Mass Timber Overview:

Systems, Products & Codes

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Photo: Structurlam

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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)

Photo: StructureCraft

Cross-Laminated Timber (CLT)

Photo: LendLease

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Photo: StructureCraft

Nail-Laminated Timber (NLT)

Photo: Think Wood

Photo: Ema Peter

Mass plywood panels (MPP)

Photo: Freres Lumber

Photo: LEVER Architecture

Decking

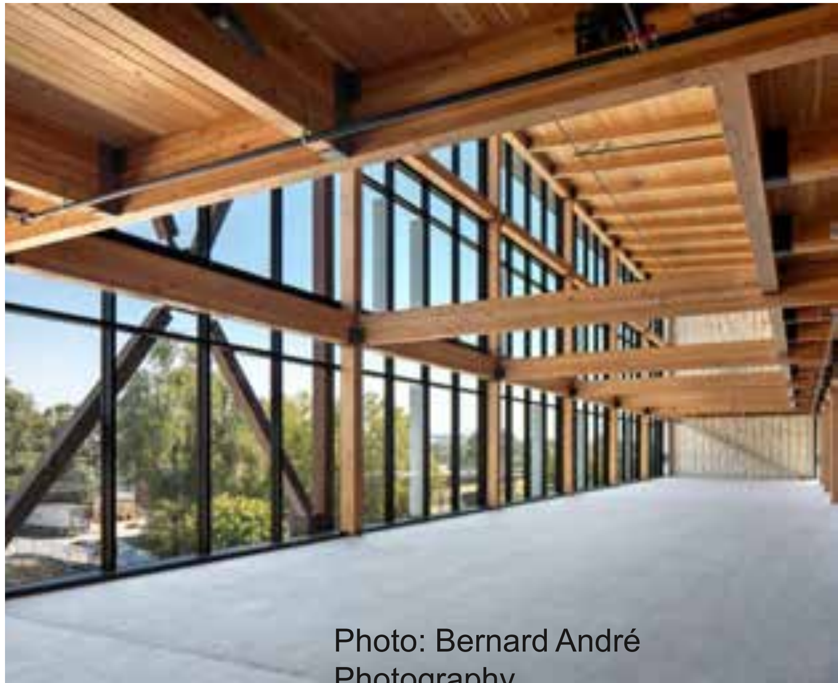


Photo: Bernard André Photography

STRUCTURAL SOLUTIONS | POST, BEAM + PLATE

STRUCTURAL SOLUTIONS | HYBRID STEEL + MASS TIMBER

Photo: Seagate Structures

STRUCTURAL SOLUTIONS | POST + PLATE

STRUCTURAL SOLUTIONS | HONEYCOMB

STRUCTURAL SOLUTIONS | HYBRID LIGHT-FRAME + MASS TIMBER

Concealed Connectors

Self Tapping Screws

Photos: Rothoblaas

Beam to Column

Photo: StructureCraft

Photo: Structurlam

OVERVIEW | CONNECTIONS

Column to Foundation

Photo: Alex Schreyer

Photo: Nordic Structures

PRECEDENT PROJECTS | UMASS AMHERST DESIGN BUILDING


Photo: ©Albert Vecerka/Esto

PRECEDENT PROJECTS | UMASS AMHERST DESIGN BUILDING


