



Design Tips for Mass Timber: Understanding the Products, Designing to Meet Code

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WoodWorks



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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



OVERVIEW | TIMBER METHODOLOGIES



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

OVERVIEW | MANUFACTURING & SUPPLY CHAIN

See Mass Timber Manufacturing videos at our [**2020 Partner Exhibit Hall**](#)



Photo: Ema Peter

STRUCTURAL SOLUTIONS | POST, BEAM + PLATE



Photo: Seagate Structures

STRUCTURAL SOLUTIONS | POST + PLATE



Photo: Lendlease

STRUCTURAL SOLUTIONS | HONEYCOMB



Photo: John Klein

STRUCTURAL SOLUTIONS | HYBRID LIGHT-FRAME + MASS TIMBER

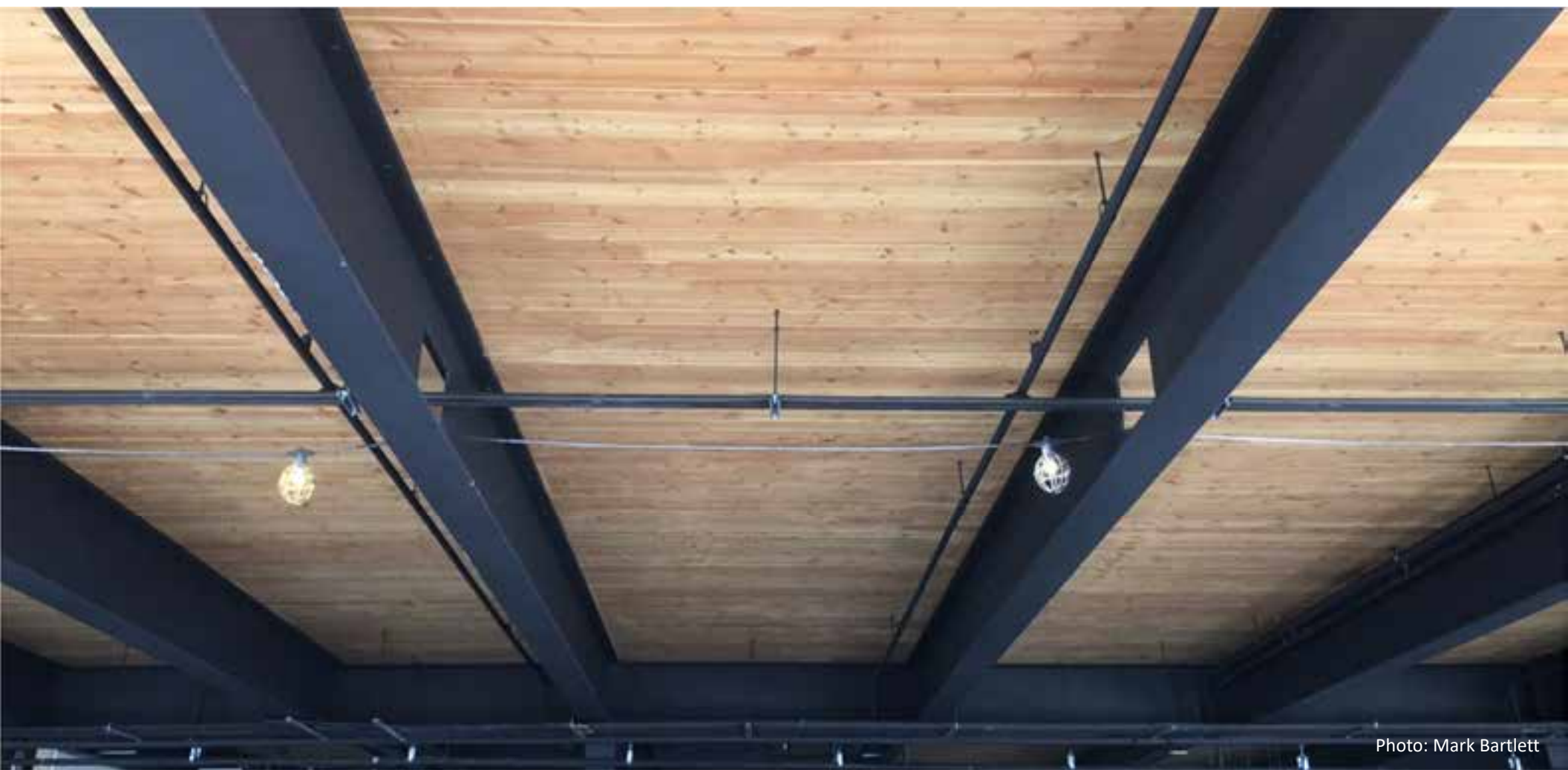


Photo: Mark Bartlett

STRUCTURAL SOLUTIONS | HYBRID STEEL + MASS TIMBER

OVERVIEW | CONNECTIONS



Concealed Connectors



Self Tapping Screws

Photos: Rothoblaas

OVERVIEW | CONNECTIONS



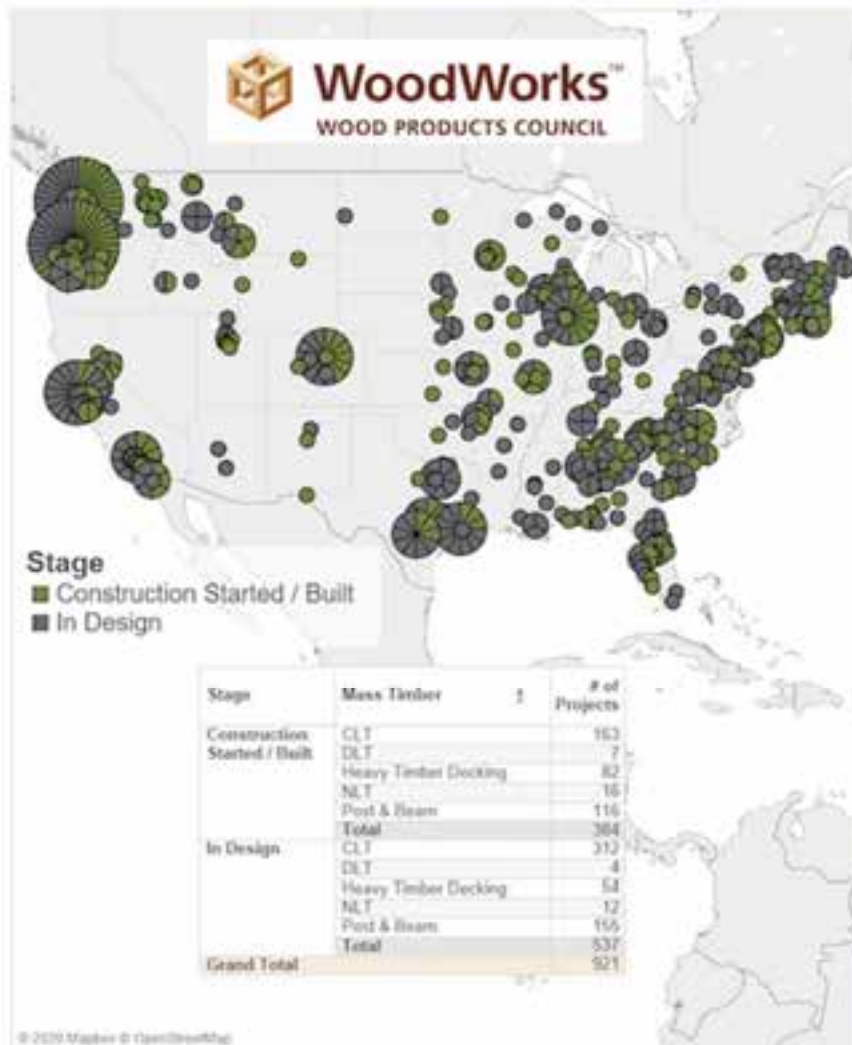
Beam to Column

Photo: StructureCraft



Photo: Structurlam

Mass Timber Projects In Design and Constructed in the US (June 2020)



