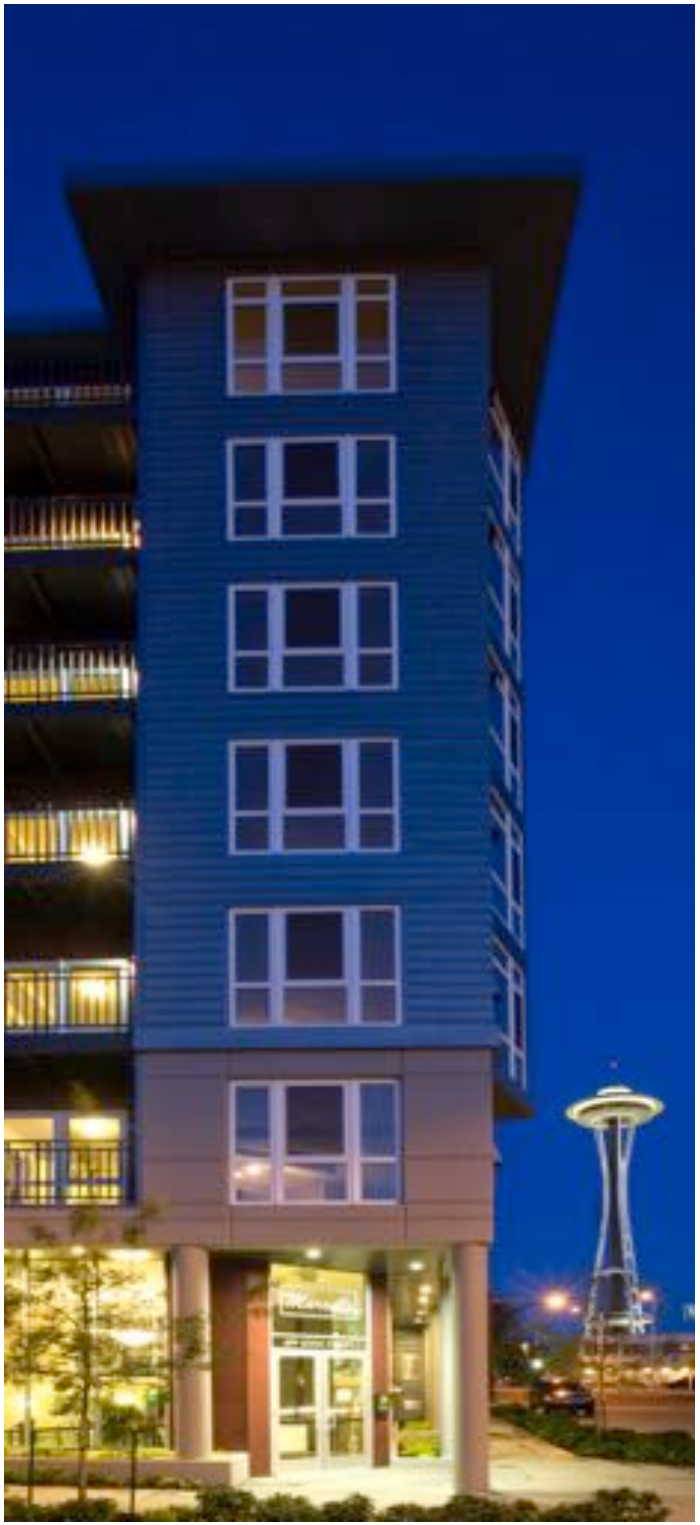
WoodWorks™
WOOD PRODUCTS COUNCIL

Practical, Code-Compliant Detailing for Mid-Rise Wood Structures

Detailing Considerations for Mid Rise Wood Frame Buildings

Marc Rivard, PE, SE



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

Learning Objectives

1. Discuss allowable construction types, occupancies, and building heights and areas for wood-frame mid-rise construction per the International Building Code.
2. Examine a variety of floor-to-exterior wall details for use in wood-frame, Type III construction and discuss code compliance paths and approval rationale for each.
3. Discuss code-permitted shaft wall and fire wall construction materials and fire-resistance requirements, and review common details for each.
4. Consider code provisions for corridor and balcony fire-resistance protection, and identify details that accommodate these requirements while maximizing wood use.

Outline

- Need for Mid-Rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

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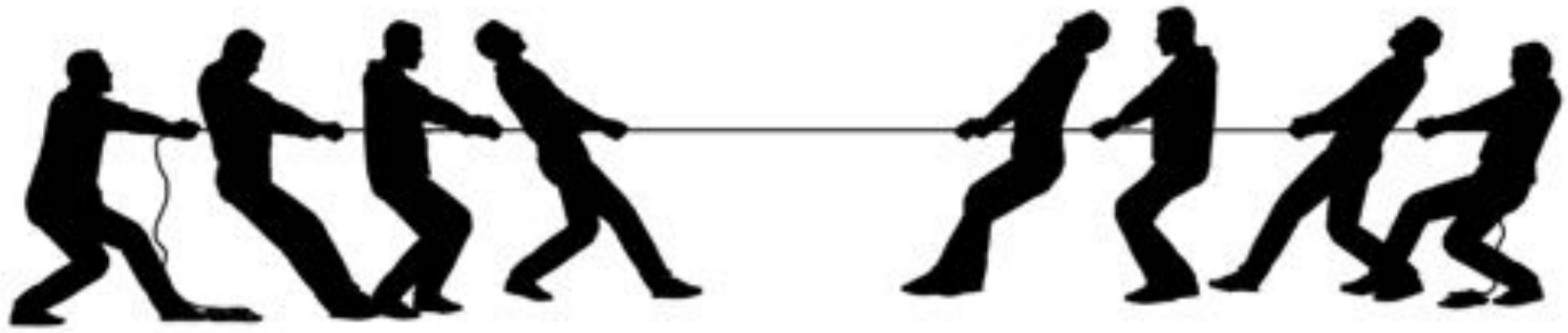
Global Population Boom

Global Population
> 7 billion now
9.0 billion by 2050
30% increase

Urban Population
5.3 billion by 2050
66% increase

Need for Sustainable Multi-Family & Mixed Use Structures

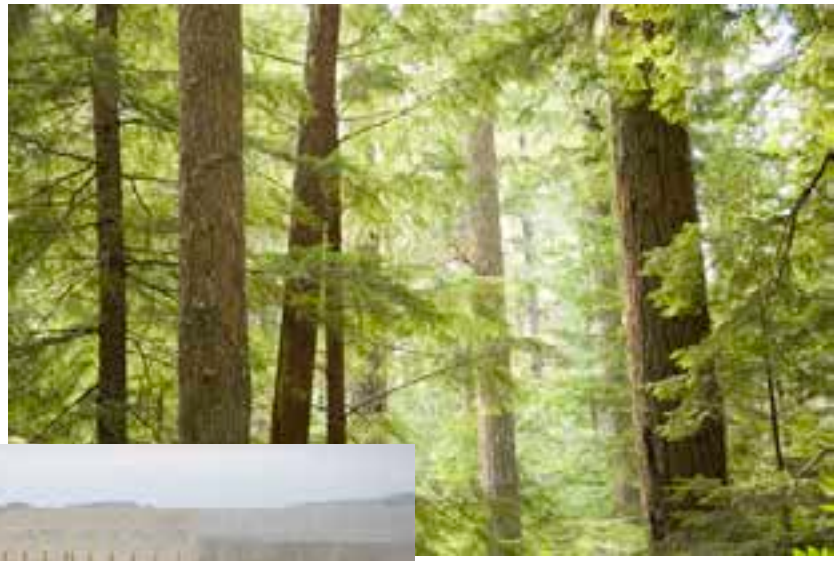


Economically Meet
Urban Housing Needs

Increase
Environmental
Responsibility

These 2 items don’t need to be in opposition-
Wood framing helps them work together!

Why Wood?



- Wood Costs Less
- Wood is Versatile
- Wood Meets Code
- Wood is Durable
- Wood is Renewable

Using Wood Helps Reduce Your Environmental Impact

Wood Products Play a Significant Role in Modern Economy

Outline

- Need for Mid-rise Construction (Urban Densification)
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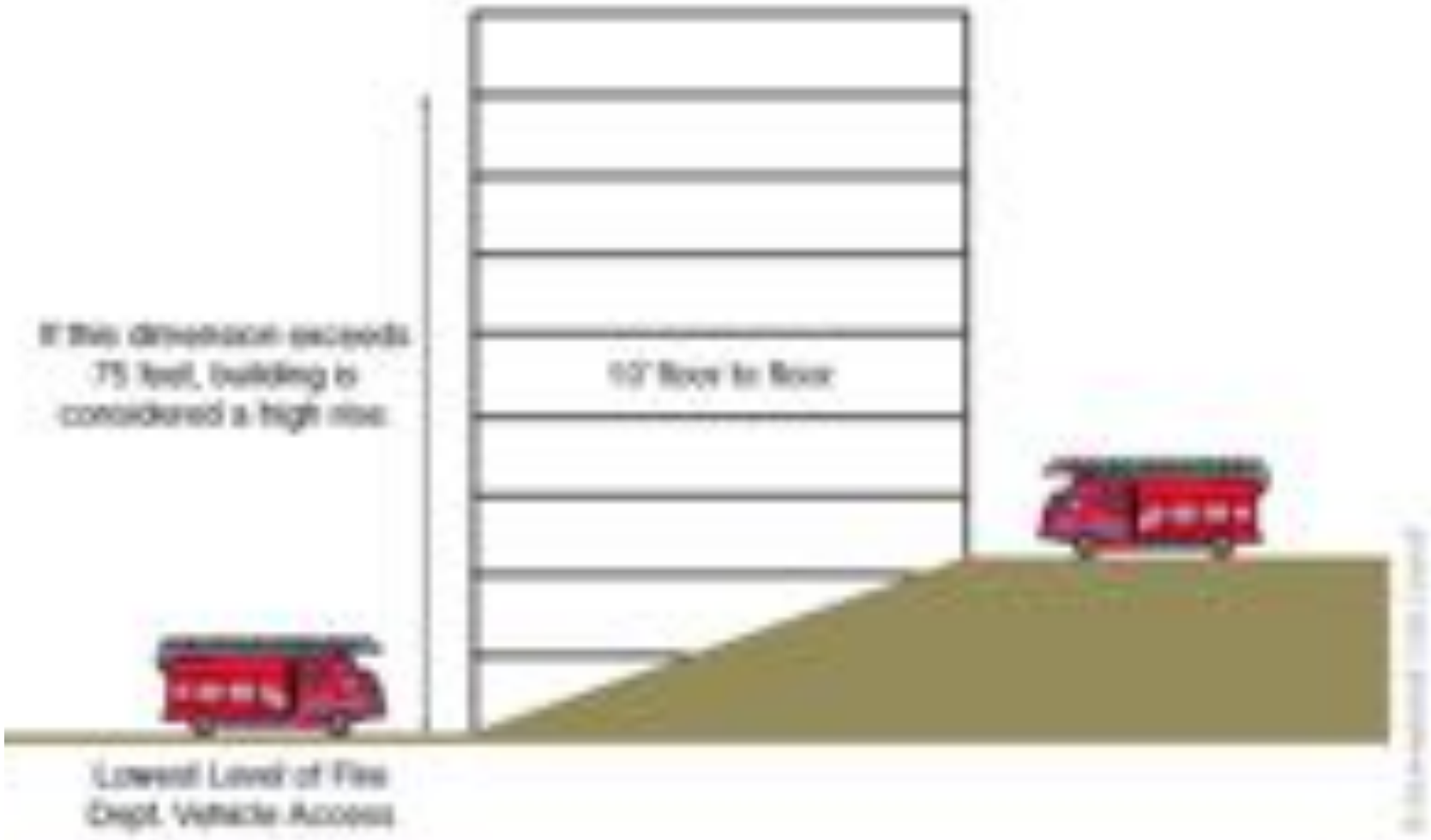
Seattle, WA
College Park , MD
Normal, IL
Los Angeles, CA
Atlanta, GA

Wood Mid-Rise Construction

Marselle Condos, Seattle, WA

6 stories for Offices, 5 stories for Residential
+ Mezzanine + Multi-Story Podium

Mid-Rise vs. High-Rise Definition – IBC 202



Determination of high-rise building

Walk-up/ Tuck Under

First floor walk up units with private garage

Benefits:

- Eliminates need for S-2 parking garage
- Can be all wood
- Least expensive overall but lowest densification rates

Wrap-Around

Walk up units surround parking structure

Benefits:

- Enhanced security
- Centralized access to parking
- Visual appeal from street
- More expensive than walk/up tuck-under
- 5 story yields 60-80 units/acre

Podium

Multiple stories of wood over an elevated concrete deck

Benefits:

- Increased number of stories
- Accommodates Mixed-use occupancies
- Most expensive but can allow increased density

Podium

4 stories of residential over podium (parking or retail)

- 60-80 units/acre

Inman Park Condos, Atlanta, GA
Davis & Church

Podium

5 stories over retail

- 100-120 units/acre

AvalonBay Stadium, Anaheim, CA
VanDorpe Chou Associates

Inman Park Condos, Atlanta, GA
Davis & Church

Mezzanine & Podium

5 stories with mezzanine + residential podium

- 125-145 units/acre

120 Union, San Diego, CA
Togawa Smith Martin

Outline

- Need for Mid-rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
  1. Construction Types
  2. Tabulate Areas & Stories
  3. Allowable increases
  4. Mezzanine & Special Design Provisions
- Fire Ratings & Requirements
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

Typical Mid-rise Occupancy

Hotels (R-1)

Apartments (R-2)

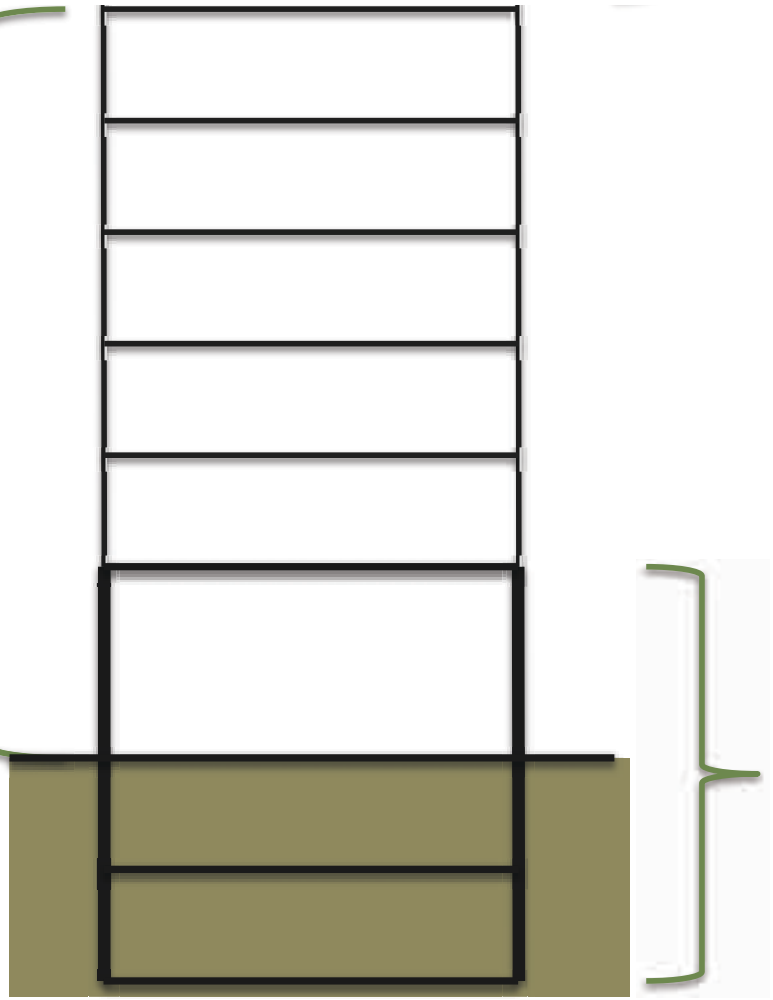
Condominiums (R-2)

Student housing (R-2)

Live/work units (R-2)

Assisted living (R-4)

Nursing homes (I-2)



(A-2) Restaurants/cafeterias

(A-3) Workout facilities

(A-3) Meeting rooms

(B)Offices

(M) Shops

(S-2) Parking

(S-1) Storage

Mid-Rise Construction Types

Type III

- Exterior walls non-combustible
- Interior elements any allowed by code

Type V

- All building elements are any allowed by code

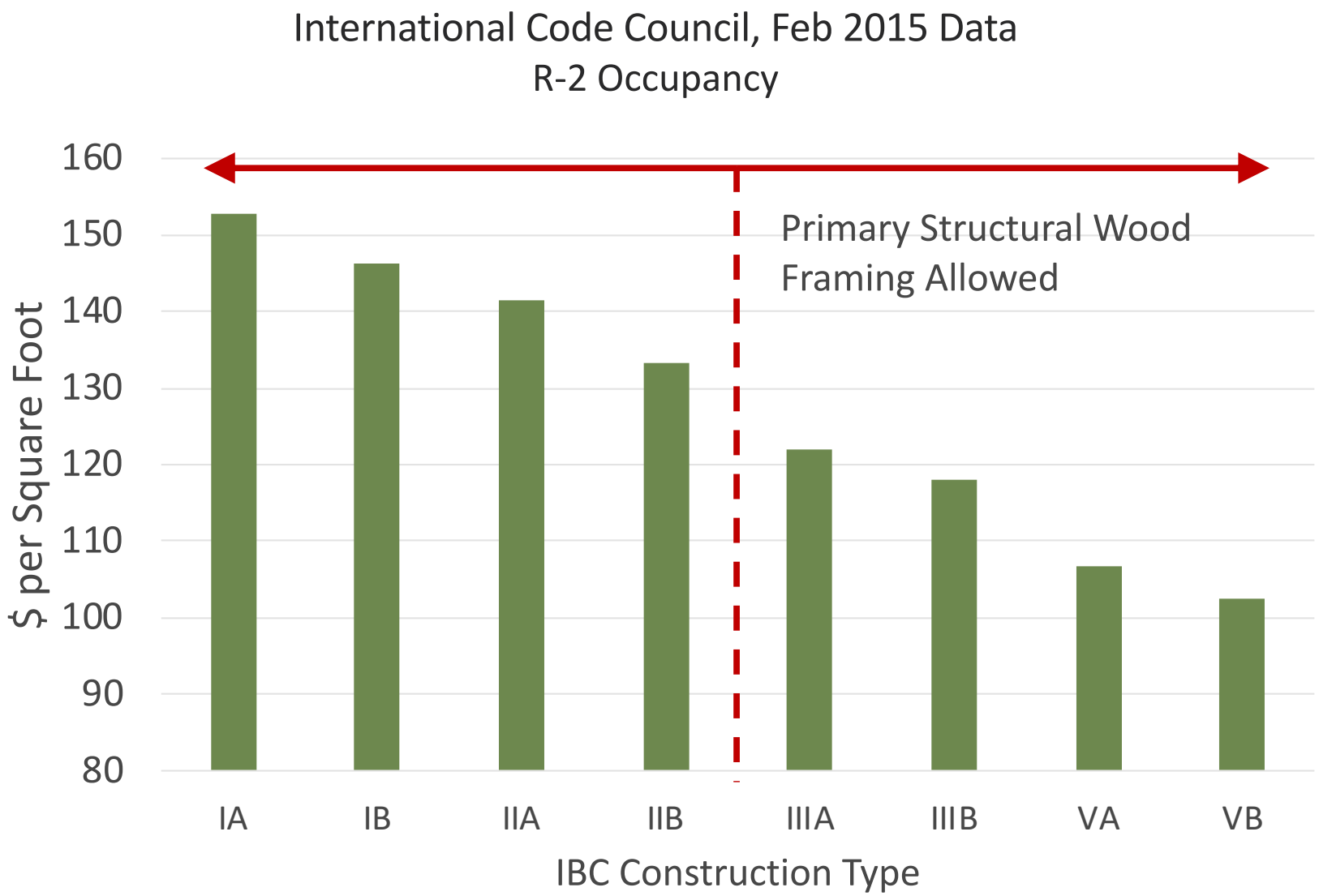
Types III and V can be subdivided to A (protected) or B (unprotected)

Type IV (Heavy Timber)

- Exterior walls non-combustible
- Interior elements qualify as Heavy Timber

More on fire ratings a little later…

IBC Building Valuation Data

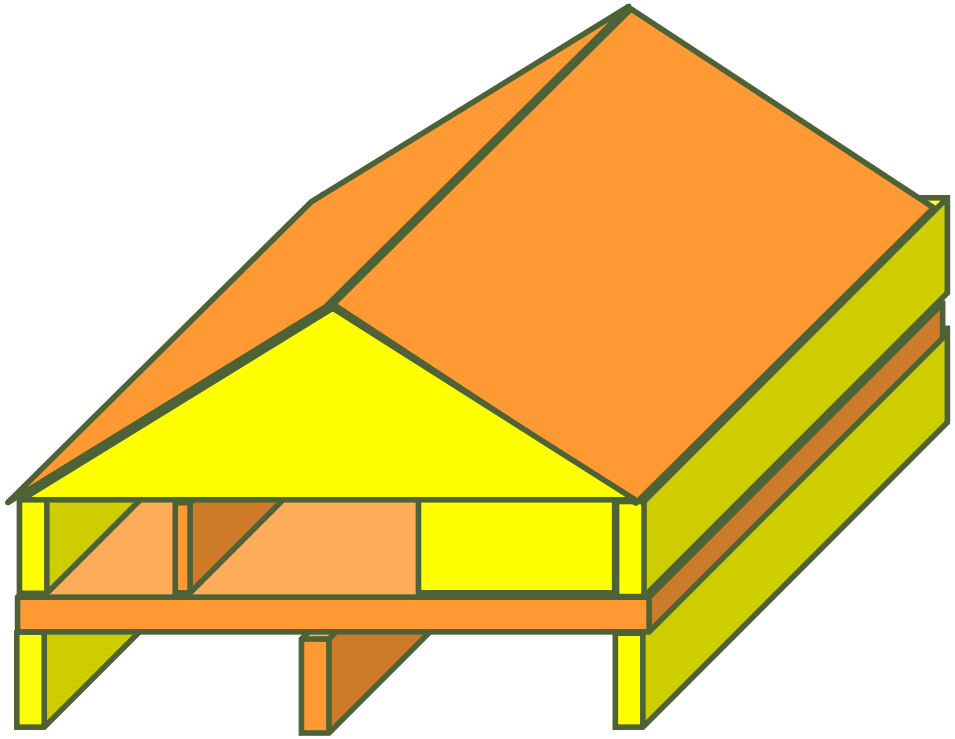


Heights and Areas – IBC Table 503

GROUP		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
	HEIGHT (feet)	UL	160	85	55	65	55	65	50	40
		STORIES(S) AREA (A)								
M	S A	UL UL	11 UL	4 21,500	2 12,500	4 18,500	2 12,500	4 20,500	3 14,000	1 9,000
R-1	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 7,000
R-2	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 7,000
R-3	S A	UL UL	11 UL	4 UL	4 UL	4 UL	4 UL	4 UL	3 UL	3 UL
R-4	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 7,000
S-1	S A	UL UL	11 48,000	4 26,000	2 17,500	3 26,000	2 17,500	4 25,500	3 14,000	1 9,000
S-2[a, c]	S A	UL UL	11 79,000	5 39,000	3 26,000	4 39,000	3 26,000	5 38,500	4 21,000	2 13,500
U[b]	S A	UL UL	5 35,500	4 19,000	2 8,500	3 14,000	2 8,500	4 18,000	2 9,000	1 5,500

Type III Construction

Exterior walls are of noncombustible materials and interior building elements are of any material. Fire Retardant Treated (FRT) wood is permitted in exterior walls of 2hr fire rating or less.

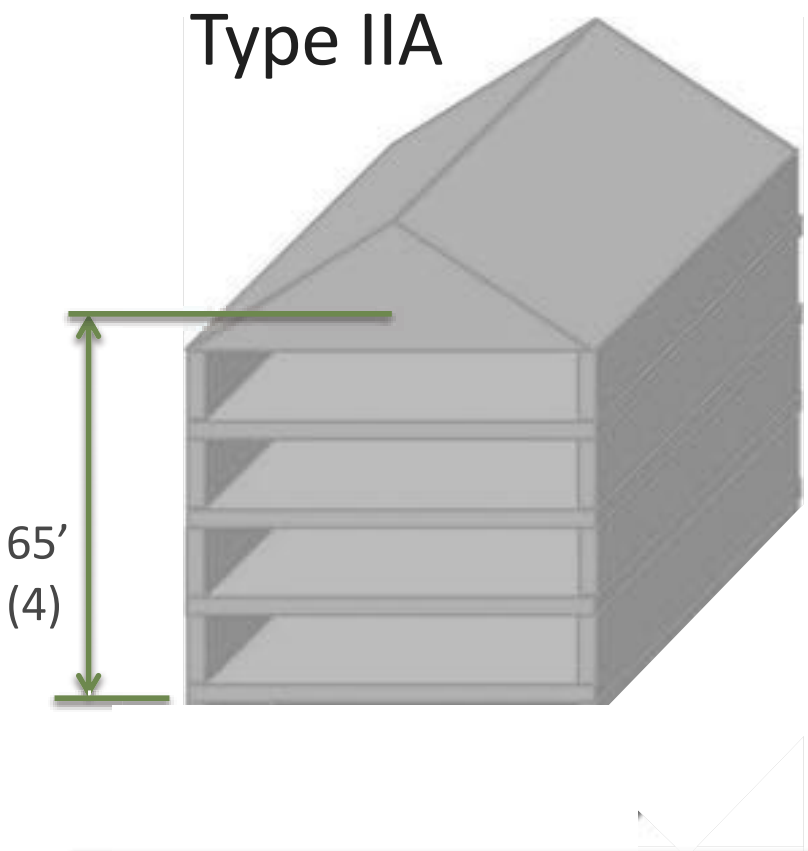


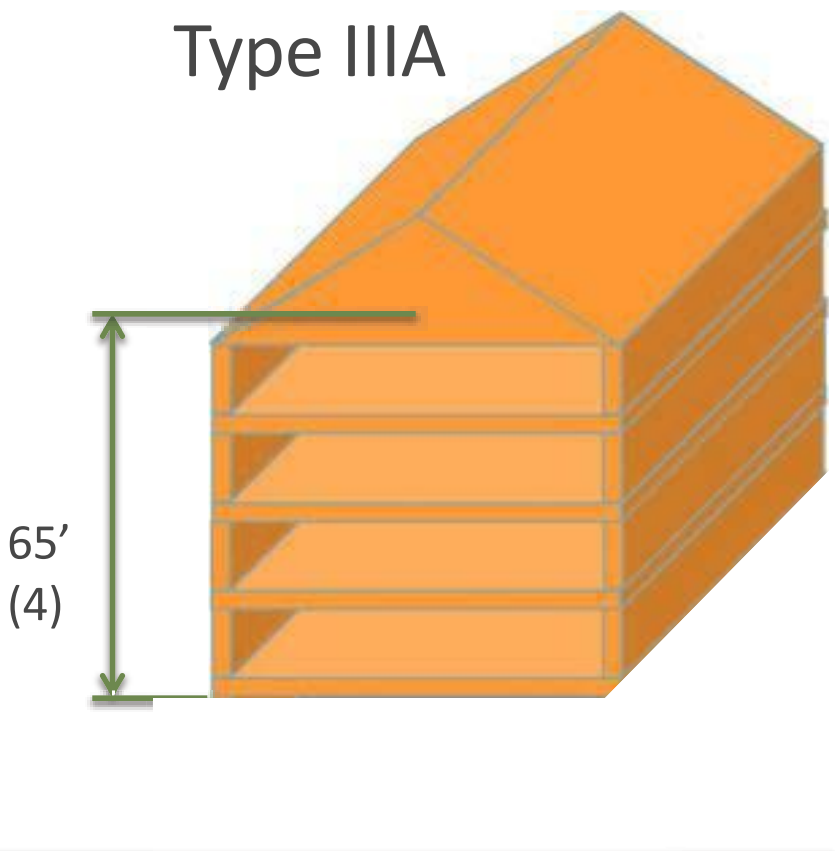
- Non combustible
  - Exterior walls

- Fire Retardant Treated allowed
  - Exterior walls if fire rating is 2hr or less

- Heavy Timber
  - HT used in place of 1hr rating or less
- Untreated Lumber
  - All interior elements

Step 1 – Tabulated Height and Area





Occupancy	IIA	IIIA
R-1	24,000	24,000
R-2	24,000	24,000

Height Modification – IBC 504

IBC 504.2 Where a building is equipped throughout with an approved sprinkler system…

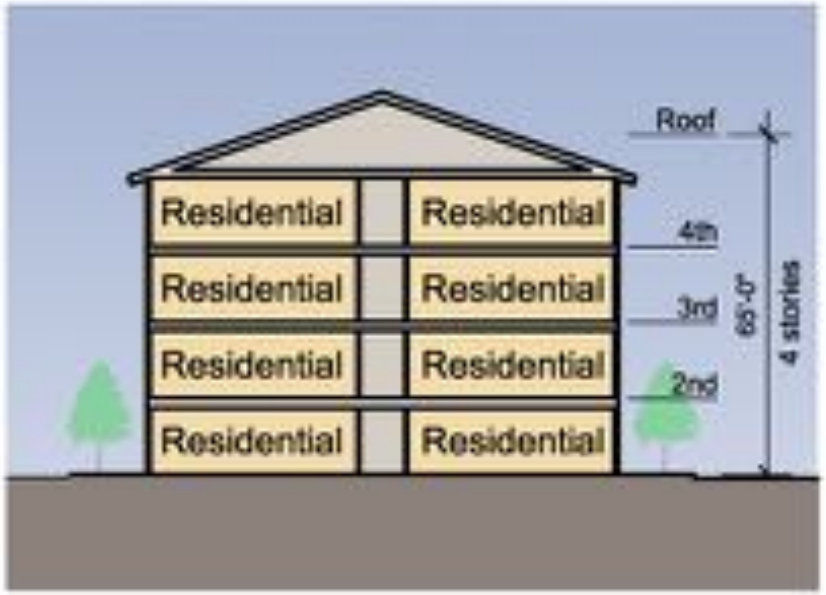
- maximum height is increased by 20 feet
- maximum number of stories is increased by one
- does not apply if using NFPA 13R sprinkler

Can be combined w/ frontage area increase - 506.2

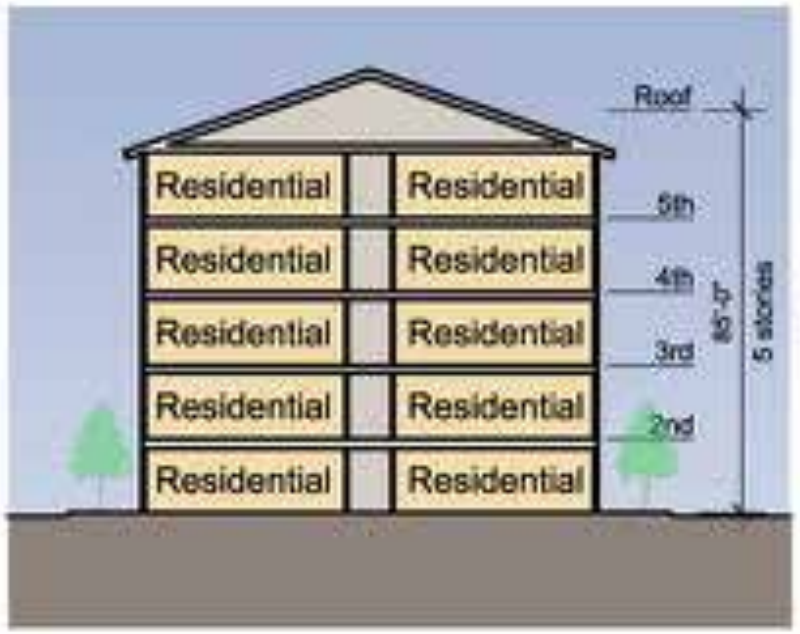
Can be combined w/ sprinkler area increase - 506.3

- EXCEPT for I-2 occupancy of Type IIB, III and V construction and H occupancies or where sprinklers are used as substitution for 1hr fire resistance.

IBC Building Size Limits



NFPA 13

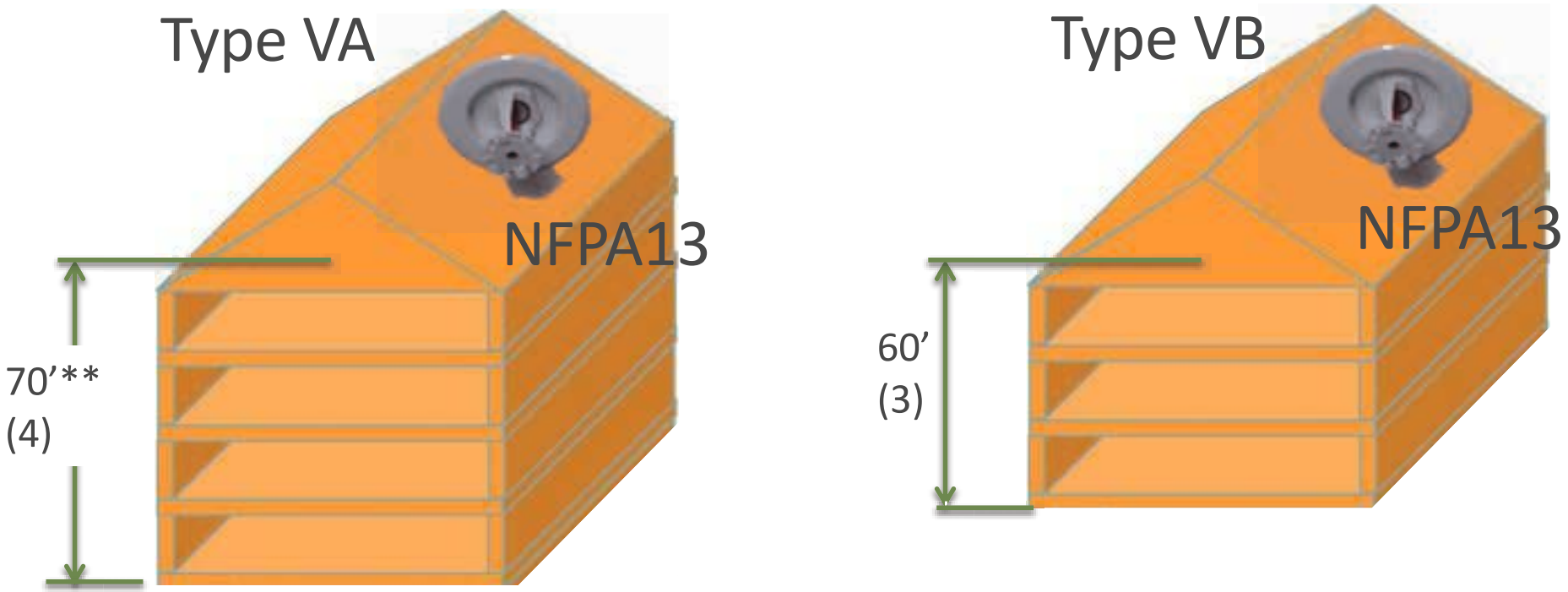


IIIA Tabular Height Limits **Increased Limits**

With NFPA 13 Sprinklers:

IBC gives an allowable Heights and Area Increase

Step 2 – Increased Height & Story Area

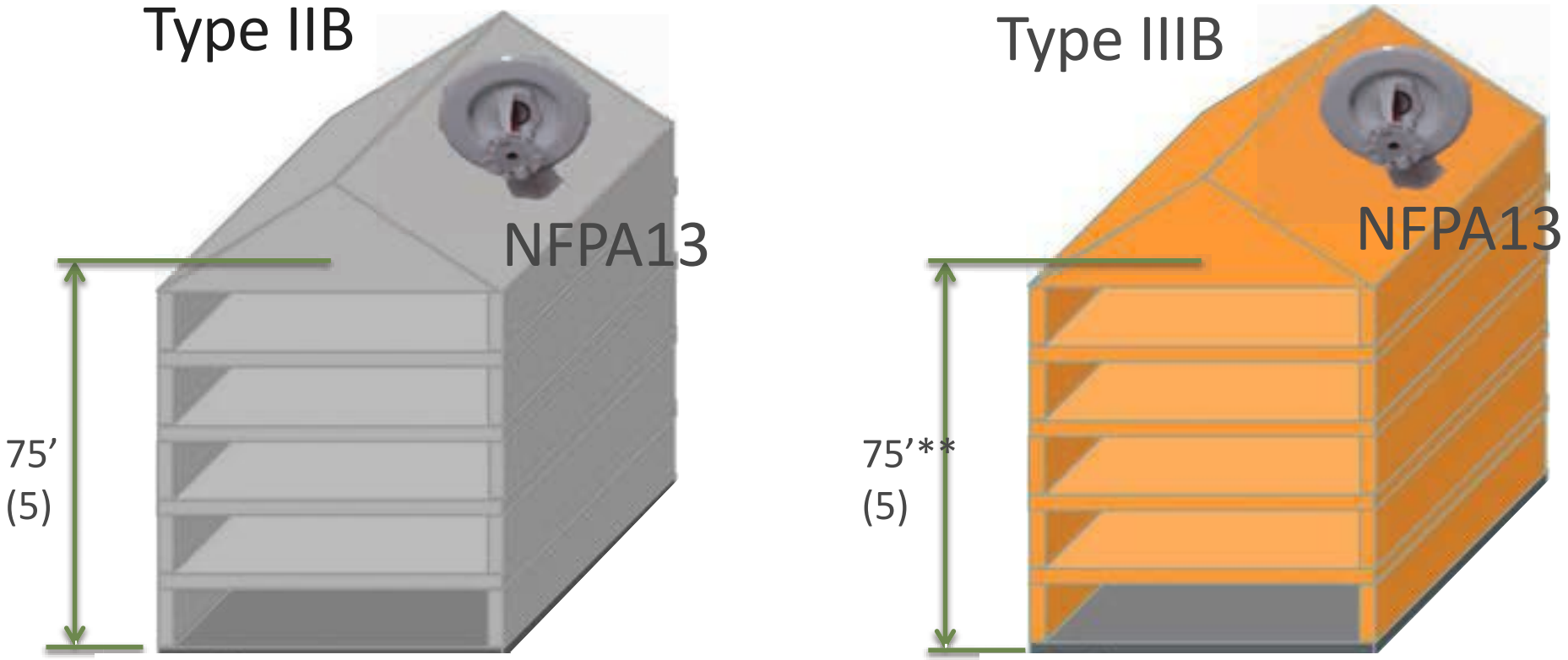


Occupancy	VA (ft²)*	VB (ft²)
R-1	36,000 +9,000(max frontage)	21,000 +5,250(max frontage)
R-2	36,000 +9,000(max frontage)	21,000 +5,250(max frontage)

*Areas reflect PER STORY max. Total building max may limit area further.

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F

Step 2 – Increased Height & Story Area



Occupancy	IIB (ft^2)*	IIIB (ft^2)*
R-1	48,000 +12,000(max frontage)	48,000 +12,000(max frontage)
R-2	48,000 +12,000(max frontage)	48,000 +12,000(max frontage)

*Areas reflect PER STORY max. Total building max may limit area further.

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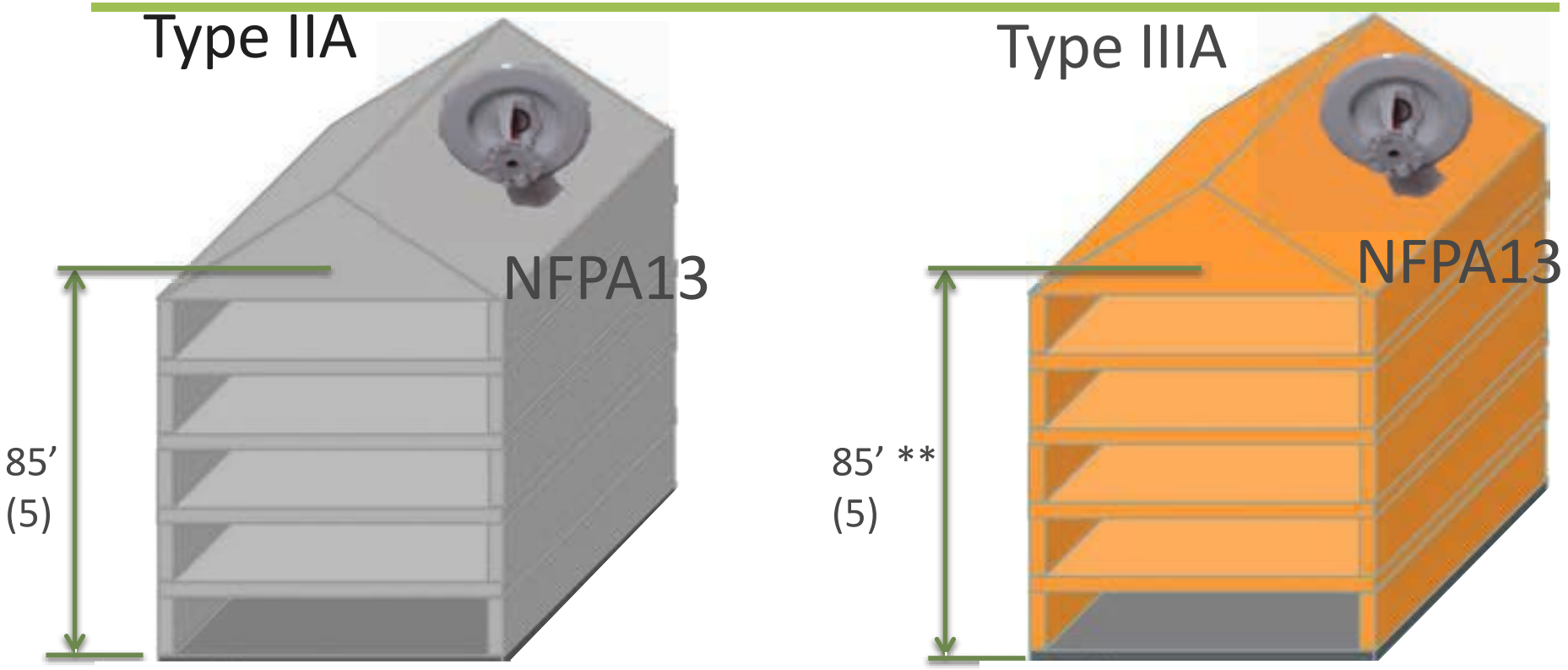
Step 2 – Increased Height & Story Area



Occupancy	IIA (ft^2)*	IIIA (ft^2)*
R-1	72,000 +18,000 (max frontage)	72,000 +18,000 (max frontage)
R-2	72,000 +18,000 (max frontage)	72,000 +18,000 (max frontage)

*Areas reflect PER STORY max. Total building max may limit area further.

