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WOOD PRODUCTS COUNCIL

Mass Timber Overview:

Systems, Products & Codes

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

Course Description

Innovations in mass timber construction are offering new opportunities for the building industry. Products such as cross-laminated timber (CLT) and glue-laminated timber (glulam) combine multiple laminations of lumber to produce solid timber elements such as floor and wall panels, beams, and columns. These elements have high strength-to-weight ratios, allowing them to replace more traditional construction materials while providing sustainable systems that can meet code criteria for acoustics, fire-resistance, seismic performance, energy efficiency, and more. However, while design and code aspects of mass timber receive a great deal of focus, it is the construction aspects that often decide whether a project goes forward. Mass timber construction has similarities to other systems, but it also has unique attributes—and a complete understanding of the differences is key to efficient project cost estimation and efficient construction. This in-depth, multi-faceted workshop will explore mass timber from design through preconstruction, fabrication, erection, and project close-out. After setting the stage with an overview of mass timber products and sustainability attributes, discussion will focus on construction topics, including risk analysis, cost case studies design team interaction, cost optimization, scheduling, site planning, and other logistics. Intended for construction industry professionals looking to gain a deep understanding of the unique attributes of mass timber construction, this workshop will leave attendees with information they need to successfully bid and construct a mass timber project.

Learning Objectives

1. Understand the preconstruction manager's role in material procurement and coordination of trades for code-compliant mass timber projects.

2. Highlight effective methods of early design-phase cost estimation and building official interaction on code compliance topics that keep mass timber options on the table.

3. Discuss potential construction schedule savings and construction fire safety practices realized through the use of prefabricated mass timber elements.

4. Explore best practices for interaction between manufacturer, design team and preconstruction manager that can lead to cost efficiency and safety on site.

MASS TIMBER OVERVIEW

Heavy Timber
Photo: Benjamin Benschneider

Mass Timber
Photo: John Stamets

Glue Laminated Timber (GLT)

Cross-Laminated Timber (CLT)

Nail-Laminated Timber (NLT)

Photo: Think Wood

Photo: StructureCraft

Photo: LendLease

Photo: Ema Peter

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Mass plywood panels (MPP)

Photo: Freres Lumber

Decking

Photo: StructureCraft

Photo: LEVER Architecture

Photo: Bernard André Photography

EFFICIENCY FOUND IN UNDERSTANDING SUPPLY CHAIN, DESIGNING ACCORDING TO ITS CAPABILITIES

Photo: DR Johnson

Photo: Ema Peter

STRUCTURAL SOLUTIONS | POST, BEAM + PLATE

Photo: Seagate Structures

STRUCTURAL SOLUTIONS | POST + PLATE

Photo: Lendlease

STRUCTURAL SOLUTIONS | HYBRID LIGHT-FRAME + MASS TIMBER

Photo: SOM

STRUCTURAL SOLUTIONS | HYBRID STEEL + MASS TIMBER

Photo: Structurlam

STRUCTURAL SOLUTIONS | HYBRID CONCRETE + MASS TIMBER

Concealed Connectors

Self Tapping Screws

Photos: Rothoblaas

Beam to Column

Photo: StructureCraft

Photo: Structurlam

Column to Foundation

Photo: Alex Schreyer

Panel to Panel & Supports

Photo: Charles Judd

Photo: Alex Schreyer

Mass Timber Projects In Design and Constructed in the US (September 2019)

Considering mass timber for a project?
Ask us anything.

For free project support, contact:
help@woodworks.org
woodworks.org/project-assistance

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

Photo: Nordic Structures

PRECEDENT PROJECTS | UMASS AMHERST DESIGN BUILDING

Photo: ©Albert Vecerka/Esto

Photos: Baumberger Studio/PATH Architecture

PRECEDENT PROJECTS | CARBON 12 | PORTLAND, OR

Photo: Hines

Photo: Corey Gaffer courtesy Perkins + Will

Photos: StructureCraft

Photo: Hartshorne Plunkard Architecture

Photos: Flank

PRECEDENT PROJECTS | 360 WYTHE BROOKYLN, NY

Photos: Swinerton | DJC Oregon

PRECEDENT PROJECTS | FIRST TECH CREDIT UNION HILLSBORO, OR

Photos: Michael Elkan | Naturally Wood | UBC

PRECEDENT PROJECTS | BROCK COMMONS

Photos: Daniel Shearin | Waugh Thistleton Architects

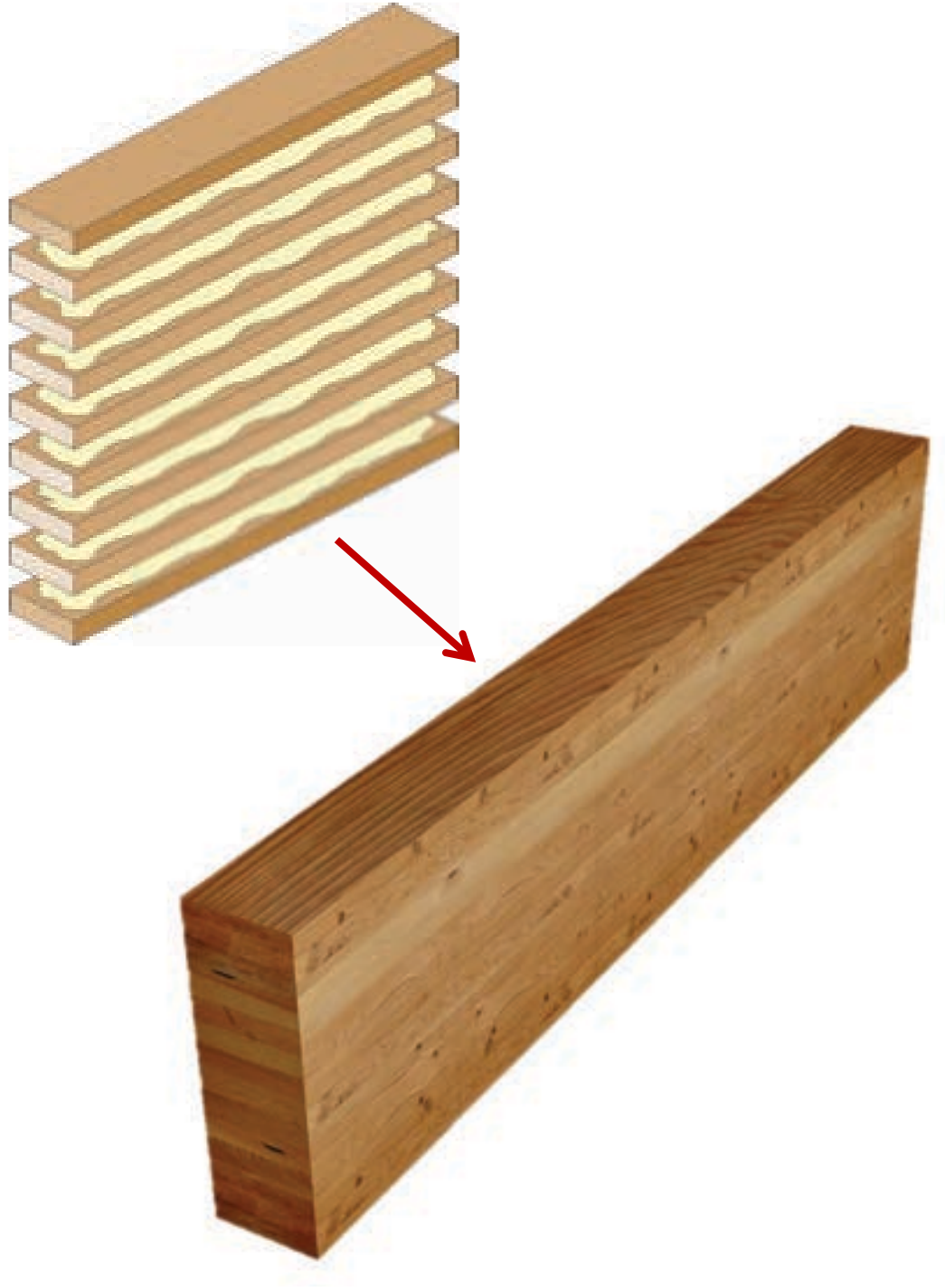
Photos: Bygg Mesteren | Voll Arkitekter

MASS TIMBER PRODUCTS

Glue Laminated Timber (GLT)