Photo: Cheyne Smith / BOKA Powell

PRECEDENT PROJECTS | THE SOTO | SAN ANTONIO, TX

Photo: Cheyne Smith / BOKA Powell

PRECEDENT PROJECTS | THE SOTO | SAN ANTONIO, TX

PRECEDENT PROJECTS | 901 EAST 6TH STREET | AUSTIN, TX

Photos: Swinerton | DJC Oregon

PRECEDENT PROJECTS | FIRST TECH CREDIT UNION HILLSBORO, OR

Photos: Baumberger Studio/PATH Architecture

PRECEDENT PROJECTS | CARBON 12 | PORTLAND, OR

Photos: Michael Elkan | Naturally Wood | UBC

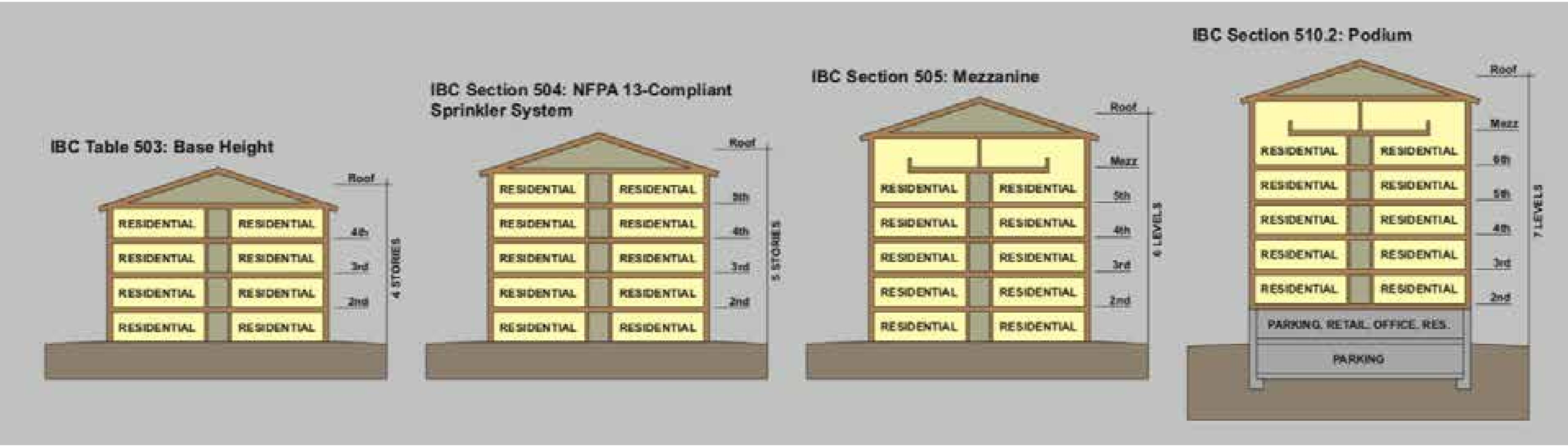
PRECEDENT PROJECTS | BROCK COMMONS

Photos: Bygg Mesteren | Voll Arkitekter

PRECEDENT PROJECTS | MJOSTARNET NORWAY

MASS TIMBER IN THE CODE

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



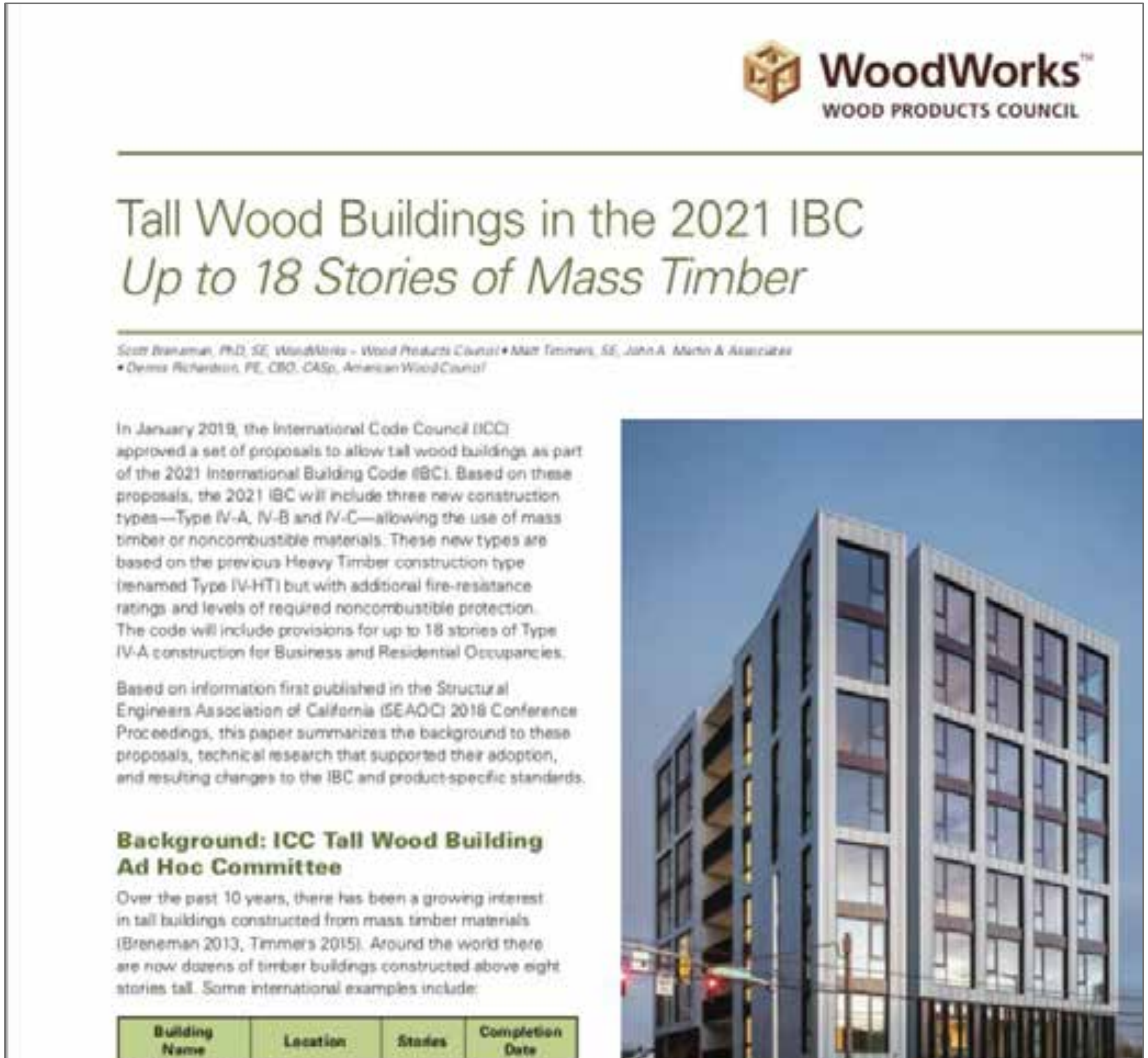
Credit: WoodWorks

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



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

Scott Breneman, PhD, SE, WoodWorks – Wood Products Council • Matt Timmers, SE, John A. Martin & Associates • Dennis Richardson, PE, CBO, CASp, American Wood Council

In January 2019, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (IBC). Based on these proposals, the 2021 IBC will include three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber or noncombustible materials. These new types are based on the previous Heavy Timber construction type (renamed Type IV-HT) but with additional fire-resistance ratings and levels of required noncombustible protection. The code will include provisions for up to 18 stories of Type IV-A construction for Business and Residential Occupancies.

Based on information first published in the Structural Engineers Association of California (SEAOC) 2018 Conference Proceedings, this paper summarizes the background to these proposals, technical research that supported their adoption, and resulting changes to the IBC and product-specific standards.

Background: ICC Tall Wood Building Ad Hoc Committee

Over the past 10 years, there has been a growing interest in tall buildings constructed from mass timber materials (Breneman 2013, Timmers 2015). Around the world there are now dozens of timber buildings constructed above eight stories tall. Some international examples include:

Building Name	Location	Stories	Completion Date

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[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

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.

