



Mid-Rise and Taller Wood Buildings: The Growing Landscape



credit: Think Wood

Mark Bartlett, PE
mark.bartlett@woodworks.org

FUNDING PARTNERS





WHAT WOODWORKS DOES

Designing a wood building? Ask us anything.



FREE PROJECT SUPPORT • EDUCATION • RESOURCES

Nationwide support for the code-compliant design, engineering and construction of non-residential and multi-family wood buildings.

- Allowable Heights/Areas
- Construction Types
- Structural Detailing
- Wood-Framed & Hybrid Systems
- Fire/Acoustic Assemblies
- Lateral System Design
- Alternate Means of Compliance
- Energy-Efficient Detailing
- Building Systems & Technologies

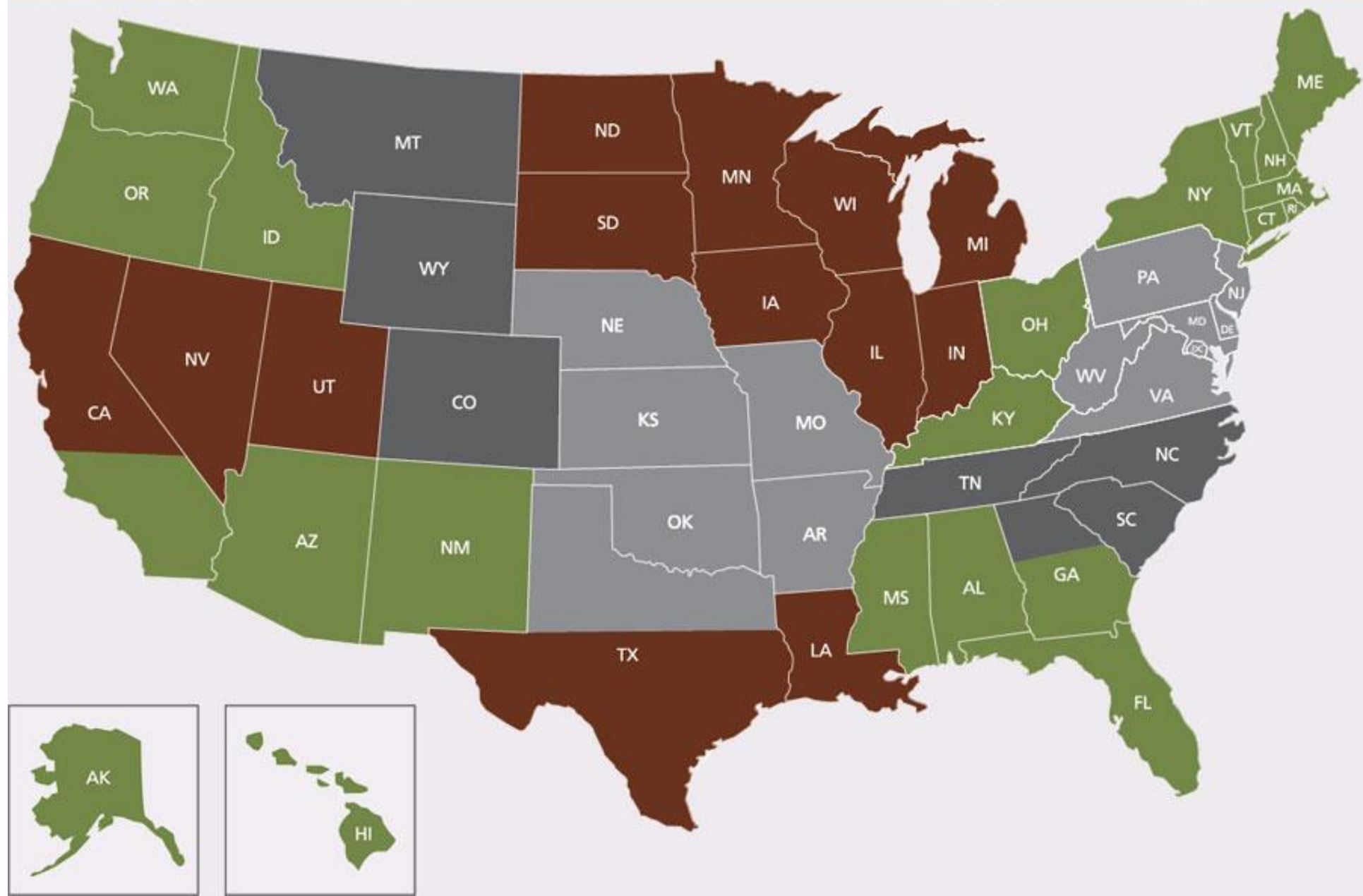


River Edge, Kitchell & Associates,
photo courtesy of McRae Construction

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

MULTI-FAMILY/MIXED-USE • EDUCATION • OFFICE • RETAIL • INDUSTRIAL • CIVIC • INSTITUTIONAL

Project Assistance



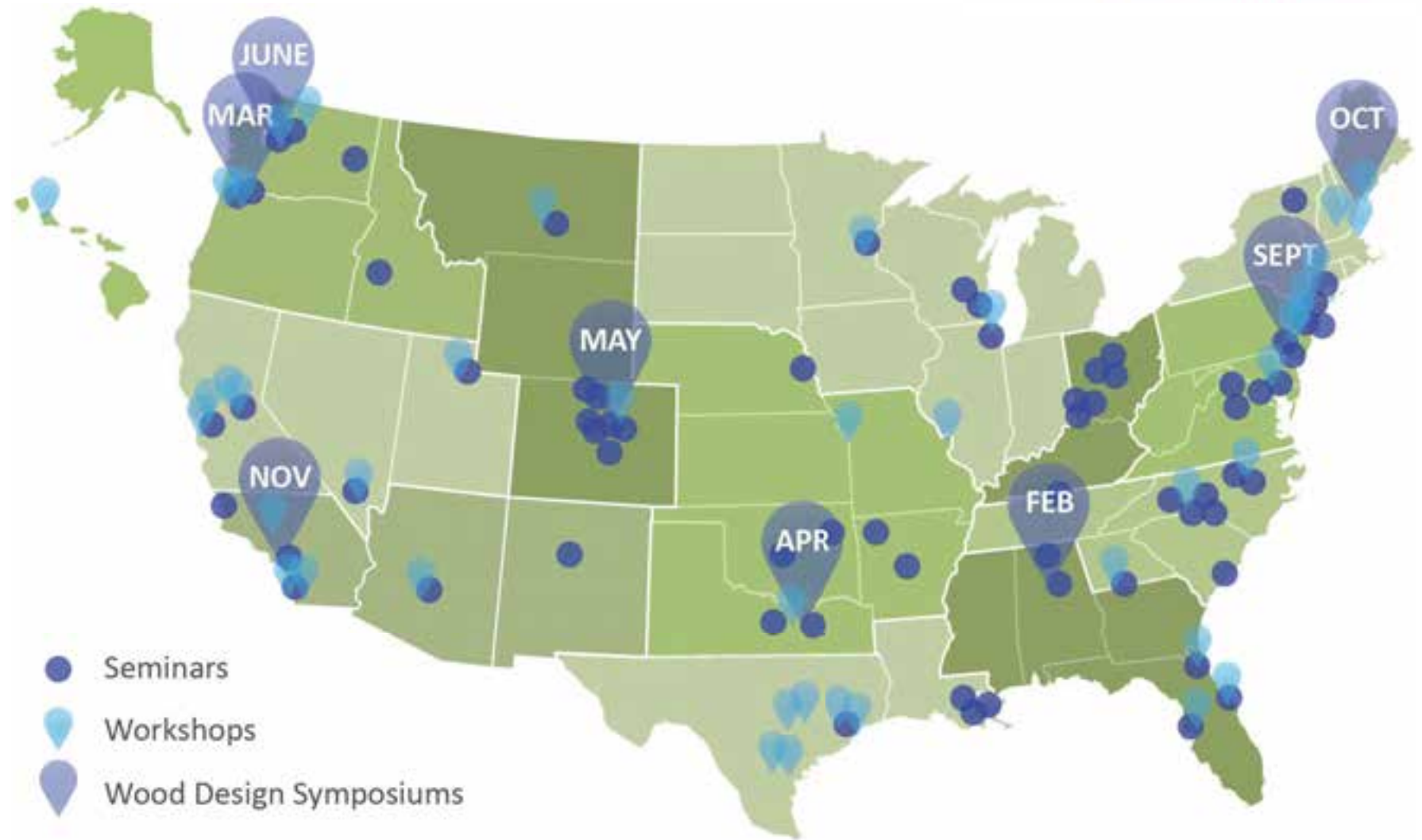
ASSISTANCE EXAMPLE



2019 EDUCATION EVENTS



WoodWorks will host or speak at almost 400 events, and provide close to 35,000 education hours in 2019, all related to the design, engineering and construction of commercial and multi-family wood buildings.



All credits are AIA/CES HSW LUs, PDH and ICC eligible.

WOOD DESIGN SYMPOSIUMS

June 19 | Seattle, WA

September 19 | Philadelphia, PA

October 16 | Portland, ME

November 13 | Long Beach, CA

UPCOMING EVENTS



SEMINARS & WORKSHOPS

Various topics and locations throughout the Summer and Fall: NYC, San Antonio, Omaha, Charlotte, Atlanta, St Louis, Kansas City and more

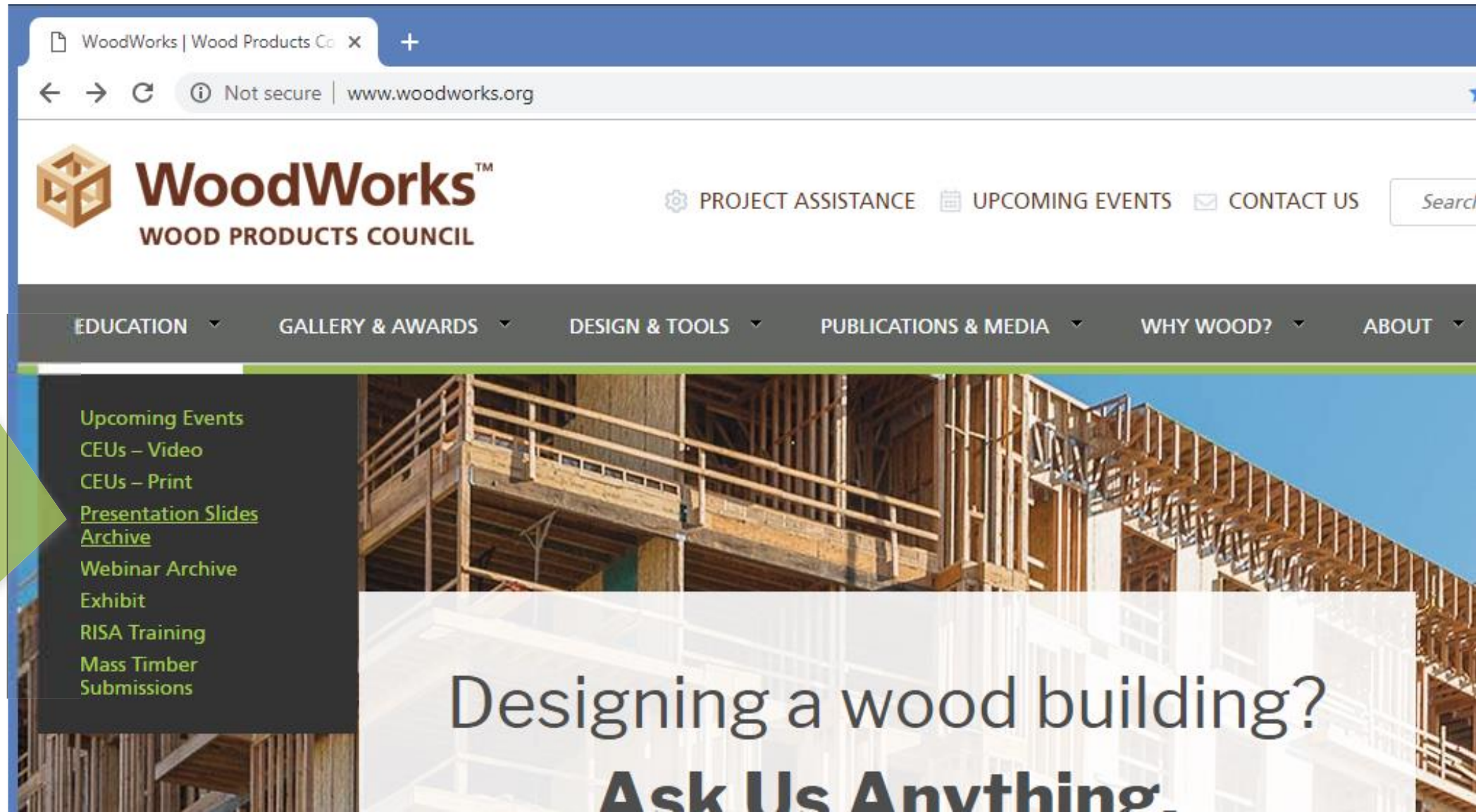
WEBINARS

June 12 | Maximizing Mid-Rise Value with Wood: Design Tips for Podiums, Sloped Sites and Other Complexities

July 10 | Timber-Concrete Composite Floor Technology: Research, Design and Implementation

August 14 | Mass Timber Connections: Building Structural Design Skills

WOODWORKS: PRESENTATION SLIDE ARCHIVE



2020 WOOD DESIGN AWARDS



The poster is a promotional graphic for the 2020 WoodWorks Wood Design Awards. It features a white top-left section with the WoodWorks logo (a stylized wooden cube) and the text "WoodWorks™ WOOD PRODUCTS COUNCIL". To the right, a green banner contains the text "CALL FOR NOMINATIONS" in white. Below the logo, a vertical wood-grain background displays "WOOD DESIGN AWARDS" in large green letters. A green box at the bottom left states "NOMINATIONS OPEN JUNE 1, 2019". The bottom of the poster is a dark green bar with a white arrow and the text "Visit woodworks.org for details." The right side of the poster is a collage of three images: a modern multi-story building with a red-brown wood facade, an interior view of a wooden deck overlooking a lake at sunset, and a large interior space with a high, vaulted wooden ceiling and a large window.

WoodWorks™
WOOD PRODUCTS COUNCIL

CALL FOR NOMINATIONS

**WOOD
DESIGN
AWARDS**

**NOMINATIONS
OPEN JUNE 1, 2019**

> Visit woodworks.org for details.



“The Wood Products Council” is a Registered Provider with The American Institute of Architects Continuing Education Systems (AIA/CES), Provider #G516.

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

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



Course Description

Innovative use of wood is changing the skyline. Increasingly, mid-rise wood buildings are rising up among traditional concrete and steel shells as designers and developers recognize timber's performance capabilities while embracing its vast potential for lower costs, faster installation, and a significantly lighter carbon footprint. Through the use of case studies, this session will showcase recently completed projects that illustrate this trend. Topics will include current code allowances for mid-rise wood buildings, design strategies and environmental performance. Discussion will then shift to taller wood buildings, made possible by emerging research and the development of advanced wood products and technologies. Project examples will be highlighted and design approaches for topics such as fire-resistance, structure and acoustics will be covered.



Learning Objectives

1. Evaluate the opportunities for wood-frame mid-rise projects.
2. Interpret local code language on the allowance of wood framing above three stories.
3. Learn how tall timber can achieve design goals beyond code requirements, including high acoustical performance, unique aesthetics and sustainability.
4. Discover how tall timber can achieve structural performance and approval in the US including fire performance.