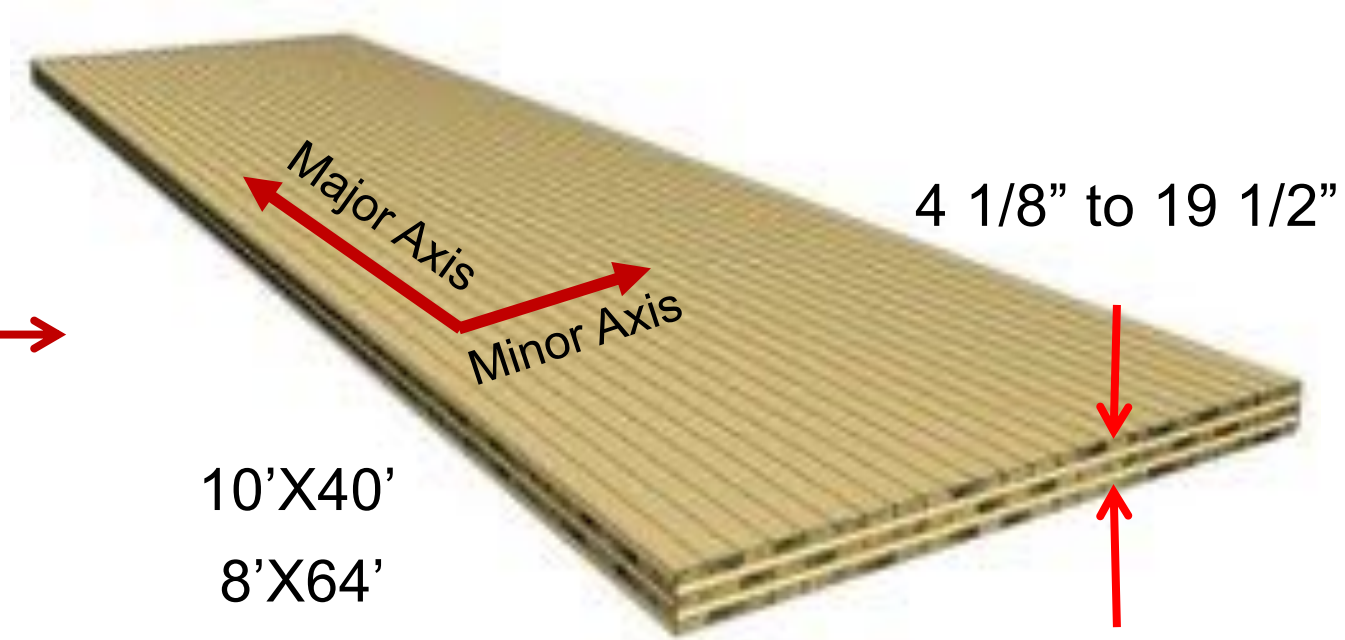
Glue Laminated Timber (GLT)

Photo: Manasc Isaac Architects/Fast + Epp



Cross-Laminated Timber (CLT)

Cross-Laminated Timber (CLT)



Nail-Laminated Timber (NLT)

Nail-Laminated Timber (NLT)

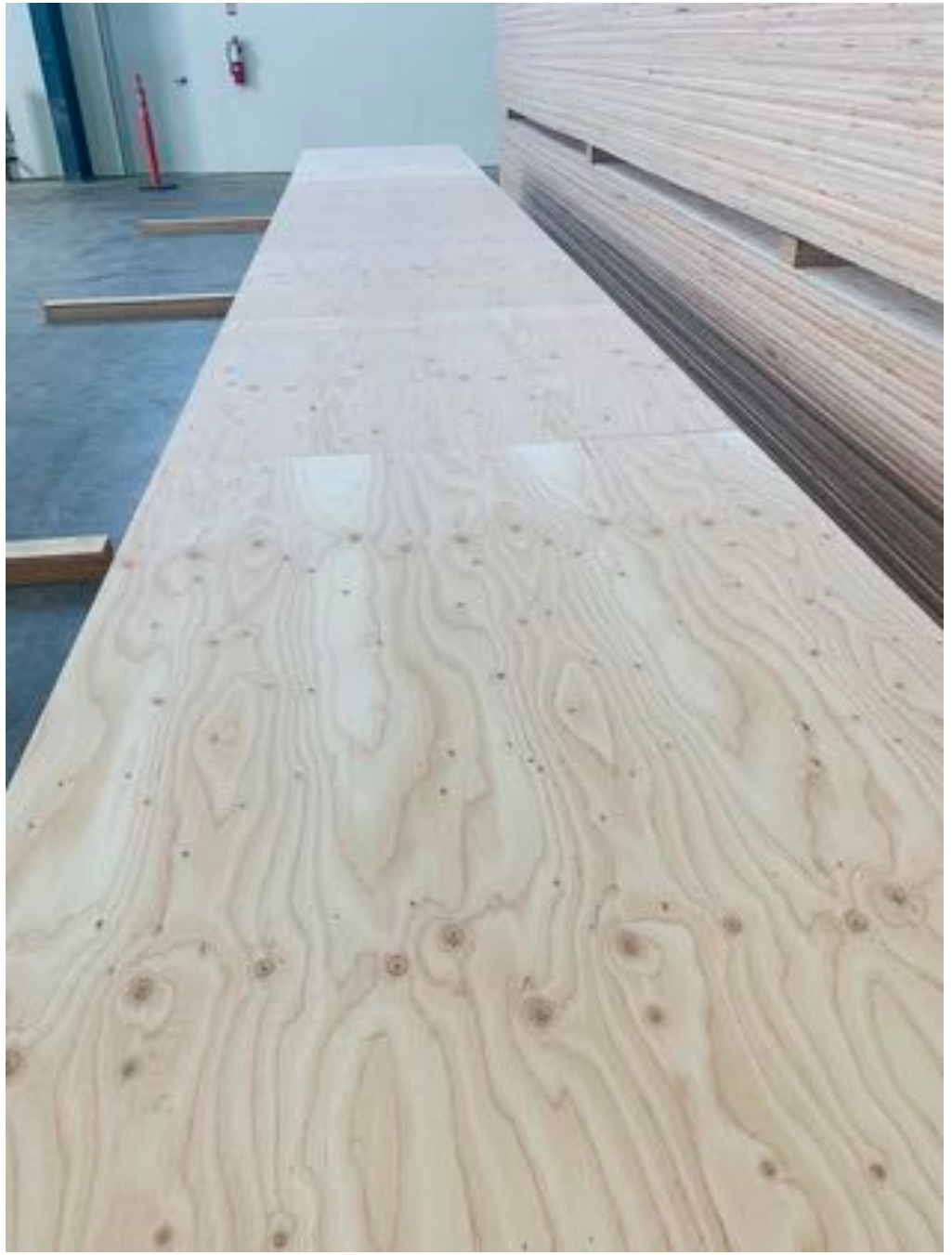
Photo: StructureCraft

Photo: Think Wood

Dowel-Laminated Timber (NLT)

Photo: StructureCraft

Mass Plywood Panels (MPP)



Photos: Freres Lumber

Other Mass Timber Product Options

Glue Laminated Timber
GLT

Laminated Veneer Lumber
LVL

Parallel Strand Lumber
PSL

Laminated Strand Lumber
LSL

Timber-Concrete Composite
TCC

Decking

Photos: StructureCraft

MASS TIMBER IN THE CODE

Mass Timber in Low- to Mid-Rise: 1-6 Stories in Construction Types III, IV or V

Credit: WoodWorks

Tall Mass Timber: Up to 18 Stories in Construction Types IV-A, IV-B or IV-C

Credit: Susan Jones, atelierjones

WoodWorks Tall Wood Design Resource

- 2021 IBC provisions
- Design Steps
- Free download at woodworks.org

MASS TIMBER FIRE-RESISTANCE

Photo Credit: FPInnovations

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[a] (see Section 202)	3[e]	2[e]	1	0	1	0	HT	1	0
Bearing walls Exterior[d, f] Interior	3 3[e]	2 2[e]	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)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

For SI: 1 foot = 304.8 mm.

a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.

b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.