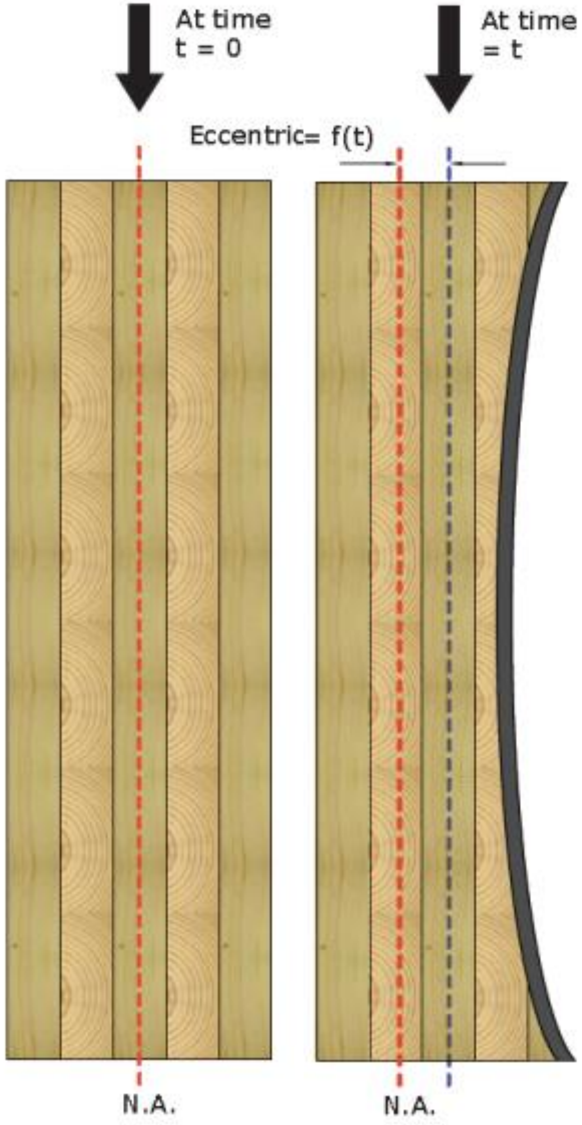
c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.

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).

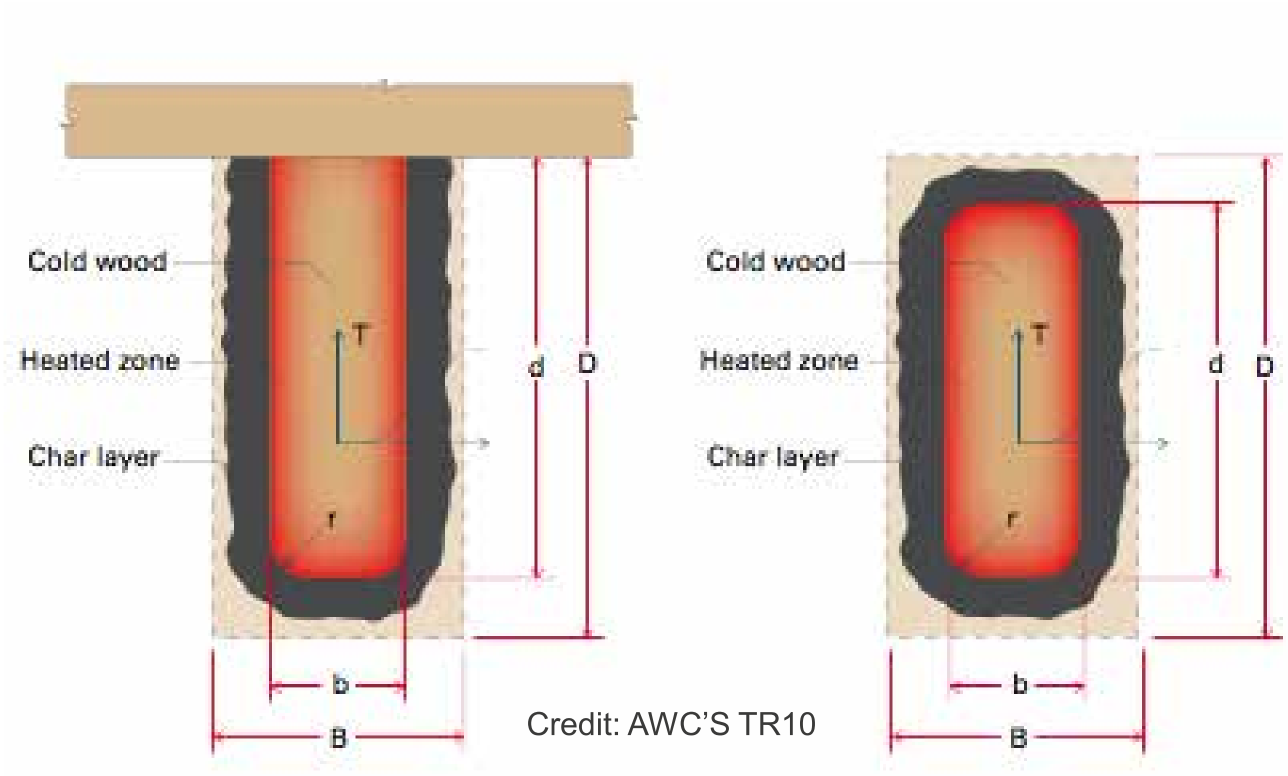
f. Not less than the fire-resistance rating as referenced in Section 704.10.

