Mass Timber Construction: Products, Design, Logistics and Risk Analysis

Presented by Anthony Harvey, PE
WoodWorks
May 26, 2022

Photo Credit: Christofer Lark

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John W. Olver Design Building at UMass Amherst
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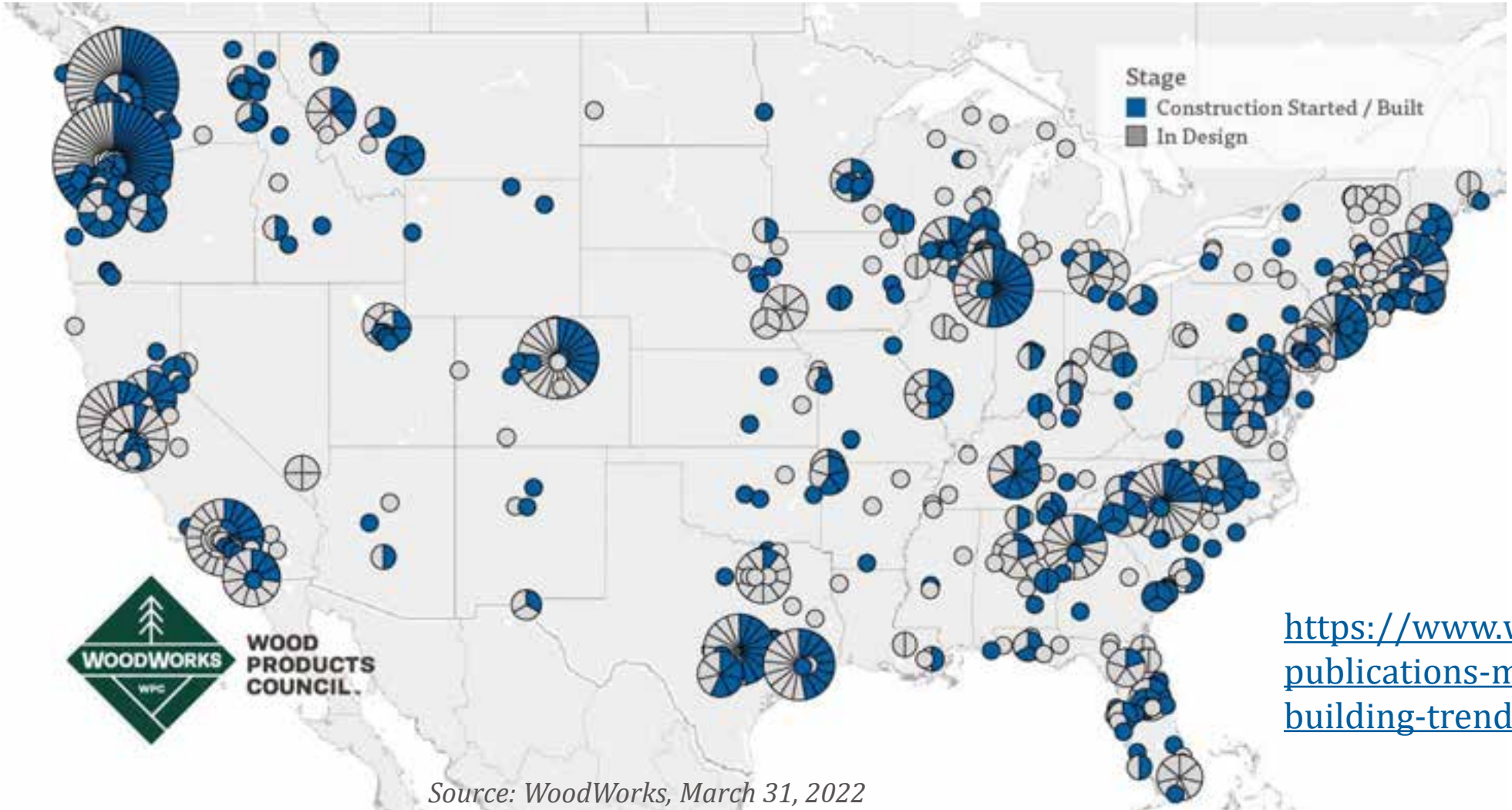
Current State of Mass Timber Projects

As of March 2022, in the US, **1,384** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.



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

Source: WoodWorks, March 31, 2022

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

MENU

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Building Systems | Building Type | Material Type | Sq Footage | Number of Stories | Construction Type

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Salvagnini Industrial Showroom Expansion

Hybrid
1 Story
25,000 sq ft

Hamilton, OH

The expanded Salvagnini customer resource campus features exposed CLT wall and roof systems, supported by glulam columns and an exterior finished concrete wall. The design tea..

Echo Park Ewing Residence

Los Angeles, CA

State of Massachusetts Public-Use Airport Buildings

Beverly, MA

Now Care, Western Montana

Find Mass Timber Projects

+ connect with the pros who worked on them.

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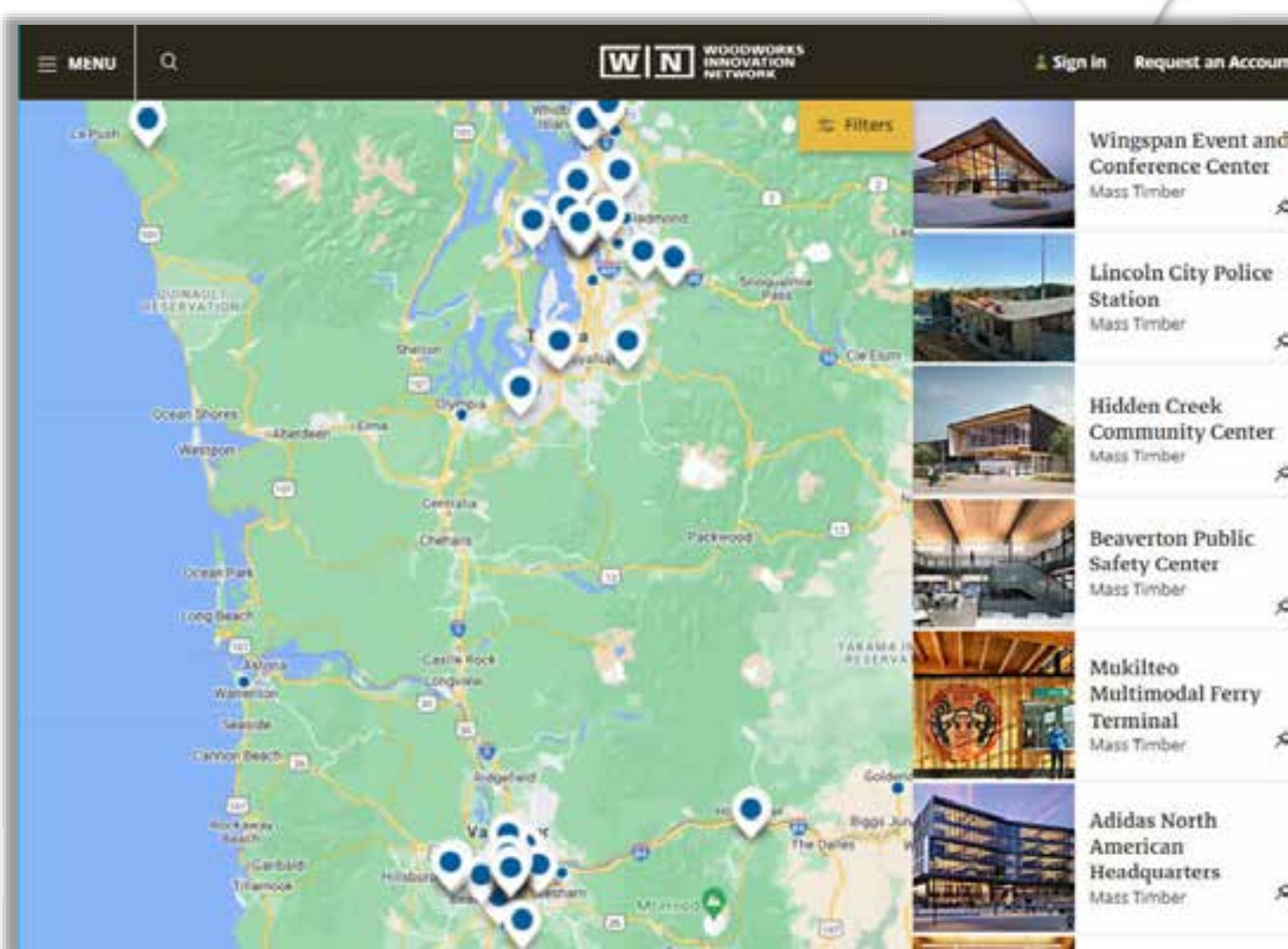

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Questions? Ask me anything.

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

Special Thanks: MassTimber@MSU

https://www.canr.msu.edu/masstimber/

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Photo: Structurlam

Mass Timber Construction:

Products, Performance and Design

Presented by
Anthony Harvey PE
WoodWorks Regional Director

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

AIA Approved Continuing Education

Course Description

Due to their high strength, dimensional stability and positive environmental performance, mass timber building products are quickly becoming materials of choice for sustainably-minded designers. This presentation will provide a detailed look at the variety of mass timber products available, including glue-laminated timber (glulam), cross laminated timber (CLT), nail laminated timber (NLT), heavy timber decking, and other engineered and composite systems. Applications for the use of these products under modern building codes will be discussed, and examples of their use in U.S. projects reviewed. Mass timber's ability to act as both structure and exposed finish will also be highlighted, as will its performance as part of an assembly, considering design objectives related to structural performance, fire resistance, acoustics, and energy efficiency. Other topics will include detailing and construction best practices, lessons learned from completed projects and trends for the increased use of mass timber products in the future.

Learning Objectives

1. Identify mass timber products available in North America and consider how they can be used under current building codes and standards.

2. Review completed mass timber projects that demonstrate a range of applications and system configurations.

3. Discuss benefits of using mass timber products, including structural versatility, prefabrication, lighter carbon footprint, and reduced labor costs.

4. Highlight possibilities for the expanded use and application of mass timber in larger and taller buildings.

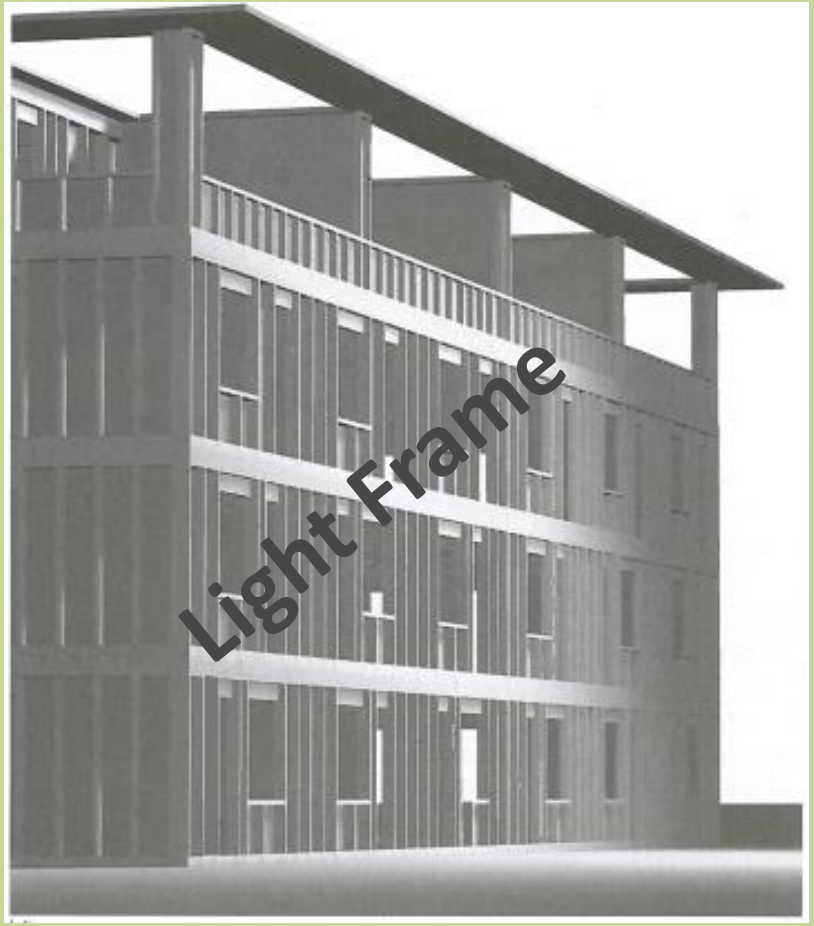
TODAY'S AGENDA

MASS TIMBER CONSTRUCTION

MASS TIMBER

- WHAT IS IT – PRODUCTS
- WHY USE IT – APPEAL
- HOW DOES IT WORK – DESIGN TOPICS
- WHERE IS IT USED – CASE STUDIES
- WHAT'S NEXT?

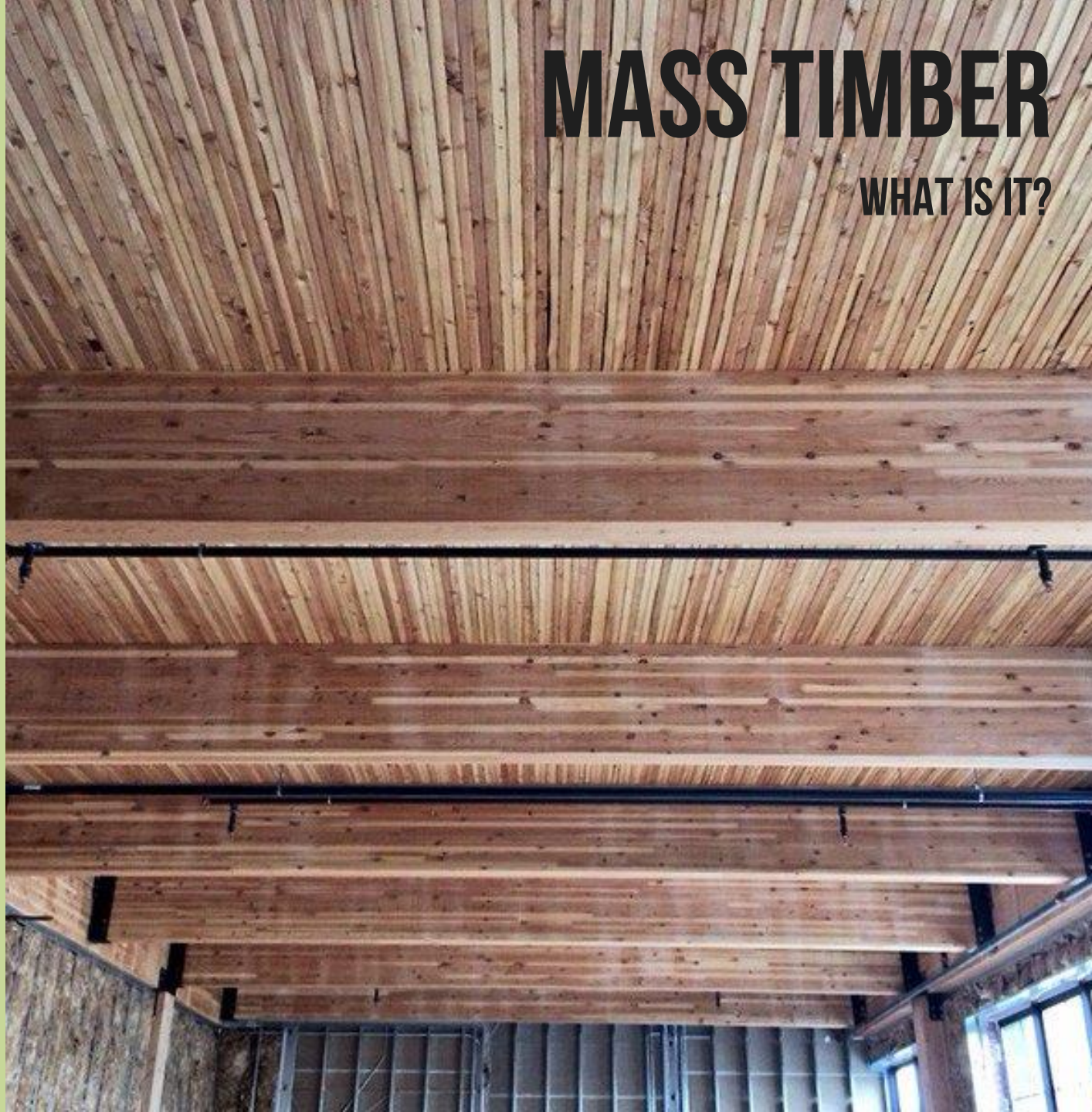
BUILDING FRAME SYSTEMS



MASS TIMBER

WHAT IS IT?

