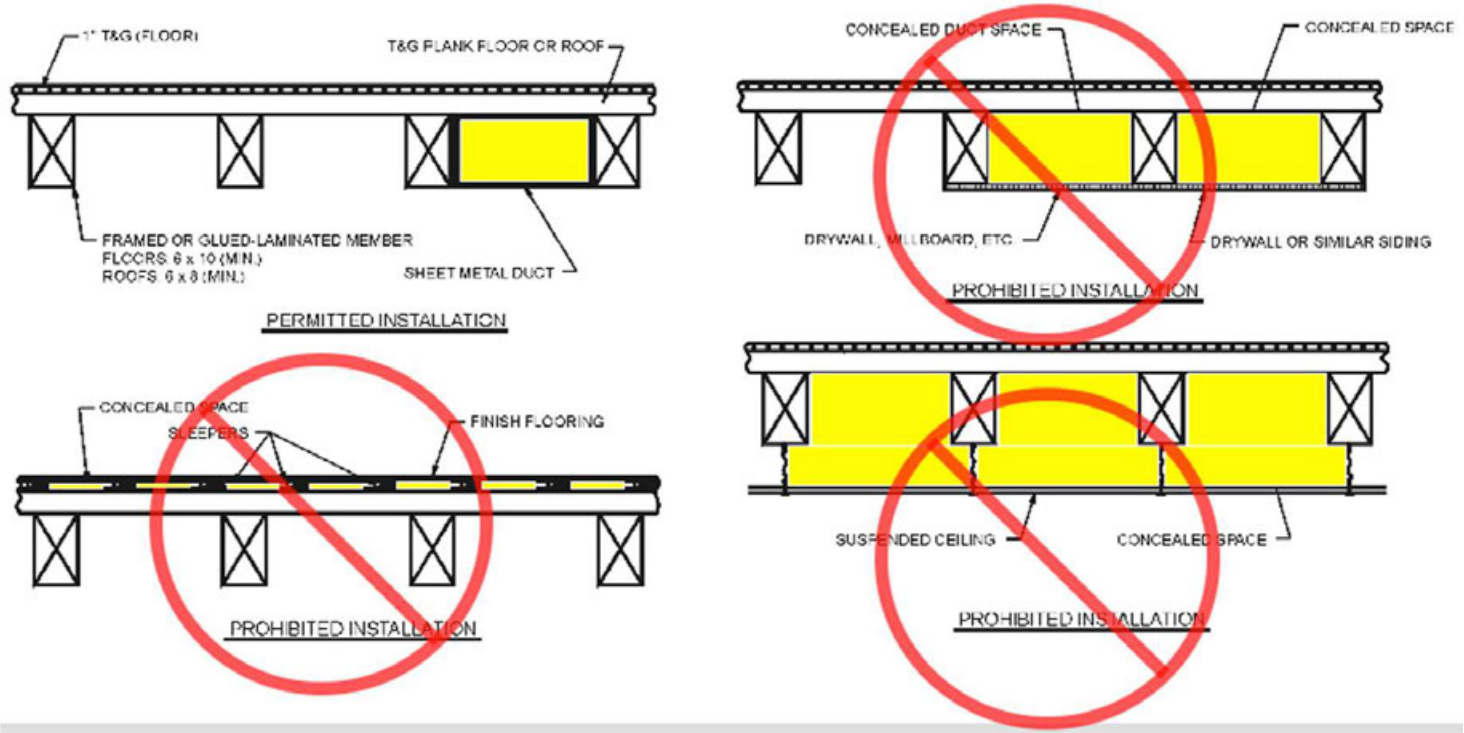
- Type IV: Any exposed interior elements & roofs, must meet min. sizes; exterior walls if CLT or FRT. Concealed space limitations (varies by code version)



Construction Types

Type IV concealed spaces

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

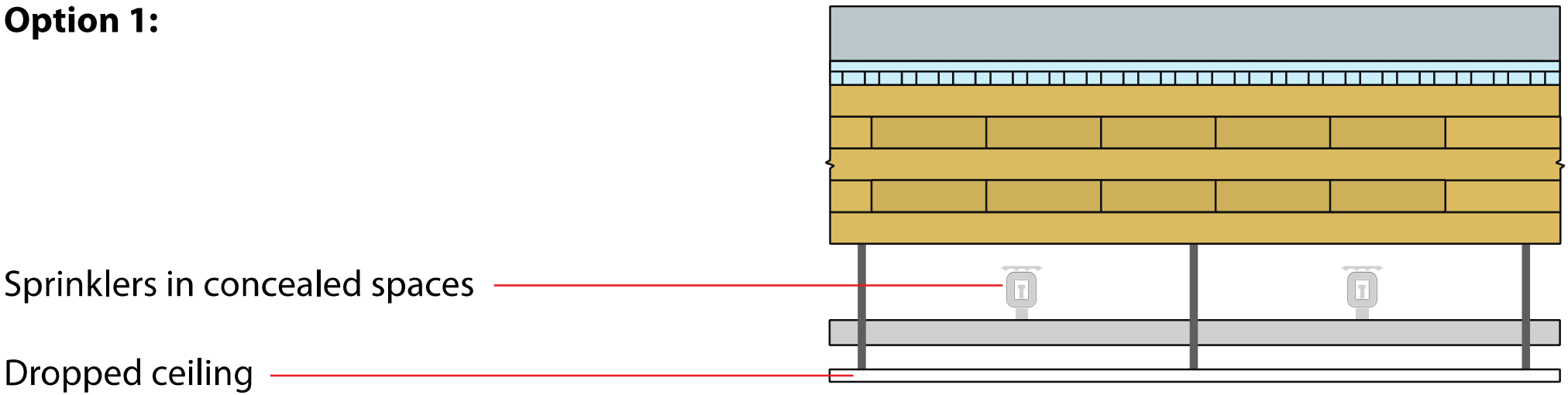


Credit: IBC

Construction Types

Type IV concealed space options within 2021 IBC

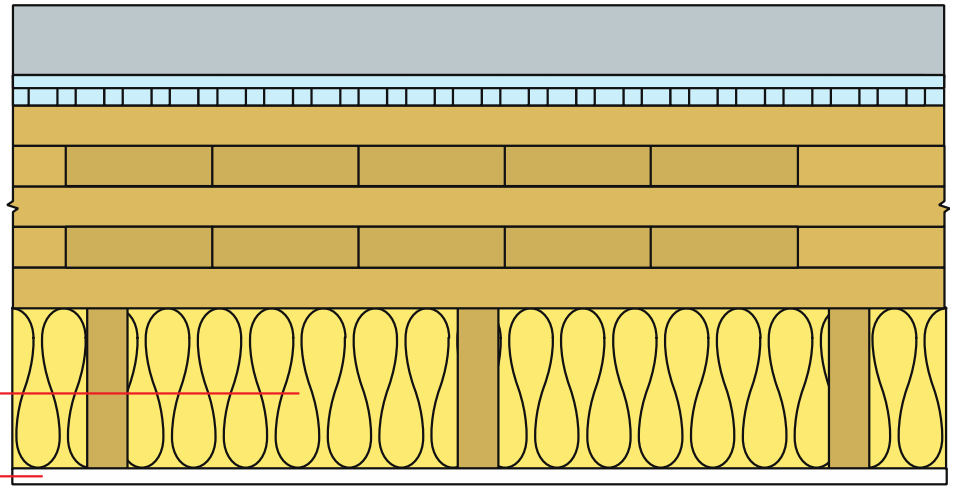
Option 1:



Construction Types

Type IV concealed space options within 2021 IBC

Option 2:



Noncombustible insulation

Dropped ceiling

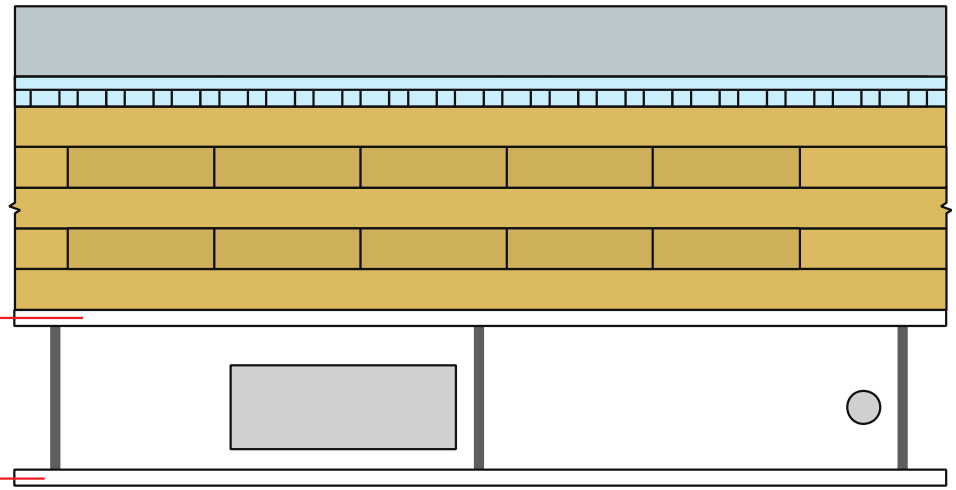
Construction Types

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

Richard McLain, PE, SE
Senior Technical Director – Tall Wood
WoodWorks – Wood Products Council

WOODWORKS

Concealed Spaces in Mass Timber and Heavy Timber Structures

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?*[1]

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, glue-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.

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

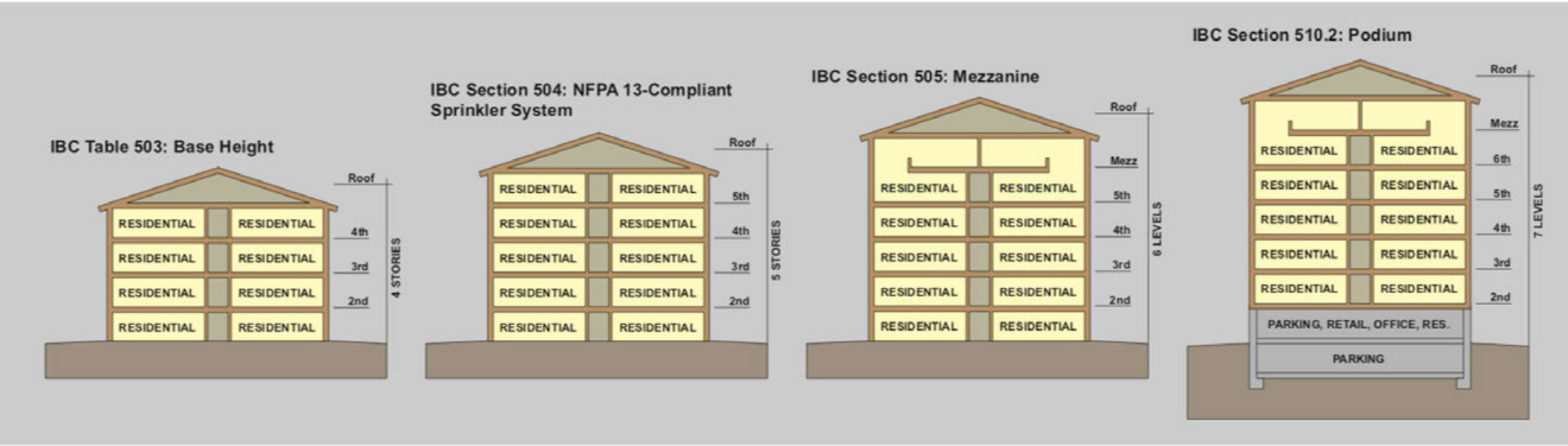
https://www.woodworks.org/wp-content/uploads/wood_solution_paper-Concealed_Spaces_Timber_Structures.pdf

Construction Types

Where does the code allow MT to be used?

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

PRESCRIPTIVE BUILDING CODES

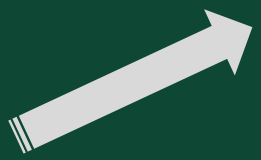


EVOLUTION

INCREMENTAL CHANGE

REVOLUTION

TRANSFORMATIONAL CHANGE



Tall Mass Timber Multi-Family

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

12 tall wood projects already under construction or built.

Carbon 12
Portland, OR
8 stories mass timber

Heartwood
Seattle, WA
8 stories mass timber

Minnesota Places
Portland, OR
8 stories – 7 mass timber

TimberView
Portland, OR
8 stories mass timber

1510 Webster
Oakland, CA
18 stories – 16 mass timber

Ascent
Milwaukee, WI
25 stories – 19 mass timber

Bakers Place
Madison, WI
15 stories – 12 mass timber

INTRO
Cleveland, OH
9 stories – 8 mass timber

11 E Lenox
Boston, MA
7 stories mass timber

80 M Street
Washington DC
10 stories – 3-story mass timber vertical addition

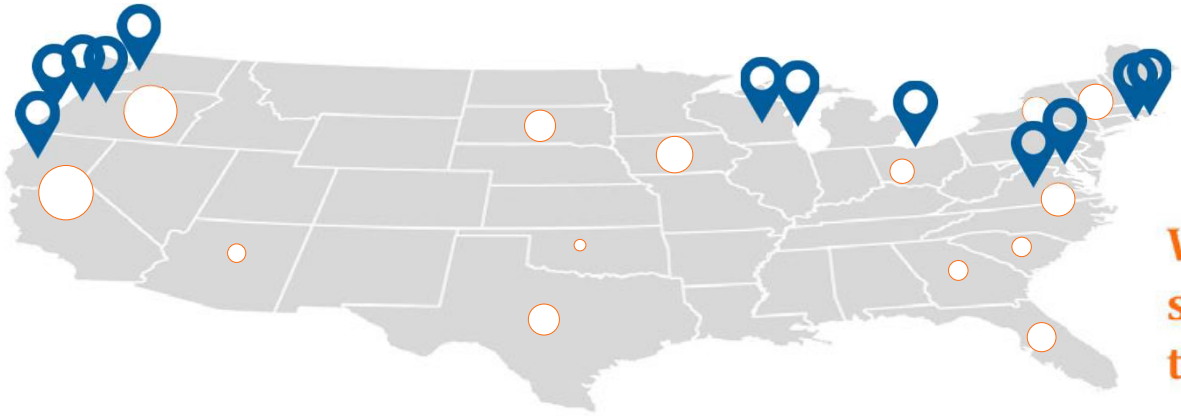
Apex Plaza
Charlottesville, VA
8 stories – 6 mass timber

Bunker Hill Housing
Boston, MA
6 stories mass timber

TALL WOOD

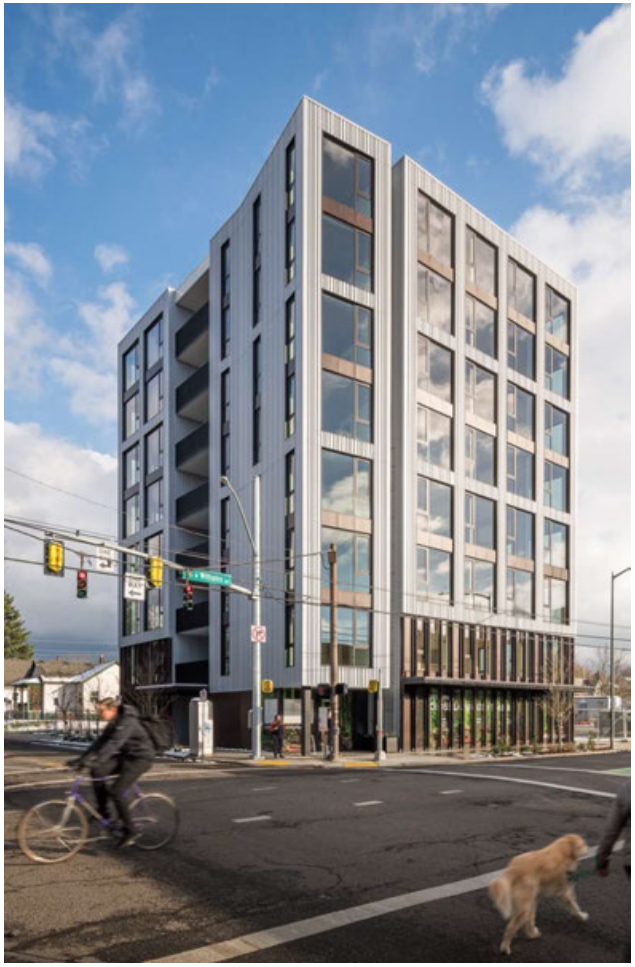
= 20 in-design tall wood projects

= tall wood project in construction or completed



WoodWorks is supporting 214 tall wood projects

CARBON 12, PORTLAND, OR



Credit: Baumberger Studio/PATH 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

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

11 E LENOX, BOSTON, MA

7 STORIES

70 FT

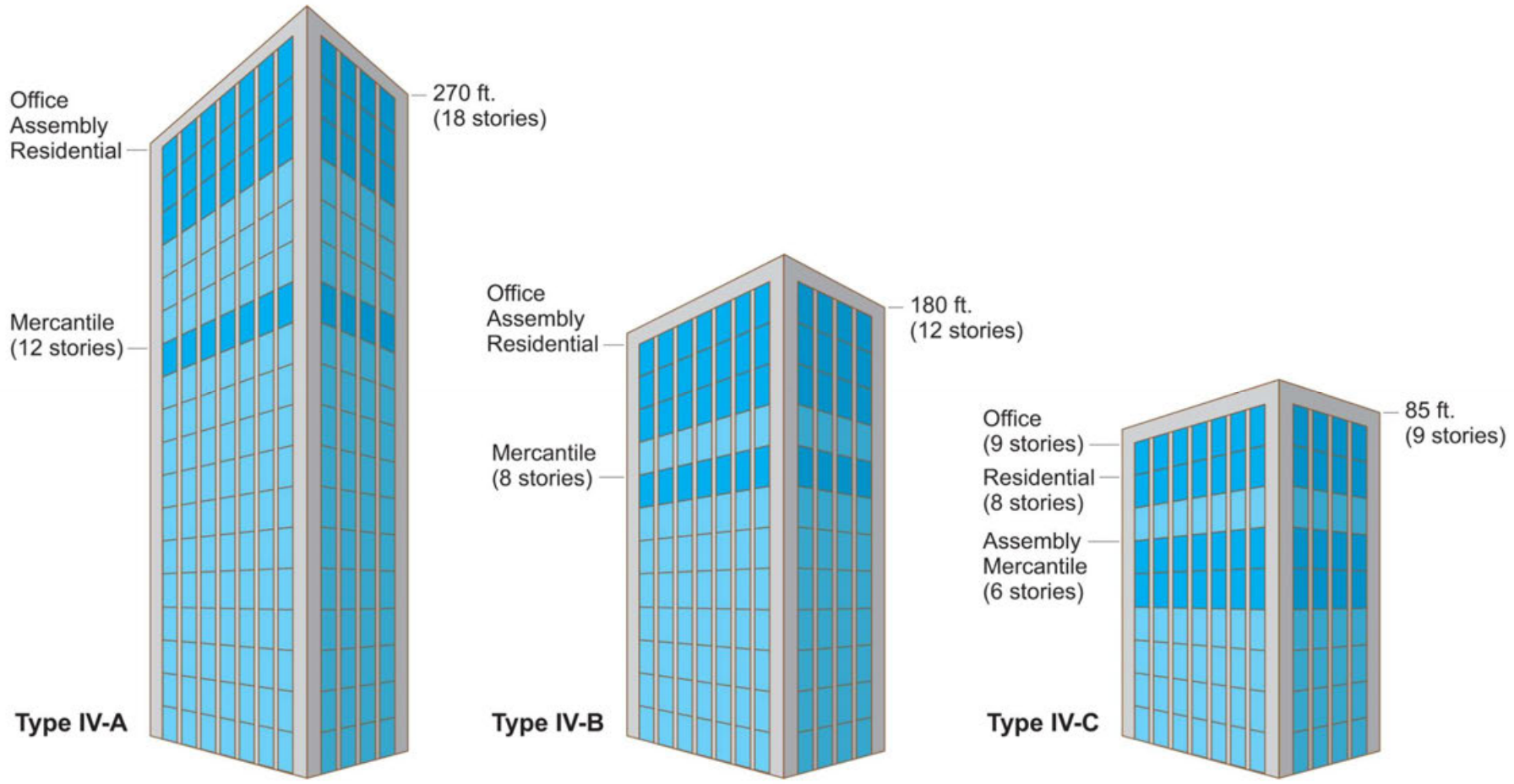
Passive House

Multi-Family

Credit: H + O Structural Engineering

Credit: Monte-Frenah Design Studio

PRESCRIPTIVE BUILDING CODES

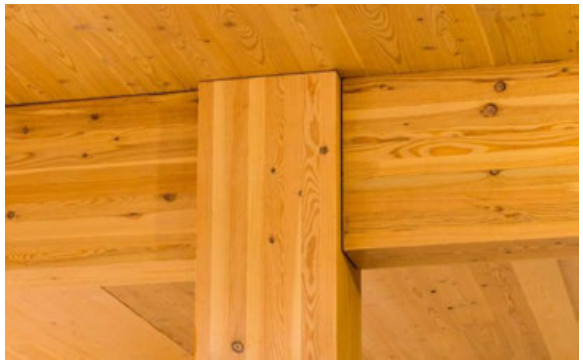


Type IV-C

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

Type IV-C Height and Area Limits

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

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

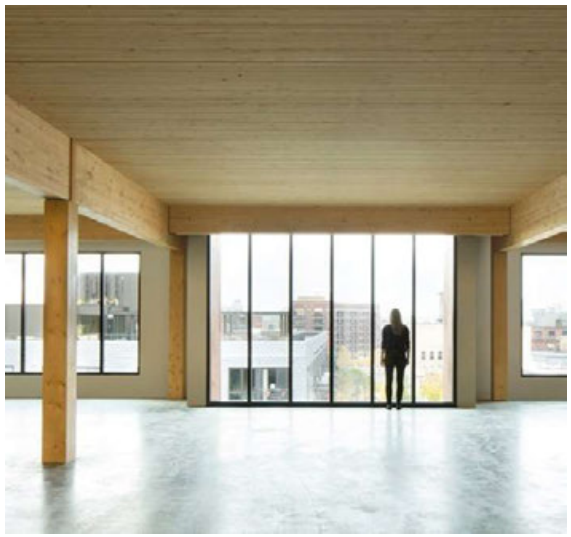
Type IV-C Protection vs. Exposed

IV-C

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

Type IV-B Height and Area Limits

IV-B

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

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, 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