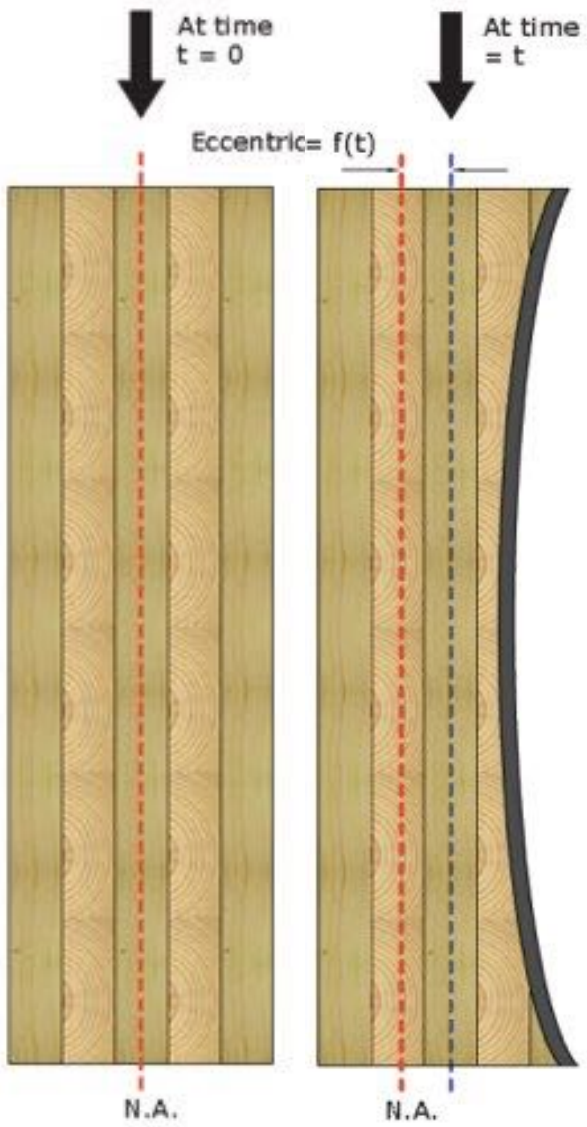
d. Not less than the fire-resistance rating required by other sections of this code.

e. Not less than the fire-resistance rating based on fire separation distance (see Table 602).

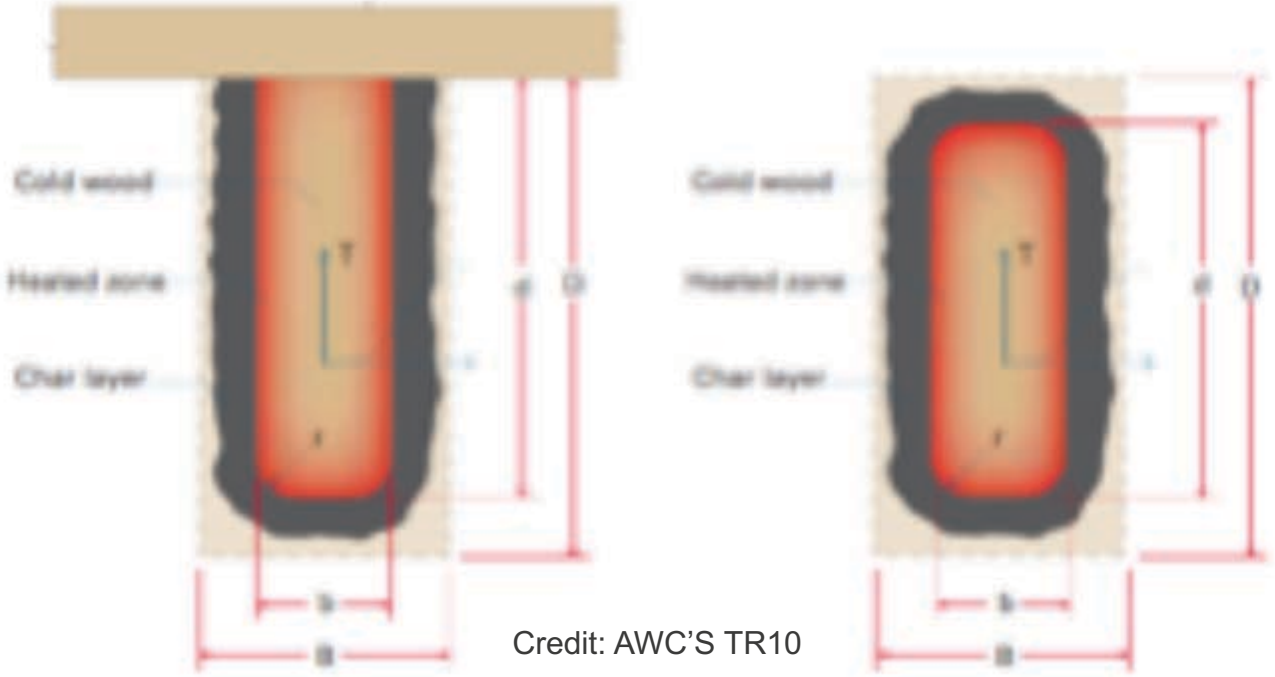
f. Not less than the fire-resistance rating as referenced in Section 704.10.

Credit: IBC Table 601

Mass Timber's Fire-Resistive Performance is Well-Tested, Documented and Recognized via Code Acceptance



Credit: CLT Handbook



Credit: AWC'S TR10

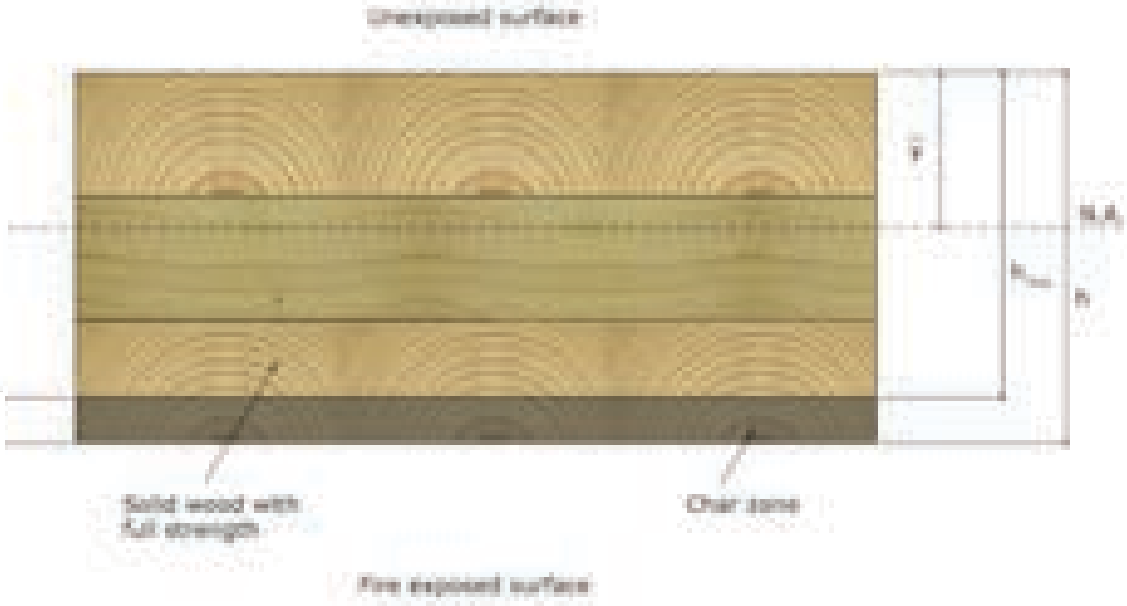
How do you determine Fire Resistance Rating of Mass Timber?