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65’ in height in SDC D,E,F

Maximum Building Area – 506.4

Single Occupancy Area determination

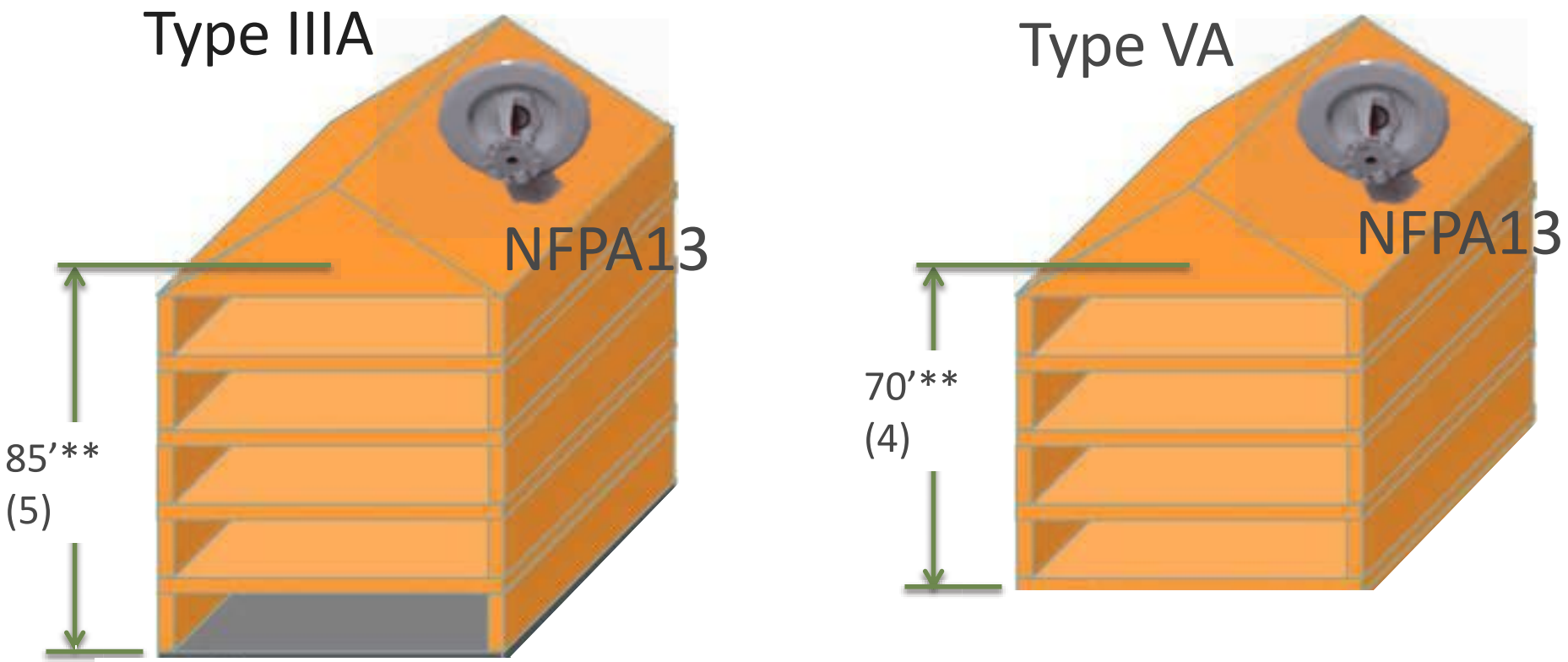
- Two stories above grade:
  - Maximum Building Area = A_a x 2
- Three stories or more above grade:
  - Maximum Building Area = A_a x 3
- No Story shall exceed A_a

Exceptions

- Unlimited area buildings
- Buildings with NFPA 13R sprinkler system

A_a – Allowable Area PER STORY

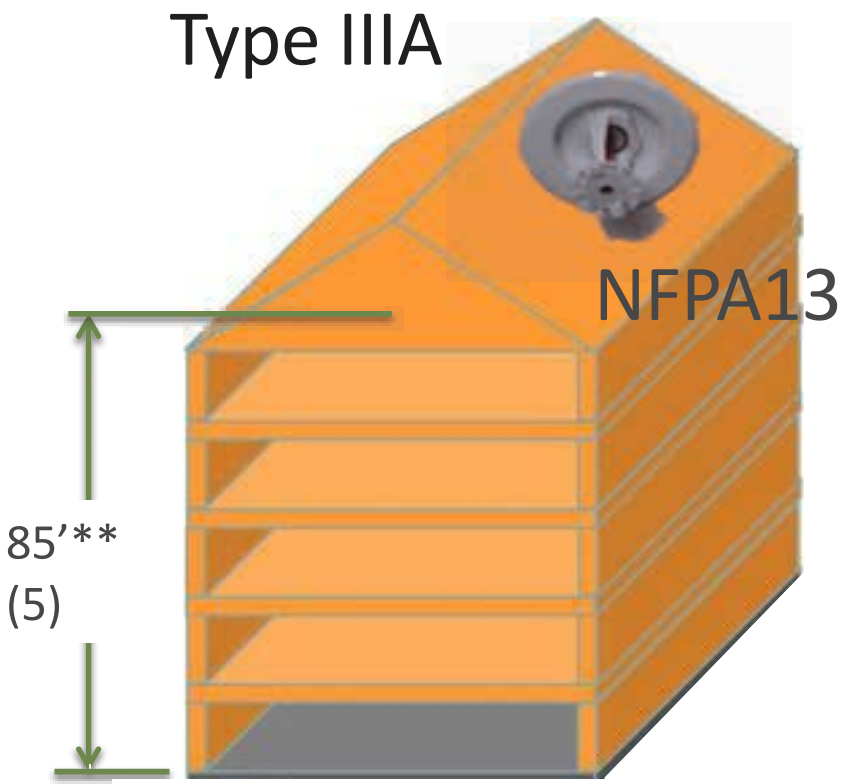
Step 3 – Max Building vs. Story Areas

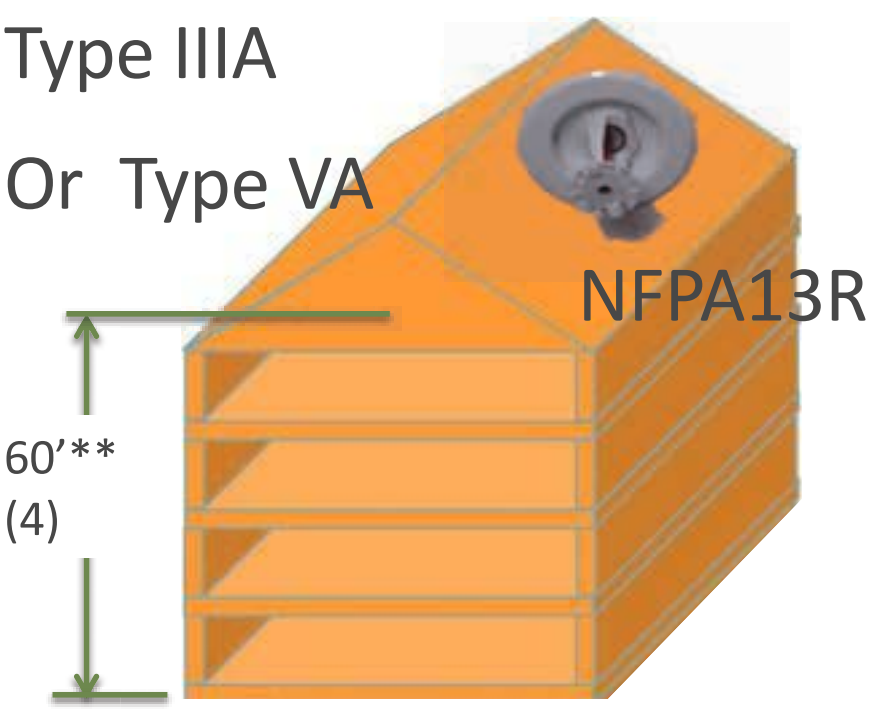


Occupancy	IIIA	VA
Story Area	72,000 +18,000 (max frontage)	36,000 +9,000(max frontage)
Building Area	216,000 +54,000 (max frontage)	108,000 +27,000 (max frontage)

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

Step 3 – Max Building vs. Story Areas





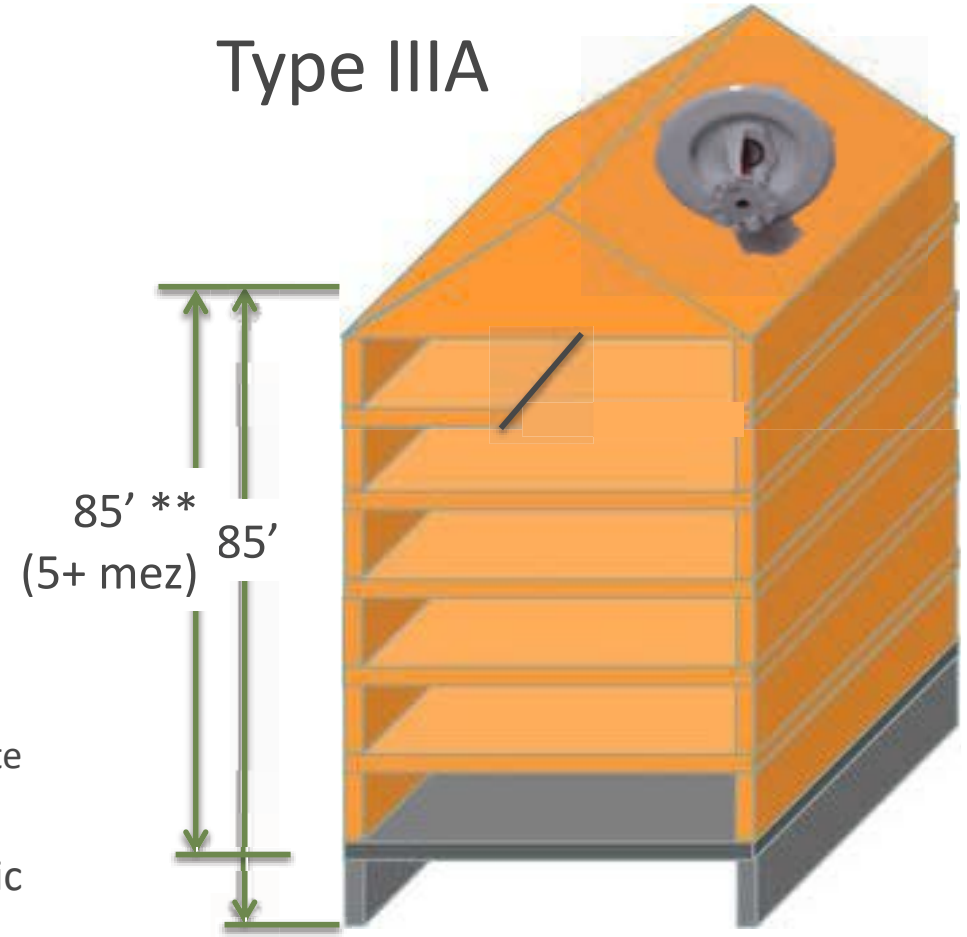
Occupancy	IIIA (NFPA 13)	IIIA (NFPA 13R)	VA (NFPA 13R)
Story Area	72,000 (3x tabulated)	24,000 (=tabulated)	12,000 (=tabulated)
Building Area	216,000 (3x story)	96,000 (4x story)	48,000 (4x story)

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

Step 4-Horizontal Building Separation

Horizontal Assembly = a fire-resistance-rated floor or roof assembly of materials designed to restrict the spread of fire in which continuity is maintained

Drs Jullian and Raye Richardson Apts.
San Francisco, CA
David Baker Architect, Photo Credits: Bruce Damonte



**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

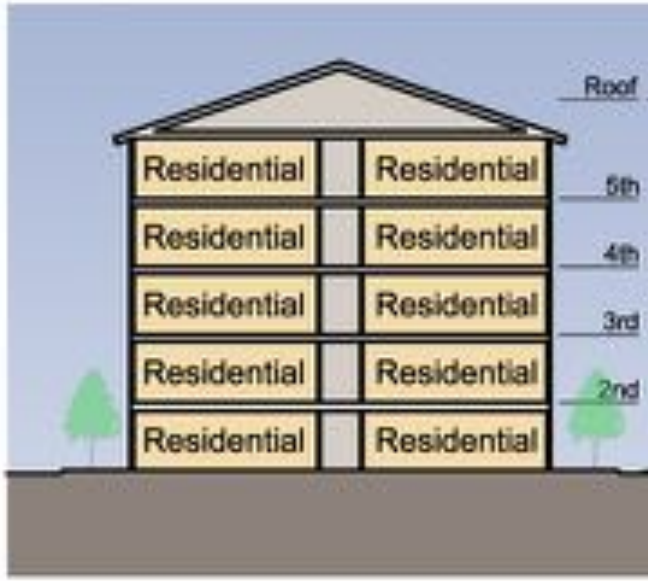
Horizontal Building Separation – 510.2

Considered separate buildings above and below for purposes of area calculations if:

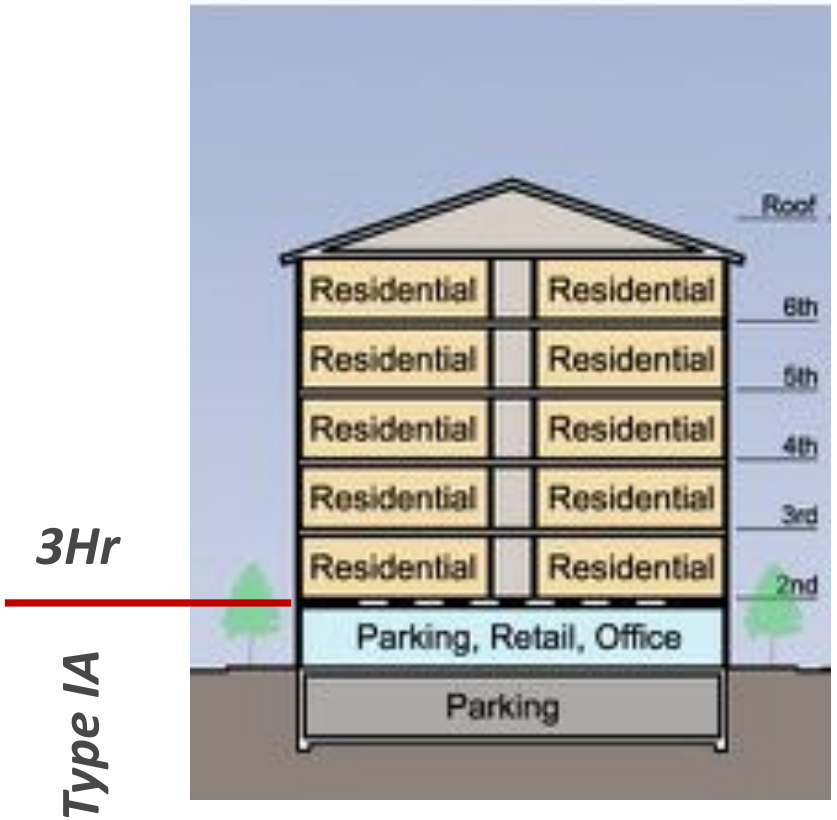
- overall height is still limited to min of either building
- 3hr rated horizontal assembly
- Building below is one story above grade
- Building below is Type 1A with sprinklers
- Enclosures penetrating horizontal assembly are 2hr rated
- occupancy above is A, B, M, R or S
- occupancy below is A, B, M, R or S-2

The Flats at ISU, Normal, IL
OKW Architects
Precision Builders & Associates

IBC Podium Provisions



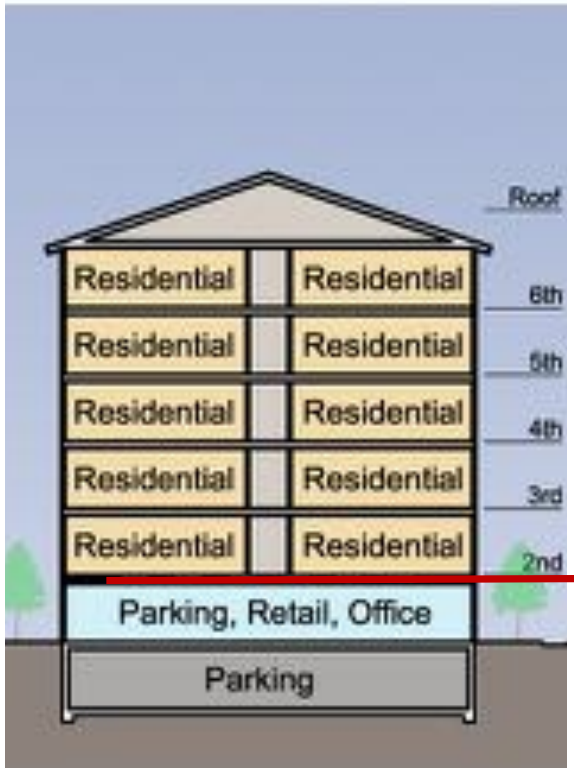
5 story Type III Building



5 story Type III Building
On Top of a Type IA Podium

Special Provisions for Podiums in IBC 2012 510.2
Increases allowable stories… not allowable building height

Evolution of IBC Mixed-Use Podium



3Hr

Type IA

IBC	2006	2009	2012	2015
Section	509.2	509.2	510.2	
Upper Occupancy	A, B, M, R or S			
Lower Occupancy	S-2 Parking	A, B, M, R or S-2 Parking		Any Except H
Podium Height	1 Story			Multi-Story

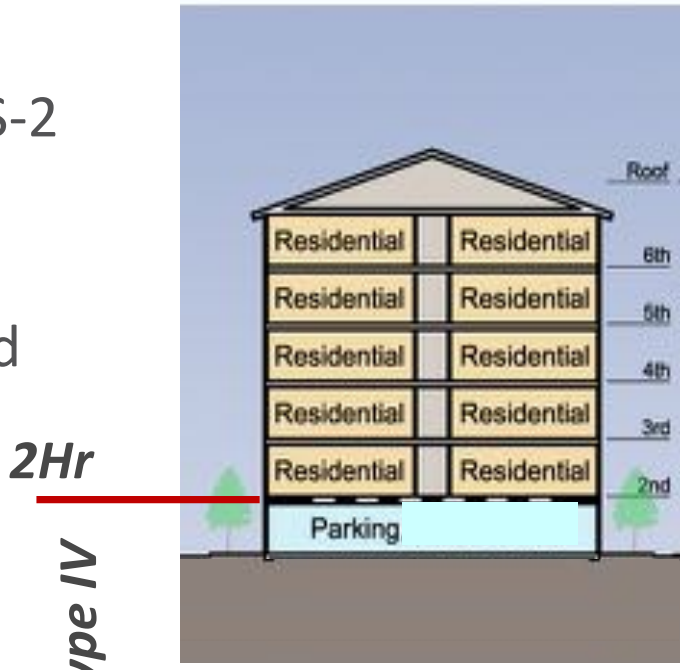
IBC Provisions for Mixed-Use podium have been evolving.

2015 IBC will allow multiple podium stories above grade.

Parking Beneath Group R – IBC 510.4

Possibility of a Type IV podium where number of stories starts above parking when:

- Occupancy above is R and below is S-2
- Lower floor is open Type IV parking with grade entrance
- Horizontal assembly between 1st and 2nd floor shall be
  - Type IV
  - Have 1 hr fire resistance rating when sprinklered
  - Have 2 hr fire resistance rating when not sprinklered
- Overall height is still limited to occupancy



5 story Type III Building On Top of a Type IV

Case Study: Horizontal Separation

Galt Place Apartments

Location: Galt, CA

Mixed Use Residential over Retail and Parking

Architect: Applied Architecture

Sloped Sites

Fashion Valley, CA
AvalonBay Communities

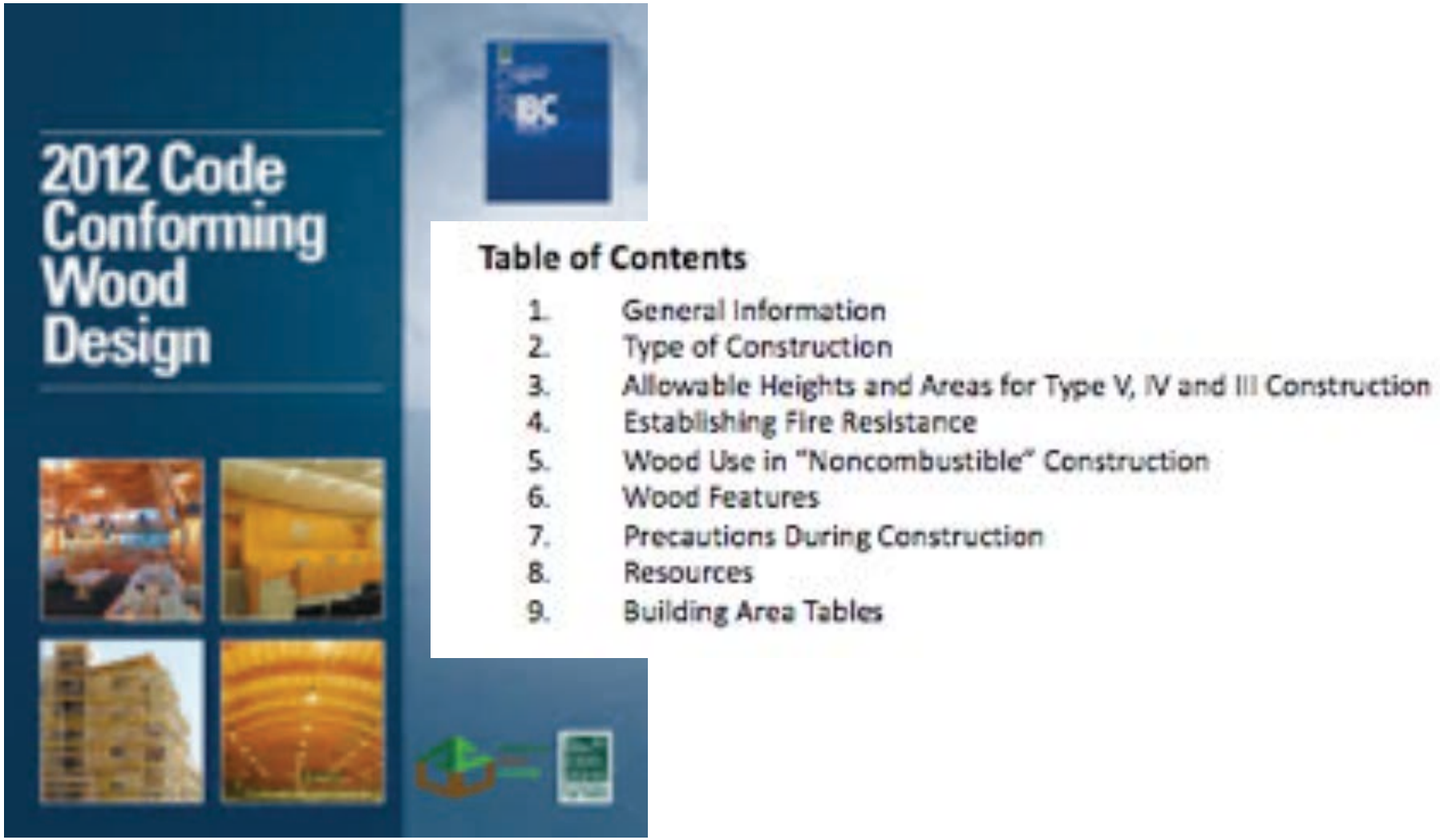
Seattle, WA
PB Architects

Fashion Valley, CA
AvalonBay Communities

Mixed Use Occupancy

Located at woodworks.org – design tools – online calculators – Heights and Areas Calculator

2015 Code Conforming Wood

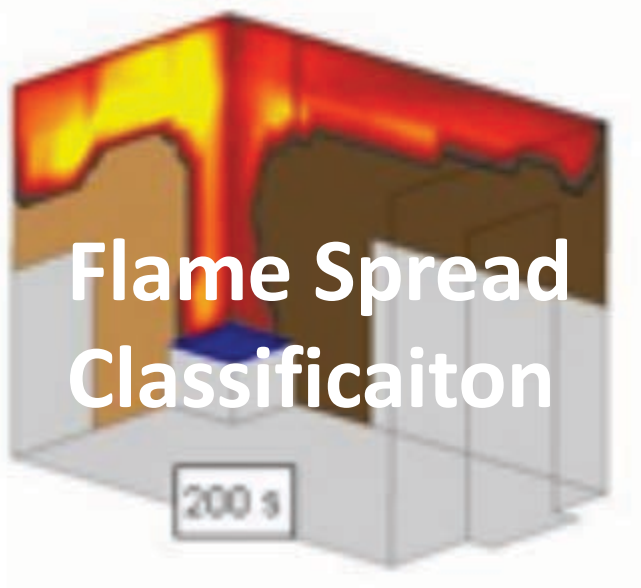


Available for Free Download: www.awc.org

Outline

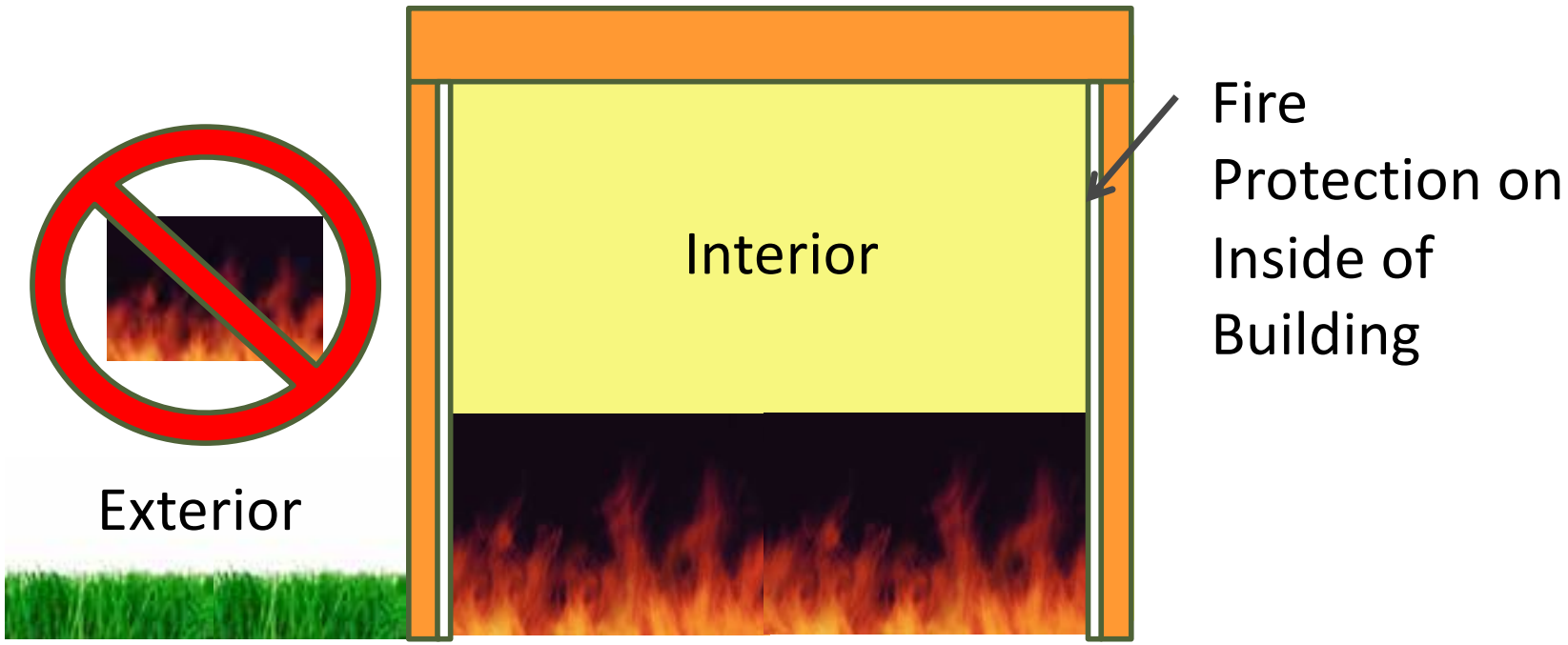
- Need for Mid-rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements
  - Overview
  - Exterior Walls
  - Fire Walls
  - Fire Barriers
  - Fire Partitions
  - Shaft Walls
  - Corridors
  - Balconies
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

Fire Performance



Exterior Walls - FSD

Basic assumption is that fires begin at the interior and rated wall assemblies are not required *from* the exterior unless close to another structure.



Exterior Walls (IBC 705)

705.5 Fire Resistance Ratings: Exterior walls shall be fire-resistance rated in accordance with Tables 601 and 602 and this section. The required fire-resistance rating of exterior walls with a fire separation distance of greater than 10 feet (3048 mm) shall be rated for exposure to fire from the inside. The required fire-resistance rating of exterior walls with a fire separation distance of less than or equal to 10 feet (3048 mm) shall be rated for exposure to fire from both sides.

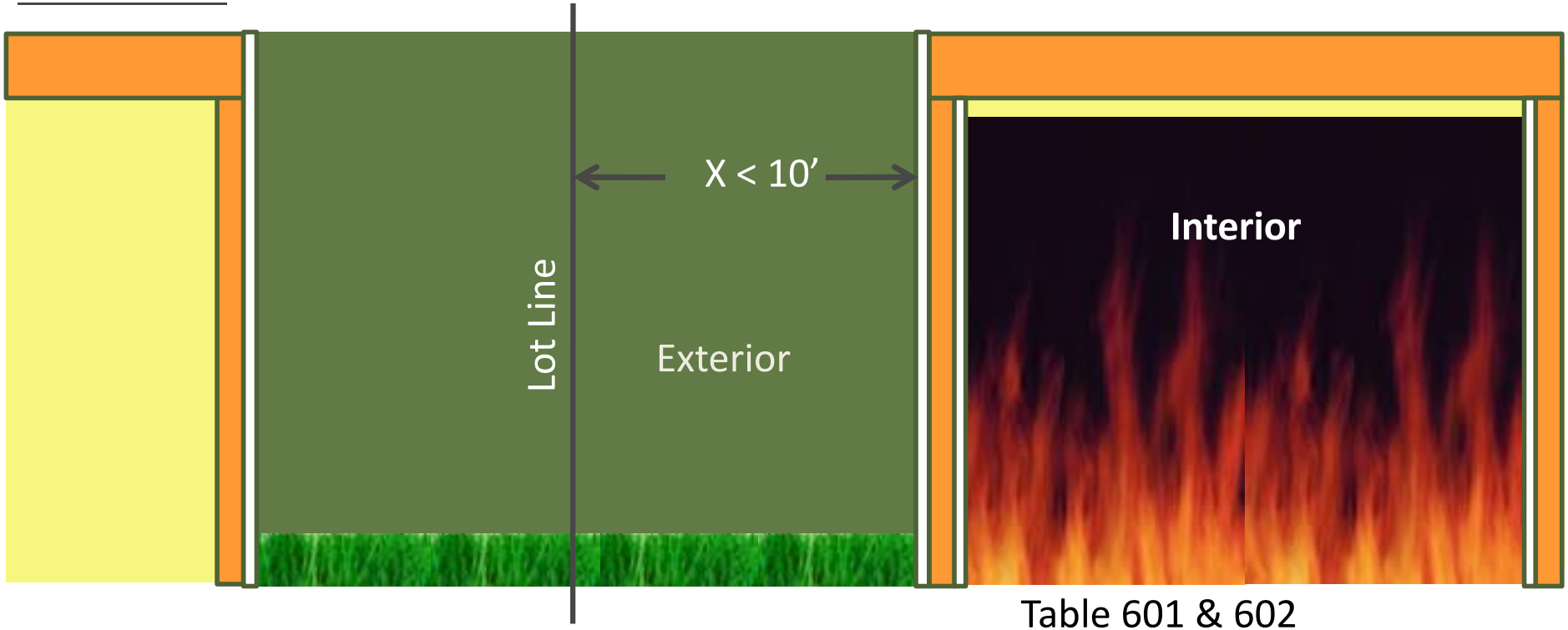
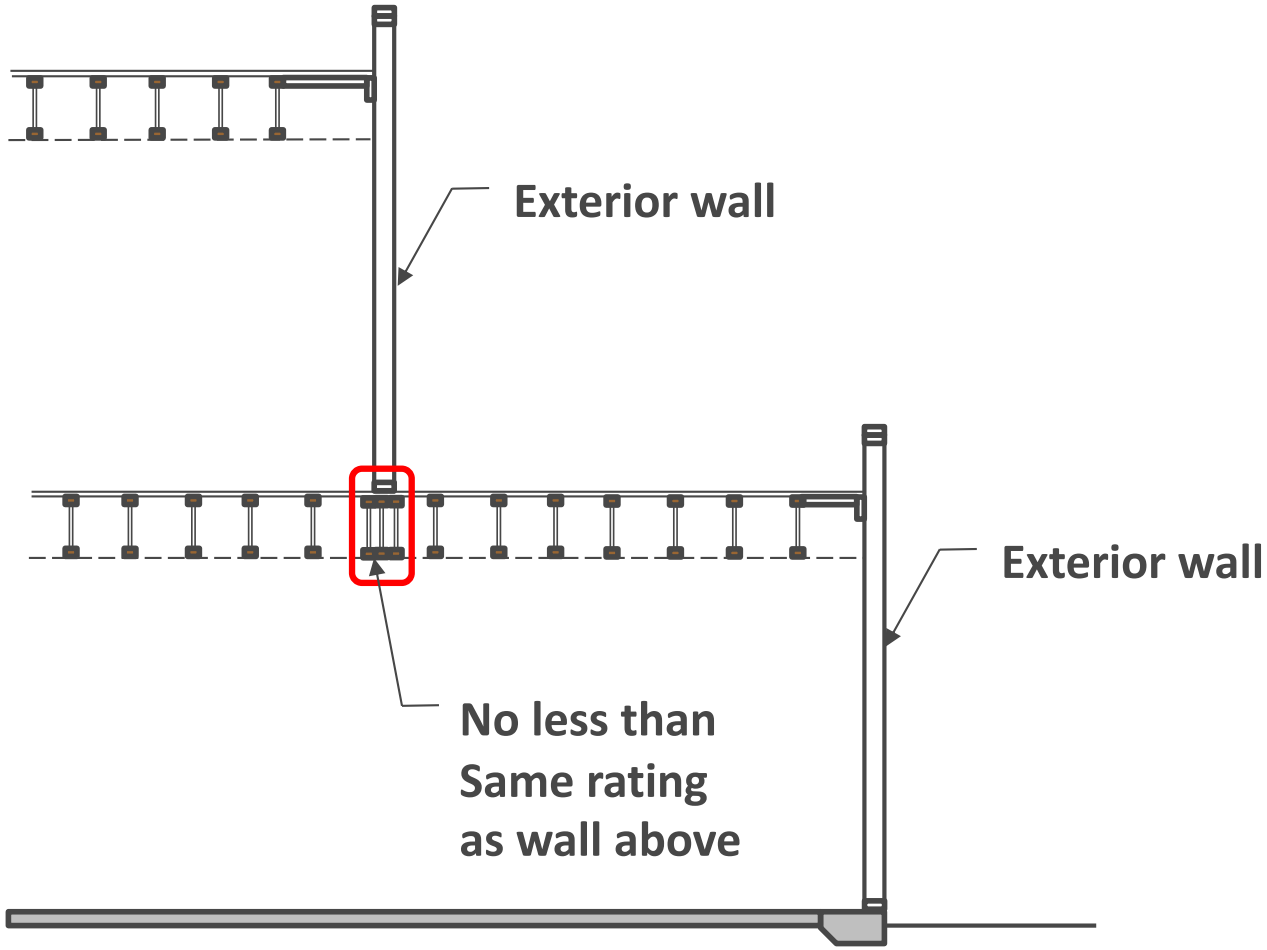


Table 601 & 602

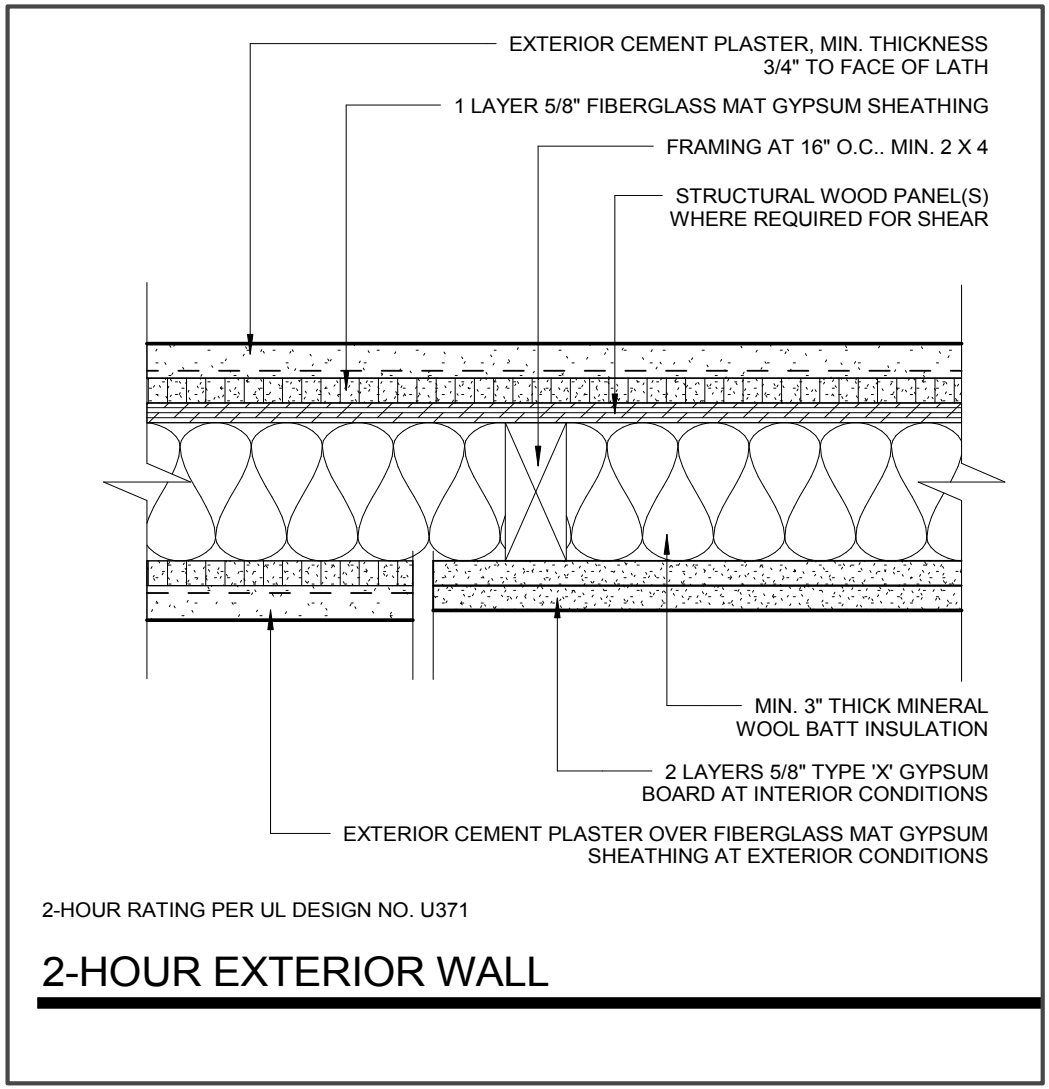
Exterior Walls – Vertical Offsets

There is no requirement for an exterior wall to extend to the foundation in a stepped building.

