

Mass Timber Bootcamp: Becoming a Mass Timber Design Expert

Brought to you by



Visit us at Booth 440

Regional Directors: **One-on-One Project Support**





Visit us at Solutions Team Booth 440



Everything WoodWorks at the Mass Timber Conference

Live from the Exhibit Floor at WoodWorks booth A1

- Tonight @ 5pm | 2023 Wood Design Award Presentation
- Tonight @ 6pm | Celebrating Women in Wood Design
- Tuesday (throughout the day) | Mass Timber Construction Demo
- Wednesday (morning break and lunch) | Manufacturing & Industry Partner Presentations

Meet our Team: Booth #440

Visit us, learn more about our program and browse our resources.

Funding provided in part by the Softwood Lumber Board



Events



Award Gallery W

Why Wood? About

Duilden Gretere	Duilding Treas	
Light-Frame Mass Timber / CLT Off-Site / Panelized Construction Hybrid	Building Types Multi-Family / Mixed Use Education Office Commercial Low-Rise	On Demand Education Find over 140 continuing education courses on wood topics for architects, engineers, general contractors, and code officials. WoodWorks Innovation Network Discover mass timber projects across the US and
i i jona	Industrial	connect with their teams.
	Institutional / Healthcare	

Our experts can help—ask us anything. Get Free Project Support 🕣

WoodWorks is your go-to resource for commercial and multi-family wood building design, engineering, and construction. We're here to support you with free one-on-



woodworksinnovationnetwork.org





Who are you looking for?





Funding Partners









Sustaining Partners –



Continuing Education Credit

» Participants will receive a certificate of completion via email within two weeks.



» AIA credits will be processed by WoodWorks "The Wood Products Council" is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES), Provider #G516.

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request. This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

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



Course Description

As mass timber transitions from novelty to mainstream, more architects and engineers are finding they need a full systems understanding of the unique design considerations associated with this type of structure. Intended for those new to mass timber design, or those looking to refresh their design knowledge, this pre-conference workshop will take a step-by-step approach to the practical design and engineering aspects of mass timber buildings. Breakout sessions at the 2023 International Mass Timber Conference will examine specific design and construction topics in depth, and this pre-conference seminar will equip attendees with the baseline experience needed both to expand their knowledge in the main track sessions and start their own mass timber designs. Topics will include mass timber products, code compliance, fire resistance, new tall mass timber construction types, structural design and layout, connection detailing, acoustics, MEP integration, and more. Project examples will be included throughout to highlight and emphasize design solutions implemented on real structures.

Learning Objectives

- 1. Identify construction types within the International Building Code where a mass timber structure is permitted.
- 2. Discuss the impacts of construction type on required fire-resistance ratings of structural elements, noting the impacts these ratings have on member spans and grids.
- 3. Demonstrate structural design steps for members and connections in common mass timber framing systems.
- 4. Highlight effective methods of integrating MEP services in a mass timber building and discuss their relative impacts on cost, aesthetics, occupant comfort, and future tenant renovations.

Agenda



Mass Timber Boot Camp: Becoming a Mass Timber Design Expert

12:00 – 1:00 pm	Mass Timber Primer: Products, Codes Applications, Fire-Resistance Design, Chelsea Drenick, SE; Jeff Peters, PE, CGC, WoodWorks
1:00 – 1:15 pm	Break
1:15 – 2:15 pm	Structural Design: Member Sizing, Optimized Grids, Connections and Lateral Load Resistance, Anthony Harvey, PE; Mike Romanowski, SE, WoodWorks
2:15 – 2:30 pm	Q&A
2:30 – 2:45 pm	Break
2:45 – 3:45 pm	Acoustics, Floor Vibration, MEP Integration, Enclosure and Moisture Protection, Jessica Scarlett, EIT; Mark Bartlett, PE; Jason Bahr, PE, WoodWorks
3:45 – 4:00 pm	Q&A