MASS TIMBER IS A CATEGORY OF FRAMING STYLES OFTEN USING SMALL WOOD MEMBERS FORMED INTO LARGE PANELIZED SOLID WOOD CONSTRUCTION INCLUDING CLT, NLT OR GLULAM PANELS FOR FLOOR, ROOF AND WALL FRAMING



HEAVY TIMBER

Federal Center South, Seattle, WA
Photo: Benjamin Benschneider

MASS TIMBER

Bullitt Center, Seattle, WA
Photo: John Stamets

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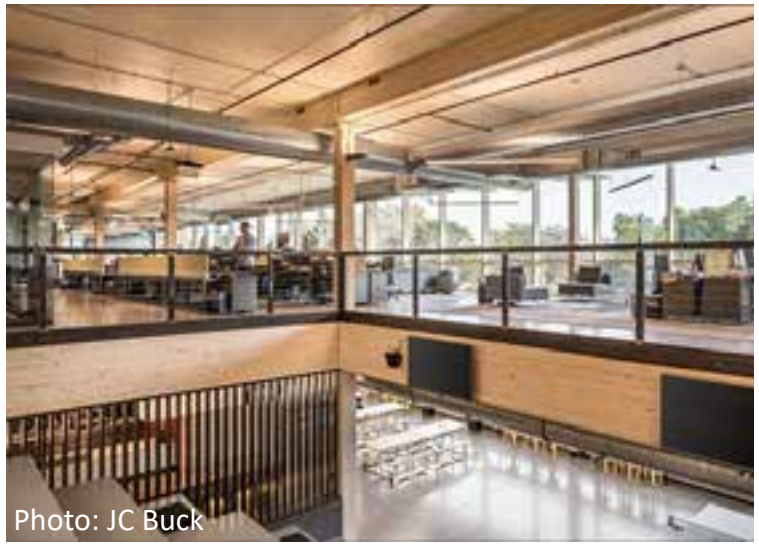


Photo: JC Buck


Photo: William Horne


Photo: LEVER Architecture


Photo: David Sundberg and Gray Organschi Architecture


Photo: ©Albert Vecerka/Esto


Photo: Christian Columbres

What's in a mass timber building?
Products used

MASS TIMBER PRODUCTS

GLULAM

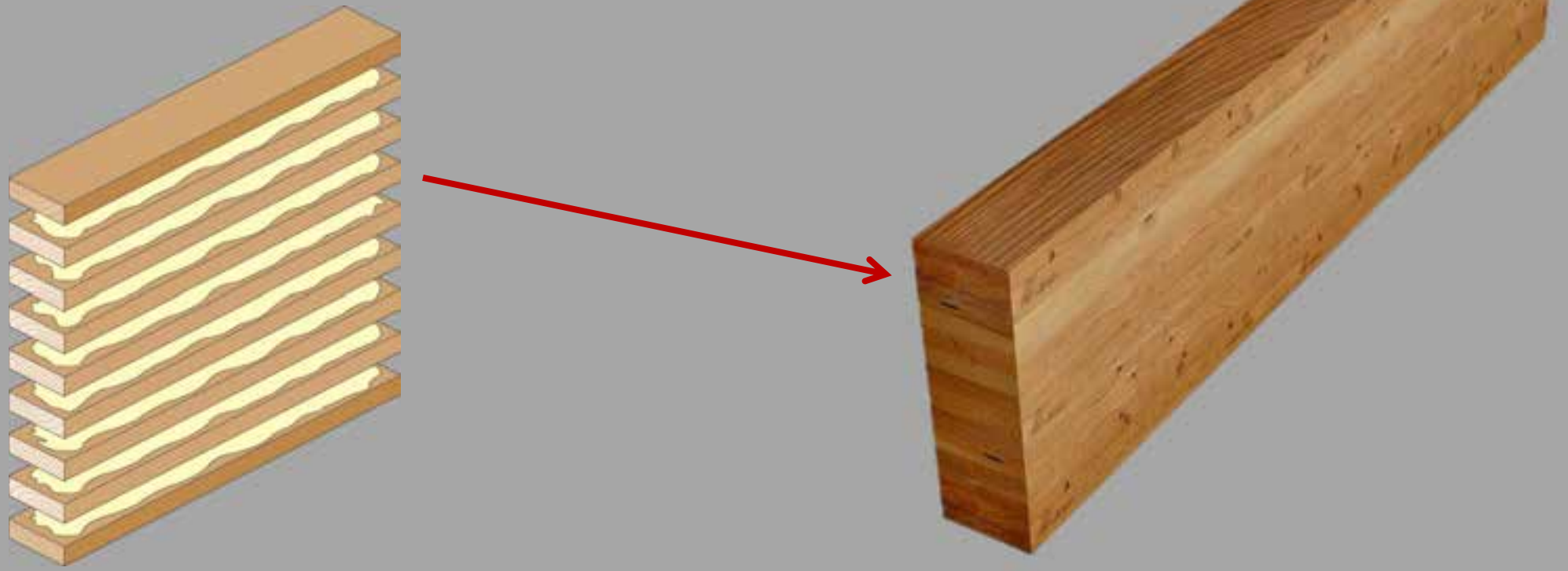
PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER PRODUCTS

GLULAM

GLULAM = A STRUCTURAL COMPOSITE OF LUMBER AND ADHESIVES

- RECOGNIZED IN IBC 2303.1.3 USING ANSI/AITC A 190.1 AND ASTM D 3737
- CAN BE USED FOR FLOOR, ROOF PURLINS, BEAMS, ARCHES, COLUMNS



MASS TIMBER PRODUCTS

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

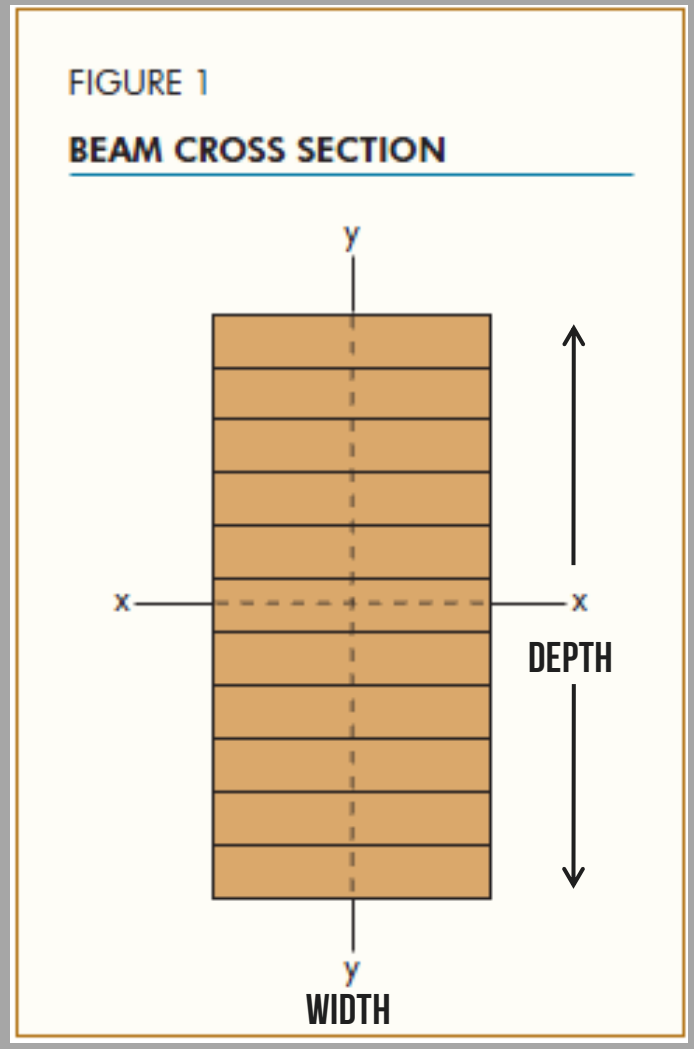


IMAGE: APA GLULAM PRODUCT GUIDE

MASS TIMBER PRODUCTS

GLULAM

PHOTO CREDIT: ANTHONY FOREST PRODUCTS

GLULAM SPECS:

PT READILY AVAILABLE
FRT MAY BE AVAILABLE, VARIES BY MANUFACTURER & TREATER

CAN BE CAMBERED, CURVED & TAPERED

DIFFERENT APPEARANCE GRADES AVAILABLE

MASS TIMBER PRODUCTS

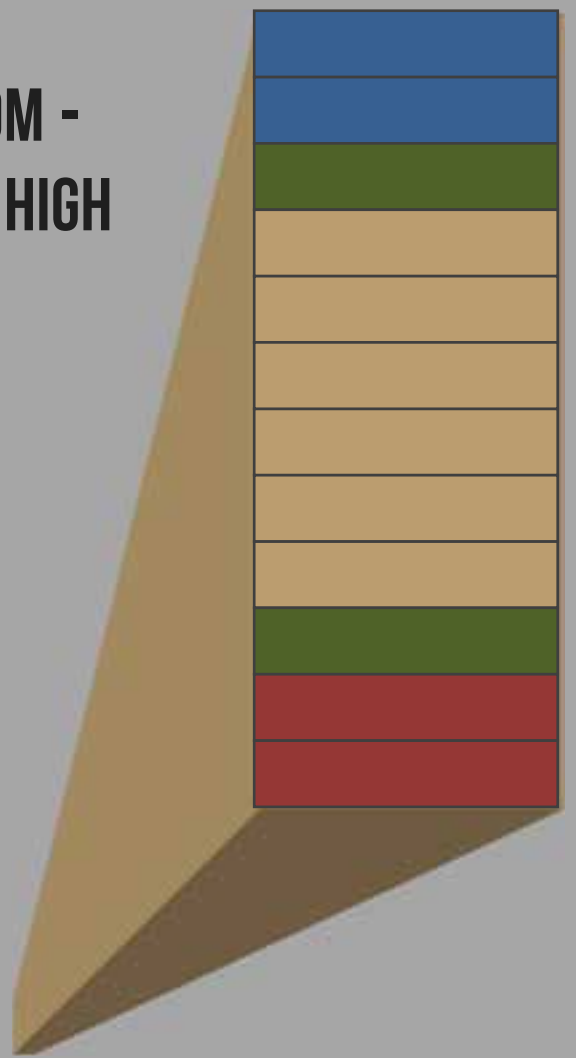
GLULAM

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



HIGH STRENGTH OUTER COMPRESSION LAMS

MEDIUM GRADE INNER COMPRESSION LAM

LOWER GRADE INNER LAMS

MEDIUM GRADE INNER COMPRESSION LAM

HIGH STRENGTH OUTER TENSION LAMS

LONG SPAN GLULAMS

PHOTO: AMERICAN WOOD COUNCIL

RADIATOR BUILDING

PORTLAND, OR

PHOTO CREDIT: JOSH PARTEE

BUILDING INFO:

OFFICE BUILDING

5 STORIES

36,000 SF

COMPLETED 2015

NAIL LAMINATED TIMBER

PHOTO CREDIT: STRUCTURECRAFT

MASS TIMBER PRODUCTS

NAIL-LAMINATED TIMBER (NLT) PANELS

What is it?

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 thickness and 4 in. to 12 in. width) on edge and fastening the individual laminations together with nails.

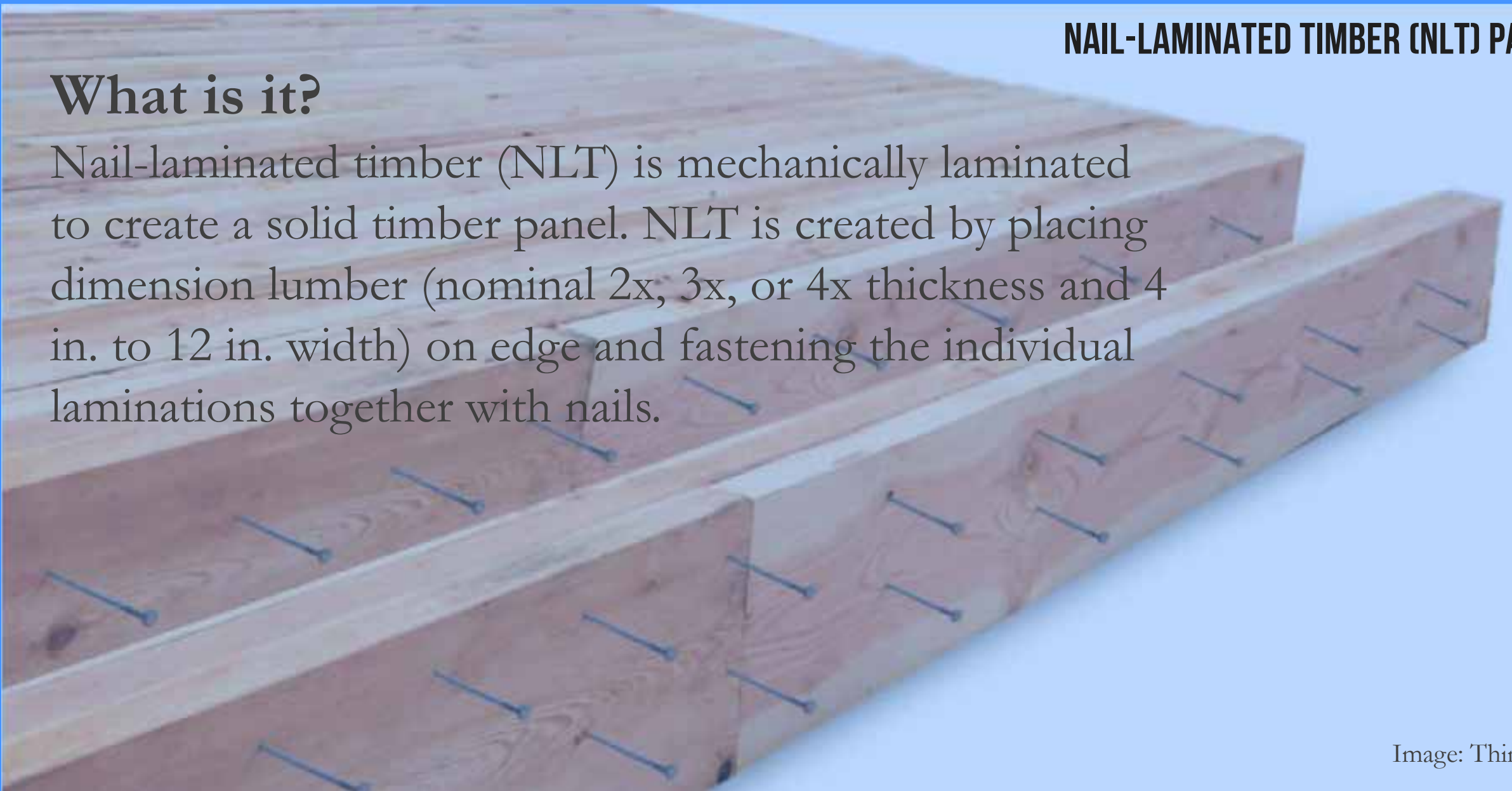


Image: Think Wood

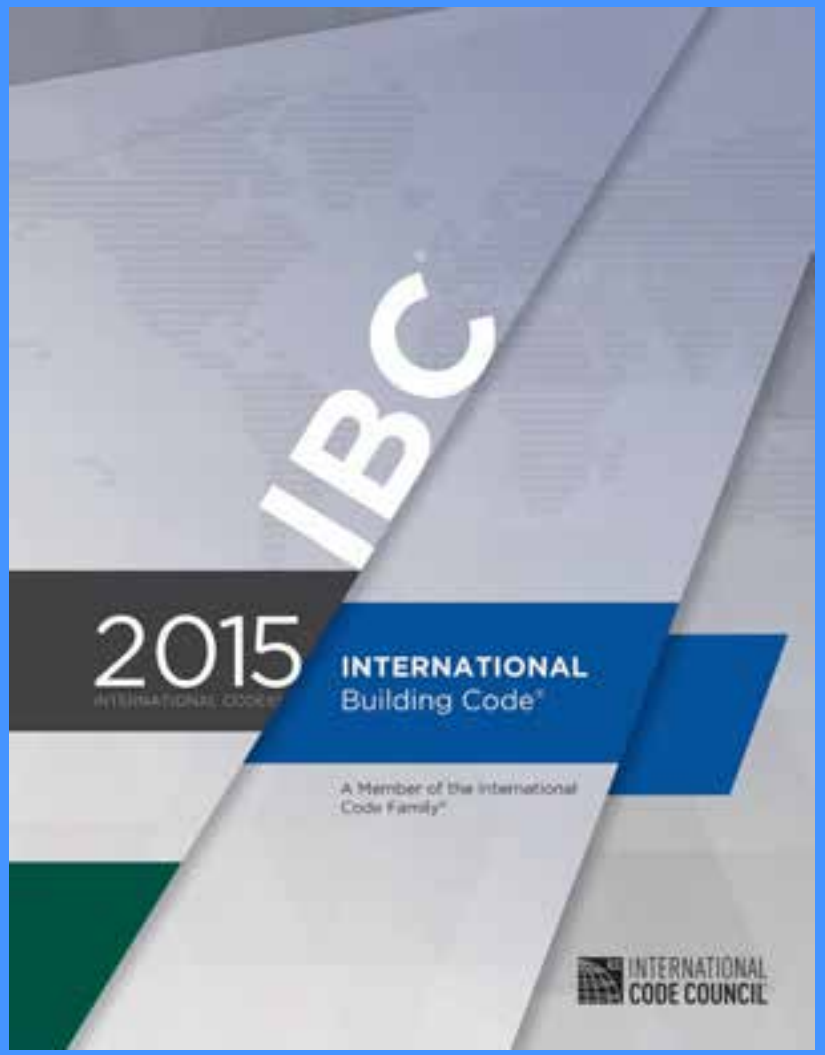
MASS TIMBER PRODUCTS

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

When is it used?