State	Stage		State	Stage	
AK	In Design	1	MS	In Design	5
AL	Construction Started / Built	5	MT	Construction Started / Built	7
AR	In Design	10		In Design	8
AR	Construction Started / Built	5	NC	Construction Started / Built	18
AZ	In Design	7		In Design	26
CA	Construction Started / Built	49	ND	In Design	1
	In Design	68	NE	Construction Started / Built	3
CO	Construction Started / Built	15		In Design	3
	In Design	18	NH	Construction Started / Built	1
CT	Construction Started / Built	4		In Design	2
	In Design	3	NJ	Construction Started / Built	1
DC	Construction Started / Built	3		In Design	7
	In Design	5	NM	Construction Started / Built	1
DE	In Design	2		In Design	1
FL	Construction Started / Built	17	NV	In Design	1
	In Design	26	NY	Construction Started / Built	8
GA	Construction Started / Built	8		In Design	22
	In Design	17	OH	Construction Started / Built	4
HI	Construction Started / Built	1		In Design	8
	In Design	2	OK	Construction Started / Built	1
IA	Construction Started / Built	3		In Design	2
	In Design	4	OR	Construction Started / Built	40
ID	Construction Started / Built	4		In Design	20
	In Design	5	PA	Construction Started / Built	4
IL	Construction Started / Built	11		In Design	6
	In Design	12	RI	Construction Started / Built	2
IN	Construction Started / Built	3		In Design	2
	In Design	1	SC	Construction Started / Built	13
KS	Construction Started / Built	2		In Design	12
	In Design	3	TN	Construction Started / Built	3
KY	Construction Started / Built	2		In Design	4
	In Design	4	TX	Construction Started / Built	22
LA	In Design	4		In Design	44
MA	Construction Started / Built	21	UT	Construction Started / Built	5
	In Design	27		In Design	5
MD	Construction Started / Built	3	VA	Construction Started / Built	7
	In Design	8		In Design	9
ME	Construction Started / Built	2	VT	Construction Started / Built	1
	In Design	14		In Design	8
MI	Construction Started / Built	2	WA	Construction Started / Built	85
	In Design	8		In Design	48
MN	Construction Started / Built	8	WI	Construction Started / Built	17
	In Design	3		In Design	10
MO	Construction Started / Built	7	WV	Construction Started / Built	2
	In Design	8		In Design	2