Global Population Boom



Global Population
7.3 billion today

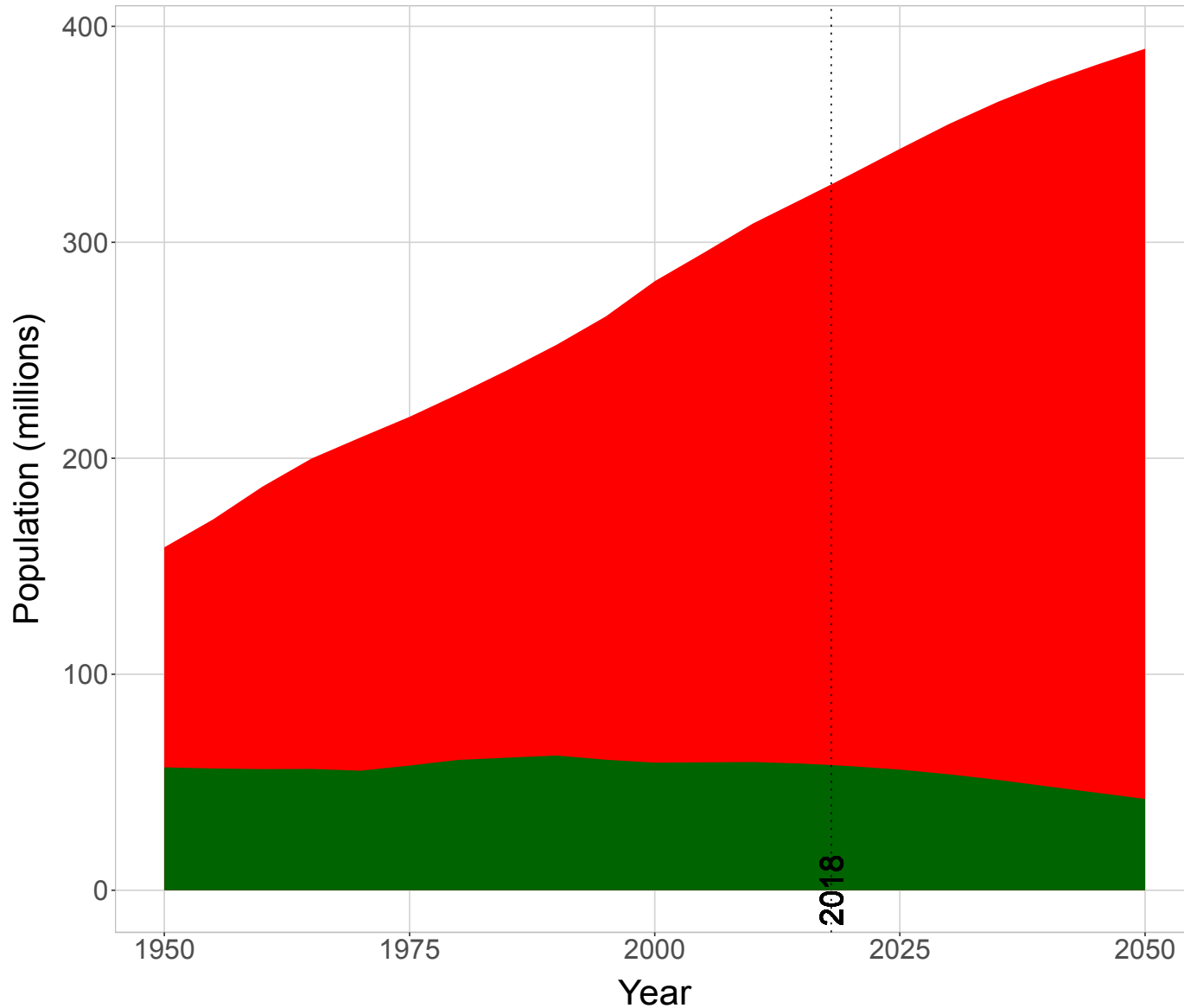
9.5 billion by 2050
30% increase

Urban Population
6.3 billion by 2050
60% increase

Urban and rural population

United States of America

Urban Rural



US URBAN POPULATION BOOM



URBAN



RURAL

2019

271.4 M

57.7 M

2030

301 M

53.7 M

2050

347.3 M

42.2 M

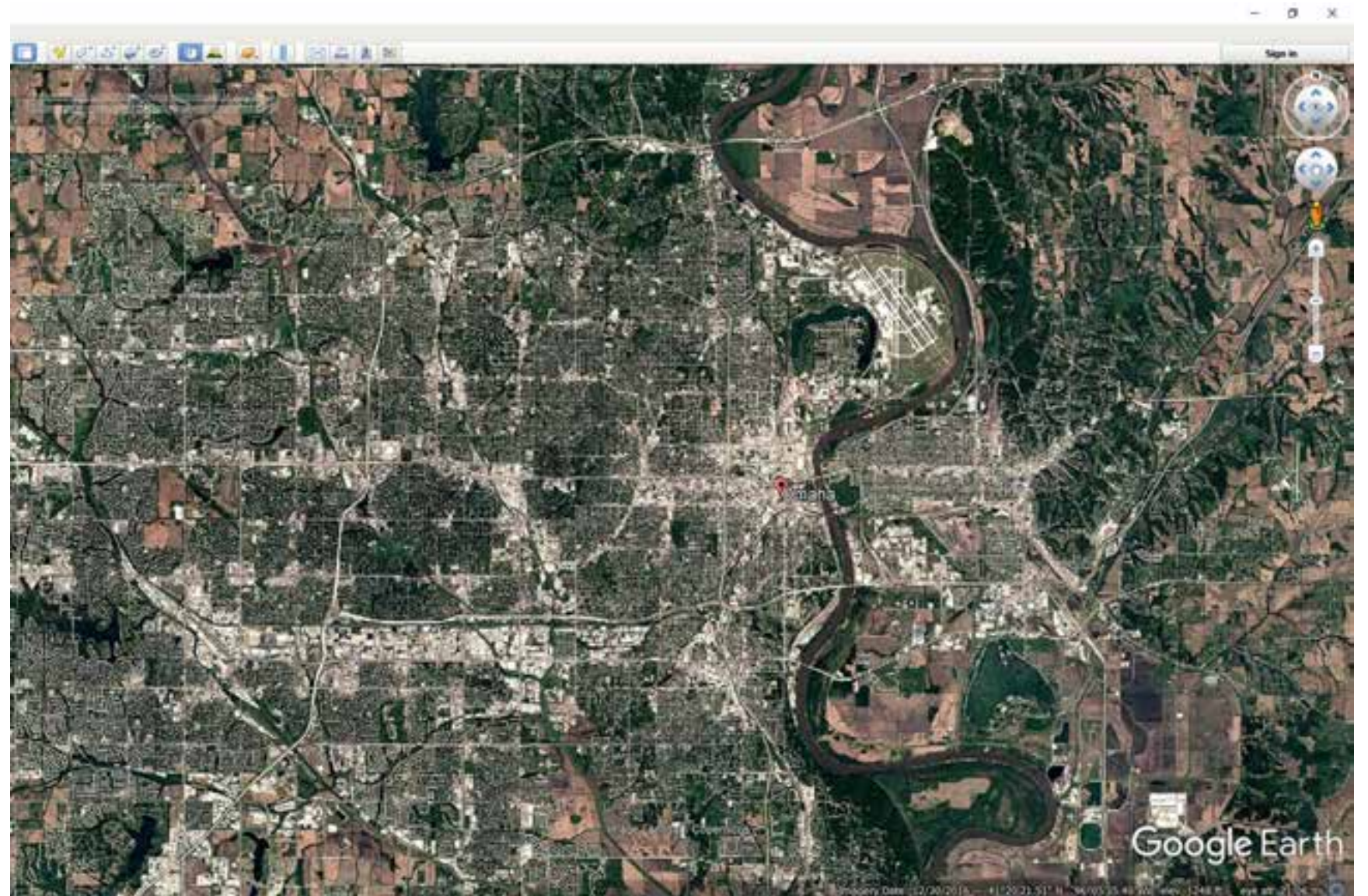


Omaha

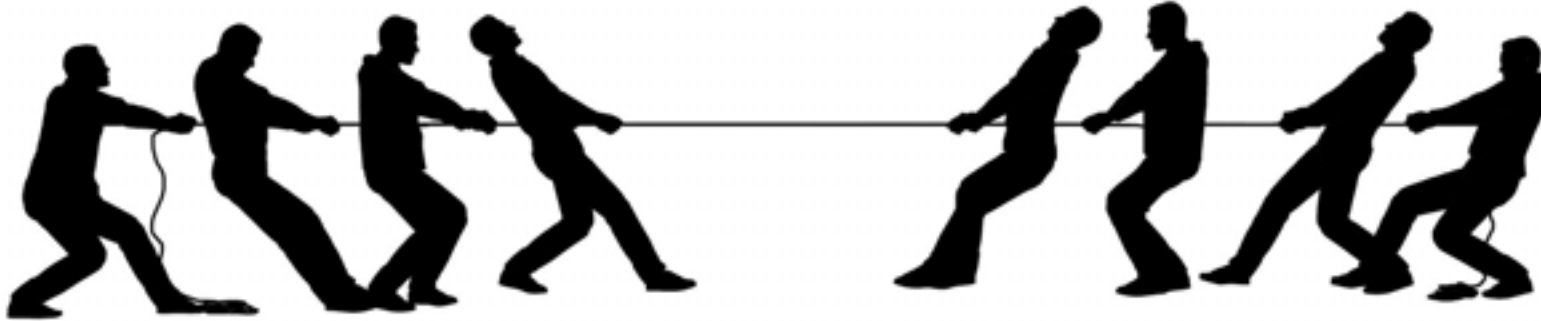
1984

2000

2016



> Need for Sustainable Structures

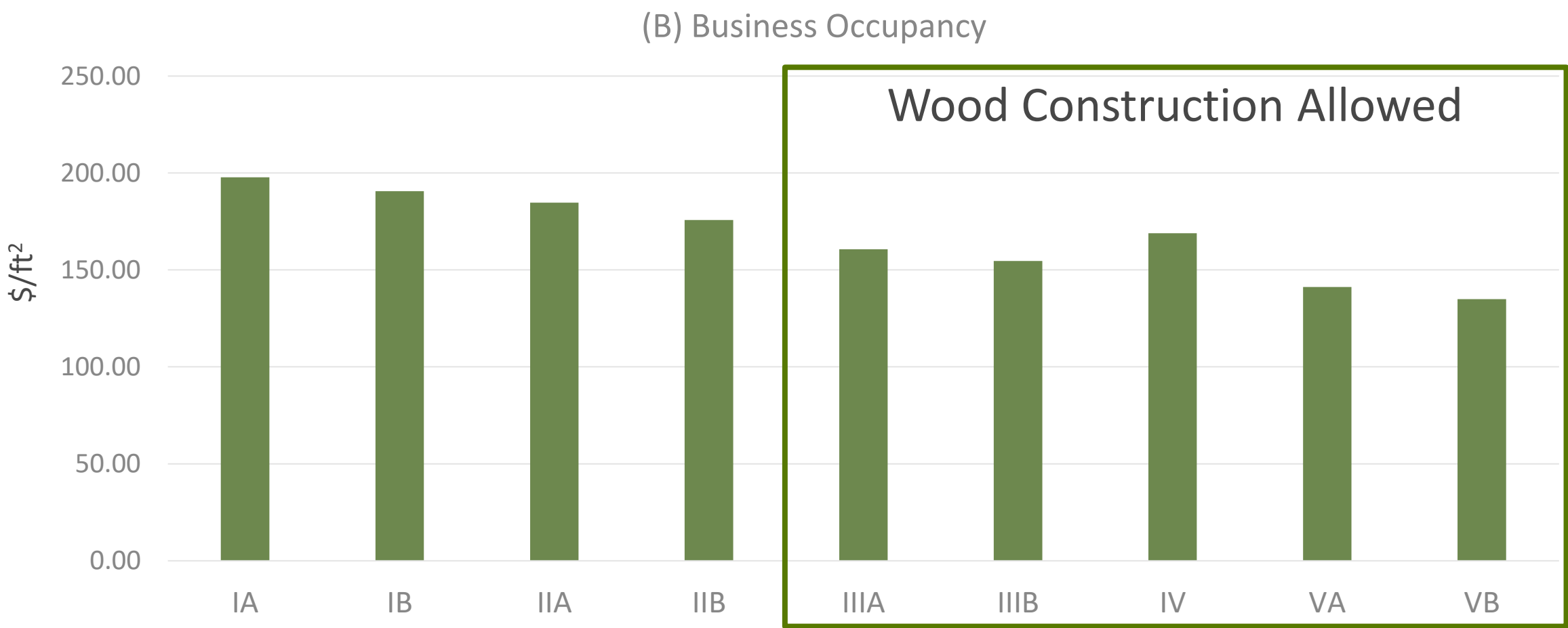


Economically Meet
Urban Housing and
Business Needs

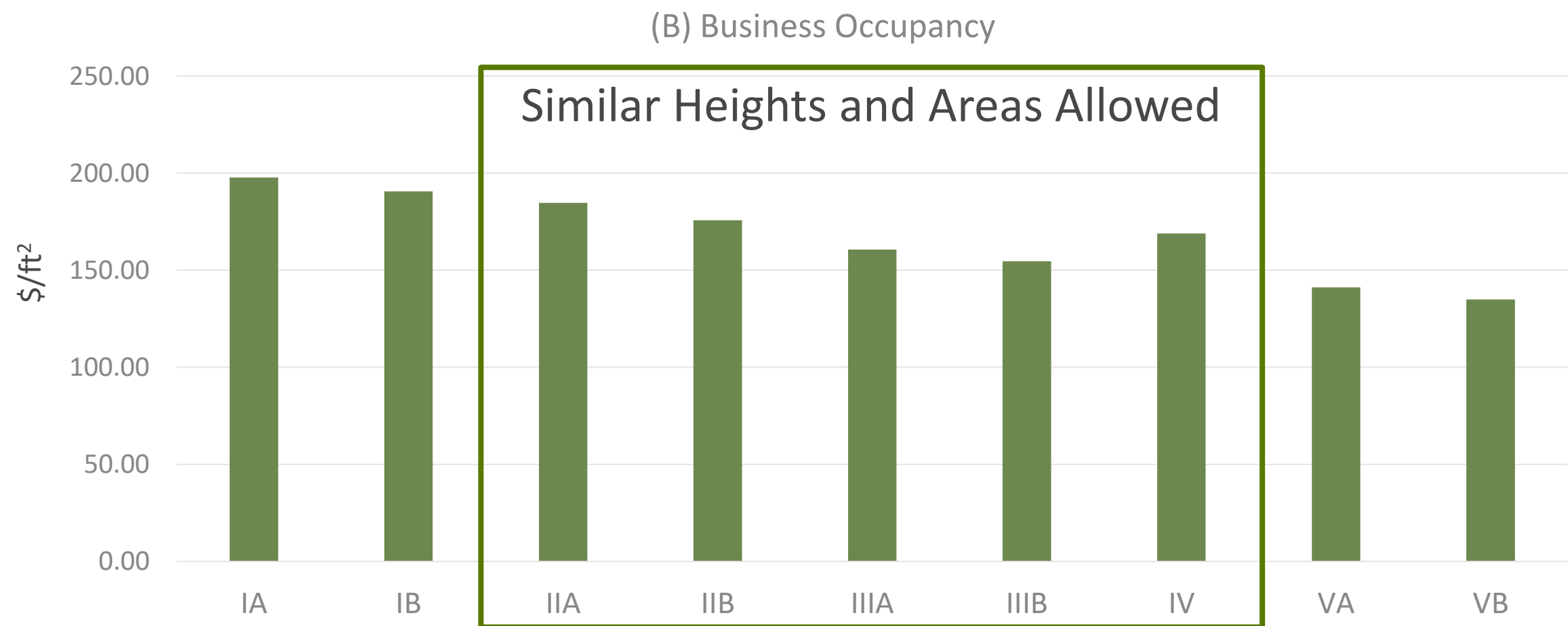
Increase
Environmental
Responsibility

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

Office Construction Costs – ICC Building Valuation



Office Construction Costs – ICC Building Valuation



Source: ICC Building Valuation Data, Feb 2019
<http://evstudio.com/construction-cost-per-square-foot-for-office-buildings/construction-cost-office-building-2-to-4-stories-2/>



Wood Mid-Rise Construction

How many stories can be wood framed in the IBC?

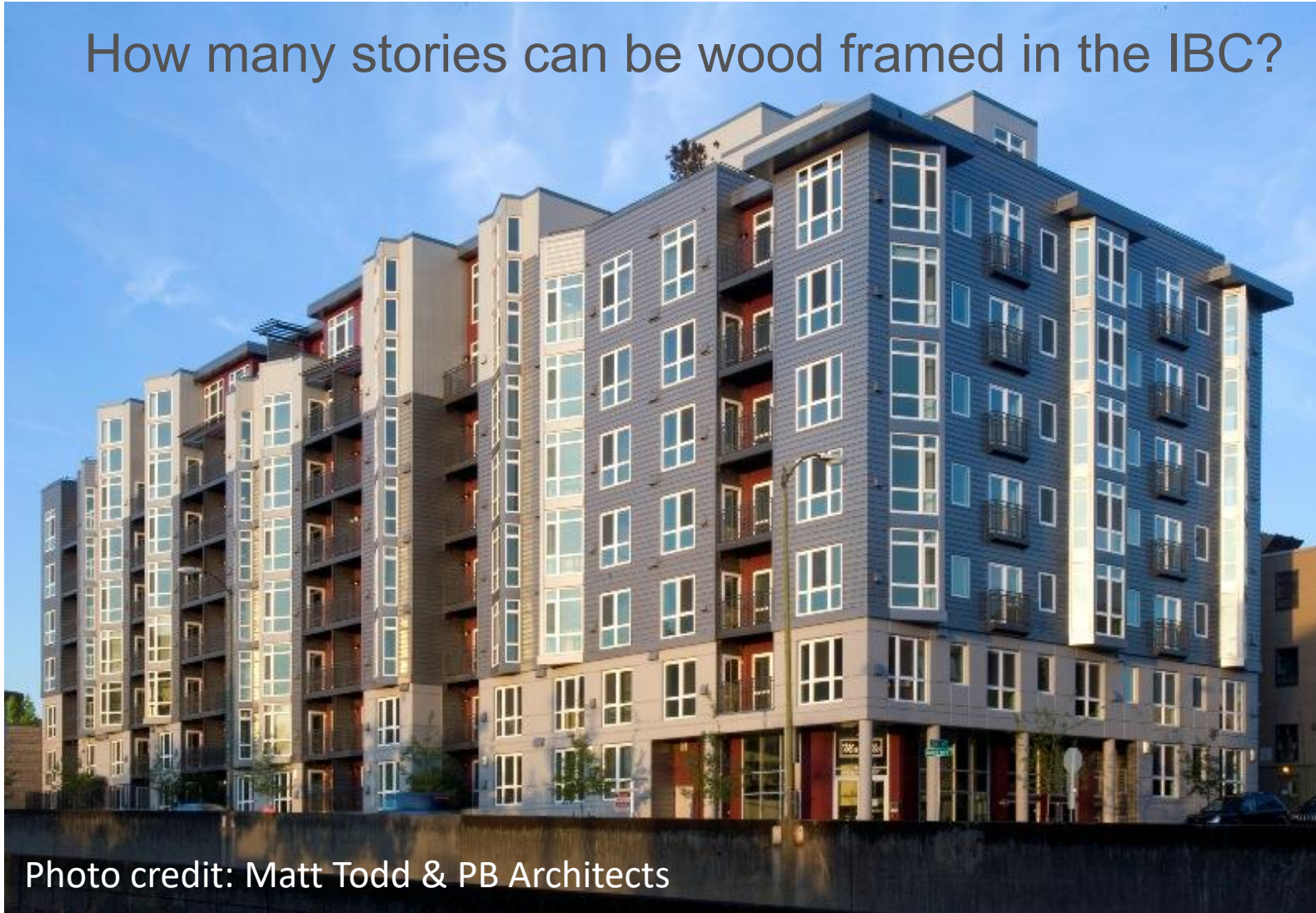


Photo credit: Matt Todd & PB Architects

6 stories for Offices, 5 stories for Residential



IBC Building Size Limits

Residential (R1, R2, and R4) Occupancies

Construction Type Allowable Limit	IIIA	IIIB	VA	VB
Stories	4	4	3	2
Height (ft)	65	55	50	40
Building Area/Story (ft ²)	24k	16k	12k	7k
Total Building Area* (ft ²)	72k	48k	36k	14k

