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Presented by
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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.
As of December 2022, in the US, 1,667 multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.

Current State of Mass Timber Projects
Mass timber is a category of framing styles often using small wood members formed into large panelized solid wood construction including CLT, NLT or glulam panels for floor, roof and wall framing.
HEAVY TIMBER
Federal Center South, Seattle, WA
Photo: Benjamin Benschneider

MASS TIMBER
Bullitt Center, Seattle, WA
Photo: John Stamets
Glue Laminated Timber (Glulam)
Beams & columns

Cross-Laminated Timber (CLT)
Solid sawn laminations

Cross-Laminated Timber (CLT)
SCL laminations

Photo: StructureCraft
Photo: LendLease
Photo: LEVER Architecture
Photo: Freres Lumber
Dowel-Laminated Timber (DLT)

Nail-Laminated Timber (NLT)

Glue-Laminated Timber (GLT)
Plank orientation
Mass Timber Building Options

Post and Beam  Flat Plate  Honeycomb
Mass Timber Building Options

Hybrid: Light-frame

Hybrid: Steel framing
Evolution of Mid-Rise Wood Structures in the US

Type V → Type III → + Mezzanines → + Podiums

Source: WoodWorks
Off-Site Construction
Modular Construction

The Graphic
Cambridge, MA

Credit: ICON Architecture
INNOVATIVE TIMBER CONSTRUCTION
UNDERSTANDING THE WHY
Biophilia - Structural Warmth is a Value-Add
Construction Impacts: Labor Availability
Construction Impacts: Schedule

INNOVATIVE WOOD APPEAL

MATERIAL MASS

75% LIGHTER WEIGHT THAN CONCRETE

SOURCE: STRUCTURLAM
How Does Wood Fit in?

CLIMATE
New Buildings & Greenhouse Gases

Buildings generate nearly 40% of annual global greenhouse gas emissions (building operations + embodied energy)

Embodied energy: 11%
Concrete, iron, steel ~9%


Image: Architecture 2030
Carbon vs CO₂

1 ton Carbon ≠ 1 ton CO₂

1 ton Carbon = (44/12=) 3.67 tons CO₂
Carbon Terms

- **Embodied Carbon**: Carbon emissions associated with the entire life cycle of the building including harvesting, mining, manufacturing, transporting, installing, maintaining, decommissioning, and disposing/reuse of a material or product.

- **Operational Carbon**: Carbon emissions associated with operating a building including power, heat, and cooling.

Image: Boston Society for Architecture
Embodied Carbon

- Primarily related to manufacturing of materials
- More significant than many people realize, has been historically overlooked
- Big upfront GHG “cost” - which makes it a good near-term target for climate change mitigation
More Carbon Terms

**Carbon Sequestration:** The process by which CO₂ is removed from the atmosphere and deposited in solid or liquid form in oceans, living organisms, or land.

**Carbon Storage:** Carbon is stored as a solid in the form of plant material: roots, trunks, branches, stems, and leaves. It can continue to be stored in wood building materials.

Image: Dovetail Partners, Inc.
Carbon Storage
Wood ≈ 50% Carbon (dry weight)
Carbon Benefits of Wood

- **Less energy intensive** to manufacture than steel or concrete
- **Less fossil fuel consumed** during manufacture
- **Avoid process emissions**
- **Carbon storage in forests** and promote forest health
- **Extended carbon storage in products**

Image: USDA US Forest Service
WoodWorks Carbon Calculator

- Available at woodworks.org
- Estimates total wood mass in a building
- Relays estimated carbon impacts:
  - Amount of carbon stored in wood
  - Amount of greenhouse gas emissions avoided by choosing wood over a non-wood material

http://www.woodworks.org/carbon-calculator-download-form/
Carbon Storage in Harvested Wood Products

As of 2019, the carbon stock for Harvested Wood Products in Use in the conterminous 48 states is estimated at **1,521 Million Metric Tons**.