2 Options:

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


Credit: Urban One

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



MT FRR Calculations Method:

- **IBC 703.3 allows several methods of determining FRR. One is calculations per 722.**
- **722.1 refers to NDS Chpt 16 for exposed wood FRR**

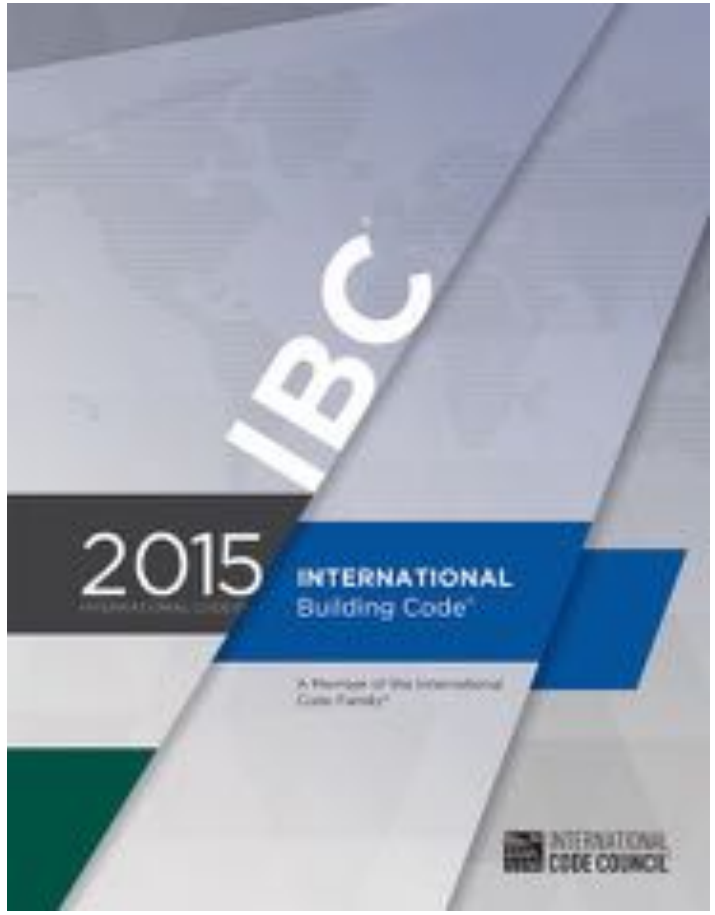
703.3 Methods for determining fire resistance. The application of any of the methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E119 or UL 263. The required *fire resistance* of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures:

3. Calculations in accordance with Section 722.

722.1 General. The provisions of this section contain procedures by which the *fire resistance* of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated *fire resistance* of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with ACI 216.1/TMS 0216. The calculated *fire resistance* of steel assemblies shall be permitted in accordance with Chapter 5 of ASCE 29. The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AF&PA *National Design Specification for Wood Construction (NDS)*.

Credit: IBC Chapter 7

Code Path for Calculated FRR of Exposed MT



Code Path for Exposed Wood Fire-Resistance Calculations

IBC 703.3
Methods for determining fire resistance

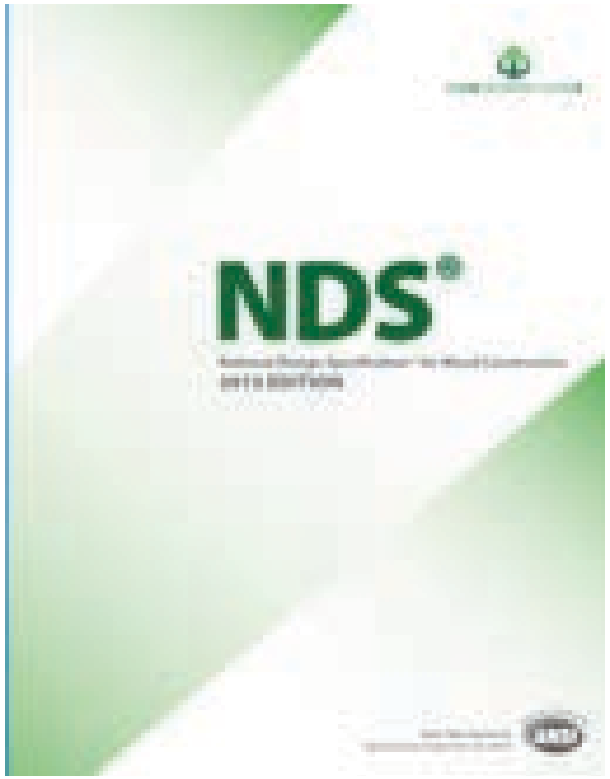
- Prescriptive designs per IBC 721.1
- ***Calculations in accordance with IBC 722***
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Alternate protection methods as allowed by 104.11

IBC 722
Calculated Fire Resistance

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

NDS Chapter 16
Fire Design of Wood Members

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




Credit: FPInnovations

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

Credit: AWC'S NDS

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

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


Credit: David Barber, ARUP

Credit: AWC’S NDS

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

Tested Assemblies Method:

- **Many successful Mass Timber ASTM E119 fire tests have been completed by industry & manufacturers**

WOODWORKS INVENTORY OF FIRE TESTED MT ASSEMBLIES

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

Mass Timber Fire Design Resource

- Code compliance options for demonstrating FRR
- Updated as new tests are completed
- Free download at woodworks.org

FIRE PROTECTION OF CONNECTIONS

Photo: Structurlam

Connections between building elements must be able to maintain FRR no less than that required of the connected members.

Photo: MyTiCon

16.3 Wood Connections

Wood connections, including connectors, fasteners, and portions of wood members included in the connection design, shall be protected from fire exposure for the required fire resistance time. Protection shall be provided by wood, fire-rated gypsum board, other approved materials, or a combination thereof.

Source: NDS

Multiple ways to demonstrate connection fire protection: calculations, prescriptive NC, test results, others as approved by AHJ


Photo: John Stamets


Photo: Josh Partee


Photo: Christian Columbres


Photo: Blaine Brownell

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

Photo: ARUP/SLB

Full Report Available:

https://www.thinkwood.com/wp-content/uploads/2018/01/reThink-Wood-Arup-SLB-Connection-Fire-Testing-Summary-web.pdf