Posts, beams or walls, that support a rated exterior wall must be fire – resistance rated not less than the rating of the supported wall (IBC 704.1)



Exterior Walls - Asymmetry



Common issues with tested assemblies:

- Assembly Asymmetry- separate assemblies for each side

Fire Wall, Barrier, Partition

Fire wall (IBC 706)

- Divides structure into separate buildings
- Continuous from foundation (or top of three hour podium) to or through roof
- Structural stability required to allow collapse on either side from fire without causing collapse of fire wall
- Special requirements at roof and intersection with exterior walls , at horizontal projecting elements and between stepped buildings
- Required to be of non-combustible construction except in type V construction
- 2 to 4 hour rated (Table 706.4)

Fire Barrier (IBC 707)

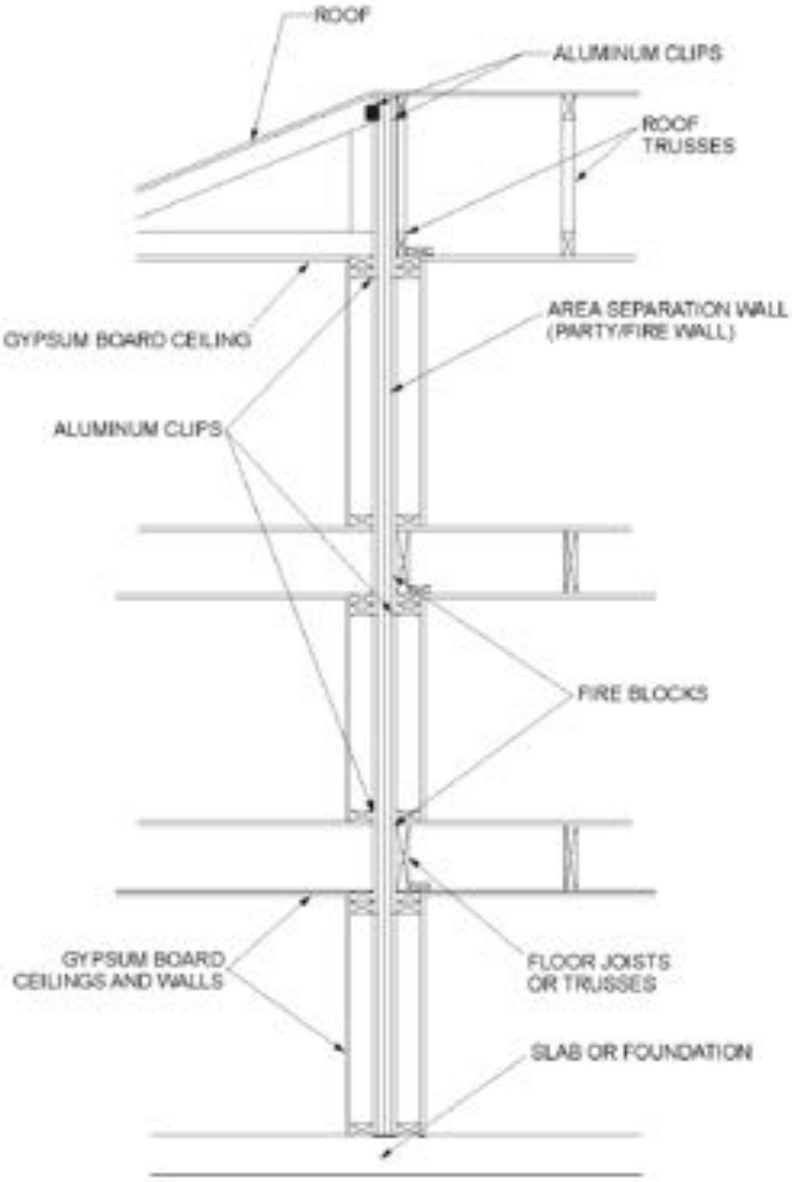
- Designed to restrict the spread of fire with continuity through the building
- Divides structure into fire areas, and fire barriers are required for various purposes such as shaft enclosures, exit enclosures, atrium separation, occupancy separations, and control or incidental use areas.
- Supported by construction of equal fire resistance-rating (except for incidental use areas in type IIB, IIIB and VB construction)
- 1 to 4 hour rated (table 707.3.10)

Fire Partition (IBC 708)

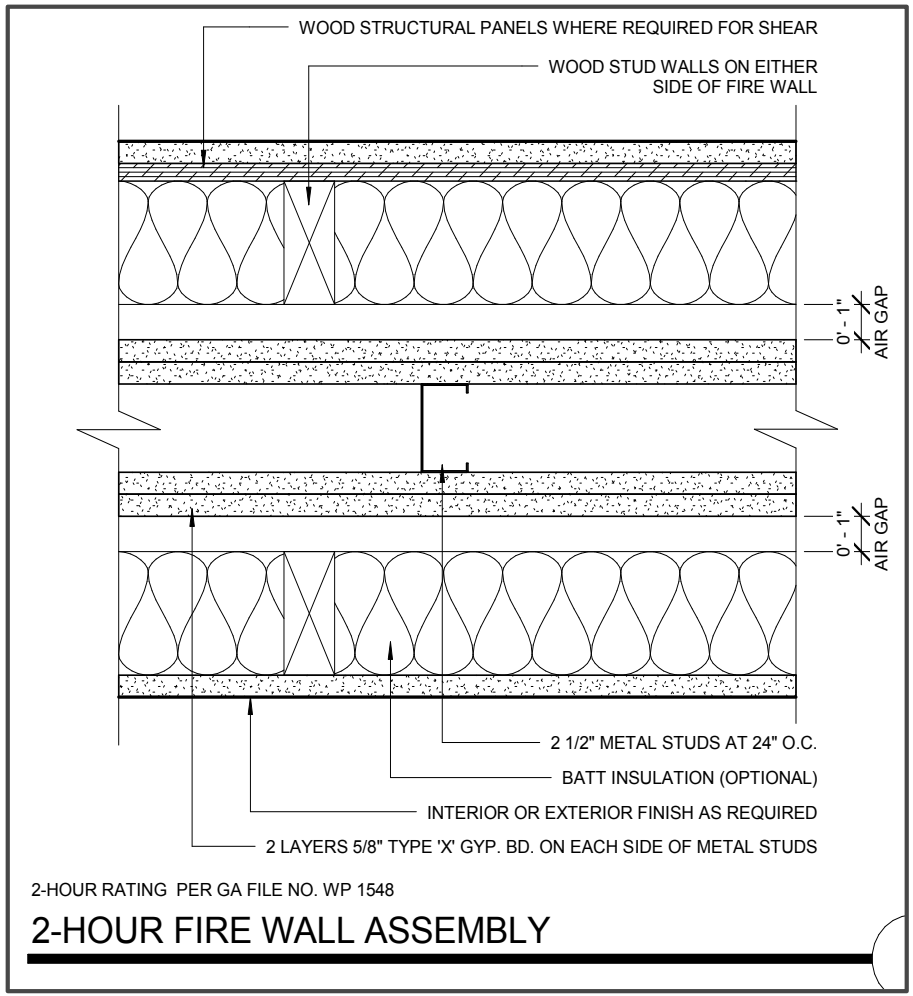
- Separates dwelling units, sleeping areas, corridors, and tenant spaces.
- May terminate at the lower side of a fire –resistance rated floor/ceiling/roof assembly
- In most instances fire partitions are not required to be supported by fire resistance-rated construction in type IIB, IIIB and VB construction (section 708.4)
- Rated 1 hour or less (IBC section 708.3)

Fire Walls – Structural Stability

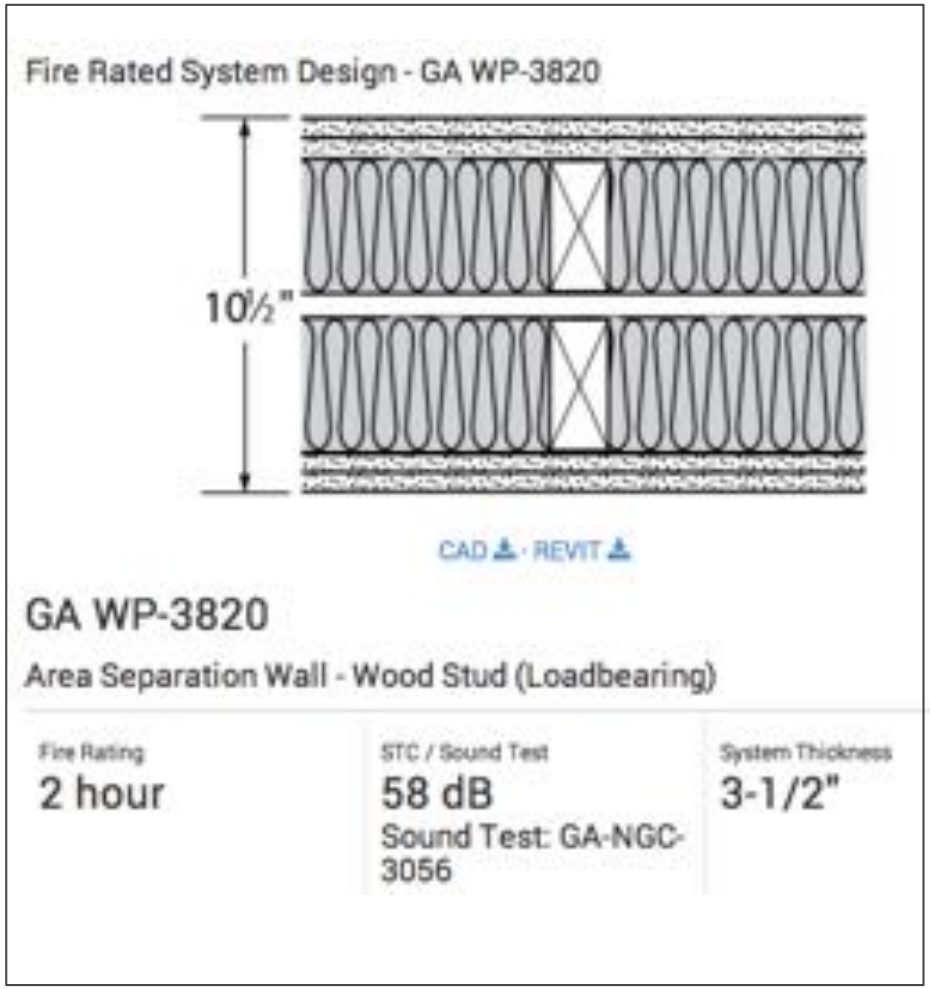
706.2 Structural Stability:
Fire walls shall have sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall for the duration of time indicated by the required fire-resistance rating or shall be constructed as double fire walls in accordance with NFPA 221.



2 HR Fire Wall– Type V



CAD & Revit Details: www.woodworks.org



http://www.usgdesignstudio.com/wall-selector.asp?framingType=18708&bldgSystem=18620

Fire Barriers – IBC 707

Supported by assembly of equal or greater fire resistance (with exceptions when required for separating incidental use areas in type IIB, IIIB and VB construction)

Commonly used in:

- Shaft enclosures
- Interior exit stairway
- Exit stairway enclosures
- Exit passageways
- Incidental uses (IBC 509)
- Occupancy separations
- Atriums
- Creating separate fire areas

Shaft Walls

705.5: Continuity:

- Extend and attach to foundation to floor/roof
- Through concealed spaces
- Joints and voids shall comply with sections 707.8 and 707.9

713.4 Fire-Resistance Rating:

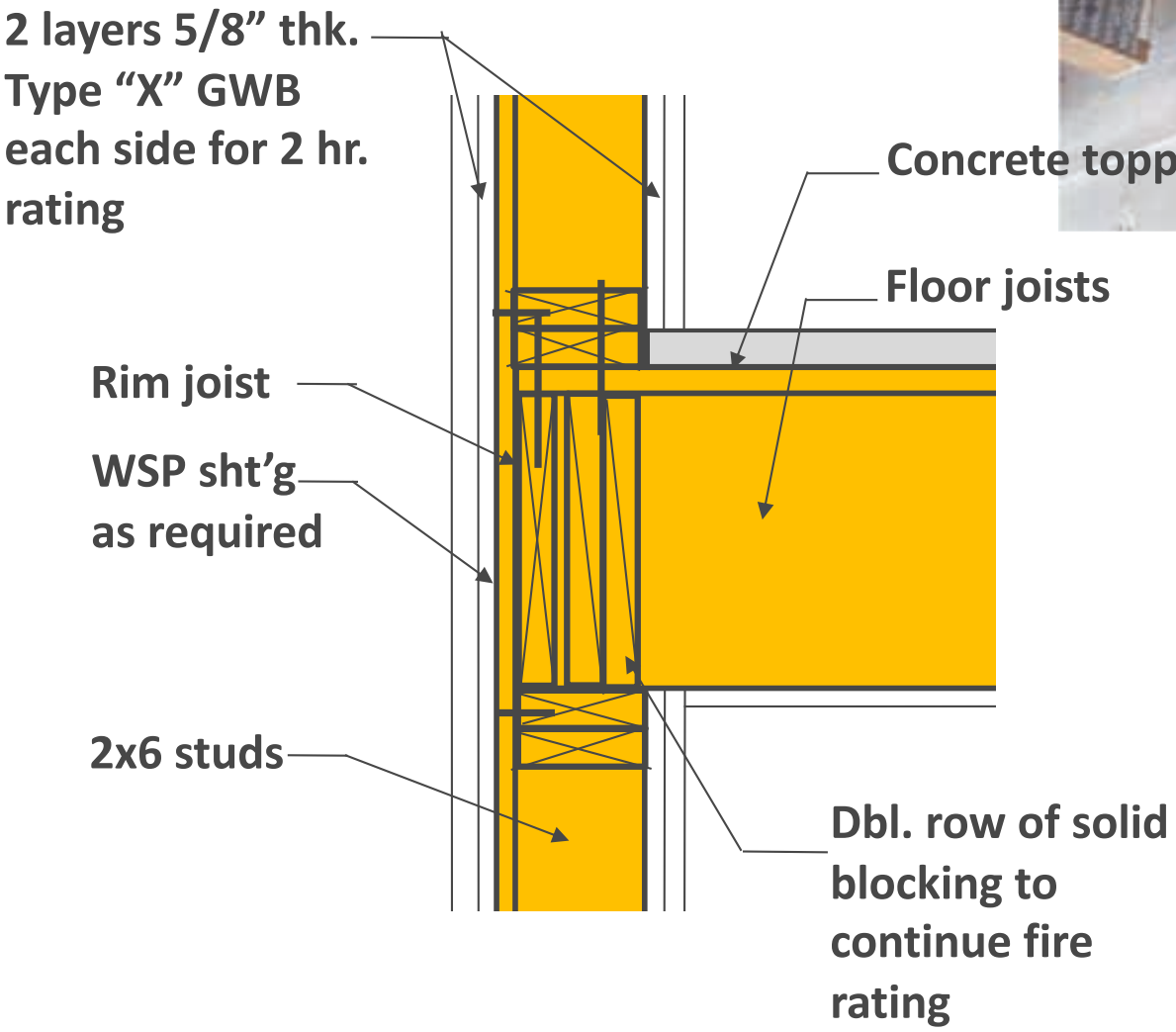
- Not less than 2 hours (4 stories or more)
- 1 hour (less than 4 stories)

Wood Framed Shaft Walls

Using wood framed shaft walls can:

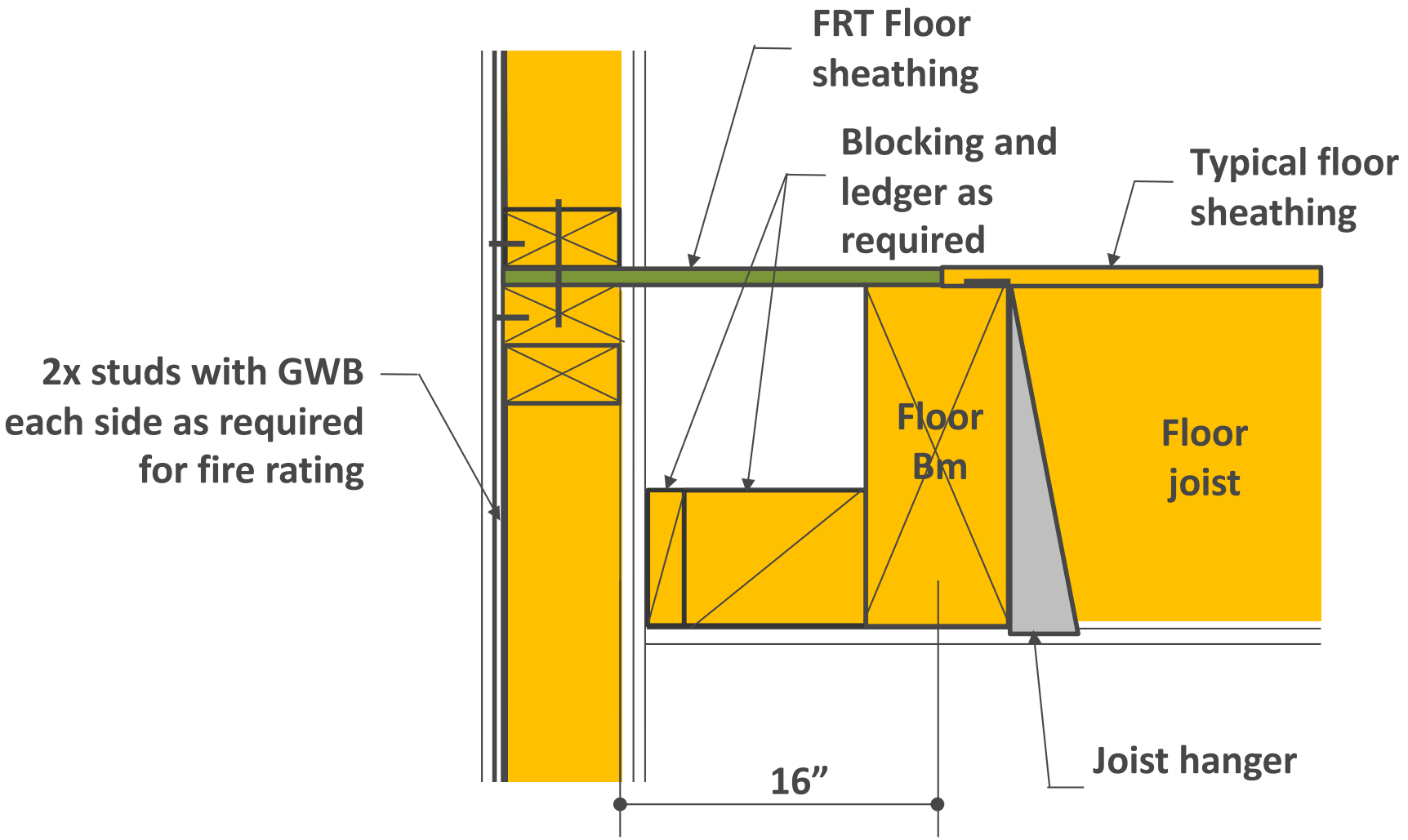
- Eliminate lateral load considerations associated with attaching wood diaphragms to concrete or masonry shaft walls (SDPWS 4.1.5)
- Eliminate differential shrinkage at floor to wall transition
- Eliminate different construction trades in building during construction
- Reduce costs
- Improve schedule

Shaft Wall Details



Wood Design Focus: Volume 22, Issue 3 by Smith

Shaft Wall Details



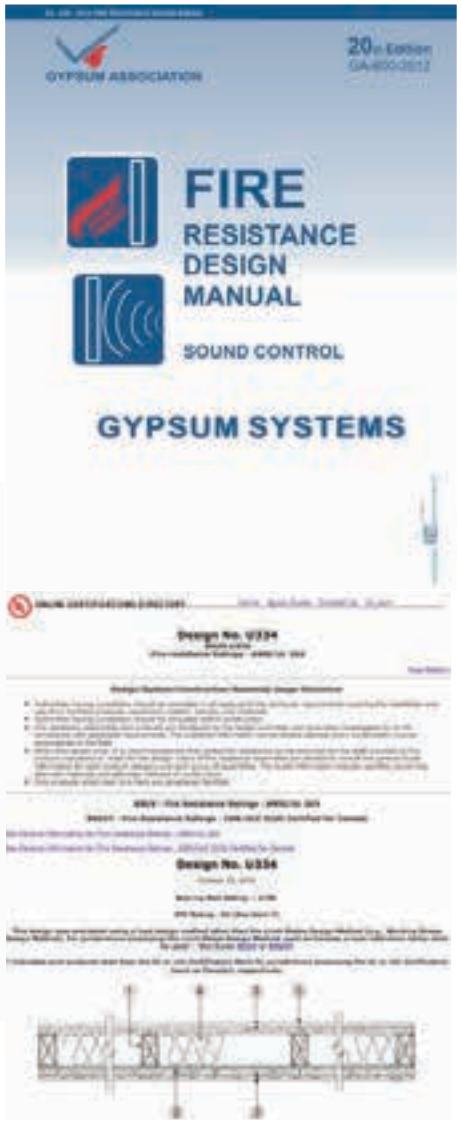
Choosing Fire Rated Assemblies

Tested assemblies (ASTM E119) per IBC 703.2:

- UL Listings
- Gypsum Catalog
- Proprietary Manufacturer Tests
- Industry Documents: such as AWC's DCA3

Alternate Methods per IBC 703.3

- Prescriptive designs per IBC 721.1
- Calculated Fire Resistance per IBC 722
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Fire-resistance designs certified by an approved agency



Balconies – IBC 1406.3

So….

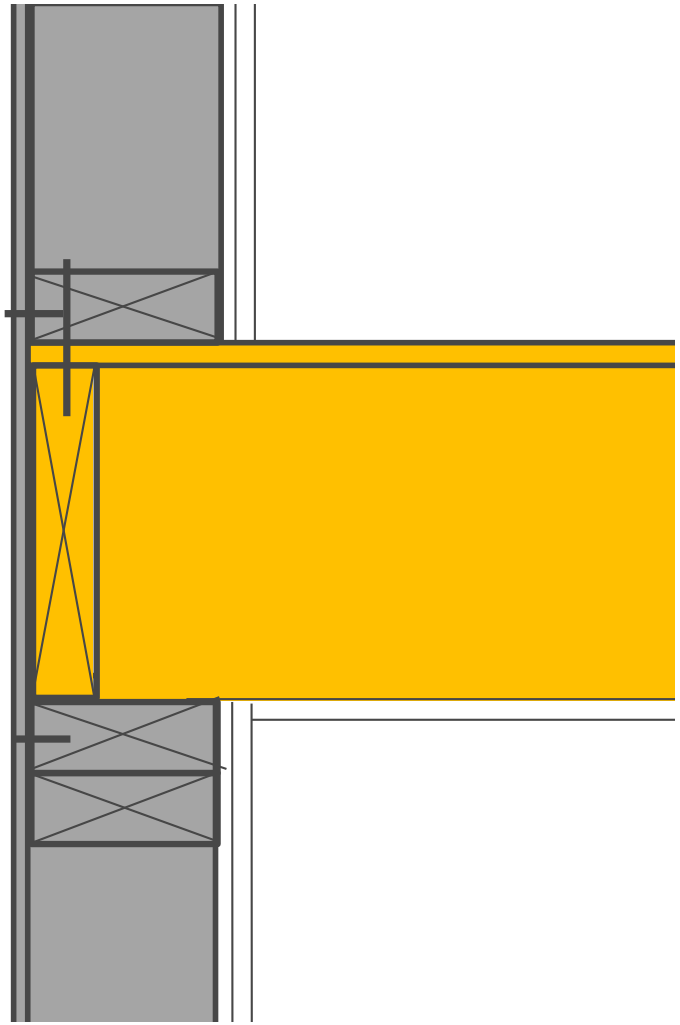
For Type III or V balcony options are:

1. Non-combustible – no sprinklers/no fire rating
2. FRT – no fire sprinklers/no fire rating
3. Type IV– no fire sprinklers/no fire rating
4. Non treated – fire sprinkler/no fire rating
5. Non treated – fire rated per 601 & 602/ no sprinkler

Outline

- Need for Mid-rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

Platform Framing



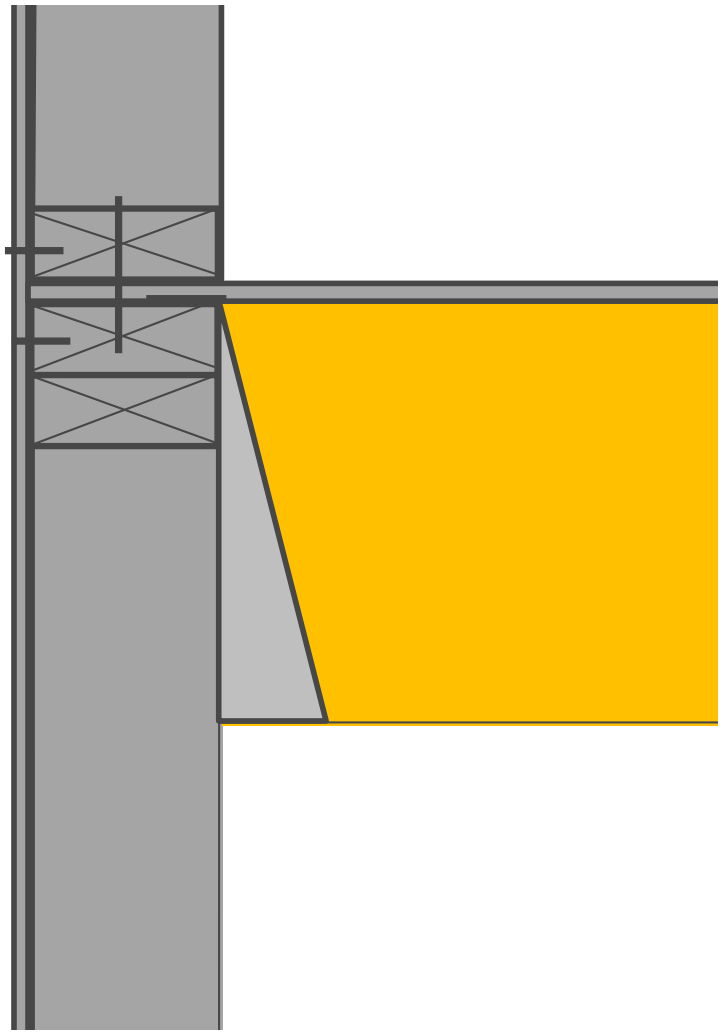
Structural

- Direct bearing/ no add'l hardware
- May require load transfer blocking for concentrated loads from above
- Wall sole plate and floor sheathing crushing may need to be considered

Constructability

- Framing can be completed before drywall and insulation are installed
- Common length studs

Semi-balloon Framing



Structural

- Additional hardware/no direct bearing
- No load transfer blocking req'd

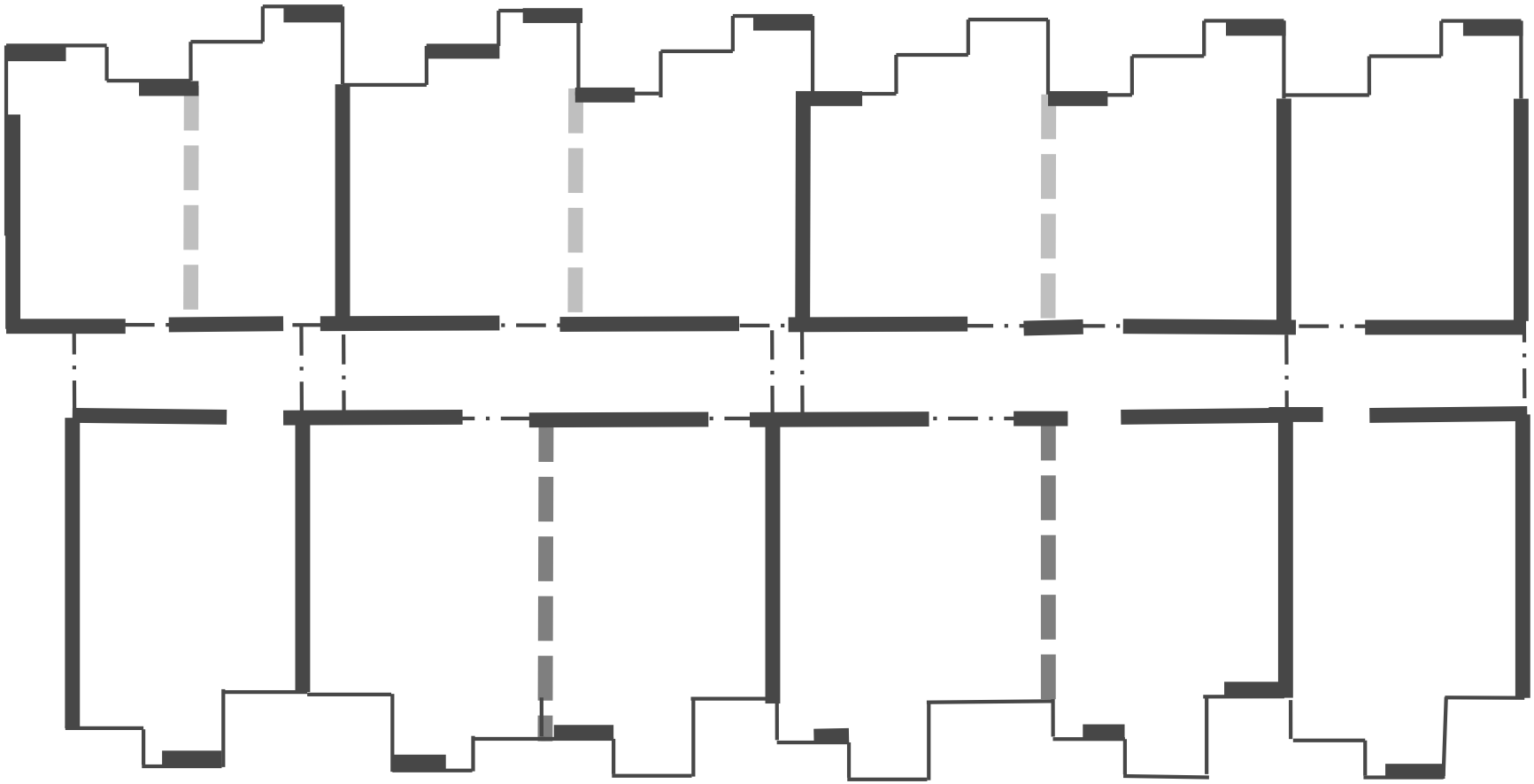
Rated Assemblies

- May accommodate continuity in exterior walls in Type III construction

Constructability

- Framing can be completed before drywall and insulation are installed
- Custom length studs
- Can help minimize building shrinkage

Shear Wall Framing Considerations

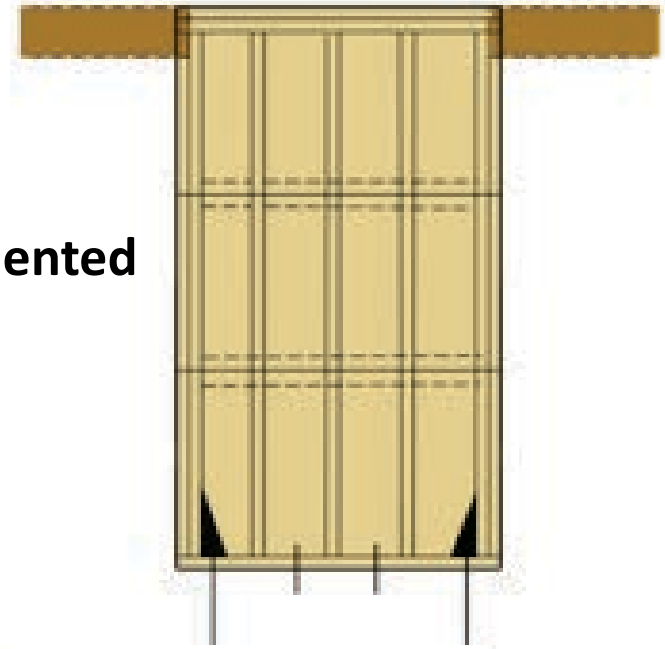


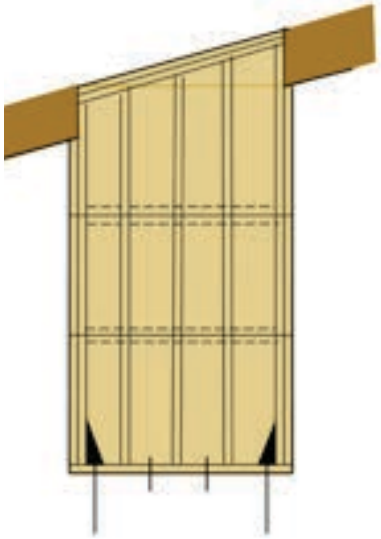
Typical Floor Plan Shear Wall Layout

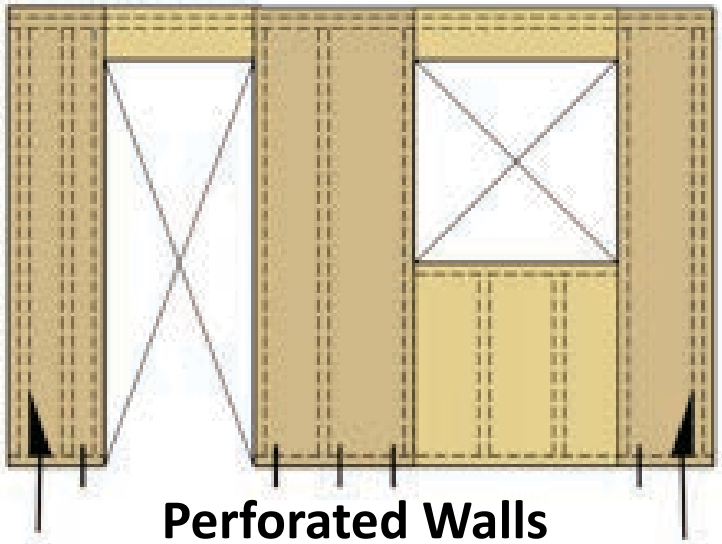
Indicates wood sheathed shear wall

Shear Wall Configuration Options

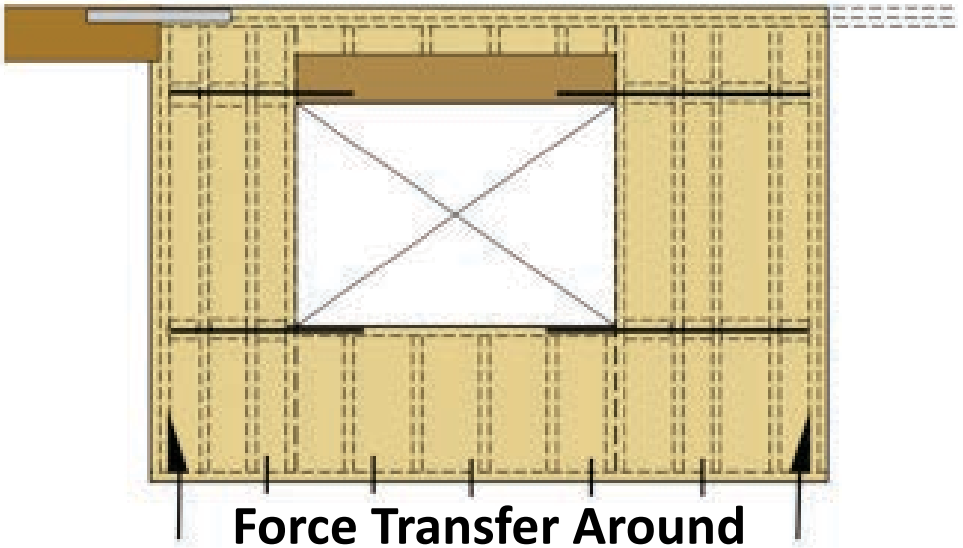
Solid or Segmented Walls





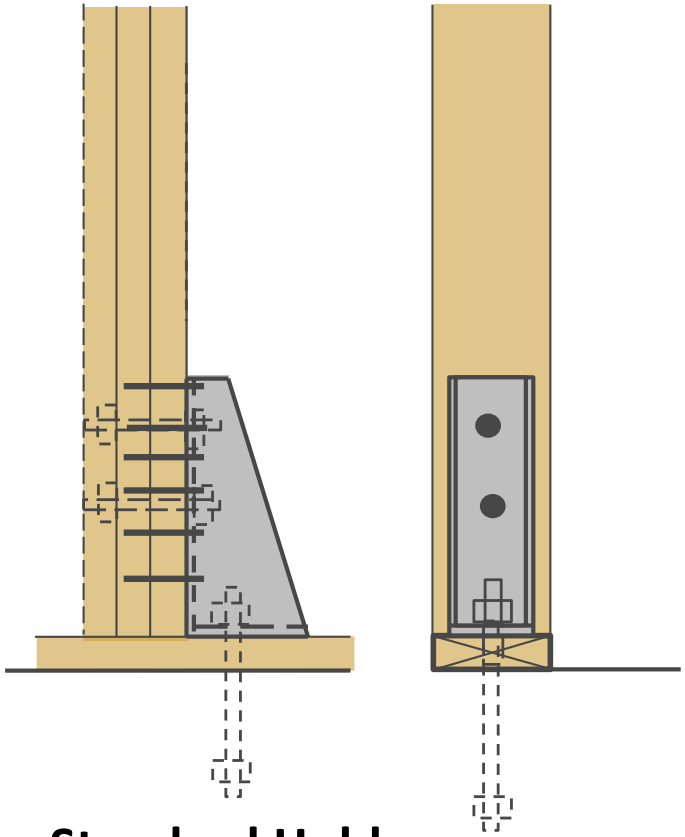


Perforated Walls

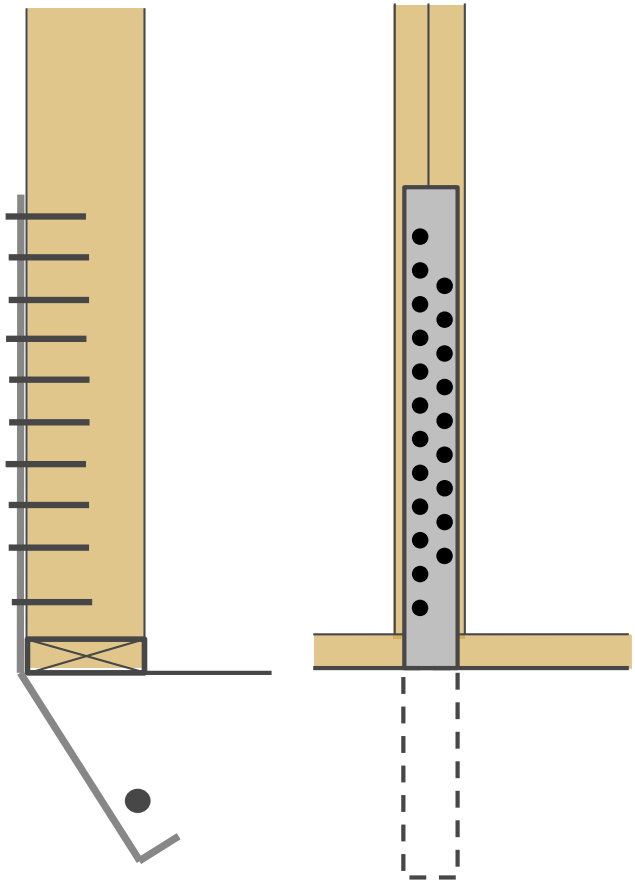


Force Transfer Around Openings Walls

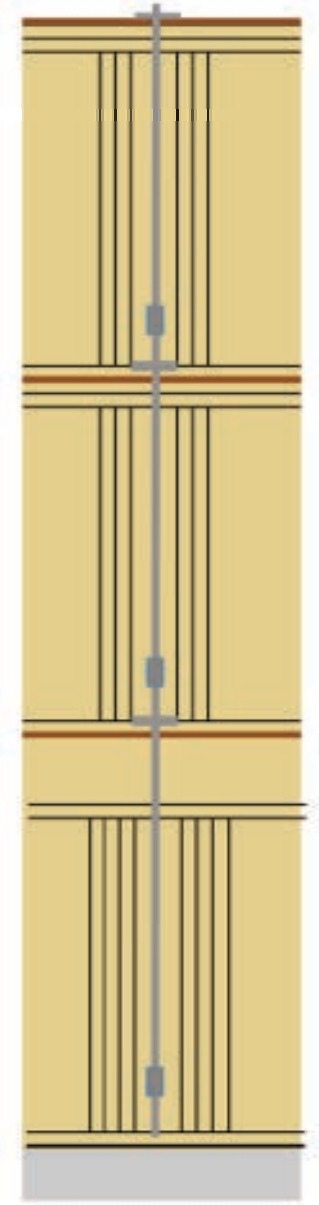
Shear Wall Hold Down Options



Standard Hold Down Installation



Strap Hold Down Installation



Continuous Rod - Automatic Tensioning Systems

Shear Wall to Podium Slab Interface

- Amplification of seismic forces is required for elements supporting discontinuous walls per ASCE 7-10 12.3.3.3
- Overstrength factor of 3 (may be reduced to 2.5 per footnote g of Table 12.2-1) is required

- Attachment to concrete slab must also conform to ACI 318 Appendix D
- Typically will be transitioning from ASD for wood design to LRFD for concrete design
- Hold down attachments to concrete options: embedded nuts or plates, sleeves through slab, welded studs & reinforcing

PT Sole Plate vs FRT Continuity

In type III construction with FRT studs, what happens where the sole plate is in contact with concrete?

- FRTW is required
- PT wood is required

FRT contains about 10x borate compound found in PT (borate is water soluble)

Can specify a product tested to do both

Outline

- Need for Mid-rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements
- Structural Design & Detailing Considerations
- Shrinkage Considerations & Detailing
  - Concepts
  - Calculations
  - Recommendations
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

IBC 2012 on Shrinkage

2304.3.3 Shrinkage. Wood walls and bearing partitions shall not support more than two floors and a roof unless an analysis satisfactory to the building official shows that shrinkage of the wood framing will not have adverse effects on the structure or any plumbing, electrical or mechanical systems, or other equipment installed therein due to excessive shrinkage or differential movements caused by shrinkage. The analysis shall also show that the roof drainage system and the foregoing systems or equipment will not be adversely affected or, as an alternative, such systems shall be designed to accommodate the differential shrinkage or movements.