Mass Timber Primer: Products, Codes Applications, Fire-Resistance Design

March 27, 2023

Presented by Chelsea Drenick and Jeff Peters

Adidas East Village Expansion / LEVER Architecture / photo Jeremy Bittermann

WOODWORKS

WPC

AJ (>) mining

OVERVIEW | TERMINOLOGY







Light-Frame Wood Photo: WoodWorks

Heavy Timber Photo: Benjamin Benschneider

Mass Timber Photo: John Stamets

Mass Timber Building Options



Flat Plate

Post and Beam

Honeycomb

Mass Timber Building Options



Hybrid: Light-frame

Hybrid: Steel framing

What's in a mass timber building? Products used

Glue Laminated Timber (Glulam) Beams & columns Cross-Laminated Timber (CLT) Solid sawn laminations

Cross-Laminated Timber (CLT) SCL laminations







Photo: Freres Lumber







Dowel-Laminated Timber (DLT)



Photo: StructureCraft

Nail-Laminated Timber (NLT)



Glue-Laminated Timber (GLT) Plank orientation



Photo: Think Wood

Photo: StructureCraft



GLULAM

GLULAM SPECS:

TYPICAL WIDTHS:

3-1/8", 3-1/2", 5-1/8", 5-1/2", 6-3/4", 8-3/4", 10-3/4", 12-1/4"

TYPICAL DEPTHS:

INCREMENTS PER # OF LAMS FROM 6" TO 60"± Western Species Lams are typically 1-1/2" Thick Southern Pine Lams are typically 1-3/8" Thick

TYPICAL SPECIES: DOUGLAS-FIR, SOUTHERN PINE, SPRUCE ALSO AVAILABLE IN CEDAR & OTHERS



IMAGE: APA GLULAM PRODUCT GUIDE

GLULAM

GLULAM LAYUP: VARY STRENGTH OF LAMINATIONS

- HIGHER STRENGTH LAMS AT TOP AND BOTTOM -Tension and compression stresses are high
- LOWER STRENGTH LAMS IN CENTER PLIES





IMAGE: APA

NAIL-LAMINATED TIMBER (NLT) PANELS



NLT shrinkage/expansion design



Nail-laminated timber (NLT) is mechanically laminated to create a solid timber panel. NLT is created by placing dimension lumber (nominal 2x, 3x, or 4x) on edge and fastening the individual laminations together with nails.

MASS TIMBER PRODUCTS NAIL-LAMINATED TIMBER (NLT) PANELS

When does the code allow it to be used? IBC defines NLT as mechanically laminated decking per IBC 2304.9.3

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



MASS TIMBER PRODUCTS NAIL-LAMINATED TIMBER (NLT) PANELS

NLT PANELS CAN BE BUILT ON-SITE/IN-PLACE OR PRE-FABRICATED OFFSITE





DOWEL-LAMINATED TIMBER (DLT)

PHOTO CREDIT: STRUCTURECRAFT BUILDERS

Dowel-Laminated Timber (DLT)





Photo credit: StructureCraft Builders



111 EAST GRAND Des moines, IA

4 STORY, 66,800 SF SPEC OFFICE BUILDING DLT PANELS, GLULAM FRAME

CREDIT: NUEMANN MONSON ARCHITECTS Courtesy: Ryan companies

MASS TIMBER PRODUCTS GLUE-LAMINATED TIMBER (GLT) PANELS

PHOTO CREDIT: STRUCTURE FUSION

3 Distant 0



GLUE-LAMINATED TIMBER (GLT) PANELS

GLULAM DECKING:

- SIMILAR TO DEEP GLULAM BEAMS LAID ON THEIR SIDE
- SAME CODE REFERENCES AND MANUFACTURING STANDARDS AS GLULAM BEAMS AND COLUMNS
- BE CAREFUL OF DESIGN STRESSES AND LAYUPS USED SPEC Uniform Layup (All Lams Same Species & Grade)



IMAGE SOURCE: STRUCTURECRAFT BUILDERS



TONGUE AND GROOVE DECKING



TONGUE AND GROOVE DECKING:

2X, 3X OR 4X SOLID OR LAMINATED WOOD DECKING Laid flat with interlocking tongue and groove On Narrow (Side) face

- RECOGNIZED IN IBC 2304.8 (LUMBER DECKING)
- 2X USUALLY HAS A SINGLE T&G; 3X AND 4X USUALLY HAVE A DOUBLE T&G
- 6" AND 8" ARE COMMON WIDTHS
- CAN BE USED FOR FLOOR, ROOF DECKING