* Assuming max stories built

IBC 2012 Table 503 Tabular Values



IBC Building Size Limits

Residential (R1, R2, and R4) Occupancies

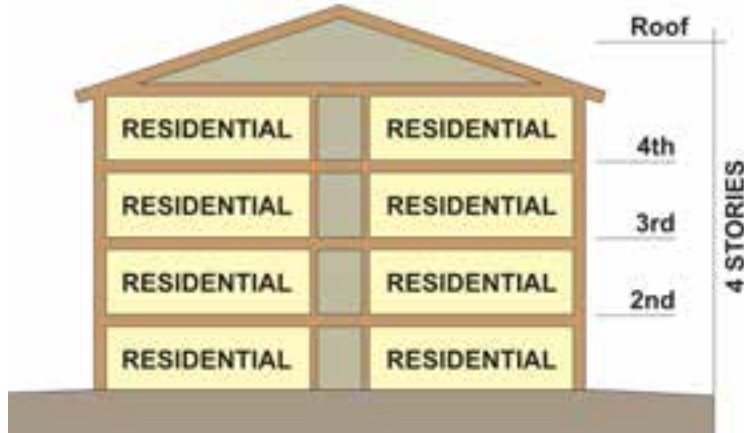
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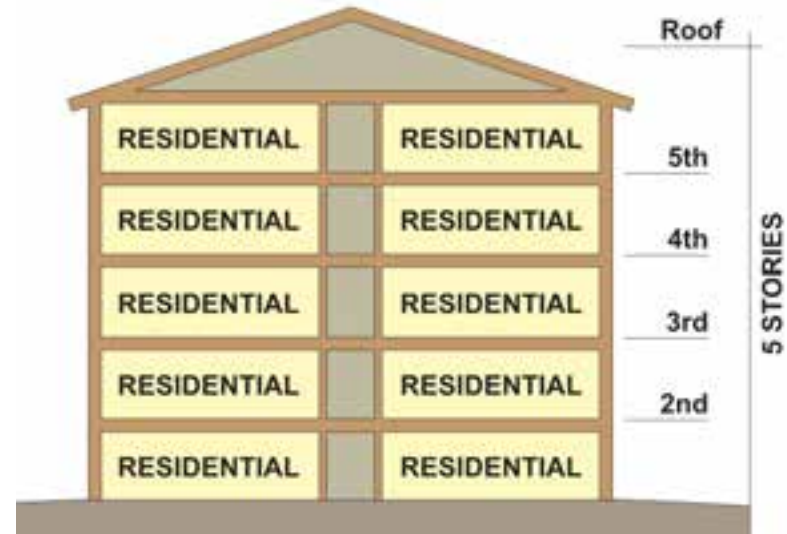
IBC 2012 Table 503 Tabular Values



IBC Building Size Limits



Tabular Limits



Increased Limits

**With NFPA Sprinklers IBC gives an allowable
Heights and Area Increase**



IBC Building Size Limits

Residential (R1, R2, and R4) Occupancies

Type IIIA Construction Allowable Limit	Table	NPFA 13	NPFA 13	Frontage Increase?
Stories	4	5	5	5
Height (ft)	65	85	85	85
Building Area/Story (ft ²)	24k	24k	72k	90k
Total Building Area* (ft ²)	72k	72k	216k	270k
IBC 2012 Section	503	504.2	506.3	506.2

* Assuming max stories built per IBC 506.4

? Maximum frontage increase possible

Type V Buildings

Multi-family



Restaurants



Retail



Office

V-B

Type V-B Height and Area Limits

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	2	60 ft	18,000 SF	36,000 SF
B	3	60 ft	27,000 SF	81,000 SF
M	2	60 ft	27,000 SF	54,000 SF
R-2	3	60 ft	21,000 SF	63,000 SF

Stories/Heights/Areas include allowable increases for sprinklers, but exclude potential frontage increase

1-story retail and restaurants

2 to 3-story residential/office

No fire resistance ratings required



V-A

Type V-A Height and Area Limits

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	3	70 ft	34,500 SF	103,500 SF
B	4	70 ft	54,000 SF	162,000 SF
M	4	70 ft	42,000 SF	126,000 SF
R-2	4	70 ft	36,000 SF	108,000 SF

Stories/Heights/Areas include allowable increases for sprinklers, but exclude potential frontage increase

3 to 4-story residential/office

1-hour fire resistance rating required for most building elements





Walk-up/ Tuck Under

3-story Row-Houses (Type V)
yield 20-30 units/acre



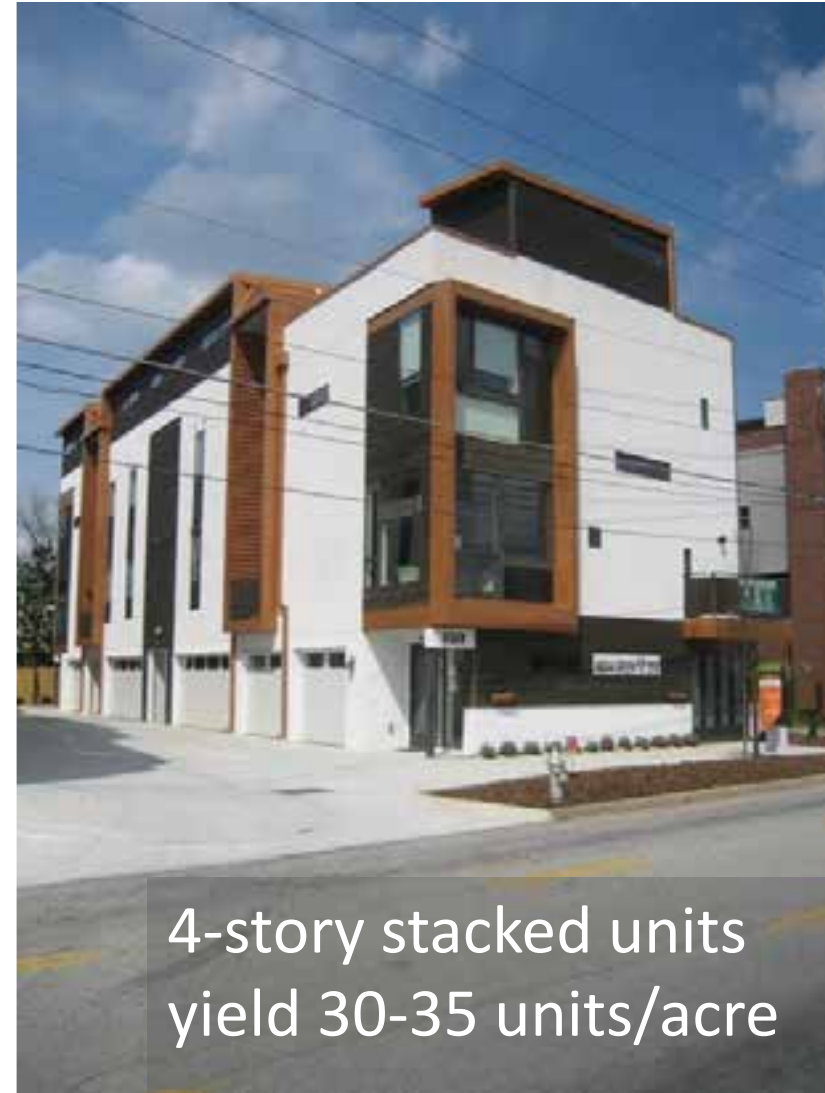
- No parking garage
- No major excavation
- All wood construction



Photos – Scott Breneman/WoodWorks



Walk-up/ Tuck Under



Type III Buildings

Multi-family



K-12/Higher Ed



Hospitality



Office

III-B

Type III-B Height and Area Limits

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	3	75 ft	28,500 SF	85,500 SF
B	4	75 ft	57,000 SF	171,000 SF
M	3	75 ft	37,500 SF	112,500 SF
R-2	5	75 ft	48,000 SF	144,000 SF

Stories/Heights/Areas include allowable increases for sprinklers, but exclude potential frontage increase

4-story office / 5-story residential

2-hour fire resistance rating required for exterior bearing walls only (non combustible or FRT construction)

III-A

Type III-A Height and Area Limits

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	4	85 ft	42,000 SF	126,000 SF
B	6	85 ft	85,500 SF	256,500 SF
M	5	85 ft	55,500 SF	166,500 SF
R-2	5	85 ft	72,000 SF	216,000 SF

Stories/Heights/Areas include allowable increases for sprinklers, but exclude potential frontage increase

5-story residential / 6-story office

2-hour rating for exterior bearing walls

1-hour rating for other building elements





Wrap-Around

5 story yields 60-80
units/acre



- No excavation
- Parking hidden
- Density still not maximized

Type IV Buildings

Residential / Mixed-Use



Higher Education



Office



IV

Type IV Height and Area Limits

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	4	85 ft	45,000 SF	135,000 SF
B	6	85 ft	108,000 SF	324,000 SF
M	5	85 ft	61,500 SF	184,500 SF
R-2	5	85 ft	61,500 SF	184,500 SF

Stories/Heights/Areas include allowable increases for sprinklers, but exclude potential frontage increase

5-story residential / 6-story office

2-hour rating for exterior bearing walls

Interior elements must qualify as Heavy Timber



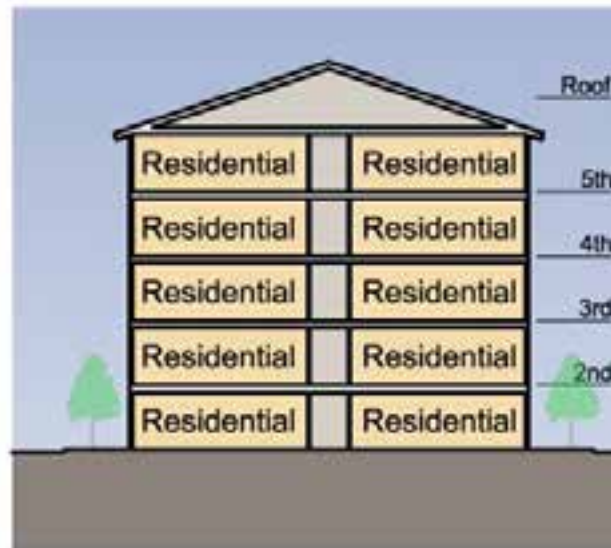


Podium

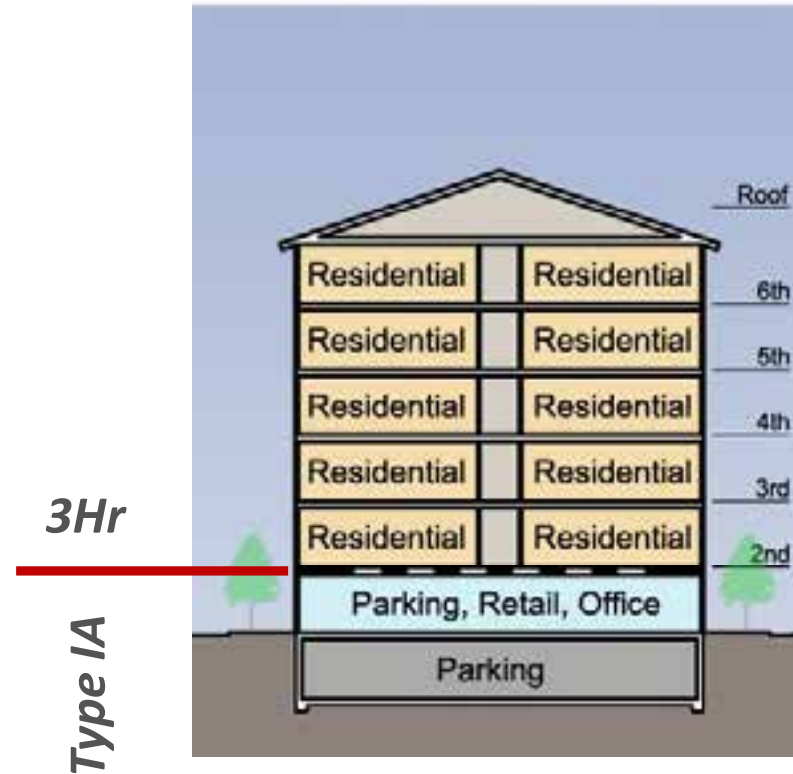




IBC Podium Provisions



5 story Type III Building

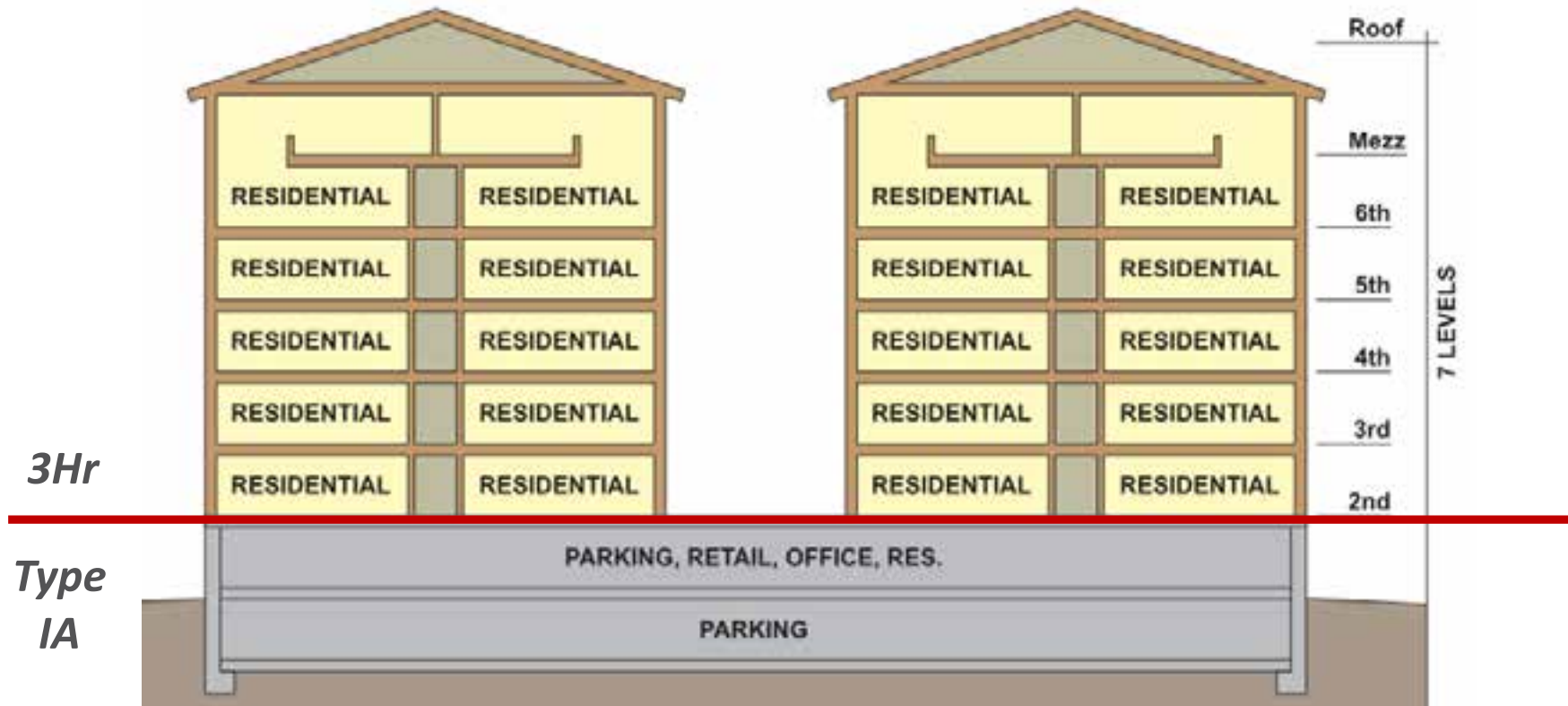


5 story Type III Building
On Top of a Type IA Podium

*See Special Provisions for Podiums in IBC 2012 510.2
Increases allowable stories... not allowable building height*



IBC Podium Provisions



Multiple Buildings over one Podium

See Special Provisions for Podiums in IBC 2012 510.2

Podium Limits



IBC	# of Podium Levels	Podium Occupancy
2009	1	S-2 Parking
2012	1	A, B, M, R or S-2 Parking
2015	Multi-story	Any except H
2018	Multi-story	Any except H

3-hour building separation

Pushing light-framed wood to the limits of code allowed heights



4 over 1 Podium

- 60-80 units/acre
- Max for Type V



Inman Park Condos, Atlanta, GA
Architect: Brown Doane Architects, Inc.
Structural: Davis & Church, LLC



5 over 1 Podium

- 100-120 units/acre

Inman Park Condos, Atlanta, GA
Architect: Brown Doane Architects, Inc.
Structural: Davis & Church, LLC



AvalonBay Stadium, Anaheim, CA
Architect: Withee Malcom Architects
Structural: VanDorpe Chou Associates



5 over 1 Podium with Mezzanine

- 125-145 units/acre
- Residential units below podium

120 Union, San Diego, CA
Togawa Smith Martin





Spartan Village, UNC Greensboro, NC



Lord, Aeck & Sargent Architecture
TFF Architects & Planners

“We assumed that wood framing would be a little less expensive, but actually found it gave us significant cost advantages. We saved \$15 per square foot—which, for a 385,000-square-foot project, is a lot of savings”

Raymond Hunt

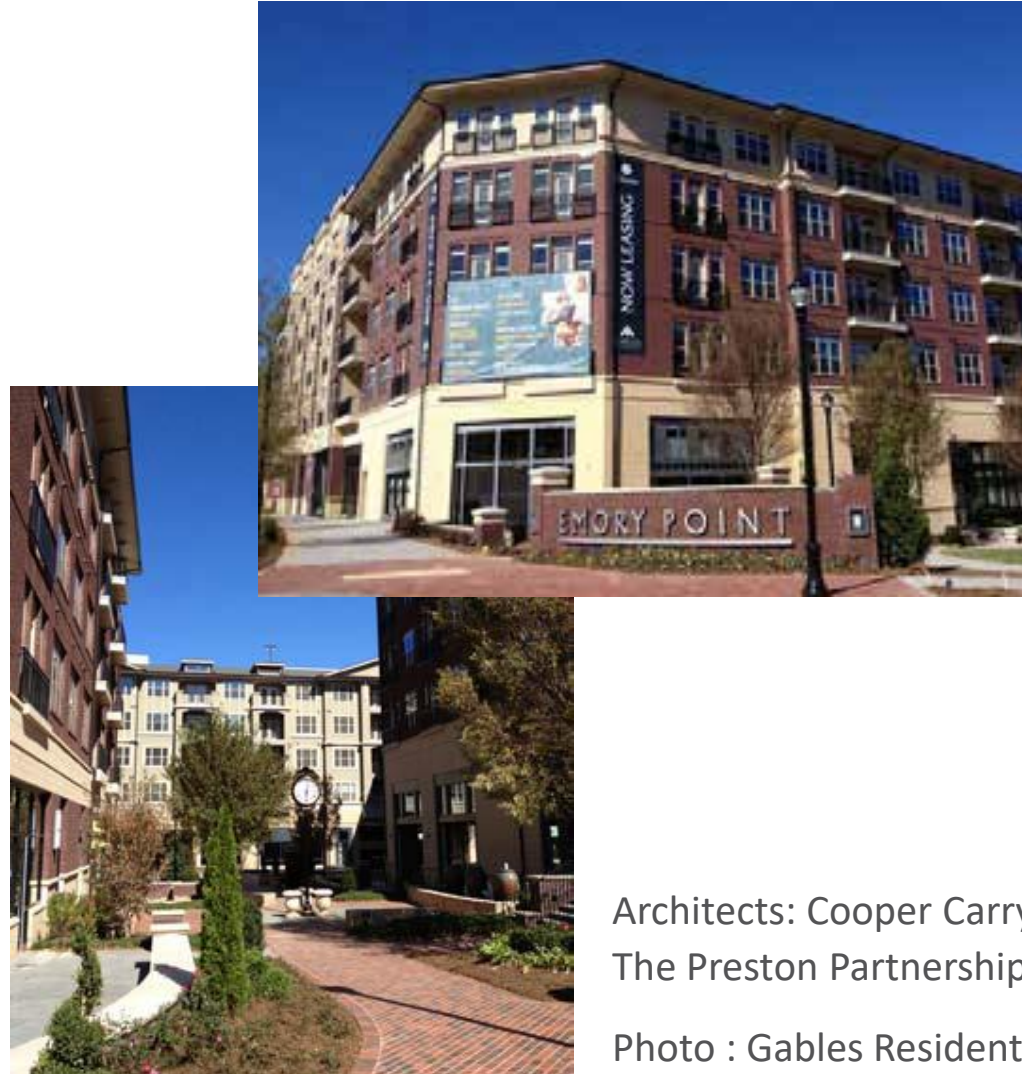
– EDC Development Management



> Emory Point, Dekalb Co., GA

3 buildings

- Luxury Apartments, retail, restaurants
- (2) 4 stories of wood over 1 story concrete podium
- (1) 5 story Type III wood frame over slab on grade



Architects: Cooper Carry &
The Preston Partnership

Photo : Gables Residential

> Emory Point, Dekalb Co., GA



Architects: Cooper Carry & The Preston Partnership

Photo: Aerial Photography Inc.