NLT is typically used for floor and roof panels. Plywood/OSB added to one face can provide in-plane shear capacity, allowing the product to be used as a diaphragm. Can also be used for walls, shafts.

PHOTO CREDIT: STRUCTURECRAFT BUILDERS

MASS TIMBER PRODUCTS

NAIL-LAMINATED TIMBER (NLT) PANELS

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

PHOTO CREDIT: JOHN STAMETS

PHOTO CREDIT: STRUCTURECRAFT

PHOTO CREDIT: STRUCTURECRAFT

MASS TIMBER PRODUCTS

NAIL-LAMINATED TIMBER (NLT) PANELS

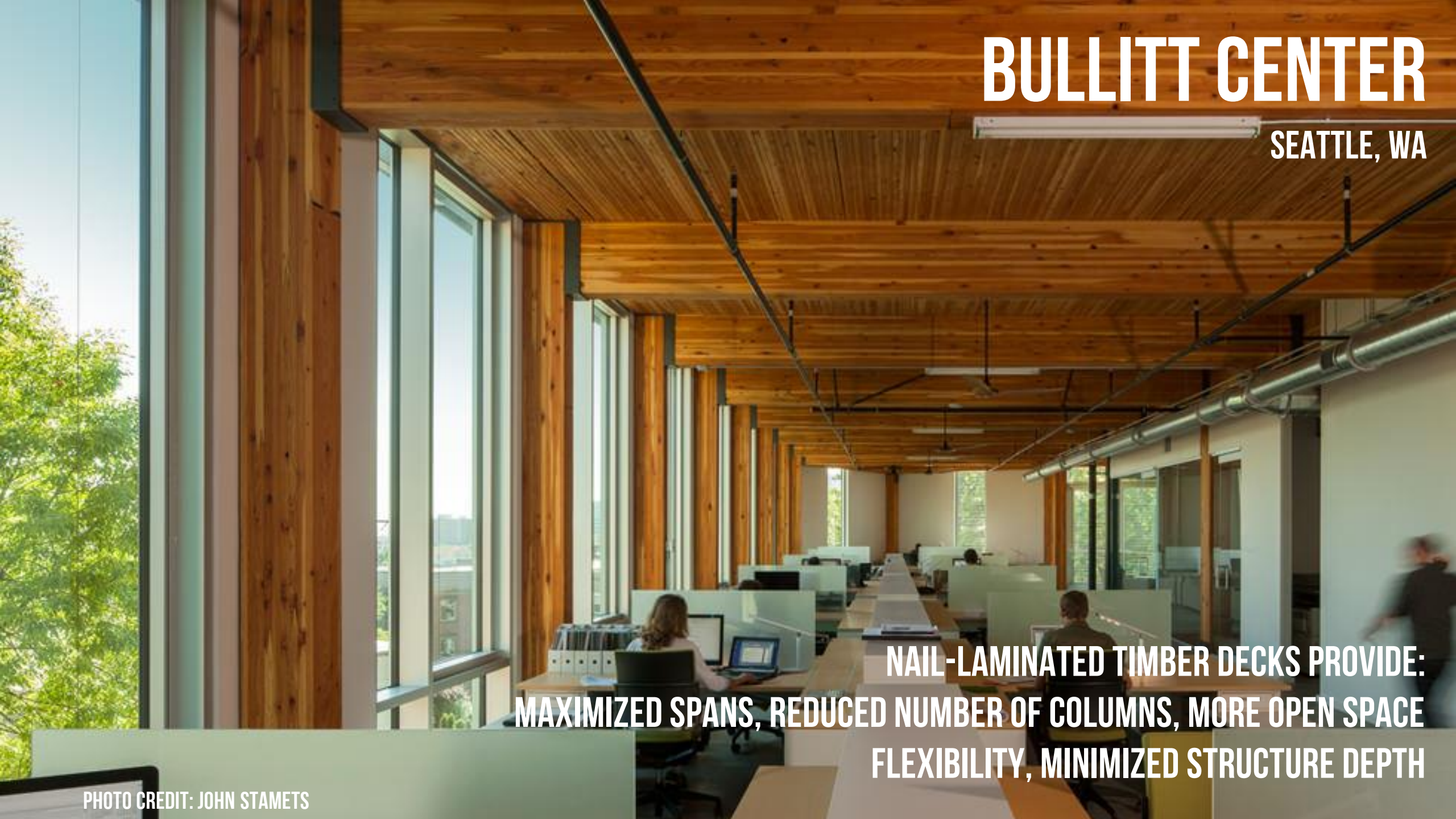
PRE-FABRICATED PANELS OFTEN PRE-SHEATHED

ONCE INSTALLED, ADD STITCHING STRIPS, TAPE JOINT IF APPLICABLE

BULLITT CENTER

SEATTLE, WA

PHOTO CREDIT: BULLITT CENTER



BULLITT CENTER

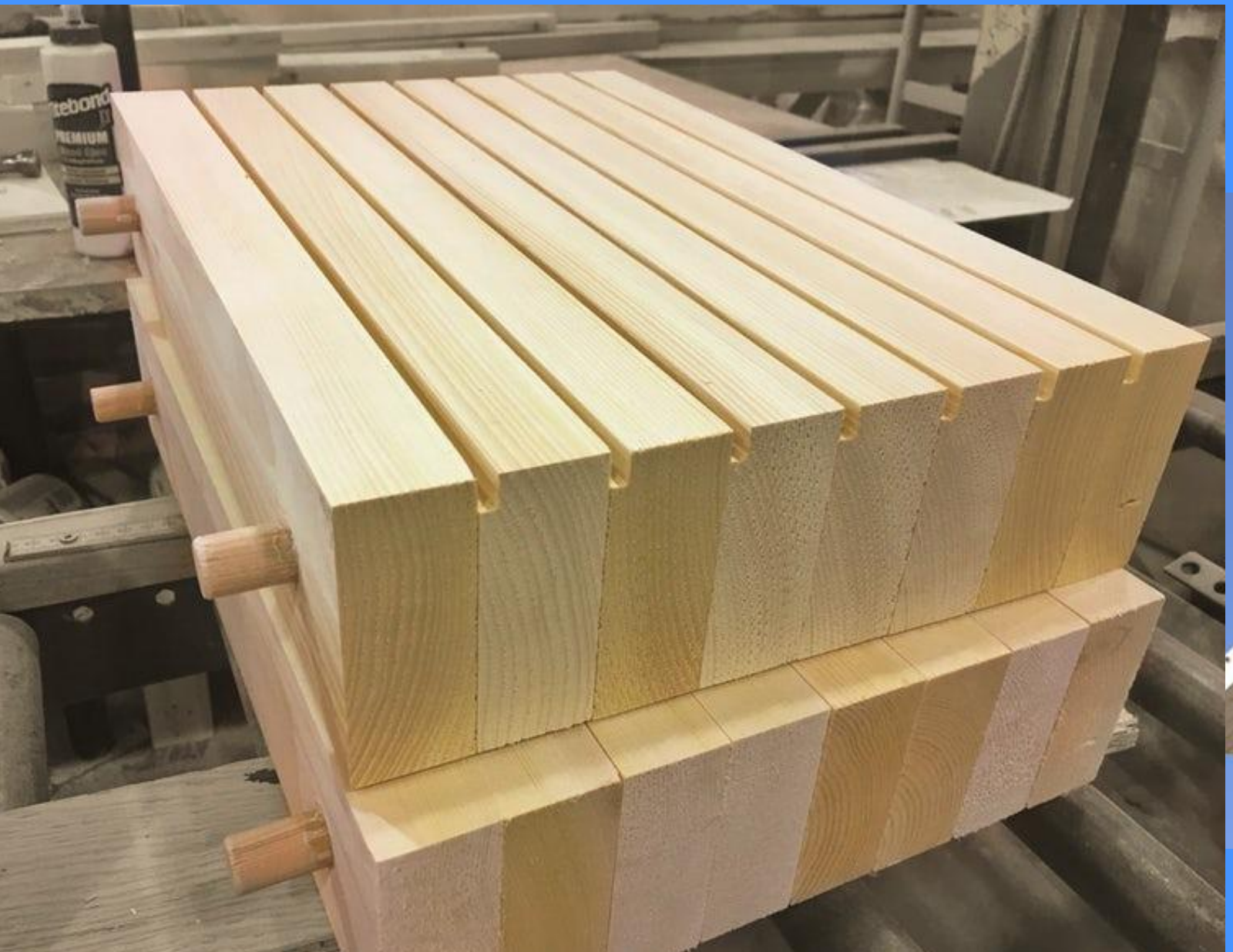
SEATTLE, WA

NAIL-LAMINATED TIMBER DECKS PROVIDE:
MAXIMIZED SPANS, REDUCED NUMBER OF COLUMNS, MORE OPEN SPACE
FLEXIBILITY, MINIMIZED STRUCTURE DEPTH

PHOTO CREDIT: JOHN STAMETS

MASS TIMBER PRODUCTS

DOWEL-LAMINATED TIMBER (DLT) PANELS



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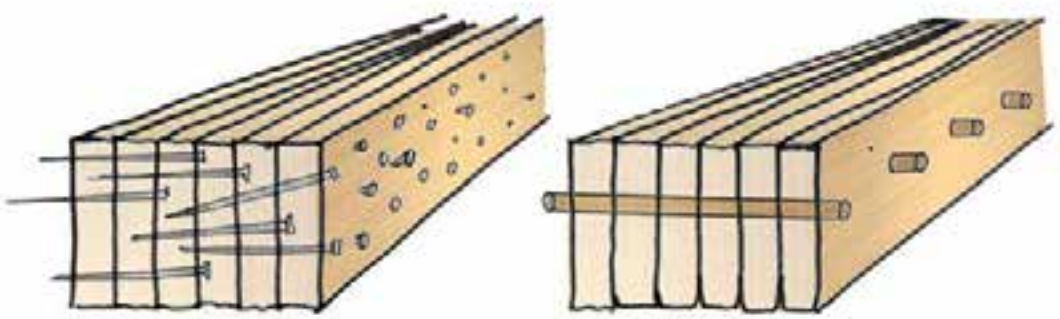


MASS TIMBER PRODUCTS

DOWEL-LAMINATED TIMBER (DLT) PANELS

DLT:

- SIMILAR TO NLT – NAILS CONNECTING LAMS REPLACED WITH HARDWOOD DOWELS
- COMMON IN EUROPE – OFTEN REFERRED TO AS BRETTSTAPEL
- NOT CURRENTLY RECOGNIZED AS PRESCRIPTIVELY PERMITTED MATERIAL IN IBC
- TIMBER FRAMERS GUILD – RESOURCES ON DOWEL DESIGN

PHOTO CREDIT: GUARDIAN STRUCTURES

MASS TIMBER PRODUCTS

DOWEL-LAMINATED TIMBER (DLT) PANELS

Dowel Laminated Timber

The All Wood Panel

Mass Timber Design Guide

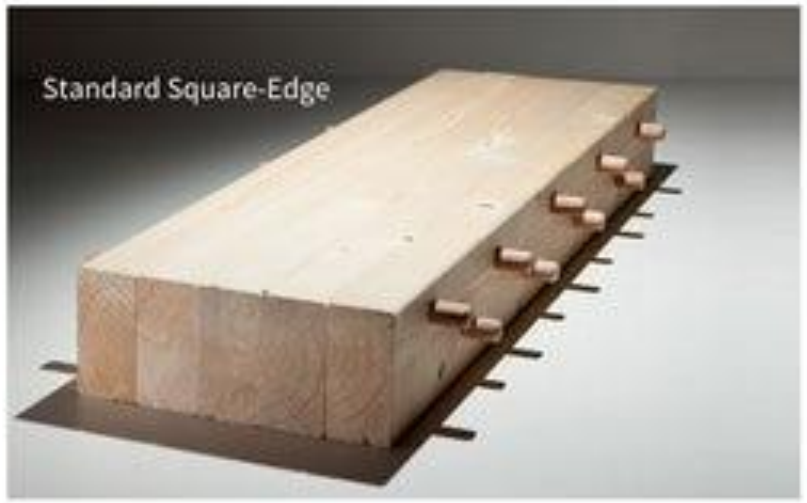
DLT: SIMILAR TO NLT – BUT LAMS ARE USUALLY FINGER JOINTED IN DLT SO JOINT LAYUPS NOT A CONCERN

CREDIT: STRUCTURECRAFT BUILDERS

MASS TIMBER PRODUCTS

DOWEL-LAMINATED TIMBER (DLT) PANELS

VARIOUS PROFILE OPTIONS



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111 EAST GRAND

DES MOINES, IA

CREDIT: NUEMANN MONSON ARCHITECTS
COURTESY: RYAN COMPANIES

111 EAST GRAND

DES MOINES, IA

CREDIT: STRUCTURECRAFT BUILDERS

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

Largest Mass Timber Building in the US: Southeast (not PNW)
T3 West Midtown, Atlanta


Photo: StructureCraft

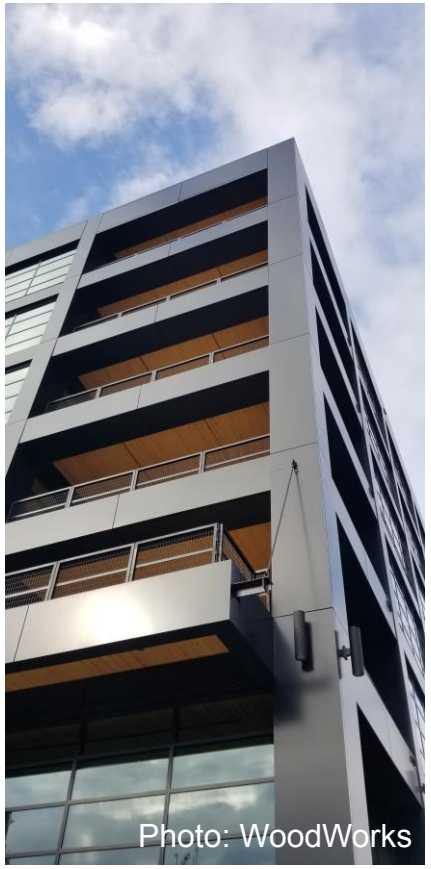


Photo: WoodWorks

IV (HT)

- 6 stories Type IV over podium
- 205,000 sf
- DLT floors, glulam frame

Location: Atlanta, GA
Architect: Hartshorne Plunkard Architects + DLR Group
Structural Engineer: Magnusson Klemencic Associates
Mass Timber Engineer: StructureCraft

