41st Annual State Construction Conference

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NC DOA
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Advancements in Heavy Timber Construction: Design & Construction

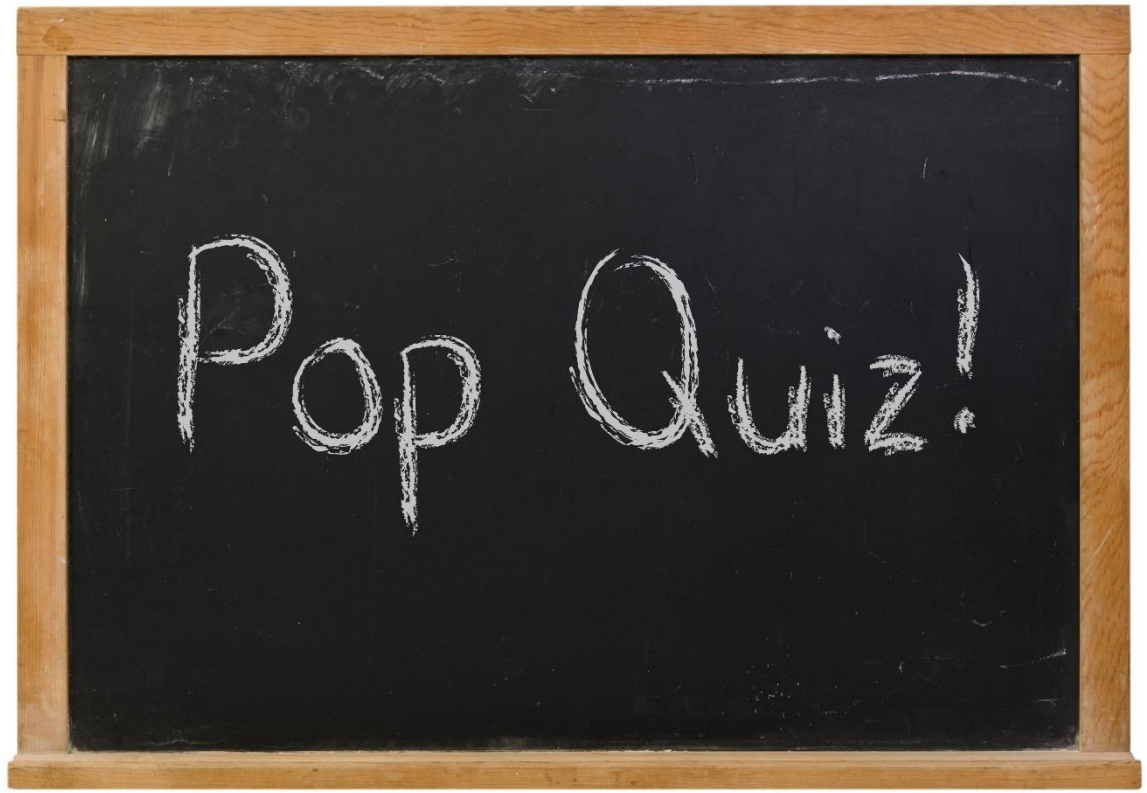
Presenter: Jessica Scarlett, Regional Director NC I SC I TN

WoodWorks – Wood Products Council

MASS TIMBER DESIGN

DESIGN TOPICS

- CONSTRUCTION TYPES
- FIRE RESISTANCE
- MEP DETAILING
- LATERAL FRAMING
- CONNECTIONS
- CONSTRUCTION PROCESS



MASS TIMBER DESIGN

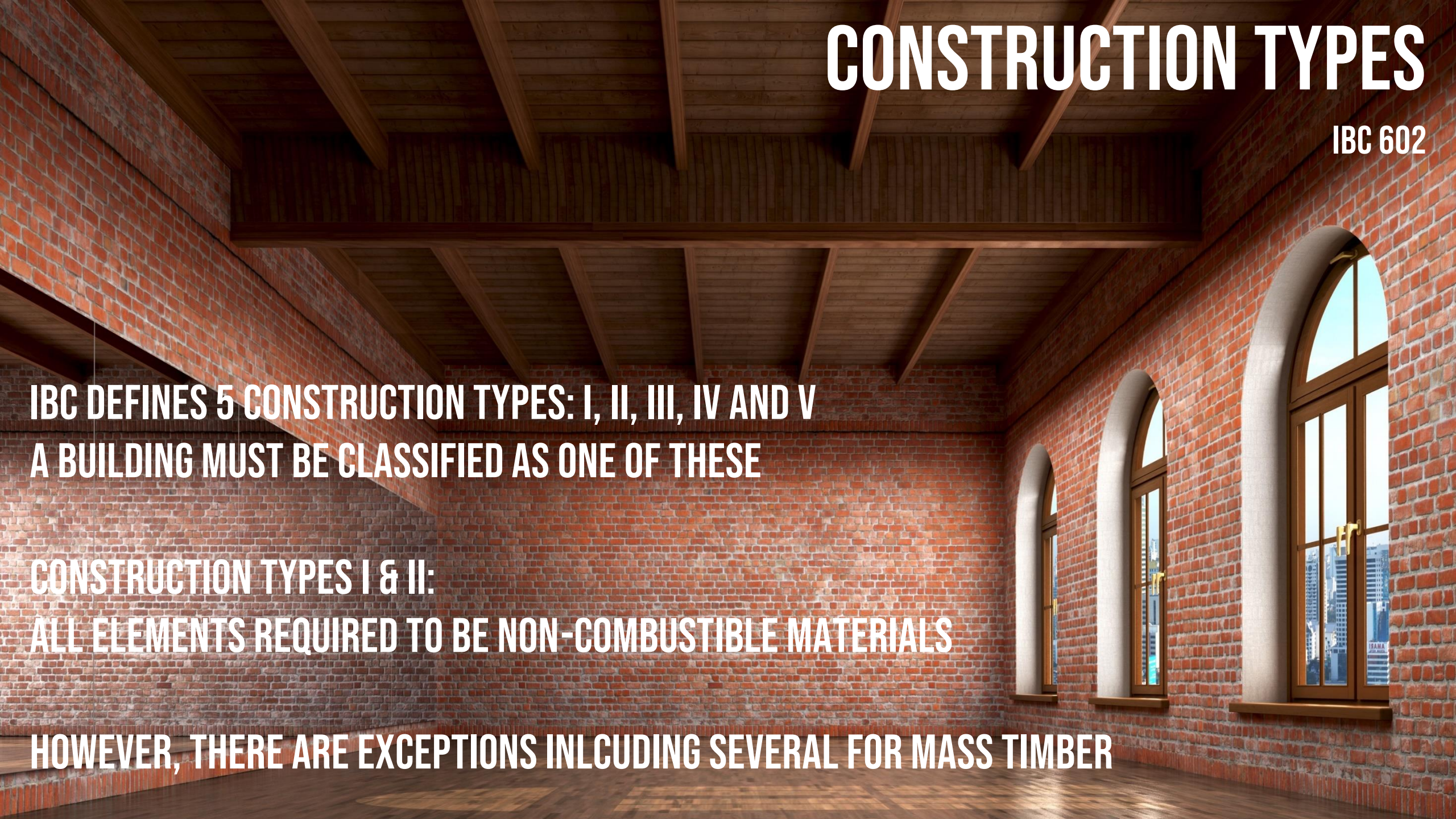
CONSTRUCTION TYPES

Q: OF THE 5 CONSTRUCTION TYPES, WHICH ONES CAN MASS TIMBER BE USED IN?

A: ALL 5!