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/>



PRECEDENT PROJECTS | UMASS AMHERST DESIGN BUILDING

Photo: ©Albert Vecerka/Esto



PRECEDENT PROJECTS | CARBON 12 | PORTLAND, OR

Photos: Baumberger Studio/PATH Architecture



PRECEDENT PROJECTS | T3 MINNEAPOLIS

Photo: Corey Gaffer courtesy Perkins + Will



Photos: StructureCraft

PRECEDENT PROJECTS | T3 ATLANTA



Photo: Hartshorne Plunkard Architecture



Photos: Michael Elkan | Naturally Wood | UBC

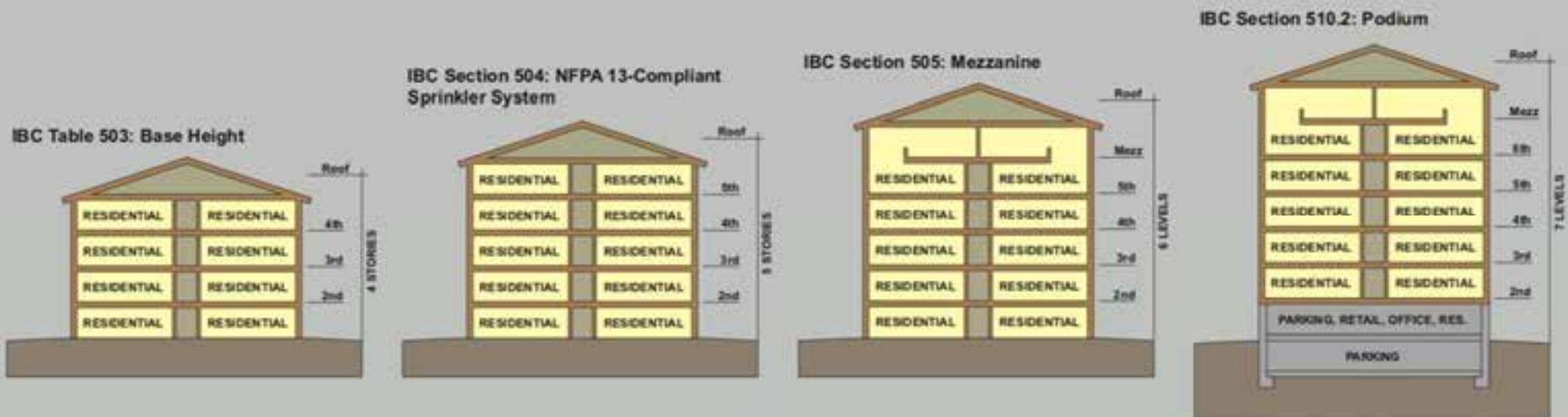
PRECEDENT PROJECTS | BROCK COMMONS

MASS TIMBER IN THE CODE



BUILDING CODE APPLICATIONS | CONSTRUCTION TYPE

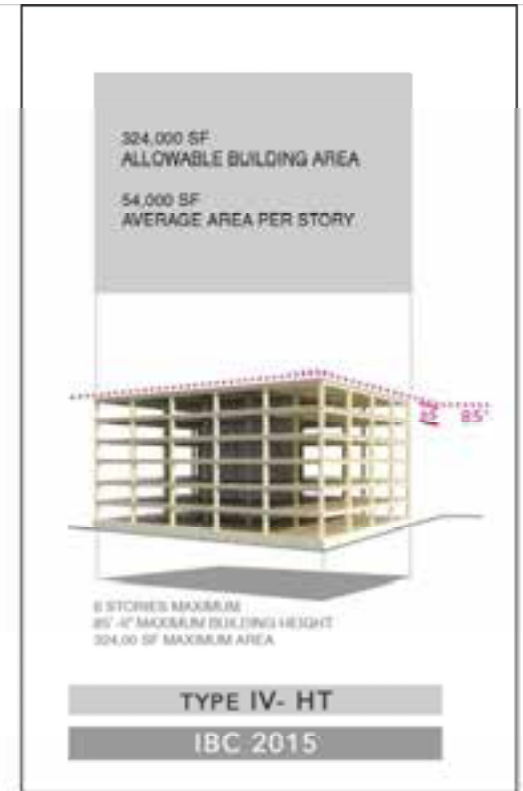
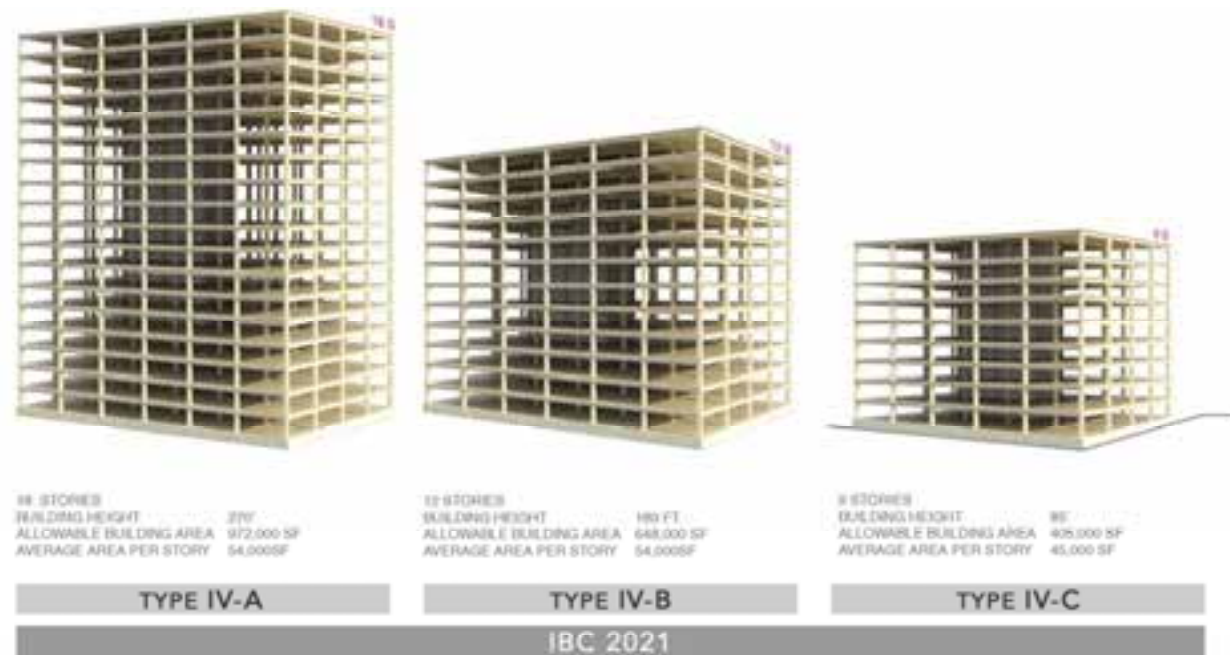
Mass Timber in Low- to Mid-Rise: 1-6 Stories in Construction Types III, IV or V