Basic Wood Shrinkage Theory

Moisture changes cause dimensional changes perpendicular to grain

Growing tree is filled with water

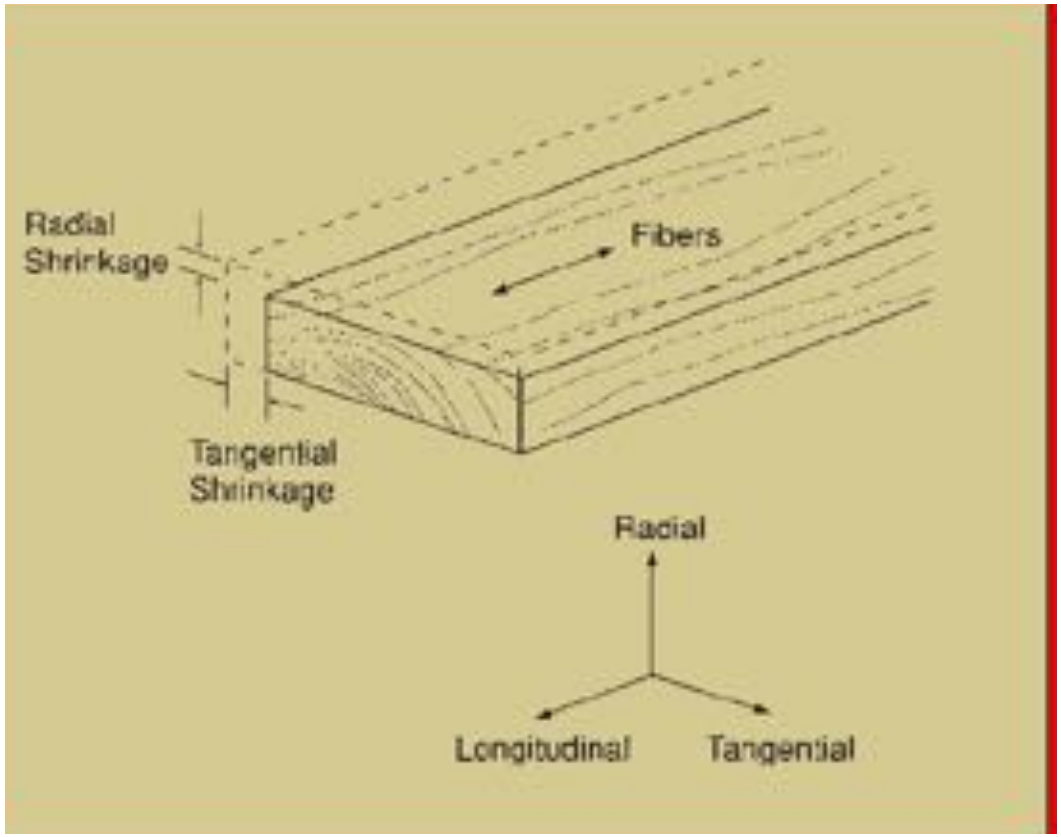
As wood dries, it shrinks perp. to grain

Image: Wood Handbook, Wood as an Engineering Material, USDA Forest Service, Forest Products Laboratory, 2010

Basic Wood Shrinkage Theory

Shrinkage in lumber expected ACROSS the grain.

Longitudinal shrinkage is negligible.



Wider & Thicker --- NOT Taller

Basic Wood Shrinkage Theory

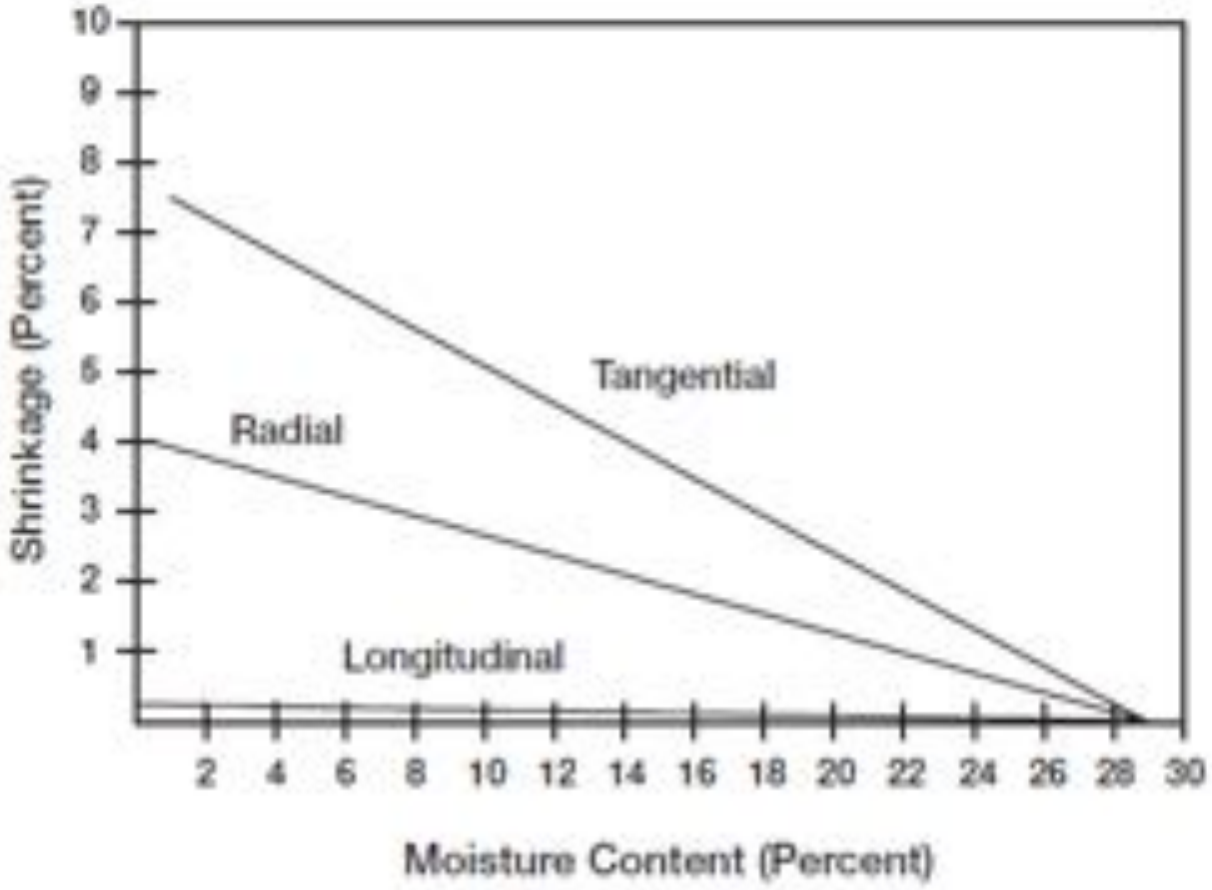


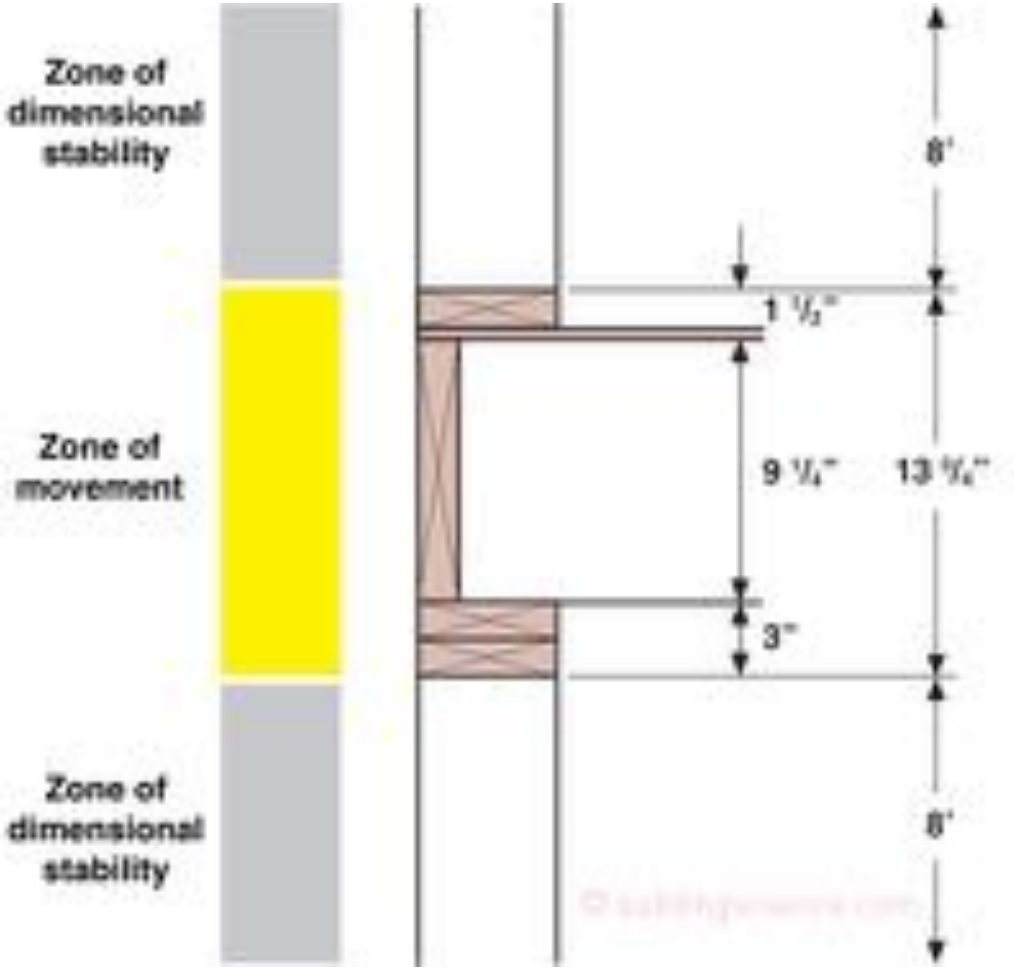
Figure 2. Average shrinkage properties

Zone of Movement

Shrinkage occurs primarily in horizontal members

- Wall plates
- Floor/rim joists

Be aware of cumulative shrinkage.



Calculating Shrinkage

For MC **between 6 to 14%** the shrinkage formula is:

$$S = D_i\left[C_T\left(M_F - M_i\right)\right]$$

S = shrinkage (in inches)

D_i = initial dimension (in inches)

C_T / C_R= dimension change coefficient, tangential/radial direction

C_T = 0.00319 for Douglas Fir-Larch

C_T = 0.00323 for Hem-Fir

C_T = 0.00263 for Spruce-Pine-Fir

C_T = 0.00263 for Southern Pine

M_F = final moisture content (percent)

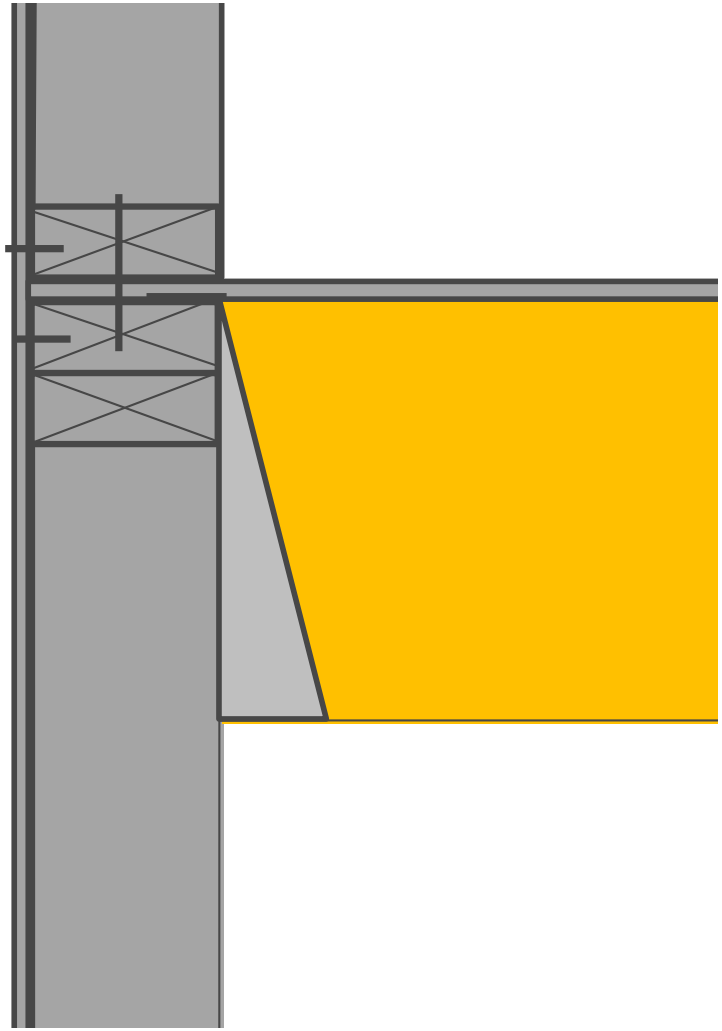
M_i = initial moisture content (percent)

Minimizing Shrinkage

Semi-balloon framing

- incorporates floor framing hanging from top plates
- Eliminates tangential shrinkage in zone of movement
- Floor framing doesn't contribute to overall building shrinkage

Non-standard stud lengths and increased hardware requirements are a result.



Differential Movement

Movement between wood frame elements and other materials that…

- do not shrink at all
- shrink much less
- expand

Shrinkage & MEP Considerations

Fully compress wall framing by completing all dead load potential PRIOR to mechanical installations.

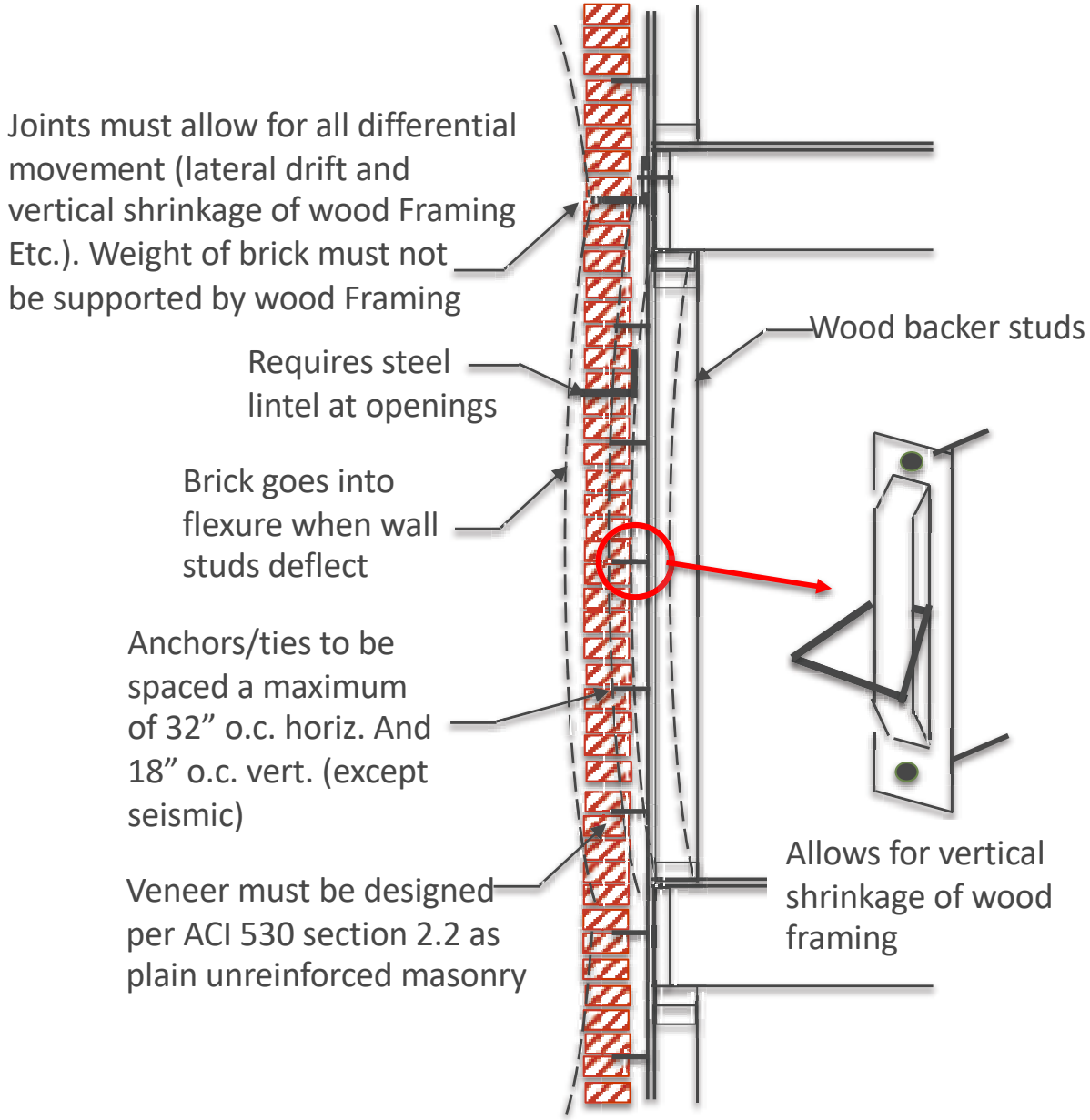
Avoid rigid vertical piping in mechanical and plumbing systems. Flexible members allow for shrinkage between floors.

Brick Façade: Solution 1- Plain Unreinforced Brick-h>30’

Design must be in strict conformance with ACI 530 section 6.2.1-Alt. design method (engineered)

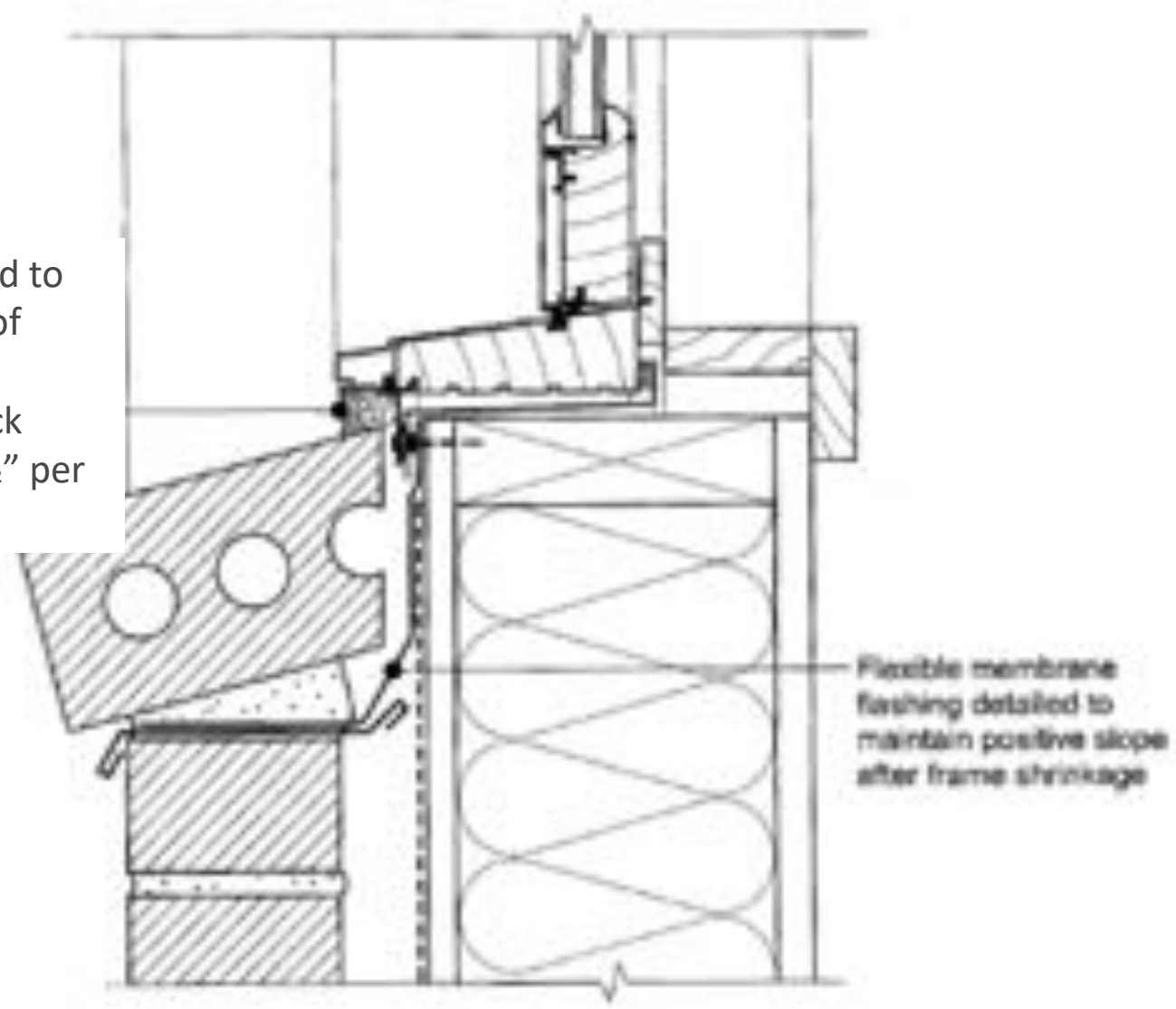
Design to section 2.2 (ASD) or 3.2.2 (strength) unreinforced masonry

Brick veneer must be self supporting and not supported off of the wood framing



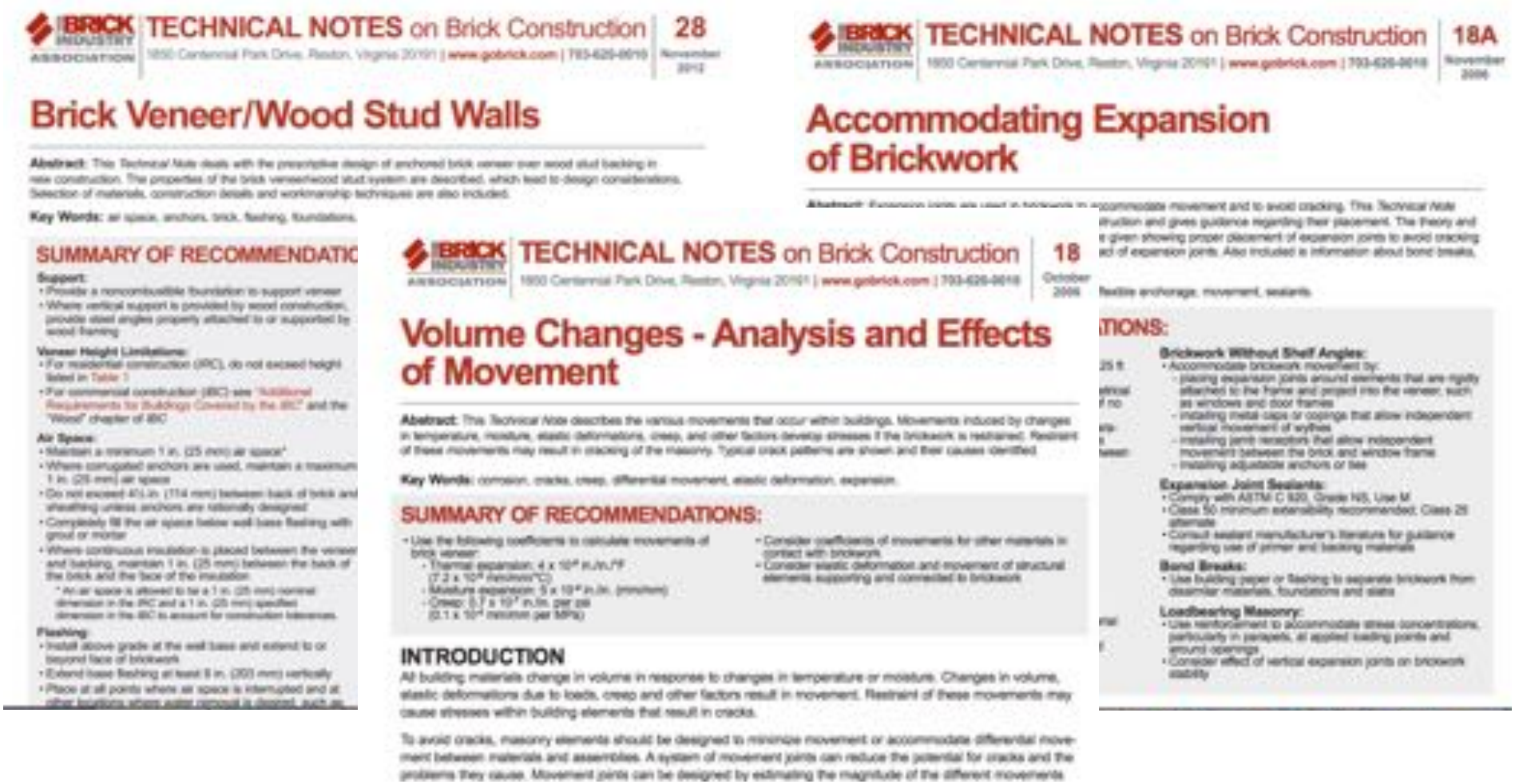
Door and Window Considerations

Sealant joint sized to allow shrinkage of wood frame and expansion of brick (typically ¼" to ½" per floor)



Façade Considerations - Resources

Brick Industry Association– www.gobrick.com



BRICK INDUSTRY ASSOCIATION
TECHNICAL NOTES on Brick Construction 28
November 2012

Brick Veneer/Wood Stud Walls

Abstract: This Technical Note deals with the prescriptive design of anchored brick veneer over wood stud backing in new construction. The properties of the brick veneer/wood stud system are described, which lead to design considerations. Selection of materials, construction details and workmanship techniques are also included.

Key Words: air space, anchors, brick, flashing, foundations

SUMMARY OF RECOMMENDATIO

Support:
- Provide a noncombustible foundation to support veneer
- Where vertical support is provided by wood construction, provide steel angles properly attached to or supported by wood framing

Veneer Height Limitations:
- For residential construction (IRC), do not exceed height listed in Table 1
- For commercial construction (IBC) see "Additional Requirements for Buildings Covered by the IBC" and the "Wood" chapter of IBC

Air Space:
- Maintain a minimum 1 in. (25 mm) air space*
- Where corrugated anchors are used, maintain a maximum 1 in. (25 mm) air space
- Do not exceed 4½ in. (114 mm) between back of brick and sheathing unless anchors are rationally designed
- Completely fill the air space below wall base flashing with grout or mortar
- Where continuous insulation is placed between the veneer and backing, maintain 1 in. (25 mm) between the back of the brick and the face of the insulation

* An air space is allowed to be a 1 in. (25 mm) nominal dimension in the IRC and a 1 in. (25 mm) specified dimension in the IBC to account for construction tolerances.

Flashing:
- Install above grade at the wall base and extend to or beyond face of brickwork
- Extend base flashing at least 8 in. (203 mm) vertically
- Place at all points where air space is interrupted and at other locations where water removal is desired, such as

BRICK INDUSTRY ASSOCIATION
TECHNICAL NOTES on Brick Construction 18
October 2009

Volume Changes - Analysis and Effects of Movement

Abstract: This Technical Note describes the various movements that occur within buildings. Movements induced by changes in temperature, moisture, elastic deformations, creep, and other factors develop stresses if the brickwork is restrained. Restraint of these movements may result in cracking of the masonry. Typical crack patterns are shown and their causes identified.

Key Words: corrosion, cracks, creep, differential movement, elastic deformation, expansion

SUMMARY OF RECOMMENDATIONS:
- Use the following coefficients to calculate movements of brick veneer:
  - Thermal expansion: 4 x 10^{-6} in./in./°F (7.2 x 10^{-6} meters/m/°C)
  - Moisture expansion: 5 x 10^{-4} in./in. (mm/m)
  - Creep: 0.7 x 10^{-7} in./in. per psi (0.1 x 10^{-4} meters/m per MPa)
- Consider coefficients of movements for other materials in contact with brickwork.
- Consider elastic deformation and movement of structural elements supporting and connected to brickwork.

INTRODUCTION

All building materials change in volume in response to changes in temperature or moisture. Changes in volume, elastic deformations due to loads, creep and other factors result in movement. Restraint of these movements may cause stresses within building elements that result in cracks.

To avoid cracks, masonry elements should be designed to minimize movement or accommodate differential movement between materials and assemblies. A system of movement joints can reduce the potential for cracks and the problems they cause. Movement joints can be designed by estimating the magnitude of the different movements

BRICK INDUSTRY ASSOCIATION
TECHNICAL NOTES on Brick Construction 18A
November 2008

Accommodating Expansion of Brickwork

Flexible anchorage, movement, sealants

TIONS:

Brickwork Without Shelf Angles:
- Accommodate brickwork movement by:
  - placing expansion joints around elements that are rigidly attached to the frame and project into the veneer, such as windows and door frames
  - installing metal caps or copings that allow independent vertical movement of wythes
  - installing jamb reveals that allow independent movement between the brick and window frame
  - installing adjustable anchors or ties

Expansion Joint Sealants:
- Comply with ASTM C 920, Grade NS, Use M
- Class 50 minimum extensibility recommended; Class 25 alternate
- Consult sealant manufacturer's literature for guidance regarding use of primer and backing materials

Bond Breaks:
- Use building paper or flashing to separate brickwork from dissimilar materials, foundations and slabs

Loadbearing Masonry:
- Use reinforcement to accommodate stress concentrations, particularly in parapets, at applied loading points and around openings
- Consider effect of vertical expansion joints on brickwork stability

Façade Considerations - Resources

www.woodworks.org

WoodWorks™
WOOD PRODUCTS COUNCIL

Options for Brick Veneer on Mid-Rise Wood-Frame Buildings

R. Terry Malone, PE, SE • Senior Technical Director • WoodWorks

Photo: Josh Meister, courtesy Cooper Carry

Emory Point • Atlanta, GA

Architects: Cooper Carry and The Preston Partnership

Structural engineers: Ellinwood • Machado LLC and Pruitt Eberly Stone Inc.

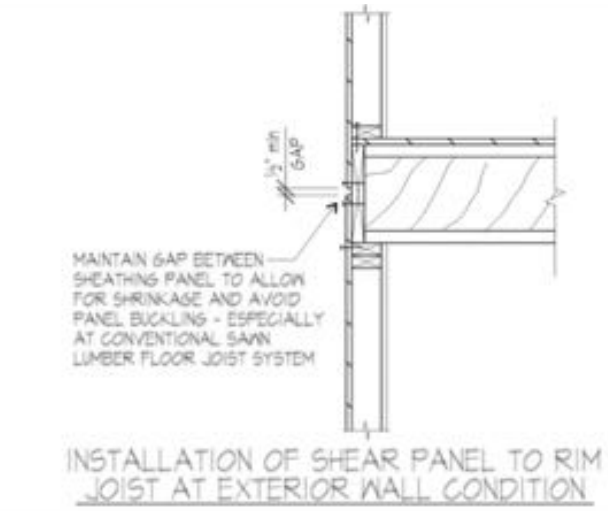
Completed: 2012

Emory point includes three buildings, one with five stories of Type III-A wood-frame construction over slab-on-grade, and two with four stories of Type V-A wood construction over a Type I-A post-tensioned concrete podium.

Shrinkage Mitigating Detailing Tips

Best practices to mitigate distress to finishes arising from cumulative differential movement:

- Be acutely aware of the fact that there will be differential movement
- Address it in detailing and specifications
- Consider where distress will occur
- Provide details to relieve or avoid it



Architects: Cooper Carry & The Preston Partnership
Photo: Aerial Photography Inc.

Outline

- Need for Mid-rise Construction (Urban Densification)
- Mid-rise Building Types/Configurations
- Maximizing Height & Area
- Fire Ratings & Requirements
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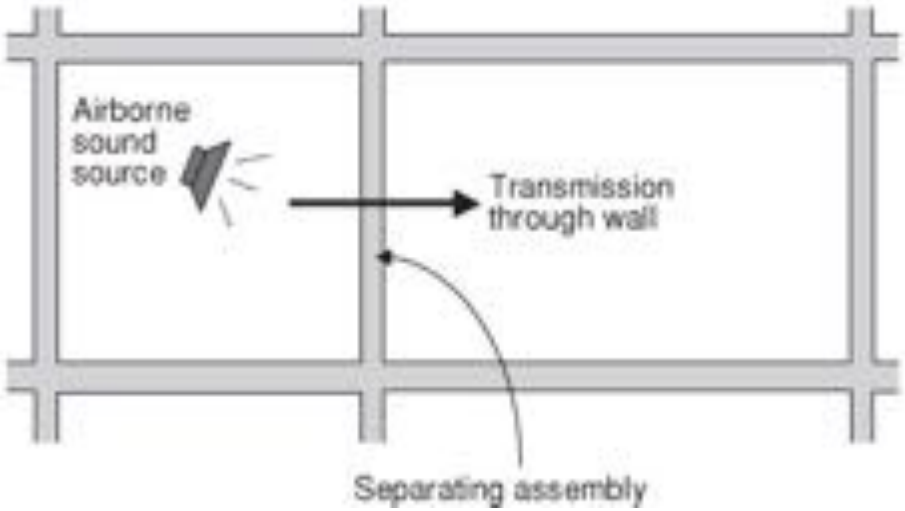
- Acoustic Requirements & Detailing
- Common Floor to Wall Detailing

Building Acoustics Overview

Air-borne sound:

- Sound Transmission Class (STC)

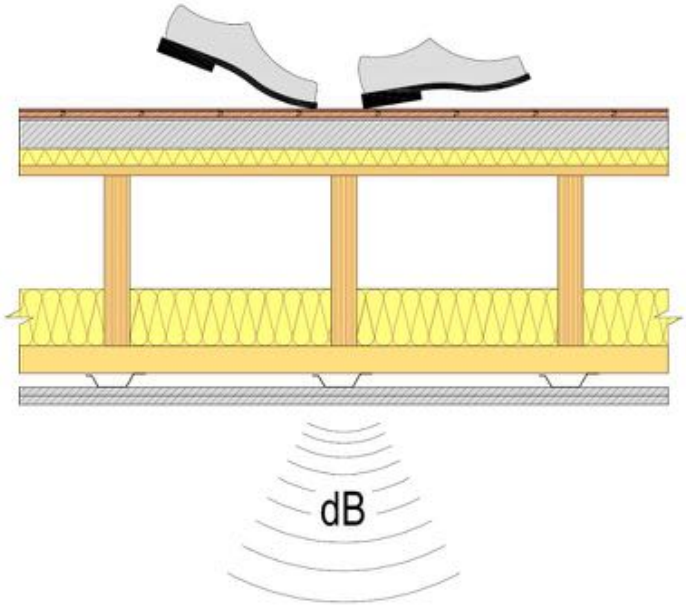
Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other



Structure-borne sound:

- Impact Insulation Class (IIC)

Evaluates how effectively an assembly blocks impact sound from passing through it



Acoustically Rated Assemblies

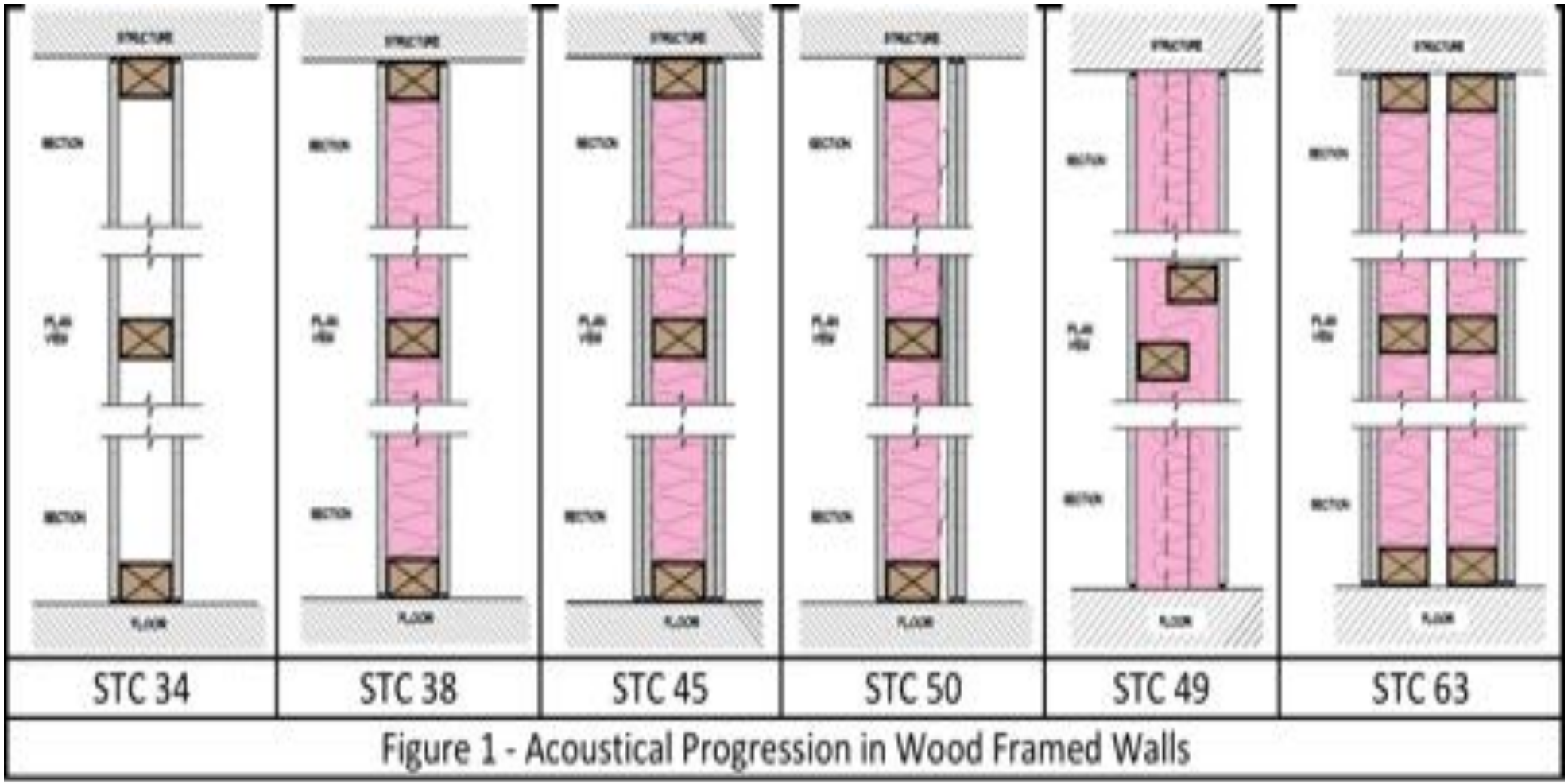


Figure 1 - Acoustical Progression in Wood Framed Walls

Many available free online STC & IIC rated assembly charts (USG, GP, others)

Acoustically Rated Assemblies

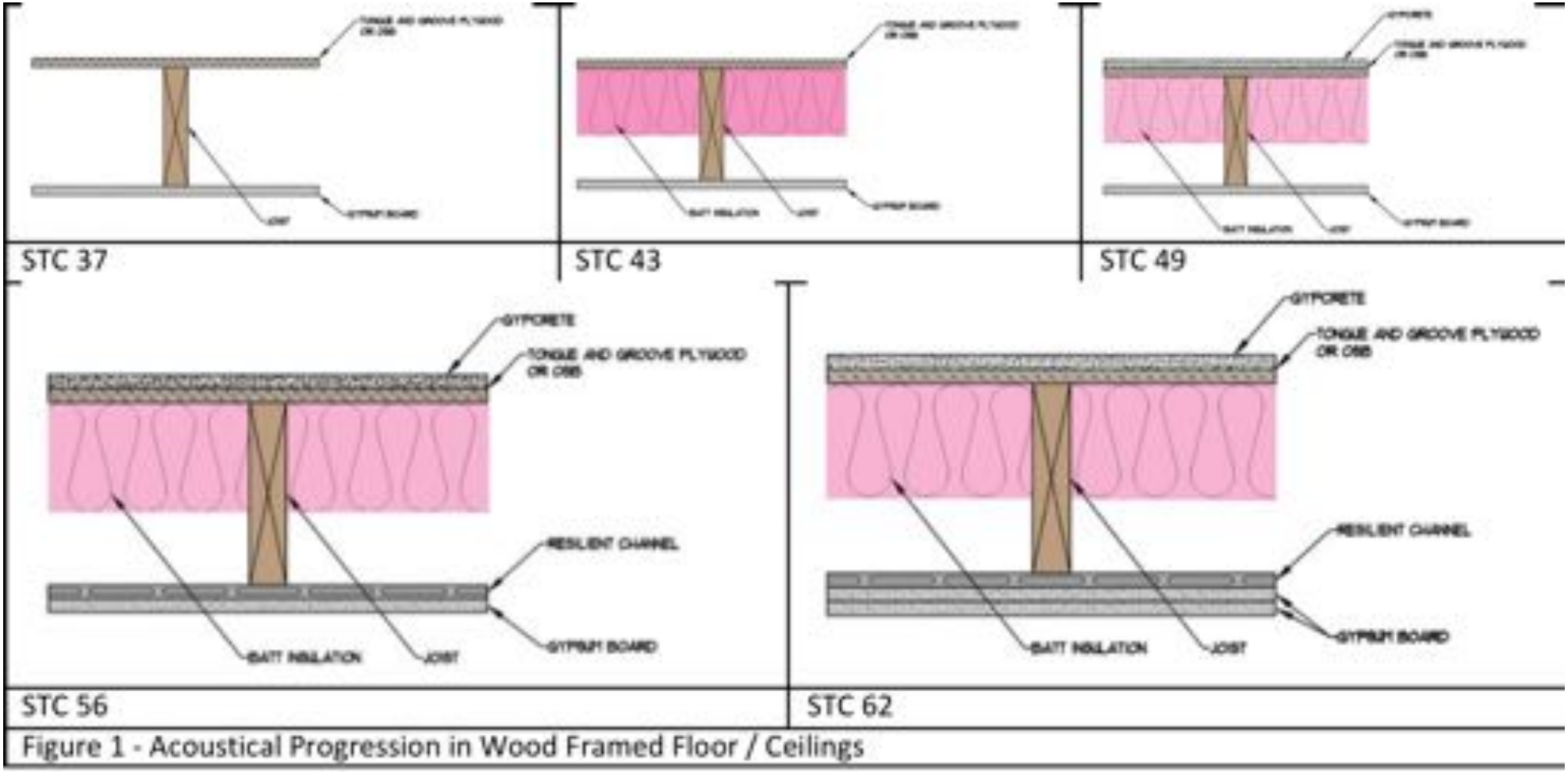
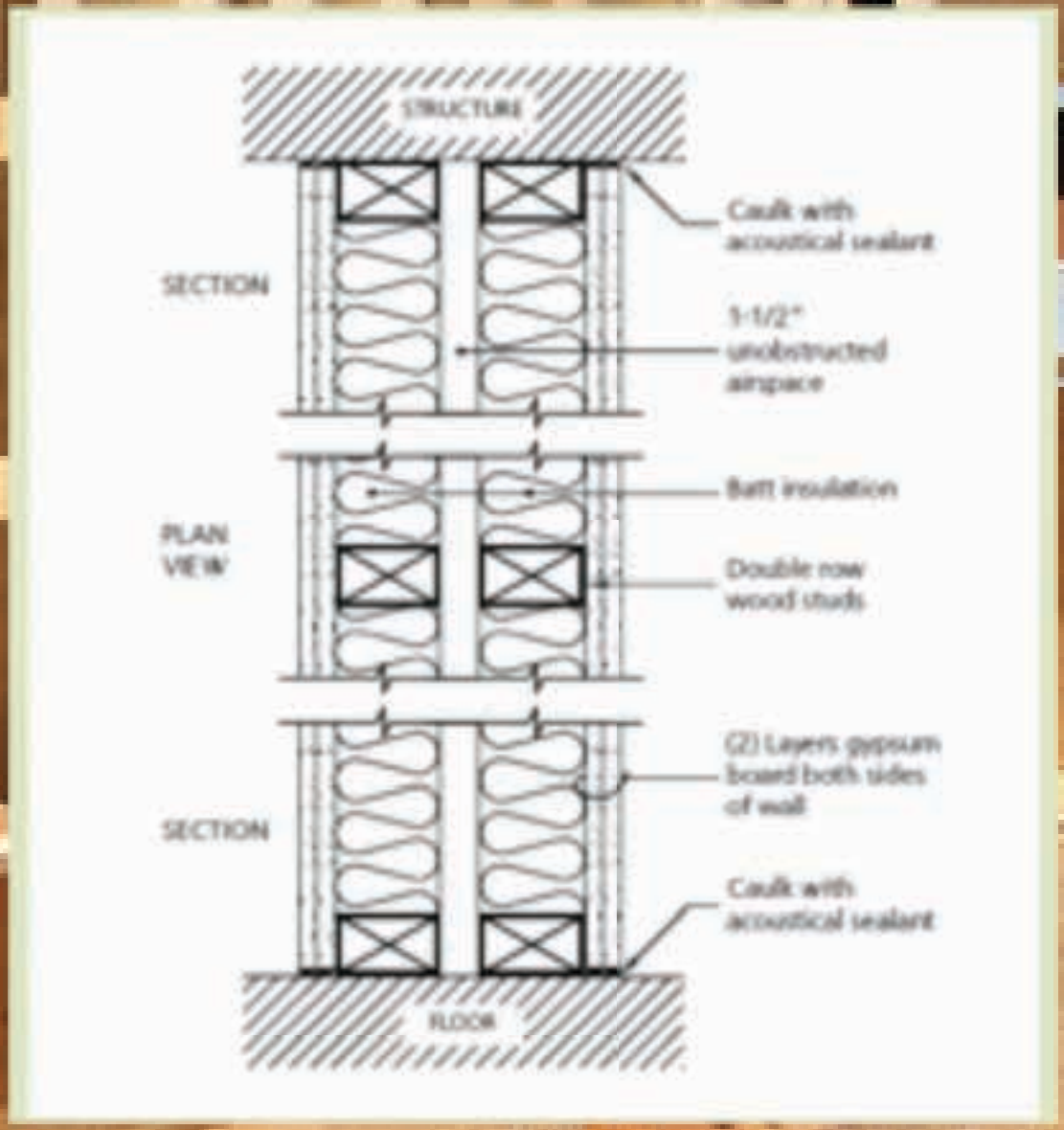


Figure 1 - Acoustical Progression in Wood Framed Floor / Ceilings

Walls – Double Stud



STC 63 Party Wall

Photo: Econonest Architecture Inc.