CONSTRUCTION TYPES

IBC 602



IBC DEFINES 5 CONSTRUCTION TYPES: I, II, III, IV AND 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 INLCUDING SEVERAL FOR MASS TIMBER

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

Image: StructureCraft Builders

Chapter 6: Types of Construction

Where does the code allow MT to be used?

- Type IB & II: Roof Decking

Construction Type IB
Exposed Timber Roof Decking and Framing

Portland International Jetport

- LEED Gold
- Completed 2012

Design Team: Gensler, Oest Associates
Photo Credit: DeStafano & Chamberlain, Inc, Robert Benson Photography

ICE Block I, RMW Architecture & Interiors, Buehler Engineering, Bernard André Photography

CONSTRUCTION TYPES

Chapter 6: Types of Construction

Where does the code allow MT to be used?

- Type III: Interior elements (floors, roofs, partitions/shafts) and exterior walls if FRT

ICE BLOCK I

SACRAMENTO, CA

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

U OF ARKANSAS STUDENT DORMS

FAYETVILLE, AR

(2) – 5 STORY BUILDINGS
TOTAL OVER 200,000 SF
368 RESIDENTIAL ROOMS

IMAGE CREDIT: MODUS STUDIO/LEERS WEINZAPFEL ARCHITECTS

CONSTRUCTION TYPES

Where does the code allow mass timber to be used?

- Type IV: Any interior elements & roofs if meets min. size; exterior walls if FRT. No concealed spaces permitted

Image: Perkins + Will

T3 MINNEAPOLIS

MINNEAPOLIS, MN

IMAGE CREDIT: EMA PETER

UMASS DESIGN BUILDING

AMHERST, MA

COMPLETED SPRING 2017

PHOTO CREDIT: ALEX SCHREYER

CONSTRUCTION TYPES

Chapter 6: Types of Construction

Image: Christian Columbres Photography

Where does the code allow MT to be used?