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

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

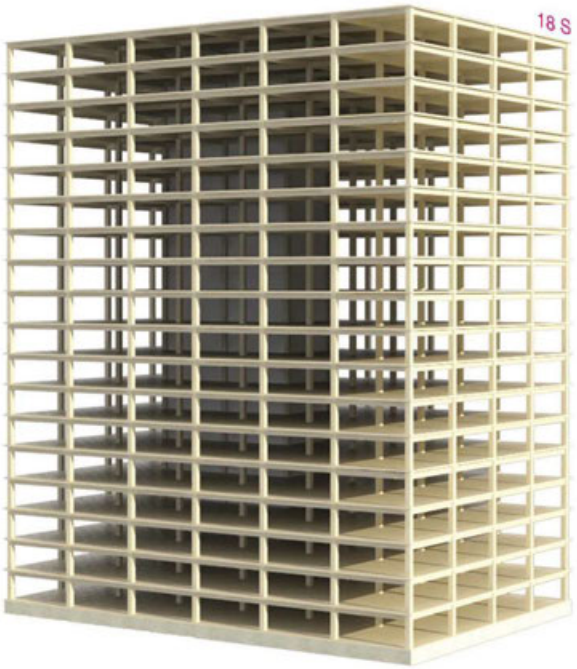
$U_{tw} = 120$ SF

- 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

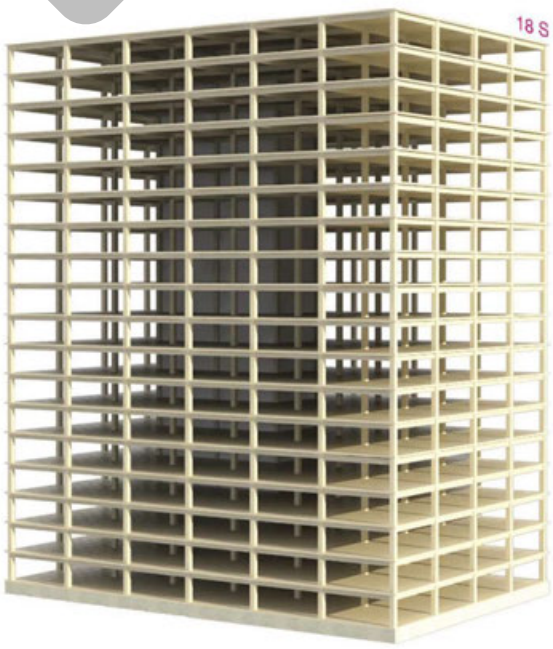
TYPE IV-A

Credit: Susan Jones, atelierjones

Photos: Structurlam, naturally:wood, Fast + Epp

IV-A

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

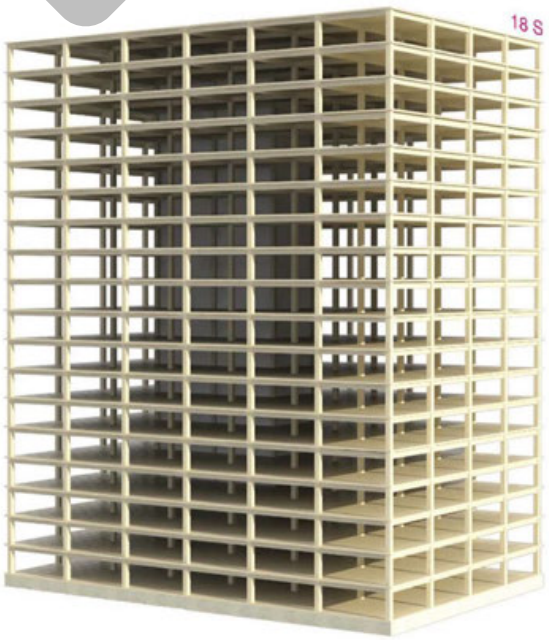
Areas exclude potential frontage increase

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

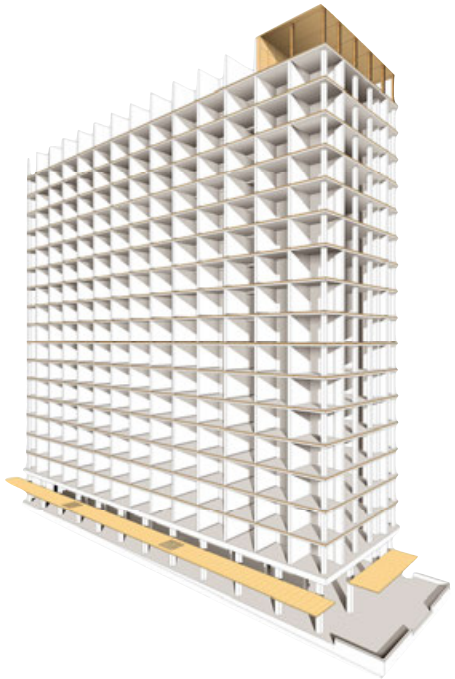
Type IV-A Protection vs. Exposed

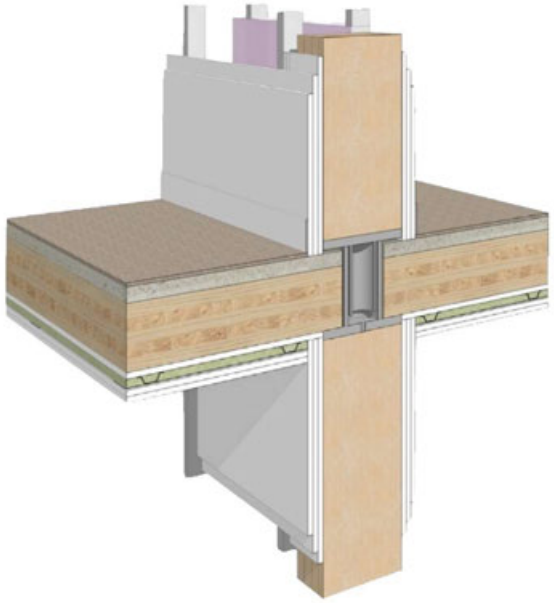


18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-A

Credit: Susan Jones, atelierjones





100% NC protection on all surfaces of Mass Timber

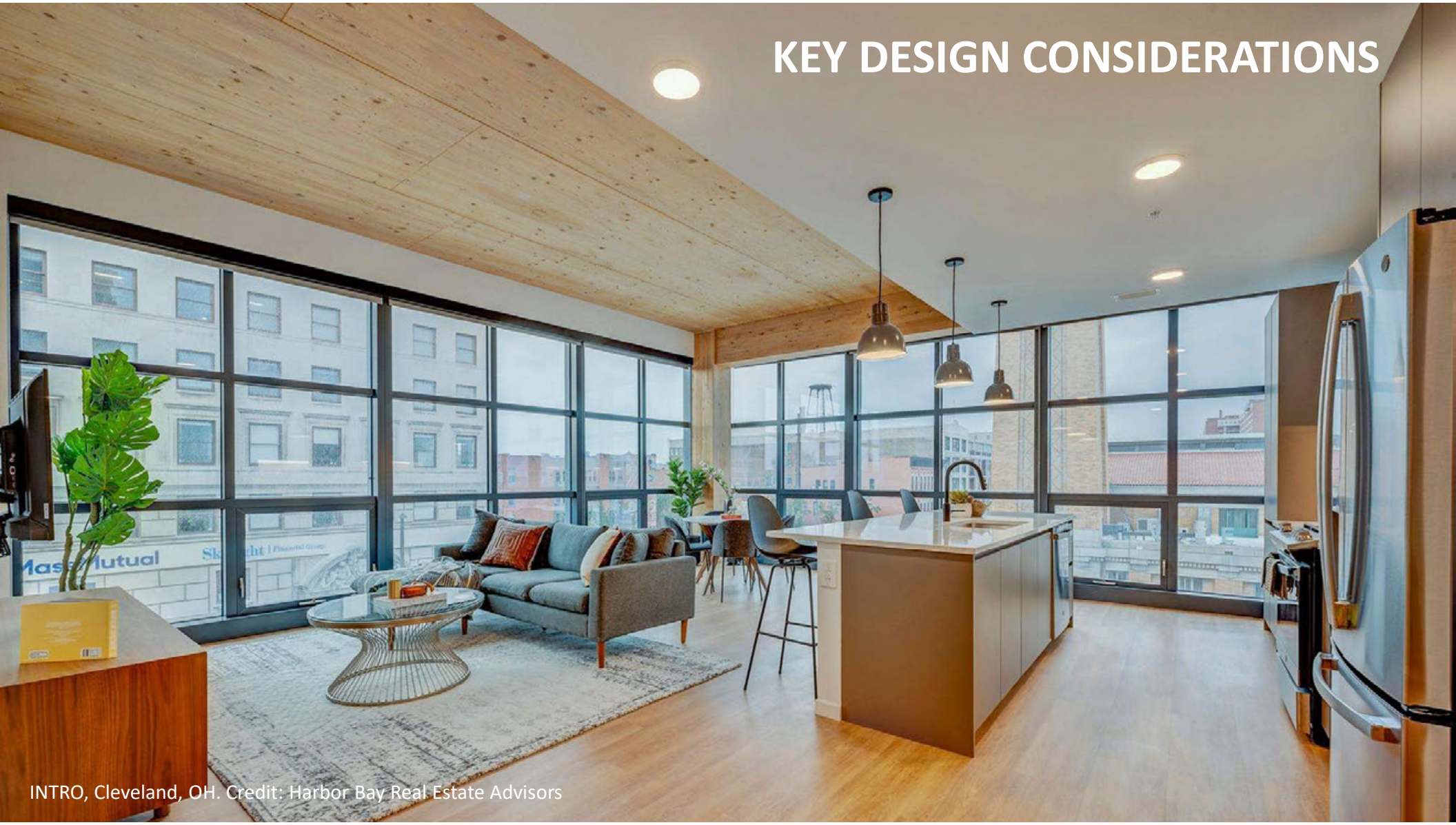
Credit: Acton Ostry Architects, Fast + Epp

IV-A

2024 IBC Changes

RISE Tests, 2020
Photo: RISE

KEY DESIGN CONSIDERATIONS



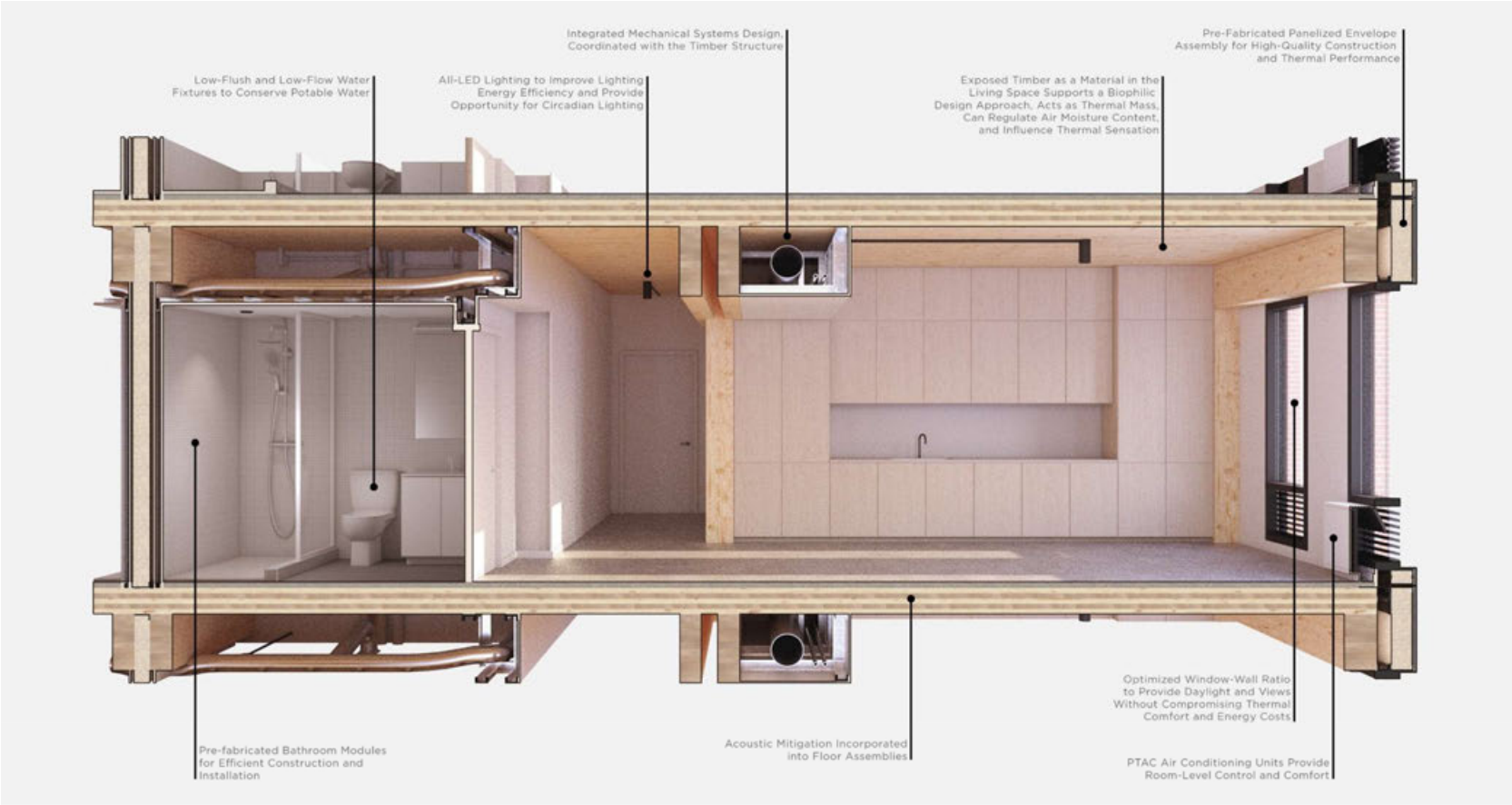
INTRO, Cleveland, OH. Credit: Harbor Bay Real Estate Advisors

MEP 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

MEP SYSTEMS, ROUTING, INTEGRATION



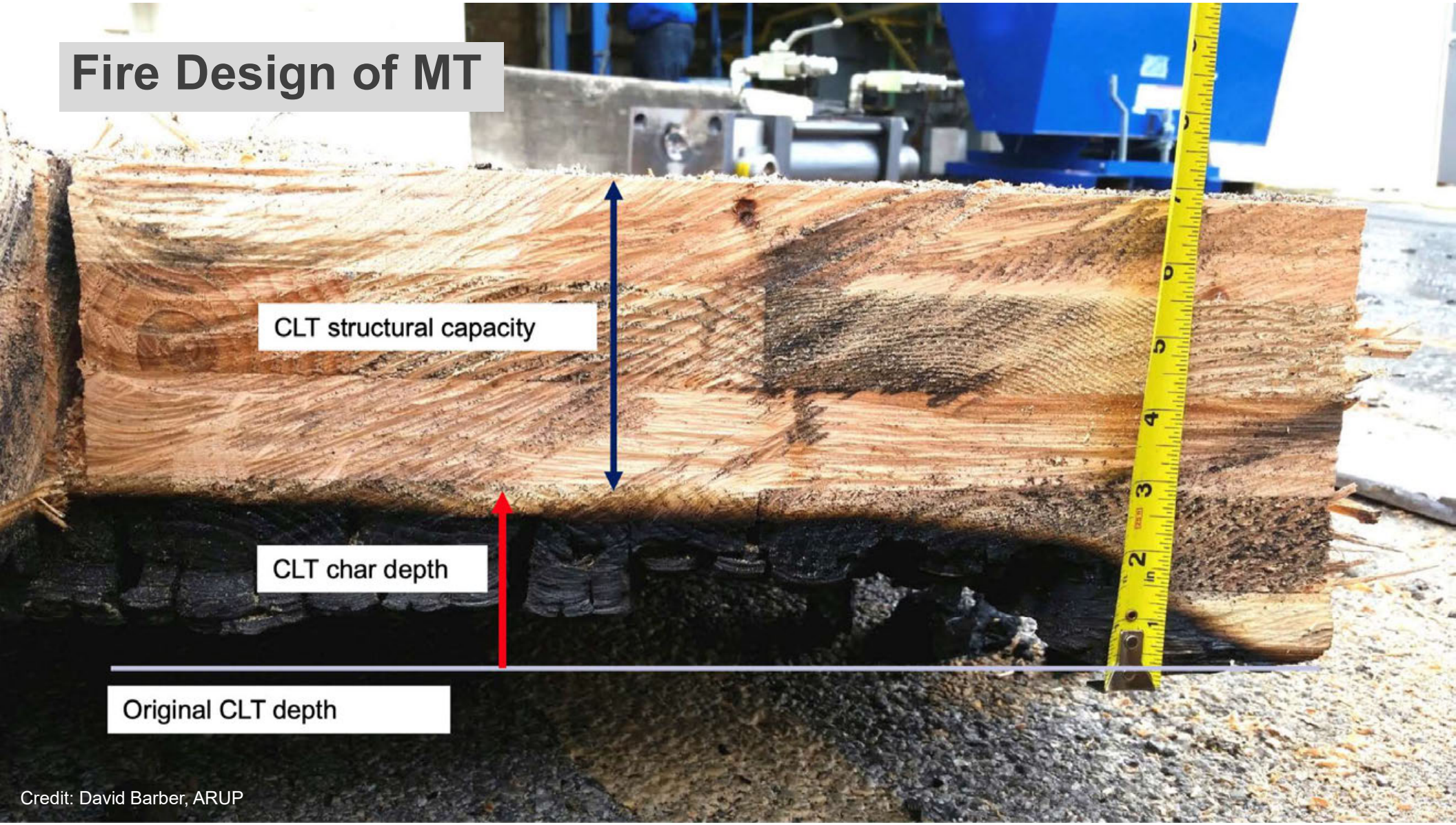
INTEGRATED SYSTEMS

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

Fire Design of MT



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 Exterior[e,f] Interior	3 3[a]	2 2[a]	1 1	0 0	2 1	2 0	2 1/HT	1 1	0 0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions 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)	$1\frac{1}{2}$[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)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1½	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


Fire Testing Laboratory

TEST REPORT

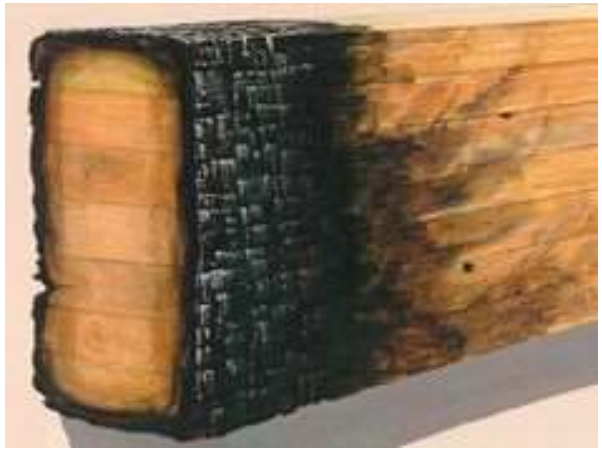
for

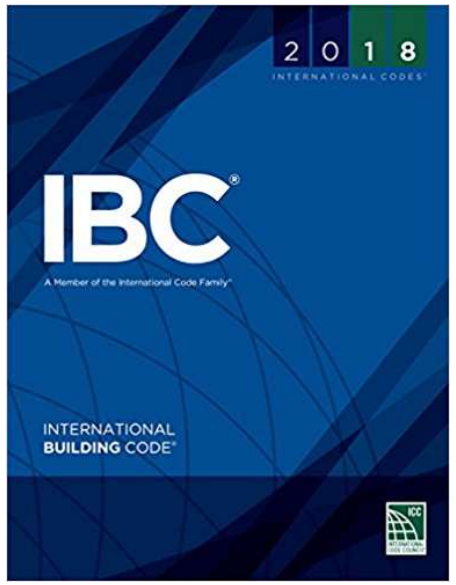
American Wood Council

222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Standard Methods of
Fire Tests of Building Construction and Materials
ASTM E 119 – 11a