MASS TIMBER PRODUCTS

GLUE-LAMINATED TIMBER (GLT) PANELS

PHOTO CREDIT: STRUCTURE FUSION

PHOTO CREDIT: UNALAM

IMAGE SOURCE: MANASC ISAAC ARCHITECTS/FAST ± EPP

MASS TIMBER PRODUCTS

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

MASS TIMBER PRODUCTS

GLUE-LAMINATED TIMBER (GLT) PANELS

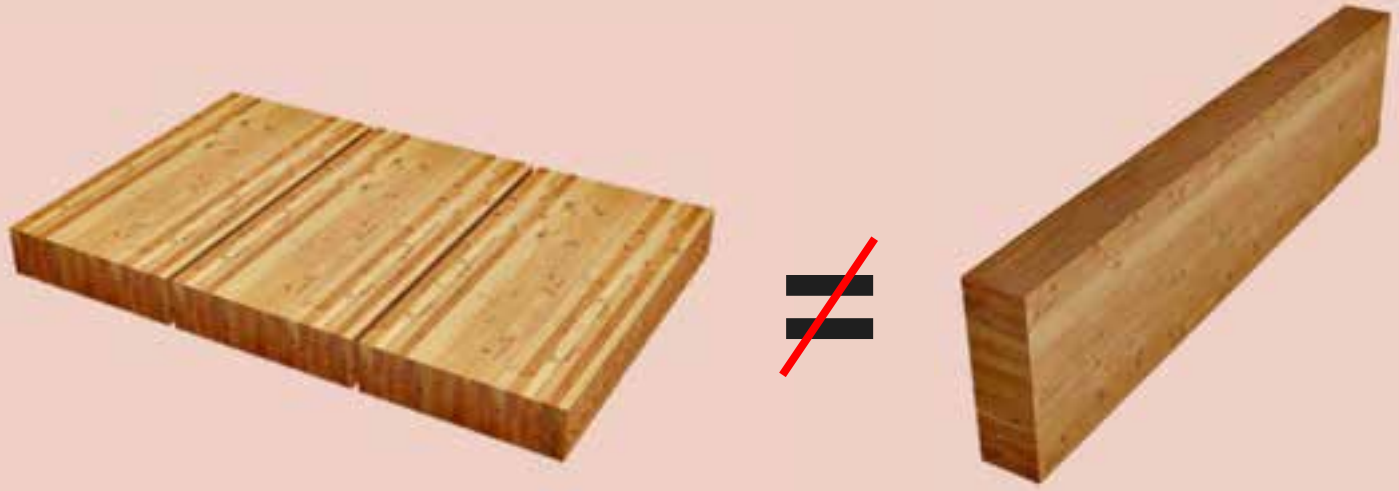


IMAGE SOURCE: STRUCTURECRAFT BUILDERS

Use with Table 5A Adjustment Factors

ecies / r/ Core	Bending About X-X Axis (Loaded Perpendicular to Wide Faces of Laminations)							Bending About Y-Y Axis (Loaded Parallel to Wide Faces of Laminations)				
	Bending		Compression Perpendicular to Grain		Shear Parallel to Grain	Modulus of Elasticity		Bending	Compression Perpendicular to Grain	Shear Parallel to Grain	Modulus of Elasticity	
	Bottom of Beam Stressed in Tension (Positive Bending)	Top of Beam Stressed in Tension (Negative Bending)	Tension Face	Compression Face		For Deflection Calculations	For Stability Calculations				For Deflection Calculations	For Stability Calculations
	F_{bx}^{+} (psi)	F_{bx}^{-} (psi)	$F_{c\perp x}$ (psi)		$F_{vx}^{(2)}$ (psi)	E_x (10^6 psi)	$E_{x\,min}$ (10^6 psi)	F_{by} (psi)	$F_{c\perp y}$ (psi)	$F_{vy}^{(2)(3)}$ (psi)	E_y (10^6 psi)	$E_{y\,min}$ (10^6 psi)
	2400	**1450**	**650**		**265**	**1.8**	**0.95**	**1450**	**560**	**230**	**1.6**	**0.85**
F/DF	2400	1850	650	650	265	1.8	0.95	1450	560	230	1.6	0.85
F/DF	2400	2400	650	650	265	1.8	0.95	1550	560	230	1.6	0.85
F/DF	2400	1450	650	650	265	1.8	0.95	1400	560	230	1.7	0.90
F/DF	2400	2400	650	650	265	1.8	0.95	1750	560	230	1.7	0.90
F/DF	2400	2400	650	650	265	1.8	0.95	1550	560	230	1.7	0.90
P/SP	2400	2000	740	740	300	1.8	0.95	1700	650	260	1.6	0.85

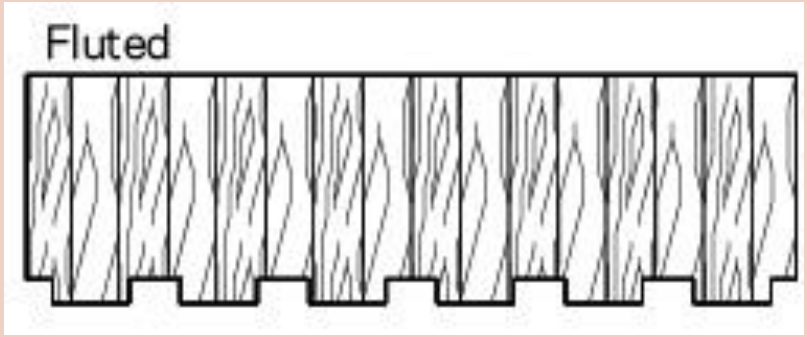
NDS SUPPLEMENT LISTS DIFFERENT DESIGN VALUES FOR BENDING. LAYUP COMBINATIONS TYPICALLY OPTIMIZED FOR BEAM APPLICATIONS. LAYUP COMBINATIONS AREN'T EFFECTIVE IN GLT DECKING APPLICATIONS

MASS TIMBER PRODUCTS

GLUE-LAMINATED TIMBER (GLT)

SAME SHRINKAGE AND DIAPHRAGM CONSIDERATIONS AS NLT:

- GAP PANELS TO ALLOW MOVEMENT
- COVER WITH WOOD STRUCTURAL PANEL FOR DIAPHRAGM
- AVAILABLE IN VARIETY OF LAMINATION OPTIONS



MASS TIMBER PRODUCTS

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, RMW ARCHITECTURE & INTERIORS, BUEHLER ENGINEERING, BERNARD ANDRÉ PHOTOGRAPHY

MASS TIMBER PRODUCTS

TONGUE AND GROOVE DECKING

T&G DIAPHRAGM DESIGN

CAN BE USED BY ITSELF AS A DIAPHRAGM: SDPWS TABLE 4.2D

OR ADD LAYER OF WSP ON TOP, TREAT AS BLOCKED DIAPHRAGM

ICE BLOCK I

SACRAMENTO, CA

ICE BLOCK I, RMW ARCHITECTURE & INTERIORS, BUEHLER ENGINEERING, BERNARD ANDRÉ PHOTOGRAPHY

ICE BLOCKS

SACRAMENTO, CA

PHOTO CREDIT: RMW ARCHITECTURE

PHOTO CREDIT: WOODWORKS

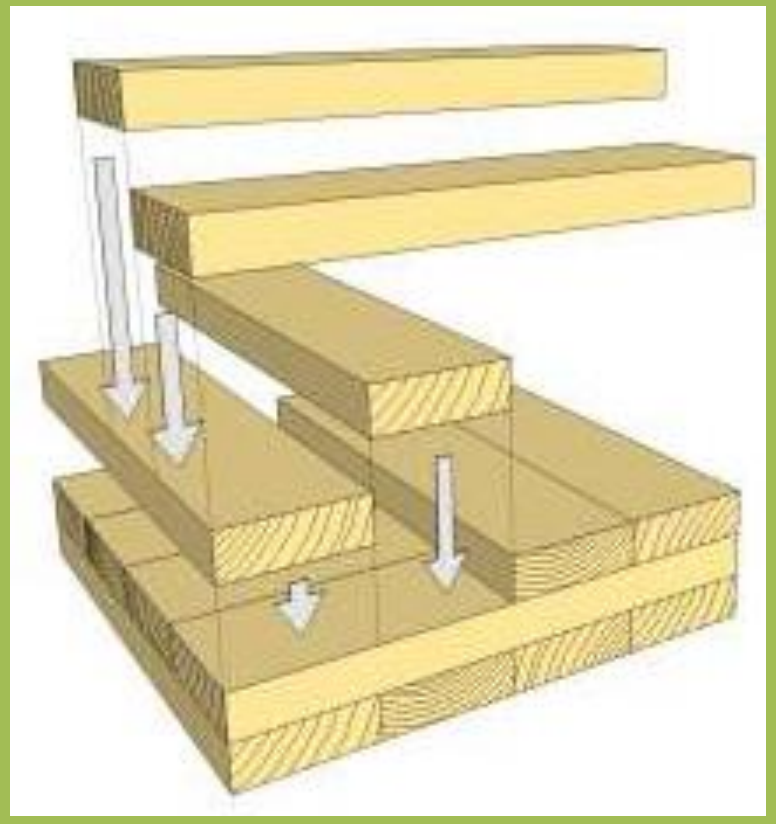
MASS TIMBER PRODUCTS

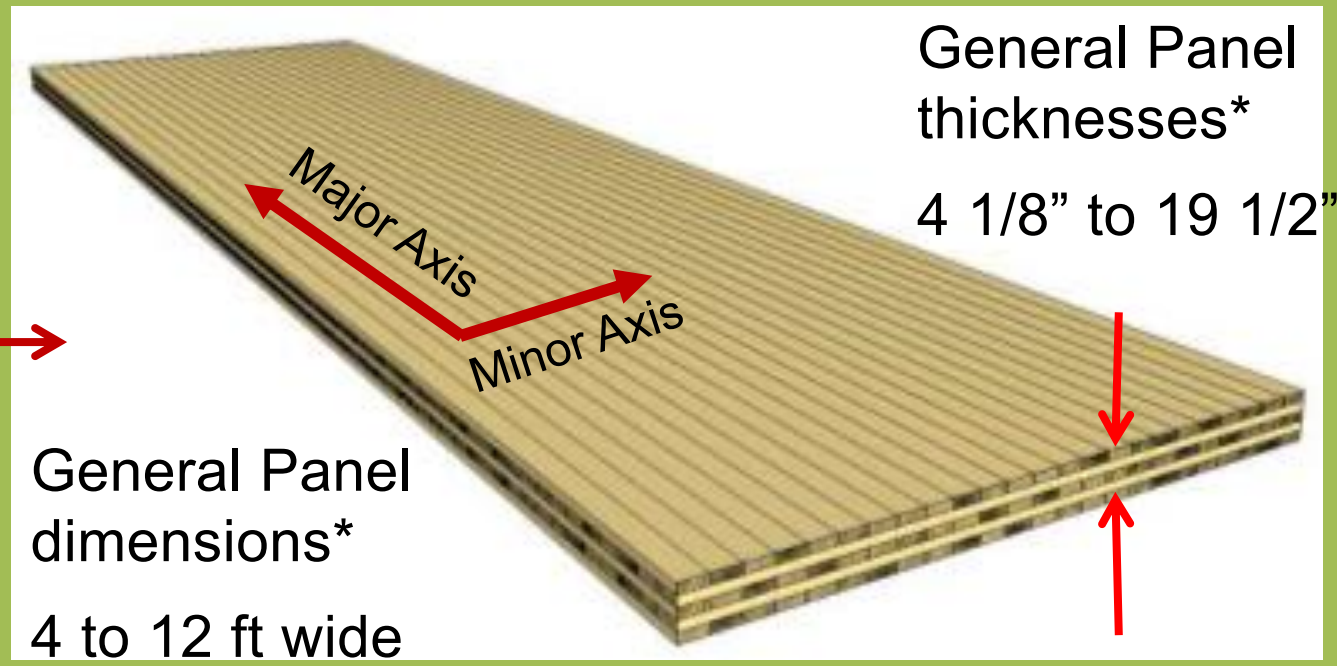
CROSS-LAMINATED TIMBER (CLT)

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)

With solid sawn laminations





General Panel thicknesses*

4 1/8” to 19 1/2”

General Panel dimensions*

4 to 12 ft wide

24 to 64 ft long

*Consult with manufacturers for available panel sizes

Cross-Laminated Timber (CLT)

With SCL laminations

Photos: Freres Lumber

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)

COMMON CLT LAYUPS

3-PLY 3-LAYER

5-PLY 5-LAYER

7-PLY 7-LAYER

9-PLY 9-LAYER

7-PLY 5-LAYER

9-PLY 7-LAYER

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)

CLT PREFABRICATION

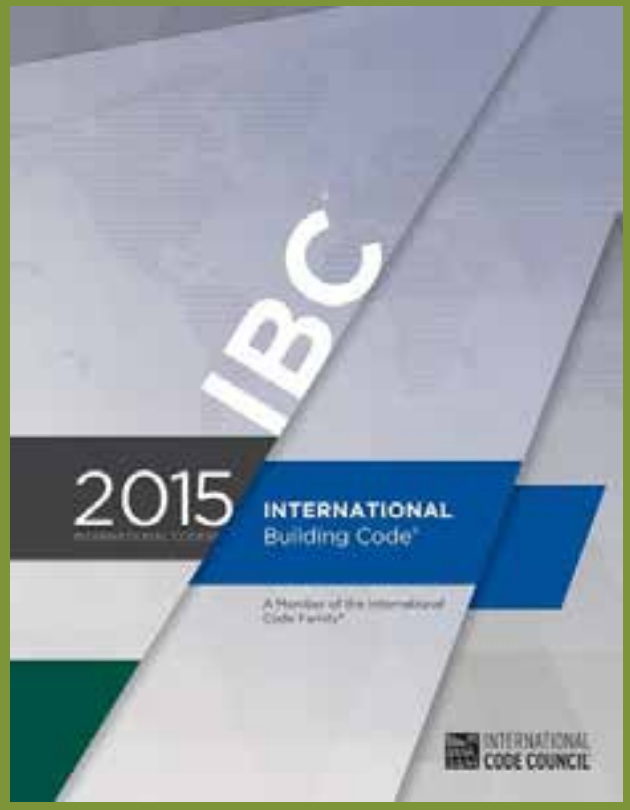
- FINISHED PANELS ARE PLANED, SANDED, CUT TO SIZE. THEN OPENINGS ARE CUT WITH PRECISE CNC ROUTERS.
- THIRD PARTY INSPECTION AT FACTORY
- CUSTOM ENGINEERED FOR MATERIAL EFFICIENCY
- CUSTOM DESIGNED FOR PROJECT
- EACH PANEL NUMBERED, DELIVERED & INSTALLED IN PREDETERMINED SEQUENCE

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)

IN 2015 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. Cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.

ALBINA YARD

PORTLAND, OR

4 STORIES
16,000 SF
GREEN ROOF

ARCHITECT: LEVER ARCHITECTURE
IMAGE CREDIT: LEVER ARCHITECTURE

FIRST TECH CREDIT UNION

HILLSBORO, OR

ARCHITECT: HACKER
IMAGE CREDIT: STRUCTURLAM

COMPLETED 2017 – 156,000 SF
626 PANELS & 988 GLULAMS

CANDLEWOOD SUITES

REDSTONE ARSENAL, AL

IMAGE CREDIT: IHG® Army Hotels, Lendlease

CANDLEWOOD SUITES

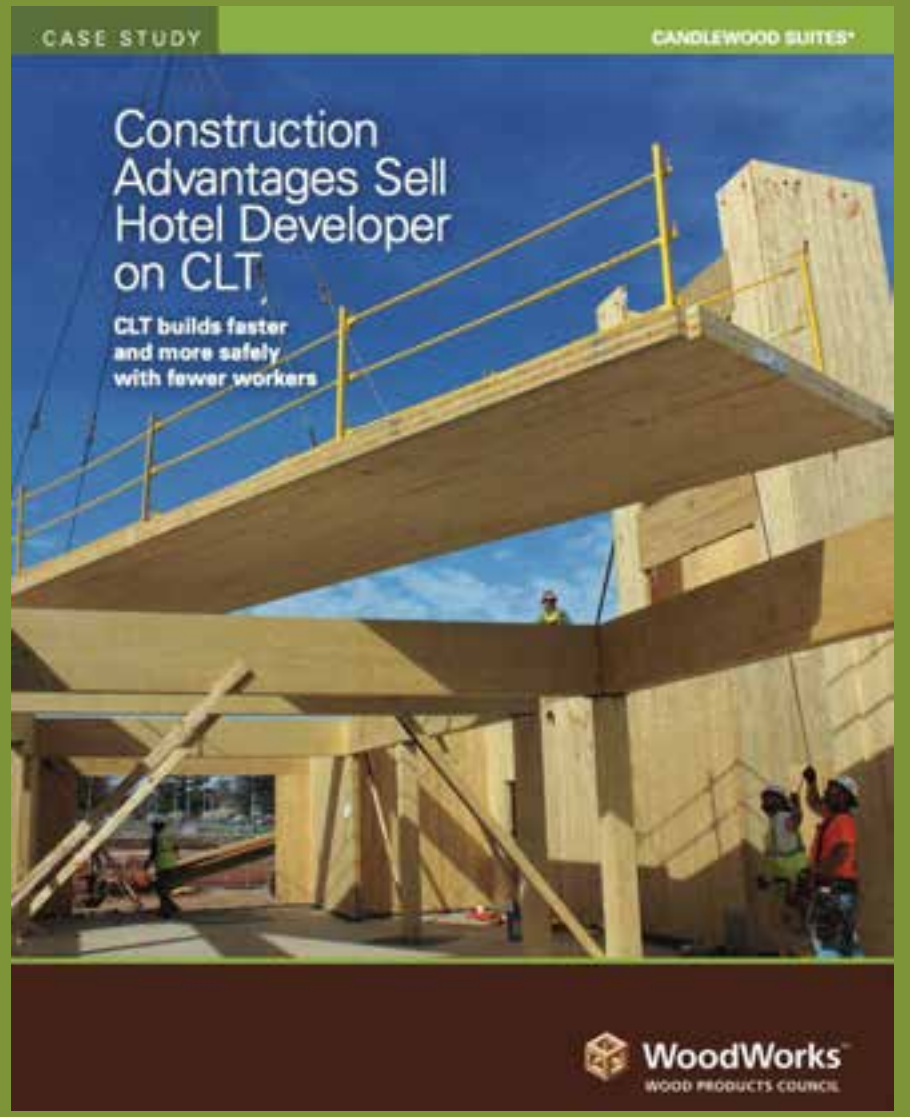
REDSTONE ARSENAL, AL

IMAGE CREDIT: LEND LEASE & SCHAEFER

CANDLEWOOD SUITES

REDSTONE ARSENAL, AL

IMAGE CREDIT: LEND LEASE & SCHAEFER



- 62,600 SF, 4 STORY HOTEL, 92 PRIVATE ROOMS
- CLT UTILIZED FOR WALLS, ROOF PANELS, AND FLOOR PANELS
- 1,557 CLT PANELS; TYPICAL FLOOR PANEL IS 8’X50’ & WEIGHS 8,000 LBS
- COMPLETED LATE 2015