Walls – Staggered and Single Stud

After double stud construction, the next best solutions are staggered and single stud.

Photos: Root Graphics (l); Arch Wood Protection

One of Many Performance Goals

University of Washington Student Housing
Seattle, WA
Architect: Mahlum
This five-building project includes a strategic combination of staggered and double stud walls to minimize sound transmission.

Photo: Benjamin Benschneider

Additional Considerations

Crescent Terminus
Atlanta, GA
Three-building, five-story mixed-use complex with resort-style amenities

Photo Crescent Communities

Outline

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- Acoustic Requirements & Detailing
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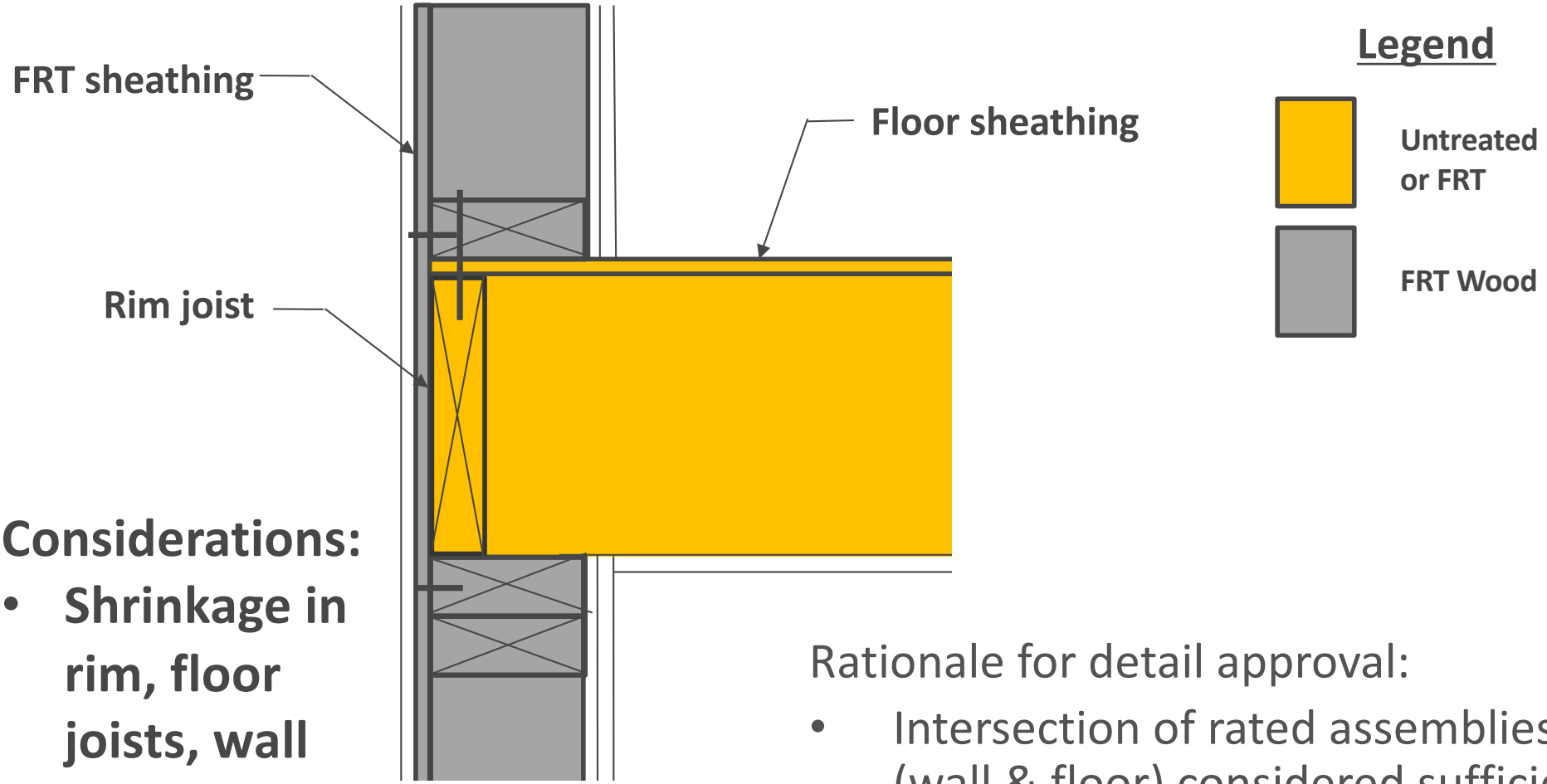
Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Typical Platform Framing



Considerations:

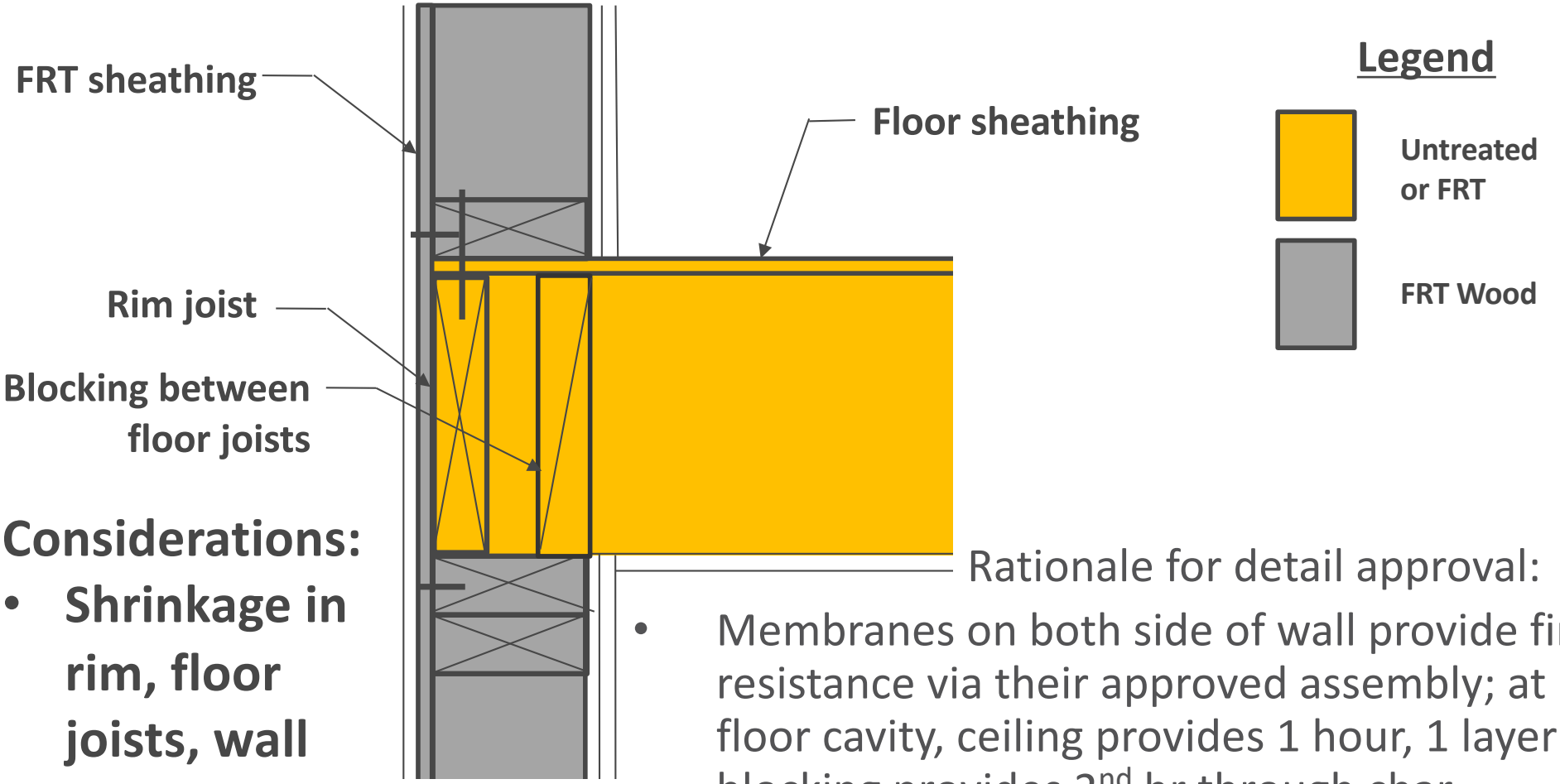
- **Shrinkage in rim, floor joists, wall plates**

Rationale for detail approval:

- Intersection of rated assemblies (wall & floor) considered sufficient

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Typical Platform Framing



Considerations:

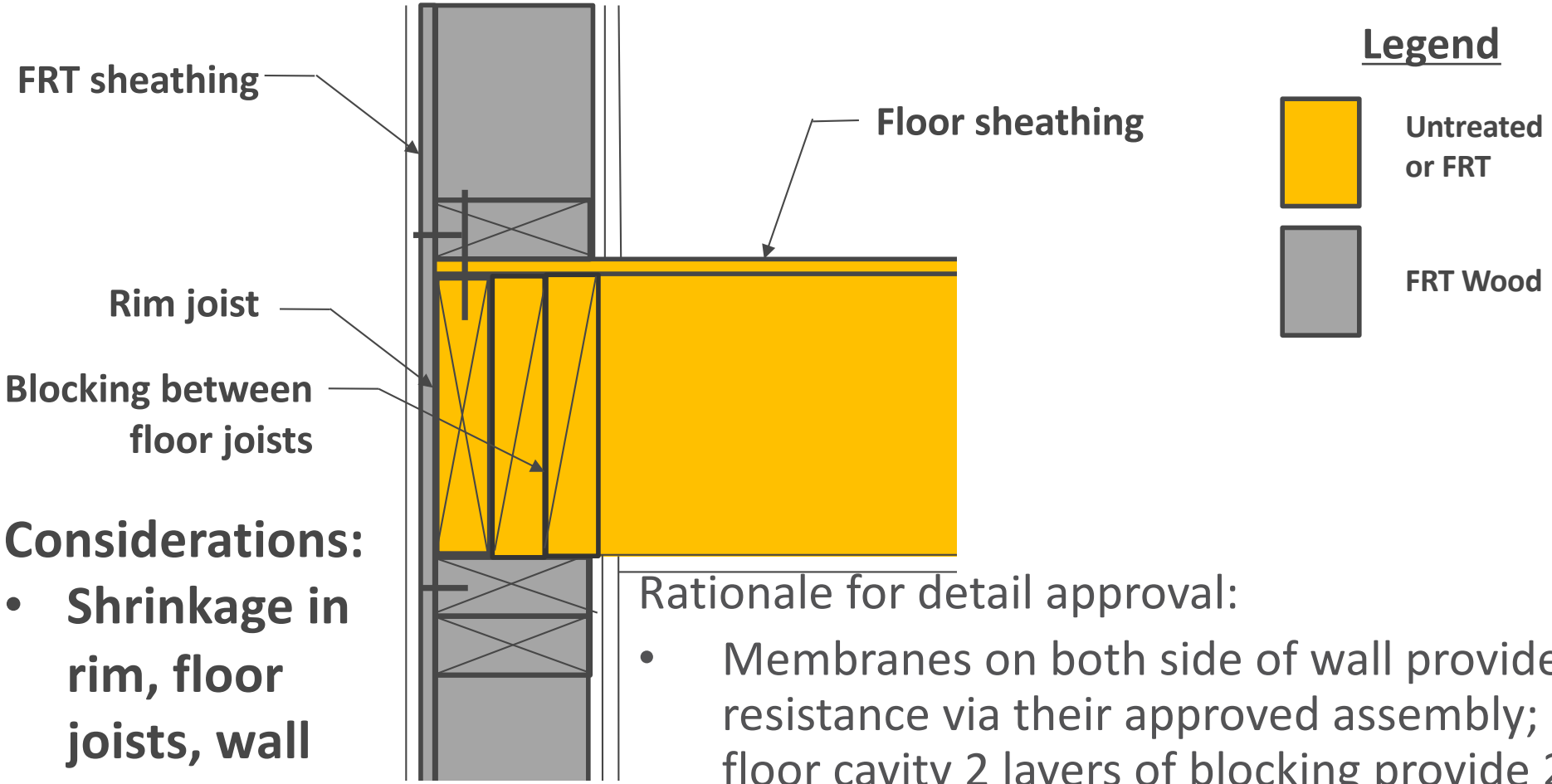
- **Shrinkage in rim, floor joists, wall plates**

Rationale for detail approval:

- Membranes on both side of wall provide fire resistance via their approved assembly; at floor cavity, ceiling provides 1 hour, 1 layer of blocking provides 2nd hr through char calculations

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Typical Platform Framing



Considerations:

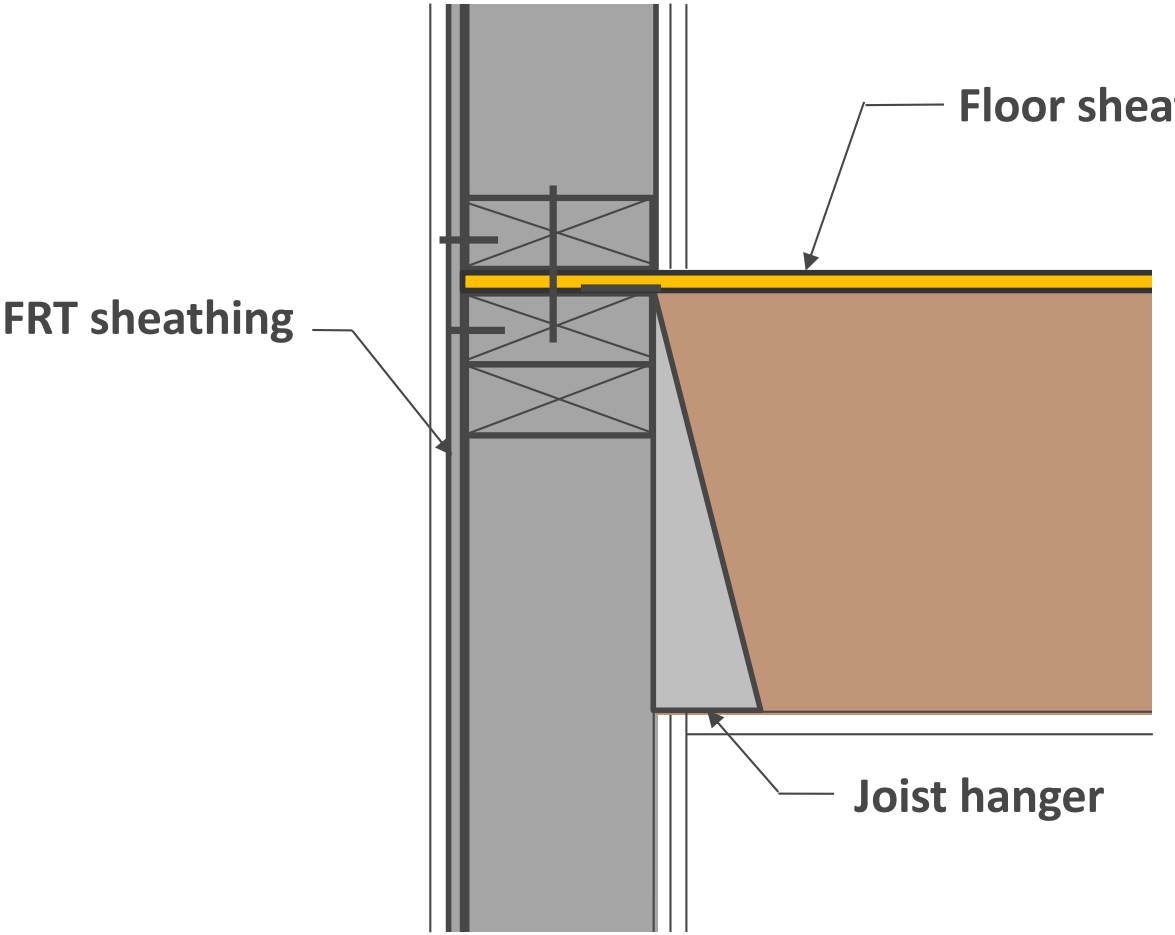
- **Shrinkage in rim, floor joists, wall plates**

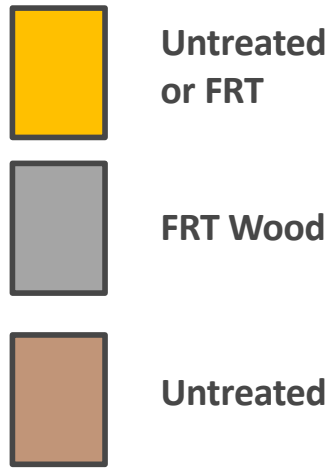
Rationale for detail approval:

- Membranes on both side of wall provide fire resistance via their approved assembly; at floor cavity 2 layers of blocking provide 2 hr protection through char calculations

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Semi-Balloon Framing



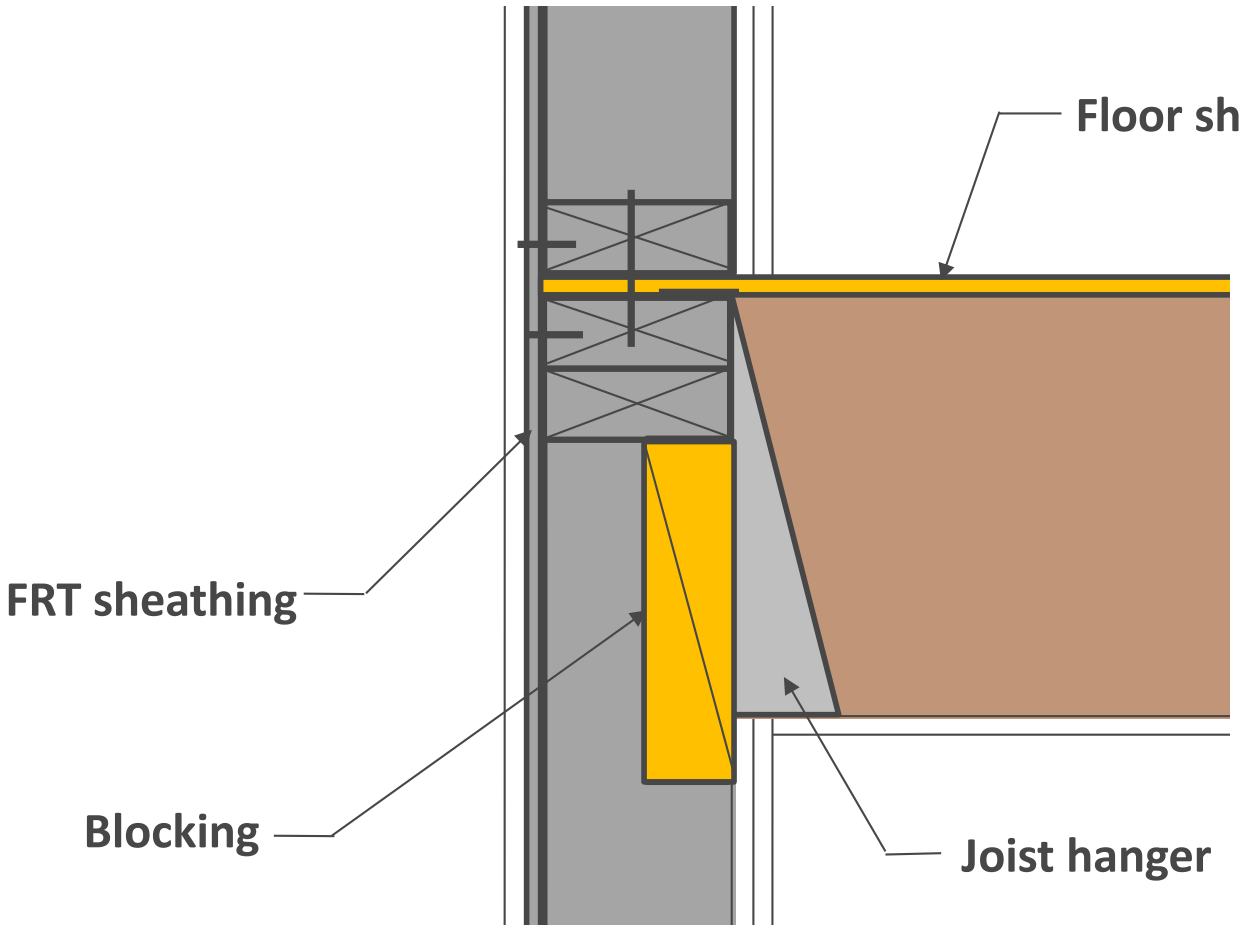


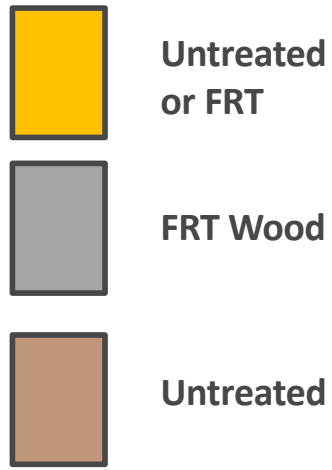
Rationale for detail approval:

- Intersection of rated assemblies (wall & floor) considered sufficient

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Semi-Balloon Framing w/Add'l Fire Protection



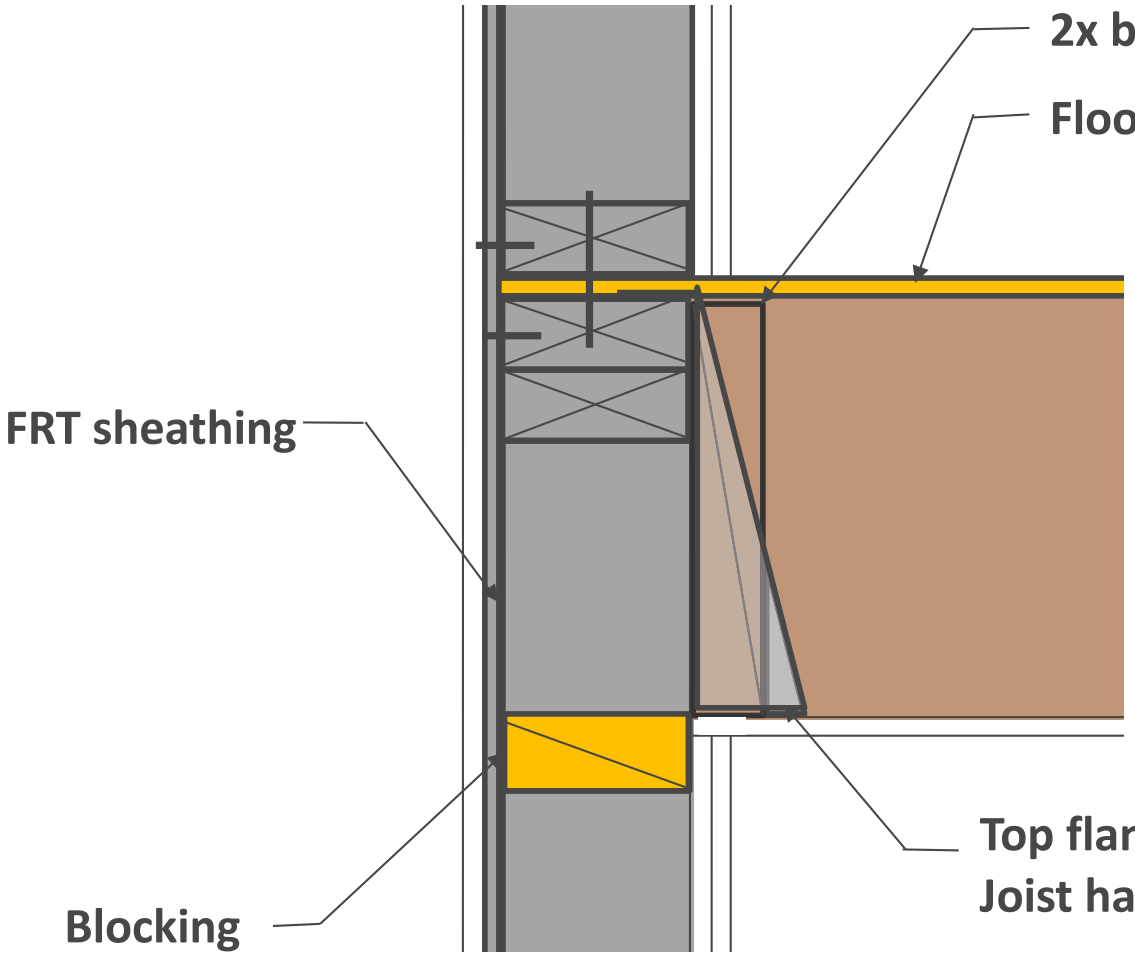


Rationale for detail approval:

- Ceiling membrane provides 1 hr protection; Blocking in wall provides 2nd hr through char calculations

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Semi-Balloon Framing w/Add'l Fire Protection



Legend

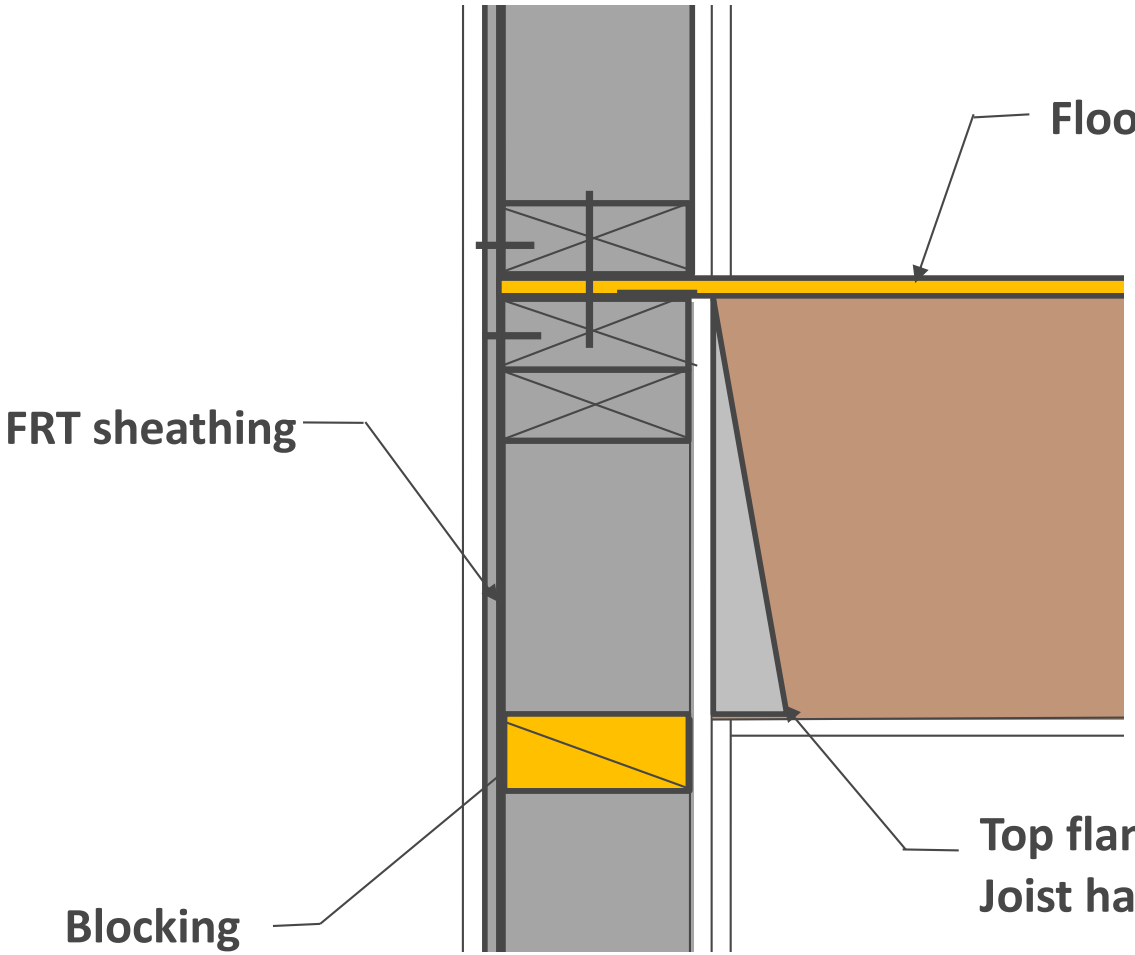
- Untreated or FRT
- FRT Wood
- Untreated

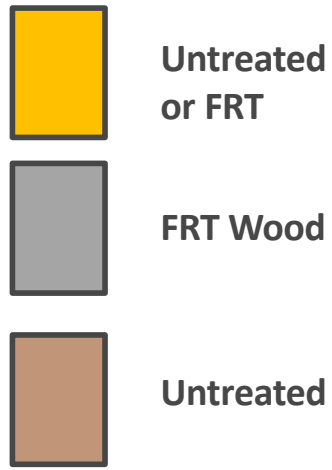
Rationale for detail approval:

- Ceiling membrane provides 1 hr protection; Blocking between joists provides 2nd hr through char calculations

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Semi-Balloon Framing w/Add'l Fire Protection



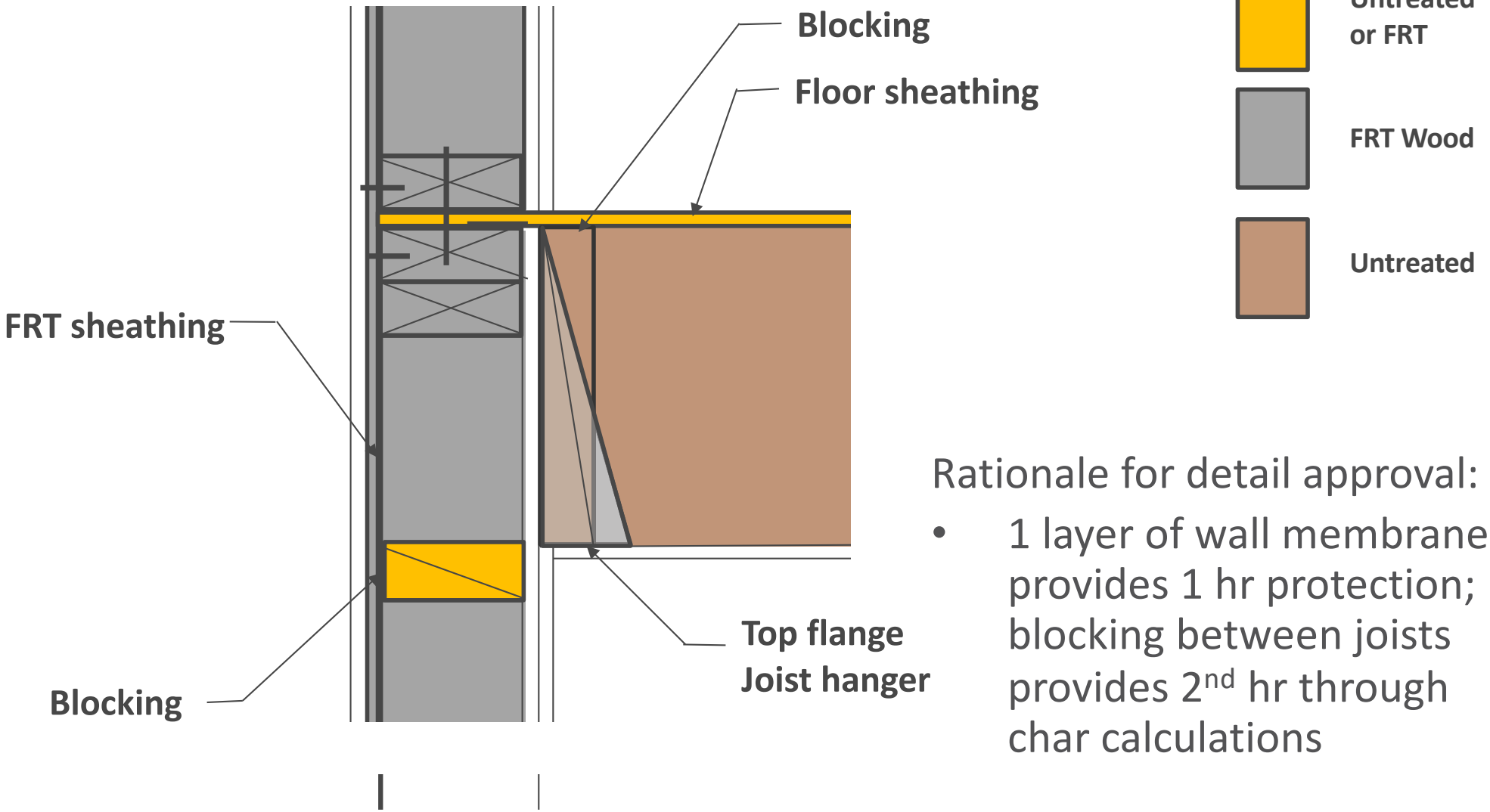


Rationale for detail approval:

- Ceiling membrane provides 1 hr protection; 1 layer of wall membrane provides 2nd hr

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Semi-Balloon Framing w/Add'l Fire Protection

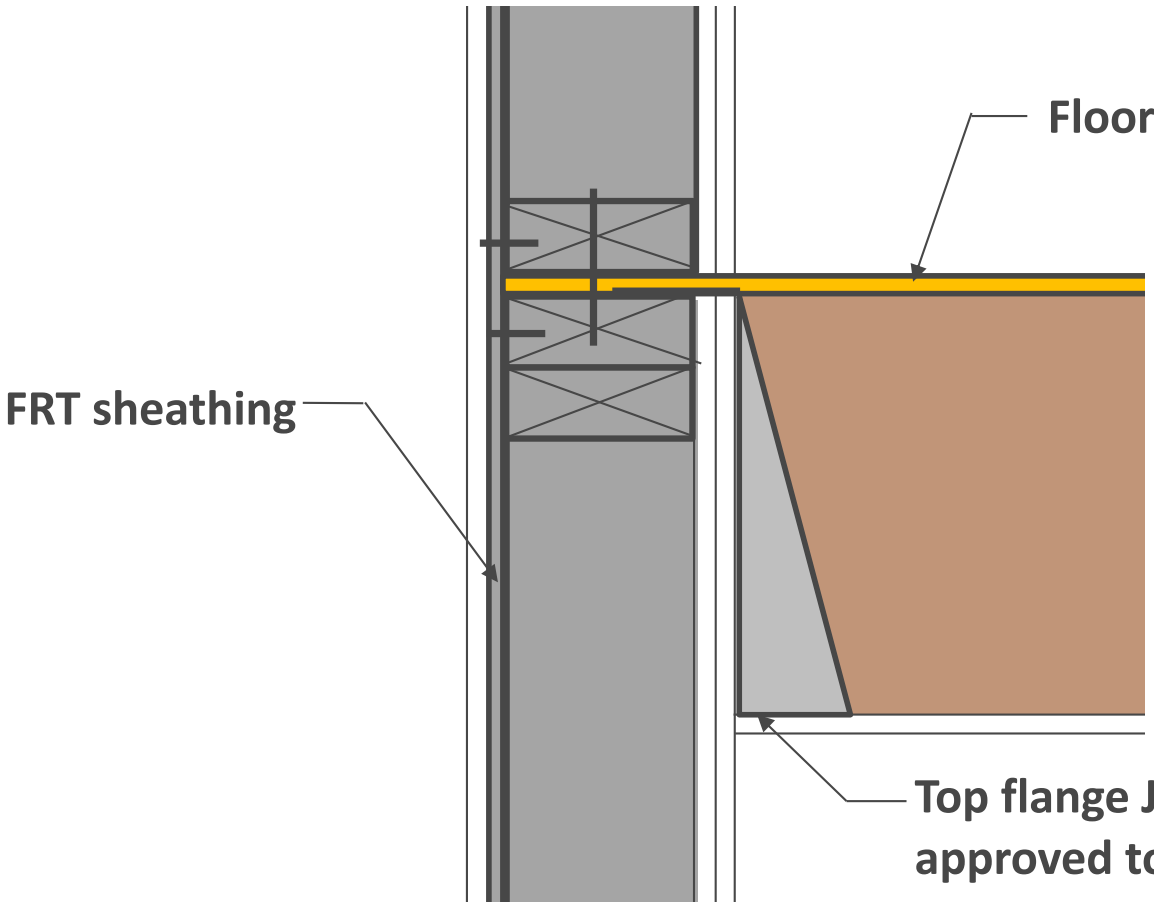


Rationale for detail approval:

- 1 layer of wall membrane provides 1 hr protection; blocking between joists provides 2nd hr through char calculations

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Semi-Balloon Framing w/Add'l Fire Protection