Credit: WoodWorks

BUILDING CODE APPLICATIONS | CONSTRUCTION TYPE

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




BUSINESS OCCUPANCY [GROUP B]

*BUILDING FLOOR-TO-FLOOR HEIGHTS ARE SHOWN AT 12'-0" FOR ALL EXAMPLES FOR CLARITY IN COMPARISON BETWEEN 2015 TO 2021 IBC CODES.

Credit: Susan Jones, atelierjones

WoodWorks Tall Wood Design Resource

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



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

Scott Brannen, PhD, SE, WoodWorks + Wood Products Council • Matt Timmers, SE, John A. Martin & Associates
• Dennis Richardson, PE, CBO, CAGS, 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 (SEAO) 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 (Brannen 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
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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 ^d (see Section 202)	3 ^a	2 ^a	1	0	1	0	HT	1	0
Bearing walls									
Exterior ^{a,f}	3	2	1	0	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions	See Table 602								
Exterior									
Nonbearing walls and partitions							See Section 602.4.6		
Interior ^d	0	0	0	0	0	0		0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1 1/2 ^b	1 ^{b,c}	1 ^{b,c}	0 ^c	1 ^{b,c}	0	HT	1 ^{b,c}	0

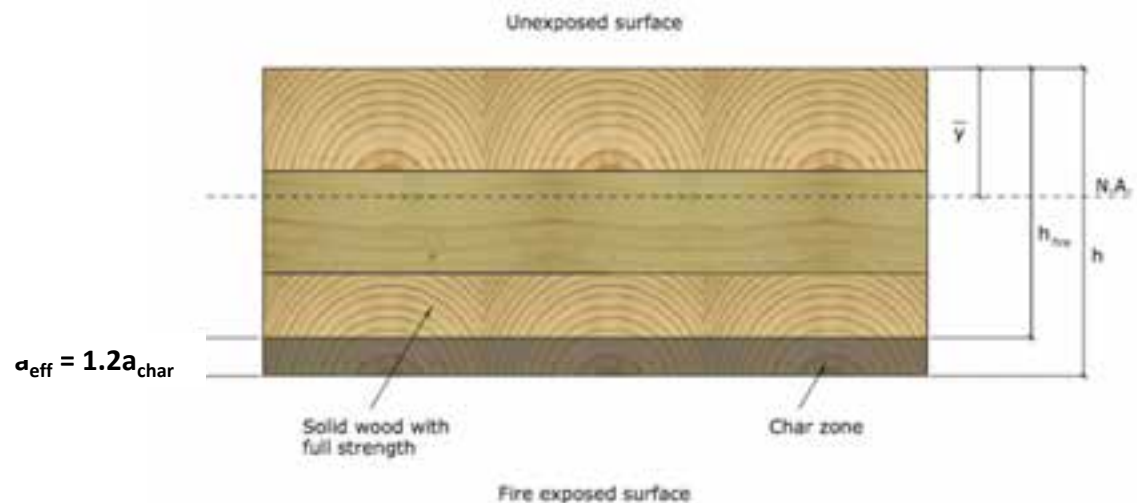
For SI: 1 foot = 304.8 mm.

- 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.
- 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.
- In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.
- Not less than the fire-resistance rating required by other sections of this code.
- Not less than the fire-resistance rating based on fire separation distance (see Table 602).
- Not less than the fire-resistance rating as referenced in Section 704.10.

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



**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



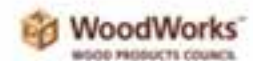
Credit: David Barber, ARUP

Table 16.2.1A Char Depth and Effective Char Depth (for $\beta_n = 1.5$ 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

WOODWORKS INVENTORY OF FIRE TESTED MT ASSEMBLIES

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



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 (110mm x 883 in)	Nordic	SPF 1430 Fb L5EMSR x SPF #1	2 layers 1/2" Type X gypsum	Half Lap	None	Refused 14% Moment Capacity	1	1 (Test 1)	NRC Fire Laboratory