PAL Portfolio	Typical New PAL Hotel (Actual*)	Redstone Arsenal (Actual)	Difference
Gross square feet (sf)	54,891	62,688	+14%
Average # of employees	18 (peak 26)	10 (peak 11)	-43%
Structural duration (days)	123	78	-37%
Structural person hours	14,735	8,203	-44%
Structural production rate/day	460 sf	803 sf	+75%
Overall schedule	15 months	12 months	-20%

* PAL New Build Hotel Historical Average

Source: Lendlease

43%

Compared to typical light gauge steel construction

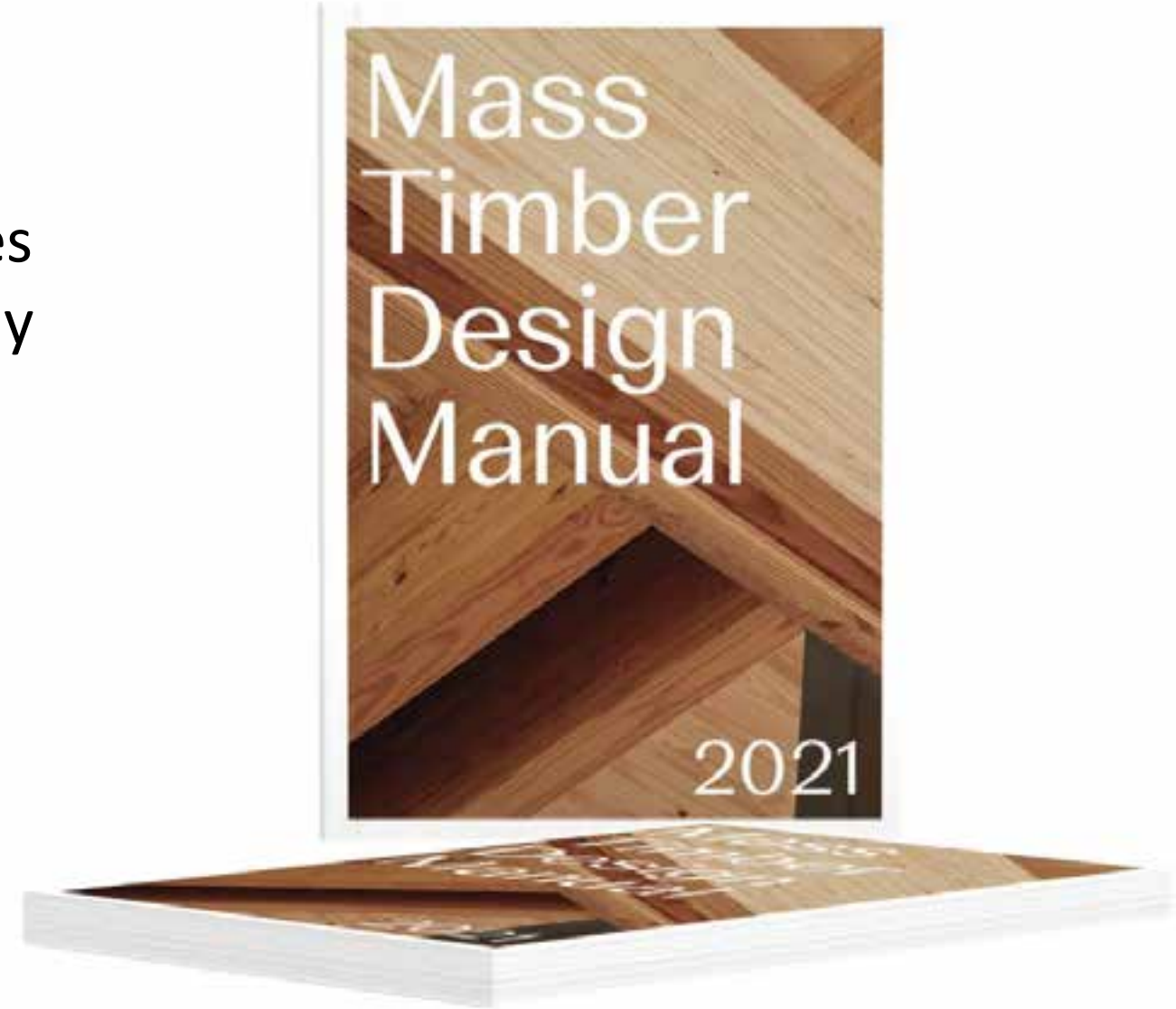
NEW MASS TIMBER DESIGN MANUAL

80+ pages of mass timber technical resources, case studies and more. Links directly to many additional resources.

Jointly Produced By:

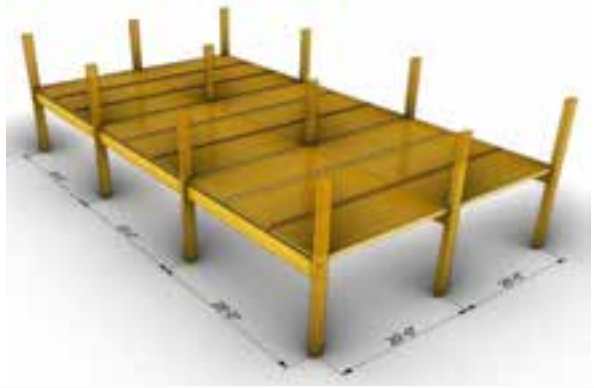
WOODWORKS™
WOOD PRODUCTS COUNCIL

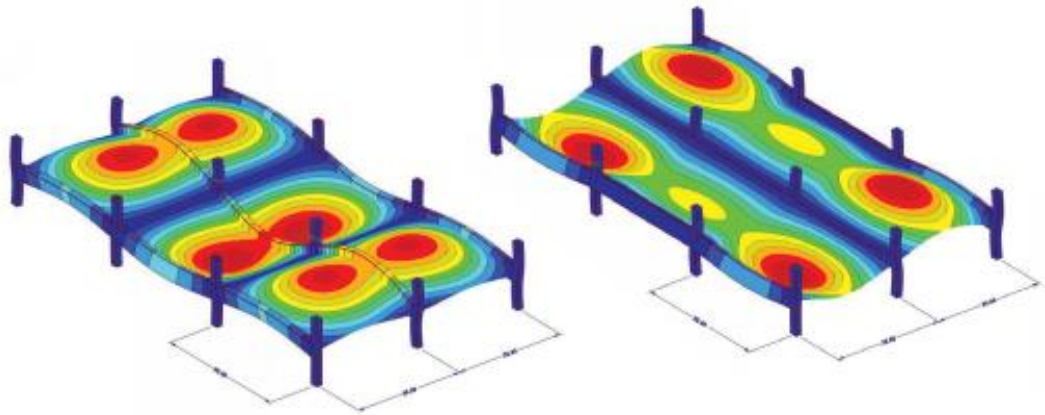
THINK WOOD®

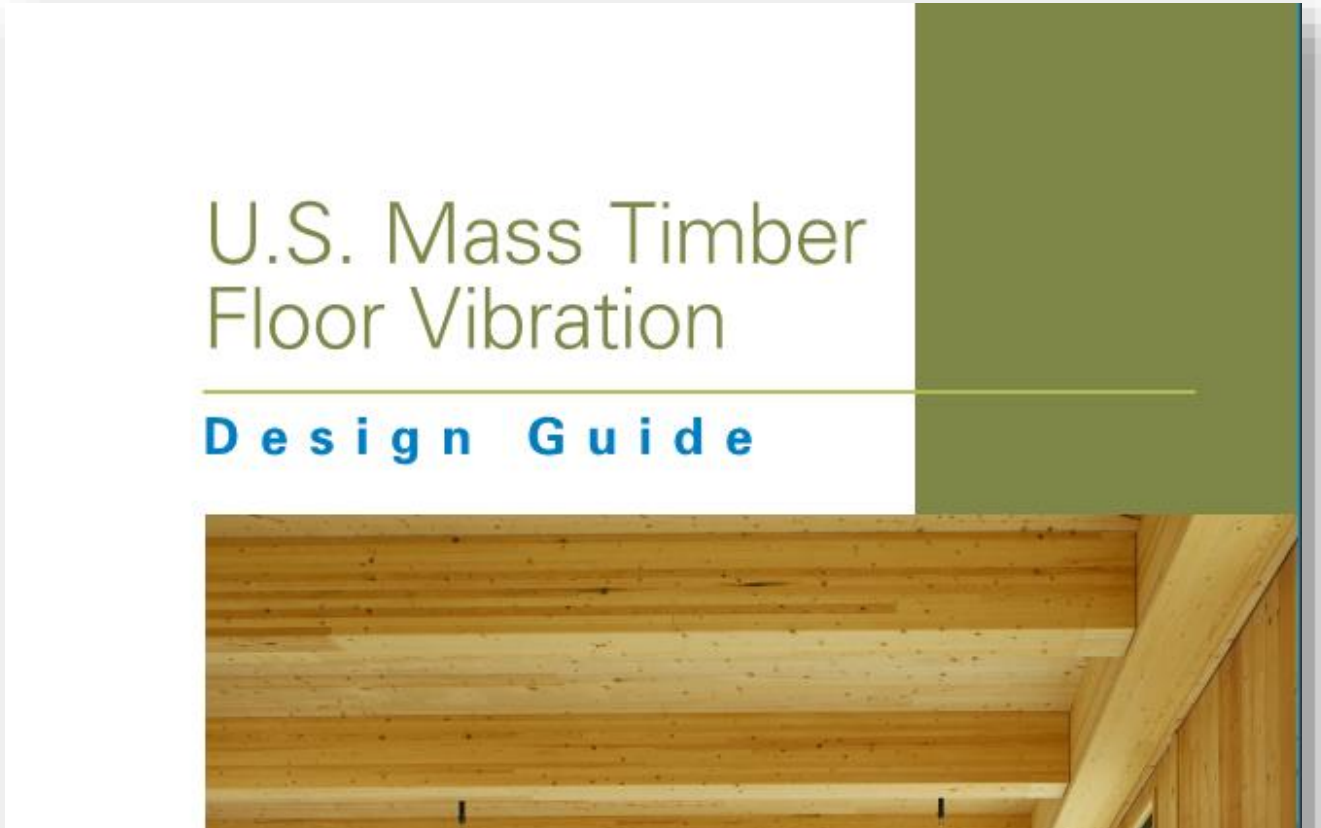


https://info.thinkwood.com/masstimberdesignmanual

NEW MASS TIMBER FLOOR VIBRATION DESIGN GUIDE







Worked office, lab and residential Examples

Covers simple and complex methods for bearing wall and frame supported floor systems

NEW MASS TIMBER CONNECTIONS INDEX

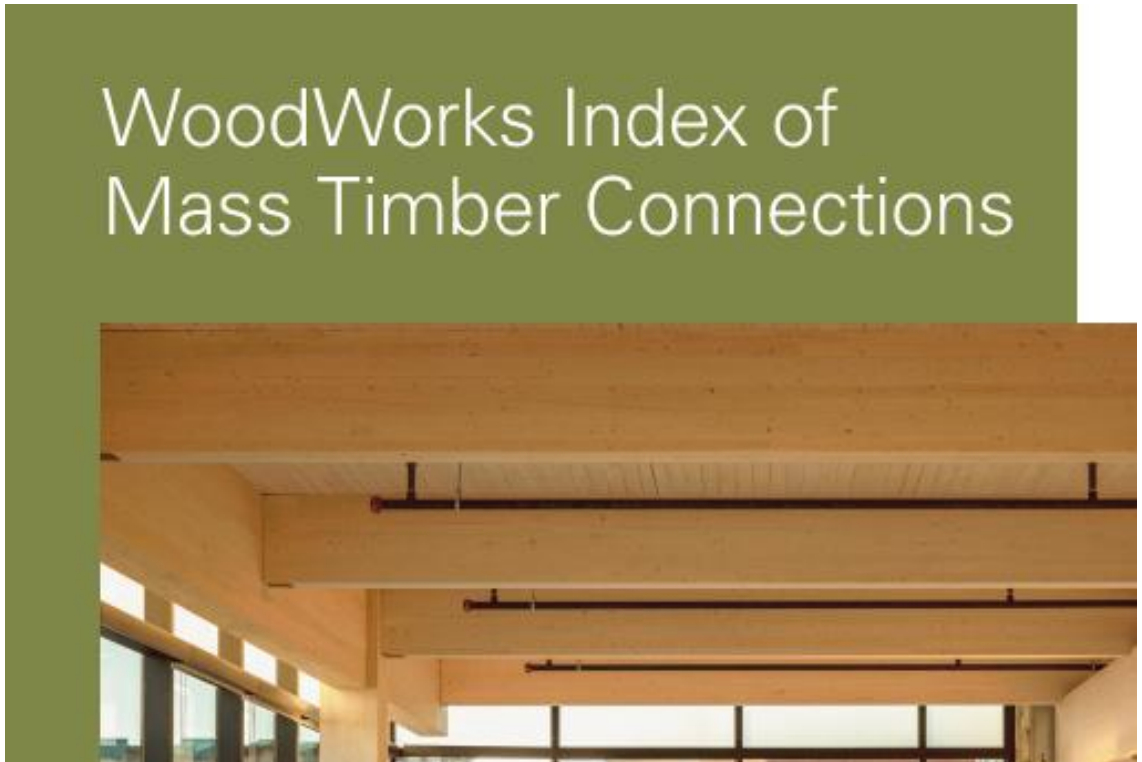
WOODWORKS
WOOD PRODUCTS COUNCIL

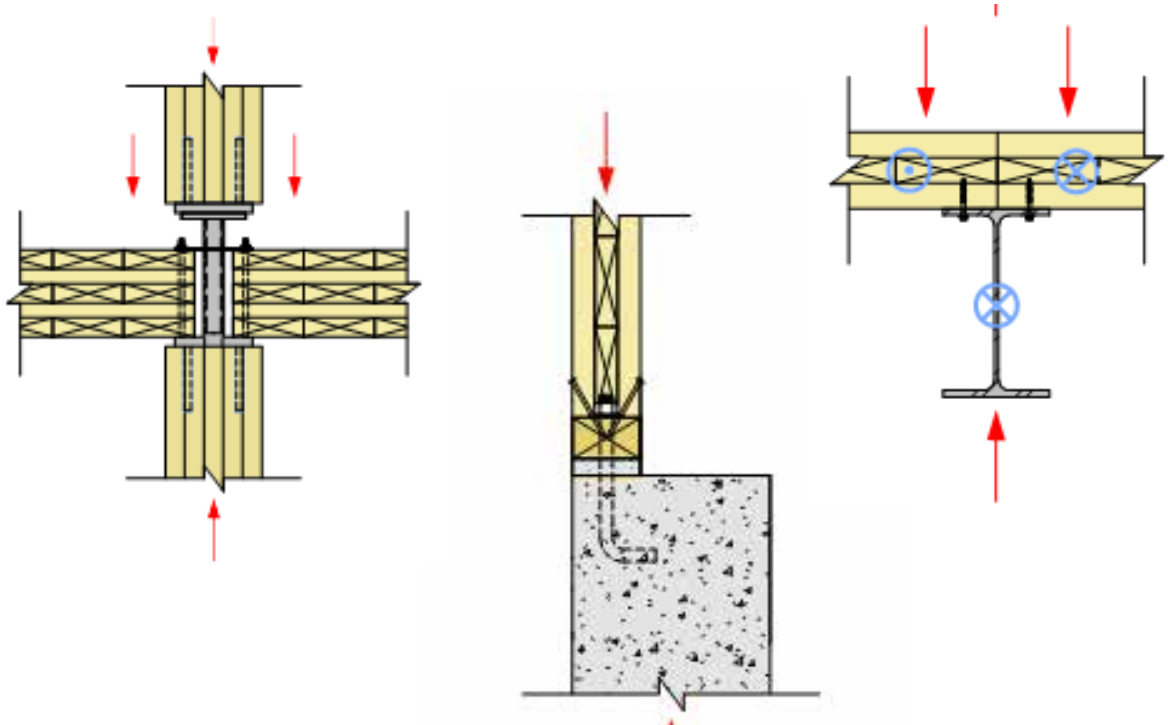
KL&A
Engineers & Builders

OZ
ARCHITECTURE
URBAN DESIGN
INTERIOR DESIGN

SWINERTON
MASS TIMBER

A library of commonly used mass timber connections with designer notes and information on fire resistance, relative cost and load-carrying capacity.