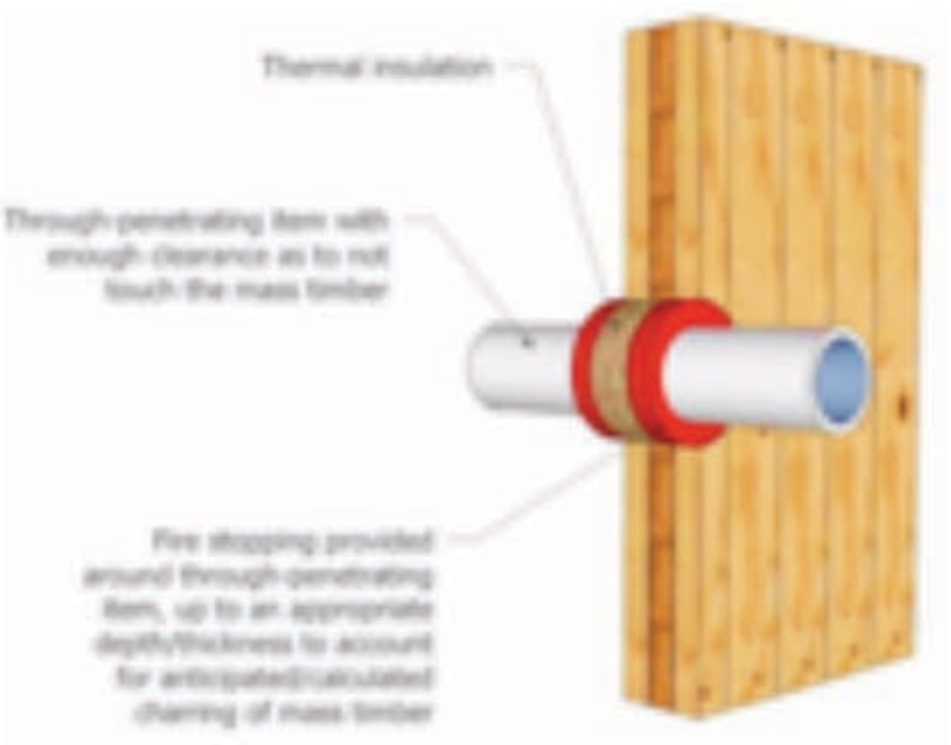
FIRE PROTECTION OF PENETRATIONS

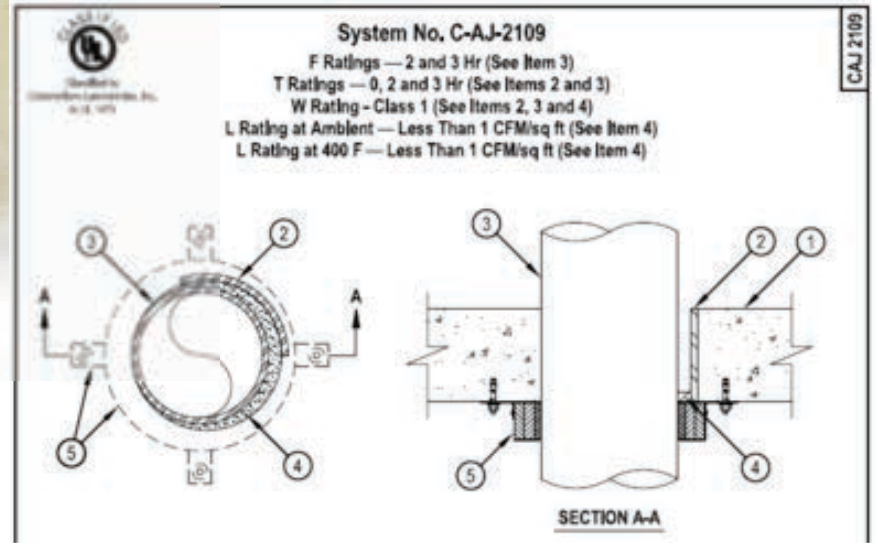
Photo: Alex Schreyer

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

Photos: AWC/FPInnovations

Most firestopping systems include combination of fire safing (eg. noncombustible materials such as mineral wool insulation) plus fire caulk





Photos: AWC/FPInnovations/Hilti

Inventory of Fire Tested Penetrations in MT Assemblies

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

ConstructionFireSafetyPractices.com

2021 IBC Construction Fire Safety for Tall Mass Timber

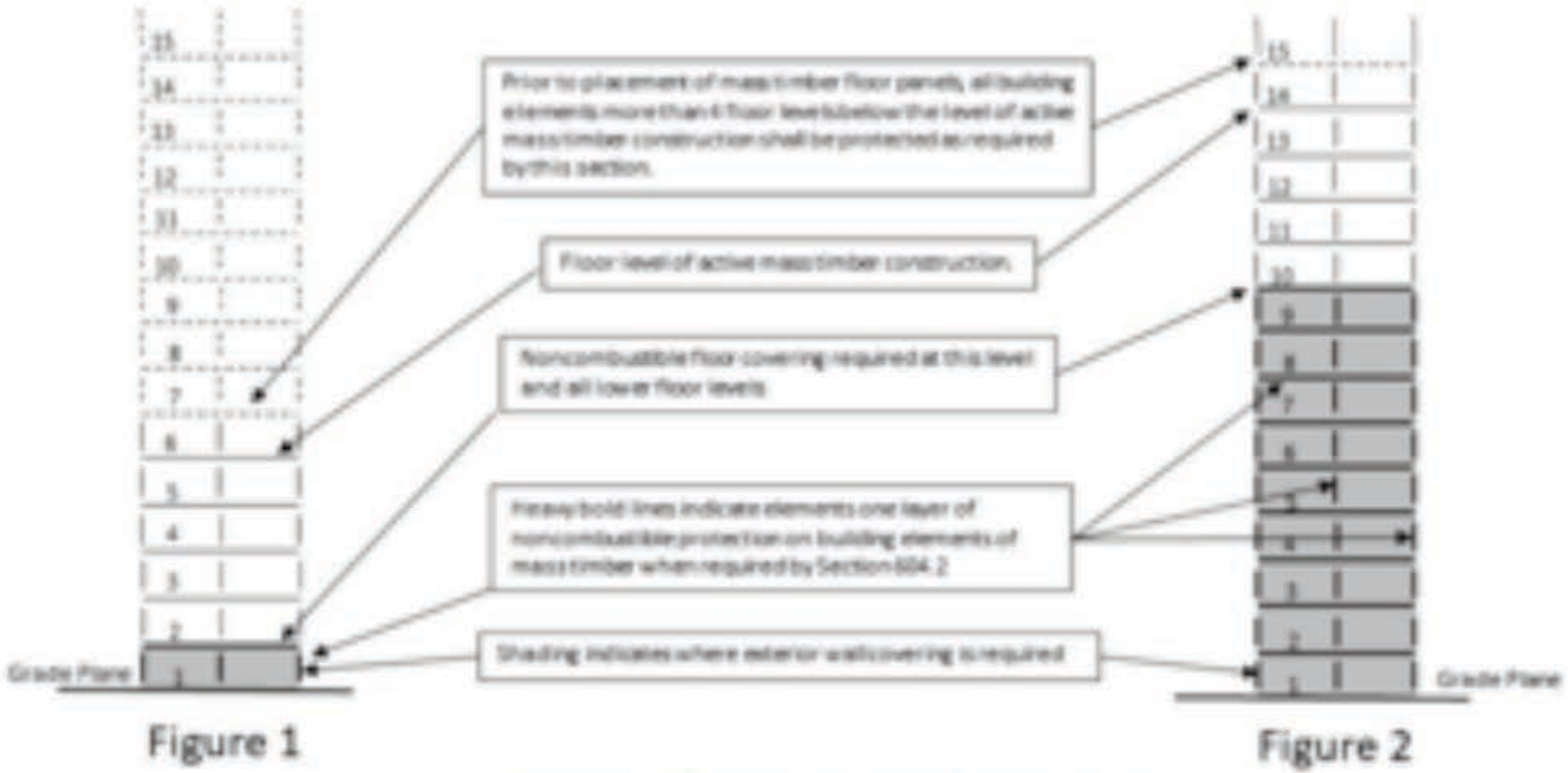


Figure 1

Figure 2

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

Credit: ICC

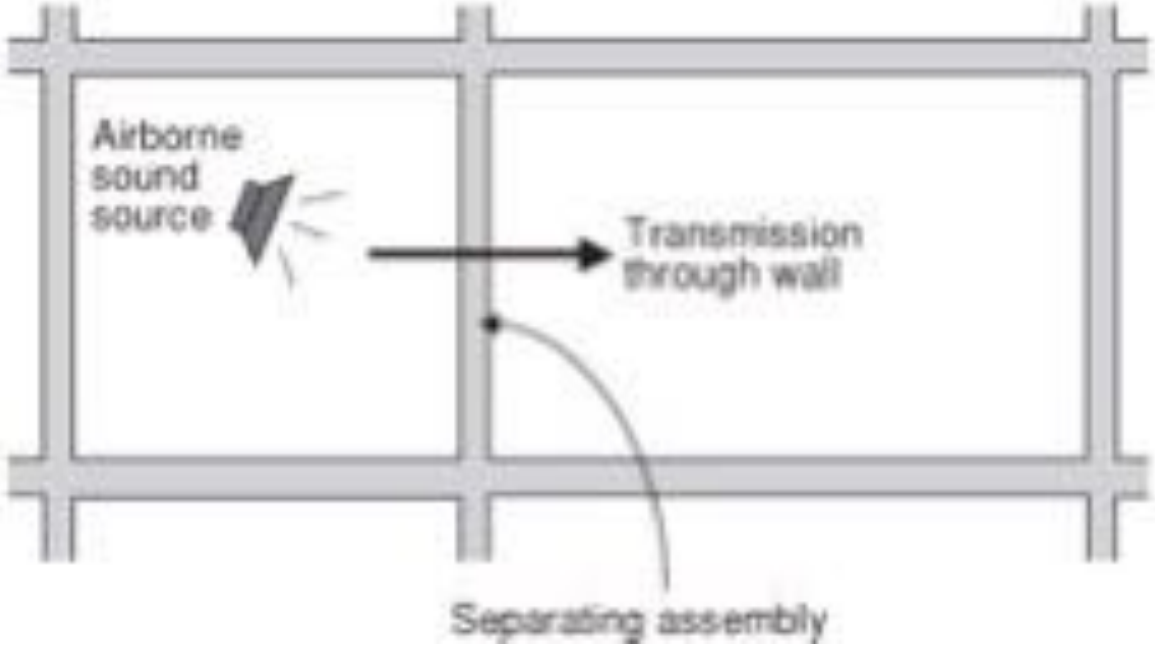
MASS TIMBER ACOUSTICS DESIGN

ACOUSTICS DESIGN

Air-Borne Sound:

Sound Transmission Class (STC)

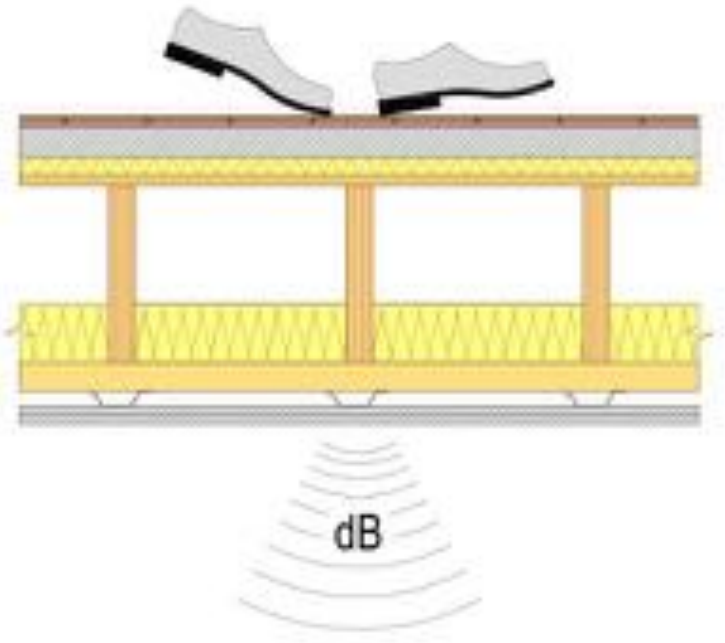
- Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other
- Applies to walls and floor/ceiling assemblies



ACOUSTICS DESIGN

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



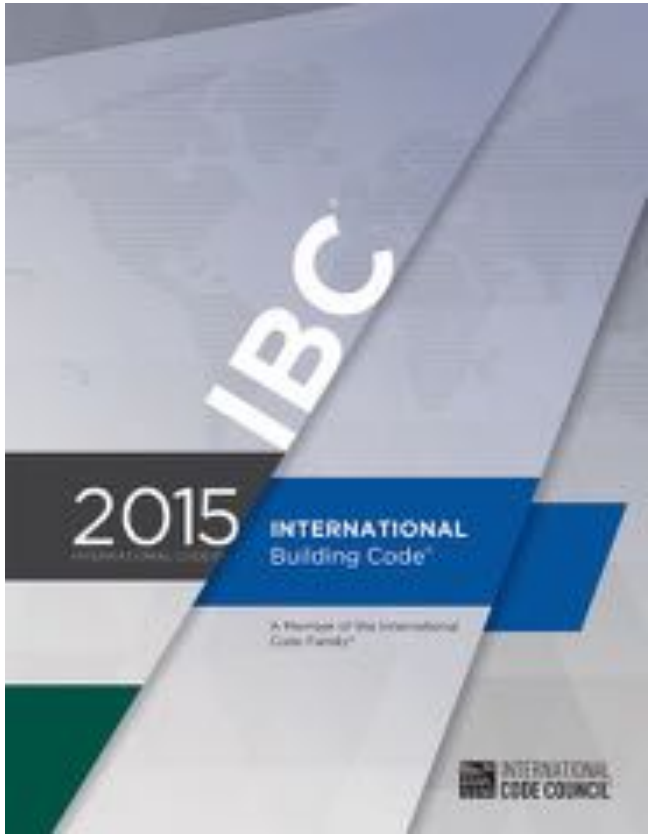
ACOUSTICS DESIGN

Code requirements only address residential occupancies:

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

Min. STC of 50 (45 if field tested):
- Walls, Partitions, and Floor/Ceiling Assemblies

Min. IIC of 50 (45 if field tested) for:
- Floor/Ceiling Assemblies



ACOUSTICS DESIGN

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

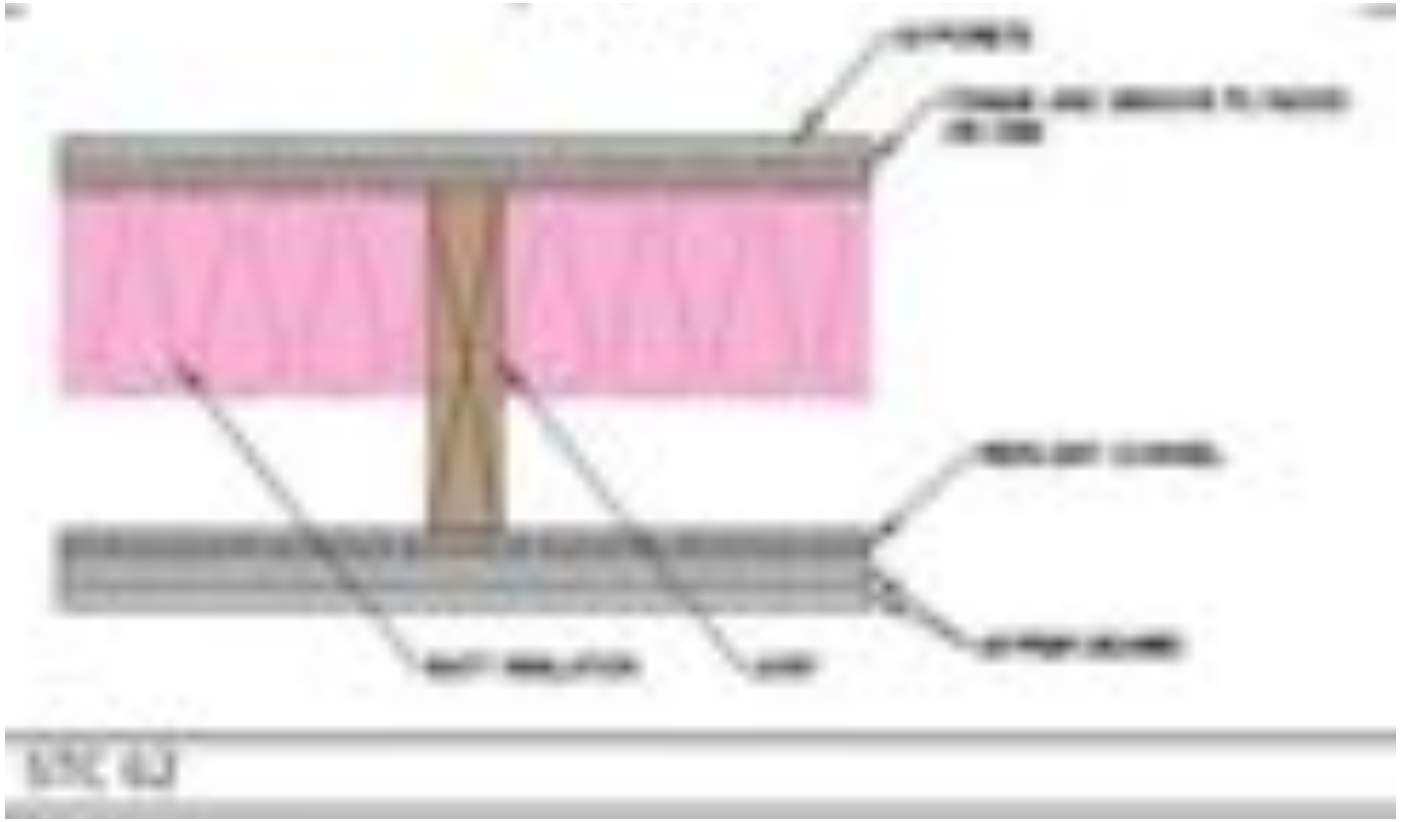
1. Add Mass
2. Add noise barriers
3. Add decouplers