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

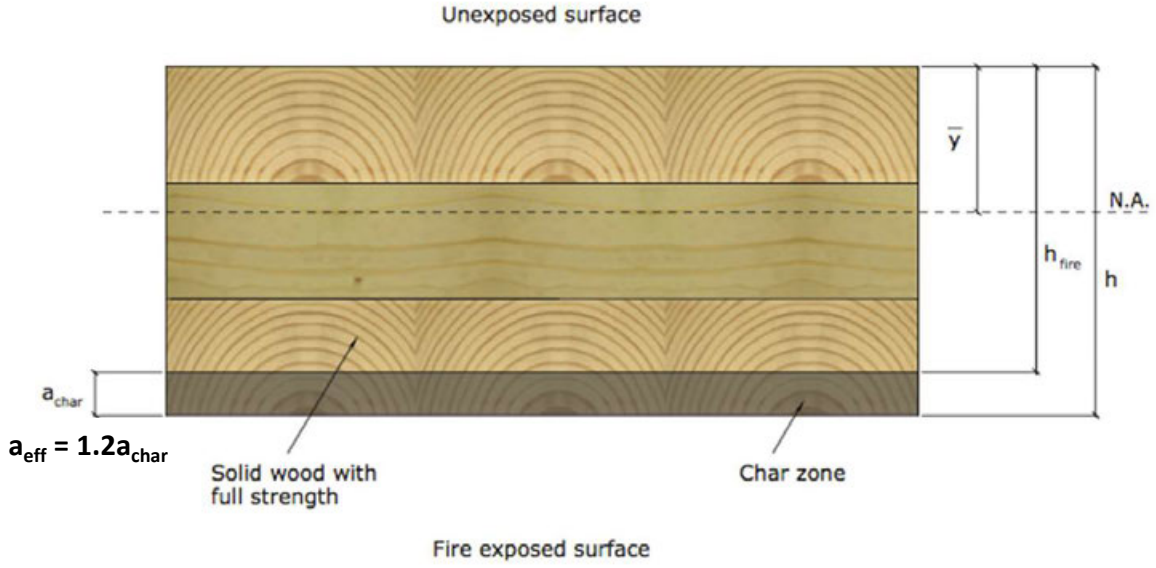




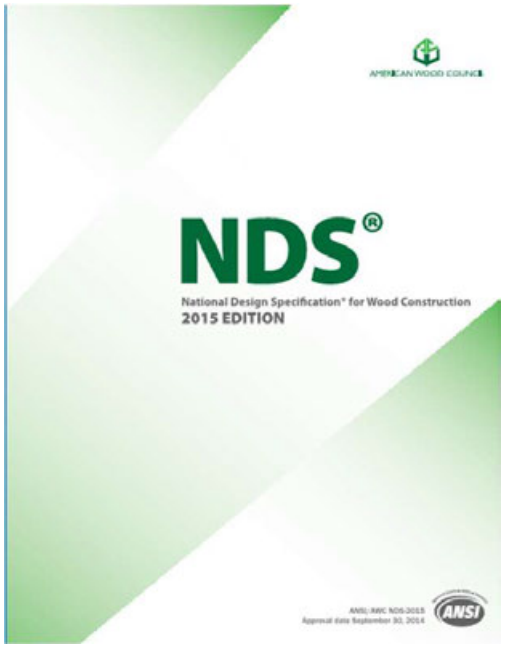
Key Early Design Decisions

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



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 β_n=1.5in./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

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

Table 16.2.1A Char Depth and Effective Char Depth (for β_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

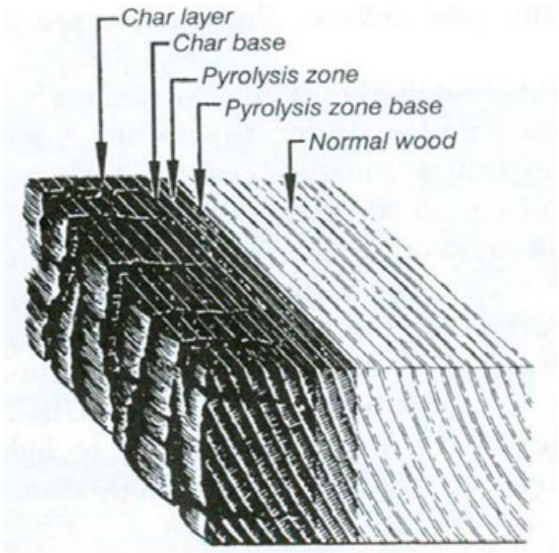
Table 16.2.1B Effective Char Depths (for CLT with β_n=1.5in./hr.)

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

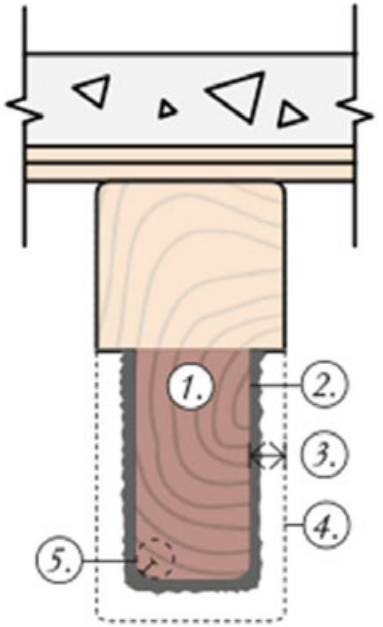
FRR Design of MT

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



$$a_{char} = \beta_t t^{0.813}$$ Solid Sawn, Glulam, SCL

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

$$a_{eff} = 1.2 a_{char}$$ Effective Char Depth

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

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 1.5E MSR 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	5	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 Capactiy	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 Capactiy	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-Grete 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 (160mm 6.3")	KLH	CV3M1	None	Half-Lap & Topside spline	None	Loaded, See Manufacturer	1	18	SwRI

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 I Path Architecture
Munzing Structural Engineering

Mass Timber Fire Design Resource

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

Noise **Acoustics** **Sound Pollution**

Whatever you call it, it all comes down to one thing:

Occupant Comfort

“Unnecessary noise is the cruelest absence of care.”

—Florence Nightingale

Acoustical Design

Types of noise to control: **Noise within a space**

Acoustical Design

Types of noise to control: **Exterior to interior**

Acoustical Design

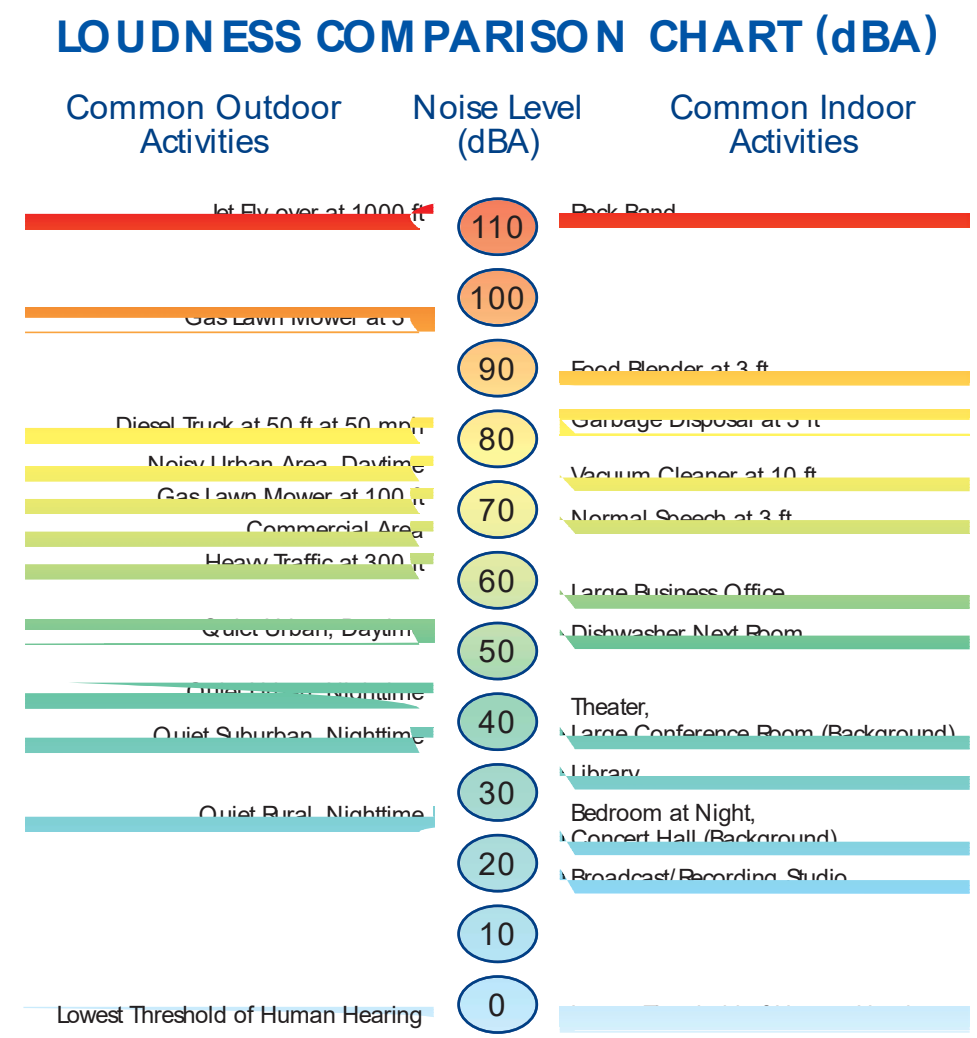
Types of noise to control: **Interior to interior**

Photo: Eckert & Eckert Photography, GBD Architects

Acoustical Design

Changes in STC Rating	Changes in Apparent Loudness
+/- 1	Almost imperceptible
+/- 3	Just perceptible
+/- 5	Clearly noticeable
+/- 10	Twice (or half) as loud

Very roughly, an STC rating is the dB reduction from one side of an assembly to the other



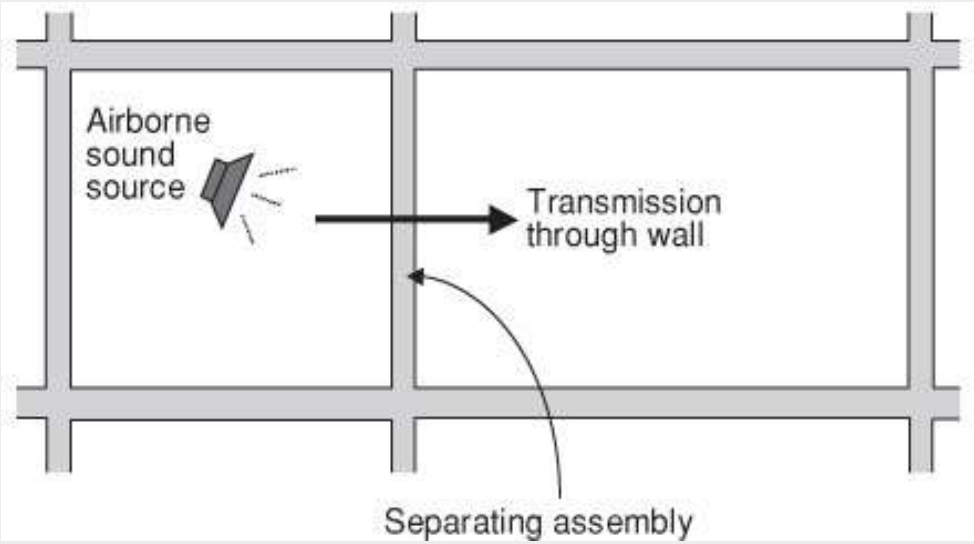
An increase of 3 dBA is barely perceptible to the human ear.

Acoustical Design

<u>Air-Borne Sound</u>: Sound Transmission Class (STC)

Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other

Applies to walls and floor/ceiling assemblies

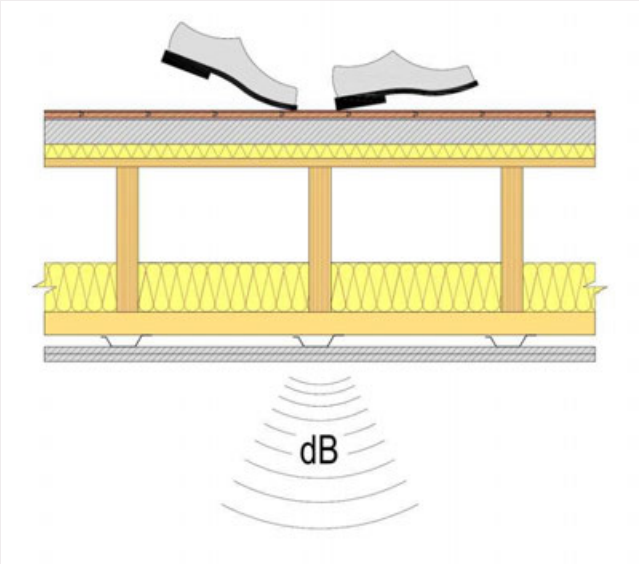


Acoustical Design

<u>Structure-borne sound</u>: Impact Insulation Class (IIC)

Evaluates how effectively an assembly blocks impact sound from passing through it

Only applies to floor/ceiling assemblies



Acoustical Design

STC/IIC contour shifted until meets criteria for deviation from actual tested data, STC/IIC rating is measured at 500 HZ

Due to single number rating over a series of frequencies, can have assemblies with same STC/IIC – one can perform well at a given frequency while the other doesn't

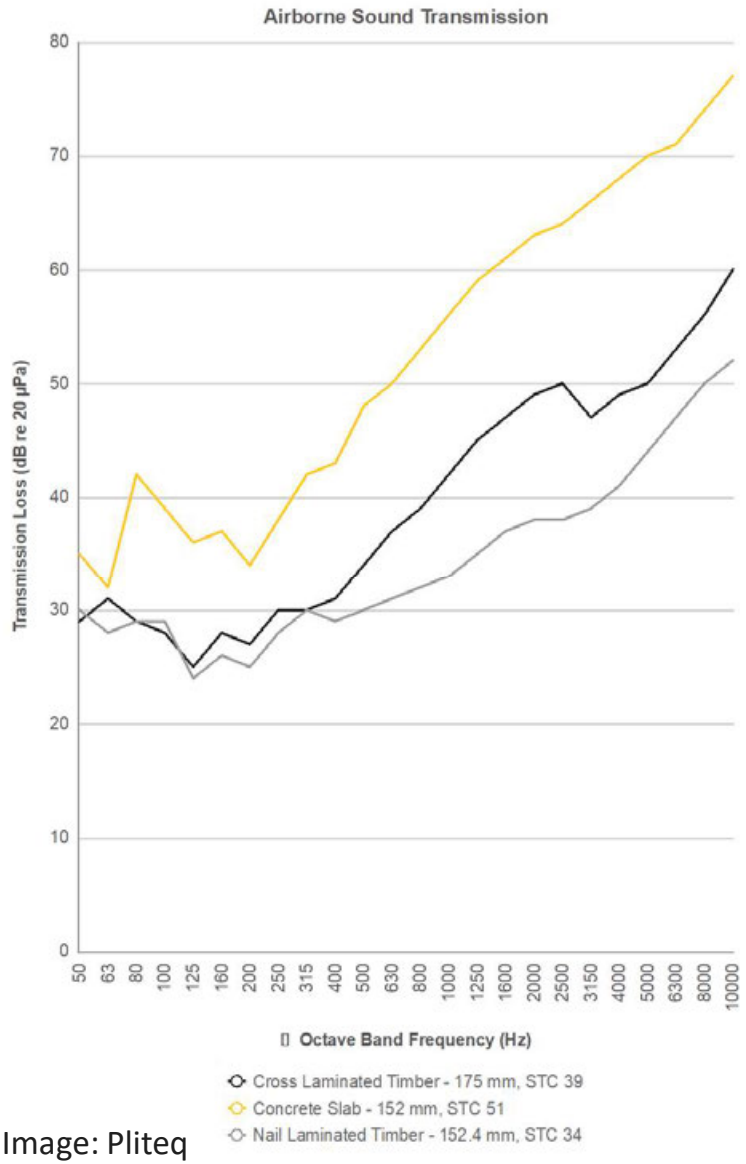


Image: Pliteq

Acoustical Criteria – IBC 1206

Code requirements only address residential occupancies:

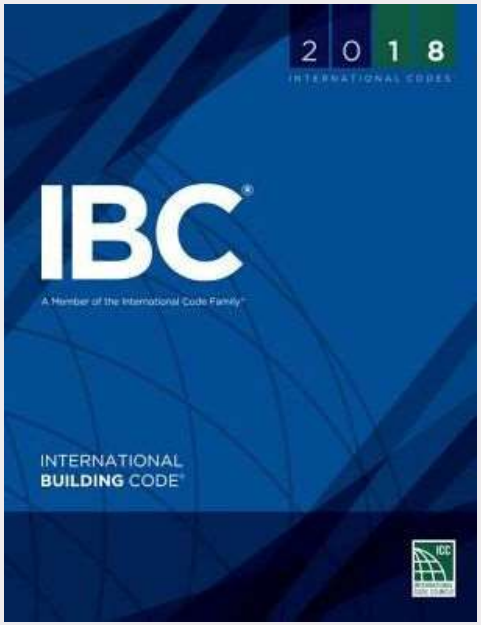
For unit to unit or unit to public or service areas:

Min. STC of 50 (45 if field tested) for:

- Walls, Partitions, and Floor/Ceiling Assemblies

Min. IIC of 50 (45 if field tested) for:

- Floor/Ceiling Assemblies



Acoustical Criteria

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

Acoustical Criteria

Acoustical Isolation Between Units – Airborne (STC) / Impact (IIC)

Class Designation	Airborne Sound Isolation (STC)	Floor Ceiling Impact Isolation (IIC)
Entry level	50	50
Market rate	55	55
Luxury	60	60

Acoustical Criteria

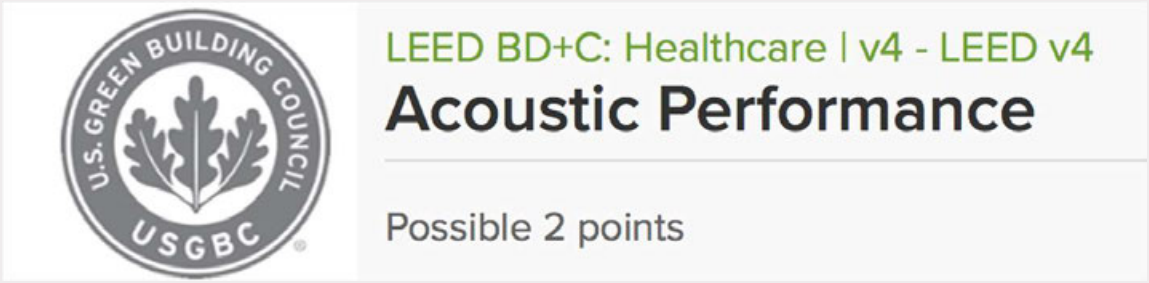
LEED has acoustics criteria for specific occupancies:

Schools:

Addresses items such as:

- HVAC background noise
- Exterior noise
- Reverberation time

Healthcare:



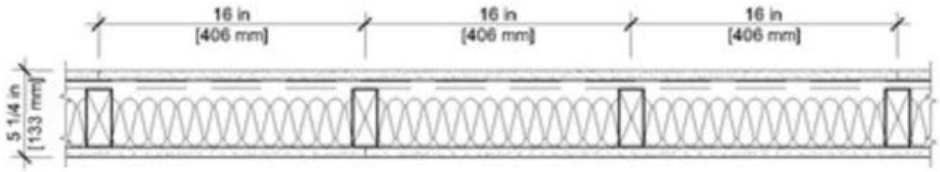
Addresses items such as:

- Speech privacy
- Background noise

Acoustical Detailing

Acoustically tested assemblies vs. calculated performance

Fire Test	Fire Rating	STC	Thickness (in.)	Featured
UL U311 Wood Stud (Load-bearing) Interior Partitions Sound Test: SA-830702	1 hr.	52	5-1/4"	



CAD · REVIT · VIEW ASSEMBLY

- **Gypsum Board** - 5/8 in. thick gypsum board applied horizontally or vertically
- **Resilient Channel** -25 ga. furring channels installed horizontally spaced 24 in. OC
- **Wood Studs** -2 in. x 4 in. wood studs spaced max. 16 in. OC
- **Batts and Blankets** -Min. 3 in. thick mineral wool batts or glass fiber insulation
- **Gypsum Board** -5/8 in. thick gypsum board applied horizontally or vertically

Source: USG

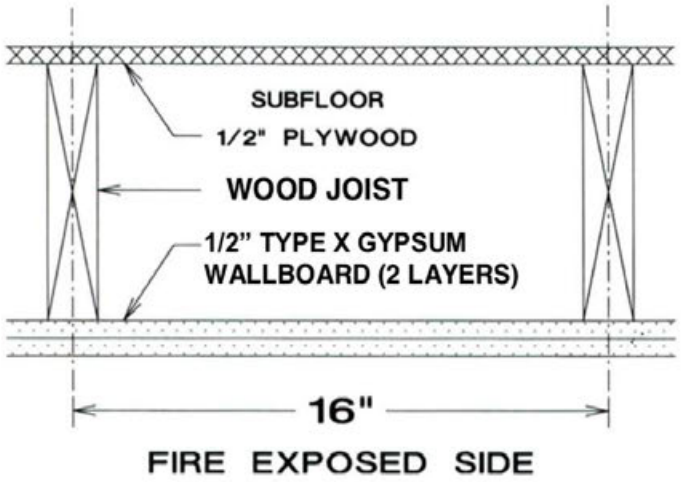
Acoustical Detailing

Can I acoustically rate individual components in an assembly and then add them up for the system rating?