ICE BLOCK I

west elm

west elm

SACRAMENTO, CA

ICE BLOCK I, RMW ARCHITECTURE & INTERIORS, BUEHLER Engineering, Bernard André Photography

Mass Timber Business Case Studies

Real financial information on real deals

- Prepared by WoodWorks and Conrad Investment Management
- Include qualitative influences + quantitative data to examine investment success

PROPERTY SUB-TYPES:

For-Rent Institutional Housing • Institutional Offices • Industrial Buildings • Redevelopment/Additions • Purpose-Built Owner/Occupied (Student Housing)





« Scan the code to download the current package.

CROSS-LAMINATED TIMBER WITH SCL LAMINATIONS







OJECT ONE

AND, CA

120

ALAN

Fis
MASS TIMBER PRODUCTS CROSS-LAMINATED TIMBER (CLT)

WHAT IS CLT? Solid wood panel 3 layers min. Of solid sawn lams 90 deg. cross-lams Similar to plywood sheathing

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)



Common CLT Layups



MASS TIMBER PRODUCTS CROSS-LAMINATED TIMBER (CLT)

PHOTO CREDIT: DR JOHNSON

DANGER

Contraction (

MASS TIMBER PRODUCTS

CLT PANEL FABRICATION

CROSS-LAMINATED TIMBER (CLT)





MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)

CLT PREFABRICATION

- FINISHED PANELS ARE PLANED, SANDED, CUT TO SIZE. THEN OPENINGS ARE CUT WITH PRECISE CNC ROUTERS.
- THIRD PARTY INSPECTION AT FACTORY
- CUSTOM ENGINEERED FOR MATERIAL EFFICIENCY
- CUSTOM DESIGNED FOR PROJECT
- EACH PANEL NUMBERED, DELIVERED & INSTALLED IN PREDETERMINED SEQUENCE

ALBINA YARD



4 STORIES 16,000 SF Green Roof



PROJECT TEAM: SOM WESTERN WOOD STRUCTURES TRUEBECK

COUNTY OFFICE BLDG #3

REDWOOD CITY, CA

5-STORY, 208,000 SF NET ZERO San Mateo County office Building



CANYONS, PORTLAND, OR



Credit: Jeremy Bittermann & Kaiser + Path

MASS TIMBER PRODUCTS CROSS-LAMINATED TIMBER (CLT)

IN 2018 IBC, CLT IS NOW DEFINED IN CHAPTER 2 DEFINITIONS:

[BS] CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than three layers of solid-sawn lumber or *structural composite lumber* where the adjacent layers are cross oriented and bonded with structural adhesive to form a solid wood element.

AND IS REFERENCED IN CHAPTER 23:

2303.1.4 Structural glued cross-laminated timber. Crosslaminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.



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 mass timber to be used?

• <u>Type IB & II</u>: Roof Decking



Portland International Jetport

- LEED Gold
- Completed 2012

Construction Type IB Exposed Timber Roof Decking and Framing

Low and Mid-Rise Construction Types

All wood framed building options:

Type V

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

Type III

Exterior walls non-combustible (may be FRTW) Interior elements any allowed by code, including mass timber

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

Type IV (Heavy Timber)

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

Construction Type – Primarily based on building size & occupancy

	Construction Type (All Sprinklered Values)											
	IV-A	IV-B	IV-C	IV-HT	III-A	III-B	V-A	V-B				
Occupancies	Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)											
A, B, R	270	180	85	85	85	85	70	60				
	Allowable Number of Stories above Grade Plane (IBC Table 505.4)											
A-2, A-3, A-4	18	12	6	4	4	3	3	2				
В	18	12	9	6	6	4	4	3				
R-2	18	12	8	5	5	5	4	3				
	Allowable Area Factor (At) for SM, Feet ² (IBC Table 506.2)											
A-2, A-3, A-4	135,000	90,000	56,250	45,000	42,000	28,500	34,500	18,000				
В	324,000	216,000	135,000	108,000	85,500	57,000	54,000	27,000				
R-2	184,500	123,000	76,875	61,500	72,000	48,000	36,000	21,000				