GRID OPTIONS AND MEMBER SIZES: WHAT'S BEEN DONE

PHOTO CREDIT: JOHN STAMETS

BULLITT CENTER

SEATTLE, WA

11’-6” BEAM SPACING
11’-6” COLUMN SPACING AT EXTERIOR
23’-0” COLUMN SPACING AT INTERIOR
2X6 NLT FLOOR DECK

PHOTO CREDIT: JOHN STAMETS

CLAY CREATIVE

PORTLAND, OR

- ~8’ FINISHED FLOOR TO BOTTOM OF BEAM
- 25’X30’ AT PERIMETER
- 30’X30’ BAYS AT CENTER
- 2X6 NLT SPANS 15’
- EXTERIOR STEEL MOMENT FRAME KEEPS CORE AREA MORE VERSATILE

HUDSON BUILDING

VANCOUVER, WA

- 25’X25’ GRID, 1 ROW INTERMEDIATE BEAMS
- 15’-18’ FLOOR TO FLOOR HEIGHTS
- COMPOSITE FLOOR: 2X4 AND 2X6 NLT FLOOR PANELS WITH 3 ½” REINFORCED CONCRETE TOPPING

IMAGE CREDIT: CHRISTIAN COLUMBRES

T3 MINNEAPOLIS

MINNEAPOLIS, MN

20’X25’ GRID

2X8 NLT FLOOR PANELS SPAN 20’ W/3” CONCRETE TOPPING

IMAGE CREDIT: EMA PETER

ALBINA YARD

PORTLAND, OR

20’X20’ GRID
BEAMS AT 10’ O.C.
3-PLY CLT

ARCHITECT: LEVER ARCHITECTURE
IMAGE CREDIT: LEVER ARCHITECTURE

FIRST TECH CREDIT UNION

HILLSBORO, OR

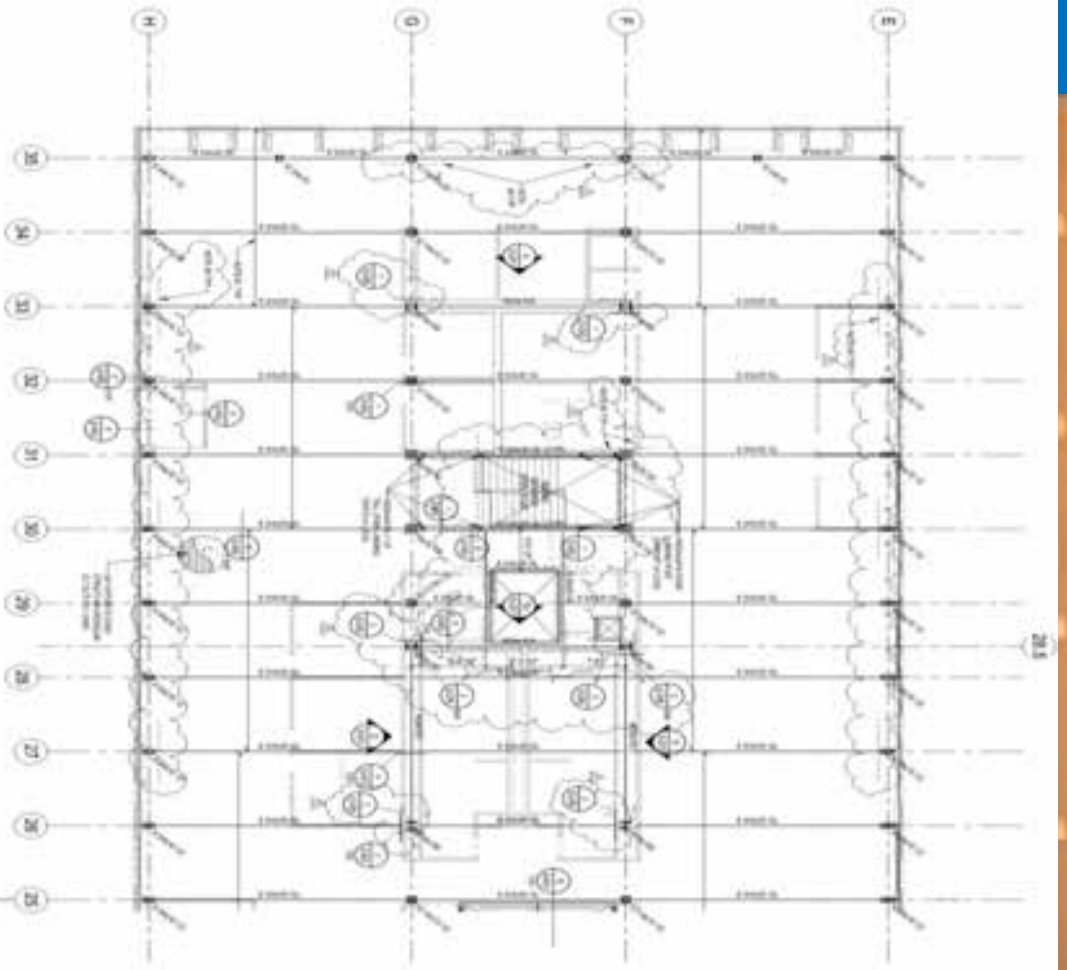


IMAGE CREDIT: SWINERTON BUILDERS

5-1/2”, 5-PLY CLT SPANS 12’

ARCHITECT: HACKER

IMAGE CREDIT: STRUCTURLAM

JOHN W. OLVER DESIGN BUILDING

UMASS, AMHERST, MA

- 5-PLY CLT FLOOR PANELS, COMPOSITE WITH HBV SYSTEM
- GRIDS 20’X24’ TO 26’

PHOTO CREDIT: ALEX SCHREYER

BROCK COMMONS

VANCOUVER, BC

5 PLY CLT PANELS, 2-WAY SPAN

~9’X13’ GRID OF COLUMNS

IMAGES: ACTON OSTRY ARCHITECTS

MASS TIMBER APPEAL

MASS TIMBER APPEAL

PRIMARY DRIVERS

CONSTRUCTION SPEED & EFFICIENCY

CONSTRUCTION SITE CONSTRAINTS – URBAN INFILL

INNOVATION/AESTHETIC

SECONDARY DRIVERS

CARBON REDUCTIONS

STRUCTURAL PERFORMANCE – LIGHT WEIGHT

MASS TIMBER APPEAL

REDUCED CONSTRUCTION TIME

MURRAY GROVE,
LONDON UK
8 STORIES OF CLT OVER 1 STORY CONCRETE PODIUM

8 STORIES BUILT IN 27 DAYS (~1/2 THE TIME OF PRECAST CONCRETE)

LESS TIME ON SITE = LESS $$

FRANKLIN ELEMENTARY SCHOOL, FRANKLIN, WV

45,200 FT2 2 STORY ELEMENTARY SCHOOL

8 WEEKS TO CONSTRUCT

MASS TIMBER APPEAL

REDUCED CONSTRUCTION TIME

1 Floor = 3 Days

17 Floors Erected in 9.5 Weeks

MASS TIMBER APPEAL

ALTERNATE TO CONCRETE & MASONRY

PHOTO CREDIT: CHARLES JUDD

MASS TIMBER APPEAL

MATERIAL MASS

75% LIGHTER WEIGHT THAN CONCRETE

ESTIMATED ENVIRONMENTAL IMPACT OF WOOD USE

Volume of wood products used:
2,233 cubic meters of CLT and Glulam

U.S. and Canadian forests grow this much wood in:
6 minutes

Carbon stored in the wood:
1,753 metric tons of CO_2

Avoided greenhouse gas emissions:
679 metric tons of CO_2

Total potential carbon benefit:
2,432 metric tons of CO_2

THE ABOVE GHG EMISSIONS ARE EQUIVALENT

511 cars off the road for a year

Energy to operate a home for 222 years

**Estimated by the Wood Carbon Calculator for Buildings, based on research by Sathre, R. and J. O'Connor, 2010, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations (this relates to carbon stored and avoided GHG).*

**CO2 in this case study refers to CO2 equivalent*

SOURCE: NATURALLY: WOOD

MASS TIMBER APPEAL

REDUCED EMBODIED CARBON

BROCK COMMONS, VANCOUVER, BC

PHOTO CREDIT: ACTON OSTRY ARCHITECTS

MASS TIMBER APPEAL

PREFABRICATED AND PRECISE

MASS TIMBER ELEMENTS FABRICATED TO TIGHT TOLERANCES (1/16” IS COMMON)

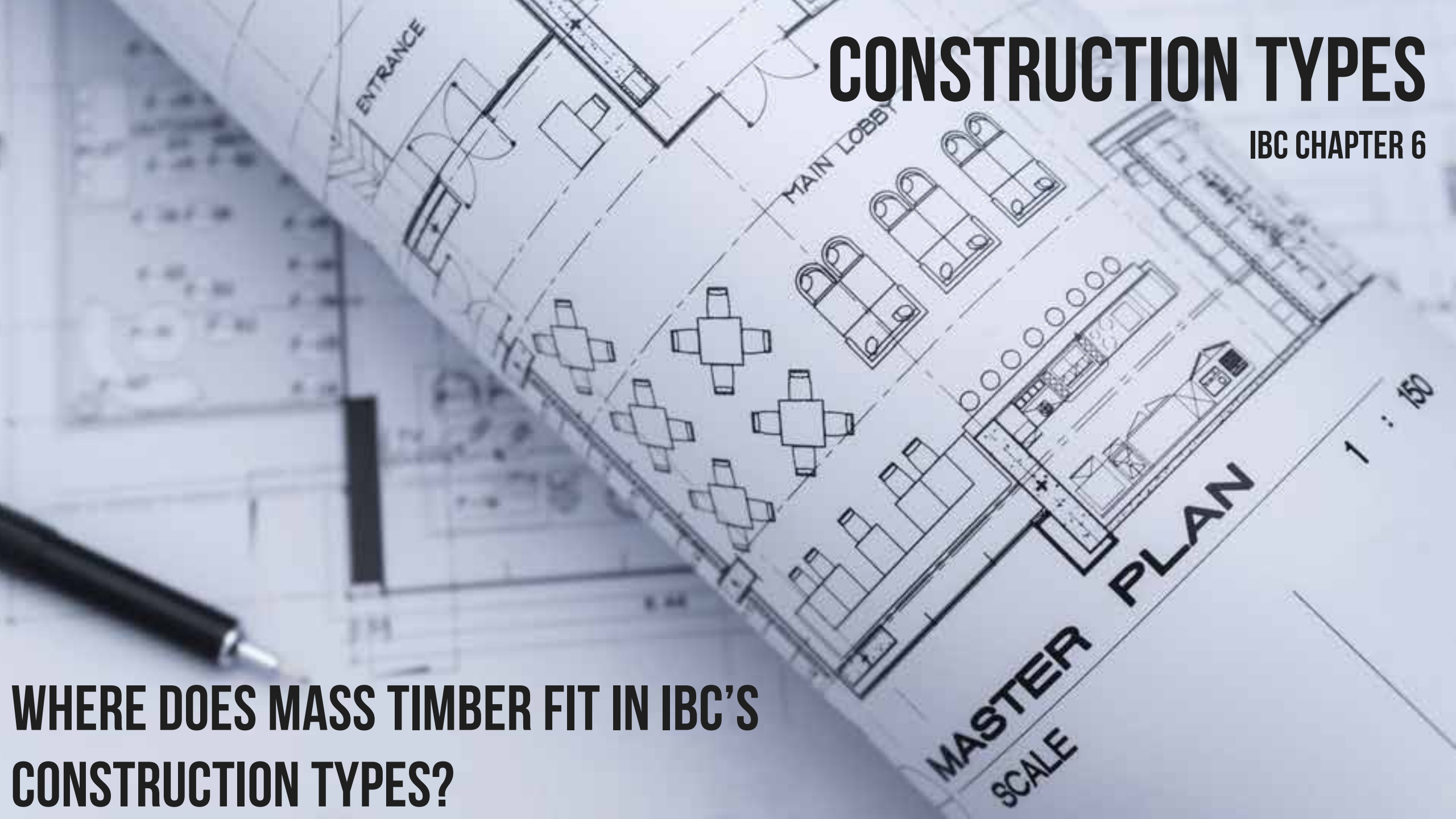
COMPUTER NUMERICALLY CONTROLLED (CNC) CONNECTIONS

PHOTO CREDIT: NATURALLY WOOD

MASS TIMBER DESIGN

DESIGN TOPICS

- CONSTRUCTION TYPES
- FIRE RESISTANCE
- ACOUSTICS
- SHAFTS
- MEP DETAILING
- BUILDING ENCLOSURE
- LATERAL FRAMING
- CONNECTIONS
- CONSTRUCTION PROCESS



CONSTRUCTION TYPES

IBC CHAPTER 6

WHERE DOES MASS TIMBER FIT IN IBC'S CONSTRUCTION TYPES?

CONSTRUCTION TYPES

IBC 602

ALL WOOD FRAMED BUILDING OPTIONS:

TYPE III

EXTERIOR WALLS NON-COMBUSTIBLE (MAY BE FRTW)

INTERIOR ELEMENTS ANY ALLOWED BY CODE, INCLUDING MASS TIMBER

TYPE V

ALL BUILDING ELEMENTS ARE 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)