Legend

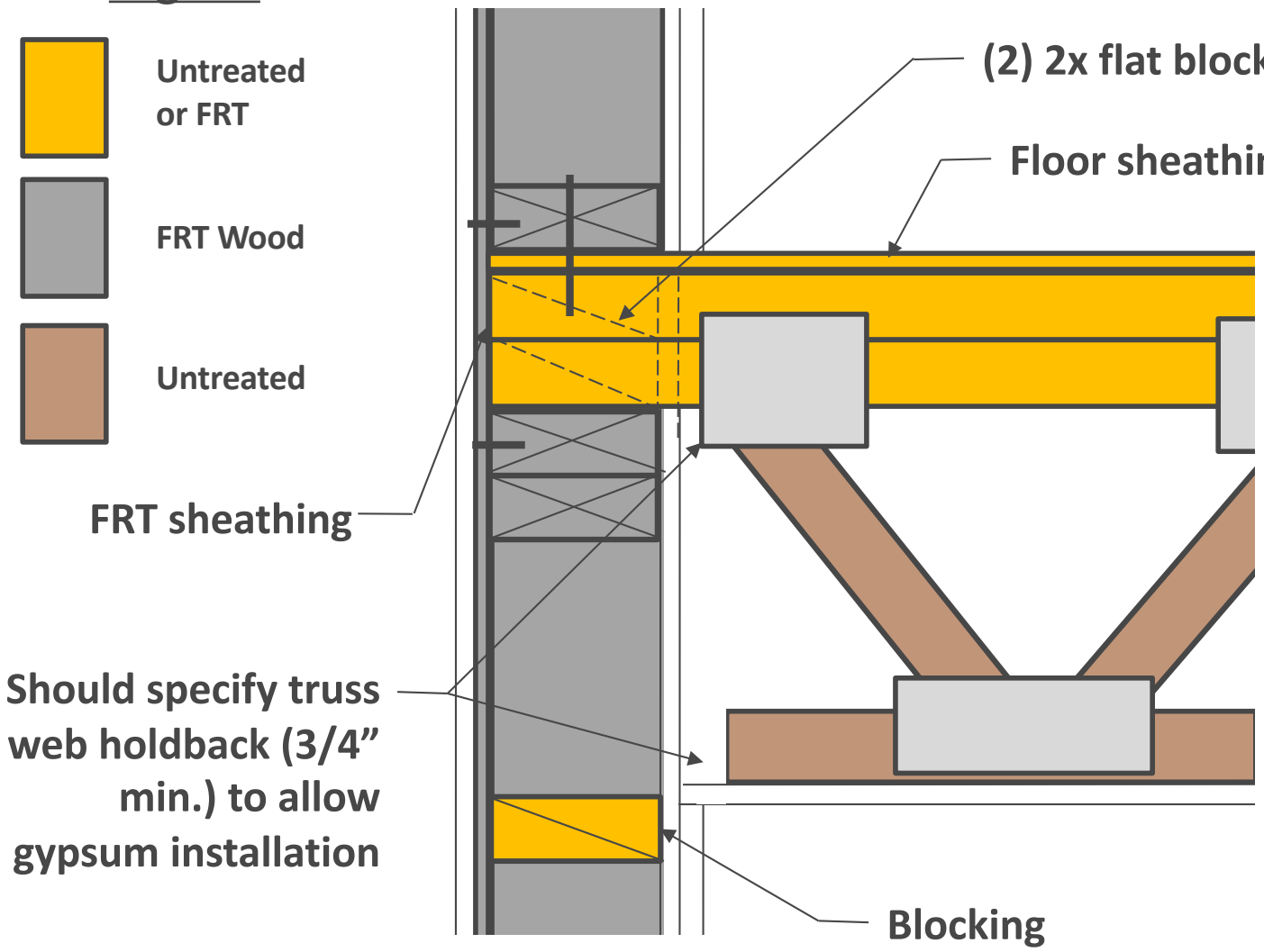
- Untreated or FRT
- FRT Wood
- Untreated

Rationale for detail approval:

- Membranes on both side of wall provide fire resistance via their approved assembly

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Platform Framing w/Top Chord Bearing

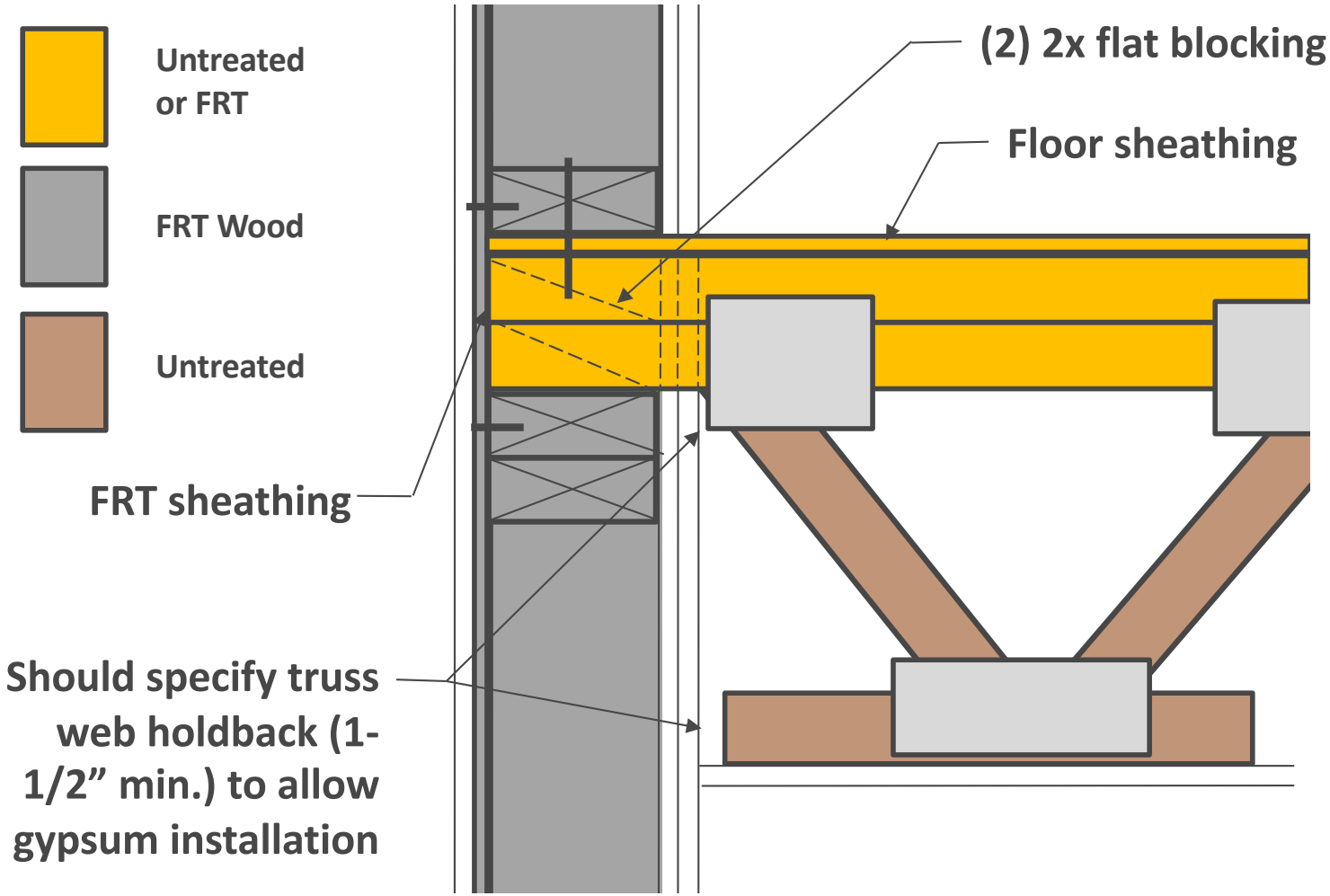


Rationale for detail approval:

- Membranes on both side of wall provide fire resistance via their approved assembly; at floor cavity ceiling membrane provides 1 hr; 1 layer of wall membrane provides 2nd hr

Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Platform Framing w/Top Chord Bearing



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Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
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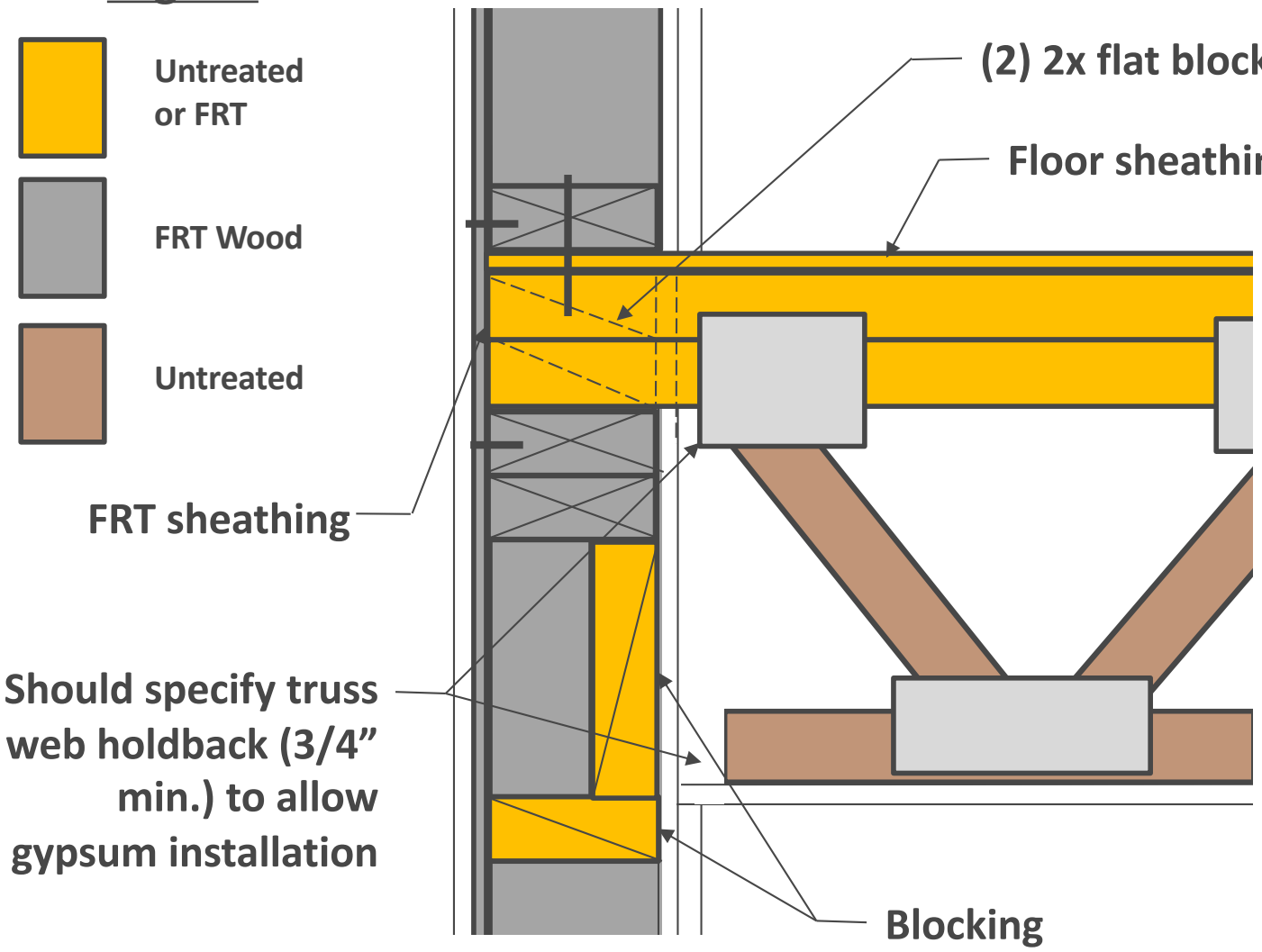

Rationale for detail approval:

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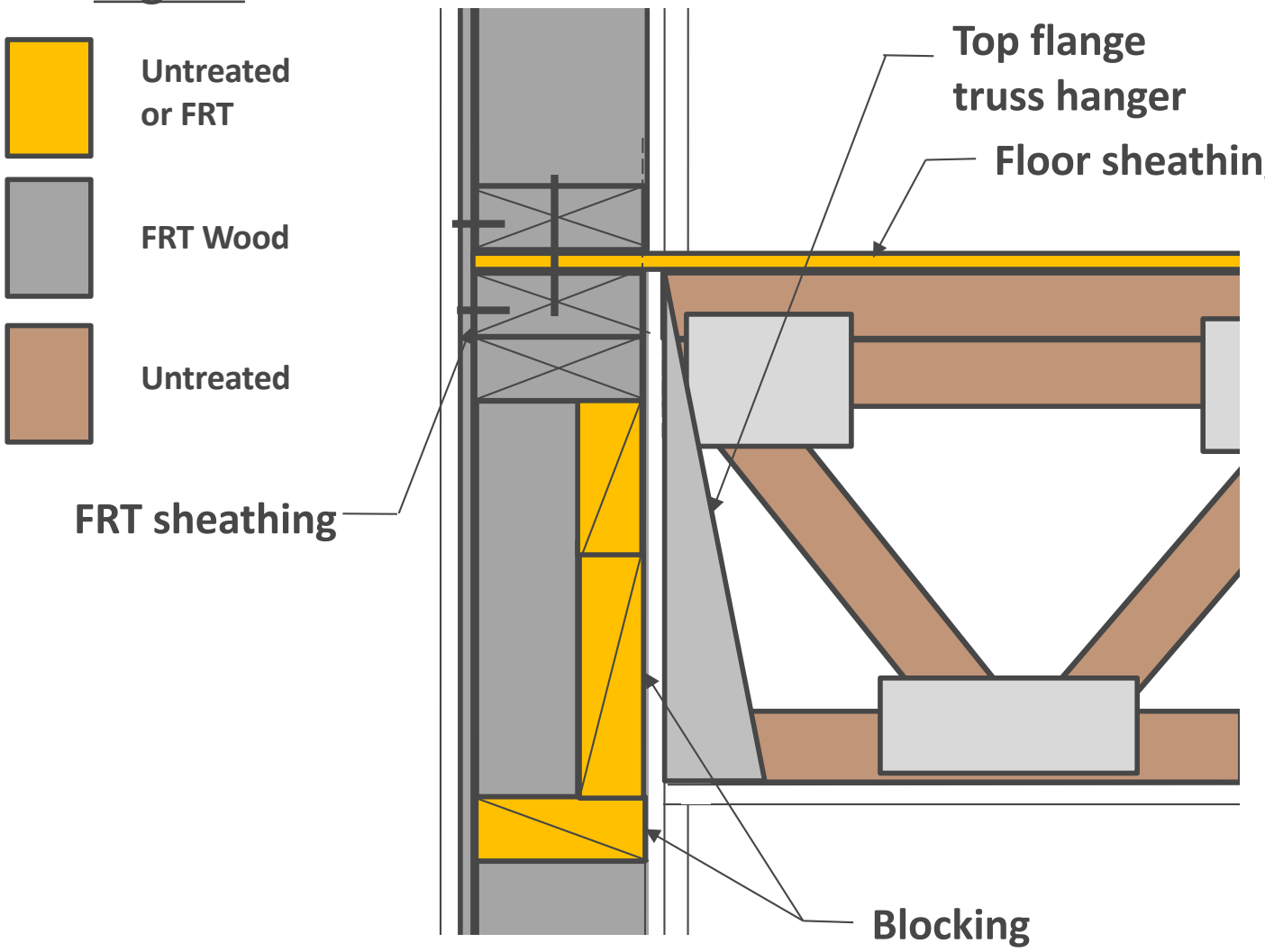
Exterior Walls – Intersecting Floors

Type III Construction – 2 HR Wall, 1 HR Floor
Platform Framing w/Top Chord Bearing



Rationale for detail approval:

- Membranes on both side of wall provide fire resistance via their approved assembly; at floor cavity blocking in wall provides 1 hr; 1 layer of wall membrane provides 2nd hr

Type III Construction Detail Examples

What is being enforced in jurisdictions you are working in?

WoodWorks™
WOOD PRODUCTS COUNCIL

Introducing Cross Laminated Timber

New Opportunities for Timber Construction

Marc J Rivard, PE, SE

WoodWorks
WOOD PRODUCTS COUNCIL

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- Structural detailing of wood-frame and hybrid material systems
- Fire resistance and acoustical-rated assemblies
- Efficient and code-compliant lateral system design
- Alternate means of code compliance
- Energy-efficient detailing
- Application of advanced building systems and technologies

woodworks.org/project-assistance • help@woodworks.org

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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

Cross laminated timber (CLT) is an engineered wood building system designed to complement light- and heavy-timber framing options. Because of its high strength and dimensional stability, it can be used as an alternative to concrete, masonry and steel in many building types. This presentation will introduce CLT with a series of project examples that demonstrate its use and associated benefits in a range of applications. Information on manufacturing, specification and code-related considerations will also be discussed.

Learning Objectives

1. Review completed CLT projects that demonstrate a range of applications and system configurations.
2. Discover how CLT can be used under current and future building codes and standards.
3. Discuss benefits of using CLT in place of concrete and steel, including structural versatility, prefabrication, lighter carbon footprint and reduced labor costs.
4. Discuss the fire characteristics of CLT, including the benefits of charring, current seismic approaches that can be used for CLT buildings, and how the acoustic and moisture performance of CLT assemblies can inform the design of a project.

Outline

- What is CLT?
  - Mass Timber
  - The Appeal
  - History
  - Availability
- Using CLT
  - Project Examples
  - Best applications
  - Cost effective design
  - Building Codes and Standards

Outline

- What is CLT?
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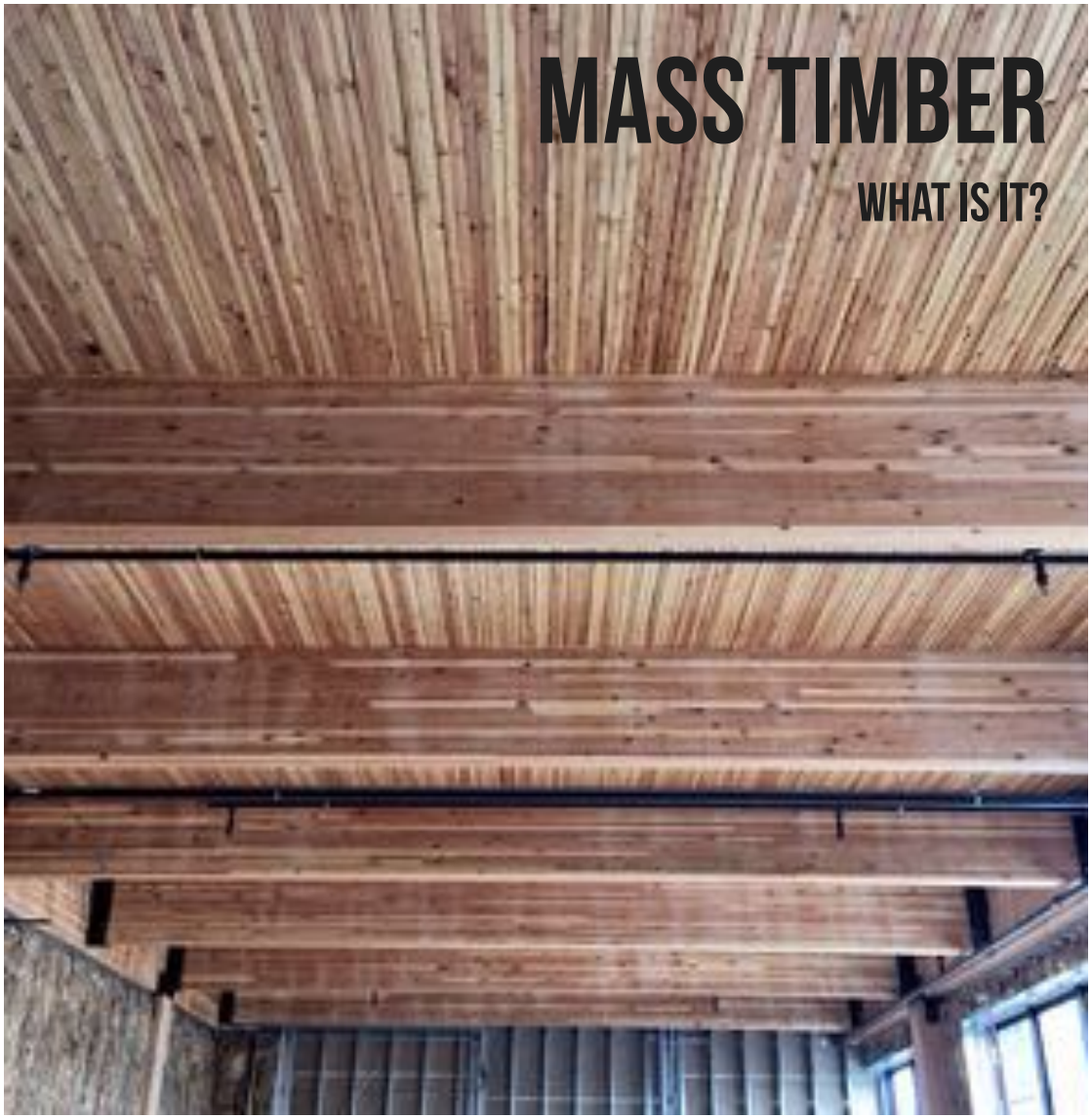
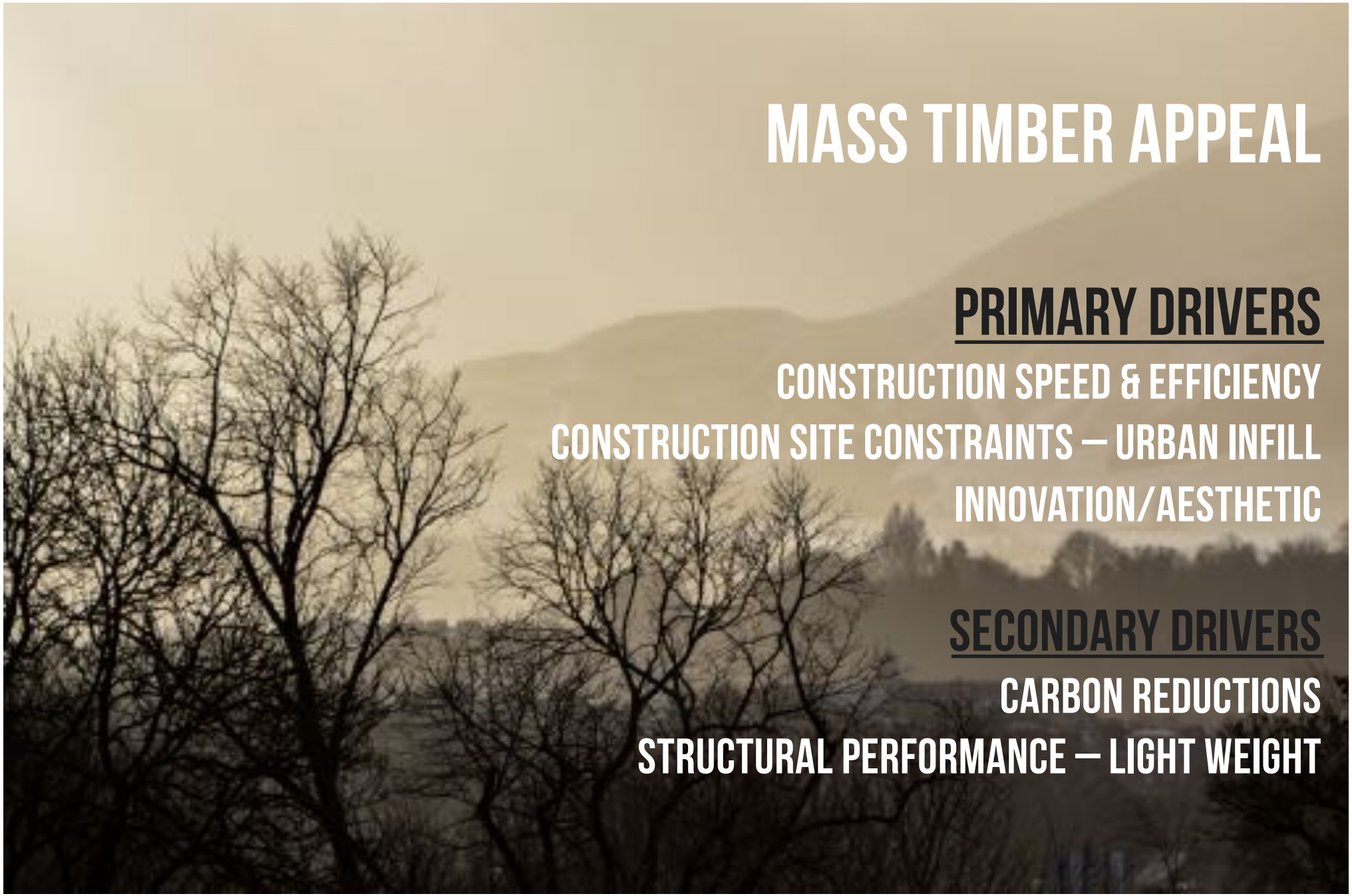
MASS TIMBER

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





MASS TIMBER APPEAL

PRIMARY DRIVERS

CONSTRUCTION SPEED & EFFICIENCY

CONSTRUCTION SITE CONSTRAINTS – URBAN INFILL

INNOVATION/AESTHETIC

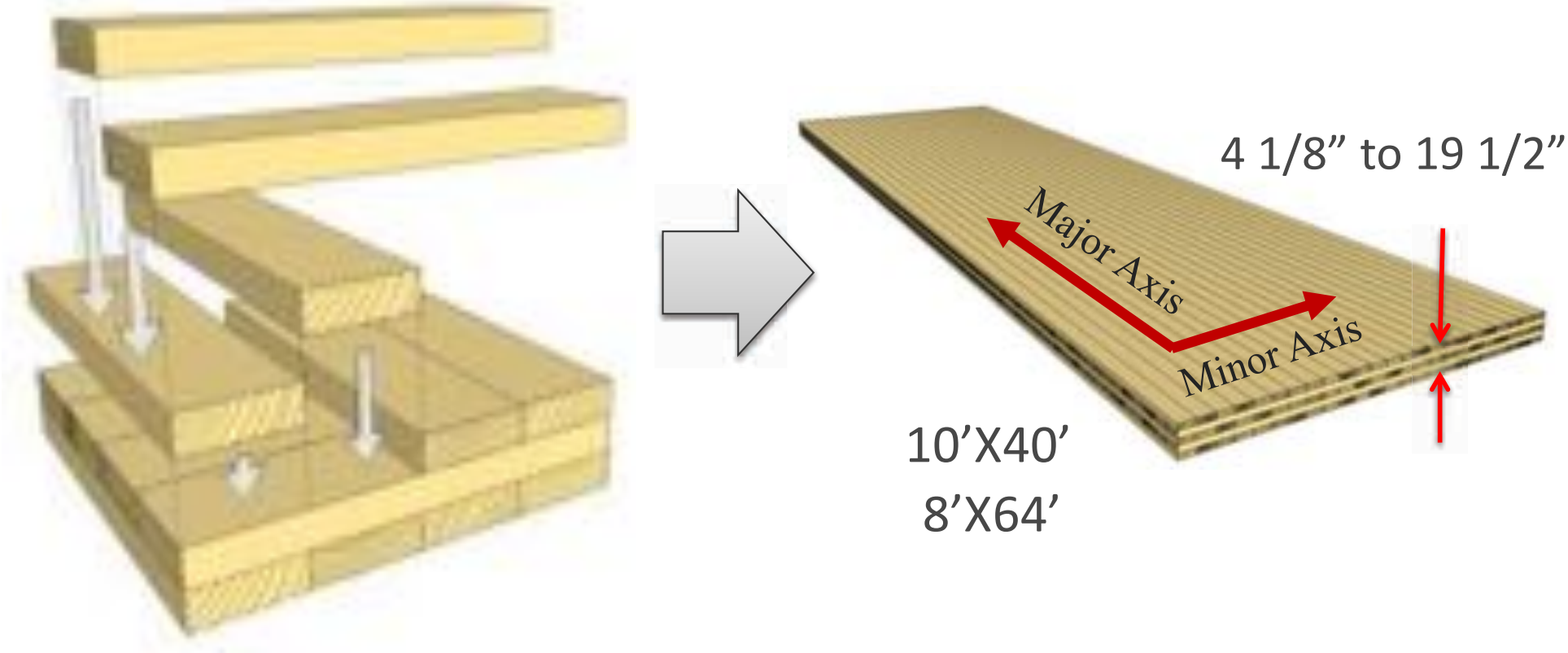
SECONDARY DRIVERS

CARBON REDUCTIONS

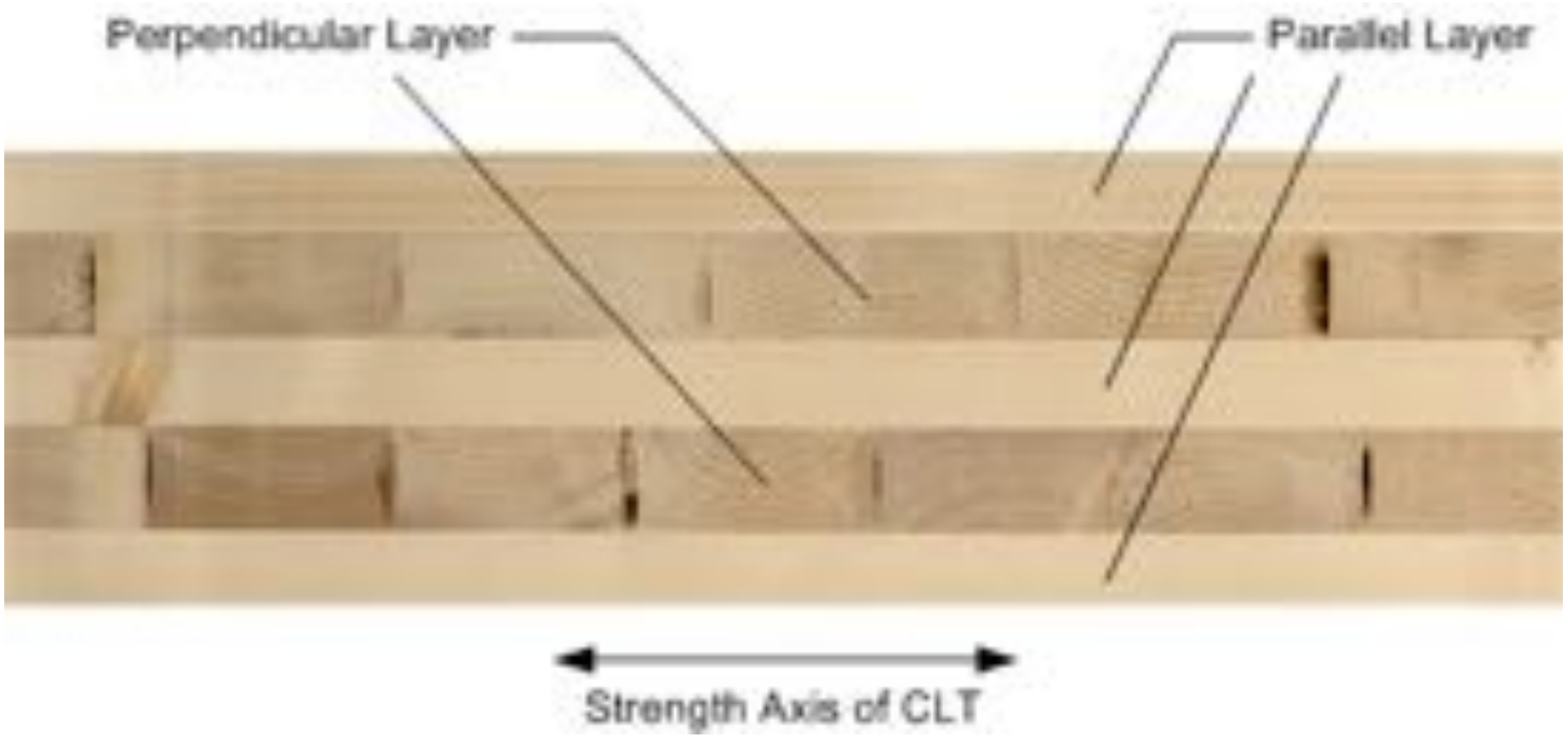
STRUCTURAL PERFORMANCE – LIGHT WEIGHT

What is Cross Laminated Timber (CLT)?

- Solid wood panel
- 3 layers min. of solid sawn lams
- 90 deg. cross-lams
- Similar to plywood sheathing



CLT Composition




CROSS LAMINATED TIMBER
LUMBER IN CLT IS FINGER JOINTED
TYPICALLY NOT EDGE GLUED

MASS TIMBER PRODUCTS

CROSS-LAMINATED TIMBER (CLT)

COMMON CLT LAYUPS

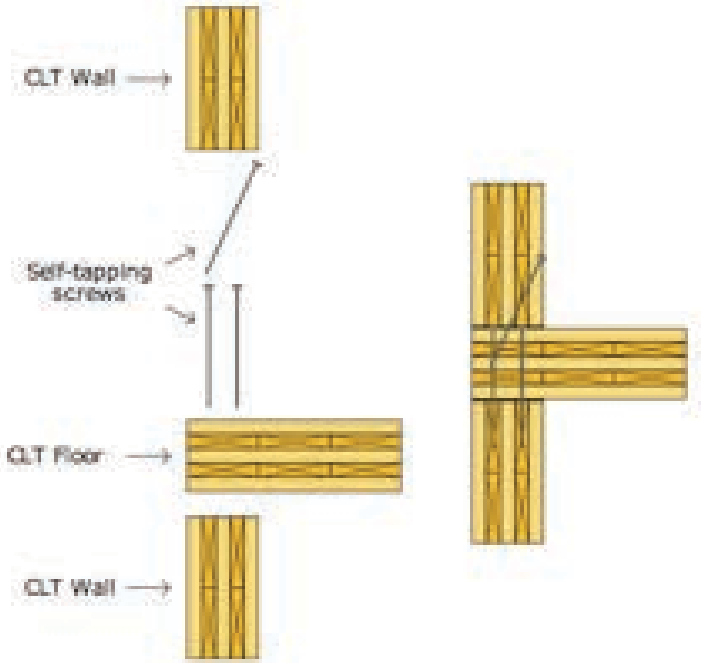
3-PLY 3-LAYER

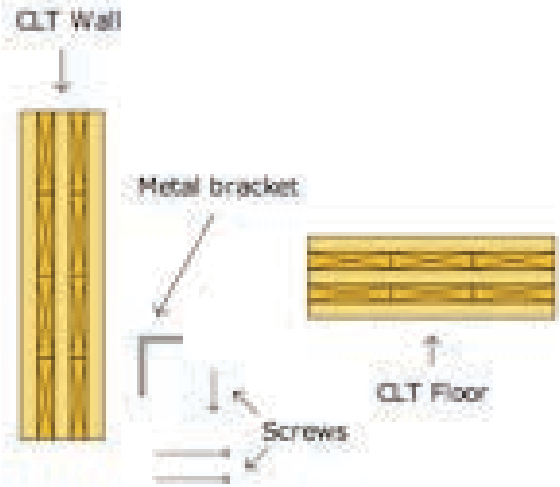
5-PLY 5-LAYER

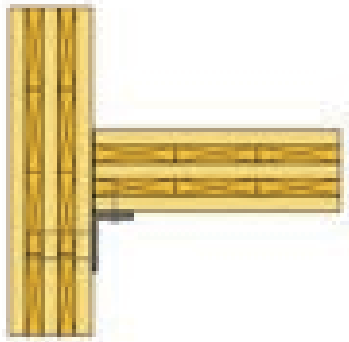
7-PLY 7-LAYER

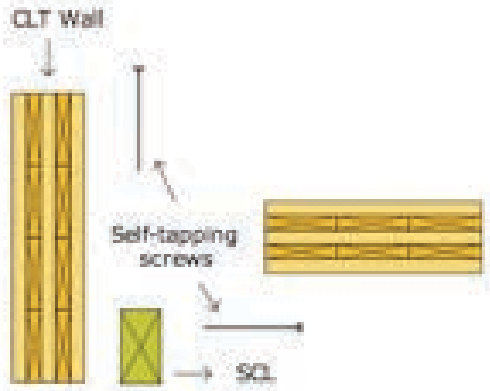
9-PLY 9-LAYER

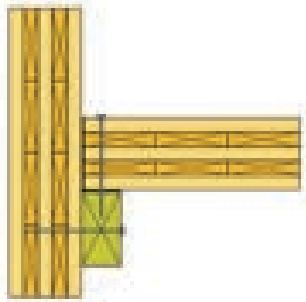
How to use CLT - Assembly











Source: US CLT Handbook

What is the appeal of CLT?

Sustainability

- Embodied Carbon

Performance

Construction Efficiency

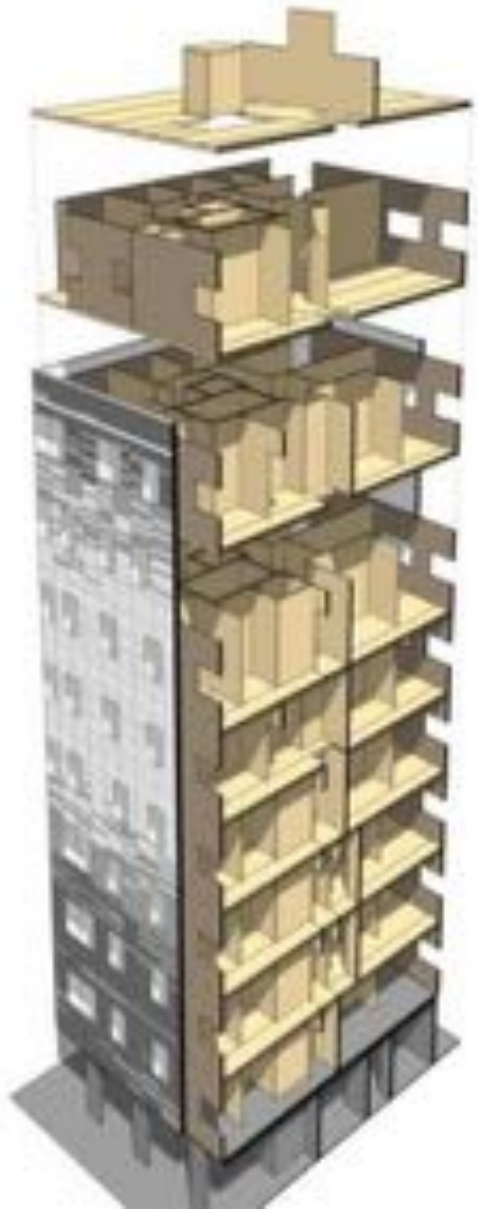
Reduced Embodied Carbon

Volume of wood used	950 m^3
Carbon sequestered and stored (CO_2e)	760 metric tons
Avoided greenhouse gases (CO_2e)	320 metric tons
Total potential carbon benefit (CO_2e)	1,080 metric tons

Carbon savings from the choice of wood in this one building are equivalent to:

1,615 passenger vehicles off the road for a year

Enough energy to operate a home for 803 years



Stadhaus, London, UK
Architect: Waugh Thistleton Architects
Photo credit: Waugh Thistleton Architects


BULLITT CENTER
SEATTLE, WA
PHOTO CREDIT: BULLITT CENTER

BULLITT CENTER

SEATTLE, WA

BUILDING INFO:

OFFICE BUILDING

4 STORIES MASS TIMBER OVER 2 STORIES CONCRETE

52,000 SF

NET ZERO

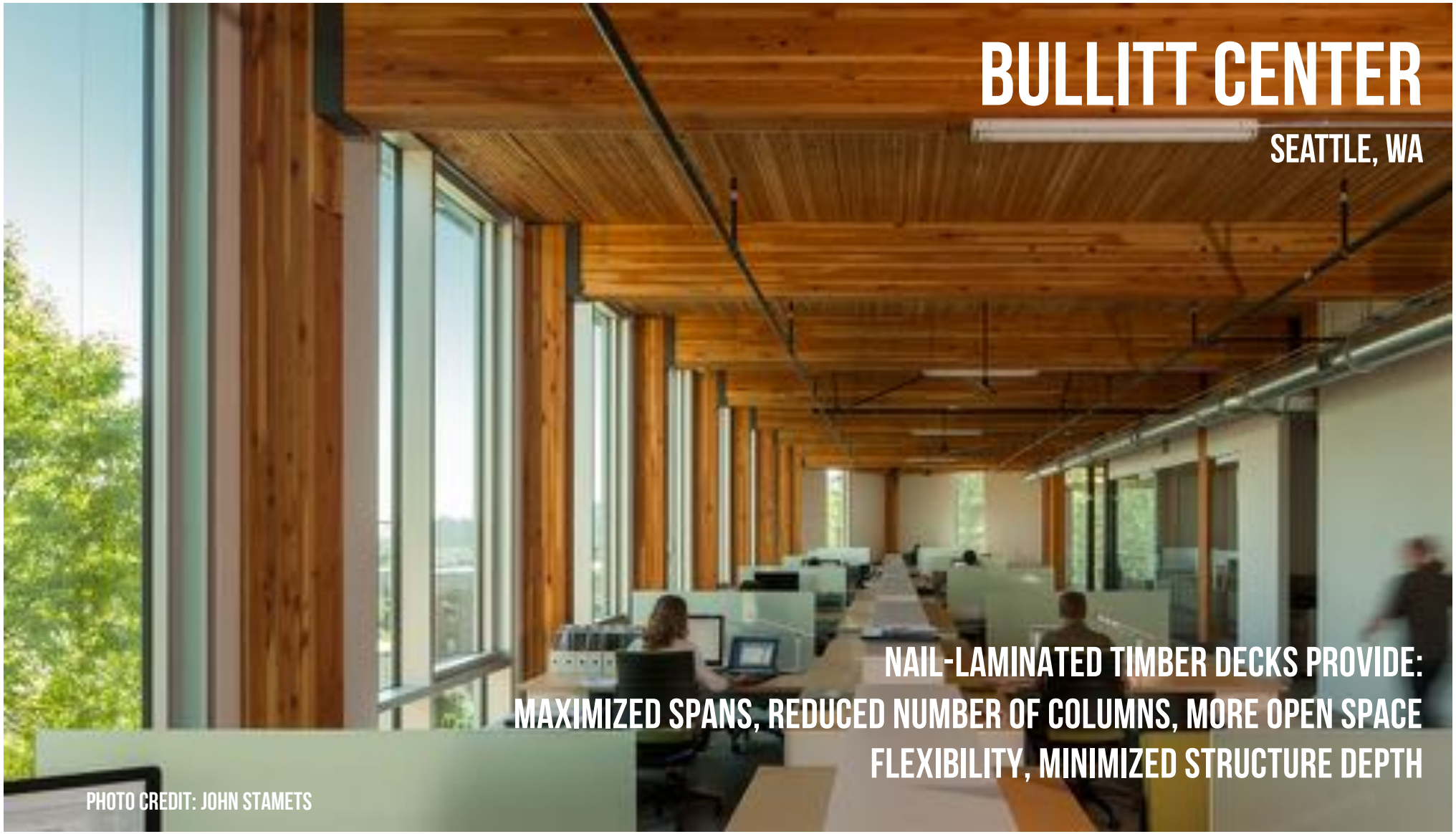
LIVING BUILDING CHALLENGE CERTIFIED

TYPE IV CONSTRUCTION

250 YR DESIGN LIFE

COMPLETED 2013

PHOTO CREDIT: MILLER HULL PARTNERSHIP



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

What is the appeal of CLT?