Credit: IBC Table 601



Credit: CLT Handbook

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



Credit: AWC'S TR10

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: AWC’S NDS

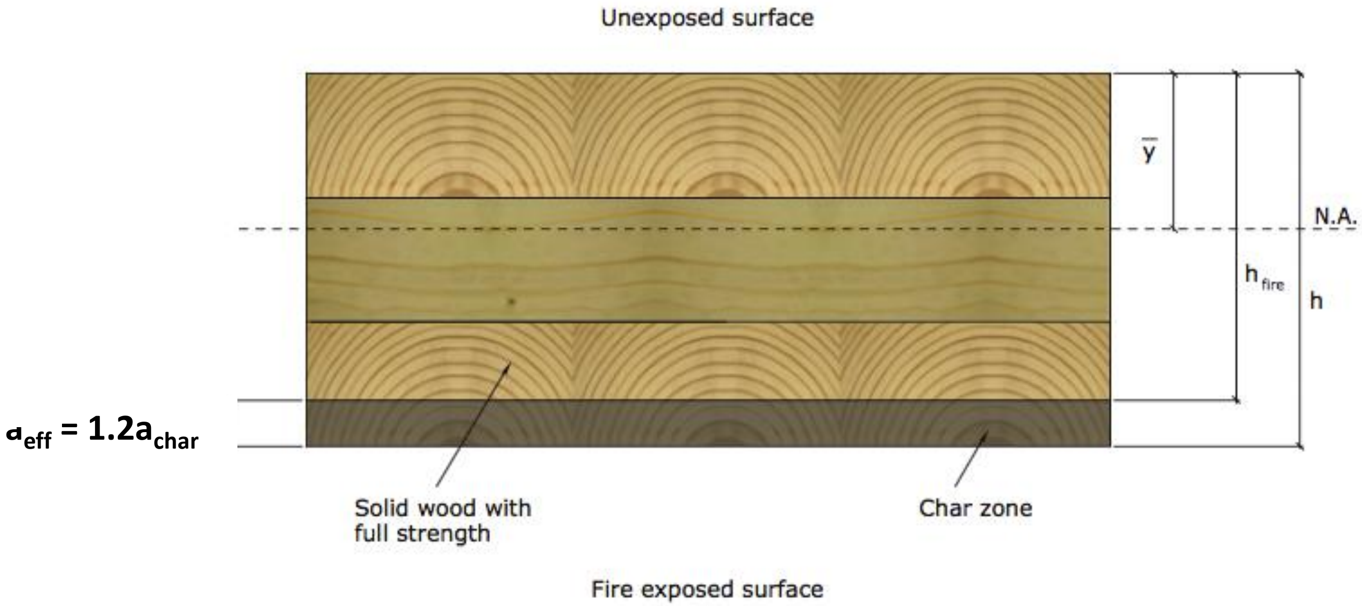
Table 16.2.1A Char Depth and Effective Char Depth (for β_n = 1.5 in./hr.)