Construction Types



Allowable mass timber building size for group B & R occupancy with NFPA 13 Sprinkler

Type III: 6-stories (B) 5-stories (R)

Credit: Christian Columbres Photog

Type V: 4-stories (B) 4-stories (R)

Type IV-HT: 6-stories (B) | 5-stories (R)

Credit: Ema Peter

MARKET DRIVERS FOR MASS TIMBER

PRIMARY DRIVERS

- » Construction Efficiency & Speed
- » Construction site constraints Urban Infill
- » Innovation/Aesthetic

SECONDARY DRIVERS

- » Carbon Reductions
- » Structural Performance lightweight

What Portion of the Construction Market is "Tall"?



In What Height Range are Most "Tall" Projects Happening?



Interest in tall wood projects in the US was rapidly increasing. Some building officials were reluctant to approved proposed plans, primarily due to lack of code direction and precedent



UBC Brock Commons Student Residence, Vancouver, British Columbia, 2016

U.S. TALL WOOD DEVELOPMENT AND CHANGES



In December 2015, the ICC Board established the ICC Ad Hoc Committee on Tall Wood Buildings. Objectives:

- 1. Explore the building science of tall wood buildings
- 2. Investigate the feasibility, and
- 3. Take action on developing code changes for tall wood buildings.

U.S. BUILDING CODES DEVELOPMENT AND CHANGES



Timeline:

Submission of code changes for the 2018 Group A Cycle (IBC) in January 2018 – changes for 2021 IBC

U.S. BUILDING CODES DEVELOPMENT AND CHANGES



5 Working Groups Created

- July 2016 November 2017: 5 in-person meetings, numerous conference calls
- 82 issues addressed, one primary topic was <u>fire performance and life safety</u>

Taller wood buildings create new set of challenges to address:

AHC established 6 performance objectives:

- 1. No collapse under reasonable scenarios of complete burn-out of fuel without automatic sprinkler protection being considered.
- 2. Highly reliable fire suppression systems to reduce the risk of failure during reasonably expected fire scenarios. The degree of reliability should be proportional to evacuation time (height) and the risk of collapse.





AHC established 6 performance objectives:

- 3. No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios.
- 4. No unusual response from typical radiation exposure from adjacent properties to present a risk of ignition of the subject building under reasonably severe fire scenarios.





AHC established 6 performance objectives:

- 5. No unusual fire department access issues
- 6. Egress systems designed to protect building occupants during the design escape time, plus a factor of safety.







U.S. BUILDING CODES Tall Wood Ad Hoc Committee

Commissioned series of 5 full-scale tests on 2-story mass timber structure at ATF lab in MD, May-June 2017



Figure 2. Elevation view of the front of the cross-laminated timber test structure.



Figure 1. General plan view of cross-laminated timber test structure.











TALL WOOD APPROVED!

Unofficial results posted Dec 19, 2018 Final votes ratified Jan 31, 2019

AWC: Tall Mass Timber code changes get final approval

Dec 19, 2018

LEESBURG, VA. – The International Code Council (ICC) has released the unofficial voting results on code change proposals considered in 2018, including passage of the entire package of 14 tall mass timber code change proposals. The proposals create three new types of construction (Types IV-A, IV-B and IV-C), which set fire safety requirements, and allowable heights, areas and number of stories for tall mass timber buildings. Official results are expected to be announced during the first quarter of 2019. The new provisions will be included in the 2021 *International Building Code* (IBC).

"Mass timber has been capturing the imagination of architects and developers, and the ICC result means they can now turn sketches into reality. ICC's rigorous study, testing and voting process now U.S. BUILDING CODES Tall Wood Ad Hoc Committee

2021 IBC Introduces 3 new tall wood construction types:

IV-A, IV-B, IV-C

Previous type IV renamed type IV-HT

BUILDING	TYPE I		TYPE II		TYPE	Ш	TYPE	IV	TYPE V			
ELEMENT	Α	В	Α	В	Α	В	Α	В	С	HT	Α	В





RASSES

Original CLT depth

Credit: David Barber, ARUP

Key Early Design Decisions

Fire-Resistance Ratings

- Driven primarily by construction type
- Rating achieved:
 - Timber alone or non-combustible protection required?