Sustainability

- Reduced Embodied Carbon
- Minimal waste production

Performance

Construction Efficiency

Minimal Waste

Why are designers drawn to CLT?

Sustainability

- Reduced Embodied Carbon
- Minimal waste production
- Highly Energy Efficient

Performance

Construction Efficiency

Energy Efficient

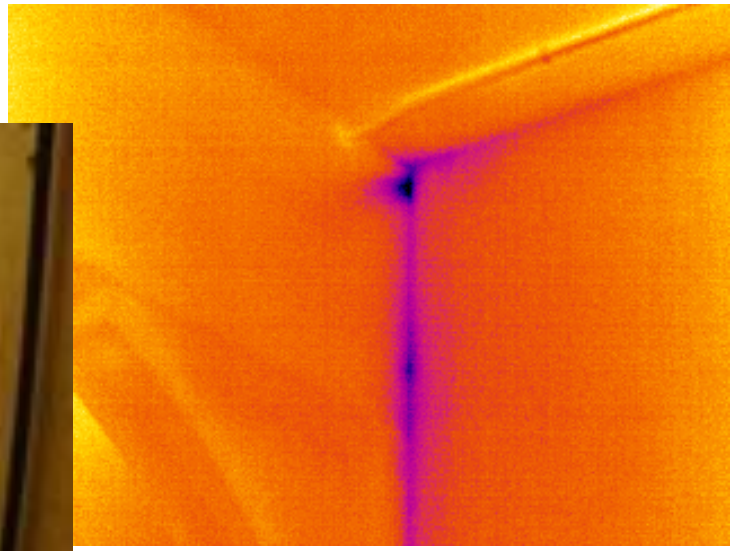


Table 2

Thermal resistance of typical softwood at various thicknesses and 12% moisture content

Thickness	1 in. (25 mm)	4 in. (100 mm)	6 in. (150 mm)	8 in. (200 mm)
R-value ($h \cdot ft.^2 \cdot °F \cdot Btu^{-1}$)	1.25	5.00	7.50	10.00
RSI ($m^2 \cdot K \cdot W^{-1}$)	0.22	0.88	1.30	1.80

CLT has an R-value of approximately 1.25 per inch of thickness.

Source: US CLT Handbook

What is the appeal of CLT?

Sustainability

- Reduced Embodied Carbon
- Minimal waste production
- Highly Energy Efficient

Performance

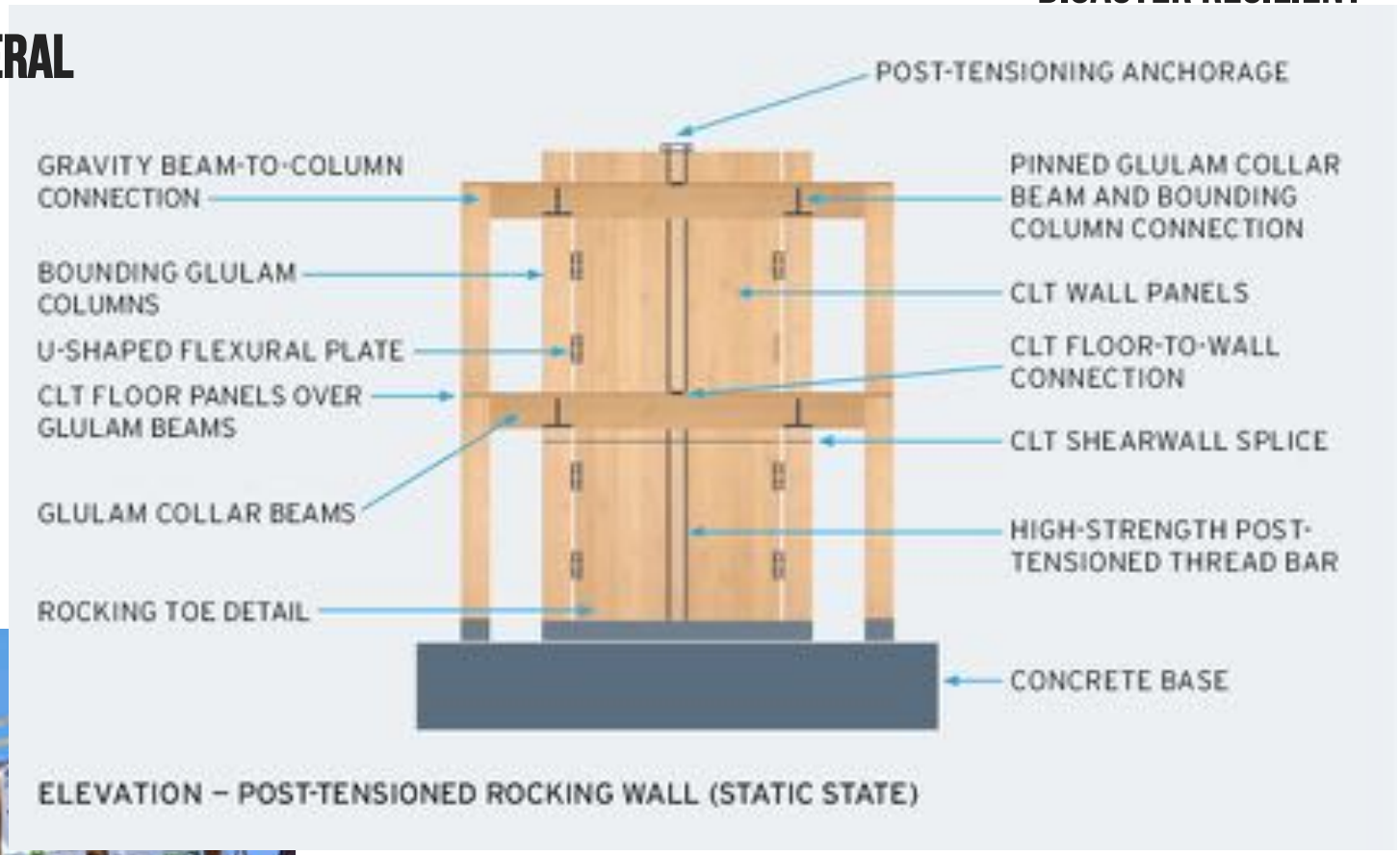
- Disaster Resilient

Construction Efficiency

MASS TIMBER APPEAL

DISASTER RESILIENT

NNOVATIVE MASS TIMBER LATERAL FORCE RESISTING SYSTEMS



MASS TIMBER SHAKE TABLE TEST AT UCSD

CLT ROCKING SHEAR WALL CONCEPT

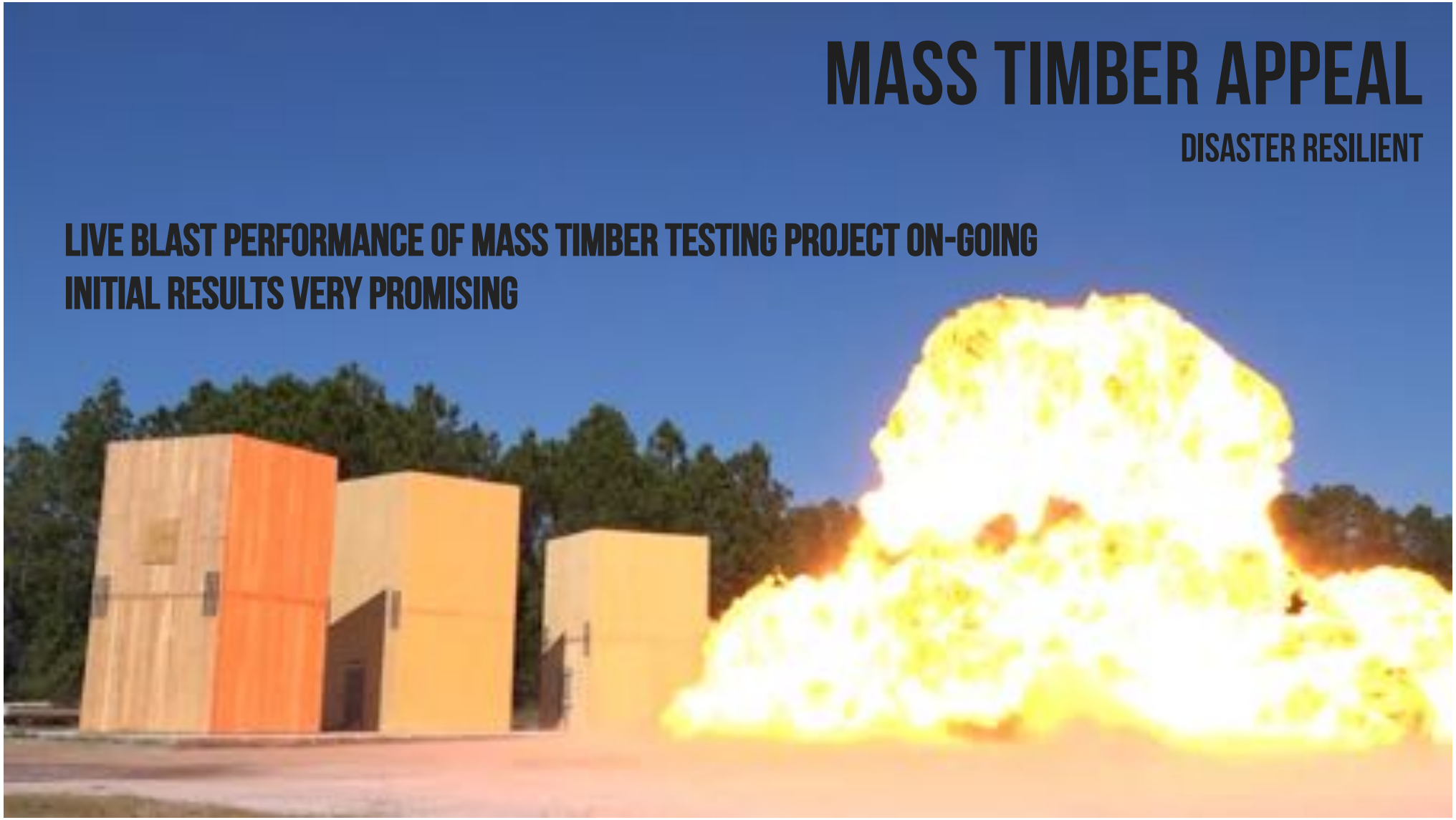
SOURCE: KPFF

MASS TIMBER APPEAL

DISASTER RESILIENT

LIVE BLAST PERFORMANCE OF MASS TIMBER TESTING PROJECT ON-GOING

INITIAL RESULTS VERY PROMISING



CANDLEWOOD SUITES

REDSTONE ARSENAL, AL

IMAGE CREDIT: IHG® ARMY HOTELS, LENDLEASE

CANDLEWOOD SUITES

REDSTONE ARSENAL, AL

IMAGE CREDIT: LEND LEASE

CANDLEWOOD SUITES

REDSTONE ARSENAL, AL

- 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

IMAGE CREDIT: LEND LEASE & SCHAEFER

What is the appeal of CLT?

Sustainability

- Reduced Embodied Carbon
- Minimal waste production
- Energy Efficient

Performance

- Disaster Resilient
- Fire Resistant

Construction Efficiency

Fire Test Results

- ASTM E119 Fire Endurance Test
  - 5-Ply CLT (6-7/8” thick)
  - 5/8” Type X GWB each side
  - 2 hour target
  - Actual 3 hours 6 minutes

- 2015 NDS Chapter 16 includes char rates for CLT to achieve up to 2 hour fire rating

Fire Testing Laboratory

TEST REPORT

Page 1 of 53

for

American Wood Council

222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Standard Methods of
Fire Tests of Building Construction and Materials
ASTM E 119 – 11a

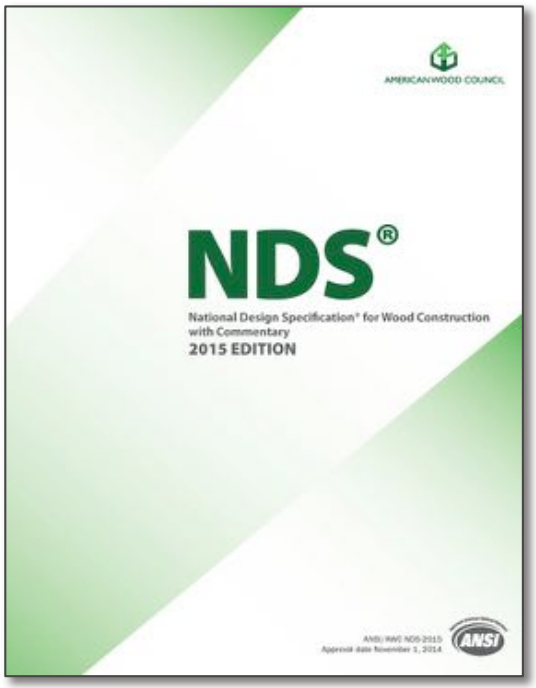
Test Report No: WP-350
Assignment No: X-1029
Subject Material: Cross-Laminated Timber and Gypsum Board Wall Assembly (Load-Bearing)
Test Date: October 4, 2012
Report Date: October 15, 2012

Prepared by:
Michael J. Ridge
Test Engineer

Reviewed by:
Robert J. Marchetti
Director, Laboratory Facilities and Testing Services

Highly Successful CLT Fire Test

As part of a project to produce a U.S. design manual for cross-laminated timber (CLT), AWC conducted a very successful ASTM E119 fire endurance test on a CLT wall at NGC Testing Services in Buffalo, NY. The wall, consisting of a 5-ply CLT (approximately 7-inches thick), was covered on each side with a single layer of 5/8" Type X gypsum wallboard. The wall was loaded to the maximum attainable by the test equipment, although it remained significantly below the full design strength of the CLT specimen. It was then exposed to a standard fire that reaches over 1800 degrees Fahrenheit in the first 90 minutes of exposure. While only seeking a 2-hour rating, as required by the targeted building code provisions, the test specimen lasted 3 hours 6 minutes. This may open up additional possibilities in a few specialized locations where a 3-hour fire resistance rating might be required. The test culminated nearly a month of intense planning and cooperation by the North American wood products industry to get the test run in advance of the recent ICC hearings where an AWC-proposed code change to specifically recognize CLT was approved.



CLT is Defined – 2015 IBC

SECTION 202
DEFINITIONS

CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of at least 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.

Add new text as follows:

2303.1.4 **Structural glued cross-laminated timber.** Cross-laminated timbers shall be manufactured and identified as required in ANSI/APA PRG 320-2011.

Add new standard to Chapter 35 as follows:

ANSI

ANSI/APA PRG 320-2011 Standard for Performance-Rated Cross-Laminated 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

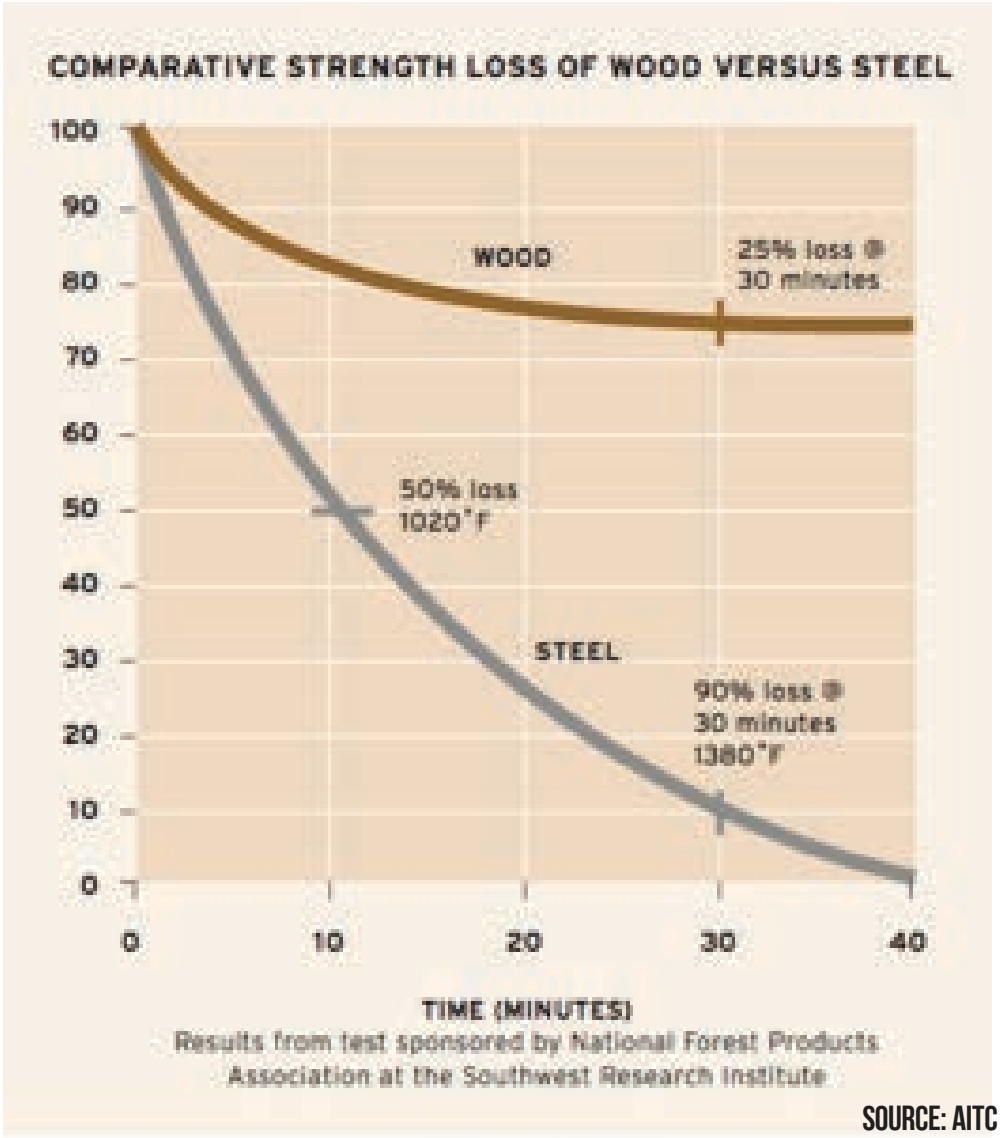
TYPES III AND V ARE SUBDIVIDED TO A (PROTECTED) AND B (UNPROTECTED)

TYPE IV (HEAVY TIMBER)

EXTERIOR WALLS NON-COMBUSTIBLE (MAY BE FRTW OR CLT)
INTERIOR ELEMENTS QUALIFY AS HEAVY TIMBER (MIN. SIZES, NO CONCEALED SPACES)

MASS TIMBER DESIGN

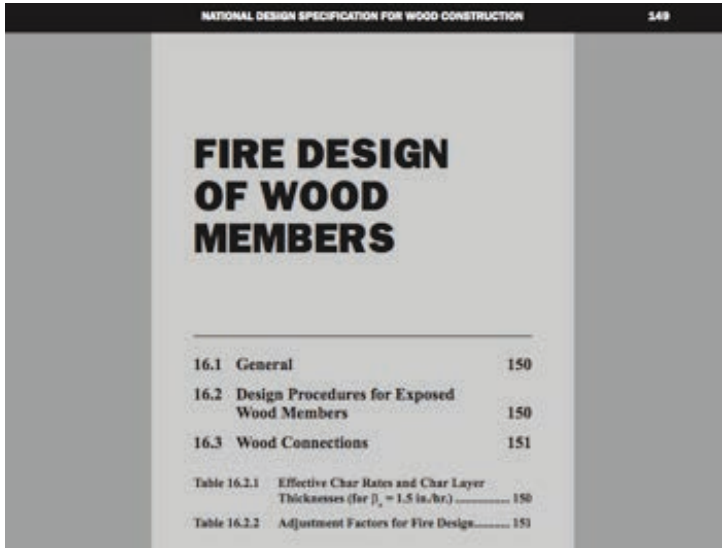
FIRE RESISTANCE



SOURCE: AITC

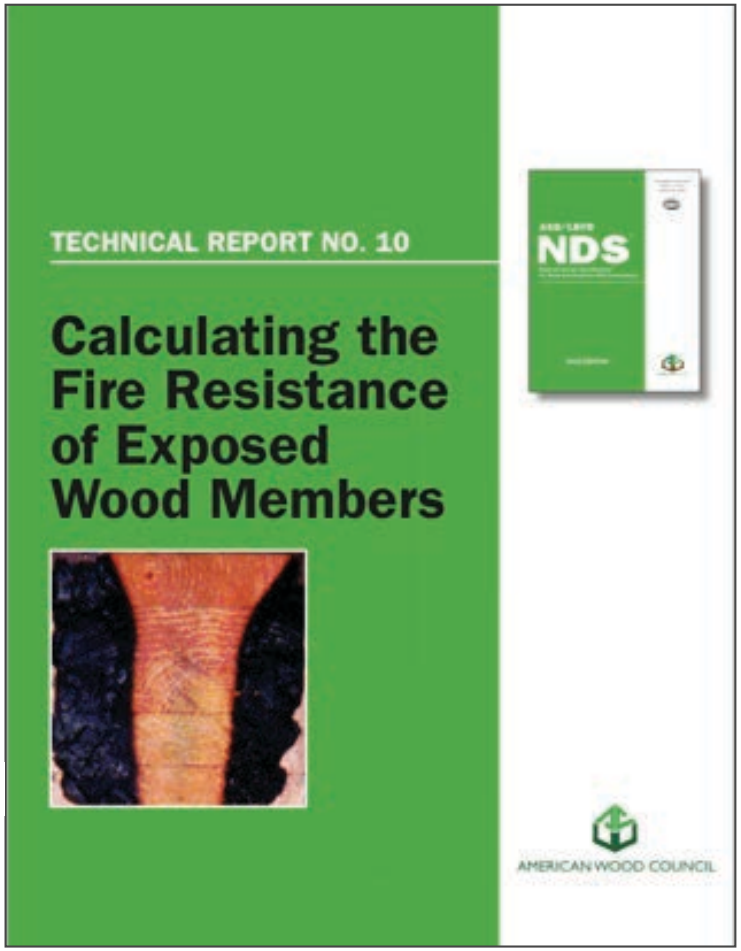
Achieving One Hour Equivalency for Protected Construction

NDS Chapter 16
Fire Design of Wood Members


NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION 149

FIRE DESIGN OF WOOD MEMBERS

OR →

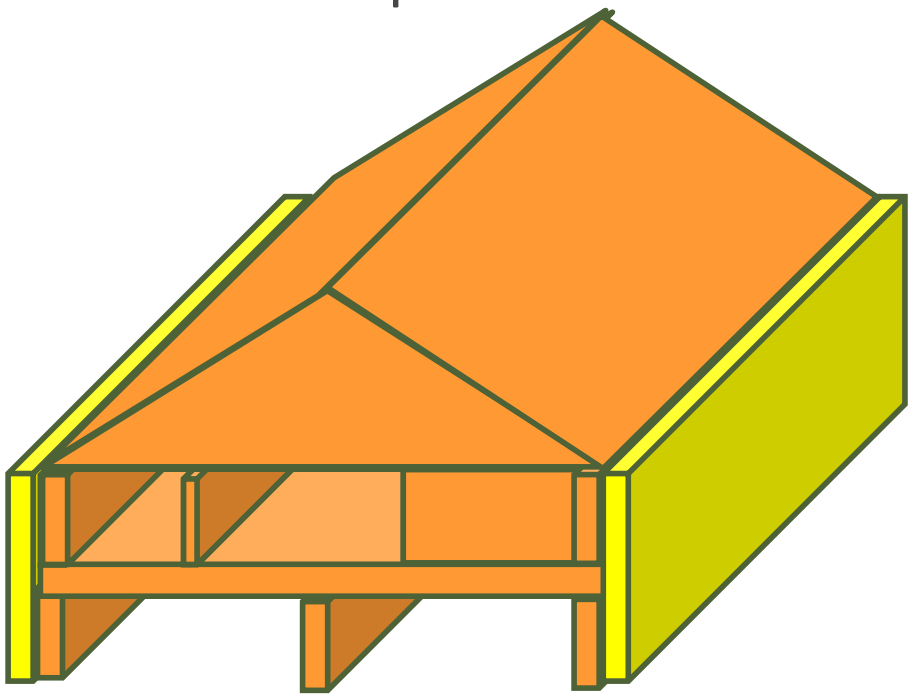


TR 10

Available from AWC website

Type IV Construction – IBC 602.4

Exterior walls are of noncombustible materials and interior building elements are of solid or laminated wood without concealed spaces. FRT wood or Cross Laminated Timber*-2015IBC is permitted in exterior walls, where 2hr fire rating or less is required



*Exterior surface of CLT is protected by FRT sheathing, ½" gypsum, or other non-combustible materials

- Non combustible Exterior walls
- Interior walls-solid without concealed spaces

- Fire Retardant Treated exterior walls or Cross laminated Timber (CLT)-2015 IBC are allowed if fire rating is 2hr or less

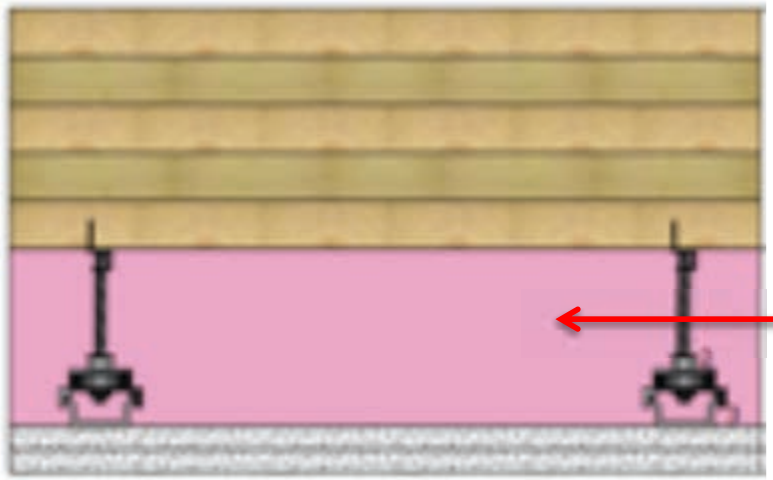
- Heavy Timber

Concealed Space Limitations on HT

Type IV Construction requires that interior elements be without concealed spaces:

- Concealed spaces include dropped ceilings, attics, chases, others

Concealed space requirement does not apply to any other construction type. If using heavy timber elements in non type IV construction, concealed spaces are permitted but may be required to be sprinklered



Example of concealed space created by dropped ceiling

Source: US CLT Handbook

HT Outside of Type IV Construction

In Type III & V Construction Requiring Fire Resistance Rating:

IBC 722.1 permits calculation of fire resistance for exposed wood members and wood decking performed in accordance with NDS Chapter 16.

- Common applications are exposed timber floors and roofs in IIIA, VA construction
- Reduced (non-charred) section is used for structural calculations
- Protection of connections required per IBC 722.6.3.3

Federal Center South – Building 1202 , Seattle, WA
Photo Credit: Benjamin Benschneider

What is the appeal of CLT?

Sustainability

- Reduced Embodied Carbon
- Minimal waste production
- Highly Energy Efficient

Performance

- Disaster Resilient
- Good Fire Resistance
- High performing Acoustics

Construction Efficiency

CLT Acoustics

Sound Insulation of Bare CLT Floors and Walls

Number of layers	Thickness (in.)	Assembly type	STC	IIC
3	3-3/4 to 4-1/2	Wall	32-34	N.A.
5	5-1/3	Floor	39	23
5	5-3/4	Floor	39	24
Measured on field bare CLT wall and floor				
Number of layers	Thickness in.	Assembly type	FSTC	FIIC
3	4-1/8	Wall	28	N.A.
7	8-1/5	Floor	N.A	25-30

Source: US CLT Handbook

MASS TIMBER DESIGN

ACOUSTICS

Common mass timber floor assembly:

- Finish floor (if applicable)
- Underlayment (if finish floor)
- 1.5” to 3” thick concrete/gypcrete topping
- Acoustical mat
- WSP (if applicable)
- Mass timber floor panels

Image credit: AcoustiTECH

Why are designers drawn to CLT?

Sustainability

- Reduced Embodied Carbon
- Minimal waste production
- Highly Energy Efficient

Performance

- Disaster Resilient
- Good Fire Resistance
- High performing Acoustics
- Structural Flexibility

Construction Efficiency

Structural Flexibility

What is the appeal of CLT?

Sustainability	• Reduced Embodied Carbon • Minimal waste production • Highly Energy Efficient
Performance	• Disaster Resilient • Good Fire Resistance • High performing Acoustics • Structural Flexibility
Construction Efficiency	• ~75% lighter than concrete

75% Lighter Weight Than Concrete

What is the appeal of CLT?

Sustainability	• Reduced Embodied Carbon • Minimal waste production • Highly Energy Efficient
Performance	• Disaster Resilient • Good Fire Resistance • High performing Acoustics • Structural Flexibility
Construction Efficiency	• ~75% lighter than concrete • Reduced construction time

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)

Franklin Elementary School, Franklin, WV

- 45,200 ft^2 2 story elementary school
- 8 weeks to construct

FRANKLIN ELEMENTARY SCHOOL

FRANKLIN, WV

FRANKLIN ELEMENTARY SCHOOL

FRANKLIN, WV

PHOTO CREDIT: PAM WEAN, MSES ARCHITECTS

What is the appeal of CLT?

Sustainability

- Reduced Embodied Carbon
- Minimal waste production
- Highly Energy Efficient

Performance

- Disaster Resilient
- Good Fire Resistance
- High performing Acoustics
- Structural Flexibility

Construction Efficiency

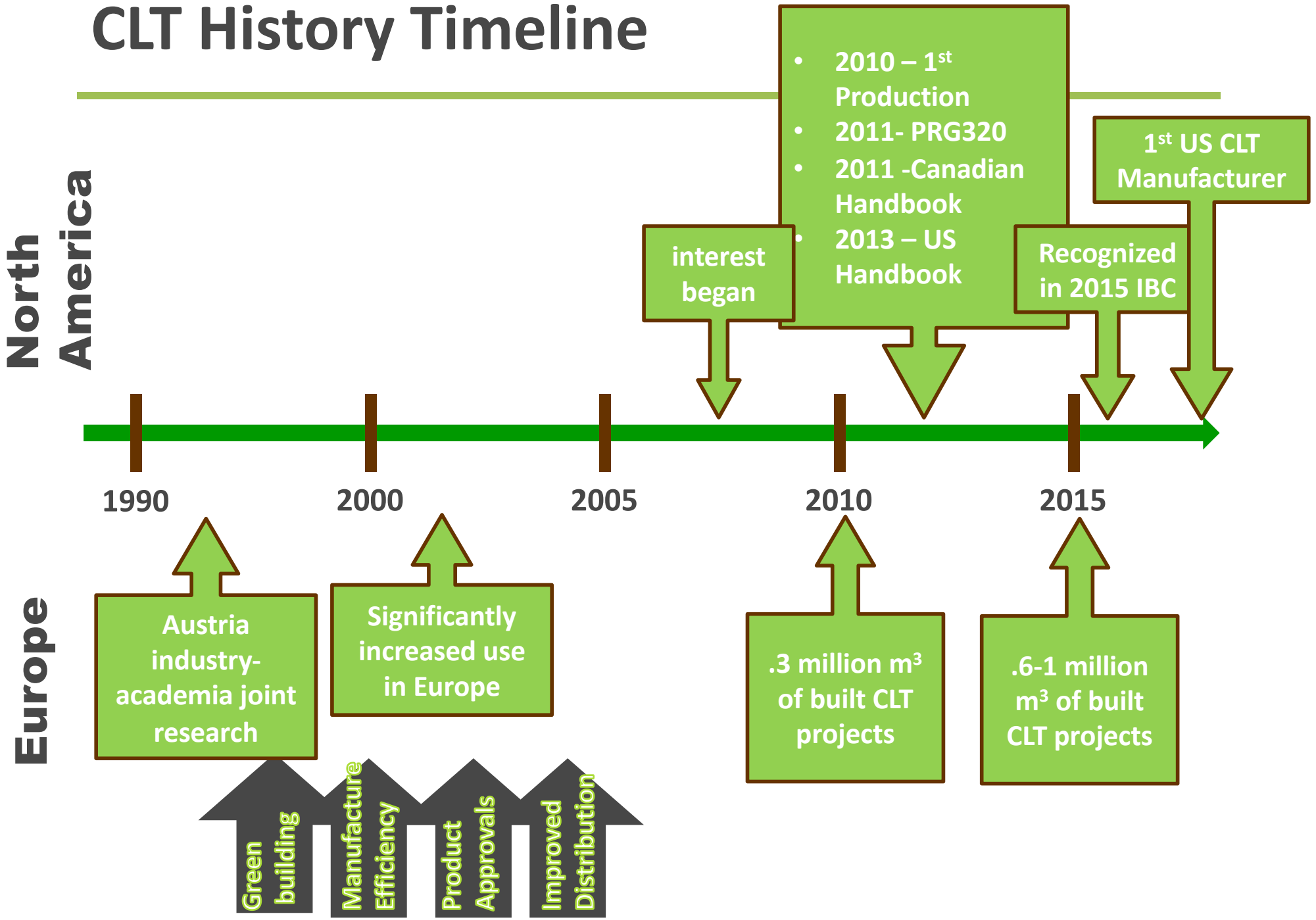
- ~75% lighter than concrete
- Reduced construction time
- Pre-fabricated and Precise

CLT: A Prefabricated Material

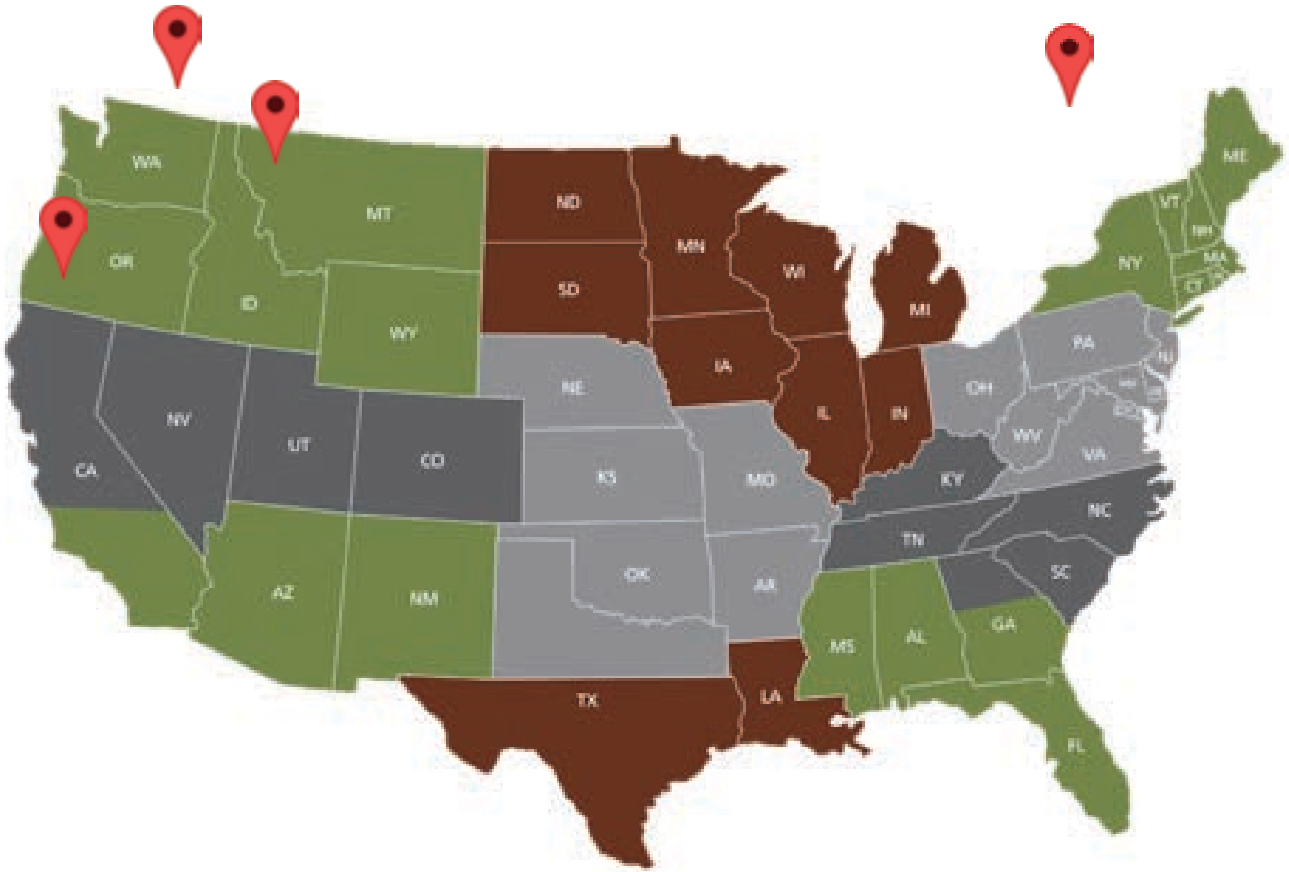
- Custom engineered for material efficiency.
- Custom designed for project.
- Each panel numbered, delivered & installed in predetermined sequence

- Finished panels are planed, sanded, cut to size. Then openings are cut with precise CNC routers.
- Third party inspection at factory.