It depends…

Description	STC	IIC
Carpet & Pad	0	20
3/4" Gypcrete®	7	1
Wood I-joist Floor	36	33
Resilient Channel	10	8
Total	***53***	***62***

Source: SBCA Table 18.1.3. Example calculation.



1/2 inch Type X Gypsum wallboard	=	25 minutes
1/2 inch Type X Gypsum wallboard	=	25 minutes
Wood joists	=	10 minutes
Combined Assembly Fire Resistance Rating	=	60 minutes

Figure 2 Floor/Ceiling Assembly

Acoustical Detailing

2018 IBC now allows engineering analysis based on comparisons

1206.2 Airborne sound.

Walls, partitions and floor-ceiling assemblies separating *dwelling units* and *sleeping units* from each other or from public or service areas shall have a sound transmission class of not less than 50, or not less than 45 if field tested, for airborne noise where tested in accordance with ASTM E90. Alternatively, the sound transmission class of walls, partitions and floor-ceiling assemblies shall be established by engineering analysis based on a comparison of walls, partitions and floor-ceiling assemblies having sound transmission class ratings as determined by the test procedures set forth in ASTM E90. Penetrations or openings in construction assemblies for piping; electrical devices; recessed cabinets; bathtubs; soffits; or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required ratings. This requirement shall not apply to entrance doors; however, such doors shall be tight fitting to the frame and sill.

1206.2.1 Masonry.

The sound transmission class of concrete masonry and clay masonry assemblies shall be calculated in accordance with TMS 0302 or determined through testing in accordance with ASTM E90.

1206.3 Structure-borne sound.

Floor-ceiling assemblies between *dwelling units* and *sleeping units* or between a *dwelling unit* or *sleeping unit* and a public or service area within the structure shall have an impact insulation class rating of not less than 50, or not less than 45 if field tested, where tested in accordance with ASTM E492. Alternatively, the impact insulation class of floor-ceiling assemblies shall be established by engineering analysis based on a comparison of floor-ceiling assemblies having impact insulation class ratings as determined by the test procedures in ASTM E492.

Room Acoustics

How is Sound Absorption Measured?

The sound absorption coefficient is the decimal fraction of the sound energy absorbed by the material.

For example, if a material has a sound absorption coefficient of 0.85, it means that 85 percent of the sound energy reflected striking that material is absorbed, and 15 percent of the sound energy reflected.

Arena Stage, Washington, DC
Photo: Nic Lehoux, Bing Thom Architects

Room Acoustics

What is the Noise Reduction Coefficient (NRC)?

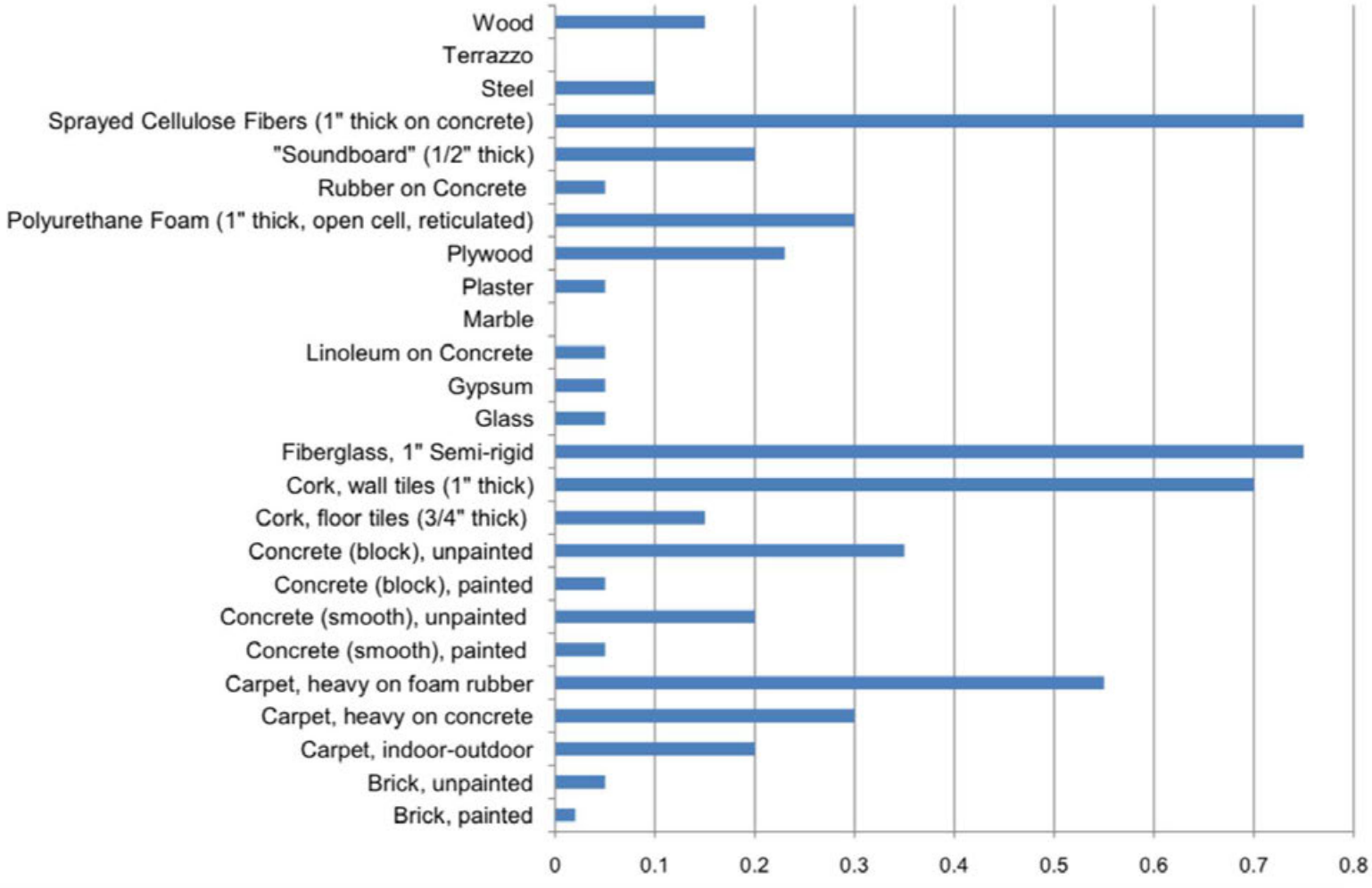
A material's sound absorbing capabilities often expressed by a single number NRC (Noise Reduction Coefficient) rating.

NRC is the average of the sound absorption coefficients measured at 250, 500, 1000, and 2000 Hz rounded off to the nearest 0.05.

Materials with an NRC greater than 0.40 are usually considered sound absorbers.

Tippet Rise Olivier Music Barn
Photo: Alban Bassuet

Noise Reduction Coefficients (NRC) for Common Building Materials:

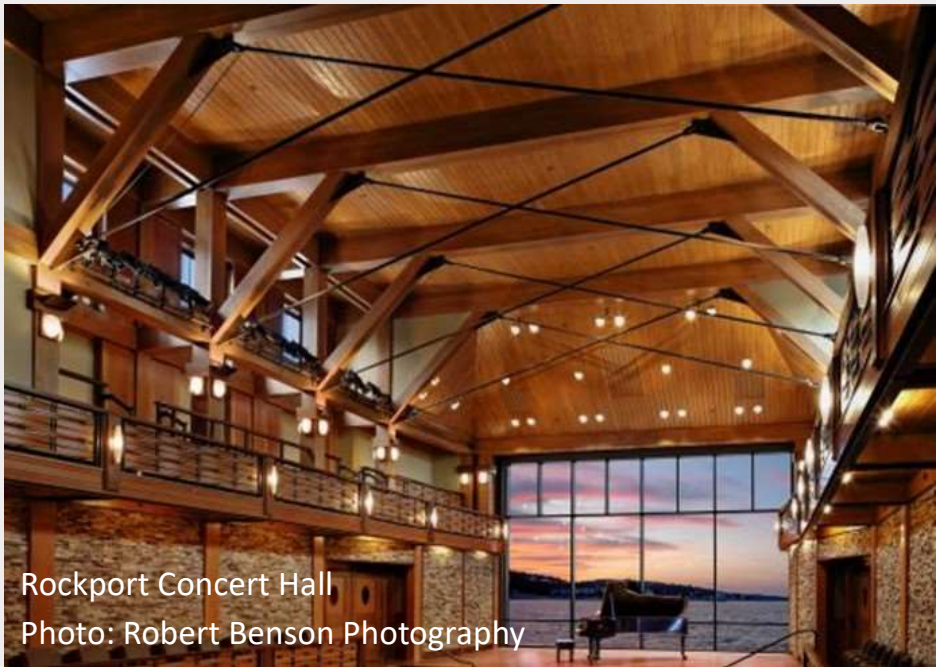


Room Acoustics

Total Space Noise Absorption:

To determine how much the sound in a space will decrease with the addition of sound absorbing materials, the total sabins of absorption for the space must be calculated.

To calculate this number, multiply the sound absorption coefficients of all the different types of materials in a room – at a particular frequency – by the area of coverage of each material.

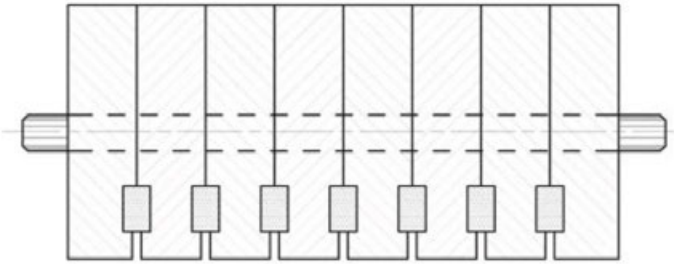


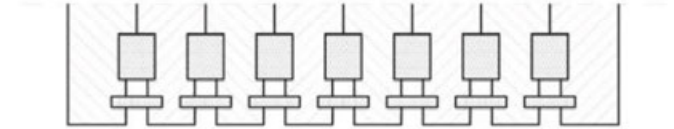
Rockport Concert Hall
Photo: Robert Benson Photography

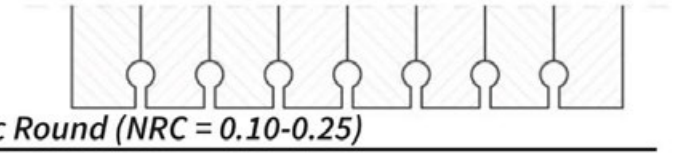
Room Acoustics

NRC of exposed wood panels like NLT & DLT can be improved with inset absorbing materials

Image: StructureCraft


Acoustic Square with Wood Fibre (NRC = 0.55-0.65)


Acoustic Square with Wood Fibre & Felt (NRC = 0.75-0.80)


Acoustic Round (NRC = 0.10-0.25)

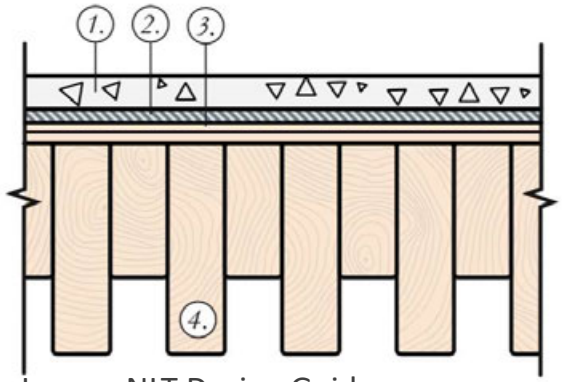


Image: NLT Design Guide

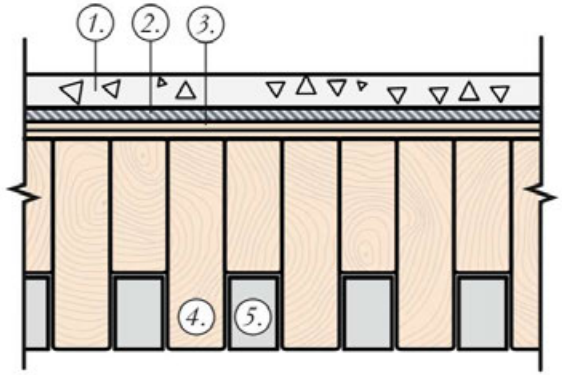


Figure 2.16: *Alternating 2x4 and 2x6 lumber with and without sound absorbing material.*

Key

1. *Concrete topping*
2. *Acoustic mat*
3. *Plywood/OSB*
4. *NLT*
5. *Sound absorbing material*

Exterior Noise

Exterior to Interior Noise control

- Not addressed in IBC
- Typically based on proximity to noise sources (airports, highways) and/or occupancy-based noise sensitivity (schools)
- Need to consider not only acoustical performance of solid wall but also windows, doors (these are usually the weak links)
- OITC – outdoor-indoor transmission class

Understanding Acoustical Detailing

Acoustical Detailing

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

1. Add mass
2. Add noise absorbers
3. Decouple (add air space or disconnect structure/finish from carrying all the way through the assembly)

Acoustical Detailing

Light-Frame Wood Wall Acoustics: STC

Acoustical Detailing

STC ratings – low to mid 60's achievable

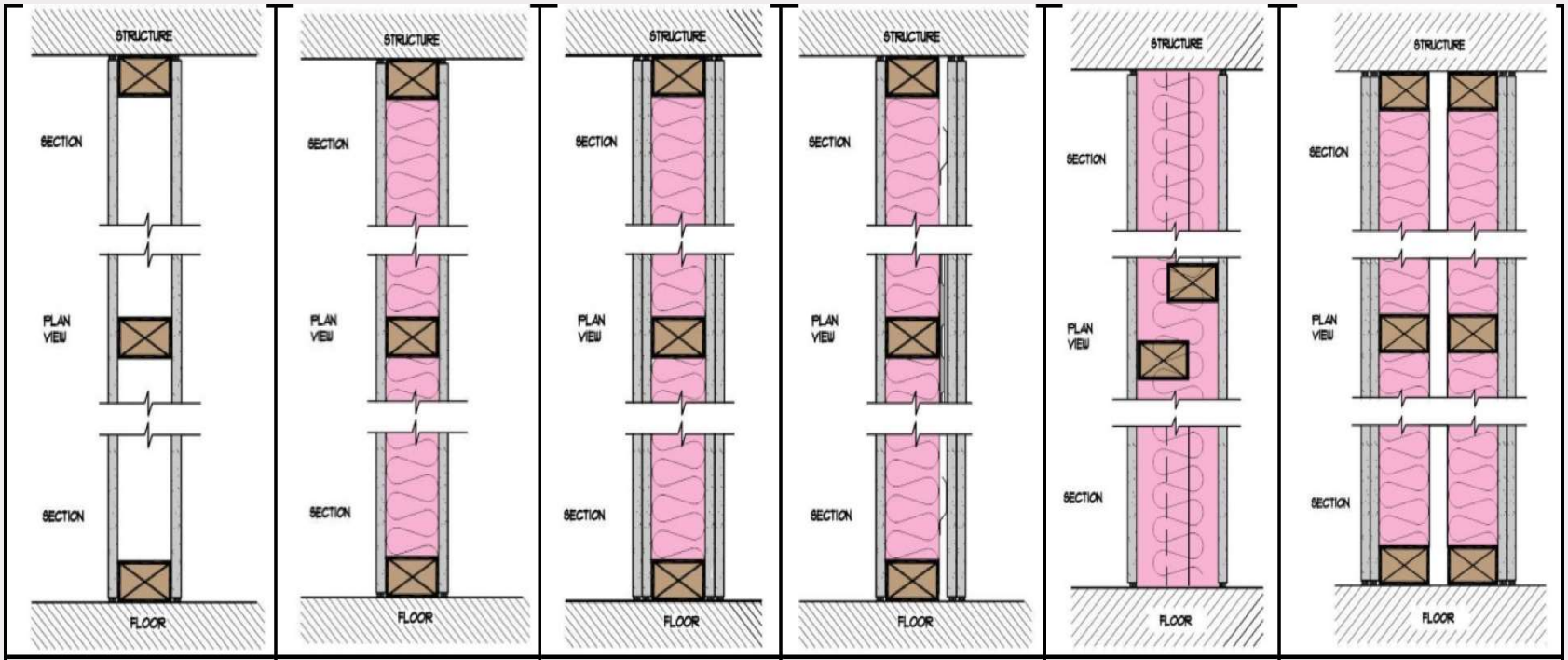
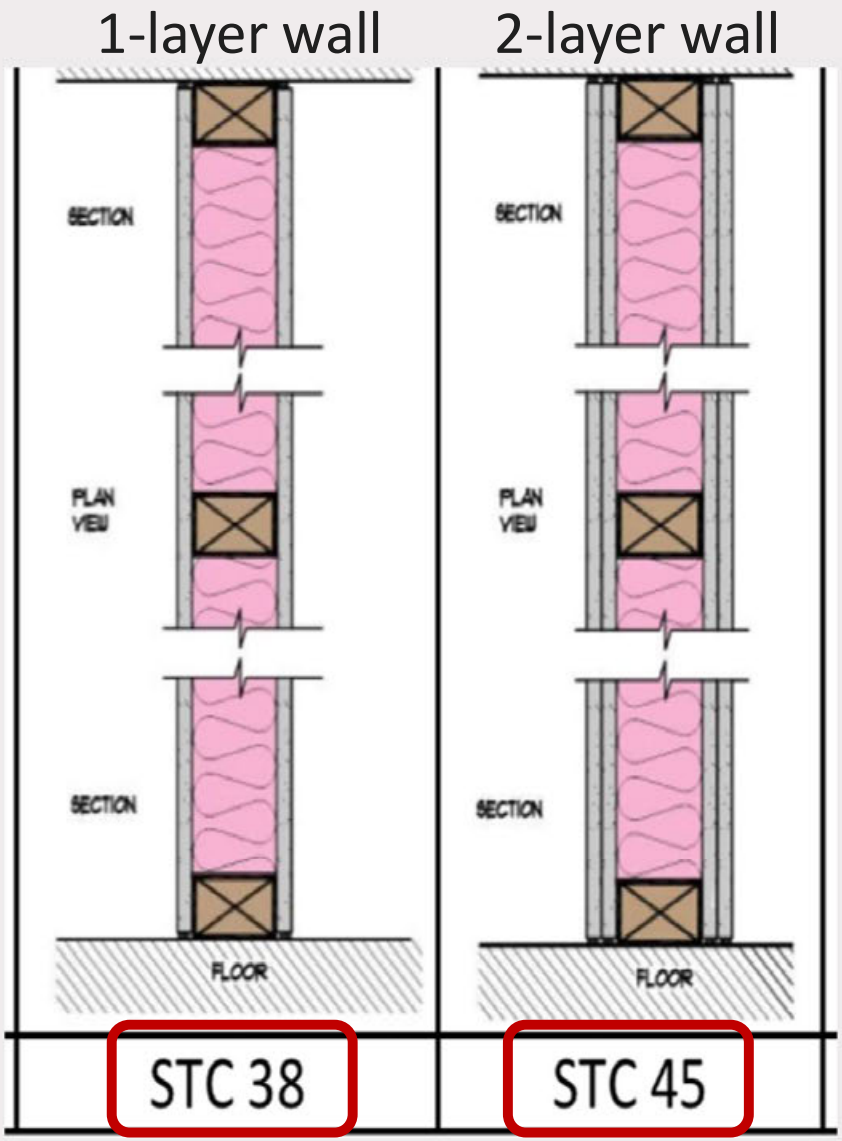