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

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



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Fire-Resistive Design of Mass Timber Members

Code Applications, Construction Types and Fire Ratings

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.

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

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

Mass Timber Fire Design Resource

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

WOODWORKS INVENTORY OF FIRE TESTED MT ASSEMBLIES

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

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

Free download at woodworks.org

MASS TIMBER ACOUSTICS DESIGN

BY ITSELF, NOT ADEQUATE FOR ACOUSTICS

Common mass timber floor assembly:

- Finish floor (if applicable)
- Underlayment (if finish floor)
- 1.5” to 4” thick concrete/gypcrete topping
- Acoustical mat
- WSP (if applicable)
- Mass timber floor 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

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.


FIGURE 3:

Example Mass Timber Wall Assembly, STC 58

Mass Timber Assembly Options: Walls

Acoustical Differences between Mass Timber Panel Options

Improving Performance by Minimizing Flanking

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

WoodWorks Inventory of Acoustically Tested MT Assemblies

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

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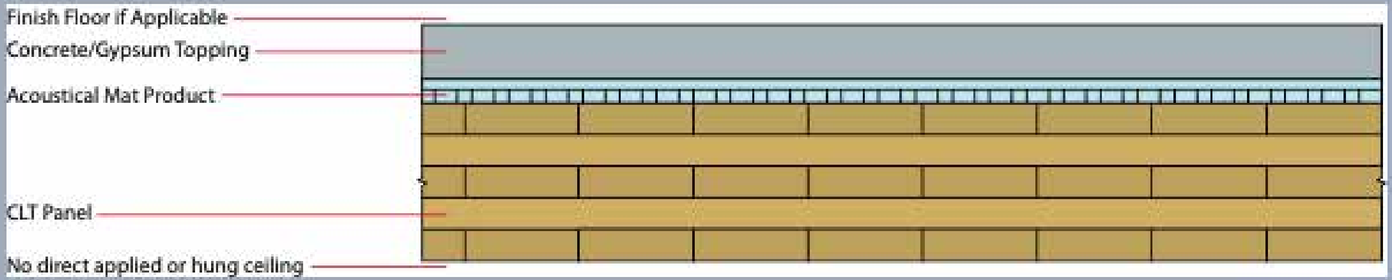
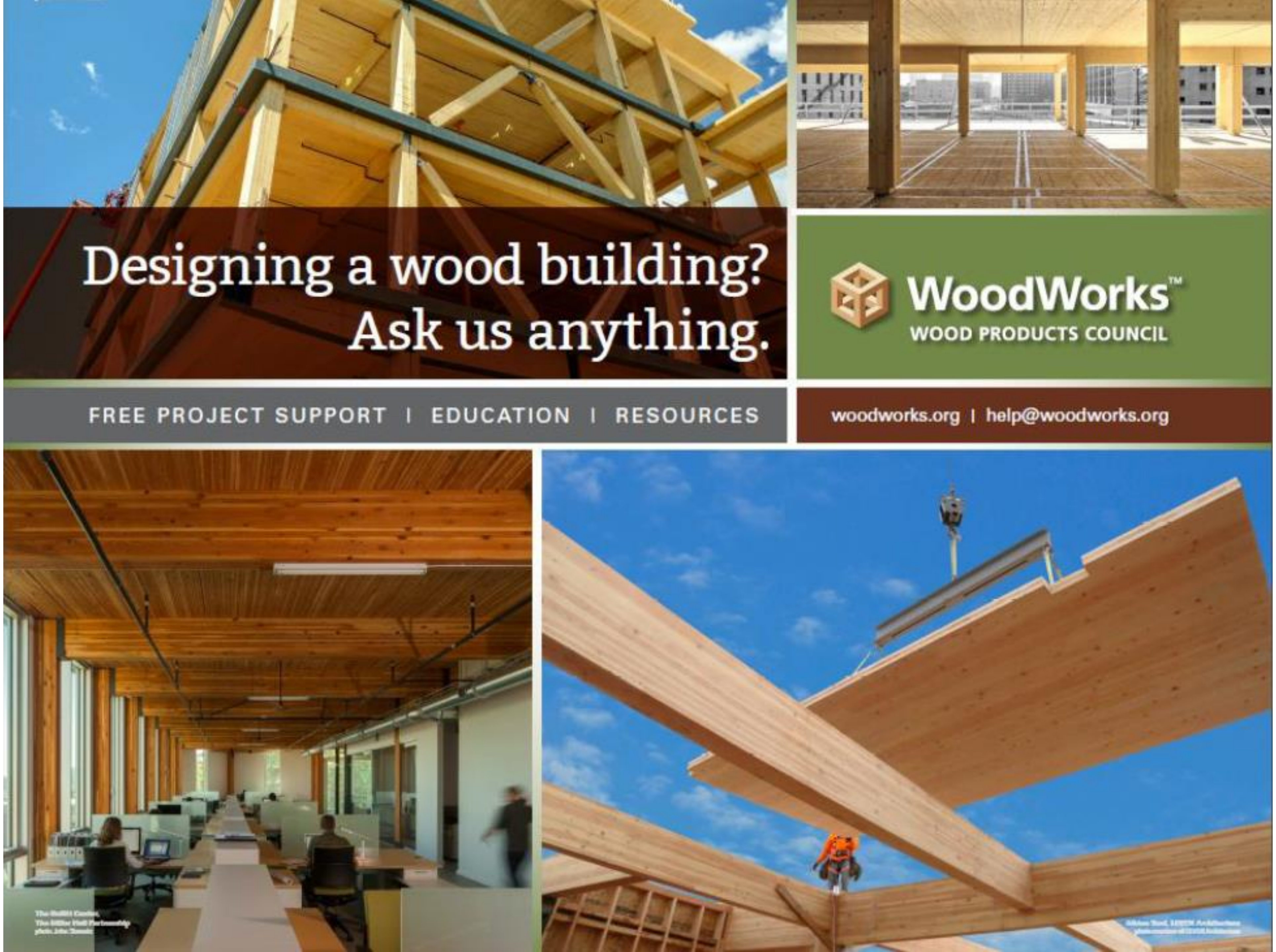


CLT Panel	Concrete/Gypsum Topping	Acoustical Mat Product Between CLT and Topping	Finish Floor	STC[1]	IIC[1]	Source
CLT 5-ply (6.875")	1-1/2" Gyp-Crete®	Maxxon Acousti-Mat® 3/4	None	47[2] ASTC	47[2] AIIC	1
			LVT	-	49[2] AIIC	
			Carpet + Pad	-	75[2] AIIC	
			LVT on Acousti-Top®	-	52[2] AIIC	
			Eng Wood on Acousti-Top®	-	51[2] AIIC	
			None	49[2] ASTC	45[2] AIIC	
		USG SAM N25 Ultra	LVT	48[6]	47[6]	16
			LVT Plus	48[6]	49[6]	58
			Eng Wood	47[6]	47[6]	59
	1-1/2" Levelrock® Brand 2500		LVT	48[6]	44[6]	16
			LVT Plus	48[6]	47[6]	58

More than 400 Tested Assemblies

Free download at woodworks.org



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WoodWorks can help connect you with:

Manufacturers

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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