CONSTRUCTION TYPES

Type III: 6 stories

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

Image credit: Ema Peter

Type IV: 6 stories

Image: Christian Columbres Photography

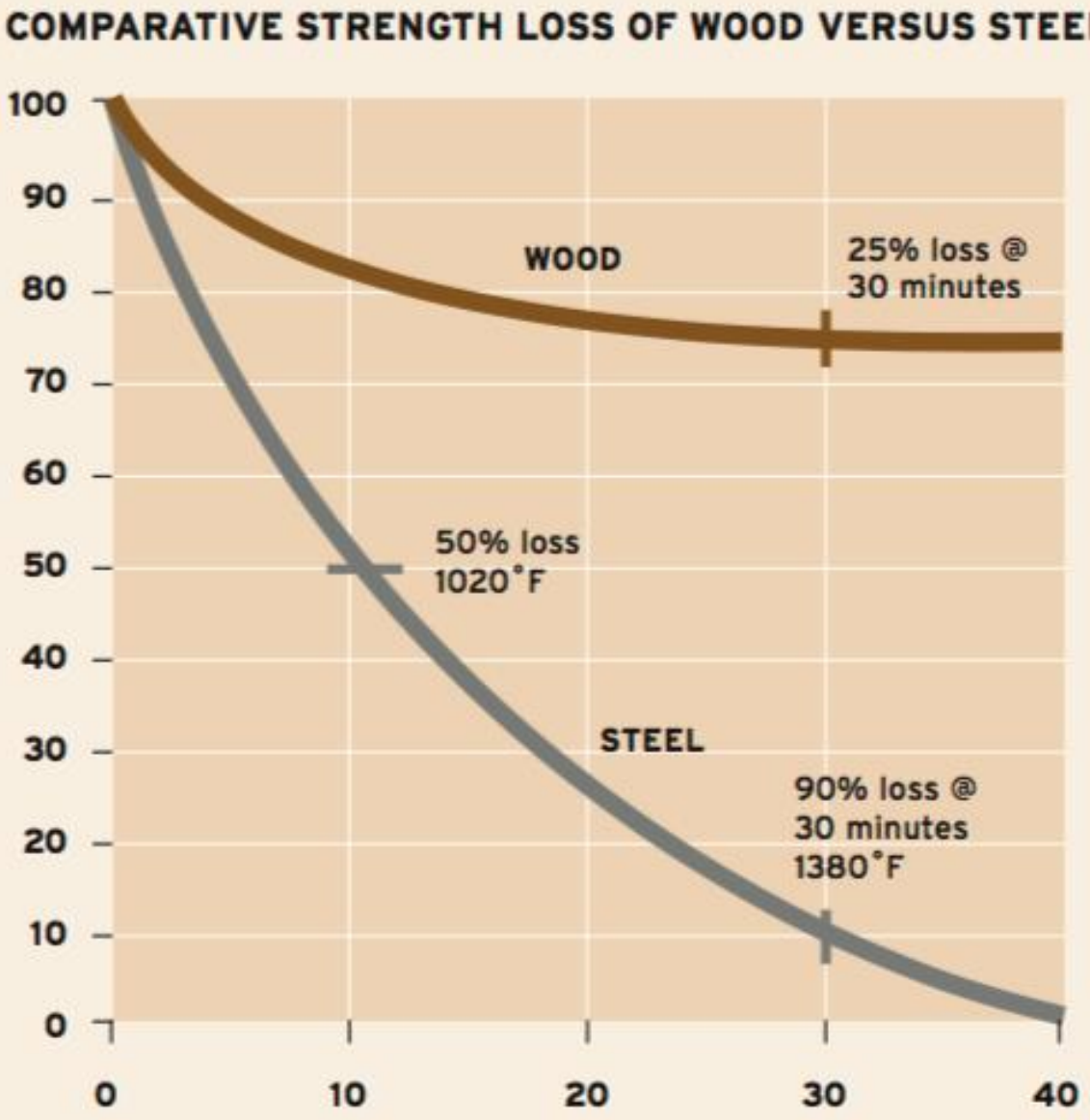
Type V: 4 stories

FIRE RESISTANCE

PHOTO CREDIT: FP INNOVATIONS

MASS TIMBER DESIGN

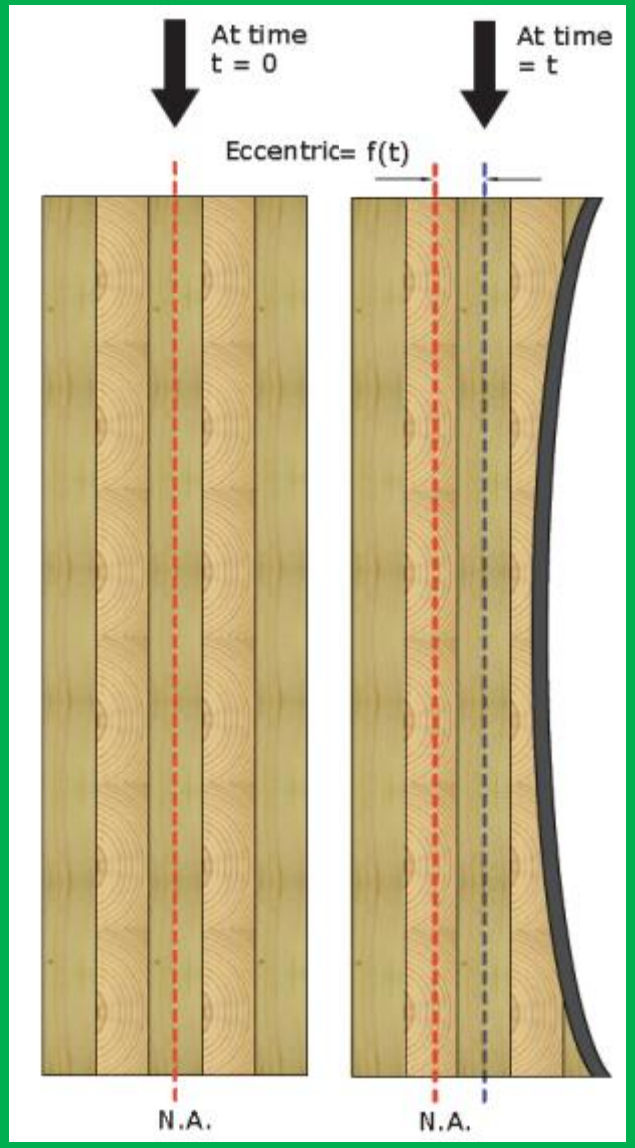
FIRE RESISTANCE



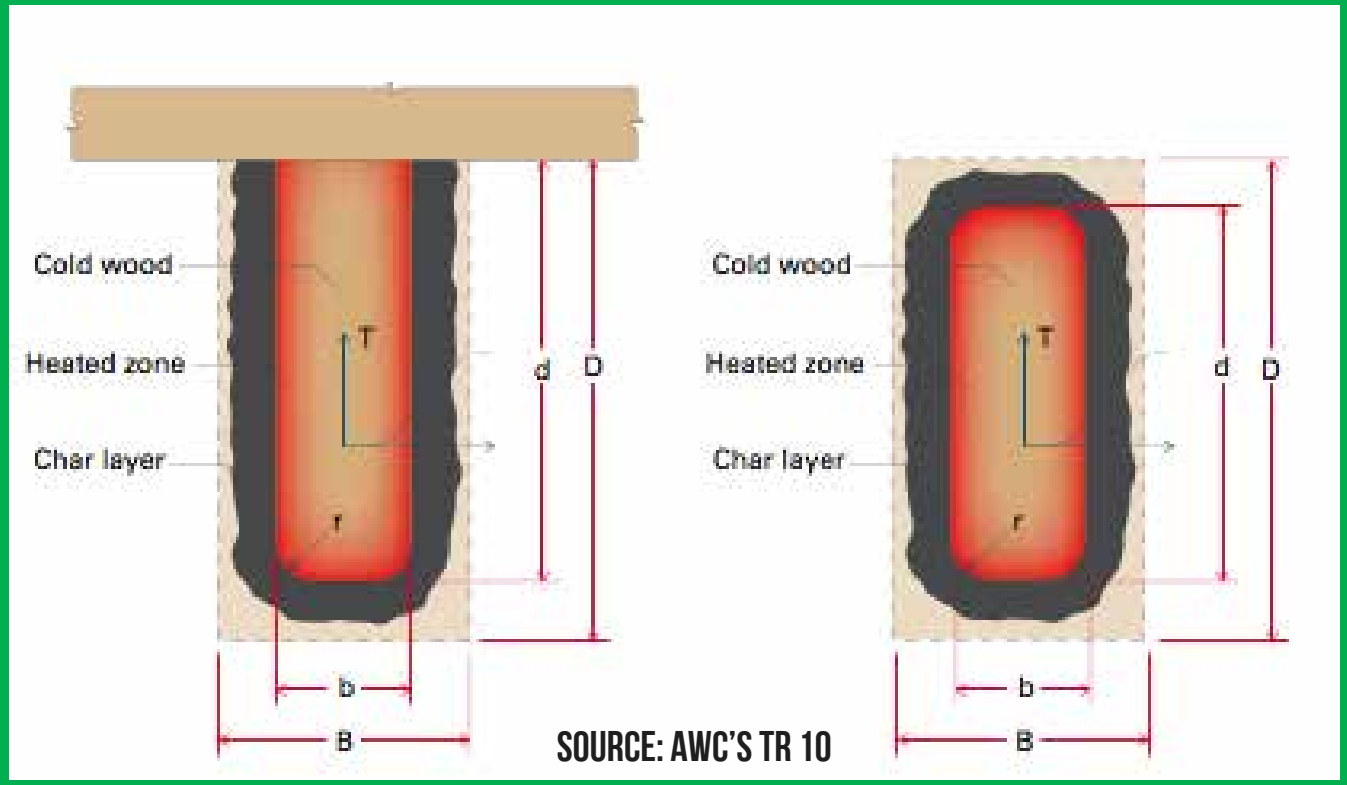
SOURCE: AITC

MASS TIMBER DESIGN

FIRE RESISTANCE



SIMILAR TO HEAVY TIMBER, MASS TIMBER PRODUCTS HAVE INHERENT FIRE RESISTANCE PROPERTIES



SOURCE: AWC'S TR 10

MASS TIMBER DESIGN

FIRE RESISTANCE

Mass timber in **other than** Type IV Construction:

- IBC 703.3 allows several options, including:
  - ASTM E119 assembly test
  - Calculations per IBC 722 → NDS Chapter 16

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)*.

MT Fire Resistance Ratings (FRR)

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

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

Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

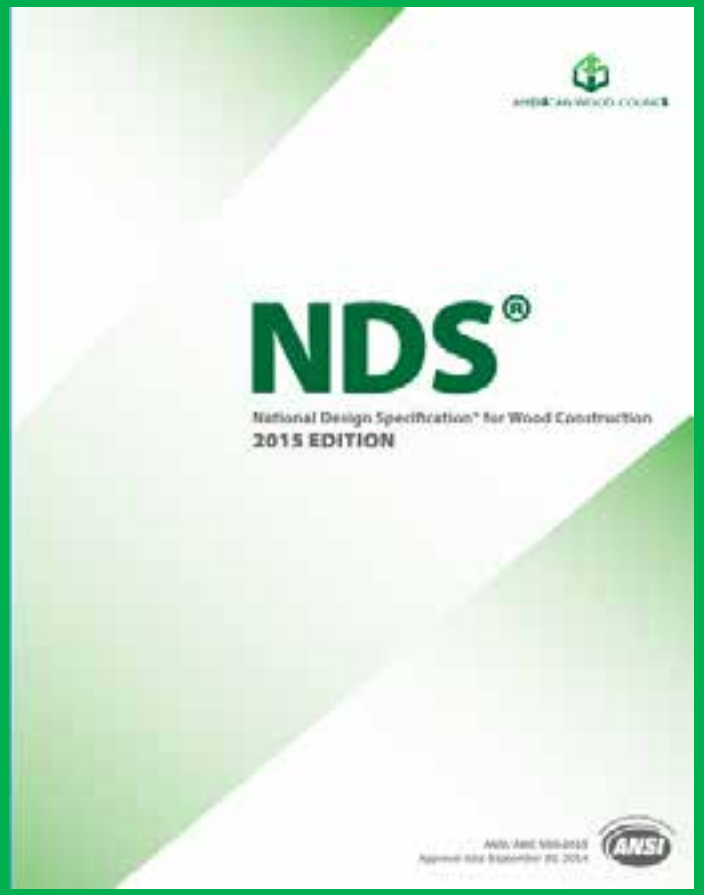
Table 16.2.1B Effective Char Depths (for CLT with β_n=1.5in./hr.)

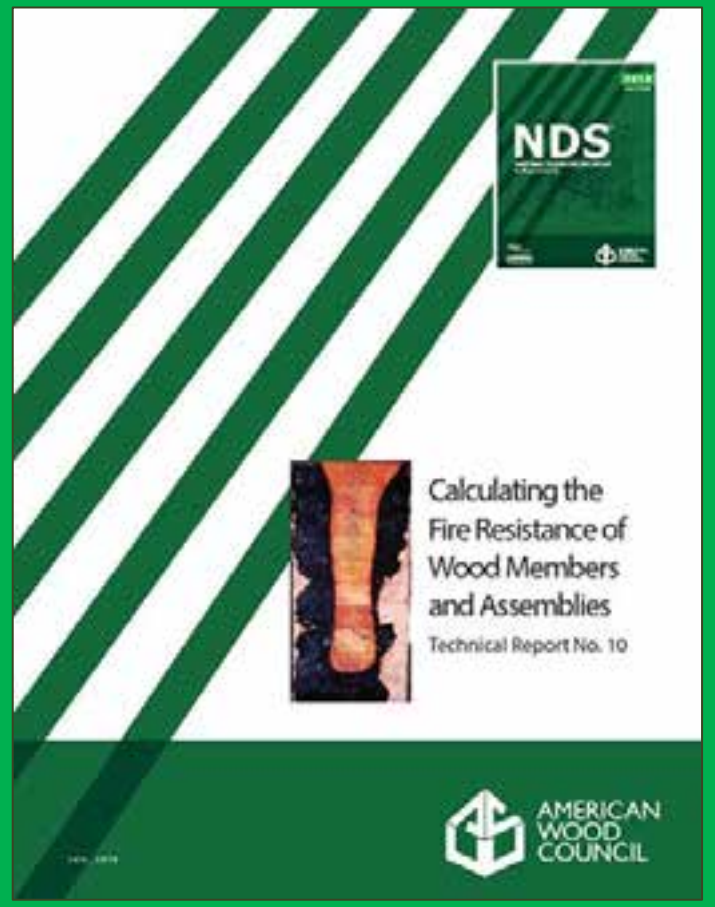
Required Fire Endurance (hr.)	Effective Char Depths, a_{char} (in.) lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

MASS TIMBER DESIGN

FIRE RESISTANCE

FOR EXPOSED WOOD MEMBERS: IBC 722.1 REFERENCES AWC'S NDS CHAPTER 16 (AWC'S TR 10 IS A DESIGN AID TO NDS CHAPTER 16)





MASS TIMBER PRODUCTS

ACOUSTICS

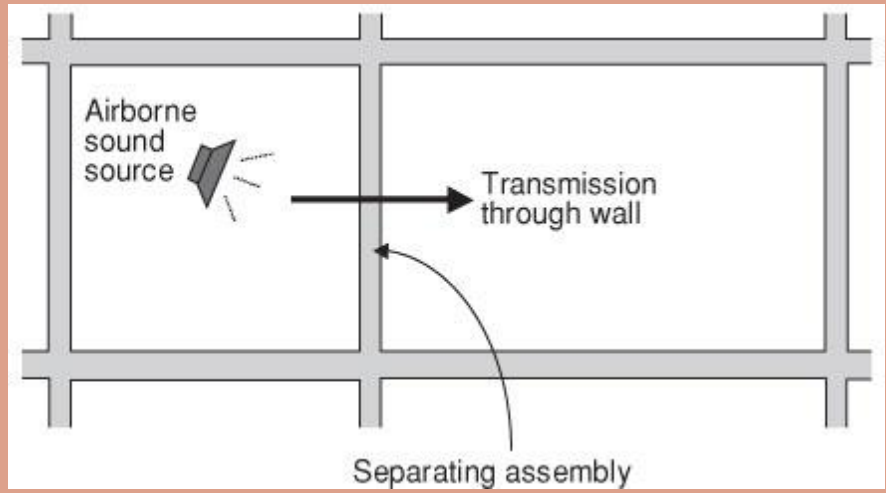
MASS TIMBER DESIGN

ACOUSTICS

AIR-BORNE SOUND:

- SOUND TRANSMISSION CLASS (STC)

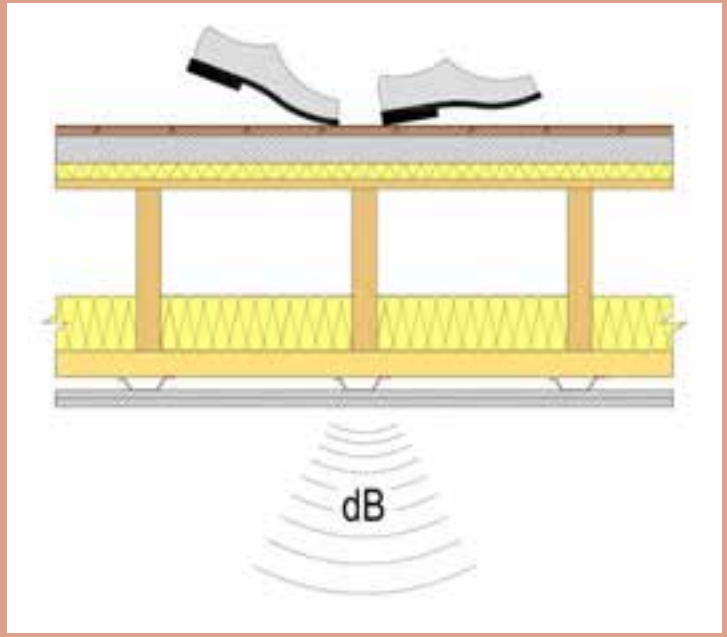
MEASURES HOW EFFECTIVELY AN ASSEMBLY ISOLATES AIR-BORNE SOUND AND REDUCES THE LEVEL THAT PASSES FROM ONE SIDE TO THE OTHER