Galt Place Apartments, Galt, CA



Mixed Use Residential
Over Retail and Parking

Applied Architecture, Inc.
Michael Malinowski



Crescent Terminus, Buckhead, Atlanta





Crescent Terminus, Buckhead, Atlanta





Crescent Terminus, Buckhead, Atlanta



Architect: Lord Aeck Sargent
Structural: SCA Consulting Engineers
Photos: Richard Lubrant



Crescent Terminus, Buckhead, Atlanta



Architect: Lord Aeck Sargent
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Architect: Lord Aeck Sargent
Structural: SCA Consulting Engineers
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Marselle Condos, Seattle, WA

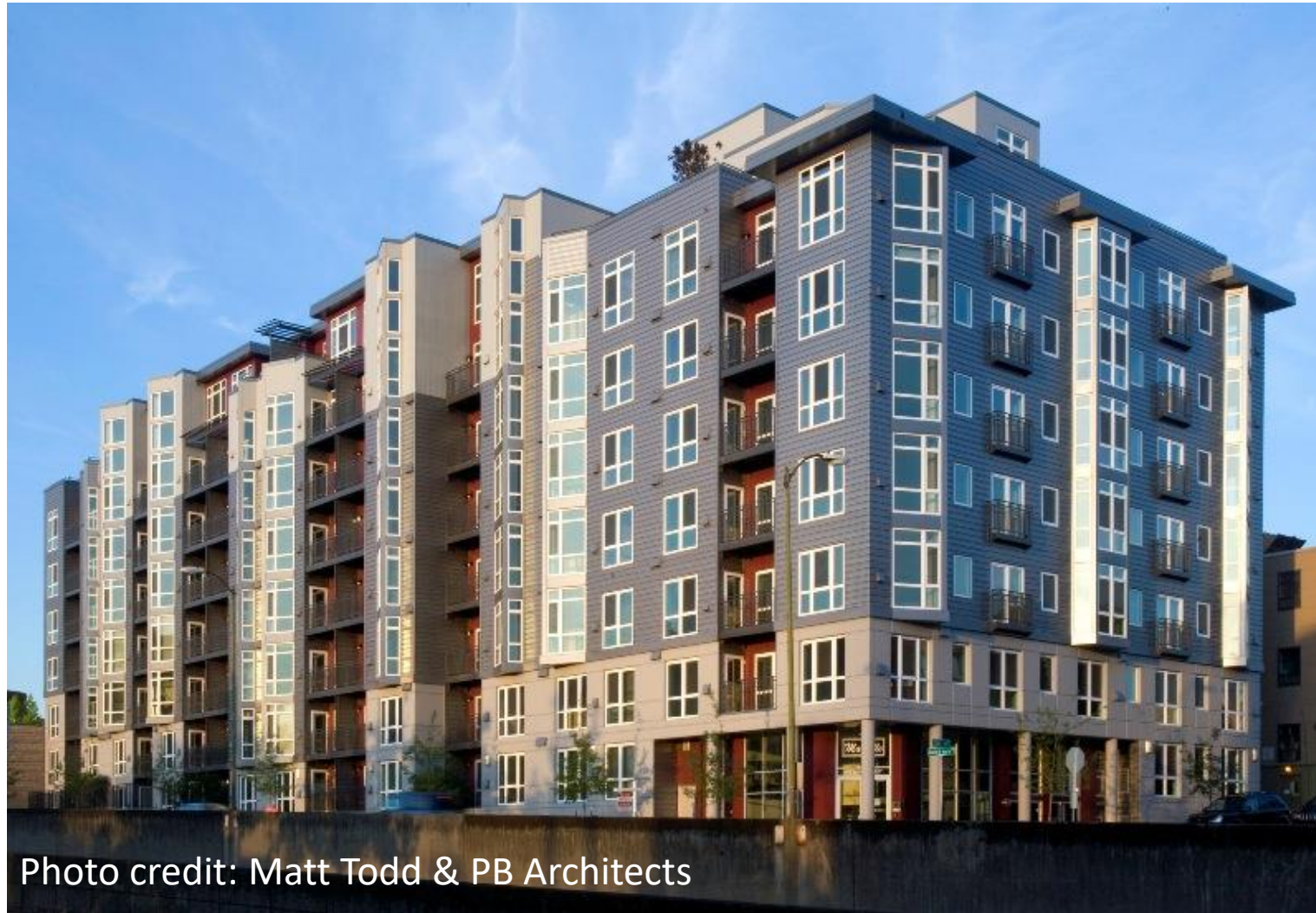


Photo credit: Matt Todd & PB Architects



Marselle Condos, Seattle, WA





Bullitt Center, Seattle, WA



Photos © Nick Lehoux for the Bullitt Center



Bullitt Center, Seattle, WA



250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

Renderings: Miller Hull Partnership

Architect: Miller Hull Partnership
Living Building Challenge Building
Completed 2013



Tall Wood Overview

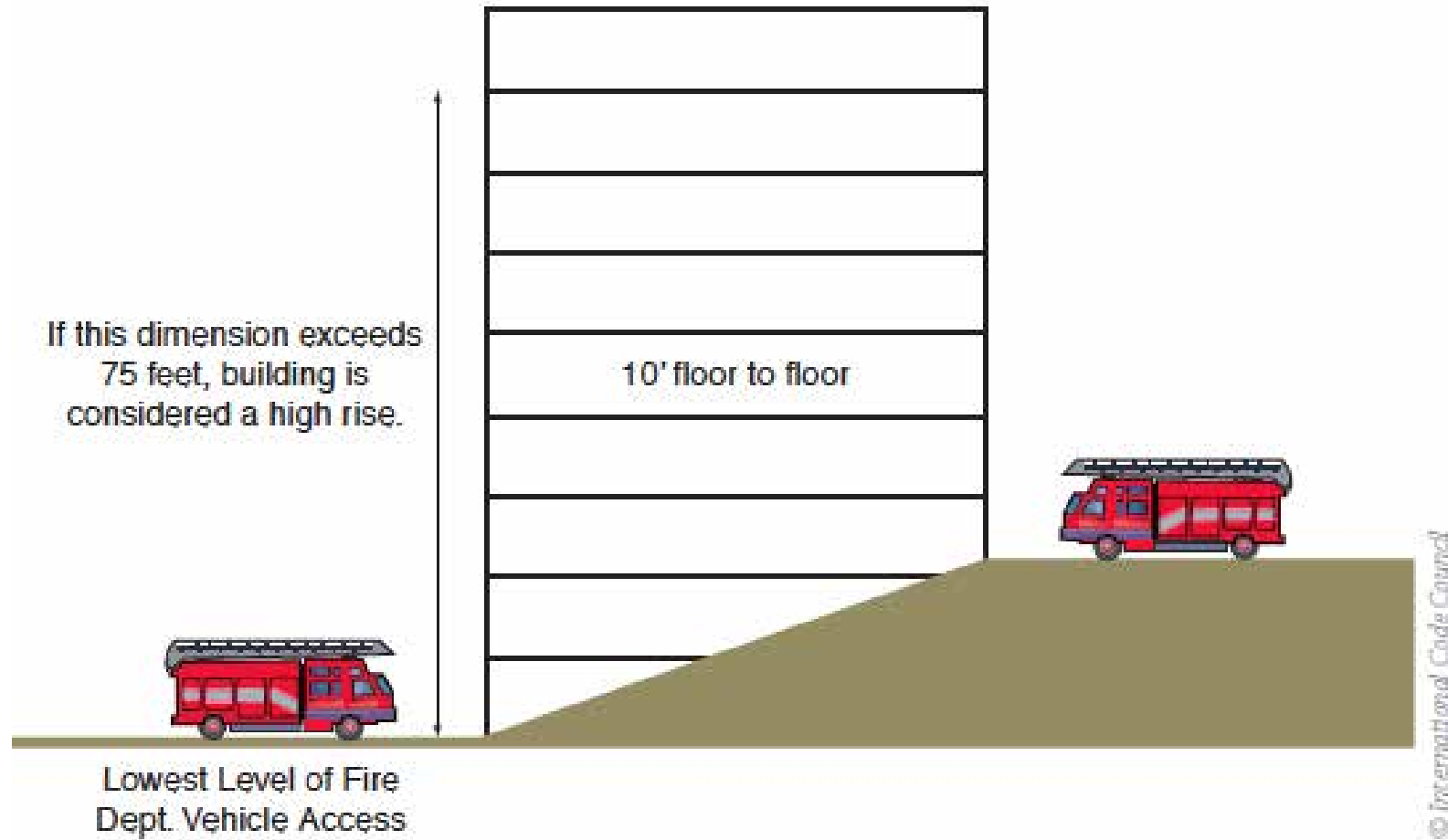
Defining Tall Wood

Precedence/Context

Motivation and Benefit

Execution Under U.S. Code

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



Determination of high-rise building



Butler Brothers Building, Minneapolis MN



Built 1906 - 9 stories - 500,000 s.f.



Butler Square today...



*Renovated 1974
9 Stories, 500,000 sf*

Momentum Starts With a Disruption



Mass Timber Building Systems



Post and Beam



Light Frame



Mass Timber

Mass Timber Products

Nail-Laminated Timber
(NLT)



Cross-Laminated Timber
(CLT)



Glue-Laminated Timber (GLT)



Dowel-Laminated
Timber (CLT)



DLT

Image source: StructureCraft

T3 Minneapolis

Minneapolis, MN



Image Credit: Michael Green Architects/Hines Group

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



T3 Minneapolis

Minneapolis, MN



Image Credit: Ema Peter

Overview

Defining Tall Wood

Precedence/Context

Motivation and Benefit

Execution Under U.S. Code

Disruption Causes a Ripple



Tall Wood Projects



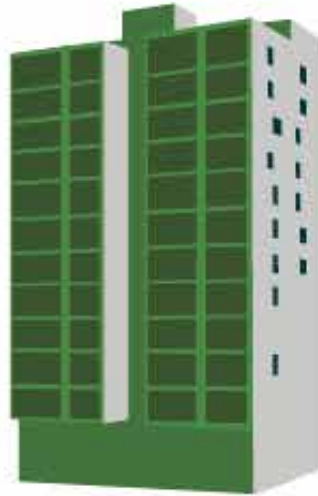
Murray Grove

London, United Kingdom
8 Stories
2009



Forté

Melbourne, Australia
10 Stories
2012



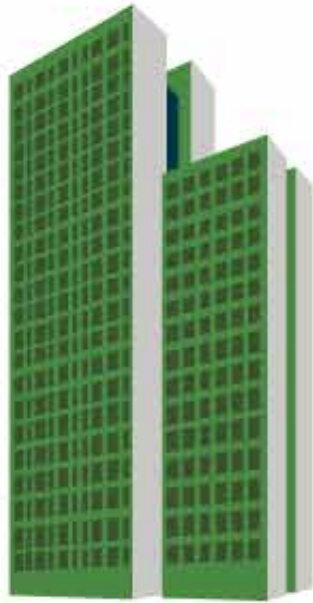
TREET

Bergen, Norway
14 Stories
2015



Brock Commons

Vancouver, Canada
18 Stories
2017



HoHo

Vienna, Austria
24 Stories
2017



2009
MURRAY GROVE
STADTHAUS
LONDON, UK
9 STORIES

Architect: Waugh Thistleton Architects
Photo Credit:



DESIGN BUILDER: Lend Lease
Photo Credit: Lend Lease



2013
FORTE'
MELBOURNE, AUSTRALIA
10 STORIES



ARCHITECT: Artec
ENGINEER: Sweco



2015
TREET APARTMENTS,
BERGEN, NORWAY
14 STORIES
173 FT
~63K SQ.FT.

Source: Toward Taller Wood Buildings Symposium 2014

Brock Commons

Vancouver, BC

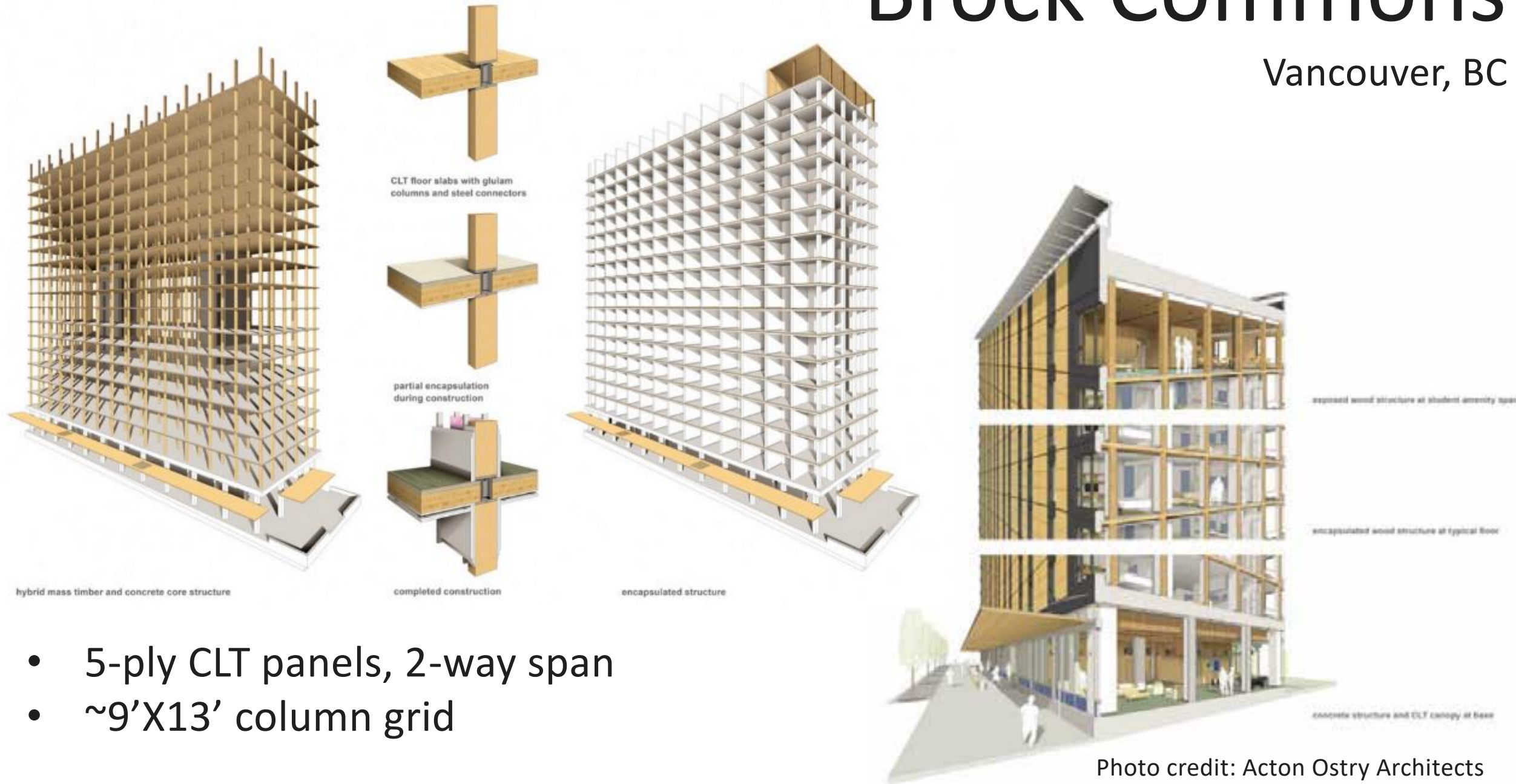


- Completed Fall 2017
- 18 Stories
- 174 FT
- 156,000 SQ.FT.