- Type V: Interior elements, roofs & exterior walls

COMMON GROUND HIGH SCHOOL

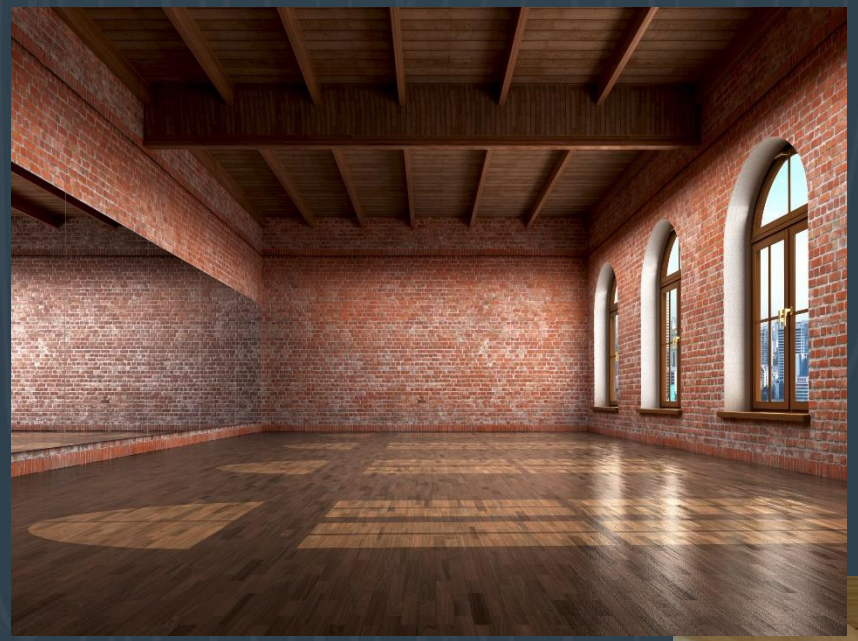
NEW HAVEN, CT

PHOTO CREDIT: DAVID SUNDBERG AND GRAY ORGANSCHI ARCHITECTURE

- 15,000 SF CLASSROOM & MULTI-PURPOSE SPACE ADDITION
- CLT & GLULAM FRAMING SCHEME
- TYPE VB CONSTRUCTION

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

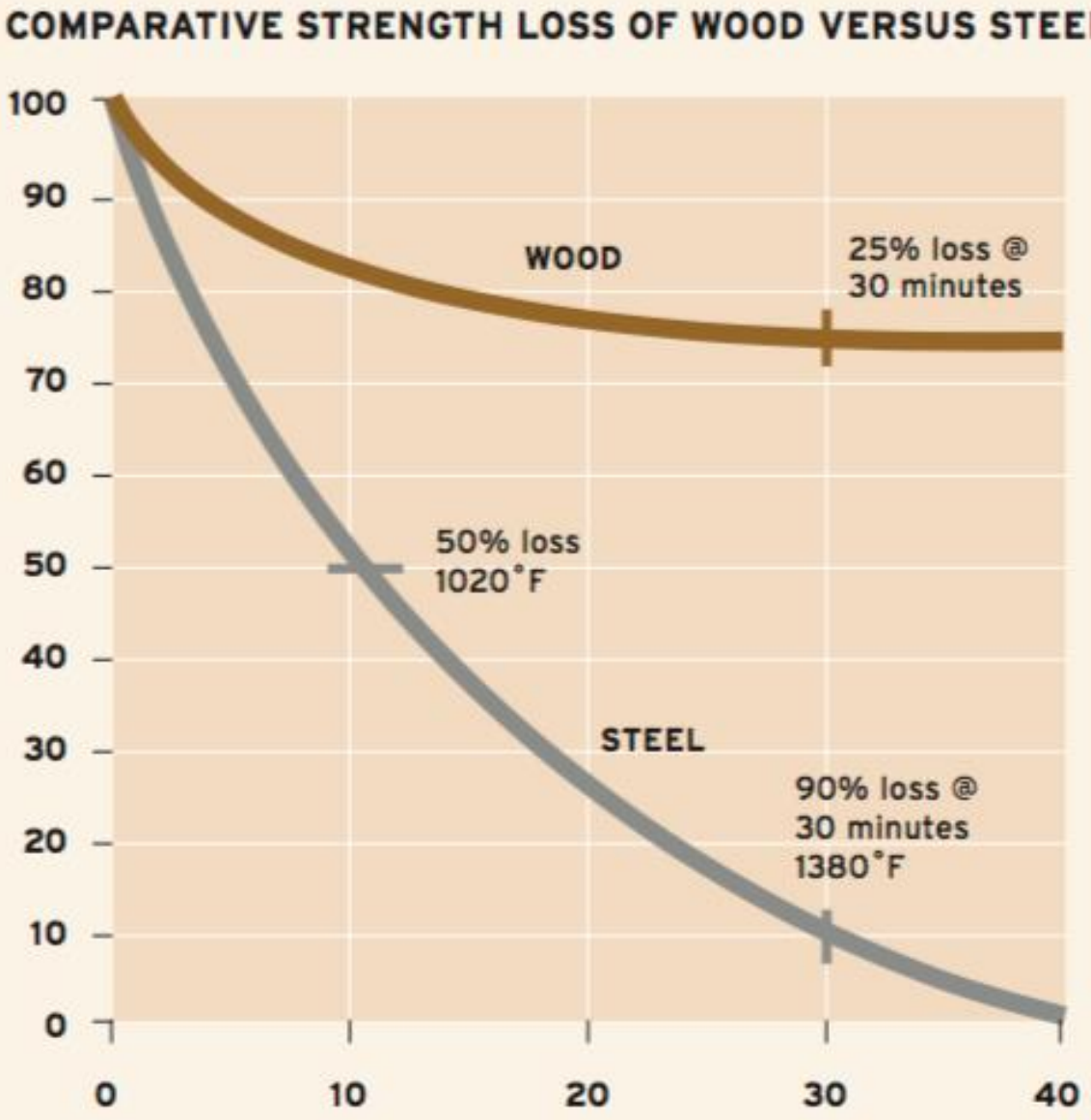
Type V: 4 stories

FIRE RESISTANCE

PHOTO CREDIT: FPINNOVATIONS

MASS TIMBER DESIGN

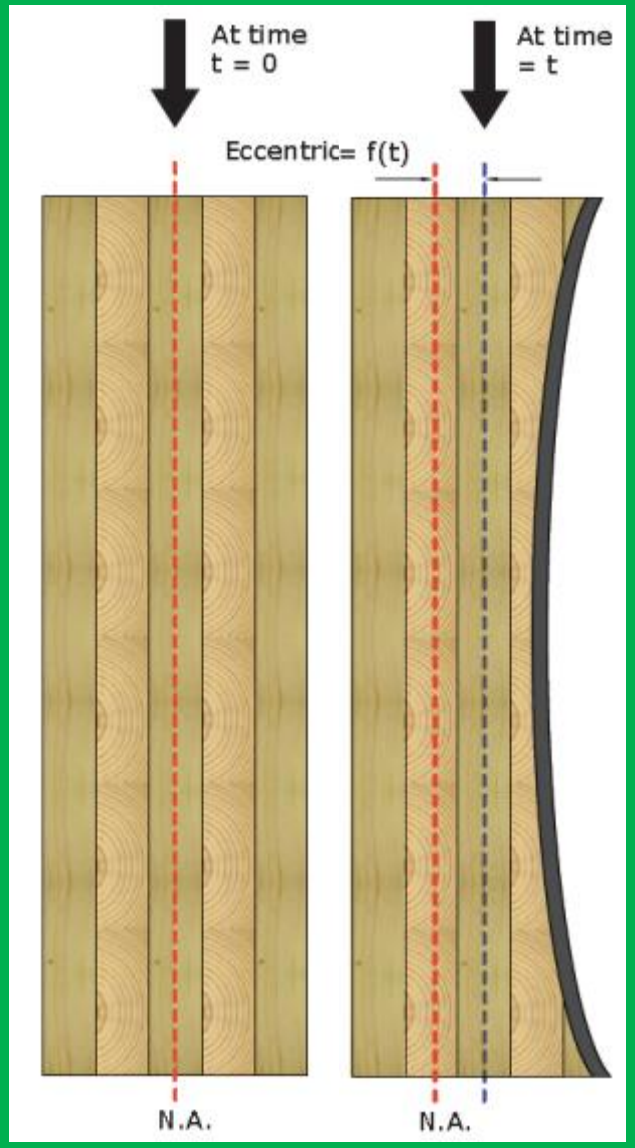
FIRE RESISTANCE



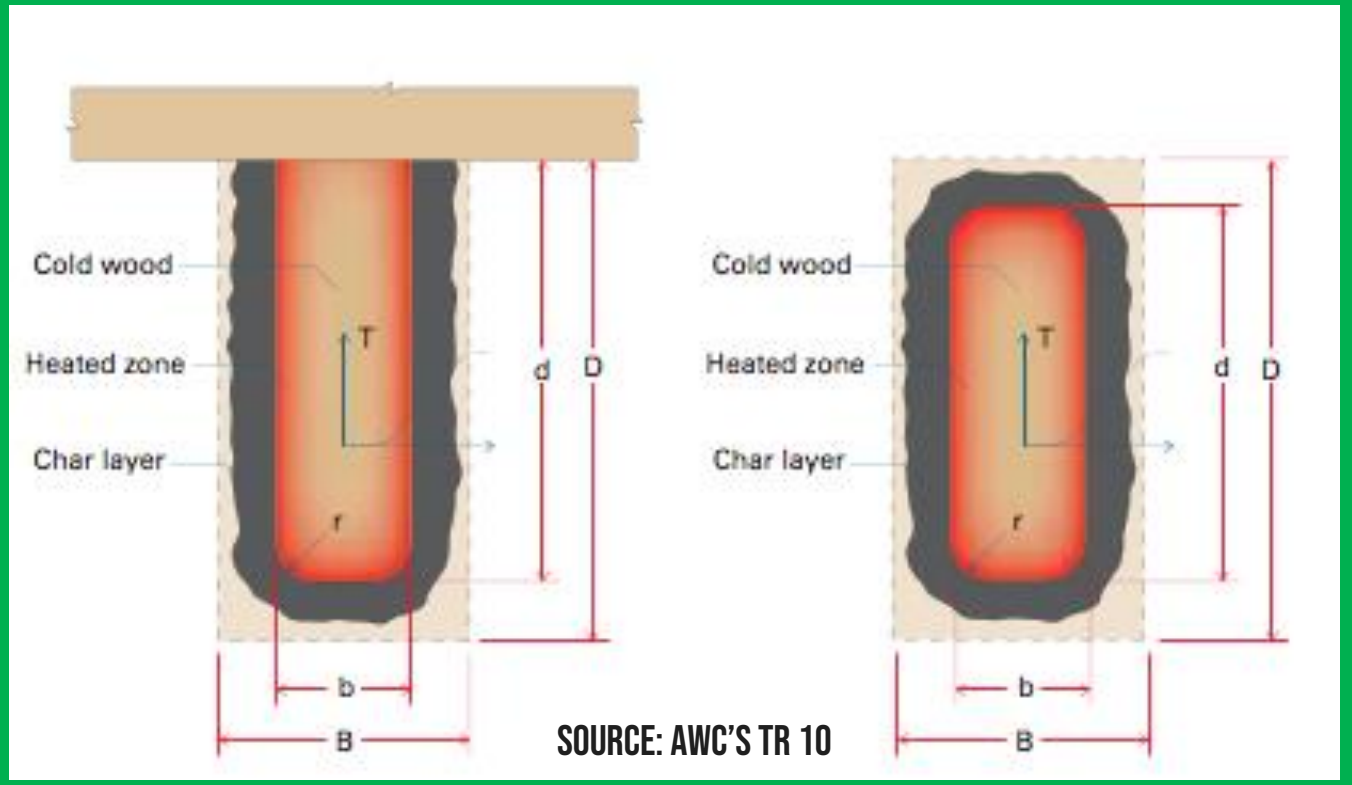
SOURCE: AITC

MASS TIMBER DESIGN

FIRE RESISTANCE



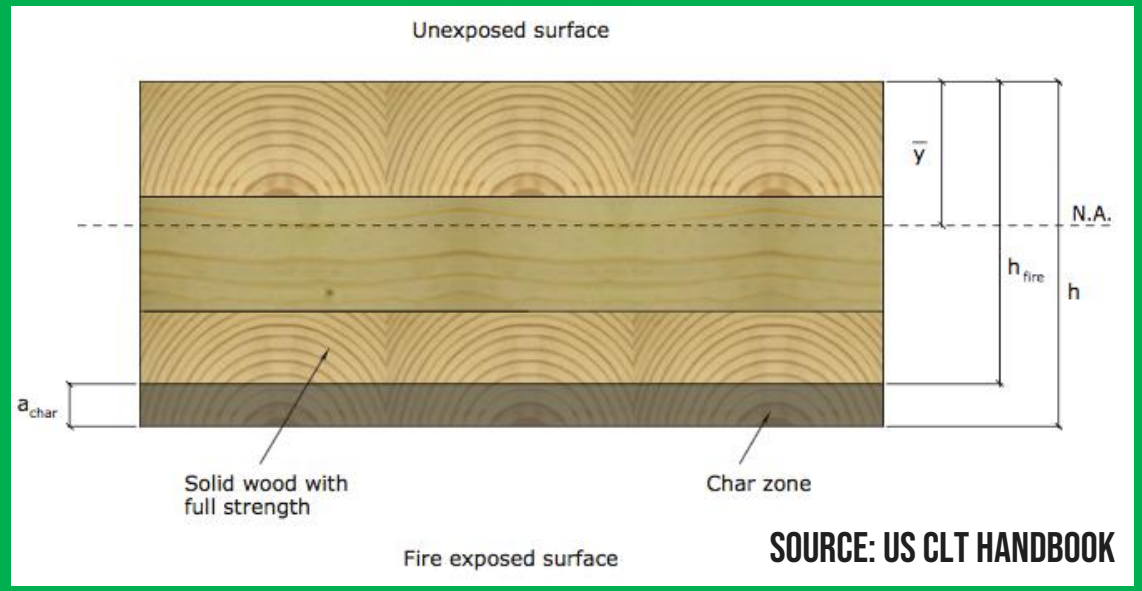
SIMILAR TO HEAVY TIMBER, MASS TIMBER PRODUCTS HAVE INHERENT FIRE RESISTANCE PROPERTIES