BUILDING ELEMENT		TYPEI		TYPE II		TYPE III		TYPE IV				TYPE V	
		В	Α	В	Α	В	Α	В	С	HT	Α	В	
Primary structural frame ^f (see Section 202)	3ª, b	2 ^{a, b, c}	1 ^{6, c}	0°	1 ^{b, c}	0	3ª	2ª	2ª	HT	1 ^{b, c}	0	
Bearing walls													
Exterior ^{•, f}	3	2	1	0	2	2	3	2	2	2	1	0	
Interior	3ª	2ª	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	1	0	1	0	2	2	2	HT	1	0	
Roof construction and associated secondary structural members (see Section 202)		1 ^{b,c}	1 ^{b,c}	0 °	1 ^{b,c}	0	1 ¹ / ₂	1	1	HT	1 ^{b,c}	0	

TABLE 601 FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)
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 2hour FRR
- Construction Type | FRR | Member Size | Grid (or re-arrange that process but follow how one impacts the others)

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



Key Early Design Decisions

Construction type influences FRR

- Type IV-HT Construction
 - (minimum sizes: Section 2304.11)
- Other than type IV-HT: Demonstrated fire resistance

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





Key Early Design Decisions

Which Method of Demonstrating FRR of MT is Being Used?

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





Unexposed surface

Fire exposed surface

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



Code Path for Exposed Wood Fire-Resistance Calculations

IBC 703.3

Methods for determining fire resistance

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



IBC 722 Calculated Fire Resistance

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



NDS Chapter 16 Fire Design of Wood Members

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



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	Effective Char Depths, a _{char} (in.) lamination thicknesses, h _{lam} (in.)									
(hr.)	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	
1 ¹ / ₂ -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	

WoodWorks Inventory of Fire Tested MT Assemblies



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

CLT Panel	Manu factu rer	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 1.5 E 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-plyCLT (105mm 4.133 in)	Structurlam	SPF #1/#2 x SPF #1/#2	1 layer 5/8" Type Xgyp sum	Half-Lap	None	Reduced 75% Moment Capacity	1	1 (Test 5)	NRC Fire Laboratory
5-ply CLT (175mm6.875*)	Nordic	El	None	Topside Spline	2 staggered layers of 1/2* cement boards	Lo aded, See Manufacturer	2	2	NRC Fire Laboratory March 2016
5-ply CLT (175mm6.875*)	Nordic	El	1 layer of 5/8" Type X gyp sum under Z- channels and furring strips with 3 5/8" fibernlass batts	Topside Spline	2 stagg ered layers of 1/2* cement boards	Loaded, See Manufacturer	2	5	NRC Fire Laboratory Nov 2014
5-ply CLT (175mm6.875*)	Nordic	EL	None	Topside Spline	3/4 in. proprietary gyperete over Maxxon acoustical mat	Reduced 50% Moment Capacity	1.5	3	UL
5-ply CLT (175mm6.875*)	Nordic	В	1 layer 5/8" normal gypsum	Topside Spline	3/4 in. proprietary gypenete over Maxx on acoustical mat or proprietary sound board	Reduced 50% Moment Capacity	2	4	UL
5-ply CLT (175mm6.875*)	Nordic	El	1 Is yer 5.8° Type X Gyp under Resilient Channel under 7 78° 1-Joints with 3 1/2° Mineral Wool beween Joints	Half-Lap	None	Loaded, See Manufacturer	2	21	Intertek 8/24/2012
5-ply CLT (175mm6.875*)	Structurlam	E1 M5 MSR 2100 x SPF#2	None	Topside Spline	1-1/2* Maxx on Cyp-Gret e 2 000 ov er Maxx on Reinforcing Mesh	Loaded, See Manufacturer	2.5	6	Intertek, 2/22/2016
5-ply CLT (175mm6.875*)	DR Johnson	· VI	None	Half-Lap & Topside Spline	2° gypsumtopping	Loaded, See Manufacturer	2	7	SwRI (May 2016)
5-ply CLT (175mm6.875*)	Nordic	SPF 1950 Fb MSR x SPF #3	None	Half-Lap	None	Reduced 5.9% Moment Capacity	1.5	1 (Test 3)	NRC Fire Laboratory
5-ply CLT (175mm6.875*)	Structurlam	SPF #1/#2 x SPF #1/#2	1 layer 5/8" Type Xgypsam	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 (175mm6.875*)	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 (175mm6.875*)	SmartLam	VI	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 (175mm6.875*)	DRJohnson	VI	None	Half-Lap	nominal 1/2* plywood with 8d nails.	Lo aded, See Manufacturer	2	12 (Test 6)	Western Fire Center 11/01/2016
5-ply CLT	KLH	CV3M1	None	Half-Lap &	None	Loaded, See Menufactures	1	18	SwRI