Photo credit: Acton Ostry Architects

Brock Commons

Vancouver, BC



Brock Commons

Vancouver, BC



Brock Commons

Vancouver, BC

- 17 stories of timber installation
- Started
 - June 6, 2016
- Finished
 - August 10, 2016



Brock Commons



Overview

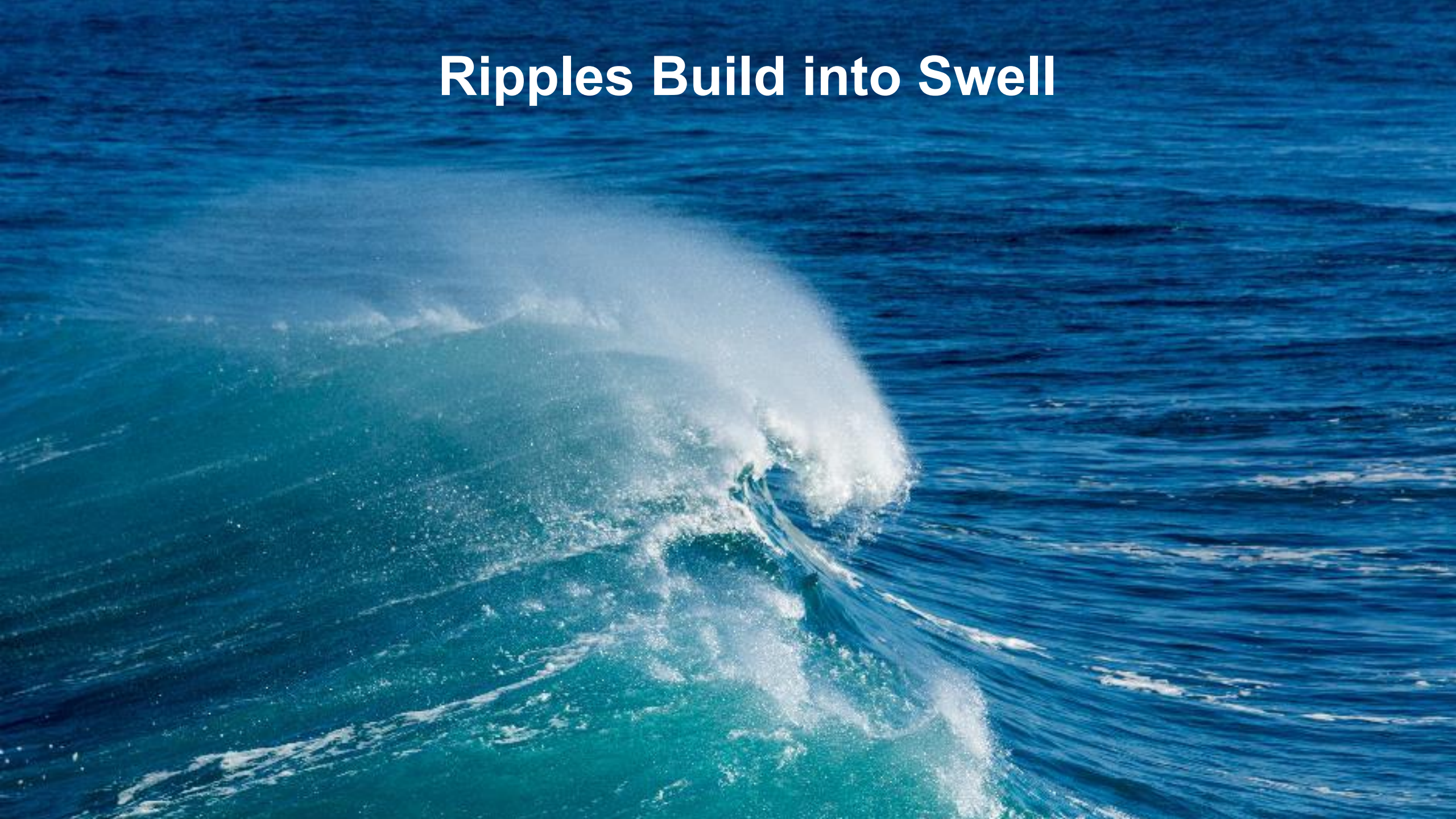
Defining Tall Wood

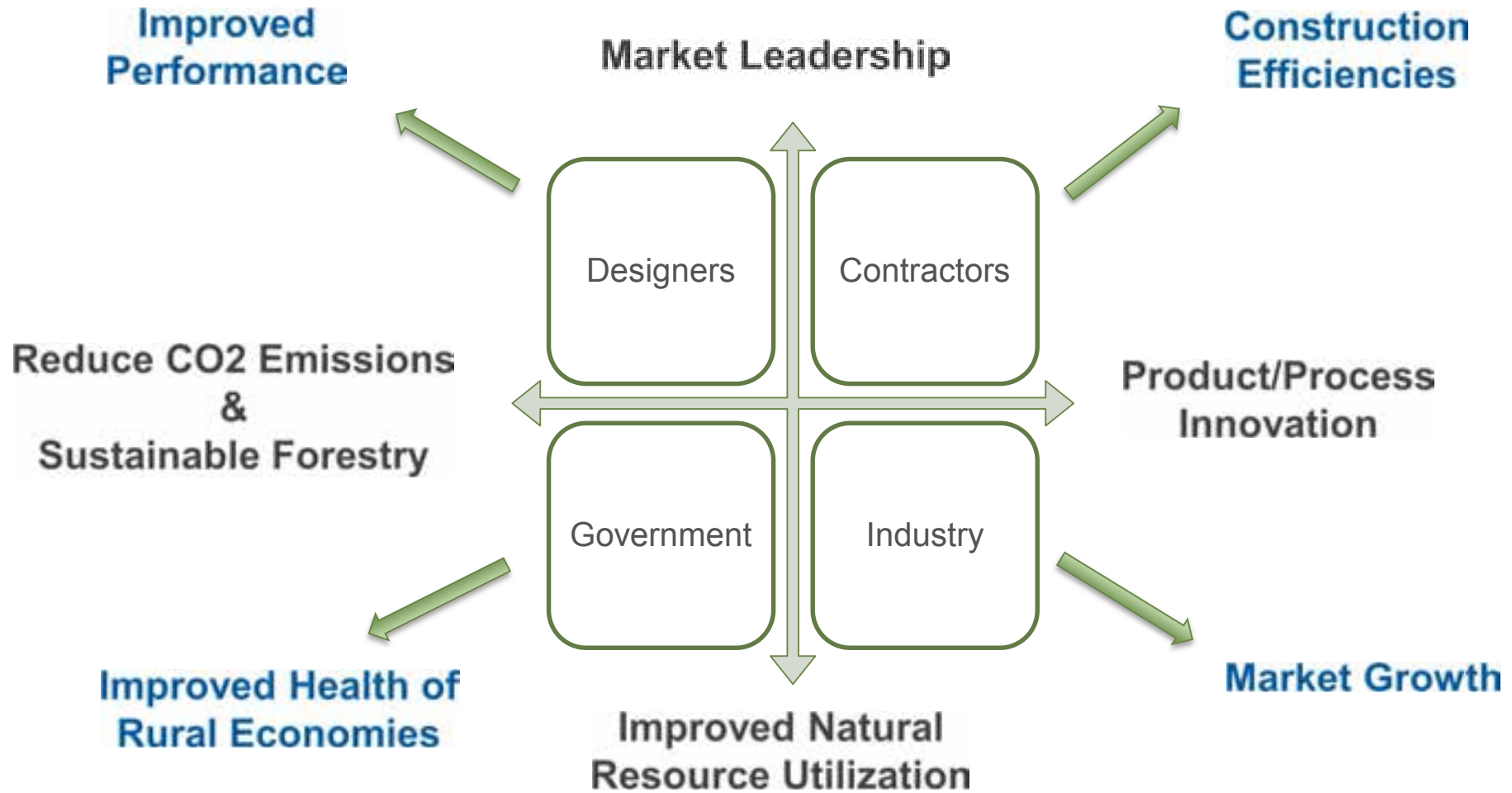
Precedence/Context

Motivation and Benefit

Execution Under U.S. Code

Ripples Build into Swell

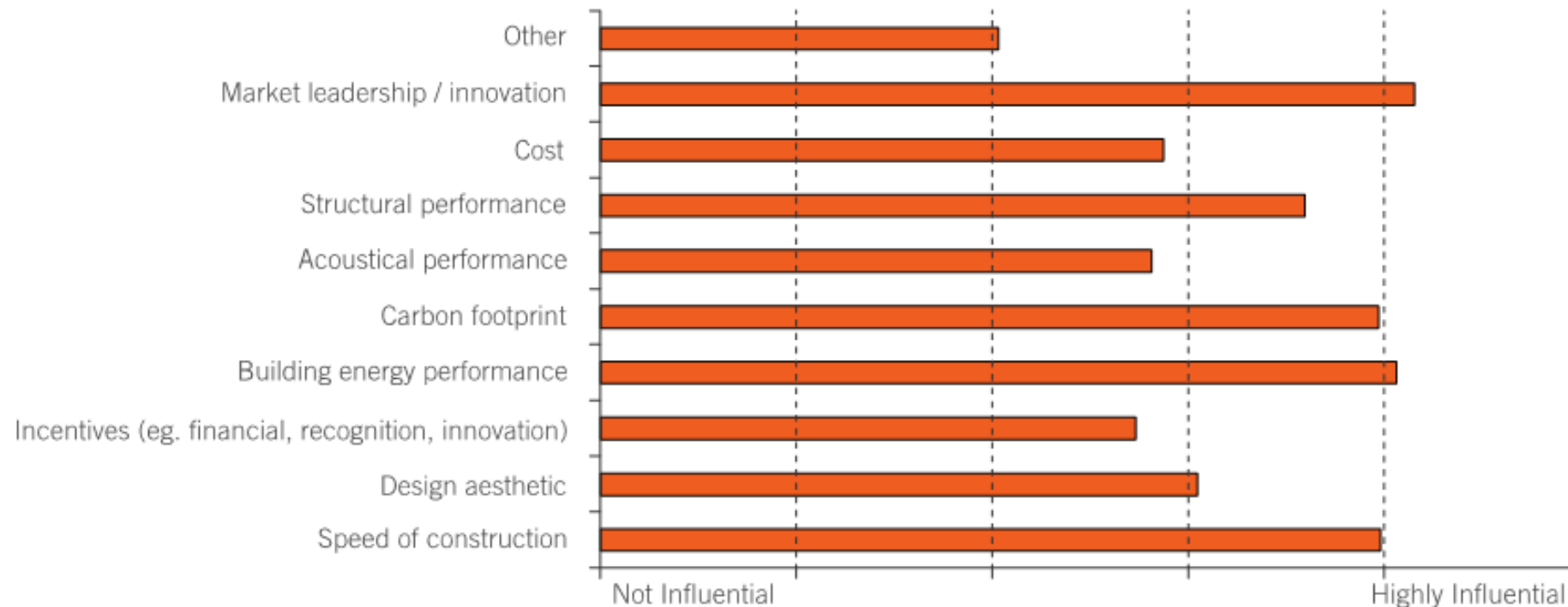




Tall Wood Motivators – Design Team

Design Team: Online Questionnaire Participant Responses

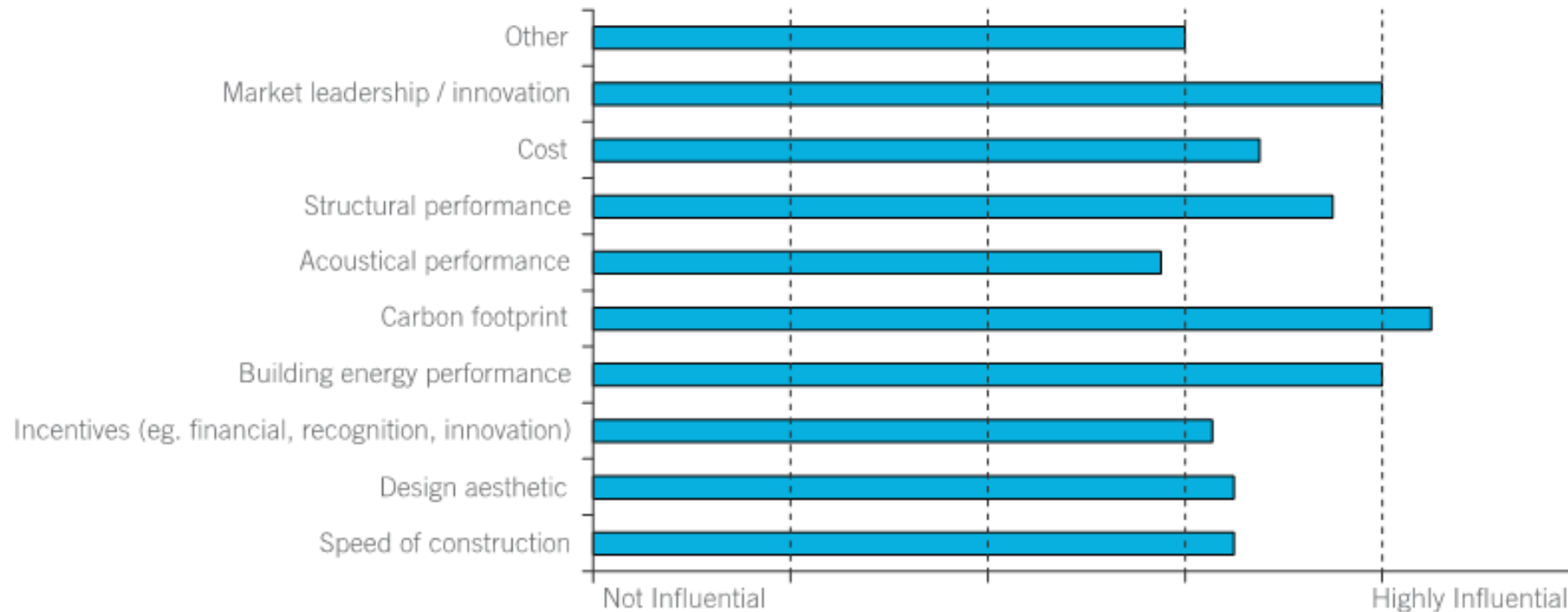
Influential Factors on the Design Team's Decision to Use Structural Wood Technology:



Tall Wood Motivators – Owner/Developer

Owner/Developer: Online Questionnaire Participant Responses

Influential Factors on the Owner / Developer's Decision to Use Structural Wood Technology:



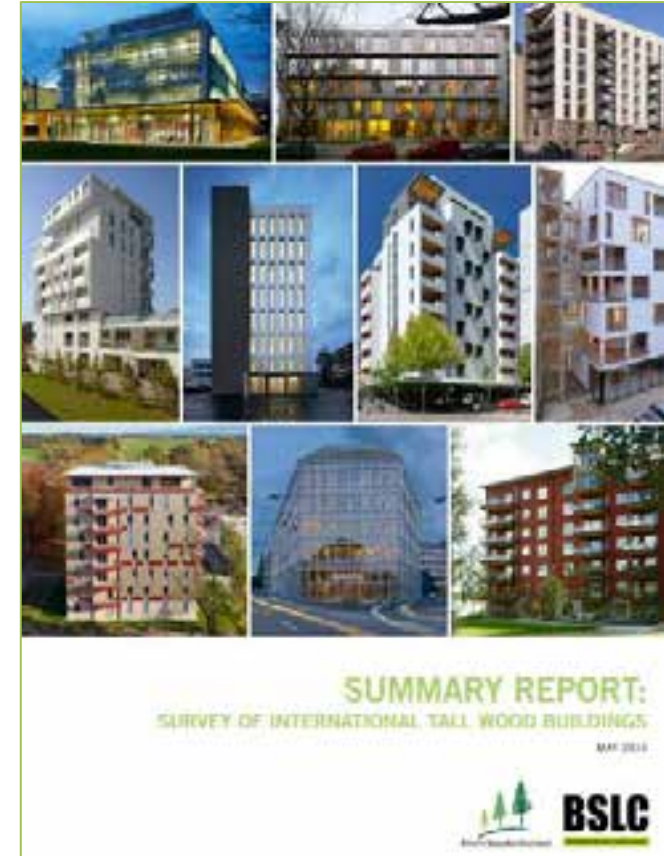
Tall Wood Motivators

Primary Motivators

- Market Leadership
- Aesthetic
- Carbon Reduction
- Schedule

Secondary Motivators

- Structural Performance
 - Light weight
- Speed of Construction



Aesthetics

ARCHITECT: Michael Green Architecture
ENGINEER: Equilibrium Engineering
PHOTO CREDIT:



ESTIMATED ENVIRONMENTAL IMPACT OF WOOD USE



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



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



Carbon stored in the wood:
1,753 metric tons of CO₂



Avoided greenhouse gas emissions:
679 metric tons of CO₂



Total potential carbon benefit:
2,432 metric tons of CO₂

THE ABOVE GHG EMISSIONS ARE EQUIVALENT



511 cars off the road for a year



Energy to operate a home for 222 years

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

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

Source: Naturally:wood⁹

Carbon Reductions

Brock Commons, Vancouver, BC



Photo credit: Acton Ostry Architects

Mass Timber Appeal

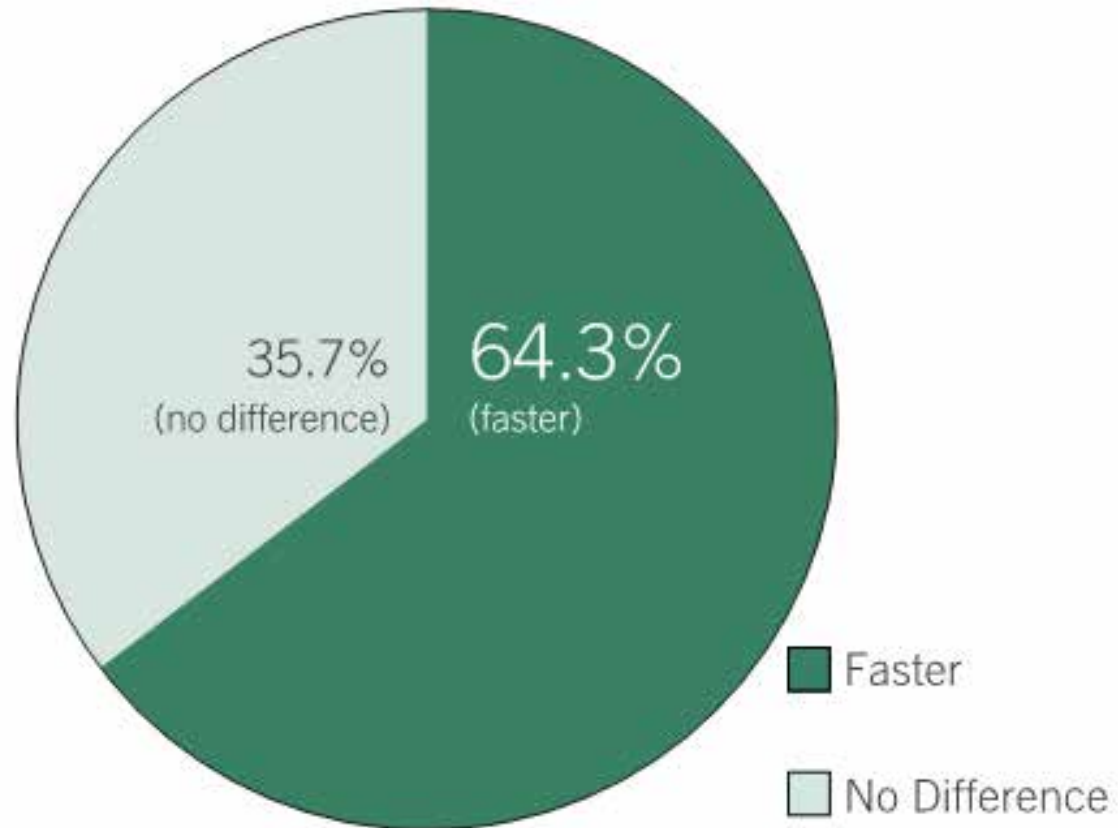
Forte time lapse video

Reduced Construction Time



Speed of Construction

How did using structural wood impact the construction schedule compared to a conventional project?