Figure 1 - Acoustical Progression in Wood Framed Walls

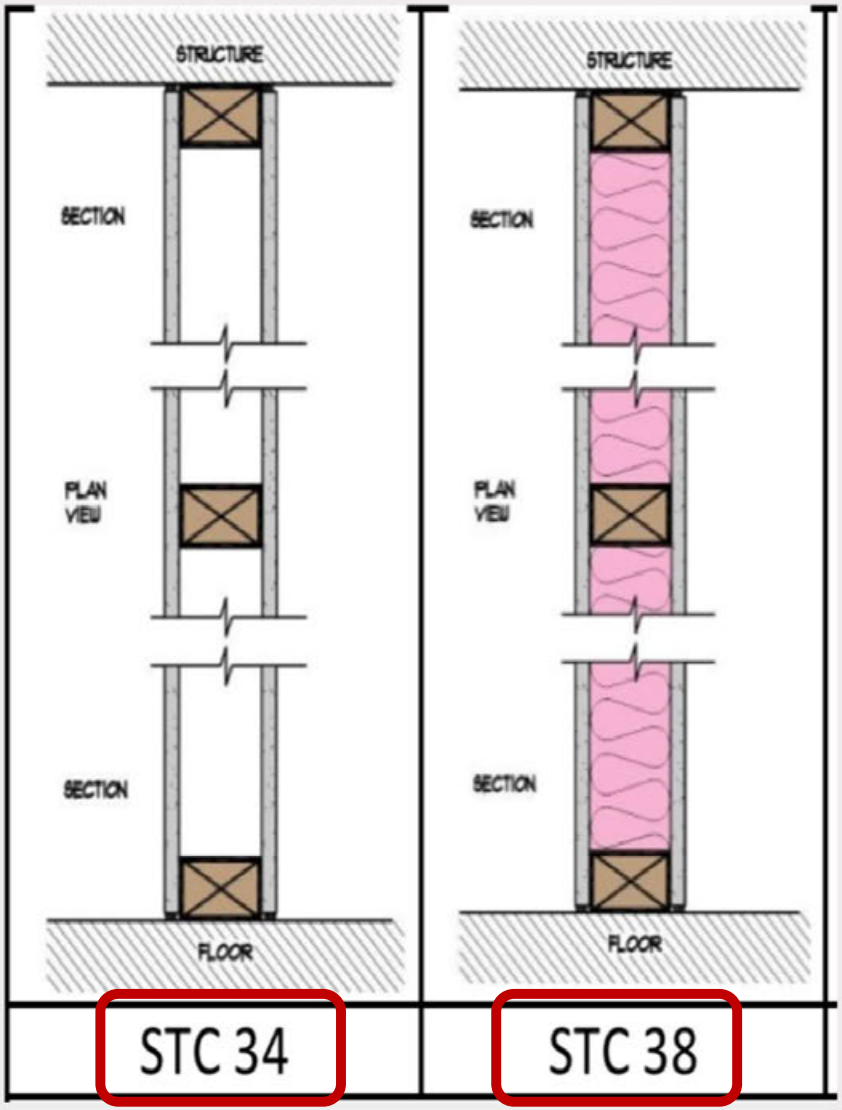
Acoustical Detailing

Adding Mass: Gypsum Wall Board



Acoustical Detailing

Adding Noise Absorbers: Batt Insulation

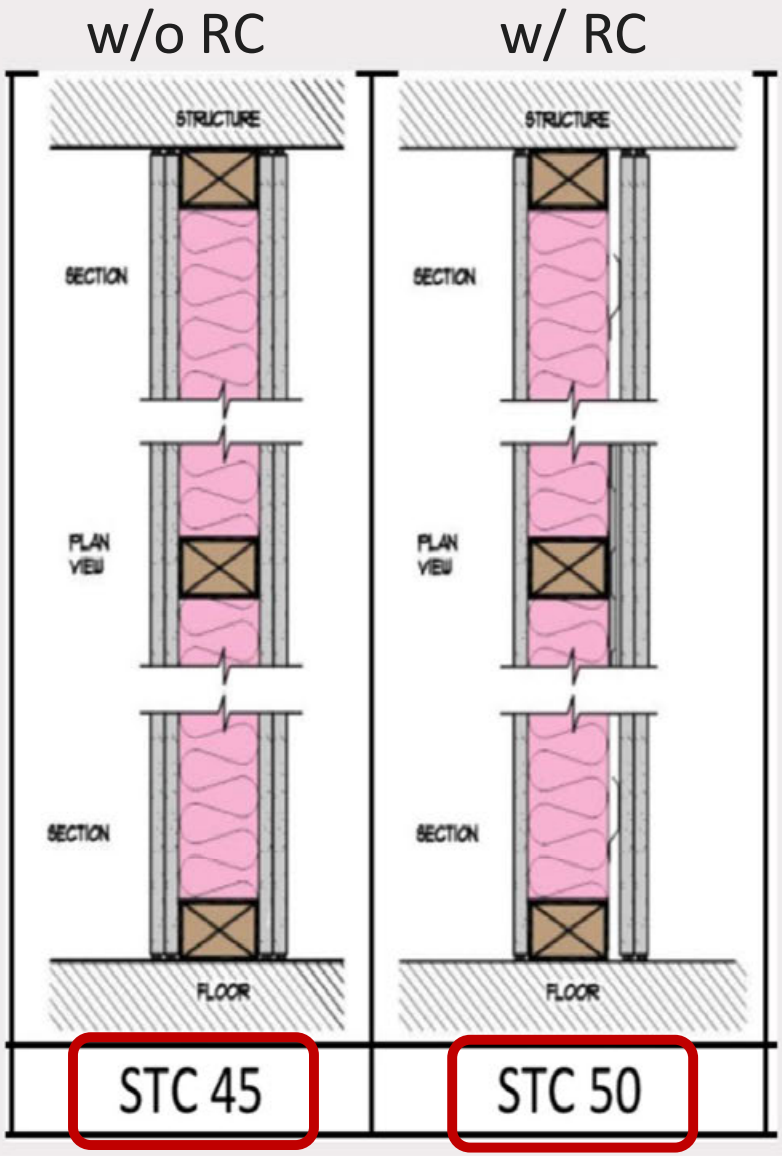


Acoustical Detailing

Good Detailing +
Good Installation =
Good Performance

Acoustical Detailing

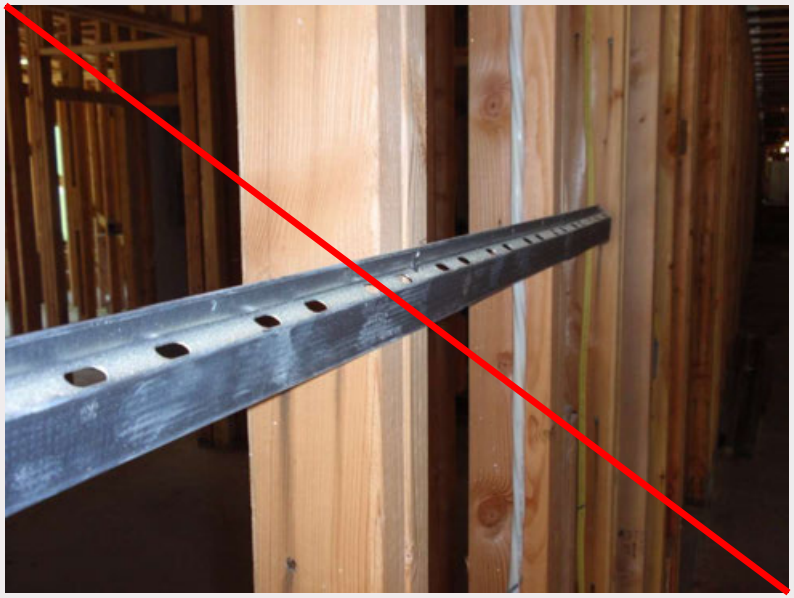
Decouple: Resilient channels

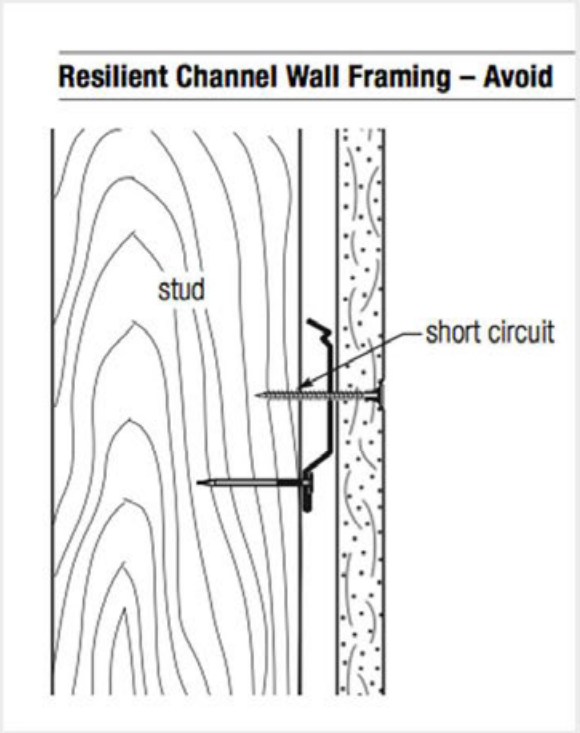


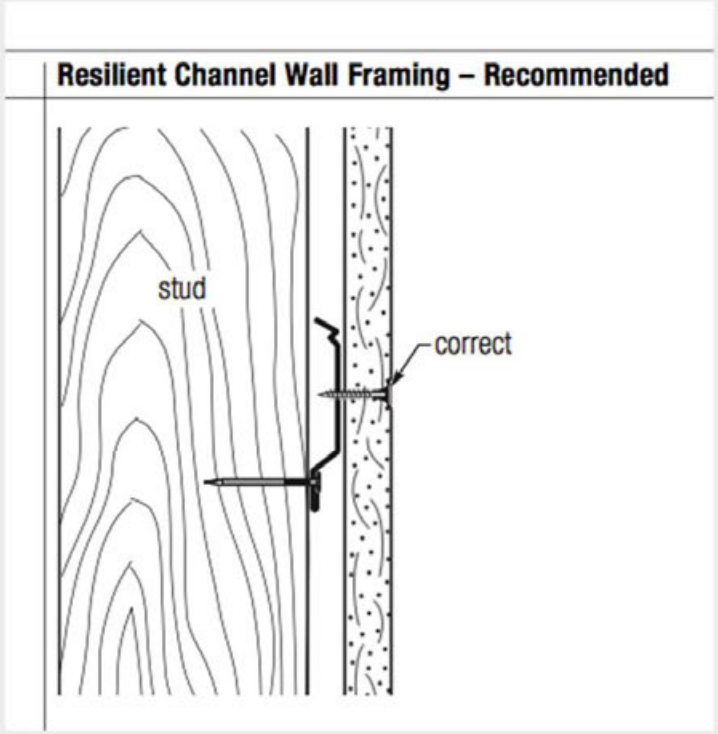
Acoustical Detailing

Good Detailing + Good Installation = Good Performance

Open leg should be up on walls







Acoustical Detailing

My interior, acoustically rated wall also needs to be a shear wall.

Can I add wood structural panels to an acoustically tested wall?

Yes, but placement is very important!

Expert Tips

Adding Wood Structural Panels to Acoustically-Tested Assemblies

Information for building designers seeking to justify the inclusion of wood structural panels to tested assemblies, including placement, approaches and additional resources.

Share

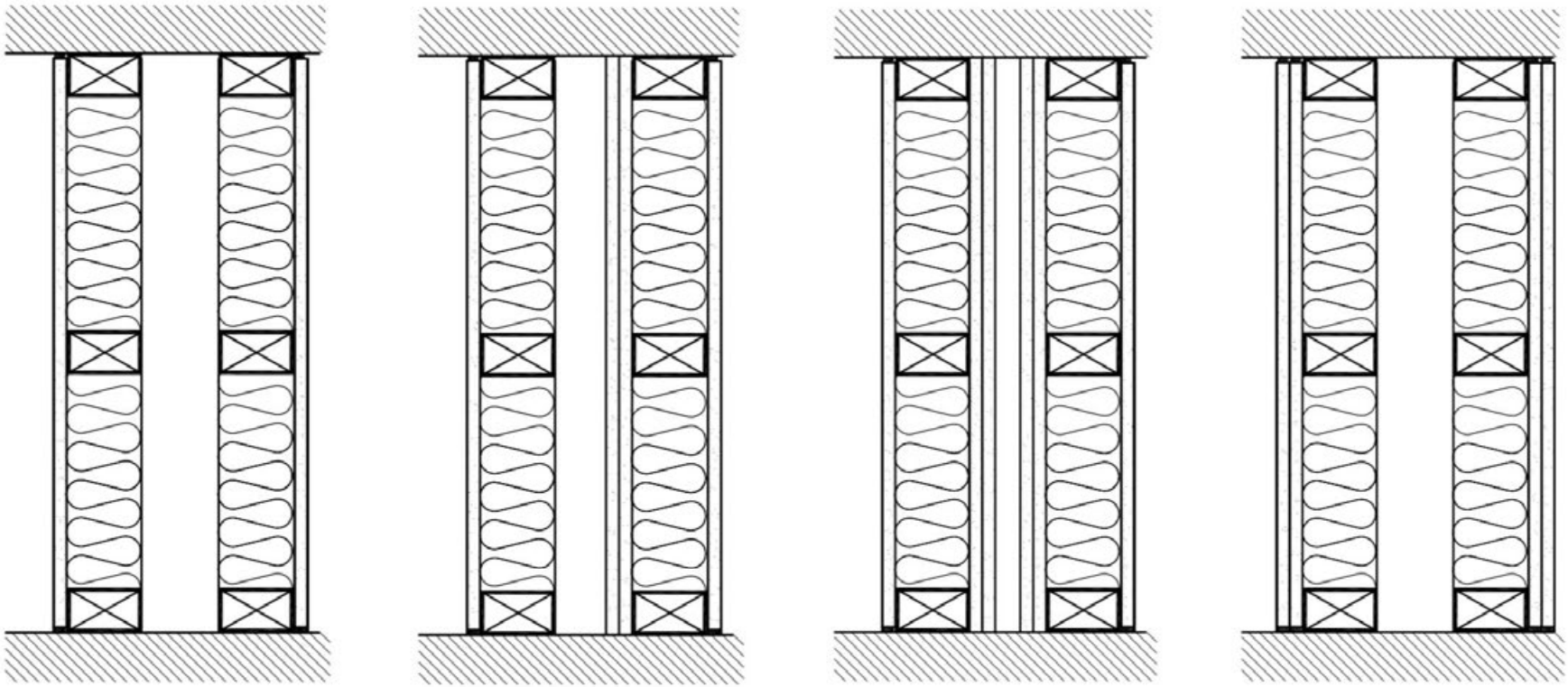
In many multi-family structures, interior demising walls that separate dwelling units from other units or from public spaces are required to have a minimum level of acoustical performance (IBC Section 1207). In some cases, these interior walls are also used as shear walls, utilizing plywood or OSB on one or both sides of the wall. Appropriate STC performance for walls are typically justified through the use of a tested assembly; however, most tested assemblies do not include wood structural panels (WSPs). This post contains information to help justify its inclusion in these cases.

In the WoodWorks technical paper, *Acoustical Considerations for Mixed-Use Wood-Frame Buildings*, author Steve Thorburn discusses the impact that WSPs can have on acoustical performance of walls. Adding shear wall sheathing to a wall assembly can actually increase its acoustical performance in certain circumstances because it adds mass to the

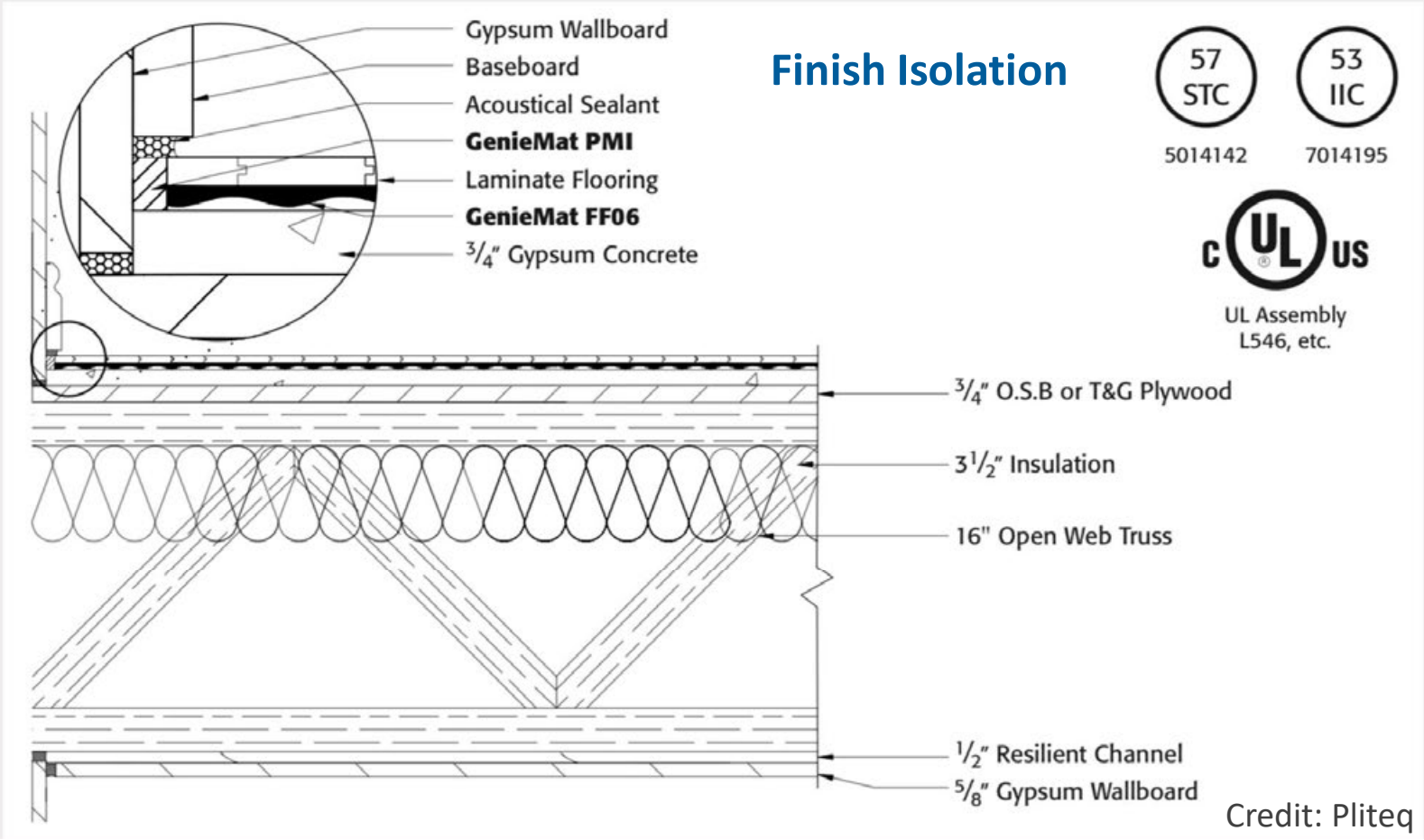
https://www.woodworks.org/resources/adding-wood-structural-panels-to-acoustically-tested-assemblies/

FIGURE 6

Effect of Sheathing Placement on Acoustical Performance (Plan View)