3-ply CLT (103mm x 133 in)	Simonsdram	SPF #1 #2 x SPF #1 #2	1 layer of 5/8" Type X gypsum	Half Lap	None	Refused 73% Moment Capacity	1	1 (Test 1)	NRC Fire Laboratory
3-ply CLT (173mm x 872")	Nordic	E1	None	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	2	NRC Fire Laboratory March 2014
3-ply CLT (173mm x 872")	Nordic	E1	3 layers of 1/2" Type X gypsum under 2 channels and facing strips with 3 1/8" channels between	Topside Spline	2 staggered layers of 1/2" cement boards	Loaded, See Manufacturer	2	3	NRC Fire Laboratory Nov 2014
3-ply CLT (173mm x 872")	Nordic	E1	None	Topside Spline	3/4 in proprietary gypsum over Maxon acoustical mat	Refused 50% Moment Capacity	1.5	3	UL
3-ply CLT (173mm x 872")	Nordic	E1	1 layer of 5/8" cement gypsum	Topside Spline	3/4 in proprietary gypsum over Maxon acoustical mat or proprietary sound board	Refused 50% Moment Capacity	2	4	UL
3-ply CLT (173mm x 872")	Nordic	E1	1 layer 3/8" Type X Gyp under Redline (Chanel) under 7/8" 1.0mm with 1/2" Mineral Wool between joints	Half Lap	None	Loaded, See Manufacturer	2	21	Intertek 8/24/2012
3-ply CLT (173mm x 872")	Simonsdram	E1 M1 MSR 2100 x SPF #2	None	Topside Spline	1 1/2" Maxon Cyp-Glue 2000 or or Maxon Reinforcing Mesh	Loaded, See Manufacturer	2.5	6	Intertek, 2/22/2014
3-ply CLT (173mm x 872")	DR Johnson	V1	None	Half Lap & Topside Spline	2" gypsum topping	Loaded, See Manufacturer	2	7	SwRI (May 2014)
3-ply CLT (173mm x 872")	Nordic	SPF 1430 Fb MSR x SPF #1	None	Half Lap	None	Refused 50% Moment Capacity	1.5	1 (Test 3)	NRC Fire Laboratory
3-ply CLT (173mm x 872")	Simonsdram	SPF #1 #2 x SPF #1 #2	1 layer of 5/8" Type X gypsum	Half Lap	None	Unloaded 140% Moment Capacity	2	1 (Test 4)	NRC Fire Laboratory
7-ply CLT (243mm x 872")	Simonsdram	SPF #1 #2 x SPF #1 #2	None	Half Lap	None	Unloaded 140% Moment Capacity	2.5	1 (Test 7)	NRC Fire Laboratory
3-ply CLT (173mm x 872")	SmartLam	SL-A4	None	Half Lap	installed 1/2" ply wood with 8 nails	Loaded, See Manufacturer	2	12 (Test 4)	Western Fire Center 10/26/2016
3-ply CLT (173mm x 872")	SmartLam	V1	None	Half Lap	installed				
3-ply CLT (173mm x 872")	DR Johnson	V1	None	Half Lap	installed				
3-ply CLT (173mm x 872")	KAH	CV3M1	None	Half Lap & Topside Spline	None	Loaded, See Manufacturer	1	14	SwRI 4/2/2014