SOURCE: AWC'S TR 10

MASS TIMBER DESIGN

FIRE RESISTANCE



SOURCE: US CLT HANDBOOK

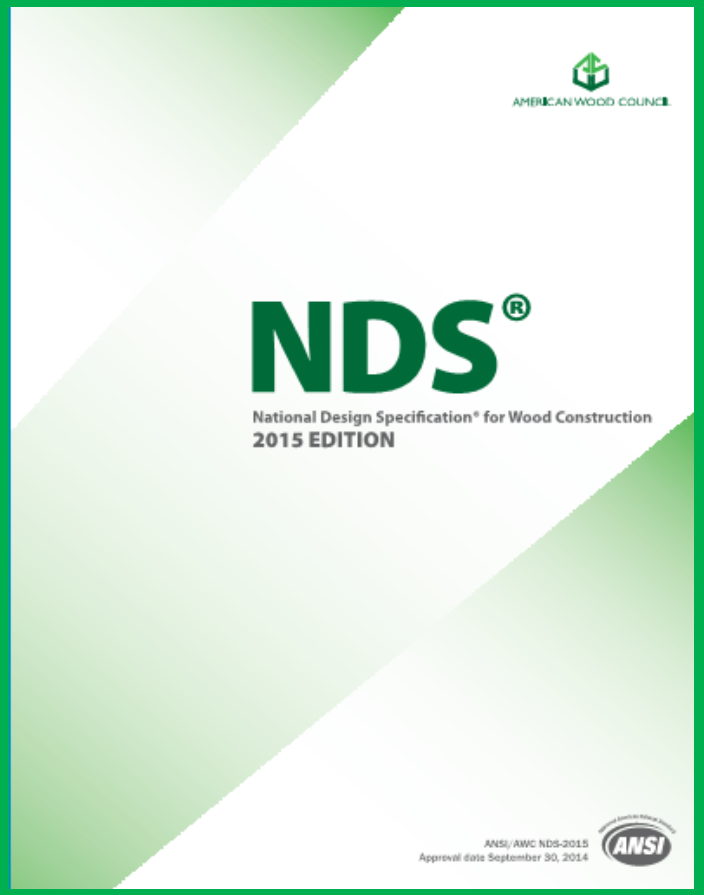
Construction type selection dictates prescriptive fire resistance requirements:

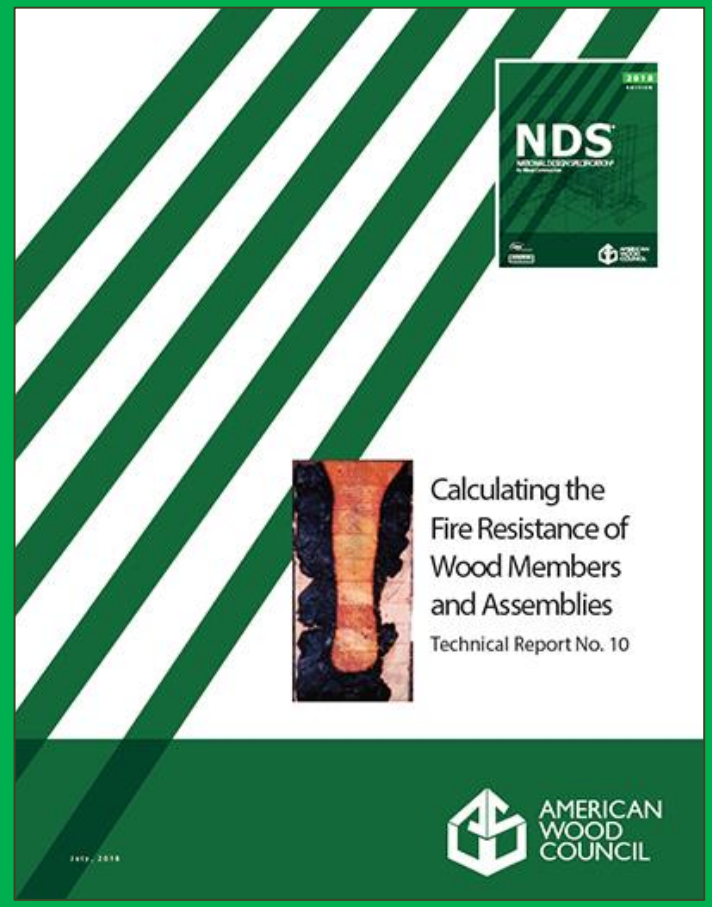
- Type IV Construction (minimum sizes)
- **Other than type IV**: Demonstrated fire resistance:
  - IBC 703.3 allows several options, including:
    - ASTM E119 assembly test
    - Calculations per IBC 722 → NDS Chapter 16

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)





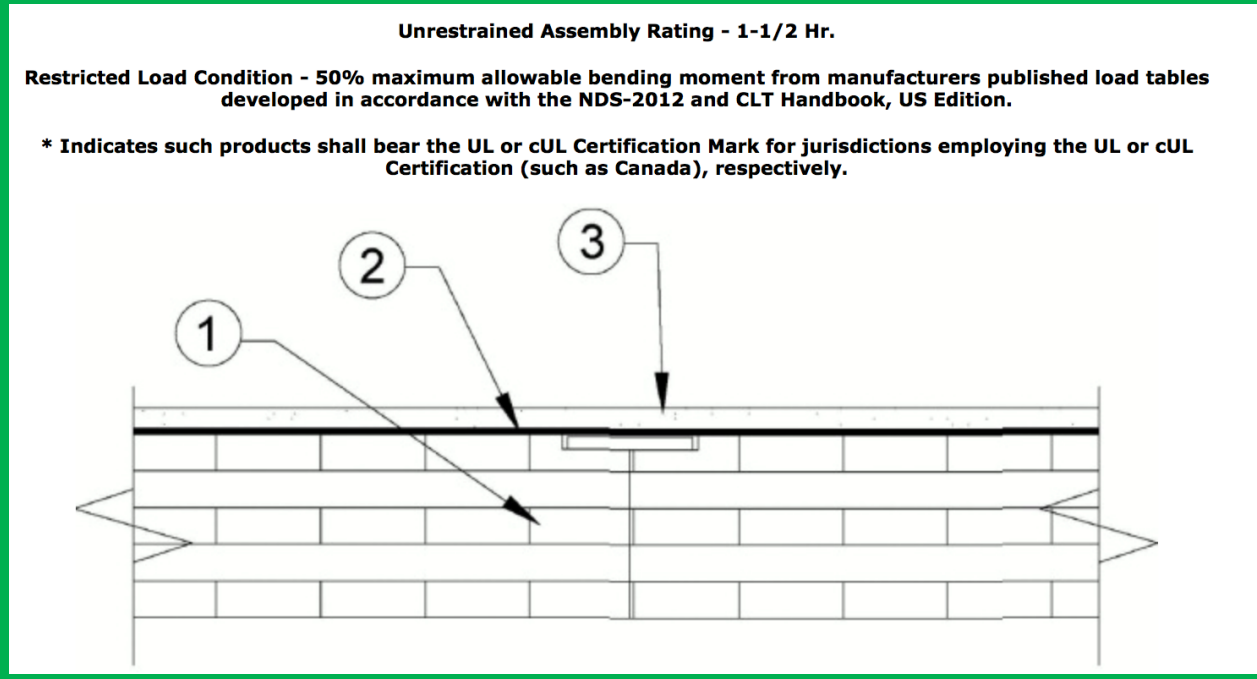
MASS TIMBER DESIGN

FIRE RESISTANCE

MASS TIMBER FIRE DESIGN METHODS:

NDS Chapter 16 Char Calculations vs. ASTM E119 Tested Assembly

- **NDS Chpt 16 calcs check structural integrity**
- **ASTM E119 checks structural integrity, thermal separation (elevated temp. on unexposed side) and burn through (ignition of cotton waste at gaps)**
- **Reasonable to assume other assembly components such as concrete topping aid in other 2 criteria**



SOURCE: UL L901

MEP DETAILING

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER PRODUCTS

ACCOMMODATING MEP

DUE TO EXPOSED MASS TIMBER STRUCTURE AND FINISH, UNIQUE MEP ACCOMMODATION SOLUTIONS ARE REQUIRED

IF USING TYPE IV CONSTRUCTION, NO CONCEALED SPACES ARE ALLOWED

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER PRODUCTS

ACCOMMODATING MEP

PHOTO CREDIT: WOODWORKS

EXPOSED MEP

MEP ITEMS LEFT EXPOSED, USUALLY ON CEILING SIDE OF FLOOR ASSEMBLY

MASS TIMBER PRODUCTS

ACCOMMODATING MEP

Photo Credit: KK Law, Courtesy: naturally:wood

RAISED ACCESS FLOOR

INSTALLED ON TOP OF FLOOR STRUCTURE

PROVIDES 2” TO 18” OF PLENUM SPACE FOR MEP

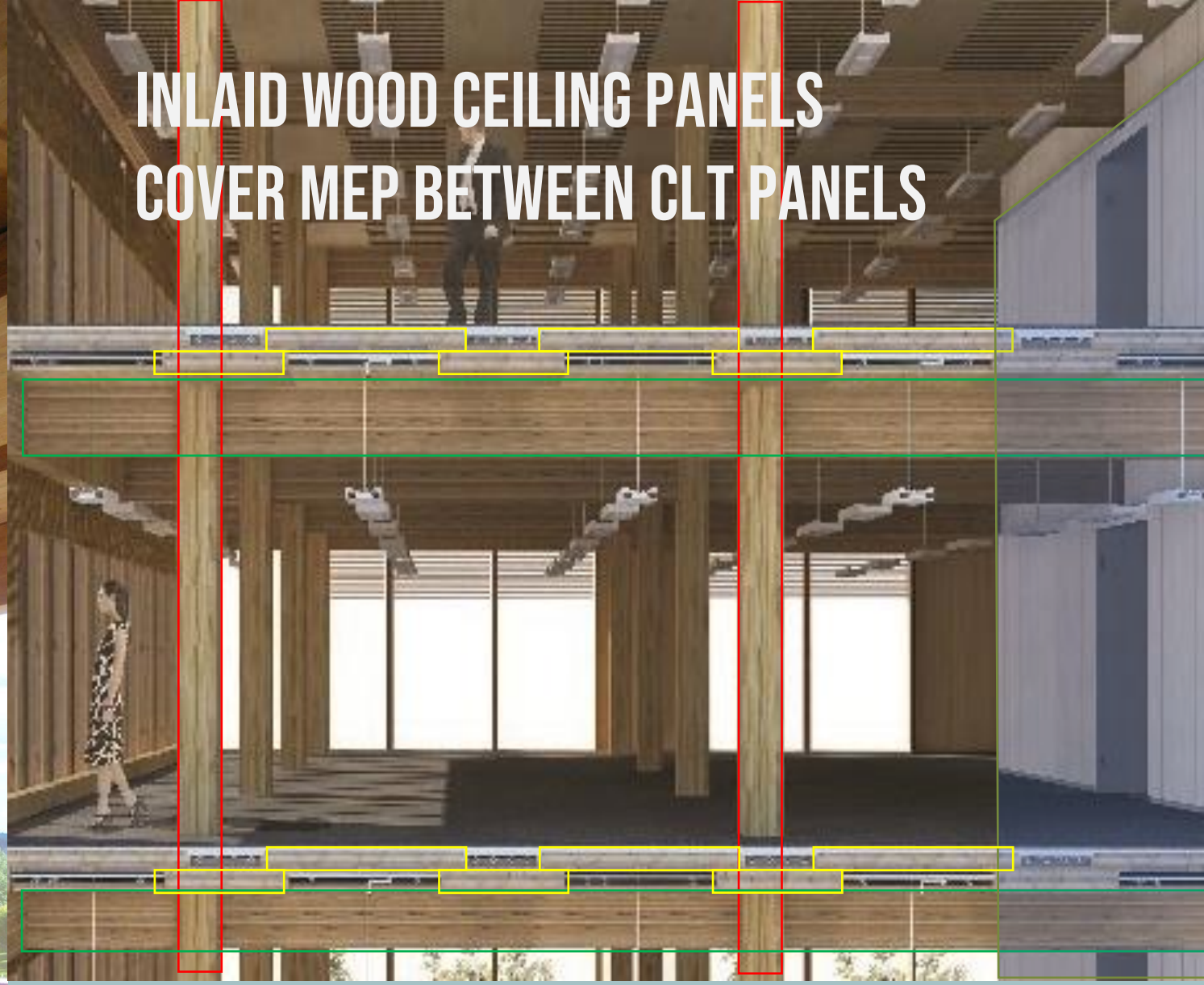
PHOTO CREDIT: WOODWORKS

WOOD INNOVATION DESIGN CENTER

PRINCE GEORGE, BC

PHOTO CREDIT: ED WHITE

PHOTO CREDIT: MGA



INLAID WOOD CEILING PANELS
COVER MEP BETWEEN CLT PANELS

WIDC MEP ACCOMMODATION

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS

LATERAL CORE RESISTING SYSTEM:

- COMMONLY USED WITH GLAZING/CURTAIN WALLS
- MAY USE RIGID OR SEMI-RIGID (IF USED WITH FRAMES AT EXTERIOR) ANALYSIS

LIGHT FRAME SHEARWALLS:

- TYPICAL FOR 1-5 STORIES
- TYPICALLY ASSUME FLEXIBLE DIAPHRAGM
- NEED AMPLE WALL AT PERIMETER

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS

CENTRAL CORE: CONCRETE SHEARWALLS

PHOTO CREDIT: STRUCTURECRAFT BUILDERS

MASS TIMBER DESIGN

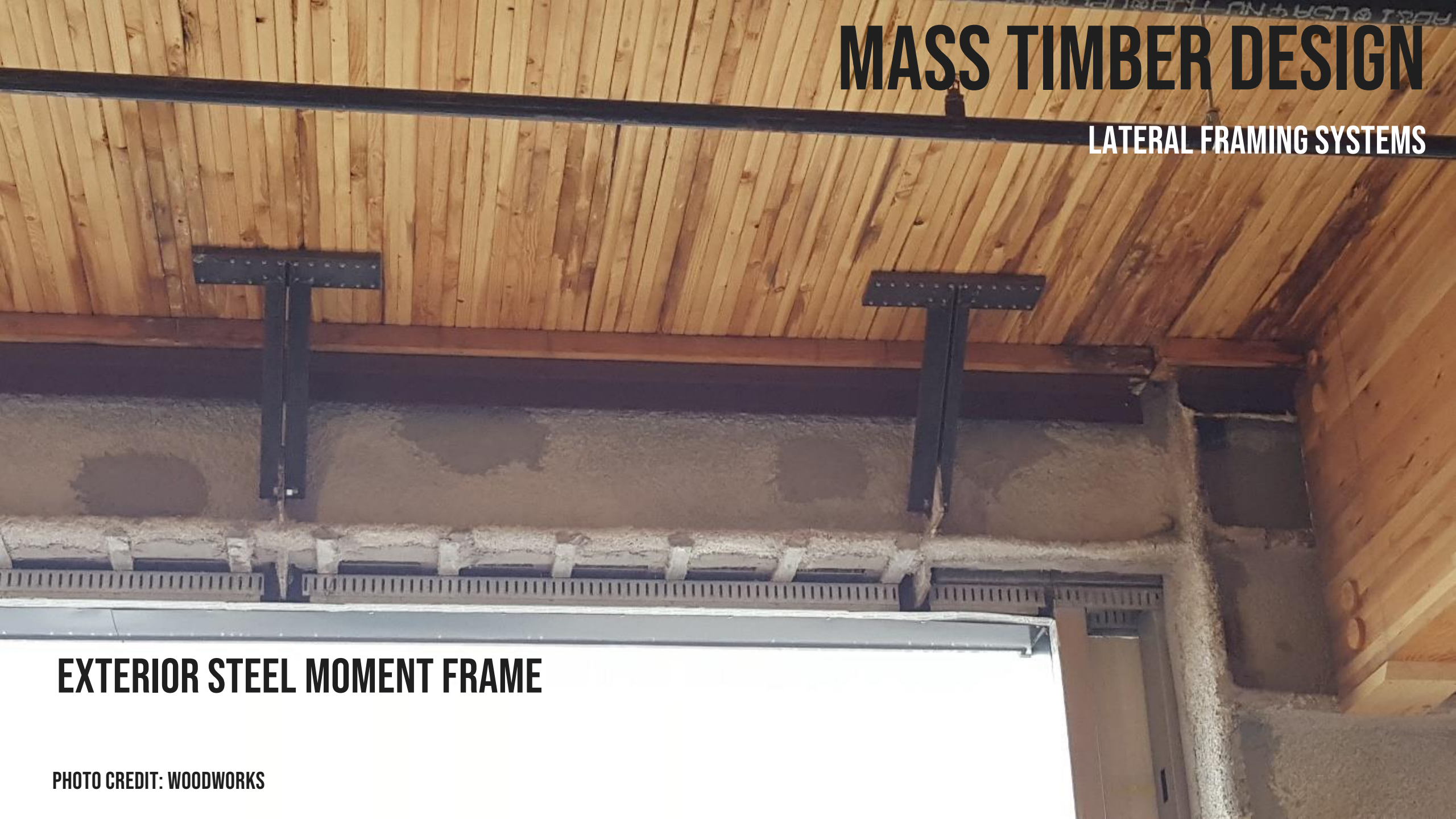
LATERAL FRAMING SYSTEMS

CENTRAL CORE: MASS TIMBER SHEARWALLS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS

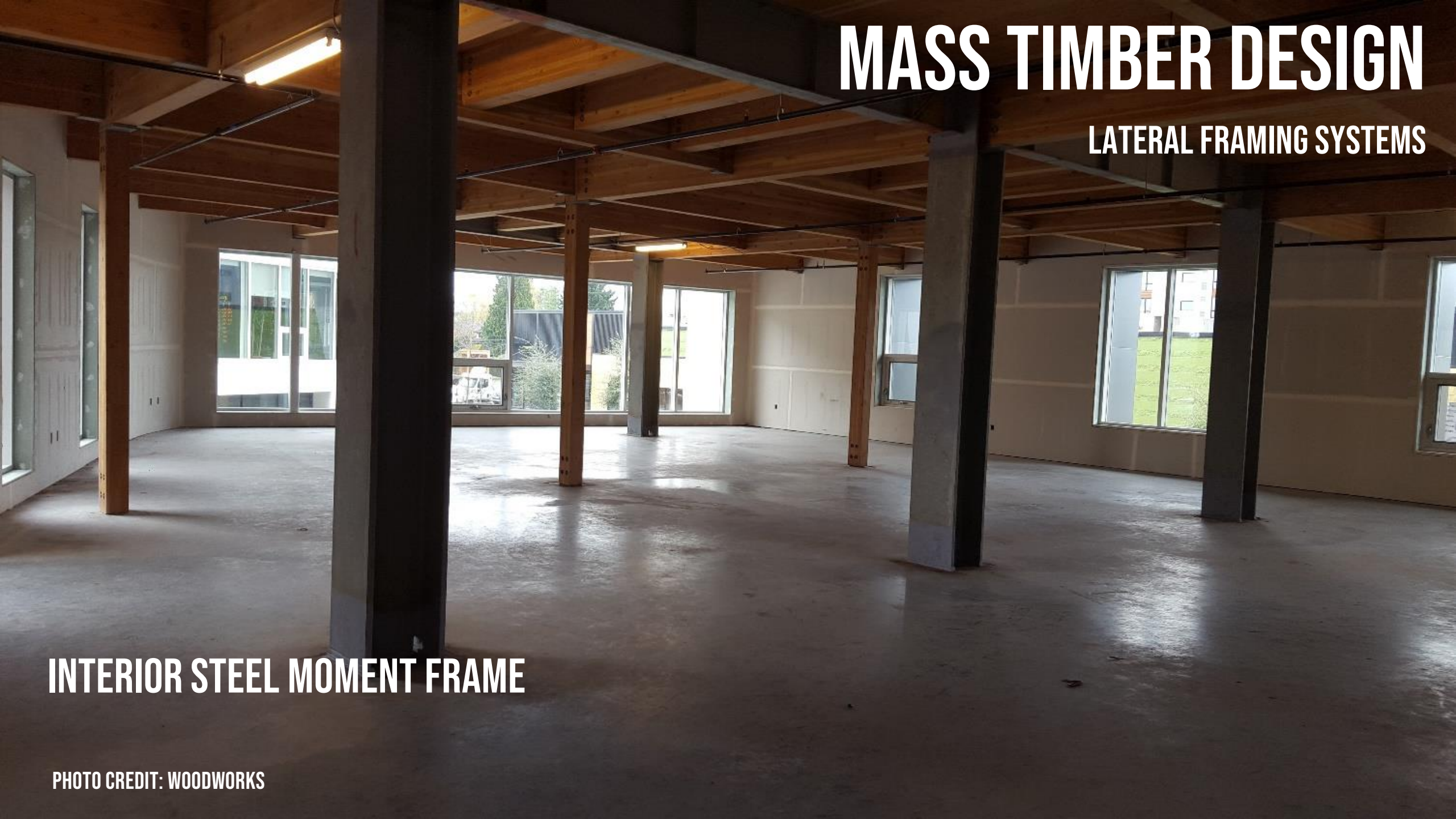


EXTERIOR STEEL MOMENT FRAME

PHOTO CREDIT: WOODWORKS

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS



INTERIOR STEEL MOMENT FRAME

PHOTO CREDIT: WOODWORKS

MASS TIMBER DESIGN

LATERAL FRAMING SYSTEMS

PHOTO: ANDREAS SAUTER, TIM CLAY PHOTOGRAPHY

PHOTO CREDIT: KOMATSU/JAPAN

PROPRIETARY RIGID/SEMI-RIGID FRAMES

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

MASS TIMBER DESIGN

CONNECTIONS

PHOTO CREDIT: MYTICON

BEAM TO BEAM CONNECTIONS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

PHOTO CREDIT: STRUCTURECRAFT BUILDERS

BEAM TO COLUMN CONNECTIONS

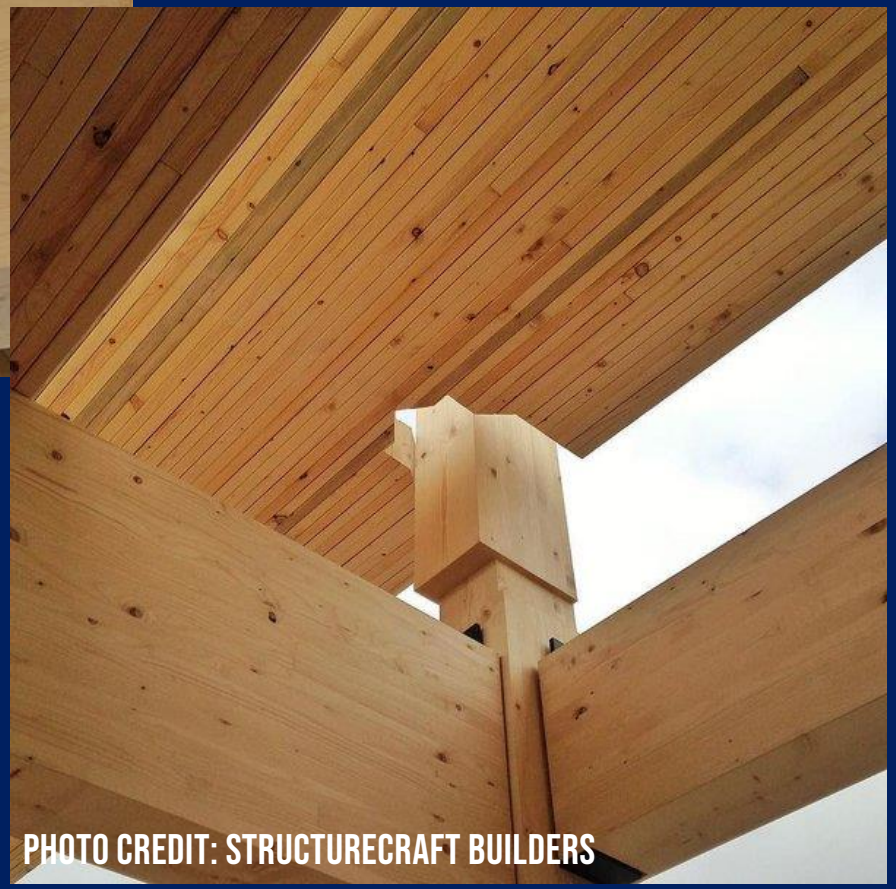


PHOTO CREDIT: STRUCTURECRAFT BUILDERS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

COLUMN TO FOUNDATION CONNECTIONS

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

PHOTO CREDIT: CHARLES JUDD

PANEL TO PANEL CONNECTIONS – SURFACE SPLINE

PHOTO CREDIT: ALEX SCHREYER

MASS TIMBER DESIGN

CONNECTIONS

PHOTO CREDIT: MYTICON

PANEL TO BEAM CONNECTIONS

MASS TIMBER

PHOTO CREDIT: SWINERTON BUILDERS

SOURCING, CONSTRUCTION & COST CONSIDERATIONS

PHOTO CREDIT: STRUCTURECRAFT BUILDERS

PHOTO CREDIT: STRUCTURLAM

MASS TIMBER PRODUCTS

CONSTRUCTION

WORKING WITH MASS TIMBER: KNOW YOUR SUPPLY CHAIN

- MANUFACTURERS - DIFFERENT SPECIES, GRADES AND MAXIMUM PANEL/BEAM SIZES
- TRUCKING LOGISTICS AND COST
- MANUFACTURERS HAVE SPECIFIC CNC CAPABILITIES
- 3RD PARTY FABRICATORS CAN HAVE ADDITIONAL CNC CAPABILITIES

Photo: DR Johnson

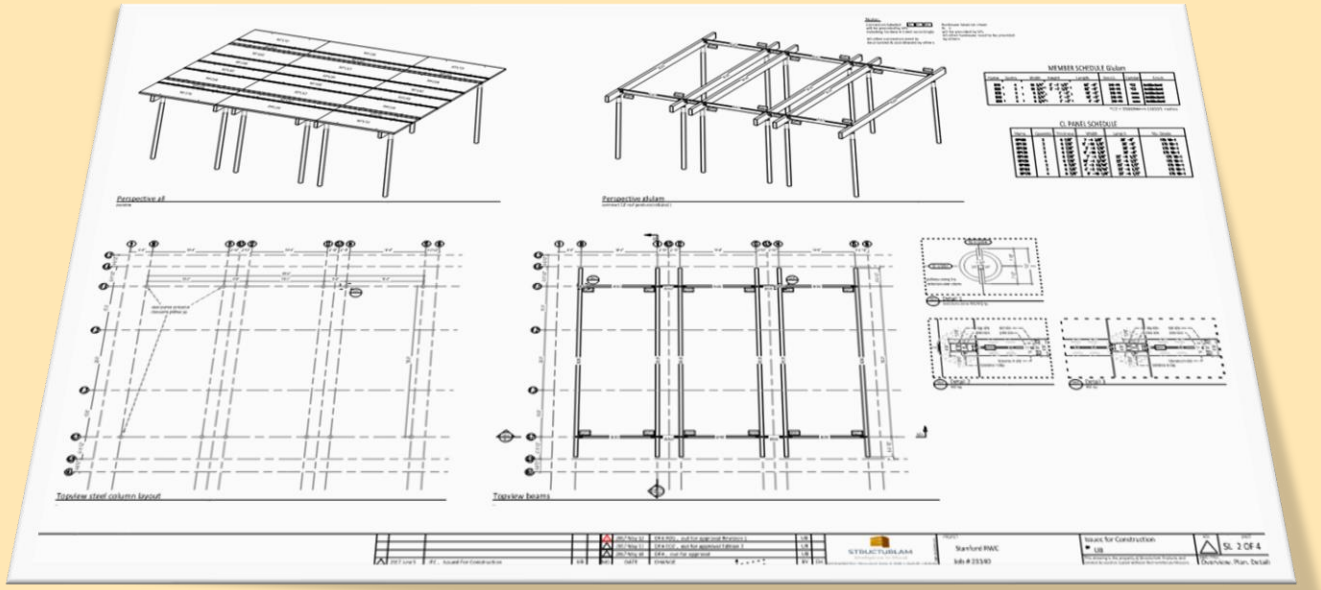

Photo: Sauter Timber

MASS TIMBER PRODUCTS

CONSTRUCTION

DEFINE & COMMUNICATE THE DELIVERABLES YOU NEED FROM THE SUPPLIER:

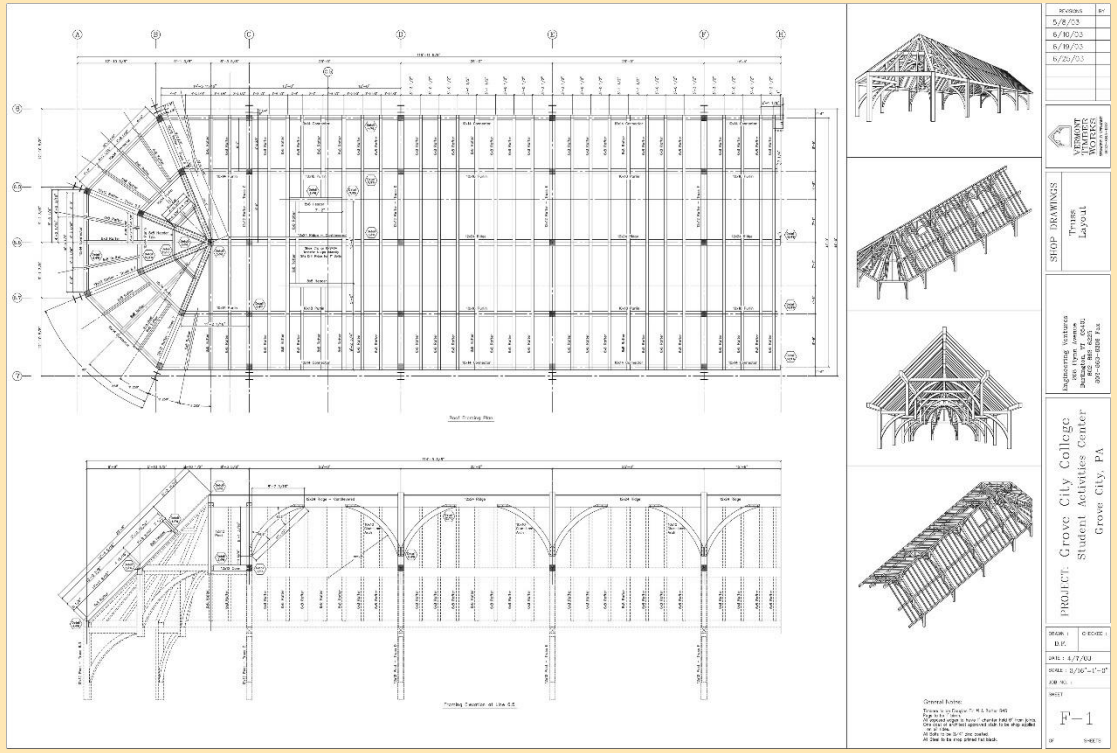
- SHOP DRAWINGS
- SHOP DRAWINGS WITH ENGINEERING STAMP
- ENGINEERED DRAWINGS AND CALCULATIONS (E.G. AS A DEFERRED SUBMITTAL)



MASS TIMBER PRODUCTS

WHAT DOES A MASS TIMBER CONSTRUCTION PROCESS LOOK LIKE?

VERY SIMILAR TO A PRECAST CONCRETE OR STRUCTURAL STEEL PROJECT



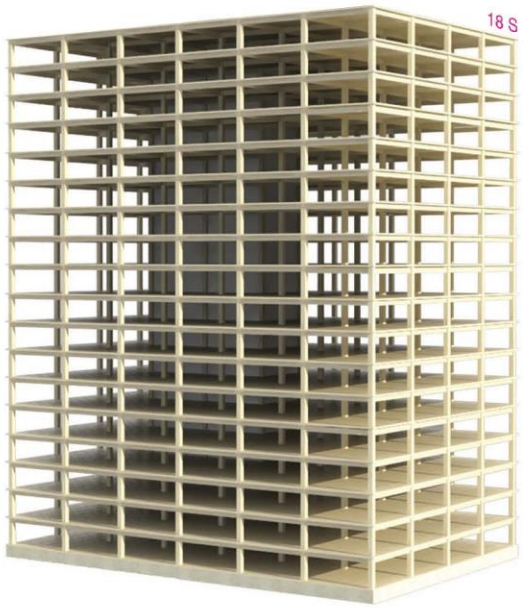
CONSTRUCTION

- SHOP DRAWINGS
- ERECTION DRAWINGS
- PREFABRICATED MEMBERS AND CONNECTIONS

- Current Prescriptive Code Limit - 6 stories or 85 feet
- Over 6 Stories - Alternate Means and Methods Request (AMMR) through performance based design
- Based on the 1910 Heights and Areas Act

U.S. BUILDING CODE STATUS

New Building Types



18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-A

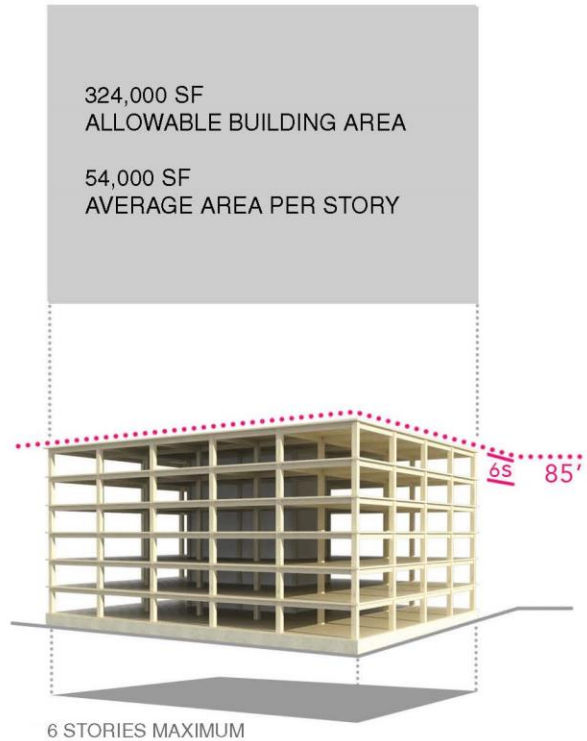
12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

9 STORIES
BUILDING HEIGHT 85'
ALLOWABLE BUILDING AREA 405,000 SF
AVERAGE AREA PER STORY 45,000 SF

TYPE IV-C

IBC 2021



6 STORIES MAXIMUM
85'-0" MAXIMUM BUILDING HEIGHT
324,00 SF MAXIMUM AREA

TYPE IV- HT

IBC 2015

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.

INTRO, CLEVELAND

9 Stories | 115 ft

8 Timber Over 1 Podium

512,000 SF

297 Apartments, Mixed-Use

Photo: Harbor Bay Real Estate Advisors, Purple Film | Architect: Hartshorne Plunkard Architecture

INTRO, CLEVELAND

9 Stories | 115 ft

8 Timber Over 1 Podium

Type IV-B

Variance to expose ~50% ceilings

Photo: Harbor Bay Real Estate Advisors, Image Fiction | Architect: Hartshorne Plunkard Architecture

ASCENT, MILWAUKEE

Photo: Korb & Associates Architects |
Architect: Korb & Associates Architects

493,000 SF

259 APARTMENTS, MIXED-USE

ASCENT, MILWAUKEE
Tallest Mass Timber Building in the World

Photo: CD Smith Construction |
Architect: Korb & Associates Architects

ASCENT, MILWAUKEE

25 STORIES

19 TIMBER OVER 6 PODIUM, 284 FT

Photo: Korb & Associates Architects | Architect: Korb & Associates Architects

Sources & Works Cited

1. LEVER Architecture: https://leverarchitecture.com/projects/albina_yard
2. Lendlease: http://www.woodworks.org/wp-content/uploads/4-Story-CLT-Hotel-WoodWorks-Case-Study-Redstone-Arsenal-01-05-16.pdf
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Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

Jessica Scarlett,
Regional Director NC I SC I TN
Jessica.Scarlett@WoodWorks.org

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