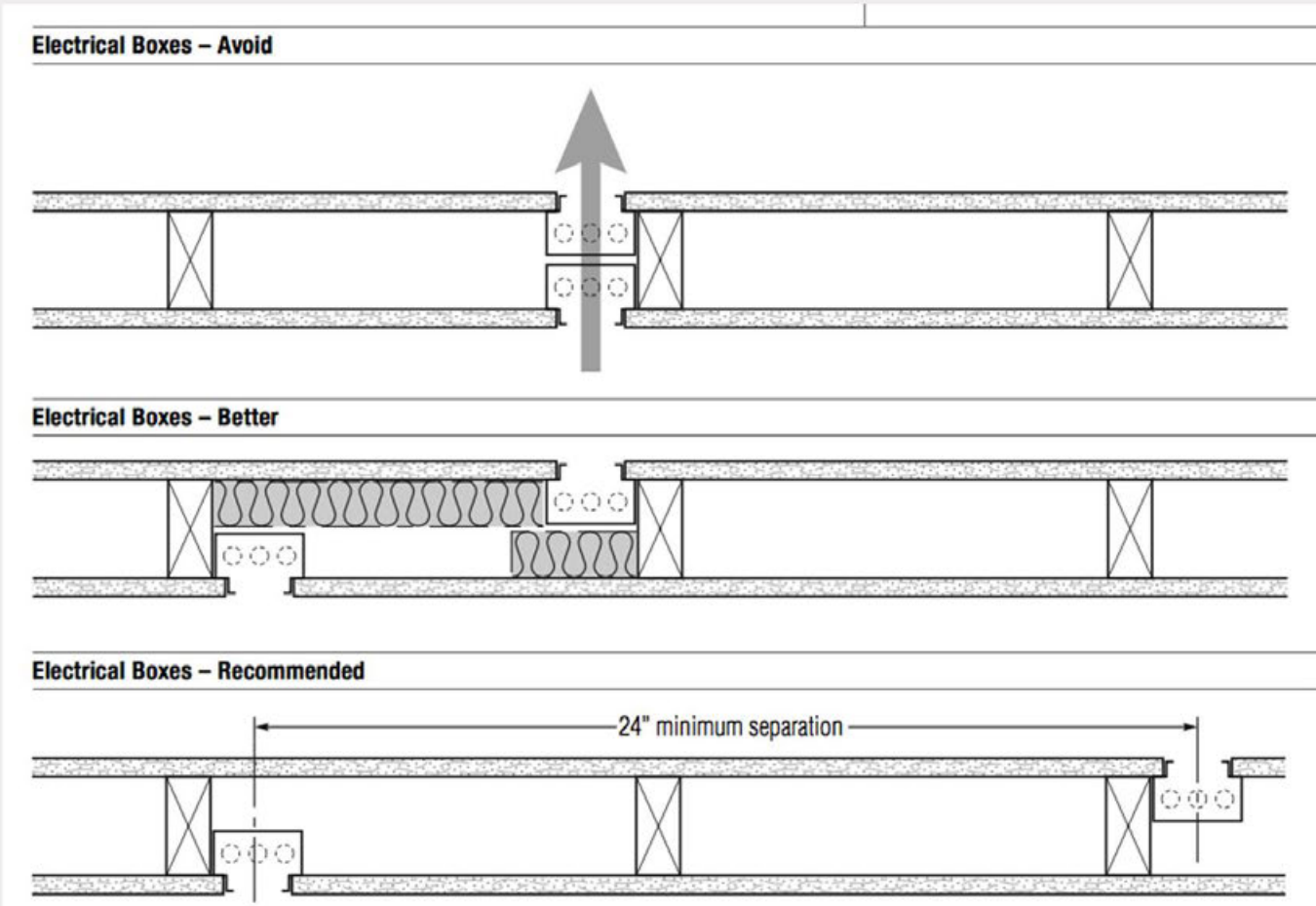
Acoustical Detailing



Credit: Pliteq

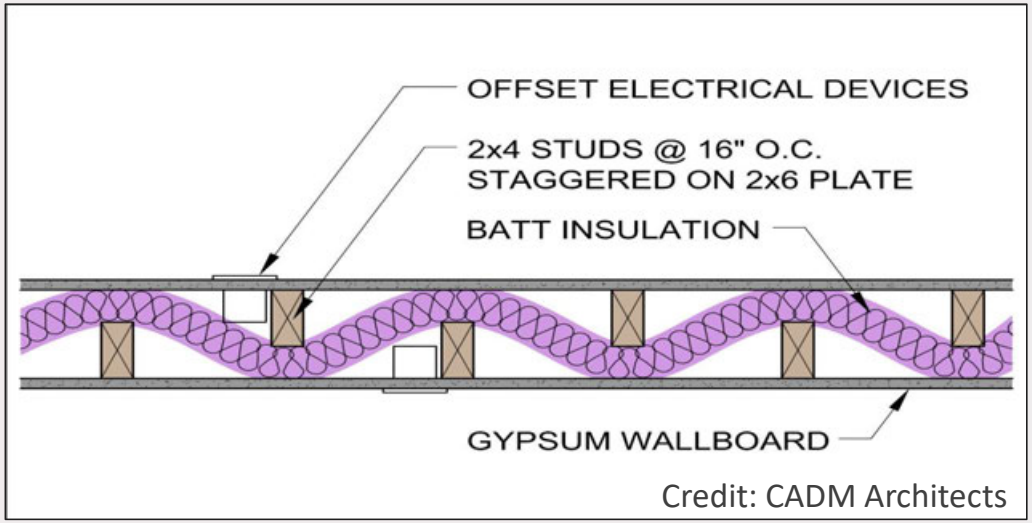
Acoustical Detailing

Outlet Placement



Acoustical Detailing

Outlet Placement



Credit: CADM Architects

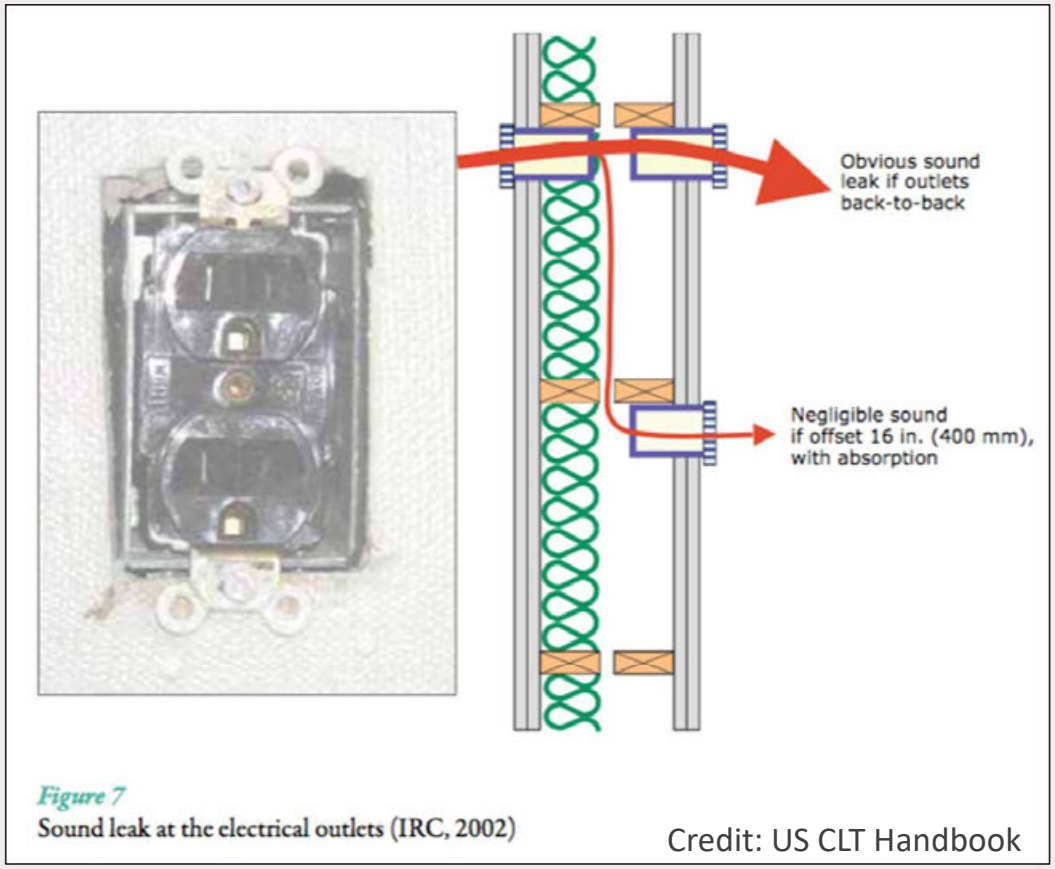
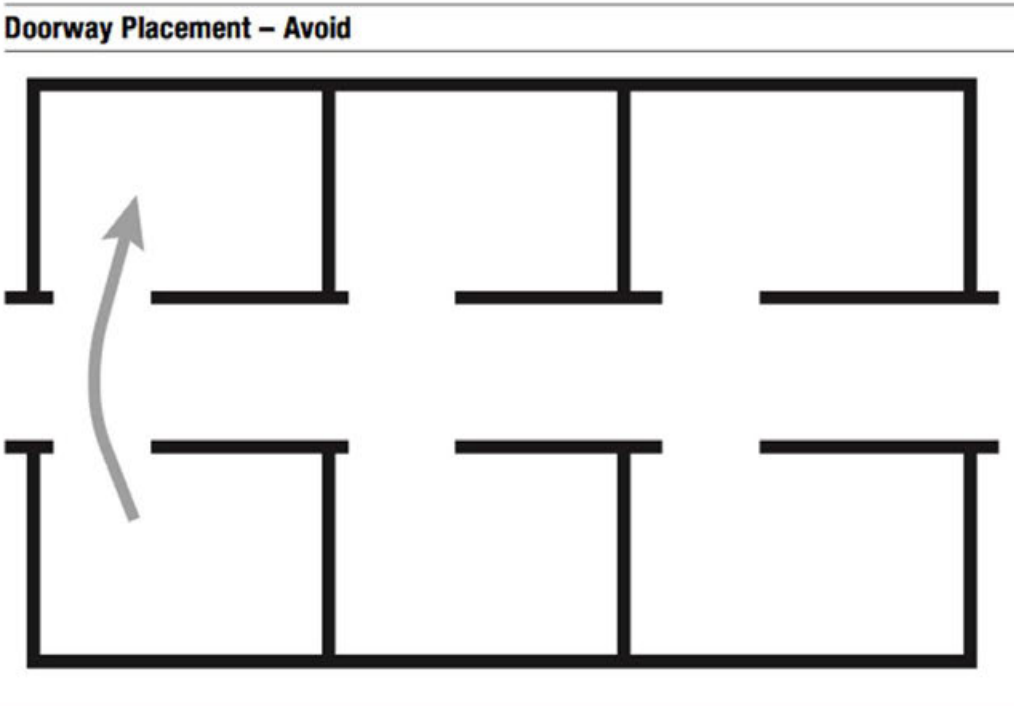


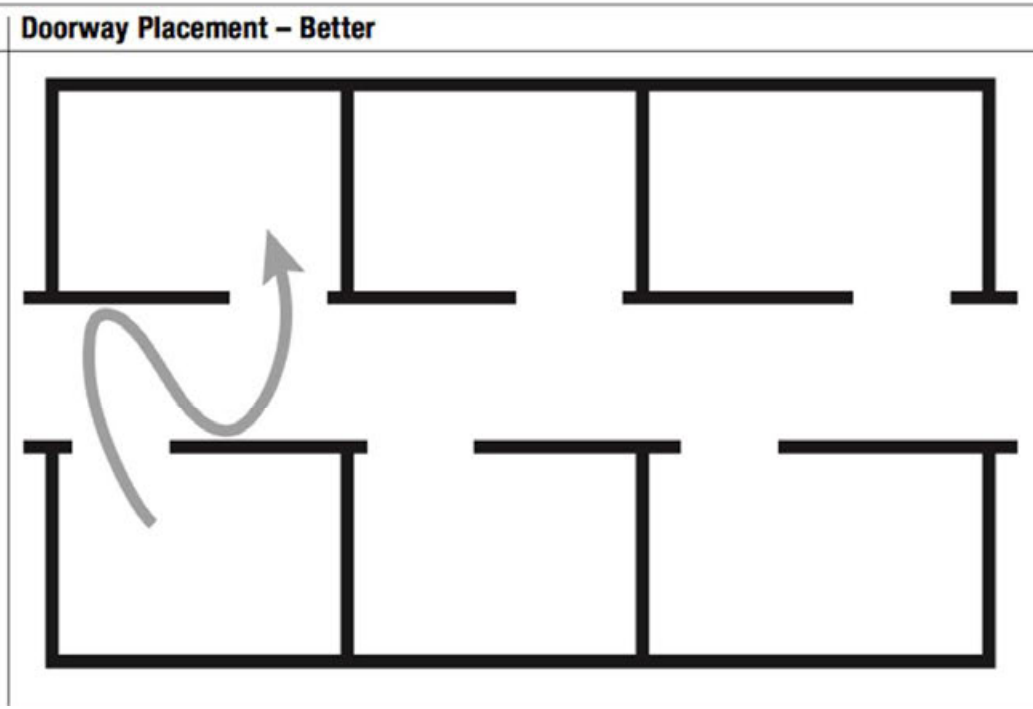
Figure 7
Sound leak at the electrical outlets (IRC, 2002)

Credit: US CLT Handbook

Acoustical Detailing

Door Placement





Acoustical Detailing

Photo: Pam Wean, MSES Architects

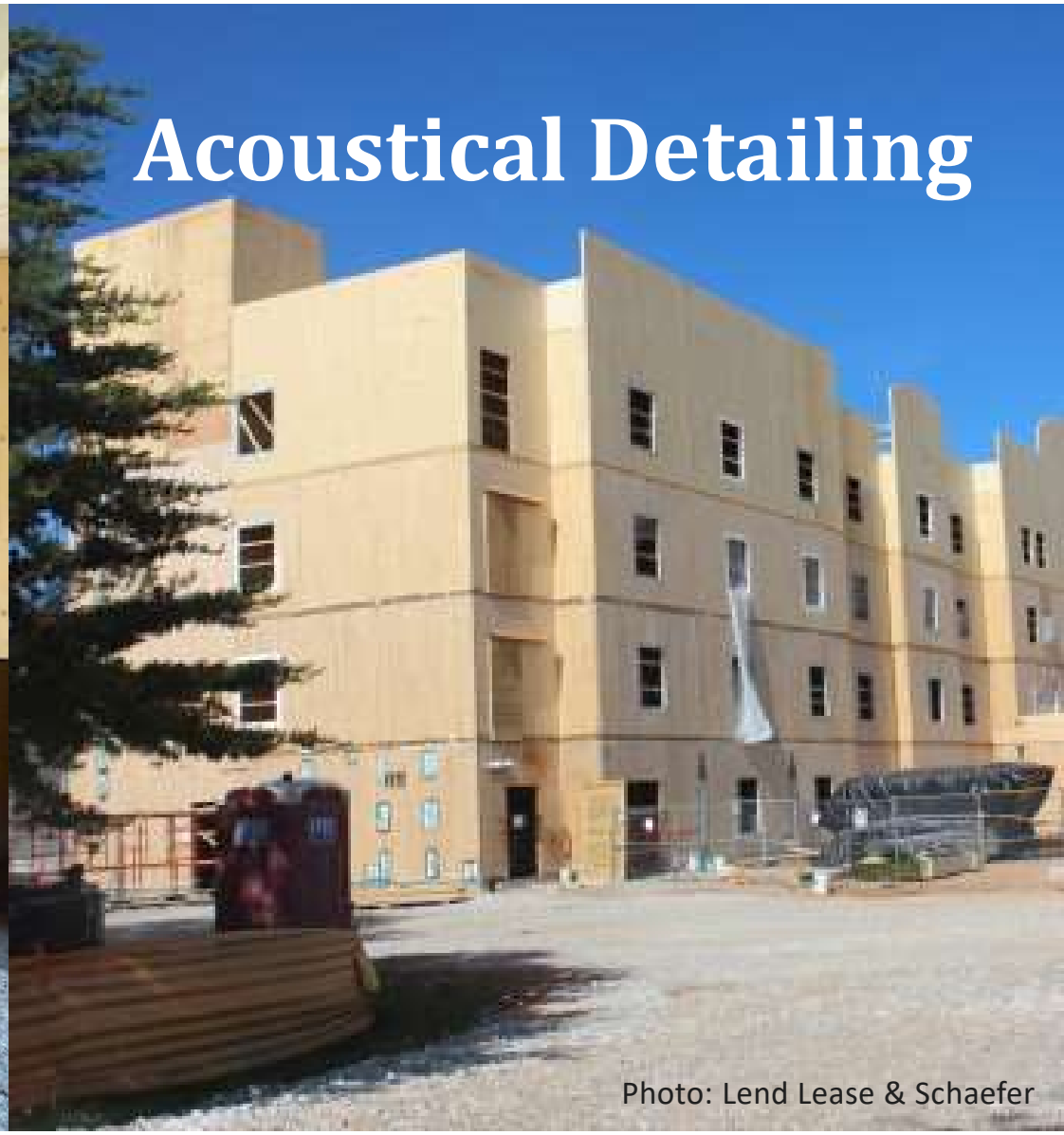


Photo: Lend Lease & Schaefer

Acoustical Detailing

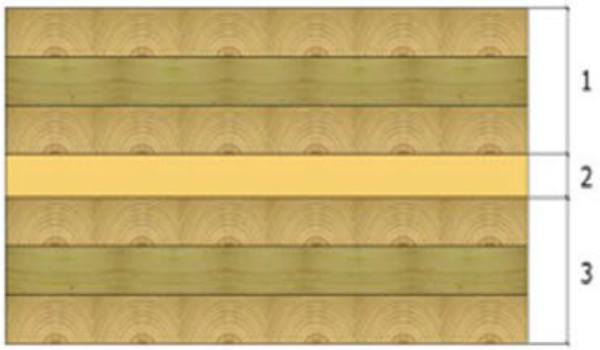
Sound Insulation of Bare CLT Floors and Walls

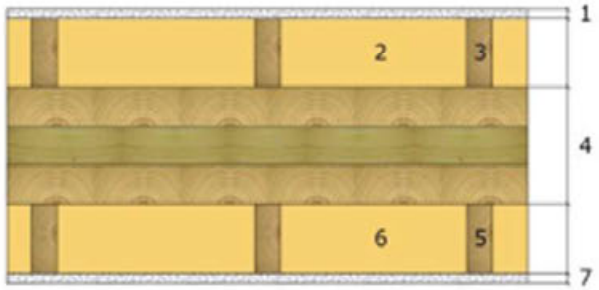
Number of layers	Thickness (in.)	Wall or Floor	STC	IIC
3	3-3/4 to 4-1/2	Wall	32-34	N.A.
5	5-1/3	Floor	39	23
5	5-3/4	Floor	39	24
Measured on field bare CLT wall and floor				
Number of layers	Thickness in.	Assembly type	FSTC	FIIC
3	4-1/8	Wall	28	N.A.
7	8-1/5	Floor	N.A	25-30

Credit: US CLT Handbook

US0

Acoustical Detailing





Design Examples for >50 STC Walls

STC 50:

1 and 3 = 4-1/2 in. CLT;

2 = 1-1/8 in. Mineral wool in the gap

STC 55:

Add 5/8 in. gypsum board directly to both sides

STC 60:

Gypsum boards plus double the thickness of the gap and mineral wool

STC 58:

1 and 7 = 5/8 in. gypsum boards

3 and 5 = 2 in. by 3 in. wood studs at least 16 in. o.c.