Image credit: Christian Columbres

ACOUSTICS DESIGN

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

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



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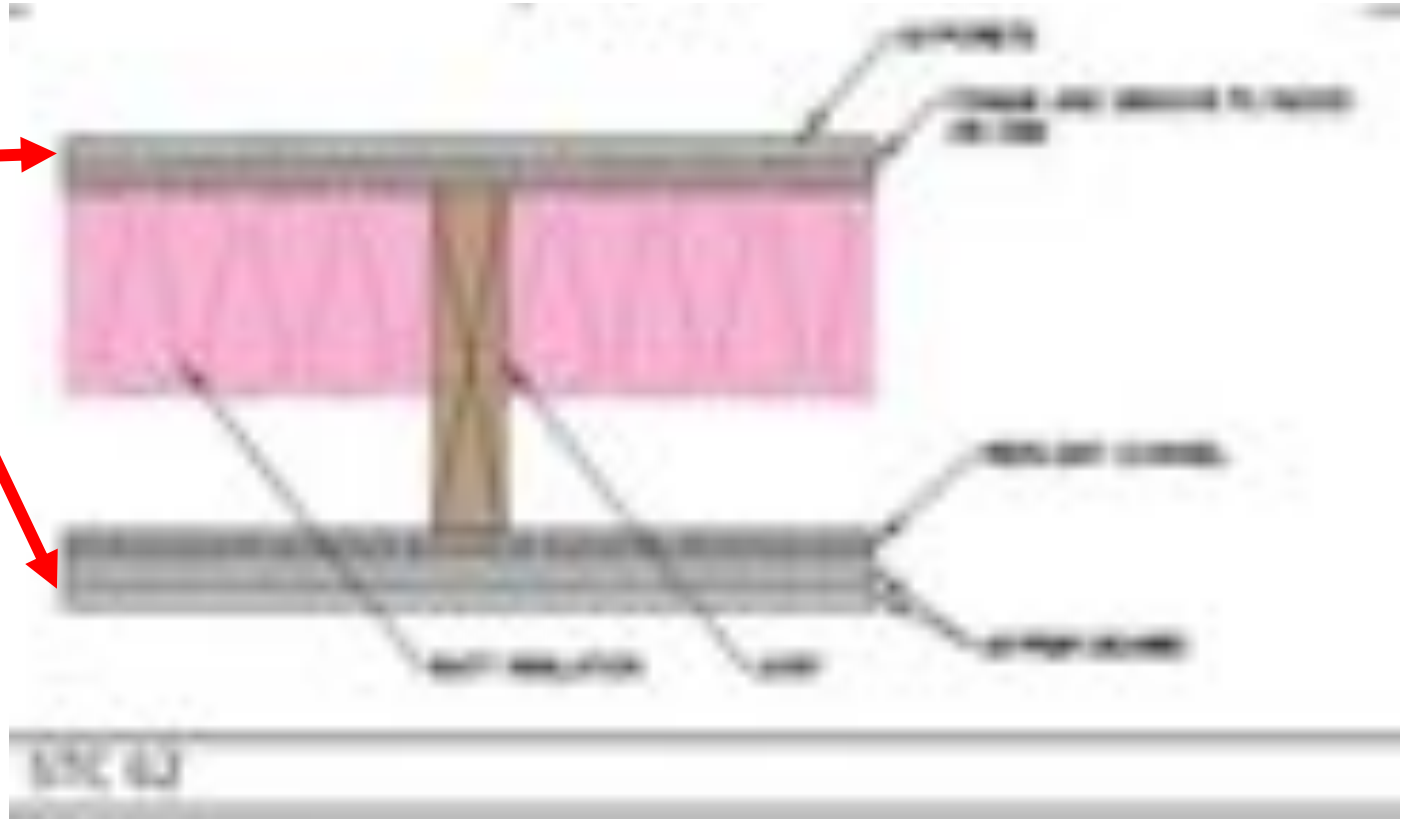

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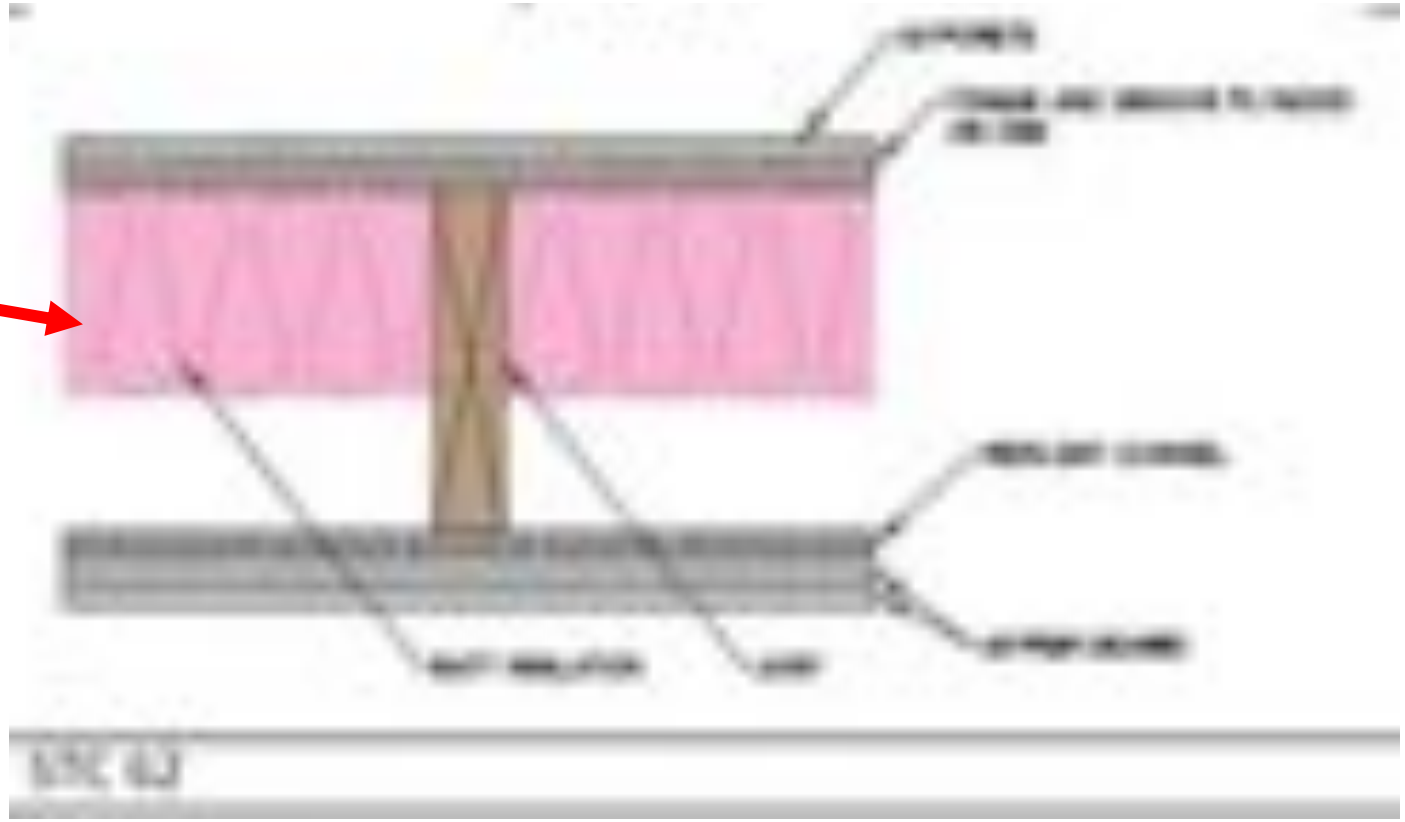