Source: Survey of International Tall Wood Buildings, 2014

Speed of Construciton - Time is Money

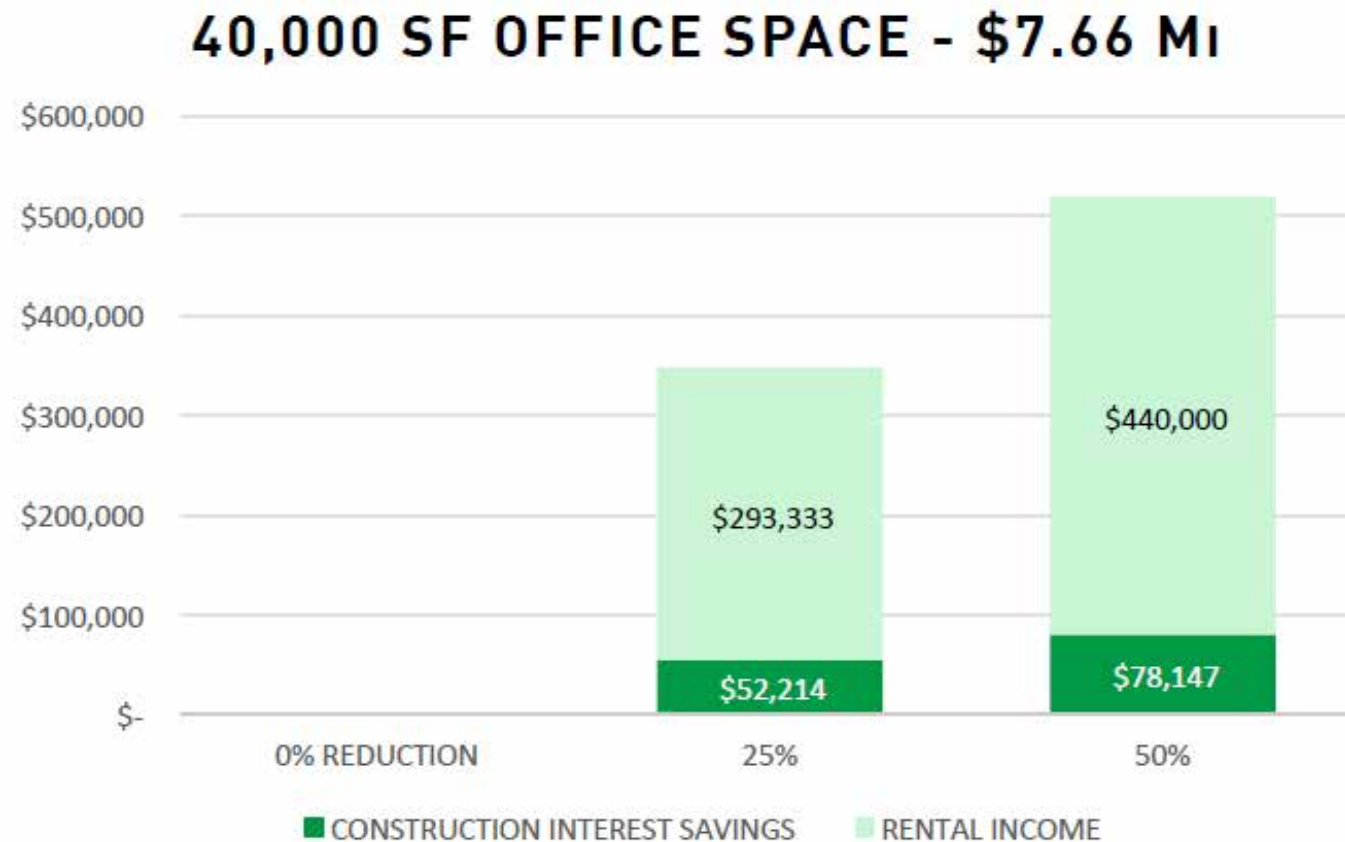


Figure 26

Pro-Formas include a cost reduction in terms of a 25% and 50% faster build time. The lease rate information assumes a 100% building occupancy to reflect the possible savings.

Mass Timber Appeal

Material Mass

75% lighter weight than
concrete



Mass Timber Appeal

Material Mass



Forte', Victoria Harbor, Melbourne, Australia
Architect: Lend Lease

Completed in 2012

10 stories

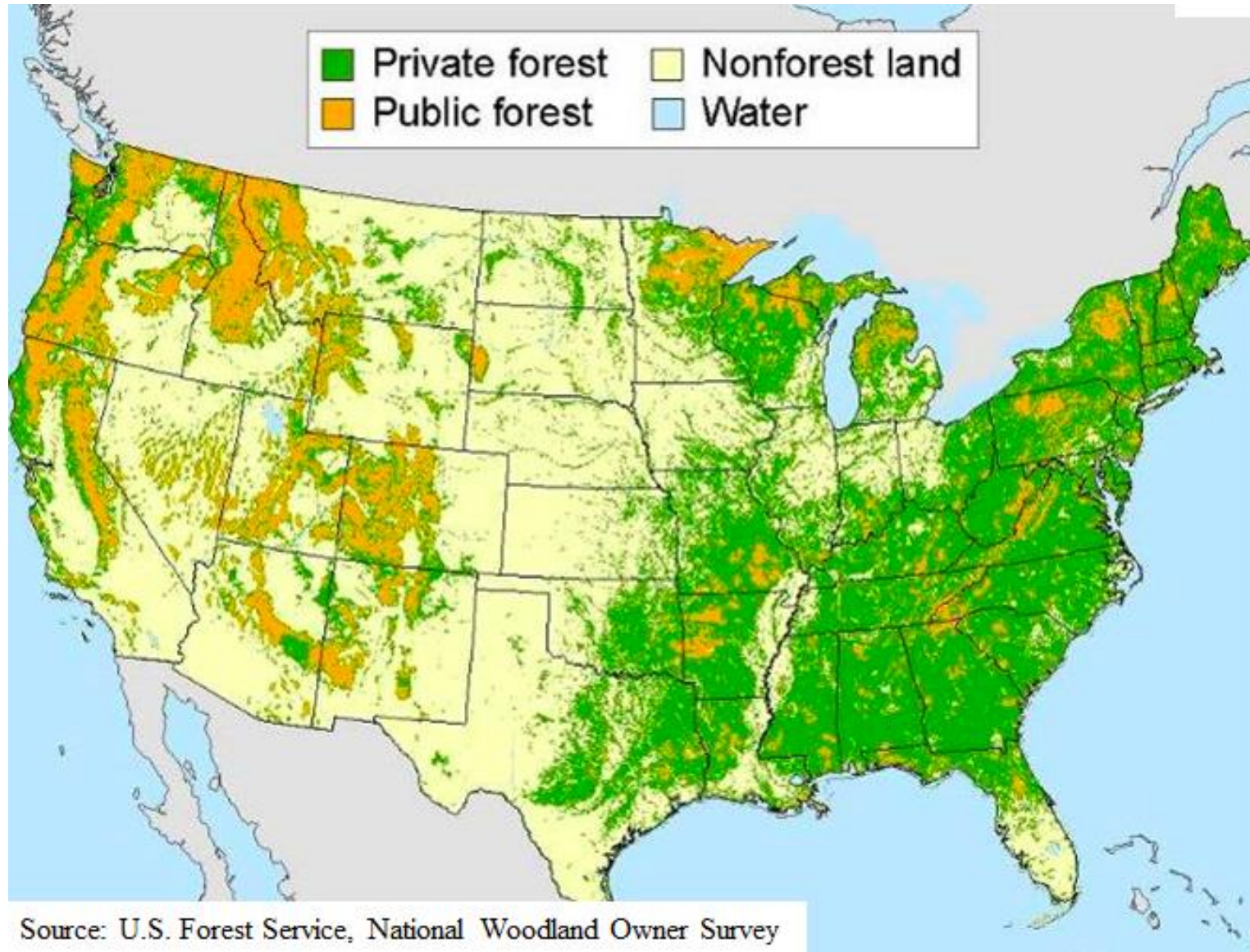
~ 105 ft. tall, > 18.6 K sqft.

3 million in R&D

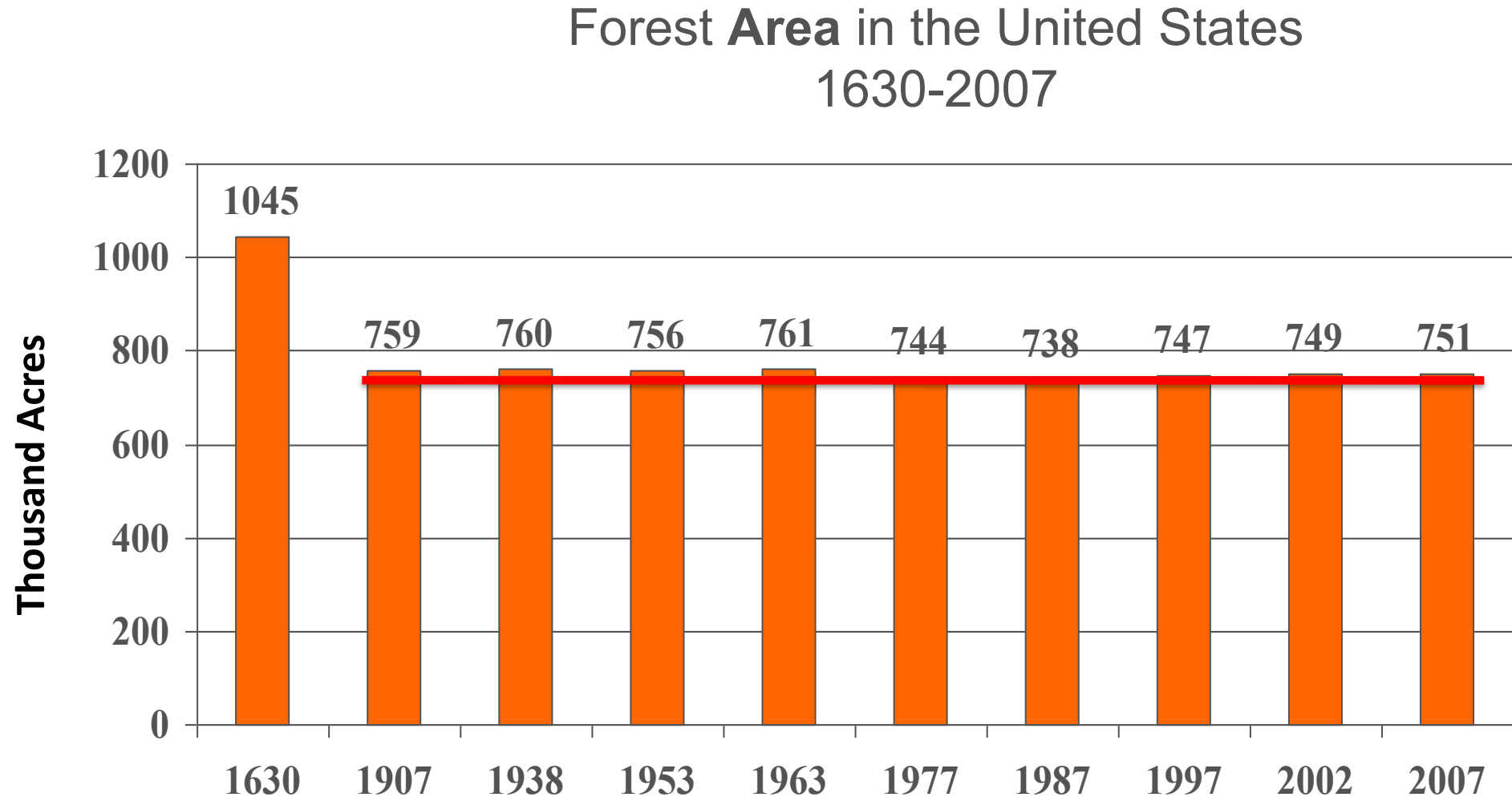
Poor soils required a much lighter building



US Forest Lands

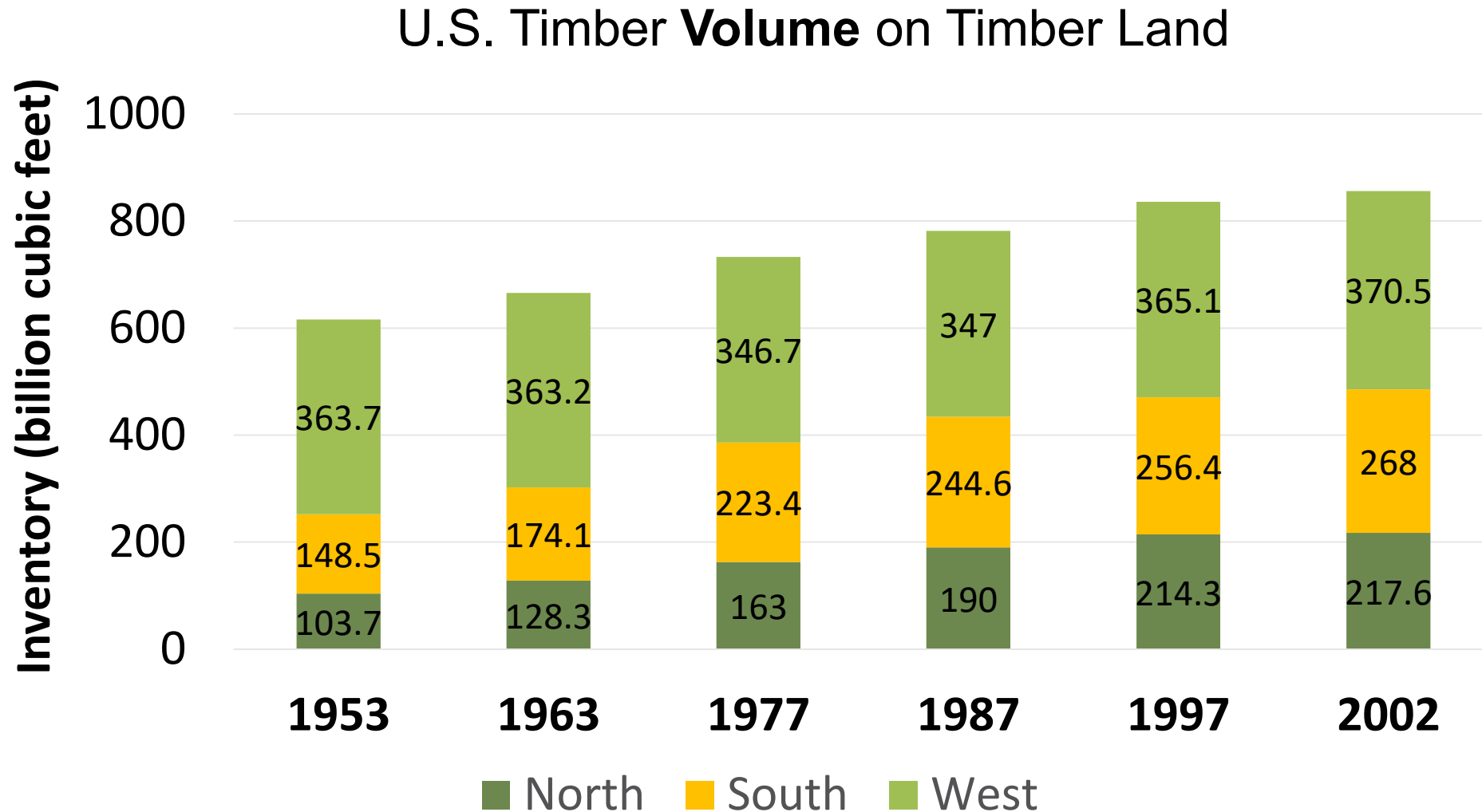


U.S. Forest Land



Source: USDA-Forest Service, General Technical Report WO-78. (2009).

U.S. Forest Land



Source: USDA-Forest Service, *US Forest Resource Facts and Historical Trends FS-801*. (2004).

Western U.S. Wild Fire Epidemic

- Fire readiness and suppression has gone from 20% of the FS budget in 2001 to 52% in 2015.
- It is not uncommon to spend \$1 million per hour fighting fires.