2 and 6 = 2.5 in. mineral wool

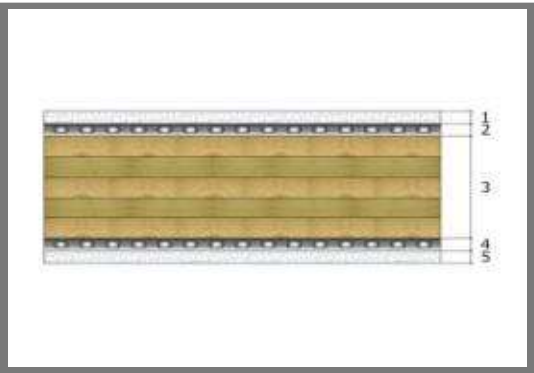
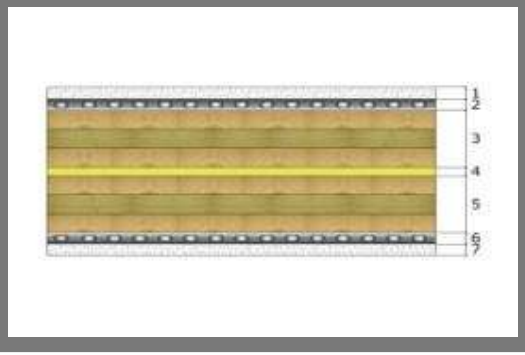
4 = 4-1/2 in. CLT

Credit: US CLT Handbook

US0

Acoustical Detailing

Design Examples for >45 FSTC Walls

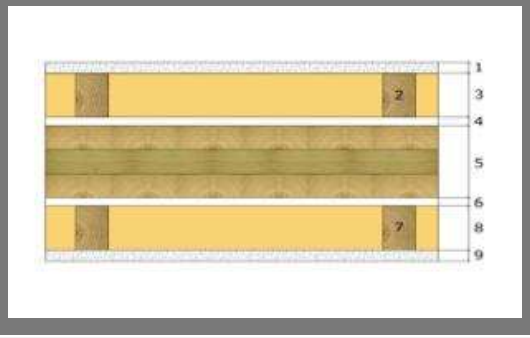
Top view of cross-section	Wall detail	FSTC
	1 & 5 = 5/8” Gypsum board 2 & 4 = Resilient channels at 24” o.c. 3. 5-layer CLT of 7-1/4”	46
	1& 7 = 5/8” Gypsum board 2& 6 = Resilient channels at 24” o.c 3& 5 = 3-layer CLT of 3.07” 4 = 1” air gap filled with mineral wool	47

Credit: US CLT Handbook

US0

Acoustical Detailing

Design Examples for >45 FSTC Walls

Top view of cross-section	Wall detail	FSTC
	1 = 3-layer CLT ~ 4-1/8” 2 = 1/2” air gap 3 = 2” by 3” wood studs at 16” o.c. 4 = 2-1/2” mineral wool 5 = 5/8” gypsum board	47
	1 & 9 = 5/8” gypsum board 2 & 7 = 2” by 3” wood studs at 16” o.c. 4 & 6 = 1/2” air gap 5 = 3-layer CLT of 4-1/8”	50

Credit: US CLT Handbook

Acoustical Detailing

Light-Frame Wood Floor
Acoustics: STC & IIC

Acoustical Detailing

STC ratings – low to mid 60's achievable

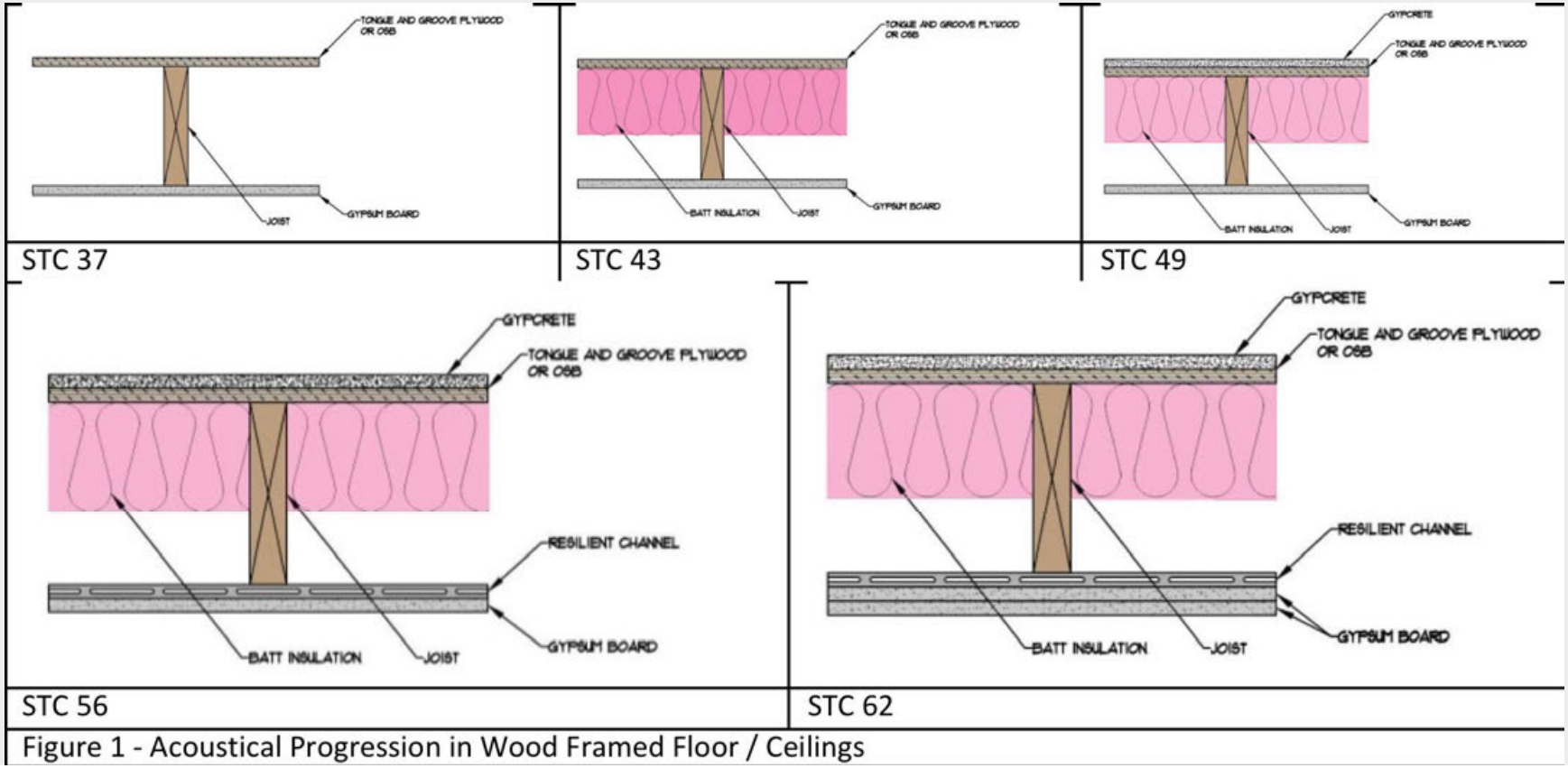
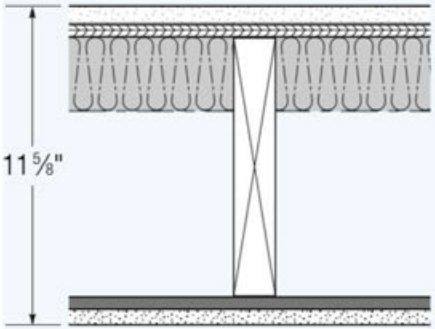


Figure 1 - Acoustical Progression in Wood Framed Floor / Ceilings

Acoustical Detailing

Dimensional Lumber

Construction Detail	Description	Acoustical Performance STC	IIC	Test Number
clg. wt. 3  	• 5/8" SHEETROCK Brand FIRECODE C Core Gypsum Panels – 2x10" wood joist 16" o.c. – RC-1 channel or equivalent 16" o.c. – Insulation held up under subfloor by lightning clips – 19/32" T&G wood subfloor • 3/4" LEVELROCK Brand Floor Underlayment	59	54	**RAL-IN04-006/TL04-033** Cushioned vinyl floor, SRM-25, 1" LEVELROCK
		58	55	**RAL-IN04-007/TL04-034** Engineered wood-laminate floor SRM-25, 1" LEVELROCK
		59	77	**RAL-IN04-005/TL04-032** Carpet with SRM-25, 1" LEVELROCK
		59	52	**RAL-IN04-009/TL04-067** Ceramic tile with crack-isolation membrane, SRM-25, 1" LEVELROCK
		58	50	**RAL-IN04-013/TL04-100** Cushioned vinyl floor, SRB board
		58	51	**RAL-IN04-012/TL04-099** Engineered wood-laminate floor, SRB board
		58	73	**RAL-IN04-010/TL04-097** Carpet with SRB board

Floor finish has a significant impact on IIC rating

Acoustical Detailing

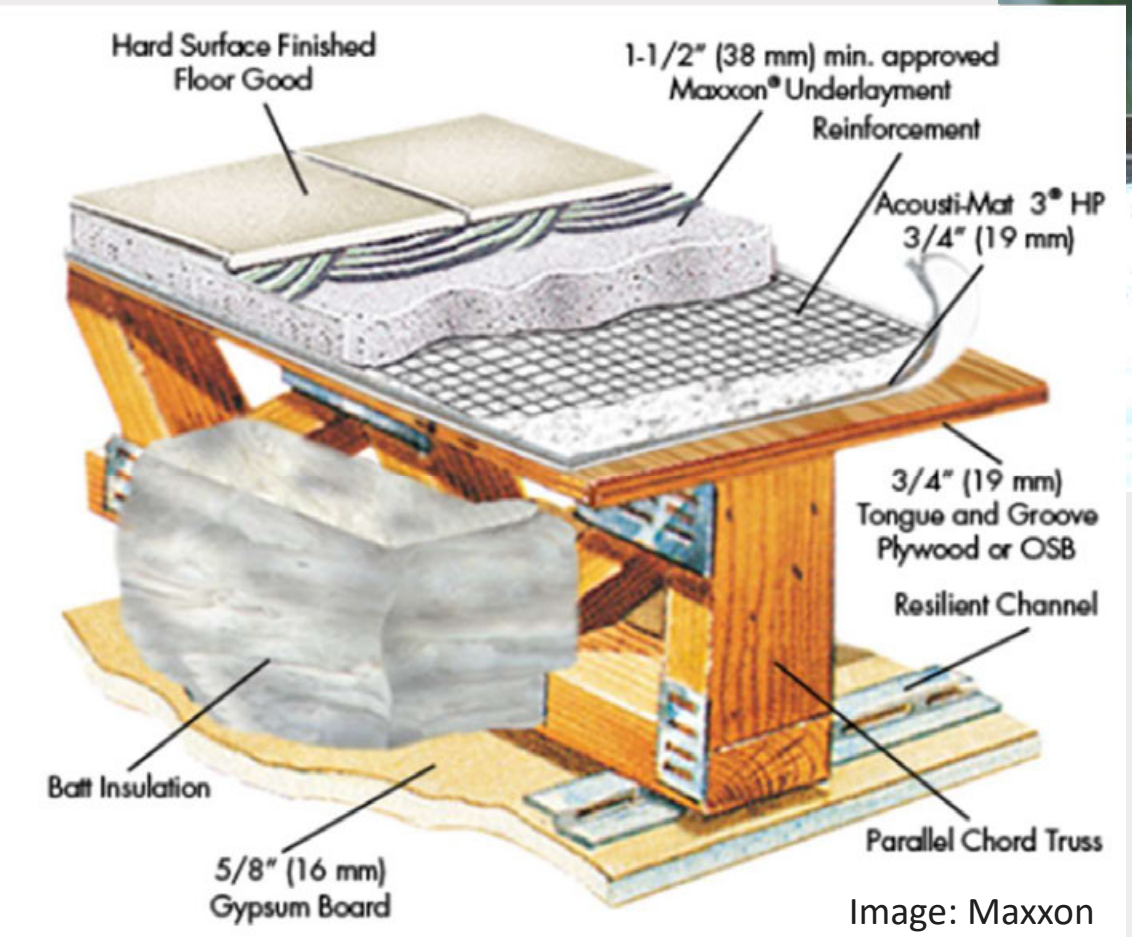
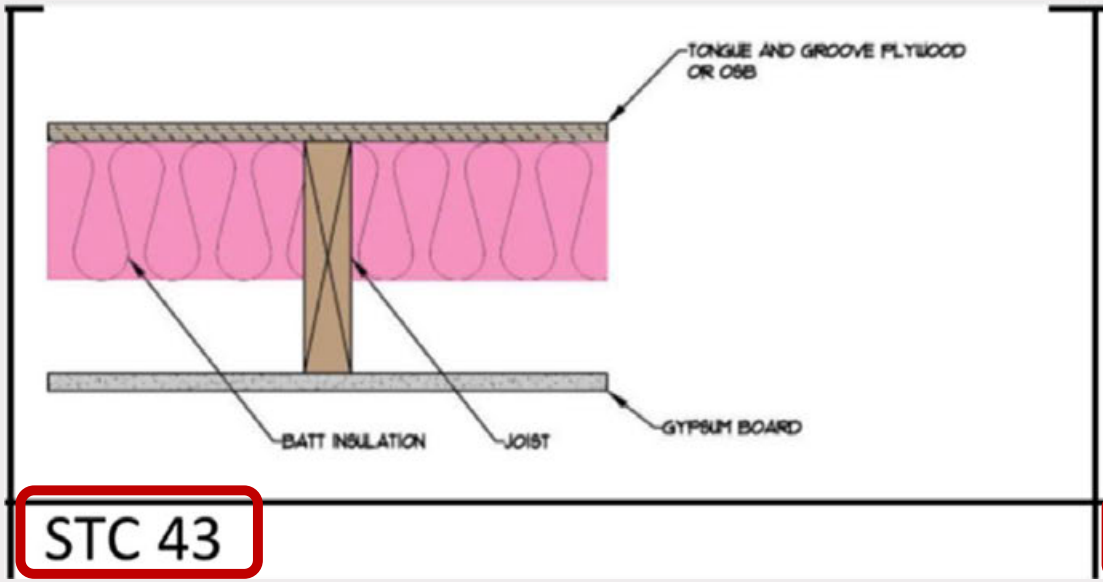


Image: Maxxon

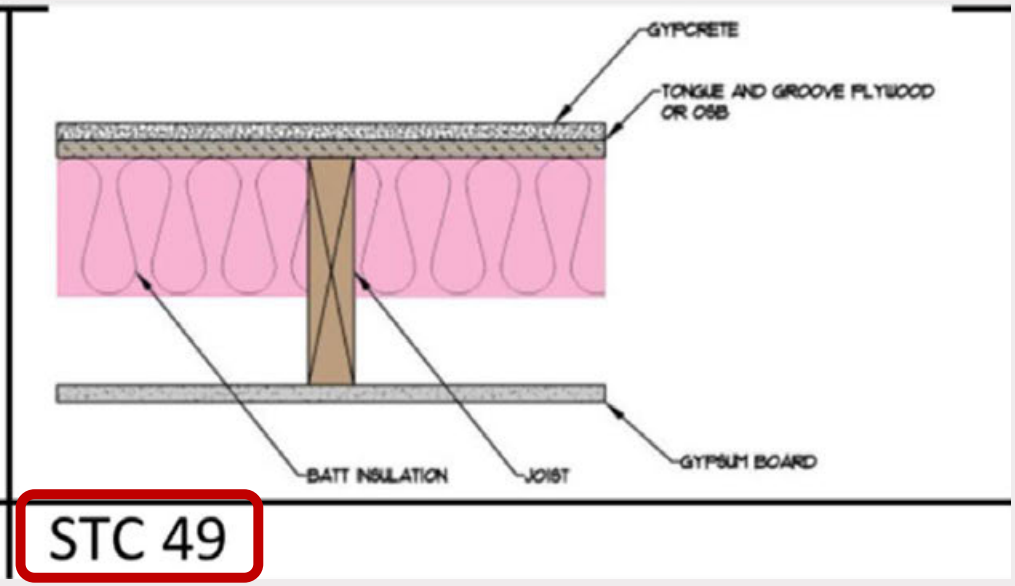
Lightweight concrete topping or other similar materials can provide improved acoustical performance, increased durability

Acoustical Detailing

Adding Mass: Concrete or gypsum topping



Without concrete topping



With concrete topping

Acoustical Detailing

Decouple:

Acoustical mat - typically installed between subfloor and topping or flooring. Can use multiple decoupling layers in sandwich assembly

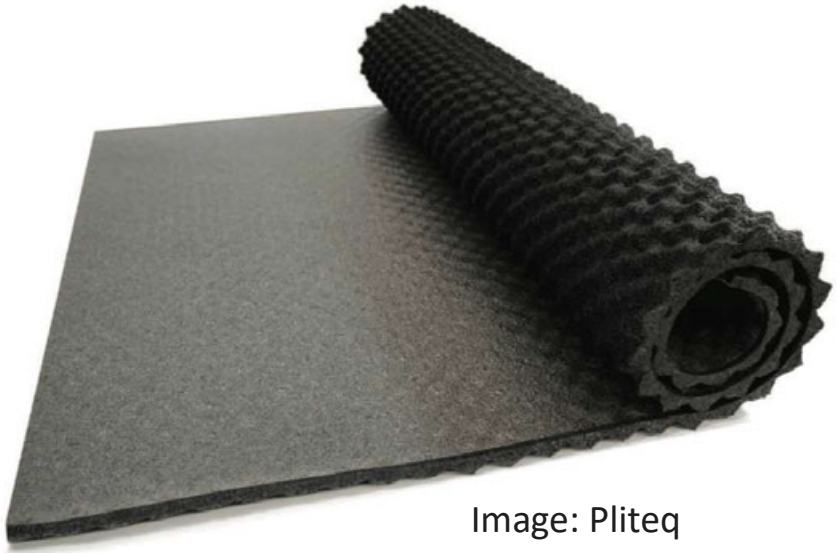
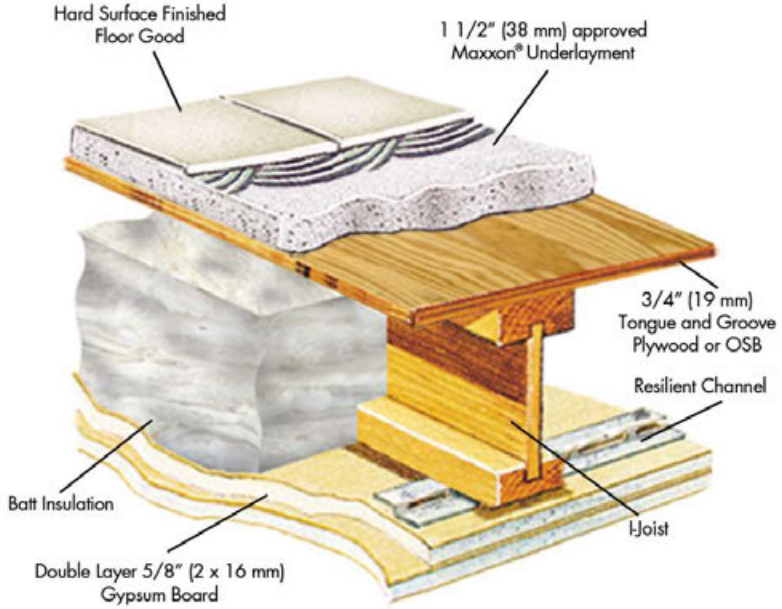


Image: Pliteq

Acoustical Detailing



Start over

Project Details:

Project Type:	Multifamily-Condos
Assembly:	I-Joist
Sound Mat:	None
Maxxon Underlayment:	1-1/2"

Selections:

Project Type:	Multifamily-Condos
Assembly:	I-Joist
Sound Mat:	None
Maxxon Underlayment:	1-1/2"

w/o Acoustical Mat

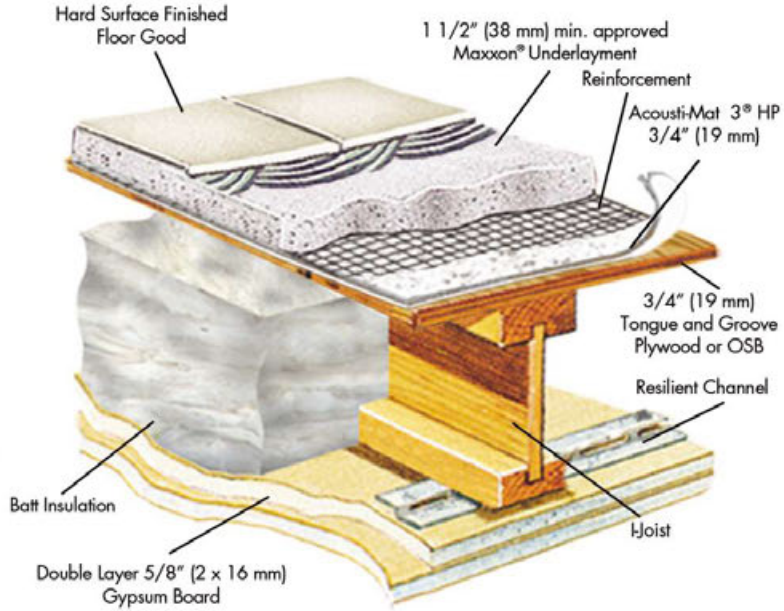
Sound Ratings in hard surface areas*	F-IIC	F-STC
Base I-Joist	40-44	43-46
With Maxxon Underlayment only	40-45	59-62
With Maxxon Underlayment & (sound mat)	n/a	n/a

Typical UL Fire Rated Design	Design
I-Joist	L589

* The UL Fire Design listed above is a common design for the specified assembly. Maxxon Underlayments are listed in over 100 UL Fire Designs. To request a copy of Maxxon's Fire & Sound Manual or for assistance in determining the right UL Design for your project, contact your Regional Representative at (800) 356-7887 or by

Image: Maxxon

Start over



Project Details:

Project Type:	Multifamily-Condos
Assembly:	I-Joist
Sound Mat:	Acousti-Mat 3 HP
Maxxon Underlayment:	1-1/2"

Selections:

Project Type:	Multifamily-Condos
Assembly:	I-Joist
Sound Mat:	Acousti-Mat 3 HP
Maxxon Underlayment:	1-1/2"

w/ Acoustical Mat

Sound Ratings in hard surface areas*	F-IIC	F-STC
Base I-Joist	40-44	43-46
With Maxxon Underlayment only	40-45	59-62
With Maxxon Underlayment & Acousti-Mat 3 HP	61-64	60-63

Typical UL Fire Rated Design	Design
I-Joist	L589

* The UL Fire Design listed above is a common design for the specified assembly. Maxxon Underlayments are listed in over 100 UL Fire Designs. To request a copy of Maxxon's Fire & Sound Manual or for assistance in determining the right UL Design for your project, contact your Regional Representative at (800) 356-7887 or by

Sound Ratings in hard surface areas*	F-IIC	F-STC
Base I-Joist	40-44	43-46
With Maxxon Underlayment only	40-45	59-62
With Maxxon Underlayment & (sound mat)	n/a	n/a

Typical UL Fire Rated Design	Design
I-Joist	L589

* The UL Fire Design listed above is a common design for the specified assembly. Maxxon Underlayments are listed in over 100 UL Fire Designs. To request a copy of Maxxon's Fire & Sound Manual or for assistance in determining the right UL Design for your project, contact your Regional Representative at (800) 356-7887 or by

Image: Maxxon


Acoustical Detailing
Mass Timber Floor
Acoustics – STC & IIC
Photo: John Stamets

Main difference between light frame wood floors and mass timber floors is that mass timber floors are usually left exposed on ceiling side.