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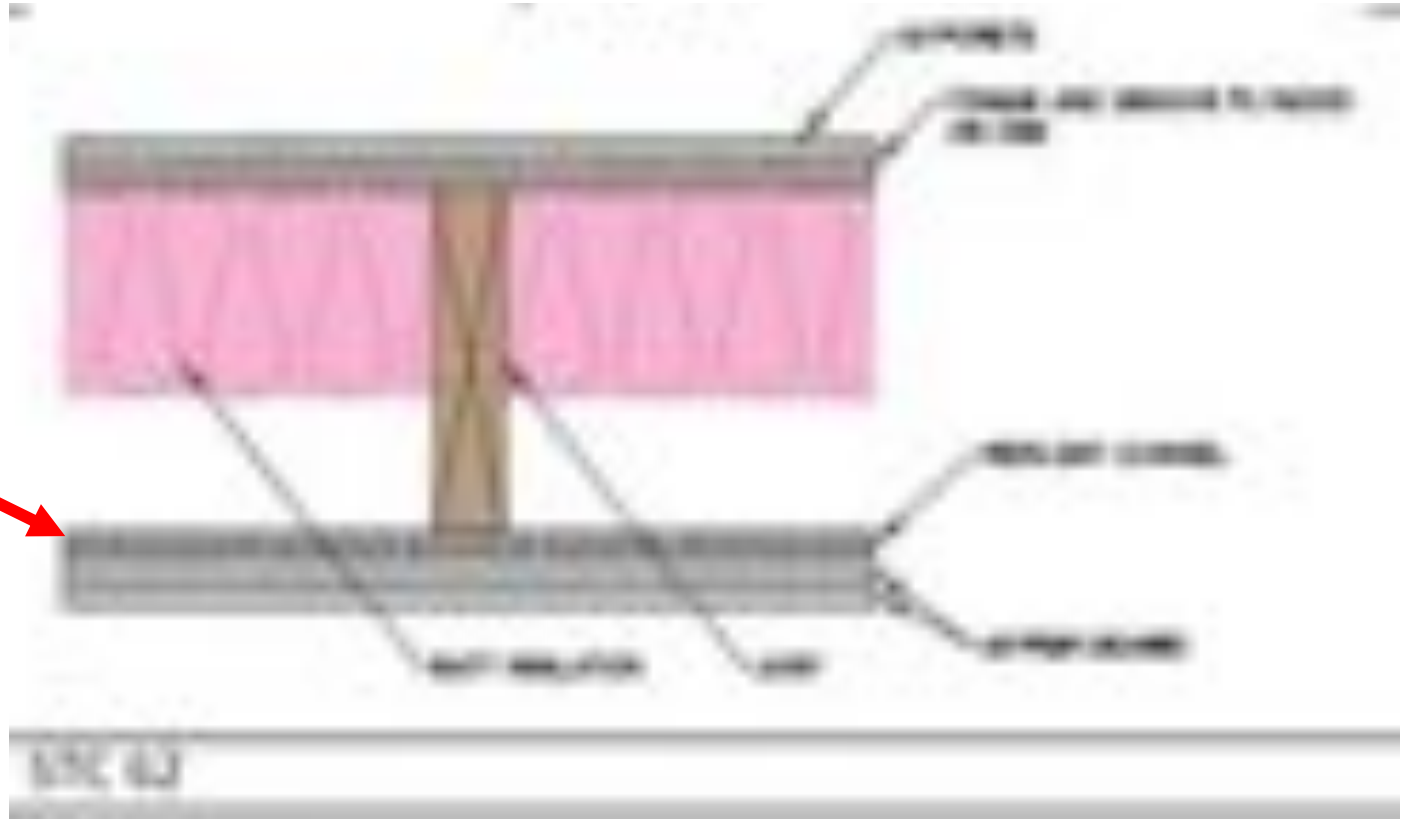


MASS TIMBER: STRUCTURE IS FINISH

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

BY ITSELF, NOT ADEQUATE FOR ACOUSTICS

TABLE 1:

Examples of Acoustically-Tested Mass Timber Panels

Mass Timber Panel	Thickness	STC Rating	IIC Rating
3-ply CLT wall[a]	3.07"	33	N/A
5-ply CLT wall[a]	6.875"	38	N/A
5-ply CLT floor[b]	5.1875"	39	22
5-ply CLT floor[a]	6.875"	41	25
7-ply CLT floor[a]	9.65"	44	30
2x4 NLT wall[a]	3-1/2" bare NLT 4-1/4" with 3/4" plywood	24 bare NLT 29 with 3/4" plywood	N/A
2x6 NLT wall[a]	5-1/2" bare NLT 6-1/4" with 3/4" plywood	22 bare NLT 31 with 3/4" plywood	N/A
2x6 NLT floor + 1/2" plywood[c]	6" with 1/2" plywood	34	33

Source: Inventory of Acoustically Tested Mass Timber Assemblies, WoodWorks[1]

Concrete Slab:

6” Thick

80 PSF ⟷ **18 PSF**

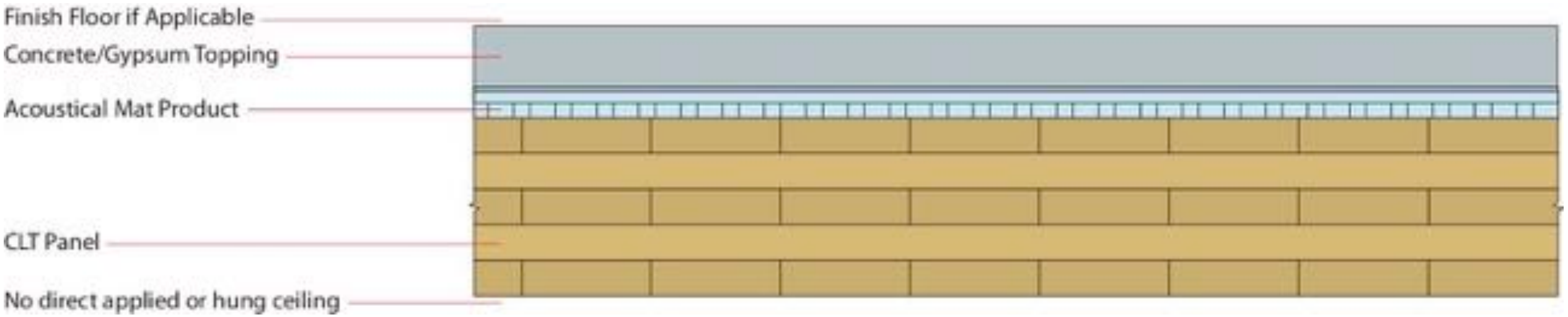
STC 53 ⟷ **STC 41**

CLT Slab:

6-7/8” Thick

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

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



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 panel exposed on ceiling side

Image credit: AcoustiTECH

MASS TIMBER ACOUSTICS DESIGN RESOURCE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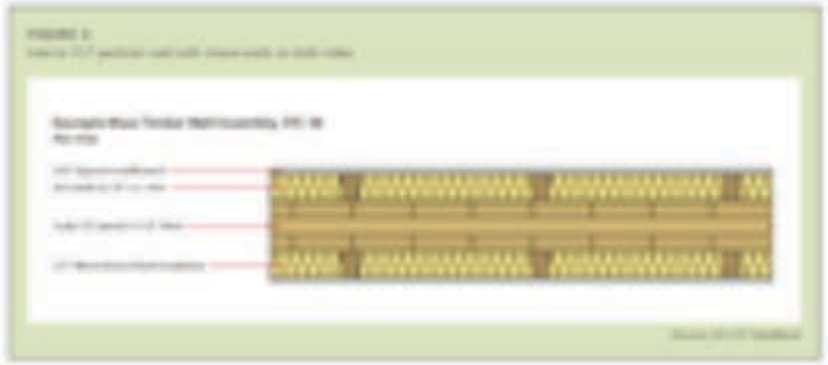
Acoustics and Mass Timber:
Room-to-Room Noise Control

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



WoodWorks Inventory of Acoustically Tested MT Assemblies

More than 400 Tested Assemblies

Free download at woodworks.org

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Ask us anything.

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woodworks.org | help@woodworks.org

WoodWorks can help connect you with:

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Suppliers
Distributors
Experienced Designers, Contractors, Installers
And Much More

Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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