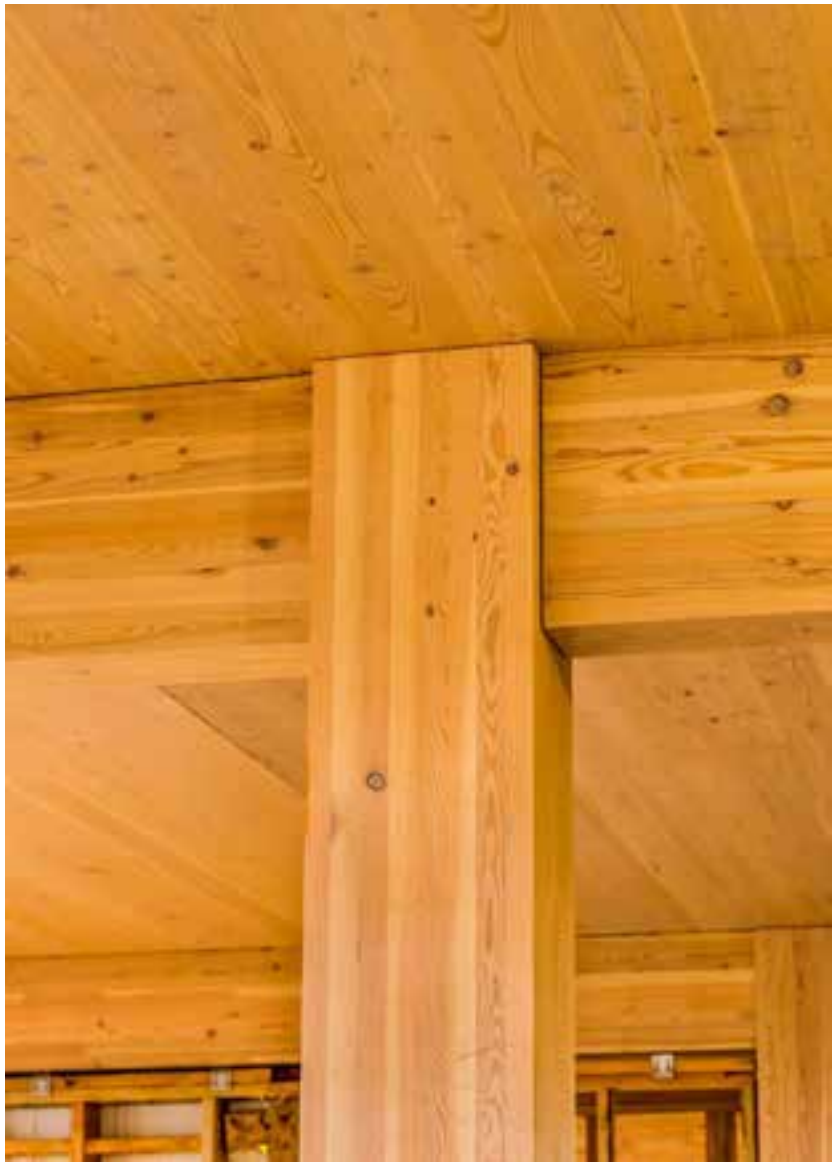
STRUCTURE-BORNE SOUND:

- IMPACT INSULATION CLASS (IIC)

EVALUATES HOW EFFECTIVELY AN ASSEMBLY BLOCKS IMPACT SOUND FROM PASSING THROUGH IT



Mass Timber: Structure Often is Finish

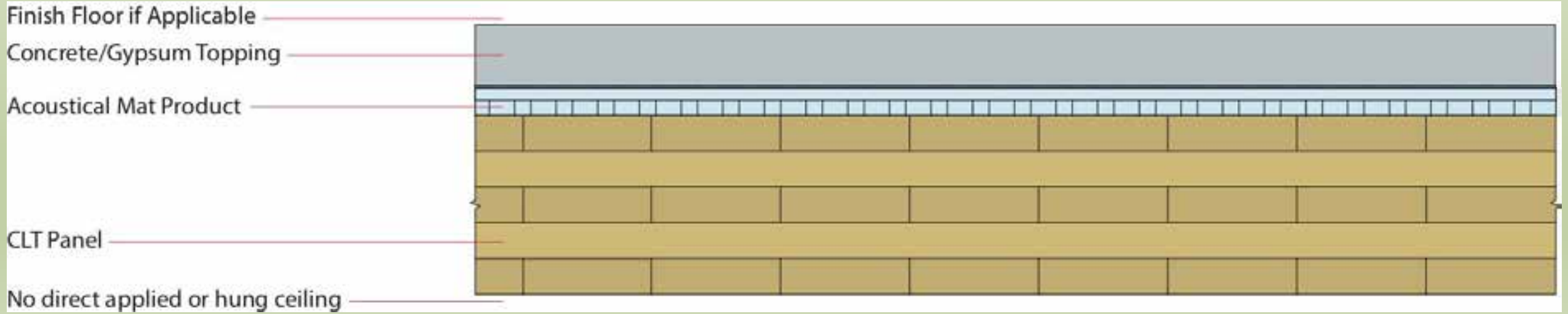


Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman | Architect: PATH Architecture

Mass Timber Acoustics

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

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



MASS TIMBER SHAFTS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER SHAFTS

MASS TIMBER SHAFT WALLS

- COST
- CONSTRUCTION SCHEDULE
- MATERIAL COMPATIBILITY (MOVEMENT & LATERAL LOAD RESISTANCE)
- CAN DOUBLE AS ARCHITECTURAL FEATURE
- SIMILAR TO TILT UP OR CONTINUOUS WALL APPLICATIONS
- SUCCESSFUL FIRE TESTS FOR 2 HR MASS TIMBER SHAFT WALLS EXIST (EXPOSED AND PROTECTED)

PHOTO CREDIT: LENDLEASE

MEP DETAILING

PHOTO CREDIT: ALEX SCHREYER

WOOD INNOVATION DESIGN CENTER

PRINCE GEORGE, BC

PHOTO CREDIT: ED WHITE

WIDC MEP ACCOMMODATION

PHOTO CREDIT: EMA PETER

MASS TIMBER PRODUCTS

ACCOMMODATING MEP

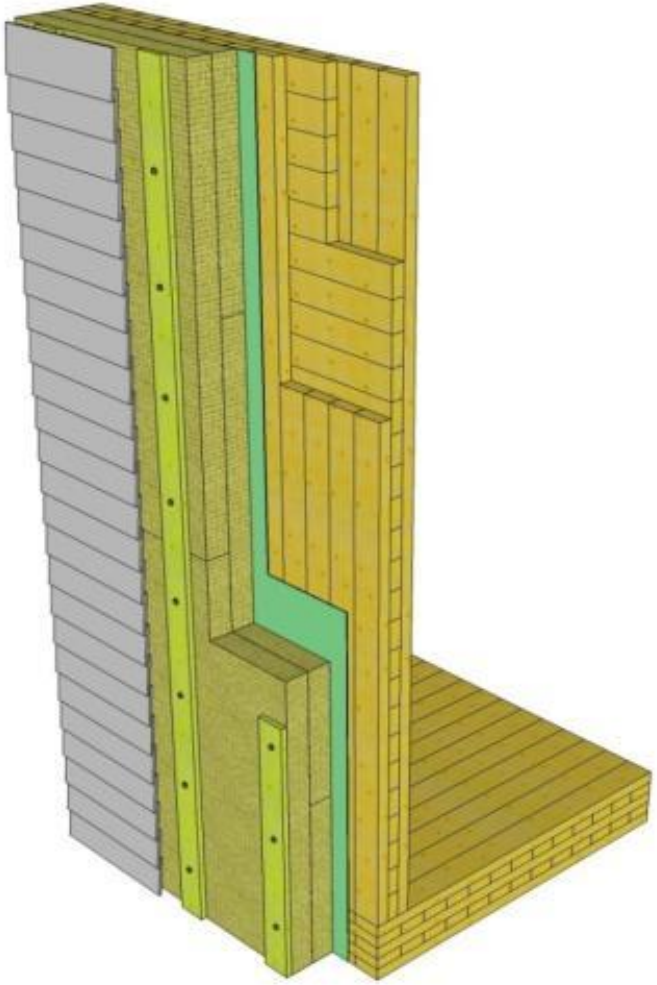
EMBEDDED CONDUIT IN CONCRETE TOPPING SLAB

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

BUILDING ENCLOSURE

MASS TIMBER BUILDING ENVELOPES



SIMILAR TO OTHER WALL ASSEMBLIES:
CONTINUOUS INSULATION AND OTHER CONTROL LAYERS
INSTALLED ON OUTSIDE OF WALL PANELS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

BUILDING ENCLOSURE

PHOTO CREDIT: JOHN STAMETS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

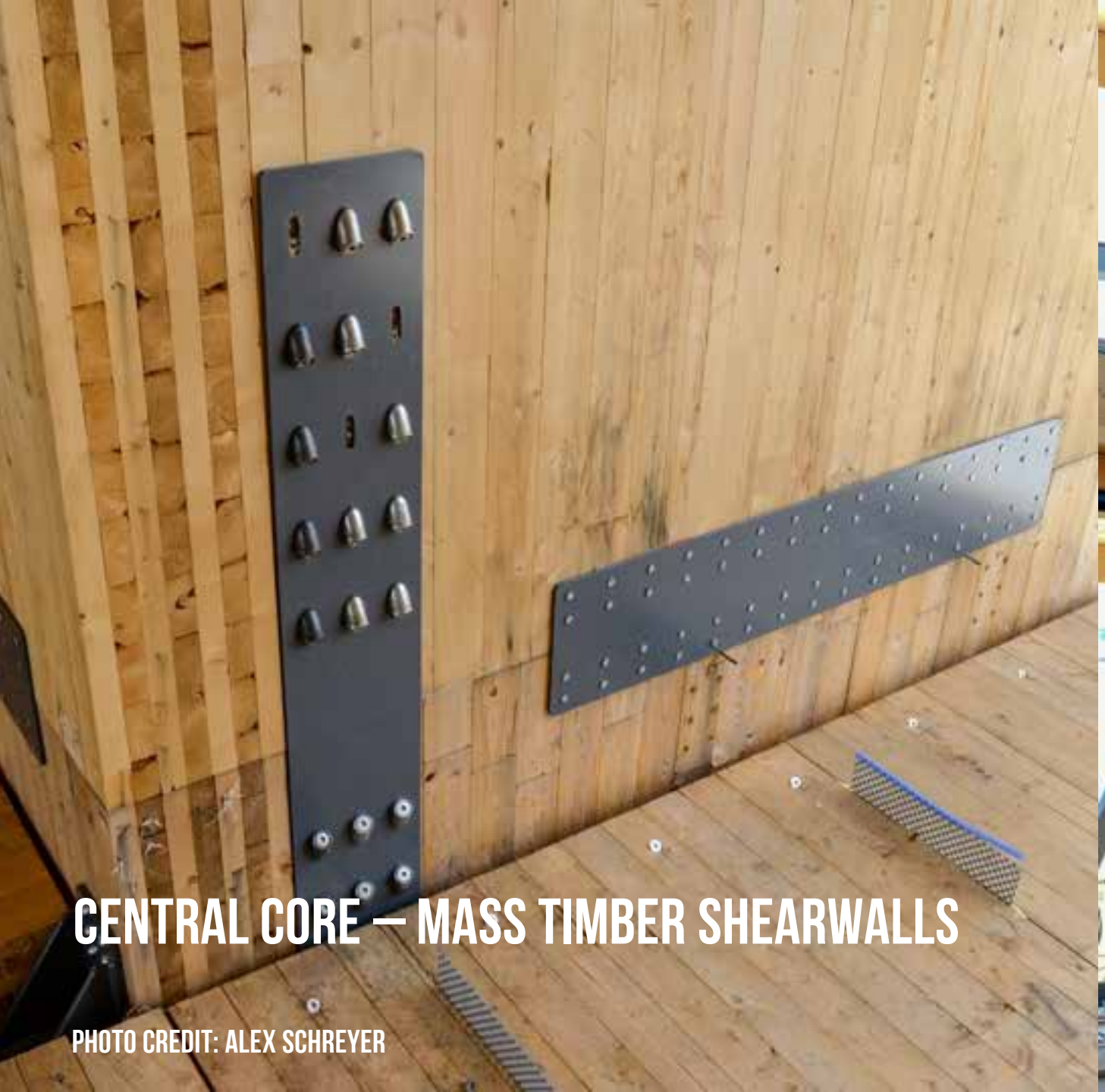
LATERAL FRAMING SYSTEMS

CENTRAL CORE – CONCRETE SHEARWALLS

PHOTO CREDIT: STRUCTURECRAFT

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS



CENTRAL CORE – MASS TIMBER SHEARWALLS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS

INTERIOR STEEL MOMENT FRAME

PHOTO CREDIT: WOODWORKS

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS

STEEL BRACED FRAME

PHOTO CREDIT: JOHN STAMETS

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS

INTERIOR WOOD SHEARWALLS

PHOTO CREDIT: WOODWORKS

MASS TIMBER DESIGN

CONNECTIONS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

CONNECTION DESIGN CONSIDERATIONS:

- STRUCTURAL CAPACITY
- SHRINKAGE
- FIRE
- CONSTRUCTABILITY
- AESTHETICS
- COST

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

PHOTO CREDIT: ALEX SCHREYER

LONG SELF TAPPING SCREWS USED EXTENSIVELY THROUGHOUT MASS TIMBER CONSTRUCTION

PHOTO CREDIT: MYTICON

MASS TIMBER DESIGN

CONNECTIONS

BEAM TO BEAM CONNECTIONS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

PHOTO CREDIT: STRUCTURECRAFT

BEAM TO COLUMN CONNECTIONS

PHOTO CREDIT: STRUCTURECRAFT

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

BEAM TO COLUMN & COLUMN TO COLUMN CONNECTIONS

PHOTO CREDIT: JOHN STAMETS

MASS TIMBER DESIGN

CONNECTIONS

COLUMN TO FOUNDATION CONNECTIONS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

PANEL TO FOUNDATION CONNECTIONS

PHOTO CREDIT: STRUCTURECRAFT

PHOTO CREDIT: CHARLES JUDD

PHOTO CREDIT: CHARLES JUDD

MASS TIMBER DESIGN

CONNECTIONS

PANEL TO PANEL CONNECTIONS – SURFACE SPLINE

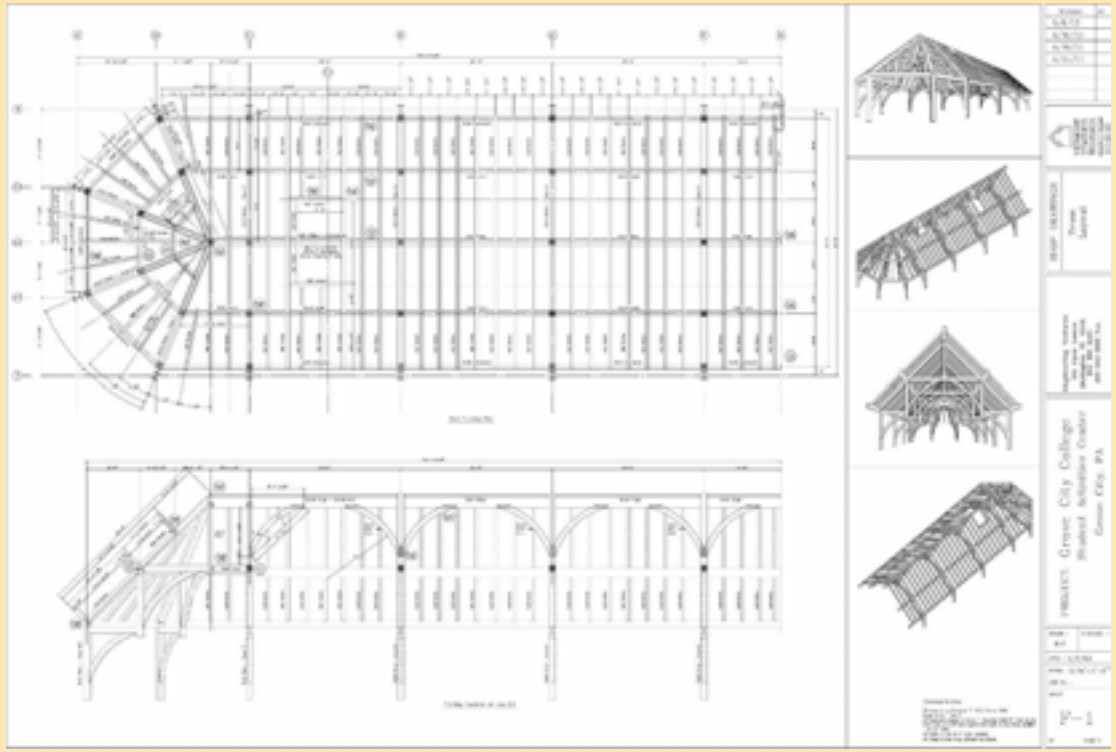
PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER PRODUCTS

CONSTRUCTION

WHAT DOES A MASS TIMBER CONSTRUCTION PROCESS LOOK LIKE?

VERY SIMILAR TO A PRECAST CONCRETE OR STRUCTURAL STEEL PROJECT



- SHOP DRAWINGS
- ERECTION DRAWINGS
- PREFABRICATED MEMBERS AND CONNECTIONS

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

Anthony Harvey, PE

Woodworks Regional Director

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513-222-3038

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Funding provided in part by the Softwood Lumber Board