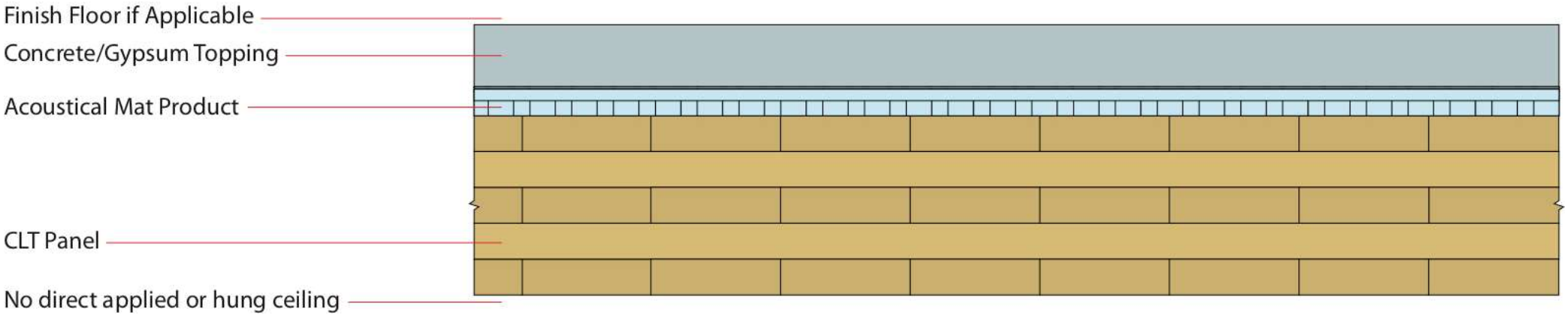
All acoustical products applied on top of assembly

Photo: Structurlam

Acoustical Detailing

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

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



Acoustical Detailing

Concrete Slab:		CLT Slab:
6” Thick		6-7/8” Thick
80 PSF	⟷	18 PSF
STC 53	⟷	STC 41

Acoustical Detailing

Common mass timber floor assembly:

- Finish floor (if applicable)
- Underlayment (if finish floor)
- 1.5” to 3” thick concrete/gypcrete topping
- Acoustical mat
- WSP (if applicable)
- Mass timber floor panels

Image: AcoustiTECH

Acoustical Detailing

Options without concrete topping:

- Gypsum/cement board (Fermacell, Permabase, etc.)
- Proprietary products

Images: AcoustiTECH

Mass Timber Acoustics

Table 2: Impact of Direct Applied Ceiling Gypsum and Dropped Ceiling on Mass Timber Floor Panels[7]

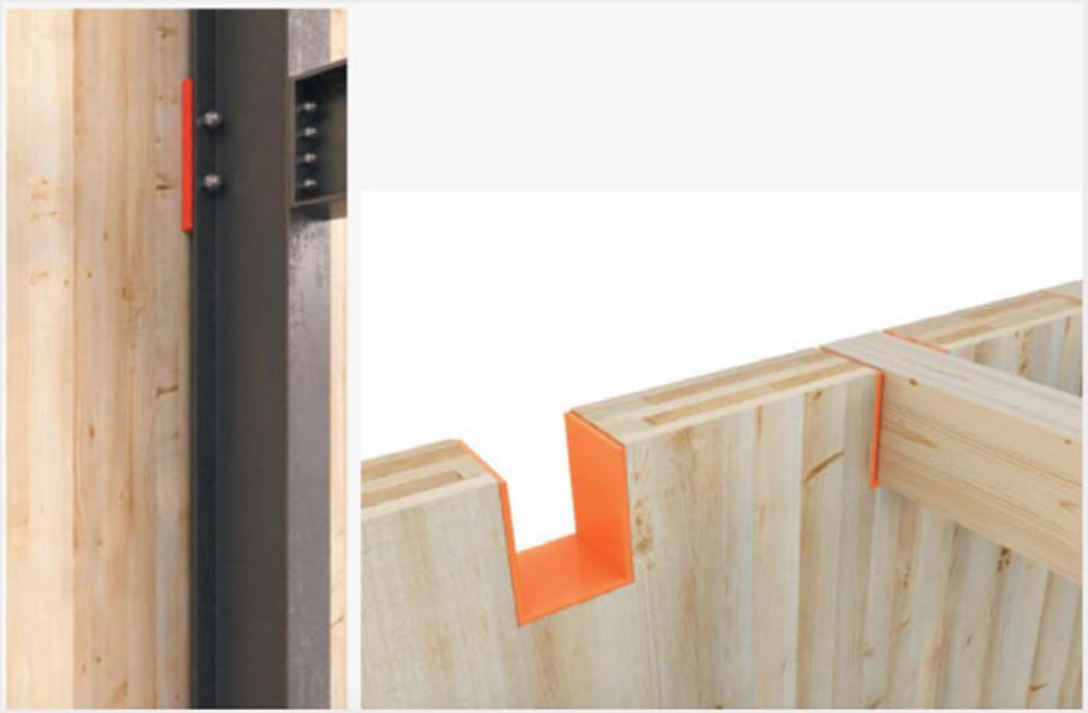
Base Assembly (top to bottom)		Base assembly plus 2 layers direct applied 5/8" gyp on underside of mass timber	Base assembly plus 2 layers direct applied gyp plus dropped ceiling
1" poured gypsum, acoustical mat, 5-ply CLT	STC 50 IIC 40	STC 52 IIC 46	STC 63 IIC 60
LVT, 1" poured gypsum, acoustical mat, 5-ply CLT	STC 51 IIC 43	STC 52 IIC 48	STC 63 IIC 63
2" concrete, acoustical mat, 5-ply CLT	STC 52 IIC 46	STC 59 IIC 52	Not tested
LVT, 2" concrete, acoustical mat, 5-ply CLT	STC 53 IIC 52	STC 58 IIC 55	Not tested

Base Assembly Exposed Timber

With Direct Applied Ceiling Gyp

With Direct Applied Ceiling Gyp & Dropped Ceiling

Acoustical Detailing

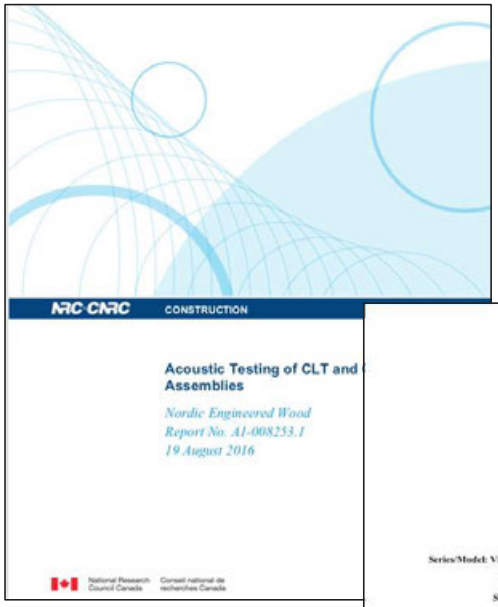


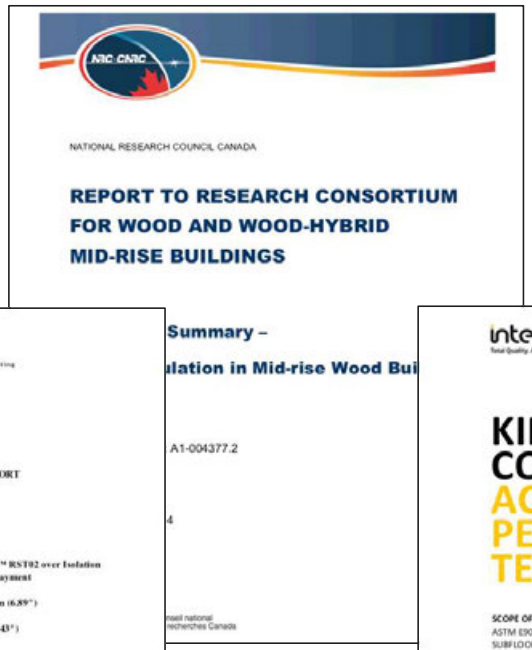
Structural Connection Isolation

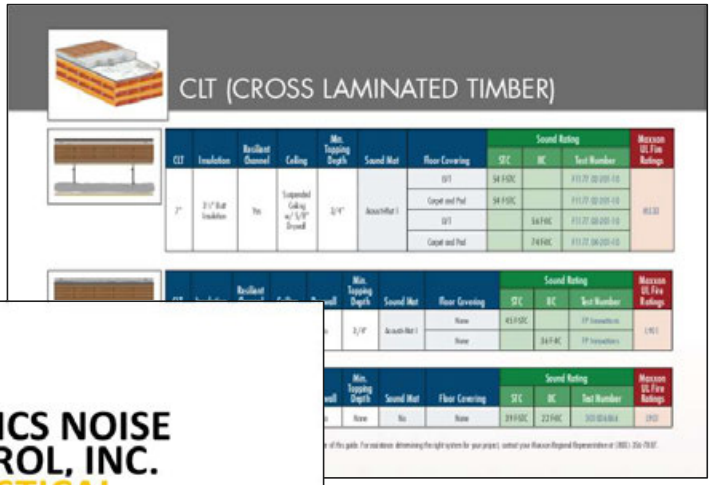
Mass Timber Sealant Strips

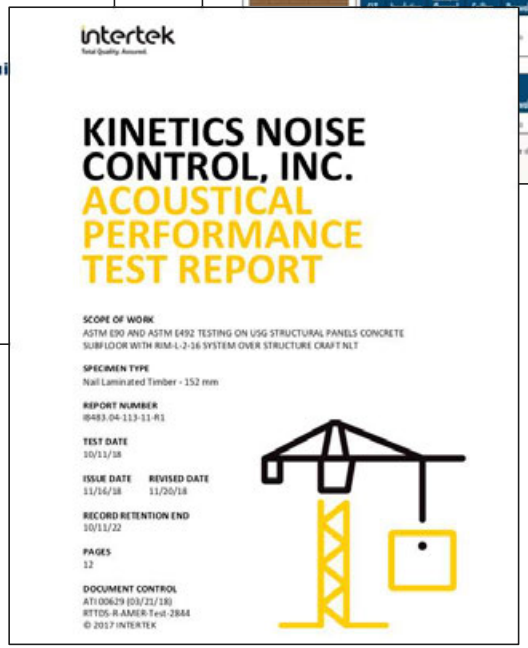
Credit: Rothoblaas

Mass Timber Acoustics









Mass Timber Acoustics

Solutions Paper

WoodWorks™
WOOD PRODUCTS COUNCIL

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

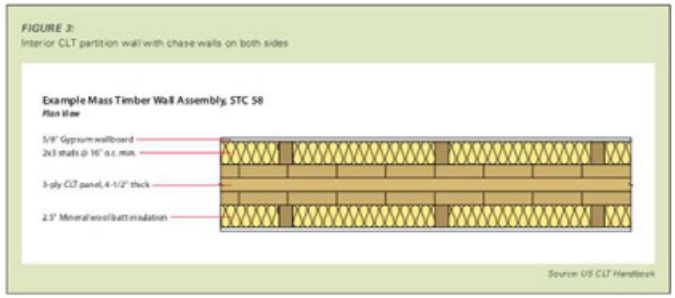
Richard McLain, PE, SE • Senior Technical Director • WoodWorks

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

The growing availability and code acceptance of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction has given designers a low-carbon alternative to steel, concrete, and masonry for many applications. However, the use of mass timber in multi-family and commercial buildings presents unique acoustic challenges.

While laboratory measurements of the impact and airborne sound isolation of traditional building assemblies such as light wood-frame, steel and concrete are widely available, fewer resources exist that quantify the acoustic performance of mass timber assemblies. Additionally, one of the most desired aspects of mass timber construction is the ability to leave a building's structure exposed as finish, which creates the need for asymmetric assemblies. With careful design and detailing, mass timber buildings can meet the acoustic performance expectations of most building types.

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



Mass Timber Assembly Options: Walls

Mass timber panels can also be used for interior and exterior walls—both bearing and non-bearing. For interior walls, the need to conceal services such as electrical and plumbing is an added consideration. Common approaches include building a chase wall in front of the mass timber wall or installing gypsum wallboard on resilient channels that are attached to the mass timber wall. As with bare mass timber floor panels, bare mass timber walls don't typically provide adequate noise control, and chase walls also function as acoustical improvements. For example, a 3-ply CLT wall panel with a thickness of 3.07" has an STC rating of 33.[4] In contrast, Figure 3 shows an interior CLT partition wall with chase walls on both sides. This assembly achieves an STC rating of 58, exceeding the IBC's acoustical requirements for multi-family construction. Other examples are included in the inventory of tested assemblies noted above.

Acoustical Differences between Mass Timber Panel Options

The majority of acoustically-tested mass timber assemblies include CLT. However, tests have also been done on other mass timber panel options such as NLT and dowel-laminated timber (DLT), as well as traditional heavy timber options such as tongue and groove decking. Most tests have concluded that CLT acoustical performance is slightly better than that of other mass timber options, largely because the cross-orientation of laminations in a CLT panel limits sound flanking.

For those interested in comparing similar assemblies and mass timber panel types and thicknesses, the inventory noted above contains tested assemblies using CLT, NLT, glued-laminated timber panels (GLT), and tongue and groove decking.

Improving Performance by Minimizing Flanking

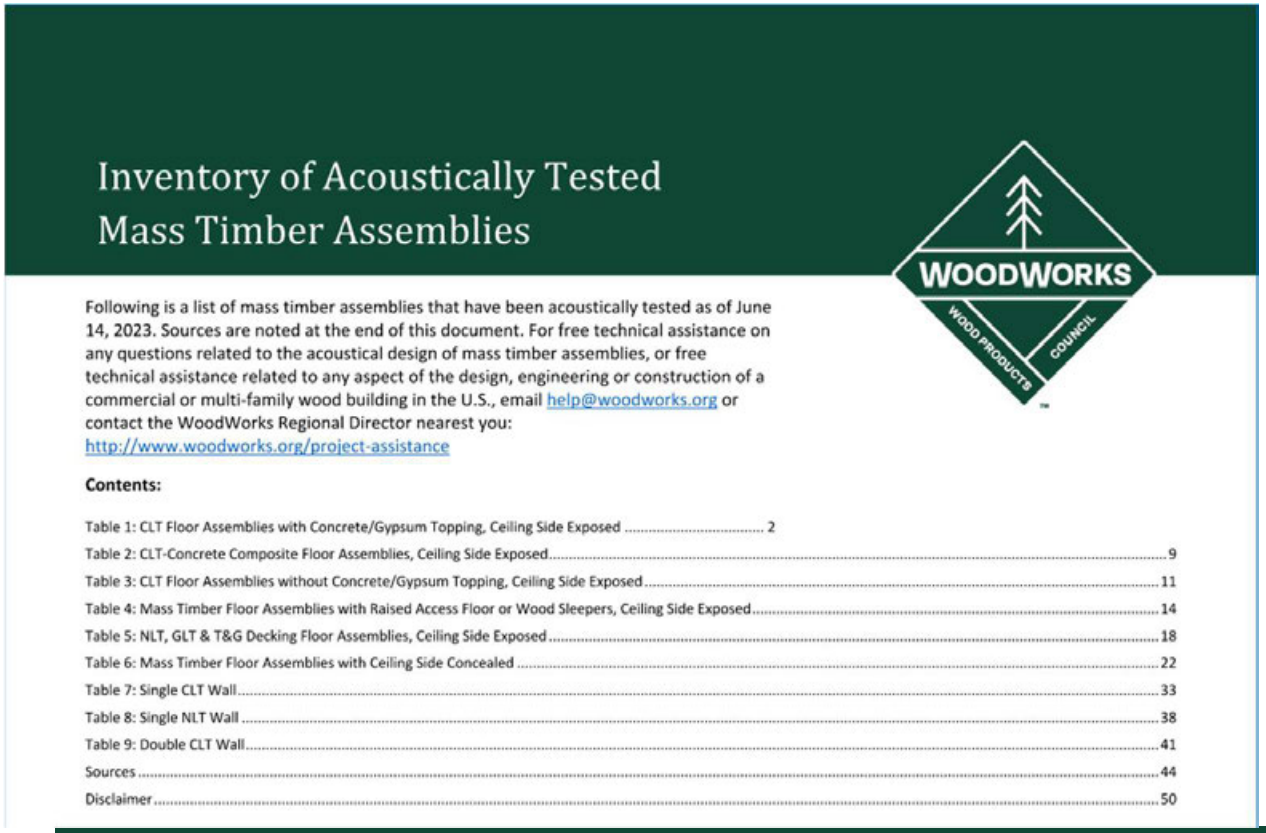
Even when the assemblies in a building are carefully designed and installed for high acoustical performance, consideration of flanking paths—in areas such as assembly intersections, beam-to-column/wall connections, and MEP penetrations—is necessary for a building to meet overall acoustical performance objectives.

One way to minimize flanking paths at these connections and interfaces is to use resilient connection isolation and sealant strips. These products are capable of resisting structural loads in compression between structural members and connections while providing isolation and breaking hard, direct connections between members. In the context of the three methods for improving acoustical performance noted above, these strips act as decouplers. With airtight connections, interfaces and penetrations, there is a much greater chance that the acoustic performance of a mass timber building will meet expectations.

https://www.woodworks.org/resources/acoustics-and-mass-timber-room-to-room-noise-control/

Mass Timber Acoustics

Inventory of Tested Assemblies



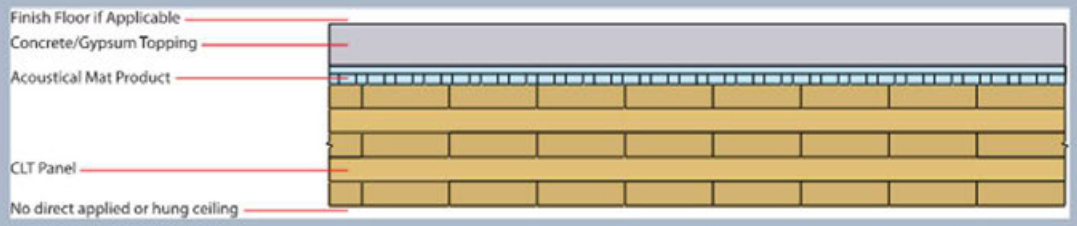
Inventory of Acoustically Tested
Mass Timber Assemblies

Following is a list of mass timber assemblies that have been acoustically tested as of June 14, 2023. 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:

https://www.woodworks.org/resources/inventory-of-acoustically-tested-mass-timber-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[1]	IIC[1]	Source
CLT 3-ply (3.5")	3" concrete	Maxxon Acousti-Mat® 3/4	None	53[2] ASTC	45[2] FIIC	72
CLT 3-ply (4.125")	2" concrete	Pliteq GenieMat™ FF25	None	54	44	89
			LVT on GenieMat RST05	53	48	90
			Eng Wood on GenieMat RST05	53	46	91
			Carpet Tile	52	50	92
	3" concrete	Kinetics® RIM-33L-2-24 System with ¾" Plywood	None	57	45	103
			LVT	-	58	104
			2 layers of ¼" USG Fiberock® on Kinetics® Soundmatt	55	55	105
			LVT on 2 layers of ¼" USG Fiberock® on Kinetics® Soundmatt	-	59	106
		Kinetics® Ultra Quiet SR with synthetic roofing felt	None	57	46	107
			LVT	-	55	108
			2 layers of ¼" USG Fiberock® on Kinetics® Soundmatt	57	53	109
			LVT on 2 layers of ¼" USG Fiberock® on Kinetics® Soundmatt	-	50	110
	4" concrete	Kinetics® RIM-33L-2-24 System with ¾" Plywood	None	60	53	111

Questions? Ask us anything.

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

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Funding provided in part by the Softwood Lumber Board