Fire-Resistive Design of Mass Timber Members

Code Applications, Construction Types and Fire Ratings

Richard McLain, PE, SE • Senior Technical Director • WoodWorks Scott Bieneman, 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 sold wood panel products such as cross-laminated timber (CLT) and naillaminated 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 lowcarbon 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

the m wood define and B framit both a timbe **Definition Definition Definition**

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 fireresistance 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

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
- Free download at woodworks.org

Beam penetrations:

- If FRR = 0-hr, analyze structural impact of hole diameter only
- If FRR > 0-hr, account for charred hole diameter or firestop penetration



Option 1: MT penetration firestopping via tested products



Inventory of Fire Tested Penetrations in MT Assemblies



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

CLT Panel	Exposed Side Protection	Pen etrating Item	Penetrant Centered or Offset in Hole	Firestopping System Description	F Rating	T Rating	Stated Test Protocal	Source	Testing Lab
3-ply (78mm3.07*)	None	1.5° diameter data cable bunch	Centered	3.5 in diameter hole. Mineral wool was installed in the 1in. annular space around the data cables to a total depth of approximately 2 - 5/64 in. The remaining 1in. annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	0.5 hour	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm 3.07*)	None	2 * copper pipe	Centered	4.375 in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 2 - 5/64 in. The remaining 1 in. annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	1 hour	N.A.	CANULC S115	26	In tertek March 30, 2016
3-ply (78mm 3.07*)	None	2.5" sched.40 pipe	Centered	4.92 in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 2 - 5/64in. The remaining 1in.annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	l hour	N.A.	CANULC SI15	26	In tert ek March 30, 2016
3-ply (78mm3.07*)	None	6" cast iron pipe	Centered	8.35 in diameter hole. Mineral wool was installed in the lin. annular space around the cast iron pipe to a total depth of approximately 2 – 5/64 in. The remaining lin. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilt i FS- On e Max caulking.	1 hour	N.A.	CANULC S115	26	Intertek March 30, 2016
3-ply (78mm3.07*)	None	Hilti 6 in drop in device. System No.: F-B-2049	Centered	9.01" diameter hole. Mineral wool was installed in the 1 – 1/4 in. annular space around the drop-in device to a total depth of approximately 1 – 7/64 in and the remaining 1 in. annular space from the top of the mineral wool to the top edge of the 9 – 1/64 in. hole in the CLT was filled with Hilti FS-One Max caulking.	1 hour	0.75 hour	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131 mm 5.16*)	None	1.5* diameter data cable bunch	Centered	3.5° diameter hole. Mineral wool was installed in the 1 in, annular space around the data cables to a total depth of approximately 4 – 5/32 in. The remaining 1 in, annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	1.5 hours	CANULC S115	26	In tert ek March 30, 2016
5-ply CLT (131mm 5.16*)	None	2* copper pipe	Centered	4.375 in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 4 - 5/32 in. The remaining 1 in. annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	N.A.	CANULC SI15	26	Intertek March 30, 2016
5-ply CLT (131 mm 5.16*)	None	2.5" sched.40 pipe	Centered	4.92 in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 4 – 5/32 in. The remaining lin. annul ar space starting at the top of the pipe wrap to the top of the floor assembly was filled with HiltiFS-One Max caulking.	2 hours	0.5 hour	CANULC S115	26	In tert ek March 30, 2016
5-ply CLT (131 mm 5.16*)	None	6* cast iron pipe	Centered	8.35 in diameter hole. Mineral wool was installed in the lin. annular space around the cast iron pipe to a total depth of approximately $4 - 5/32$ in. The remaining lin. annular space starting at the top of the pipe wrap to the top of the floor assembly was filled with Hilti FS-One Max caulking.	2 hours	NA.	CANULC S115	26	Intertek March 30, 2016
5-ply CLT (131 mm 5.16*)	None	Hilti 6 in drop in device. System No.: F-B-2049	Centered	9.01" diameter hole. Mineral wool was installed in the 1 – 1/4 in. annular space around the drop-in device to a total depth of approximately 1 – 7/64 in and the remaining 1 in. annular space from the top of the mineral wool to the top edge of the 9 – 1/64 in. hole in the CLT was filled with Hilti FS-One Max caulking.	2 hours	1.5 hours	CANULC S115	26	Intertek March 30, 2016
5-ply (175mm6.875*)	None	1* nominal PVC pipe	Centered	4.21 in diameter with a 3/4 in plywood reducer flush with the top of the slab reducing the opening to 2.28 in. Two wraps of Hilti CP 648-E W45/1-3/4" Firestop wrap strip at two locations with a 30 gauge steel sleeve which extended from the top of the slab to 1 in below the slab. The first location was with the bottom of the wrap strip flush with the bottom of the steel sleeve and the second was with the bottom of the wrap strip 3 in. from the bottom of the slab. The void between the steel sleeve and the CLT and between the steel sleeve and pipe at the top was filled with Roxul Safe mineral wool leaving a 3/4 in deep void at the top of the assembly. Hilti FS-One Max Intumescent Firestop Scalant was applied to a depth of 3/4 in on the top of the assembly between the plywood and steel sleeve as well as the steel sleeve and pipe.	2 hours	2 hours	ASTM E8 14	24	QAI Laboratories March 3, 2017
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1						1.000