Carbon Stocks in Forest Land and Harvested Wood Pools, 2019

Whole Building Life Cycle Analysis (WBLCA)

“Evaluation of the inputs, outputs, and potential environmental impacts… throughout its life cycle”

• WBLCA covers all stages in the life cycle of a building and its components

• Several tools available; various methodologies

• https://www.thinkwood.com/education/calculate-wood-carbon-footprint

• https://www.thinkwood.com/blog/understanding-the-role-of-embodied-carbon-in-climate-smart-buildings
State of Our Forests
Common Environmental Concerns About Specifying Wood

1. Is North America running out of Forests?

2. Does specifying wood products contribute to deforestation?

3. Is wood a renewable resource?
U.S. Forest Land: Forest Area in the United States 1630 – 2012

State of our Forests: US Timber Volume on Timber Land

US Forest Lands

Forest Land Ownership

This map displays the basic vegetation (forest vs. non-forest) of the conterminous United States as well as ownership (private vs. public). The lands displayed as “public” include Federal and State lands but do not generally include lands owned by local governments and municipalities.
US Forest Lands

Forest Land Ownership
This map displays the basic vegetation (forest vs. non-forest) of the conterminous United States as well as ownership (private vs. public). The lands displayed as "public" include Federal and State lands but do not generally include lands owned by local governments and municipalities.

56% Privately Owned
42% Family Owned
US Forest Lands

Economic value of forest products is motivation for private landowners to keep land forested.
Regeneration vs. Deforestation

Deforestation is the permanent conversion of forest land to non-forest land uses. Worldwide, agricultural expansion is the main driver of deforestation, but in the U.S., the rate of deforestation has been virtually zero for decades.

Good Forestry = Sustainable Forestry

“Forestry is the art and science of creating, using and conserving forests. The forestry profession was a pioneer in developing techniques for sustainable management and, later, techniques for the multiple use of forests. [...] The term sustainable forest management is synonymous with good forestry”.

Photos: Oregon Forest Resources Institute
Sustainable Forestry Management Systems

- Wood from well-managed forests is sustainable over the long term.
- Forest certification shows that the wood comes from well-managed forests.
- The major North American programs are:

FSC  SFI  CSA  ATFS
The What, Why and How of Tall Mass Timber
1510 Webster, rendering oWow Architecture; Minnesota Places, rendering Wright Architecture; Carbon 12, Kaiser+Path, photo Andrew Pogue; Heartwood, rendering Atelier Jones; INTRO Cleveland, Harbor Bay Real Estate Advisors, HPA Architecture; Ascent, Korb + Associates Architects, Thornton Tomasetti; 11 E Lenox, rendering Monte French Design Studio; 80 M Street, Hickok Cole Architects, Columbia Property Trust; Apex Plaza, rendering William McDonough + Partners
TALL MASS TIMBER
ASSESSING THE WHAT

Brock Commons, Vancouver, BC | Architect: Acton Ostry | Image Courtesy: naturallywood
BROCK COMMONS, BRITISH COLUMBIA

18 STORIES | 174 FT
MJOSTARNET, NORWAY

18 STORIES | 280 FT
HOHO, AUSTRIA

24 STORIES | 275 FT
INTRO, CLEVELAND

9 Stories | 115 ft
8 Timber Over 1 Podium

Type IV-B
Variance to expose ~50% ceilings

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

Tallest Mass Timber Building in the World

25 STORIES
19 TIMBER OVER 6 PODIUM, 284 FT

Photo: CD Smith Construction | Architect: Korb & Associates Architects
APEX PLAZA
CHARLOTTESVILLE, VA

8 STORIES
6 TIMBER OVER 2 PODIUM, 100 FT

PRIMARILY OFFICE SPACE
11 E LENOX, BOSTON, MA

7 STORIES

70 FT, Passive House, Multi-Family

Credit: WoodWorks, Kure Creative
80 M ST, WASHINGTON, DC

3 STORY VERTICAL ADDITION
7 STORY EXISTING BUILDING
Tallhouse
Boston

GLOBAL WARMING POTENTIAL & MATERIAL MASS
(PER BUILDING ASSEMBLY)

Source: Generate Architecture
TALL WOOD IN THE CODE
2018 IBC and All Previous Editions:

» Prescriptive Code Limit - 6 stories (B occupancy) or 85 feet

» Over 6 Stories - Alternate Means and Methods Request (AMMR) through performance based design

» Based on the 1910 Heights and Areas Act
U.S. TALL WOOD
DEVELOPMENT AND CHANGES

Seen as the catalyst for the mass timber revolution, CLT first recognized in US codes in the 2015 IBC

[BS] CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than three layers of solid-sawn lumber or structural composite lumber where the adjacent layers are cross oriented and bonded with structural adhesive to form a solid wood element.