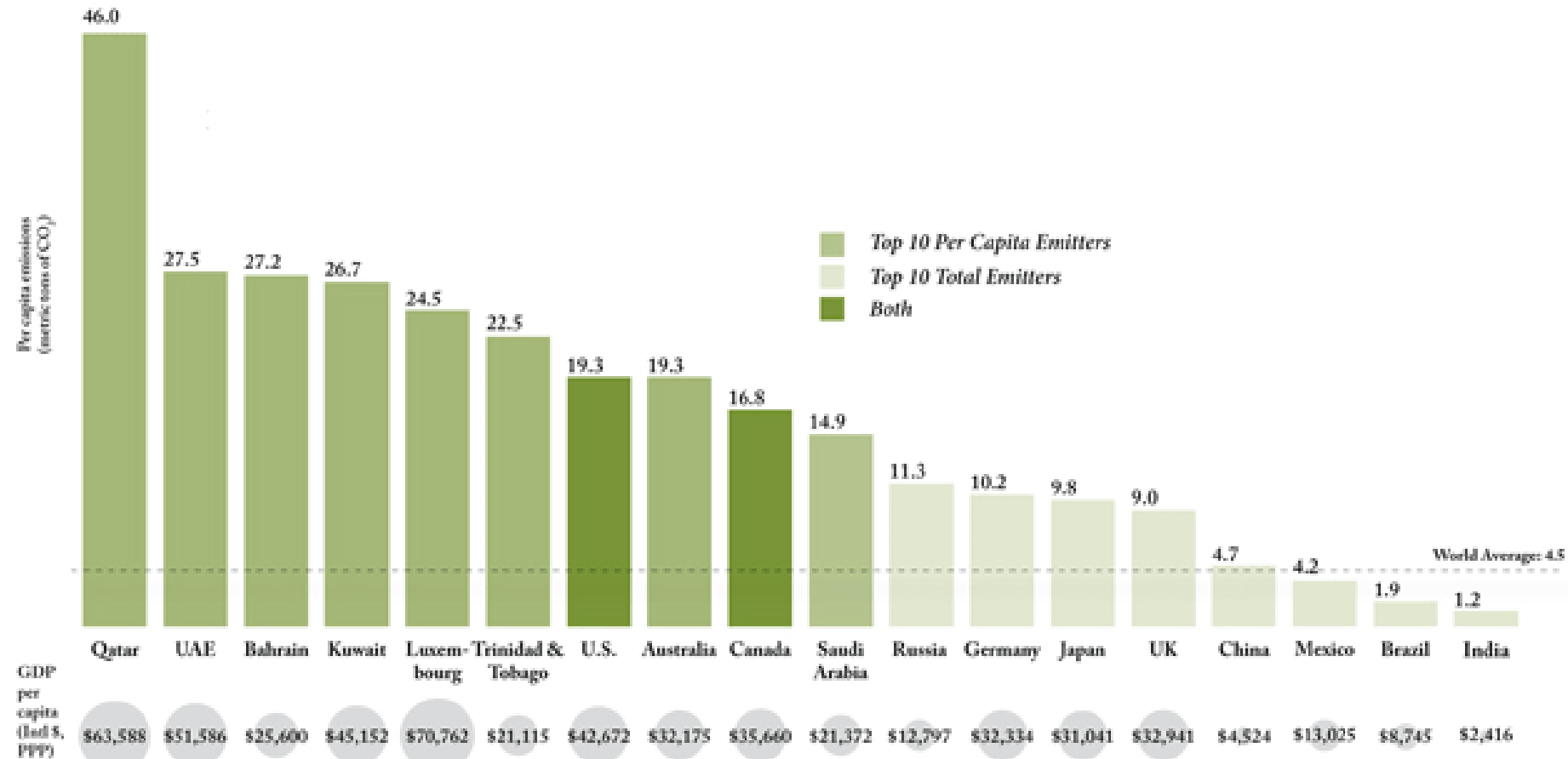
Source: US Forest Service –
<http://www.fs.fed.us/about-agency/budget-performance/cost-fire-operations>

Inter-Mountain West Insect Devastation



U.S Contribution to World Emissions

Per Capita CO₂ Emissions and Per Capita GDP for the Top Ten Total Emitters and Top Ten Per Capita Emitters, 2006



Data Source & Notes: WRI, CAIT (2009). Qatar GDP per capita estimate is for 2005; all other data presented are for 2006.

Rural Economy Benefits



Overview

Defining Tall Wood

Precedence/Context

Motivation and Benefit

Execution Under U.S. Code

- Acoustics
- Structure
- Fire

Mass Timber Products

IBC

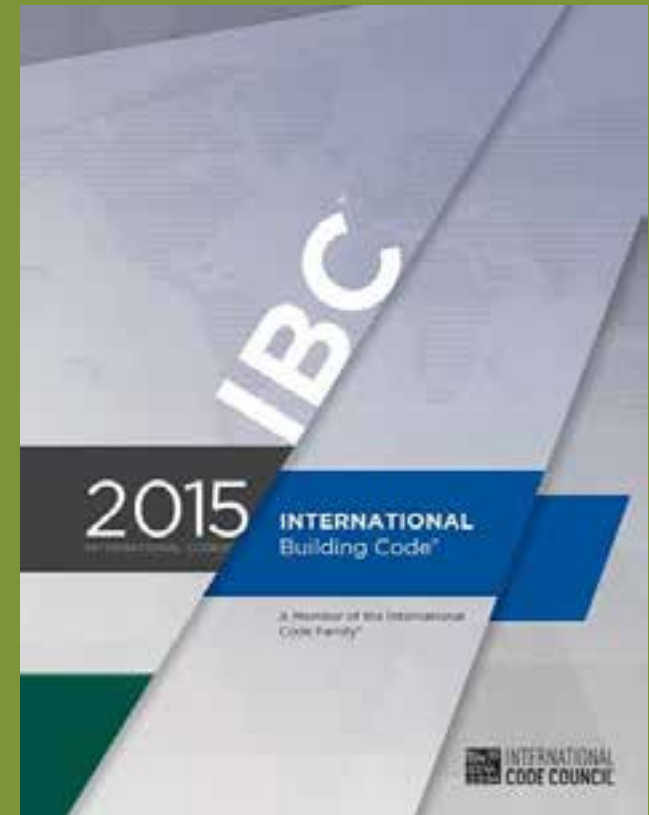
NLT / DLT*

- Recognized in IBC 2304.8.3 (mechanically laminated decking)

CLT / MPP

- In 2015 IBC, CLT is now defined in Chapter 2 Definitions
- And is referenced in Chapter 23:

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



Acoustics

Common floor assembly:

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



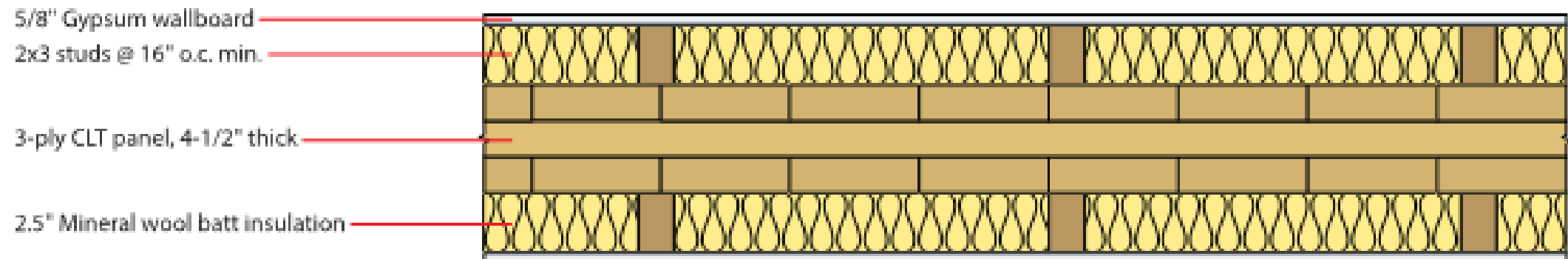
Acoustics

FIGURE 3:

Interior CLT partition wall with chase walls on both sides

Example Mass Timber Wall Assembly, STC 58

Plan View



Source: US CLT Handbook

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

Richard McLain, PE, SE • Senior Technical Director • WoodWorks



T3 Minneapolis
Architect: MGA | Michael Green Architects, BLA Group
Structural Engineer: Magnusson Karmann Associates
Design Assist + Build: StructureCraft

The growing availability and code acceptance of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction has given designers a low-carbon alternative to steel, concrete, and masonry for many applications. However, the use of mass timber in multi-family and commercial buildings presents unique acoustic challenges.

While laboratory measurements of the impact and airborne sound isolation of traditional building assemblies such as light wood-frame, steel and concrete are widely available, fewer resources exist that quantify the acoustic performance of mass timber assemblies. Additionally, one of the most desired aspects of mass timber construction is the ability to leave a building's structure exposed as finish, which creates the need for asymmetric assemblies. With careful design and detailing, mass timber buildings can meet the acoustic performance expectations of most building types.

Acoustics

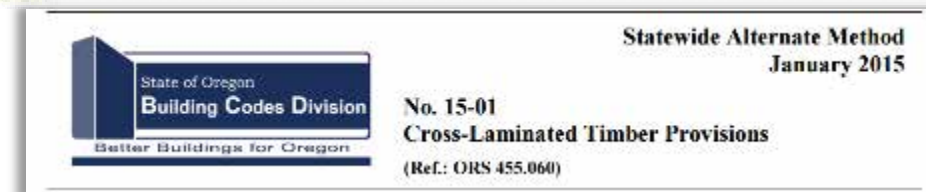
New WoodWorks – Wood Solutions Paper

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

Structural Design



CLT HANDBOOK



Mass Timber Design

Lateral Framing Systems

Central Core –
Concrete Shearwalls

Photo Credit: StructureCraft



Mass Timber Design

Lateral Framing Systems

Interior Steel Moment Frame

Photo Credit: WoodWorks

Mass Timber Design

Lateral Framing Systems

Steel Braced Frame

Photo Credit: John Stamets



Mass Timber Design

Lateral Framing Systems

Timber Braced Frame

Photo Credit: Alex Schreyer



Mass Timber Design

Lateral Framing Systems

Interior Wood Shearwalls

Photo Credit: WoodWorks



Mass Timber Design

Lateral Framing Systems

A close-up photograph of a mass timber wall corner. Two dark grey metal plates are bolted to the vertical and horizontal timber members. The vertical plate has several large, conical metal fasteners. The horizontal plate is covered in a grid of smaller bolts. The timber is light-colored and shows natural grain patterns.

Central core:
Mass Timber Shearwalls

Photo Credit: Alex Schreyer



Code Compliance Pathway – ASCE 7-10

12.2 STRUCTURAL SYSTEM SELECTION

12.2.1 Selection and Limitations

Seismic force-resisting systems not contained in Table 12.2-1 are permitted provided analytical and test data are submitted to the authority having jurisdiction for approval that establish their dynamic characteristics and demonstrate their lateral force resistance and energy dissipation capacity to be equivalent to the structural systems listed in Table 12.2-1 for equivalent values of response modification coefficient, R , overstrength factor, Ω_0 , and deflection amplification factor, C_d .

EQUIVALENCY



1.3.1.3 Performance-Based Procedures

Structural and nonstructural components and their connections shall be demonstrated by analysis or by a combination of analysis and testing to provide a reliability not less than that expected for similar components designed in accordance with the Strength Procedures of Section 1.3.1.1 when subject to the influence of dead, live, environmental, and other loads. Consideration shall be given to uncertainties in loading and resistance.

1.3.1.3.1 Analysis Analysis shall employ rational methods based on accepted principles of engineering mechanics and shall consider all significant sources of deformation and resistance. Assumptions of stiffness, strength, damping, and other properties of components and connections incorporated in the analysis shall be based on approved test data or referenced Standards.

1.3.1.3.2 Testing Testing used to substantiate the performance capability of structural and nonstructural components and their connections under load shall accurately represent the materials, configuration, construction, loading intensity, and boundary conditions anticipated in the structure. Where an approved industry standard or practice that governs the testing of similar components exists, the test program and determination of design values from the test program shall be in accordance with those industry standards and practices. Where such standards or practices do not exist, specimens shall be constructed to a scale similar to that of the intended application unless it can

be demonstrated that scale effects are not significant to the indicated performance. Evaluation of test results shall be made on the basis of the values obtained from not less than 3 tests, provided that the deviation of any value obtained from any single test does not vary from the average value for all tests by more than 15%. If such deviation from the average value for any test exceeds 15%, then additional tests shall be performed until the deviation of any test from the average value does not exceed 15% or a minimum of 6 tests have been performed. No test shall be eliminated unless a rationale for its exclusion is given. Test reports shall document the location, the time and date of the test, the characteristics of the tested specimen, the laboratory facilities, the test configuration, the applied loading and deformation under load, and the occurrence of any damage sustained by the specimen, together with the loading and deformation at which such damage occurred.

1.3.1.3.3 Documentation The procedures used to demonstrate compliance with this section and the results of analysis and testing shall be documented in one or more reports submitted to the authority having jurisdiction and to an independent peer review.

1.3.1.3.4 Peer Review The procedures and results of

Fire Resistance

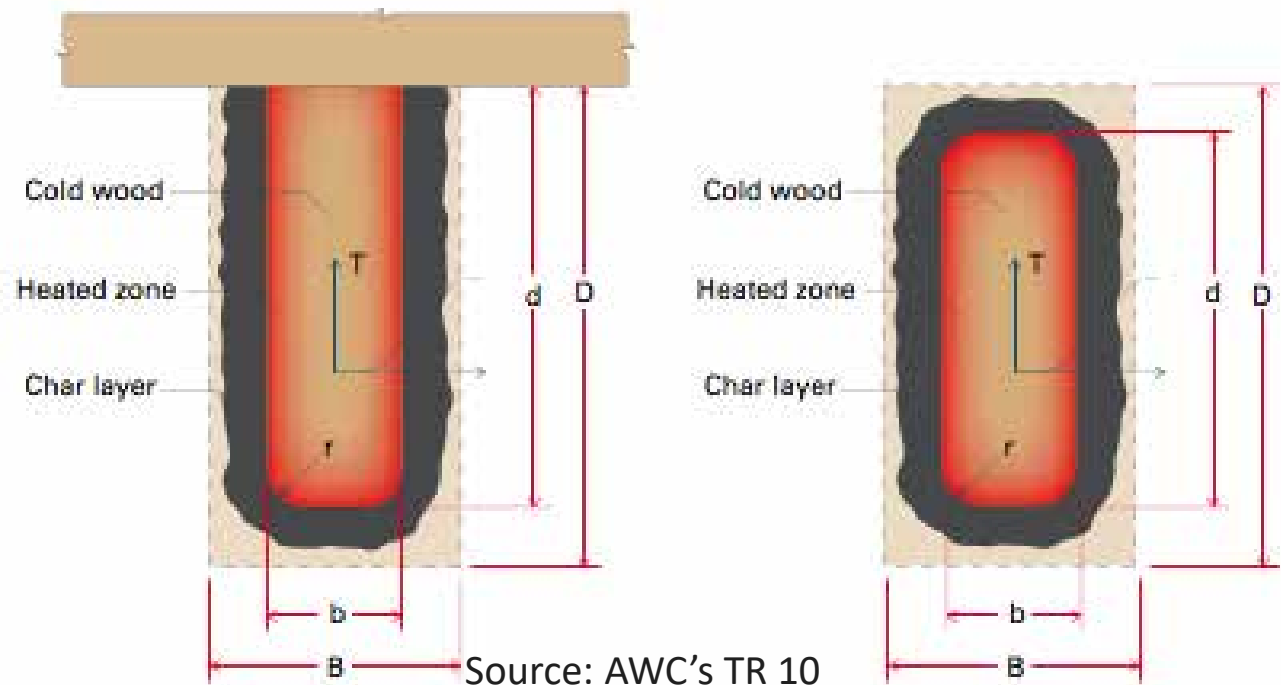
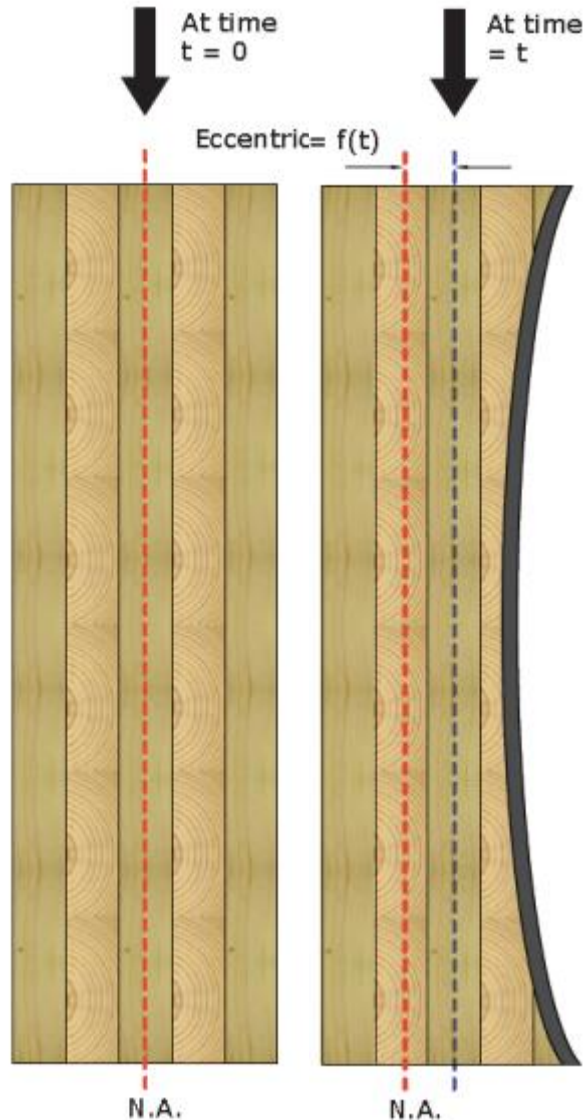


Photo Credit: FP Innovations

Mass Timber Design

Fire Resistance

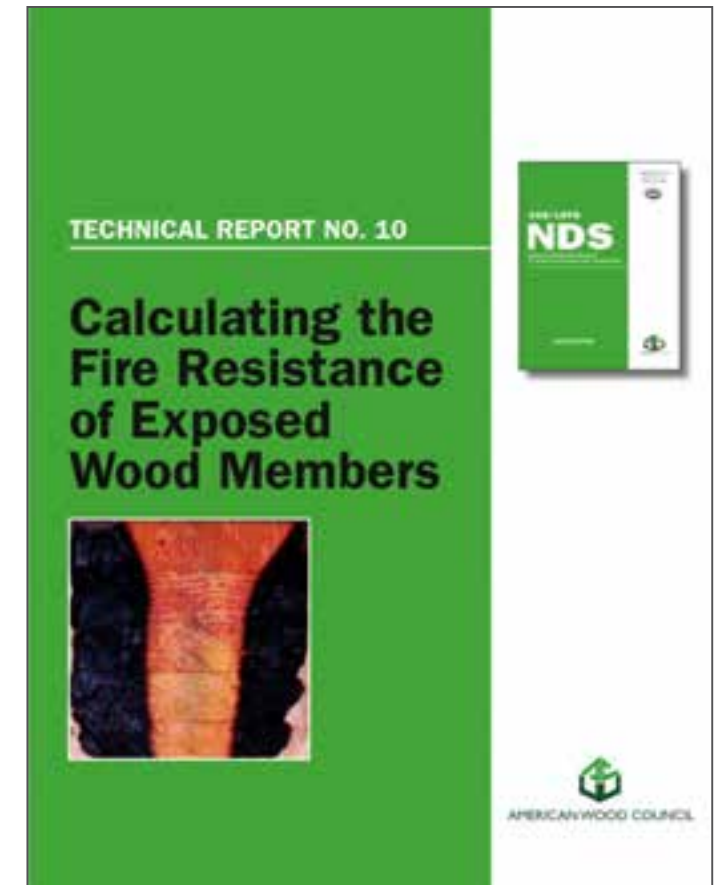
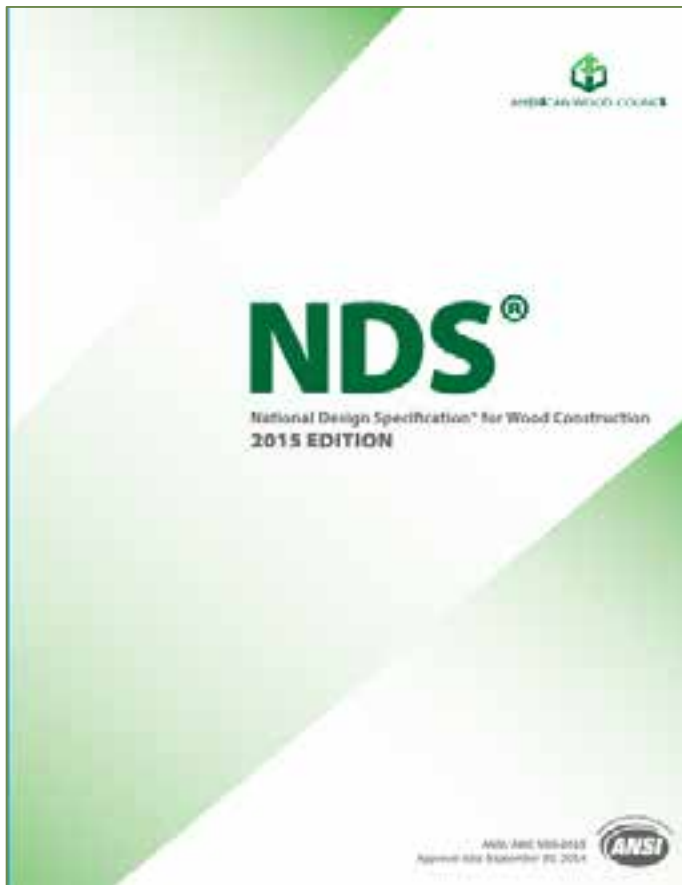
Similar to heavy timber, mass timber products have inherent fire resistance properties



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

Several successful CLT fire tests have been conducted, both with and without gypsum board protection

D.R. Johnson Passes Two Critical Tests for Safety of its Cross-Laminated Timber Panels – Flame Spread and Fire Resistance

Results are "a first" for CLT manufactured in North America, says expert.