CLT History Timeline



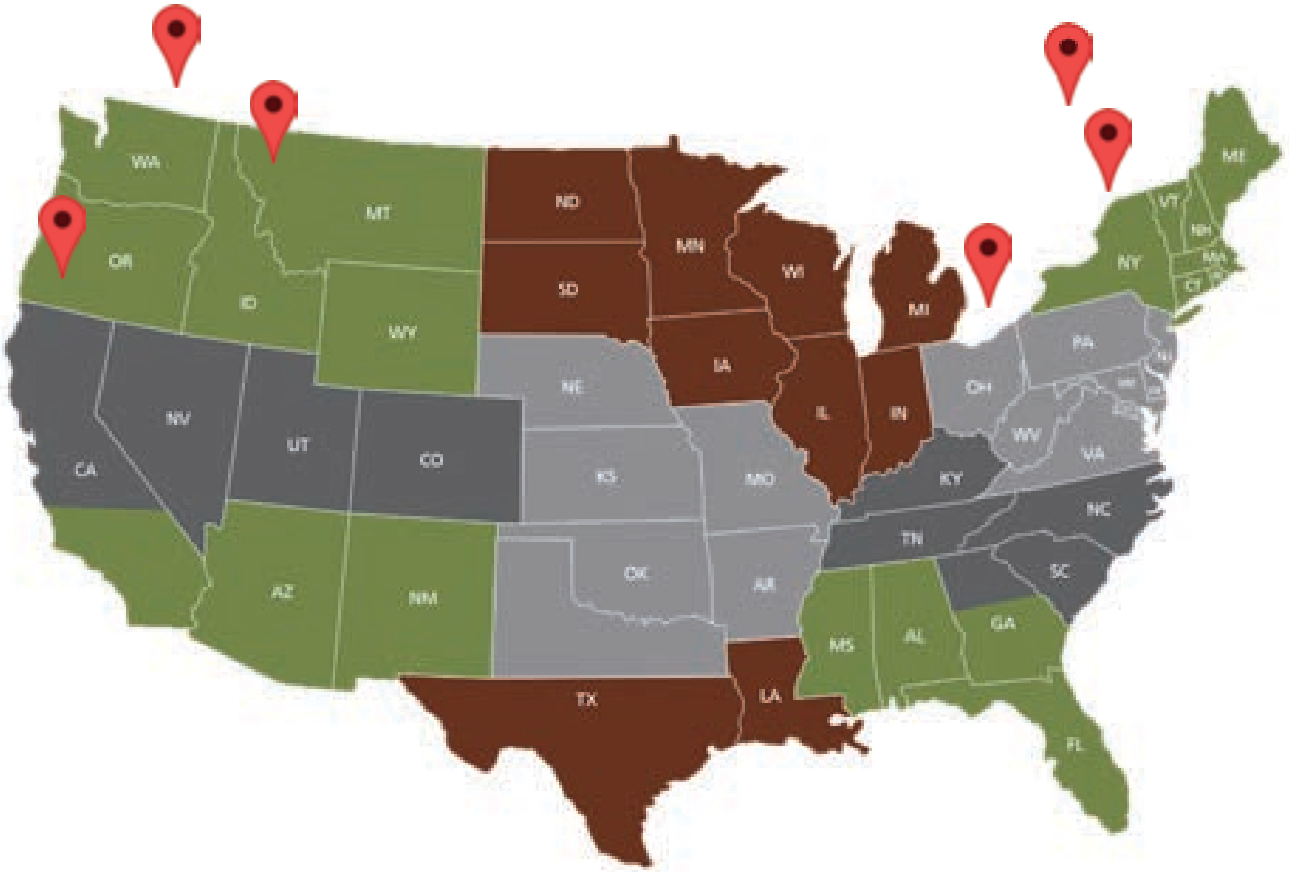
Certified North American CLT Manufacturers



Certified CLT:

- **Nordic** (Chibougamau , QU, Canada)
- **SmartLam** (Whitefish, MT, US)
- **Structurlam** (Penticton, BC, Canada)
- **DR Johnson Lumber** (Riddle, OR, US)

CLT Manufacturers Serving Non-Structural Markets



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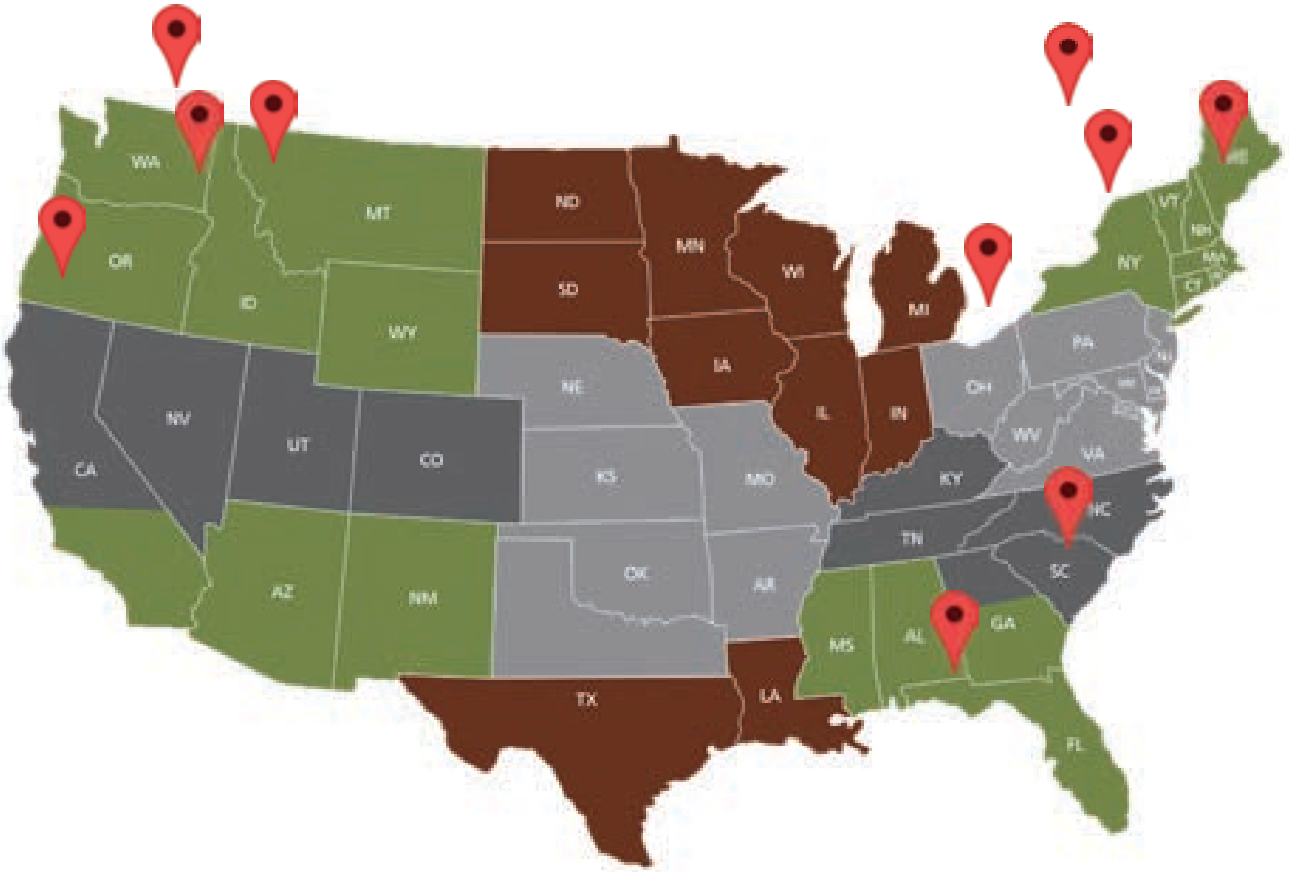
- **DR Johnson Lumber** (Riddle, OR, US)

Not Yet Certified:

- **Guardian Structures** (St. Marys, ON, Canada)
- **Element 5** (Ripon, QC, Canada)

New Manufacturing Facilities Underway



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Not Yet Certified:

- **Guardian Structures** (St. Marys, ON, Canada)
- **Element 5** (Ripon, QC, Canada)

Coming Soon:

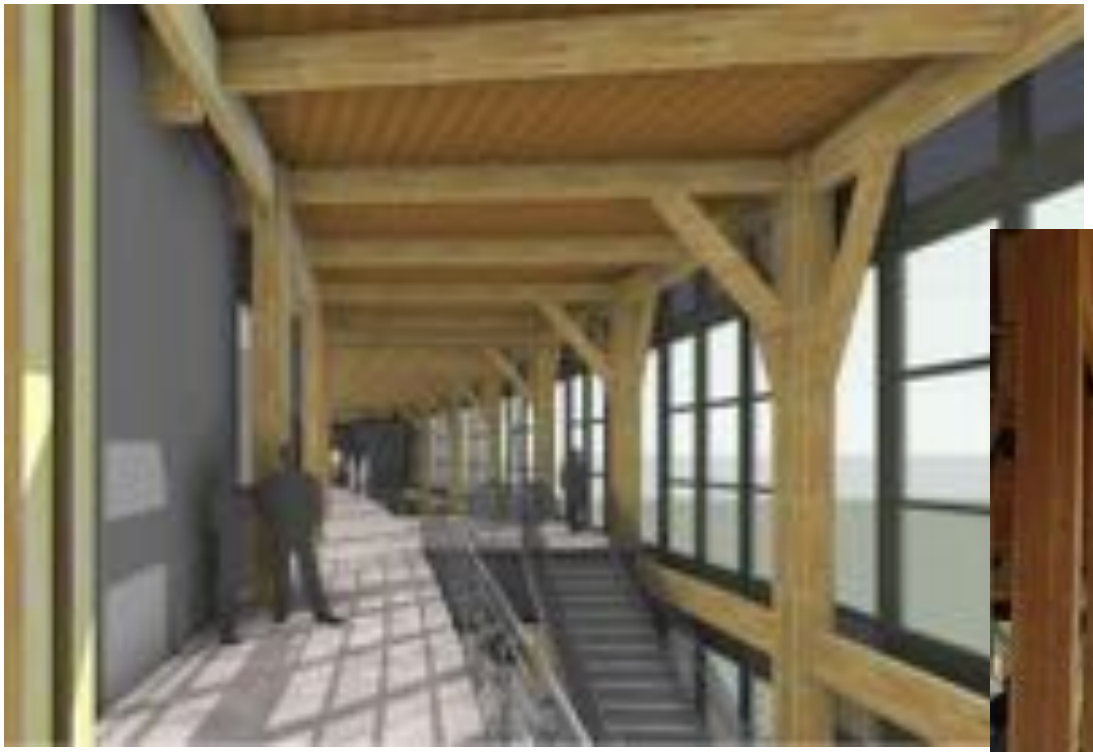
- **International Beams** (Dothan, AL)
- **Katerra** (Spokane, WA)
- **SmartLam** (TBD)

Outline

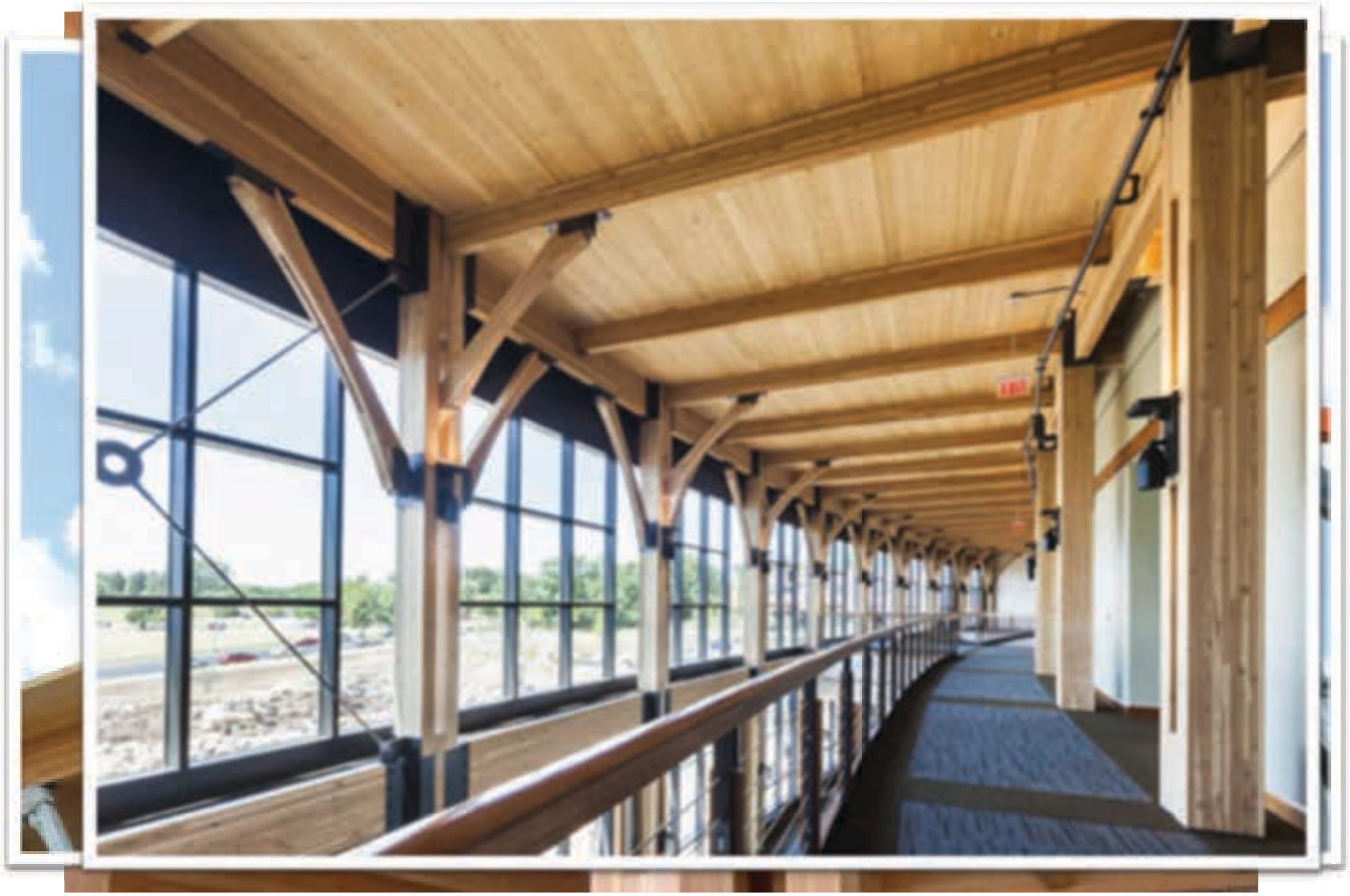
- What is CLT?
  - Mass Timber
  - The Appeal
  - History
  - Availability
- Using CLT
  - Project Examples
  - Best applications
  - Cost effective design
  - Building Codes and Standards

Mass Timber Building Options

- Completed in 2013
- 1st Commercial CLT Building in US built with North American CLT
- CLT used only in the roof



Promega GMP Facility, Fitchburg, WI
Architect: Uihlein Wilson Architects



Promega Feynman Center, The Crossroads, Madison, Wisconsin
Photos: Aitor Sanchez/EwingCole

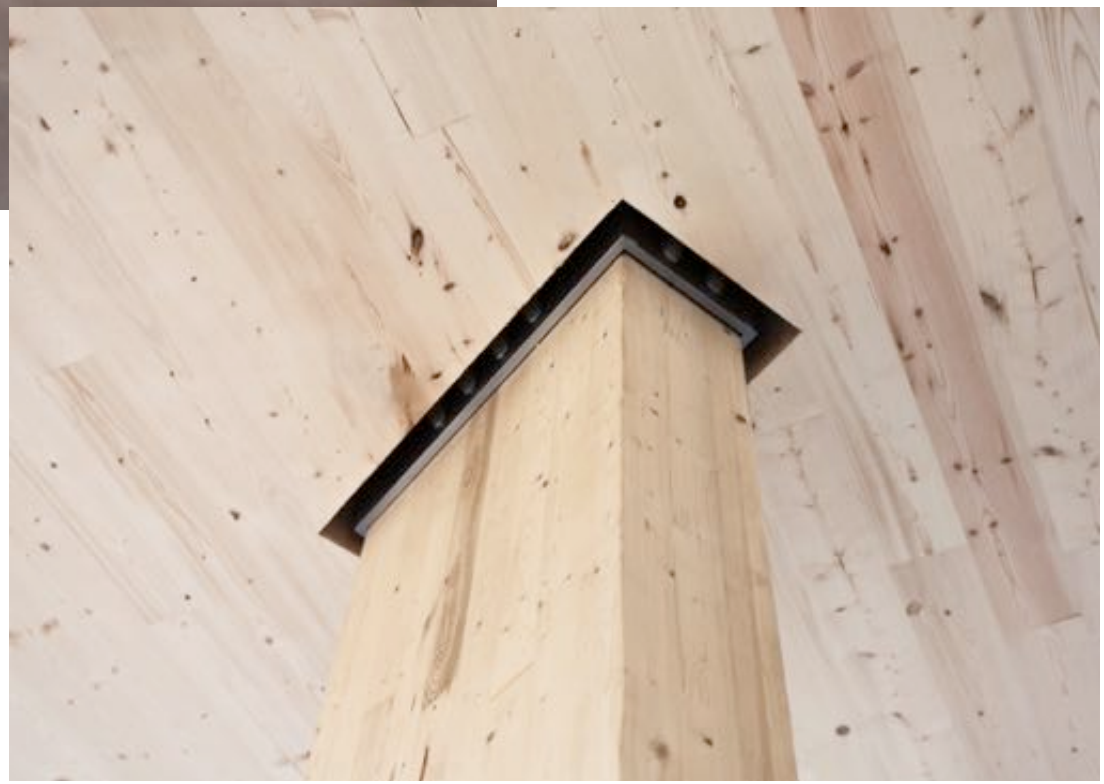
Chicago Horizon Pavilion
Chicago, IL

56’ square kiosk

2 Layers of 3-ply, 4-1/8” CLT roof panels in opposite directions, each panel 8’ x 56’, creating 2 way spanning plate

Chicago Horizon Pavilion
Photos: Tom Harris

Chicago Horizon Pavilion
Photos: Aaron Forrest



Total roof structure thickness 8-1/4”

Spans up to 30 feet between columns at points

Chicago Horizon Won Chicago Architecture Biennial's 2015 Lakefront Kiosk Competition

Photo Credit: Tom Harris

CONSTRUCTION TYPES

IBC 601 & 603

MASS TIMBER ROOFS (DECKS & SECONDARY MEMBERS) CAN BE USED WHERE THE REQUIRED FIRE RESISTANCE RATING IS 1 HOUR OR LESS IN ANY CONSTRUCTION TYPE EXCEPT 1A PER IBC TABLE 601 FOOTNOTE C & SECTION 603.1

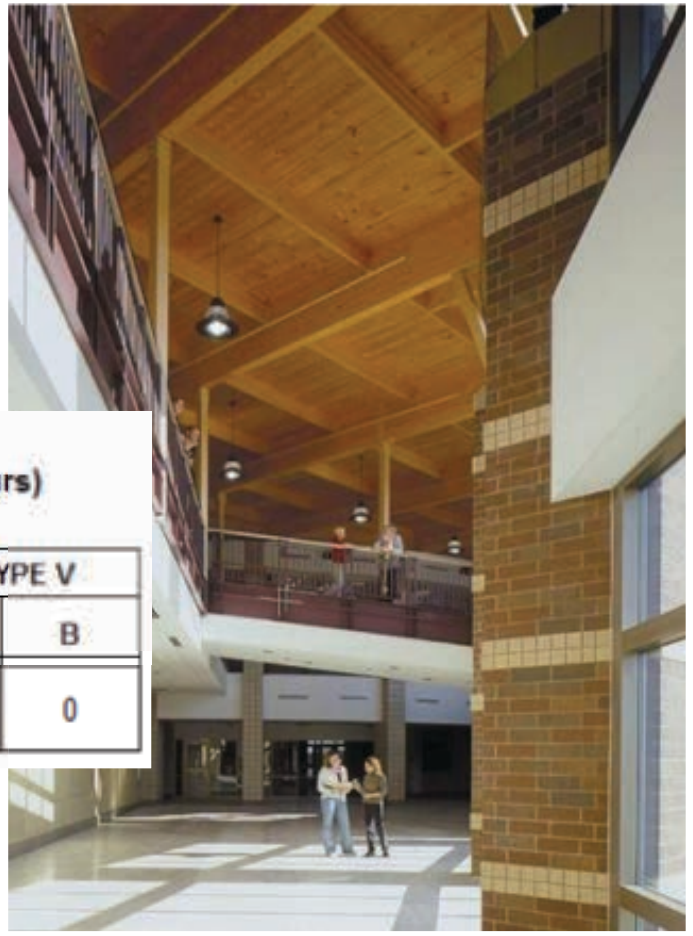


TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[d]	B	A[d]	B	HT	A[d]	B
Roof construction and 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

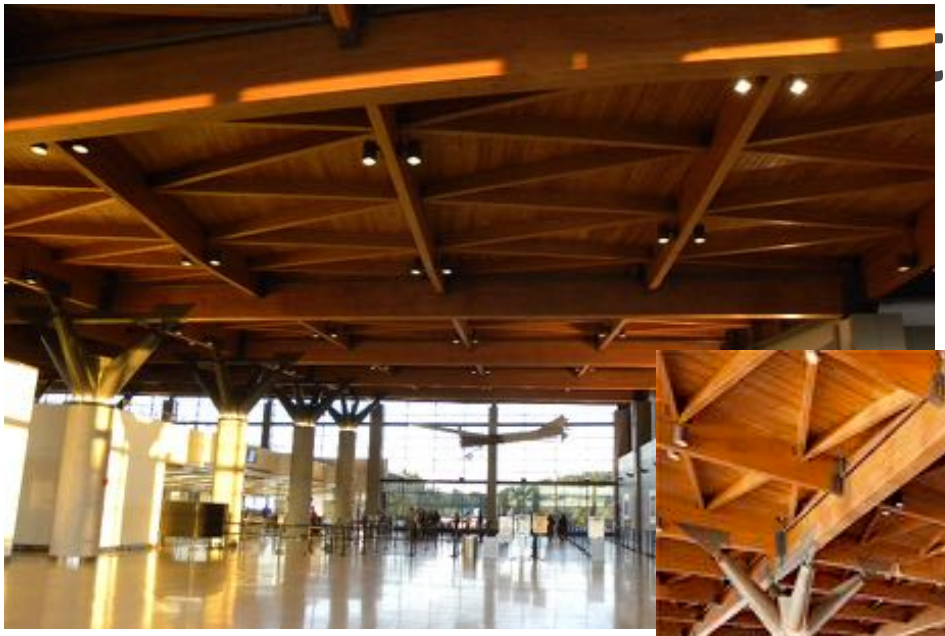
C. IN ALL OCCUPANCIES, HEAVY TIMBER SHALL BE ALLOWED WHERE A 1-HOUR OR LESS FIRE-RESISTANCE RATING IS REQUIRED

Portland International Jetport, Portland, Maine

Architect : Gensler
Structural Engineer: Oest Associates
Timber Engineer: DeStefano & Chamberlain

Photos courtesy DeStafano & Chamberlain, Inc.

Case Study: Portland



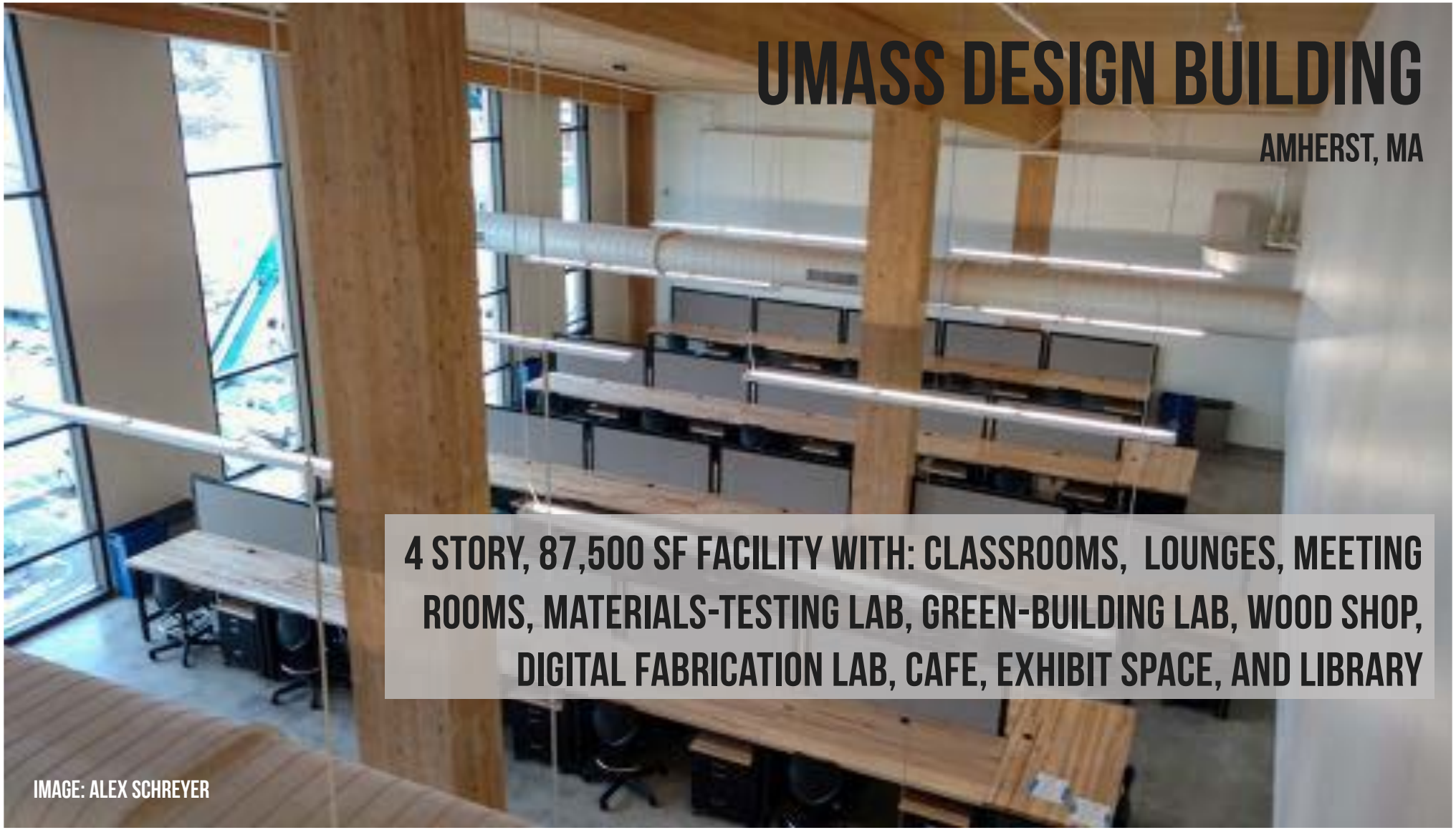
Portland International Jetport

- Location: Portland, ME
- LEED Gold
- Completed 2012

Design Team: Gensler, Oest Associates

Photo Credit: DeStafano & Chamberlain, Inc, Robert Benson Photography


UMASS DESIGN BUILDING
AMHERST, MA
IMAGE CREDIT: ALEX SCHREYER



UMASS DESIGN BUILDING

AMHERST, MA

4 STORY, 87,500 SF FACILITY WITH: CLASSROOMS, LOUNGES, MEETING ROOMS, MATERIALS-TESTING LAB, GREEN-BUILDING LAB, WOOD SHOP, DIGITAL FABRICATION LAB, CAFE, EXHIBIT SPACE, AND LIBRARY

IMAGE: ALEX SCHREYER


UMASS DESIGN BUILDING
AMHERST, MA
COMPLETED JAN 2017
PHOTO CREDIT: ALEX SCHREYER

PHOTO CREDIT: ALEX SCHREYER

UMASS DESIGN BUILDING

AMHERST, MA


T3 MINNEAPOLIS
MINNEAPOLIS, MN
Photo Credit: Blaine Brownell

TYPE IV CONSTRUCTION
7 STORIES (6 TIMBER ON 1 CONCRETE)
234,000 SF
2X8 NLT FLOOR PANELS W/3” CONCRETE TOPPING
GLULAM BEAM AND COLUMN FRAME
20’X25’ GRID

T3 MINNEAPOLIS

MINNEAPOLIS, MN

Type IV Construction
7 stories (6 Timber on 1 Concrete)
234,000 sf
2x8 NLT Floor Panels w/3” Concrete Topping
Glulam Beam and Column Frame
20’x25’ Grid

Image Credit: StructureCraft Builders

IMAGE CREDIT: STRUCTURECRAFT/HINES/MICHAEL GREEN ARCHITECT

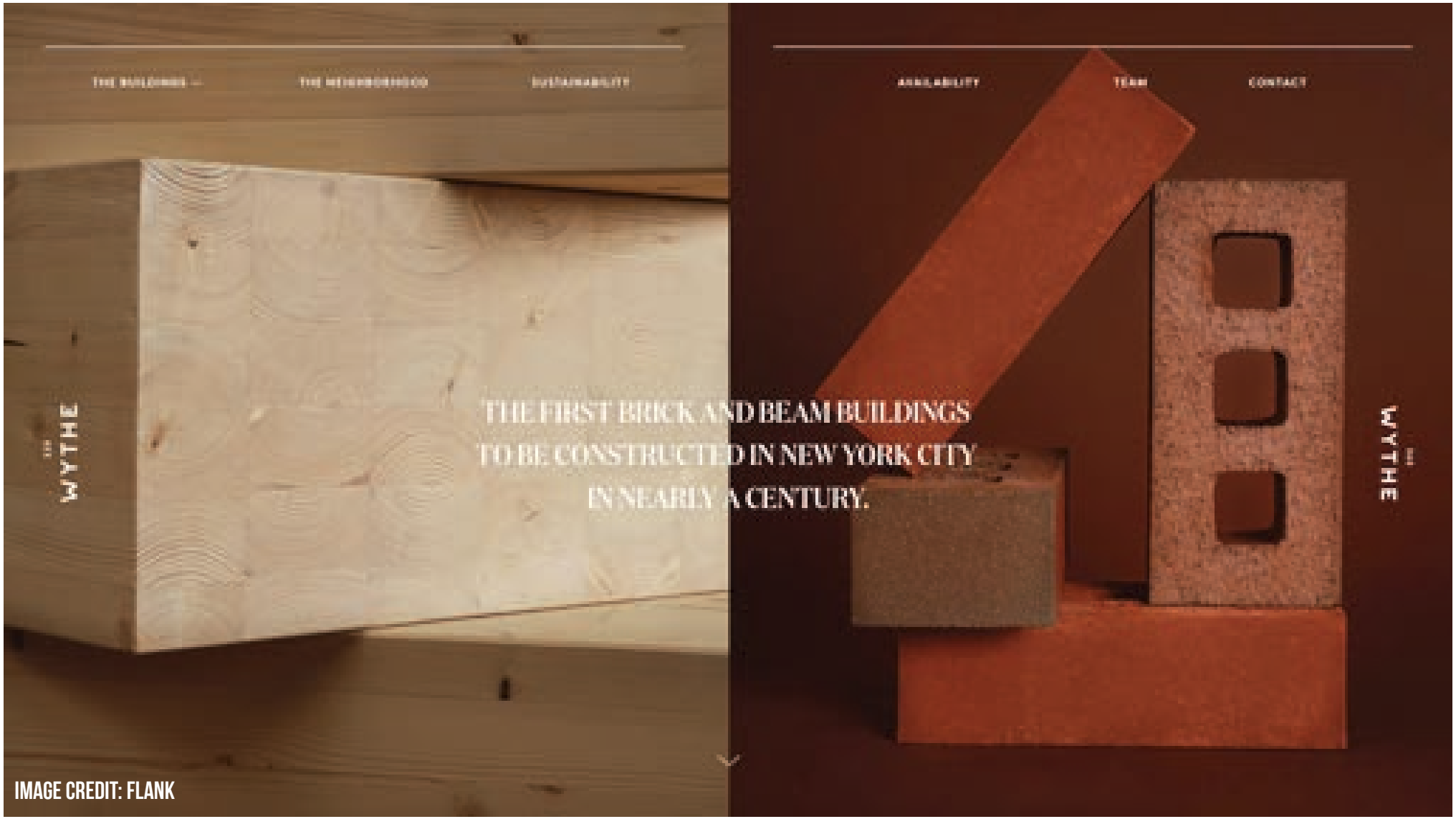


IMAGE CREDIT: FLANK

IMAGE CREDIT: FIELD CONDITION/FLANK

320 & 360 WYTHE AVE.

NEW YORK, NY

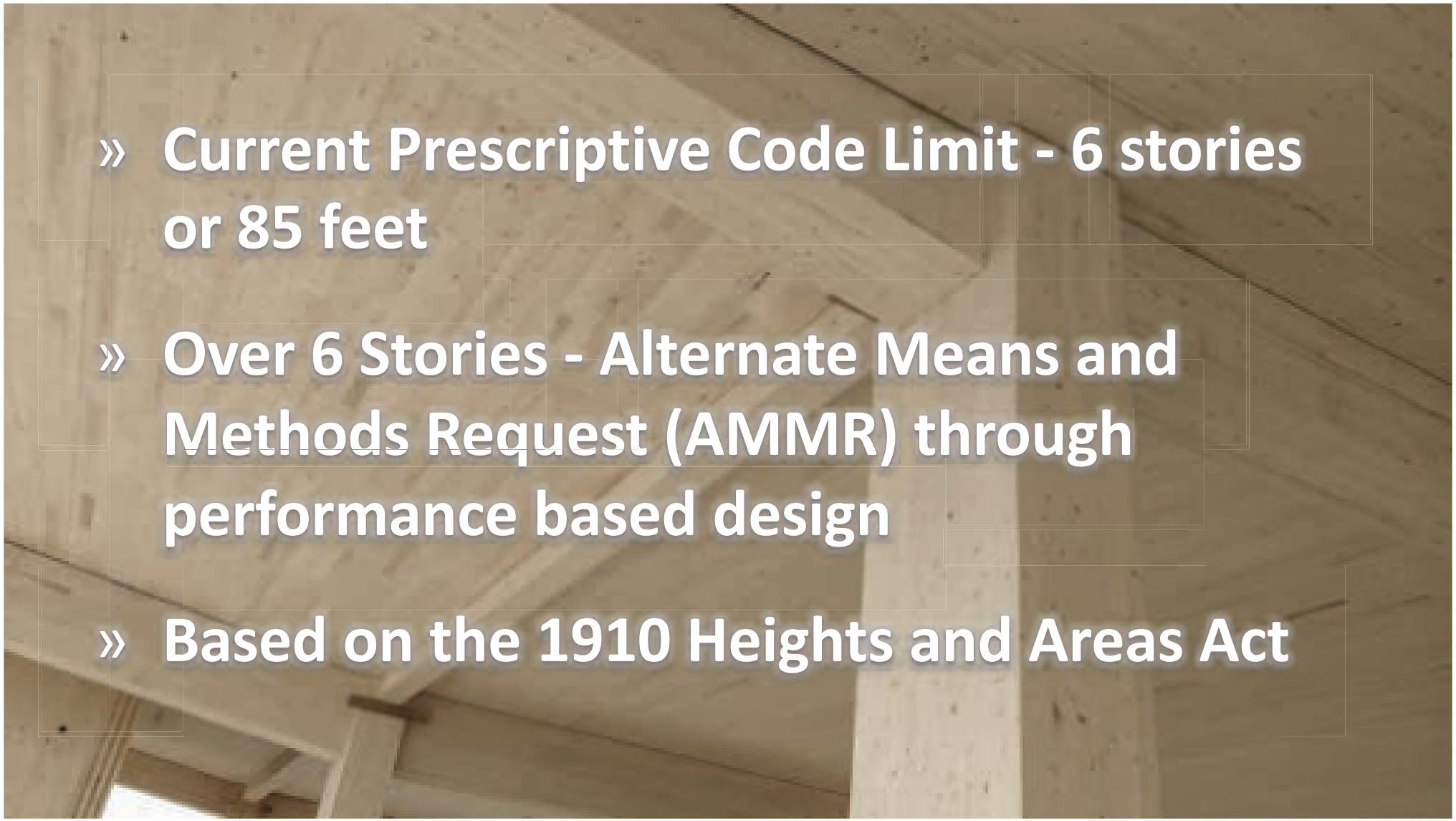
3 STORY & 5 STORY BUILDINGS
MOSTLY OFFICE, SOME APARTMENTS
NLT & GLULAM

320 & 360 WYTHE AVE.

NEW YORK, NY

IMAGE CREDIT: FLANK

U.S. BUILDING CODE STATUS



- 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

MASS TIMBER CONSTRUCTION
THE FUTURE'S LOOKING UP

PHOTO CREDIT: NATURALLY: WOOD


TALL WOOD IN THE U.S.
©2011 NATTAPOL PORNSALNUWAT
www.fiveoclockstudio.com

U.S. BUILDING CODES

Tall Wood Ad Hoc Committee

Balanced Committee: 2016-2018

Development of code change proposals for prescriptive code allowances of tall wood buildings.

Mass Timber Fire Testing at ATF Lab

Mass Timber Shake Table Test at UCSD

New Building Types

TYPE IV-A

TYPE IV-B

TYPE IV-C

IBC 2021

TYPE IV- HT

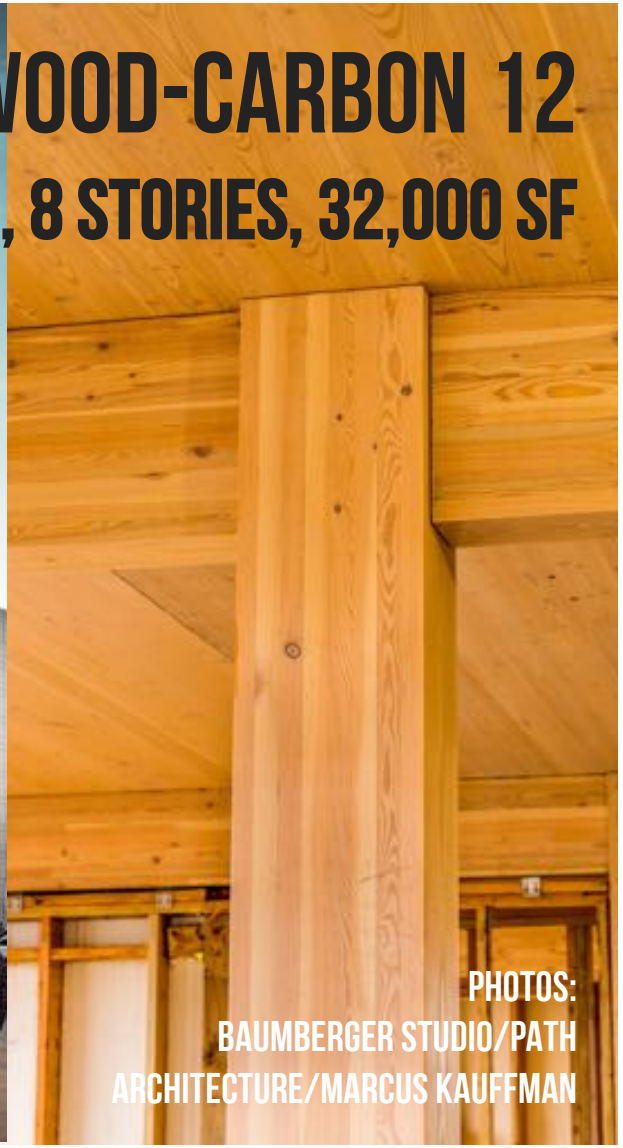
IBC 2015

BUSINESS OCCUPANCY [GROUP B]

PORTLAND, OR

MODERN TALL WOOD-CARBON 12

2017, 8 STORIES, 32,000 SF



PHOTOS:
BAUMBERGER STUDIO/PATH
ARCHITECTURE/MARCUS KAUFFMAN

BROCK COMMONS

VANCOUVER, BC

18 STORIES

174 FT

156K SQ.FT.

BROCK COMMONS

VANCOUVER, BC

17 STORIES OF TIMBER INSTALLATION

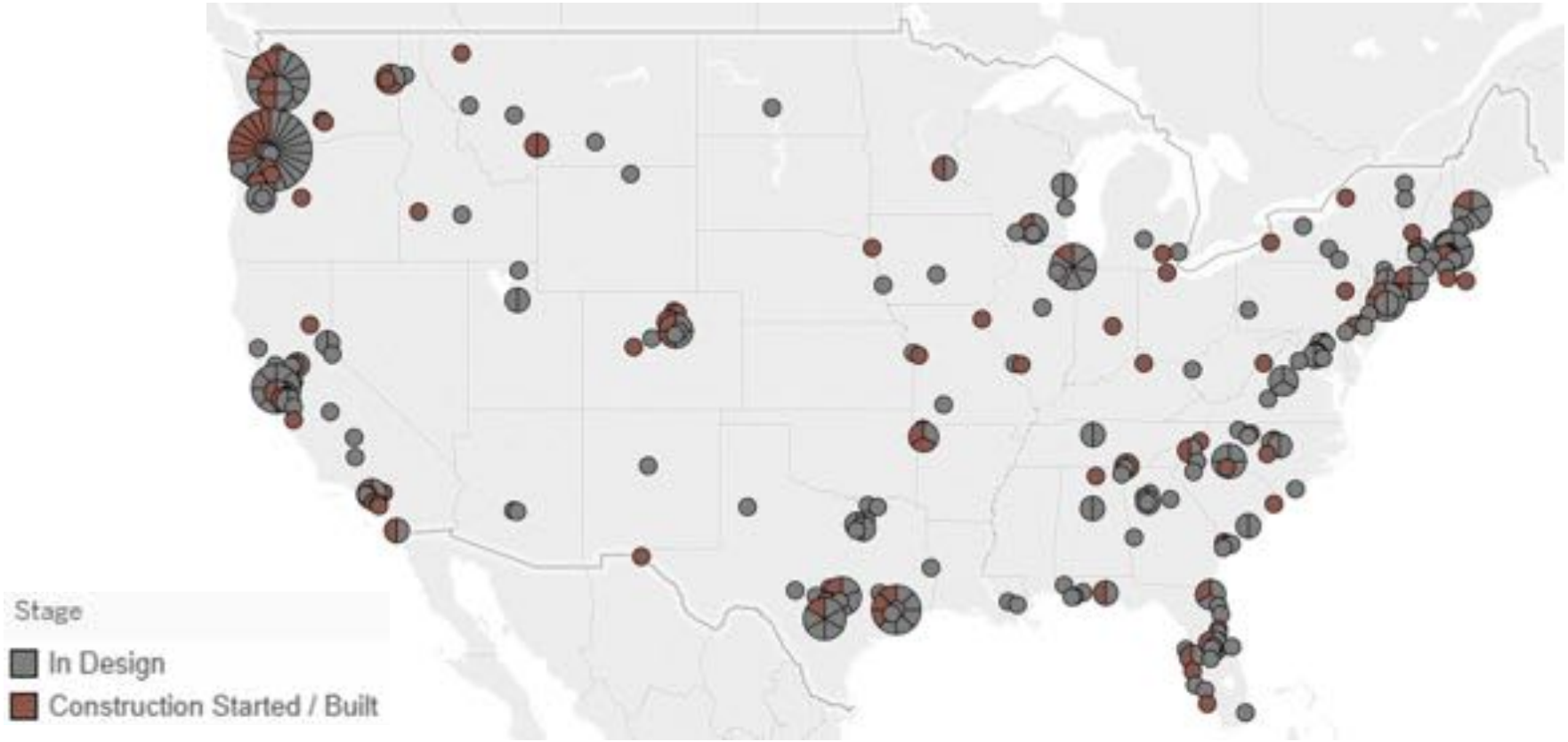
STARTED JUNE 6, 2016

FINISHED AUGUST 10, 2016

CURRENT STATE OF MASS TIMBER PROJECTS

As of June 2018, more than **400** multi-family, commercial, or institutional projects have been constructed out of mass timber across the U.S., or they're currently in design.

WoodWorks™
WOOD PRODUCTS COUNCIL



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

Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

Marc J Rivard, PE, SE

Project Assistance available at:
marc.rivard@woodworks.org