Option 2: MT penetration firestopping of penetrations via engineering judgement details (contact firestop manufacturer)



- 3-PLY CROSS LAMINATED TIMBER FLOOR ASSEMBLY (MINIMUM 3" THICK) (1-HR. FIRE-RATING).
 HILTI CFS-DID FIRESTOP DROP-IN DEVICE INSERTED INTO OPENING (SEE TABLE BELOW) AND SECURED TO TOP SURFACE OF CROSS LAMINATED TIMBER FLOOR ASSEMBLY WITH THREE 1/4" x 1" LONG STEEL WOOD SCREWS WITH WASHERS.
- 3. MINIMUM 3" THICKNESS MINERAL WOOL (MIN. 4 PCF DENSITY) TIGHTLY PACKED, AND FLUSH WITH TOP AND BOTTOM SURFACE OF CFS-DID FIRESTOP DROP-IN DEVICE.
- 4. MINERAL WOOL (MIN. 4 PCF DENSITY) TIGHTLY PACKED, RECESSED TO ACCOMMODATE SEALANT, AND COMPLETELY FILLING SPACE BETWEEN CFS-DID FIRESTOP DROP-IN DEVICE AND PERIPHERY OF OPENING.
- 5. MINIMUM 1" DEPTH HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT BETWEEN CFS-DID FIRESTOP DROP IN DEVICE AND PERIPHERY OF OPENING.



- 1. MASS TIMBER WALL ASSEMBLY (MINIMUM 12" THICK) (1-HR. OR 2-HR. FIRE-RATING).
- 2. MAXIMUM 2" NOMINAL DIAMETER PVC PLASTIC PIPE (SCH 40).
- 3. MINIMUM 4" THICKNESS MINERAL WOOL (MIN. 4 PCF DENSITY) TIGHTLY PACKED AND RECESSED TO ACCOMMODATE SEALANT.
- 4. MINIMUM 3/4" DEPTH HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT.

Thank you!



Chelsea Drenick, SE Regional Director | CA-North, NV, UT

(303) 588-1300

chelsea.drenick@woodworks.org



Jeff Peters PE, CGC Regional Director | FL, AL, LA

(386) 871-8808

jeff.peters@woodworks.org

The Loading Dock / OZ Architecture / KL&A Engineers & Builders / photo Joe Anastasi