RIDDLE, Ore. (August 9, 2016) – D.R. Johnson Wood Innovations, the nation's first certified U.S. manufacturer of cross-laminated timber (CLT), has become the first North American CLT manufacturer to achieve significant fire safety requirements for flame spread and fire resistance. No other manufacturer of CLT has been certified under the new APA-208 standard. D.R. Johnson has subjected its panels to such rigorous tests.

"We're proud of our team and the quality of the CLT panels they're manufacturing," said Valerie Johnson, CEO of D.R. Johnson Wood Innovations. "Our panels are manufactured to the highest possible standards and perform safely under fire conditions. We prove you don't sacrifice safety when you build with CLT."

The flame spread test was performed by QAI Laboratories in California using the standard flame spread tests in accordance with ASTM Designation E84-15b, "Standard Method of Test for Surface Burning Characteristics of Building Materials." The test identifies the rate of the spread of fire across the building material, and it places the results in a rating system with A being the highest rating and C being the lowest. D.R. Johnson's CLT panel achieved an A rating, the highest possible, for its resistance to the spread of fire across the building material over the test's standard time period.

 **Fire Testing Laboratory** 

TEST REPORT Page 1 of 53
for
American Wood Council
222 Catoclin 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-1950
Assignment No: K-1089
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. Rizzo
Test Engineer

FPInnovations 
AFC-CARC

Project No. 301006155
Final Report 2012/13

Preliminary CLT Fire Resistance Testing Report

by
Lindsay Osborne, M.A.Sc.
Christian Dagenais, Eng., M.Sc.
Scientists
Advanced Building Systems – Serviceability and Fire Group

and
Nourreddine Bénichou, Ph.D.
Senior Research Officer
National Research Council of Canada – Fire Research Resource Centre

July 2012


Lindsay Osborne
Research Leader


Nourreddine Bénichou
Reviewer


Conroy Lam
Research Leader

A large, powerful blue wave is crashing over a sandy beach. The wave is curling over, creating a tunnel-like structure. The water is a deep blue color, and the beach is visible in the foreground. The sky is bright blue with some white clouds. The text "And Then the Wave" is overlaid on the image in a bold, black font.

And Then the Wave

Tall Wood Projects in the US

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



6 Stories/85 ft



5 Stories



3 Stories/63 ft



5 Stories



5 Stories



6 Stories/ 85 ft



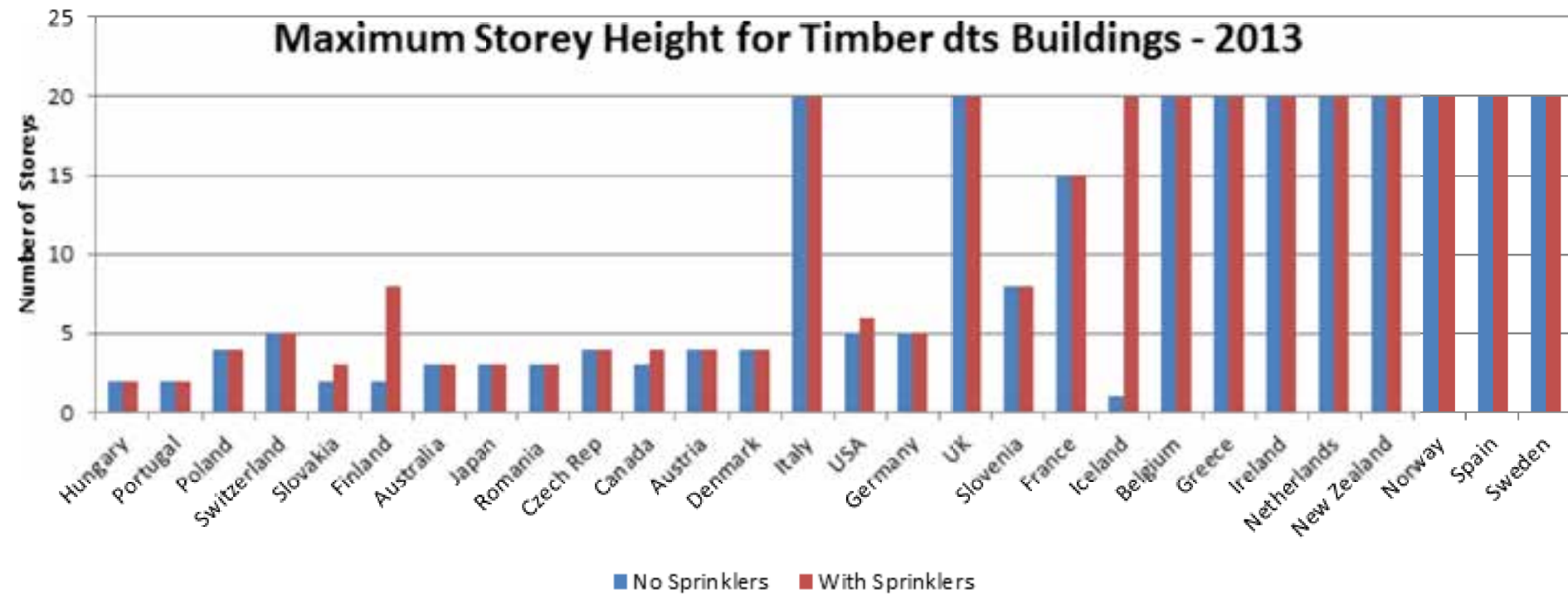
4 Stories



7 Stories/ 85 ft



Building Height Limits in Timber



Source: Arup

U.S. TALL WOOD DEVELOPMENT AND CHANGES



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

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

Modern Tall Wood: Carbon 12

2017, 8 stories, 32,000 sf, CLT



Portland, OR



Photos:
Baumberger Studio/PATH
Architecture/Marcus Kauffman

2021 IBC Tall Wood – Type IV Construction



16 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 60,750 SF

TYPE IV-A



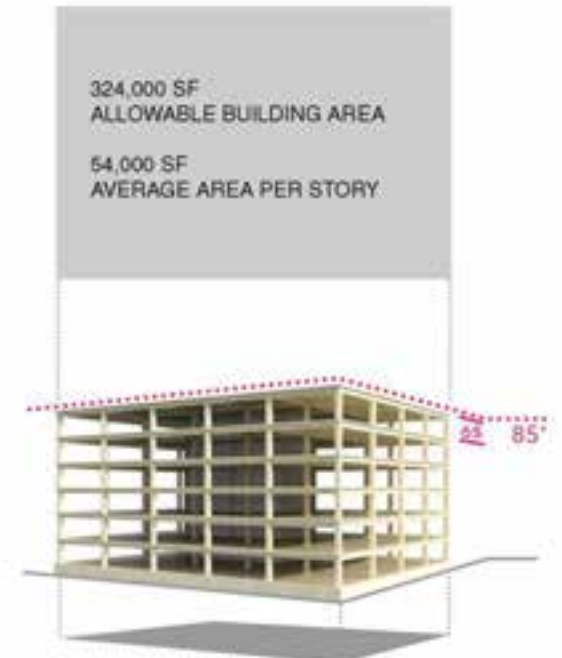
12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000 SF

TYPE IV-B



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

TYPE IV-C



8 STORIES MAXIMUM
85'-0" MAXIMUM BUILDING HEIGHT
324,000 SF MAXIMUM AREA

TYPE IV- HT

IBC 2015

IBC 2021

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.

Type IV-C



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

TYPE IV-C



Credit: Susan Jones, atelierjones

Photos: Baumberger Studio/PATH
Architecture/Marcus Kauffman

Type IV-C Height and Area Limits



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

TYPE IV-C

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	6	85 ft	56,250 SF	168,750 SF
B	9	85 ft	135,000 SF	405,000 SF
M	6	85 ft	76,875 SF	230,625 SF
R-2	8	85 ft	76,875 SF	230,625 SF

Areas exclude potential frontage increase

In most cases, Type IV-C height allowances = Type IV-HT height allowances, but add'l stories permitted due to enhanced FRR

Type IV-C area = 1.25 * Type IV-HT area

Type IV-B



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

TYPE IV-B

Credit: Susan Jones, atelierjones



Credit: LEVER Architecture



Type IV-B Height and Area Limits



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

TYPE IV-B

Credit: Susan Jones, atelierjones

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	12	180 ft	90,000 SF	270,000 SF
B	12	180 ft	216,000 SF	648,000 SF
M	8	180 ft	123,000 SF	369,000 SF
R-2	12	180 ft	123,000 SF	369,000 SF

Areas exclude potential frontage increase

In most cases, Type IV-B height & story allowances = Type I-B height & story allowances

Type IV-B area = 2 * Type IV-HT area

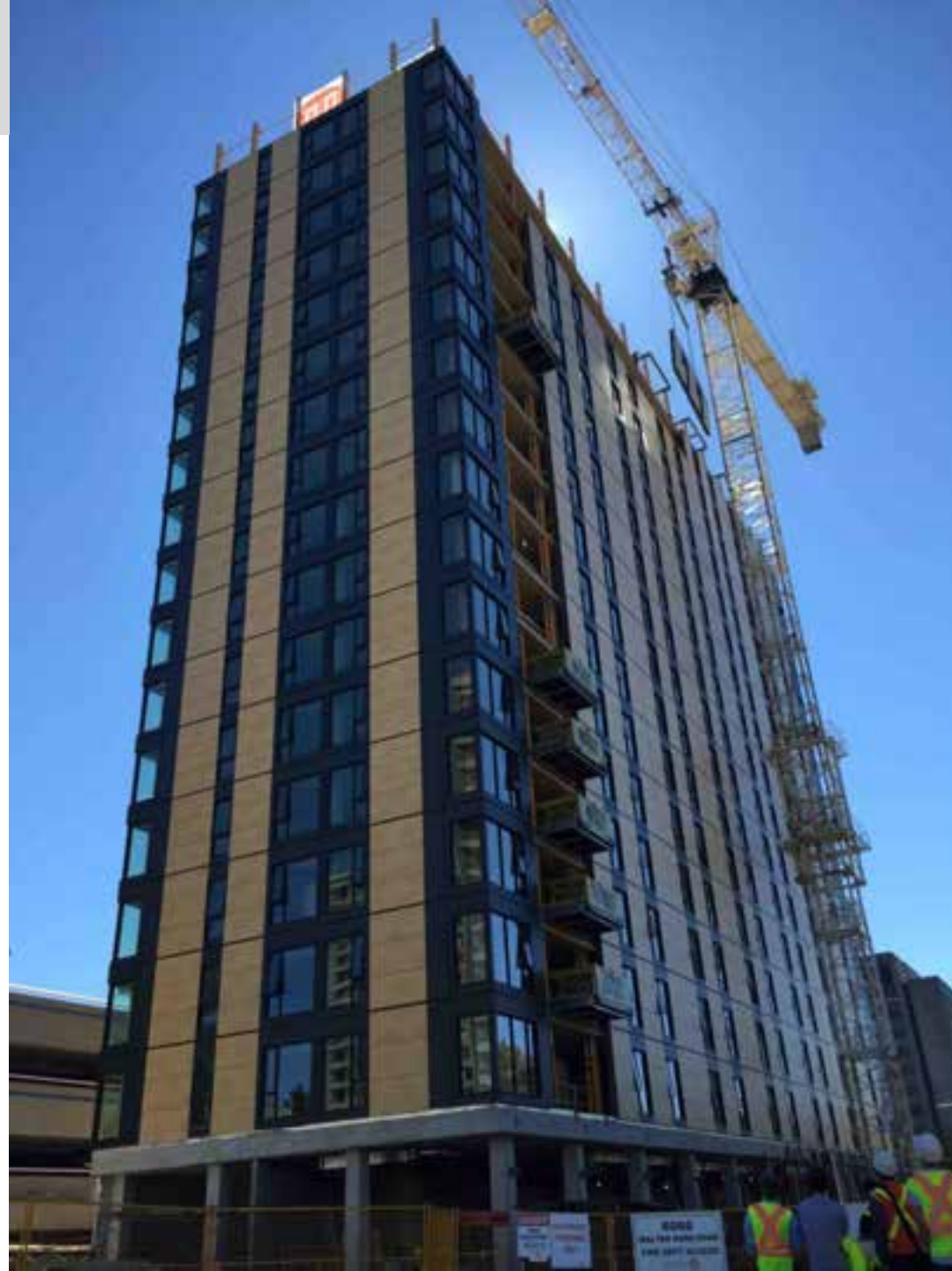
Type IV-A



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

TYPE IV-A

Credit: Susan Jones, atelierjones



Photos: Structurlam, naturally:wood,
Fast + Epp

Type IV-A Height and Area Limits



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

TYPE IV-A

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	18	270 ft	135,000 SF	405,000 SF
B	18	270 ft	324,000 SF	972,000 SF
M	12	270 ft	184,500 SF	553,500 SF
R-2	18	270 ft	184,500 SF	553,500 SF

Areas exclude potential frontage increase

In most cases, Type IV-A height & story allowances = 1.5 * Type I-B height & story allowances

Type IV-A area = 3 * Type IV-HT area

Tall Wood Fire Resistance Ratings (FRR)



Primary Frame or Brng Wall FRR

Floor Construction FRR

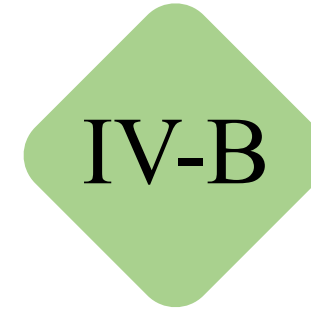
Roof Construction FRR

Floor Surface Protection

Roof Construction Protection

3 HR (2 HR at Roof)	2 HR (1 HR at Roof)	2 HR (1 HR at Roof)
2 HR	2 HR	2 HR
1.5 HR	1 HR	1 HR
1 inch of NC protection	1 inch of NC protection	No protection req'd
2 layers 5/8" type X gyp on inside face	2 layers 5/8" type X gyp on inside face	No protection req'd unless concealed space

Tall Wood Materials & Protection



Exterior Walls

Structural Materials

Concealed Spaces

Gypsum Protection

Mass Timber, exterior surface protected with 1 layer 5/8" type X gyp

Mass Timber or NC

Permitted, requires NC protection on MT surfaces

**All MT is protected
3 HR: 3 layers 5/8"
type X gyp
2 HR or less: 2 layers
5/8" type X gyp**

**Same as IV-A for
protected MT. Limited
exposed MT
permitted, FRR still
applies**

**All MT permitted may
be exposed except as
noted**

- Download at www.woodworks.org

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

Just Benner, P.E. SE Building • Wood Products Council • Ben Benner, SE, John R. Martin & Associates
• Delmar-Bethesda, PE, CBE Corp, Delmar-Bethesda

In January 2019, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (IBC). Based on these proposals, the 2021 IBC will include three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber or noncombustible materials. These new types are based on the previous Heavy Timber construction type (referred to as Type IV-HT) but with additional fire-resistance ratings and levels of required noncombustible protection. The code will include provisions for up to 18 stories of Type IV-A construction for Business and Residential Occupancies.

Based on information first published in the Structural Engineers Association of California (SEAOC) 2018 Conference Proceedings, this paper summarizes the background to these proposals, technical research that supported their adoption, and resulting changes to the IBC and product-specific standards.

Background: ICC Tall Wood Building Ad Hoc Committee

Over the past 10 years, there has been a growing interest in tall buildings constructed from mass timber materials (Benner 2013, Timmers 2016). Around the world there are now dozens of timber buildings constructed above eight stories tall. Some international examples include:

Building Name	Location	Stories	Completion Date
OnePark at Madison Square	London, UK	8 stories	2006
Yere	Mallorca, Spain	8 stories	2012
Via Cenci	Milan, Italy	10	2013
Tree	Bergen, Norway	14	2015
UIC Wood Commons	Chicago, Canada	10	2016
Alameda	San Francisco	10	2016
Stella Wien	Vienna, Austria	28	2018

OnePark at Madison Square, London, UK
Photo: David J. Smith
Architect: Bjarke Ingels Group

Tall Wood – Not waiting for 2021

- Milwaukee, WI
- 21-stories / 238'
- 9-story concrete podium
- 12-stories of mass timber
- 410,000 sf
- 201 Apartments
- City has given preliminary approval to plans



**Are you ready for the
Next Wave?**





Questions?

This concludes The American
Institute of Architects
Continuing Education Systems
Course

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