Free download at woodworks.org



Mass Timber Fire Design Resource

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

MASS TIMBER ACOUSTICS DESIGN



TECHNICAL DETAILS | DESIGN PRINCIPLES

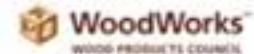
BY ITSELF, NOT ADEQUATE FOR ACOUSTICS



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

WoodWorks Inventory of Acoustically Tested MT 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
	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	
CLT 5-ply (6.875")		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®		LVT	48 ⁶	44 ⁶	16
			LVT Plus	48 ⁶	47 ⁶	58

More than 400 Tested Assemblies

Free download at woodworks.org

MASS TIMBER ACOUSTICS DESIGN RESOURCE

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

By David McLean, PE, SE & David Thompson, Director of WoodWorks

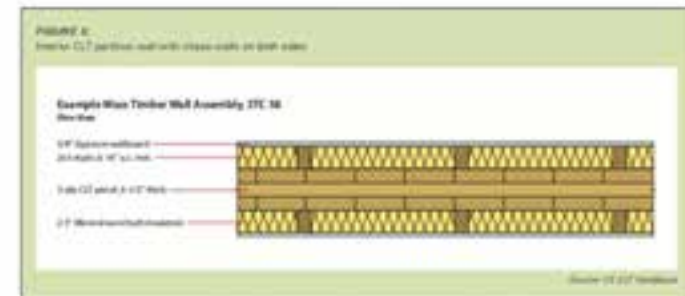


To learn more:
Contact David McLean (david.mclean@woodworks.org) or David Thompson (david.thompson@woodworks.org) at WoodWorks.

The growing availability and wide 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.

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



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 partition wallboard on surface channels that are attached to the mass timber wall. As with other mass timber floor panels, basic 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 3-1/2" has an STC rating of 52. 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 IRC'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-rated mass timber assemblies include CLT. However, tests have also been done on other mass timber panel options such as NLT and glued laminated timber (GLT), as well as traditional heavy timber options such as log-cabin and grooved decking. Most tests have concluded that CLT acoustical performance is slightly better than that of other mass timber options, largely because the cross-lamination 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 log-cabin and grooved decking.

Improving Performance by Minimizing Flanking

Even when the assemblies in a building are carefully designed and matched for high acoustical performance, consideration of flanking paths—i.e., areas such as assembly intersections, beam-to-columned connections, and MJGP 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 seismic strips. These products are capable of resisting in-situ 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.





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Photo: Structurlam | Seagate Structures



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