2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.
Interest in tall wood projects in the US was rapidly increasing. Some building officials were reluctant to approve proposed plans, primarily due to lack of code direction and precedent.
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.
5 Working Groups Created
• July 2016 – November 2017: 5 in-person meetings, numerous conference calls
• 82 issues addressed, one primary topic was fire performance and life safety
Fire resistance of mass timber for low- to mid-rise structures well understood, codified
1. No collapse under reasonable scenarios of complete burn-out of fuel without automatic sprinkler protection being considered.

2. Highly reliable fire suppression systems to reduce the risk of failure during reasonably expected fire scenarios. The degree of reliability should be proportional to evacuation time (height) and the risk of collapse.

AHC established 6 performance objectives:
AHC established 6 performance objectives:

3. No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios.

4. No unusual response from typical radiation exposure from adjacent properties to present a risk of ignition of the subject building under reasonably severe fire scenarios.
AHC established 6 performance objectives:

5. No unusual fire department access issues
6. Egress systems designed to protect building occupants during the design escape time, plus a factor of safety.
U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

Commissioned series of 5 full-scale tests on 2-story mass timber structure at ATF lab in MD, May-June 2017

Figure 1. General plan view of cross-laminated timber test structure.

Figure 2. Elevation view of the front of the cross-laminated timber test structure.
U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

Tests on exposed mass timber, gypsum-covered mass timber; normal sprinkler protection, delayed sprinkler protection
Majority of flames seen are from contents, not structure
## U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Construction Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>All mass timber surfaces protected with 2 layers of 5/8” Type X Gypsum. No Sprinklers.</td>
<td>IV-A</td>
</tr>
<tr>
<td>Test 2</td>
<td>30% of CLT ceiling area in living room and bedroom exposed. No Sprinklers.</td>
<td>IV-B</td>
</tr>
<tr>
<td>Test 3</td>
<td>Two opposing CLT walls exposed – one in bedroom and one in living room. No Sprinklers.</td>
<td>IV-B</td>
</tr>
<tr>
<td>Test 4</td>
<td>All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – normal activation</td>
<td>IV-C</td>
</tr>
<tr>
<td>Test 5</td>
<td>All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – 20 minute delayed activation</td>
<td>IV-C</td>
</tr>
</tbody>
</table>
ICC TWB Ad Hoc Committee proposals consisted 17 total code changes:

**Requirements for the new Types of Construction:**
- IBC Section 602.4 – Type of Construction (G108-18)
- IBC Section 703.8 – Performance Method for Fire Resistance from Noncombustible Protection (FS5-18)
- IBC Section 722.7 – Prescriptive Fire Resistance from Noncombustible Protection (FS81-18)
- IBC Section 703.9 – Sealants at Edges (FS6-18)
- IBC Section 718.2.1 – Fire and Smoke Protection (FS73-18)
- IBC Section 403.3.2 – High-Rise Sprinkler Water Supply (G28-18)
- IBC Section 701.6 – Owners’ Responsibility (F88-18)
- IFC Section 3308.4 – Fire Safety During Construction (F266-18)

**Allowable building size limits:**
- IBC Table 504.3 – Building Height (G75-18)
- IBC Table 504.4 – Number of Stories (G80-18)
- IBC Table 506.2 – Allowable Area (G84-18)

**Housekeeping changes:**
- IBC Section 3102 – Special Construction (G146-18)
- IBC Appendix D – Fire Districts (G152-18)
- IBC Section 508.4 and 509.4 – Fire Barriers (G89-18)
- IBC Table 1705.5.3 Special Inspections (S100-19)
- IBC Section 110.3.5 Connection Protection Inspection (ADM35-19)
- IBC Section 2304.10.1 Connection Fire Resistance Rating (S170-19)
TALL WOOD APPROVED!

Unofficial results posted Dec 19, 2018
Final votes ratified Jan 31, 2019

AWC: Tall Mass Timber code changes get final approval
Dec 19, 2018

LEESBURG, VA. – The International Code Council (ICC) has released the unofficial voting results on code change proposals considered in 2018, including passage of the entire package of tall mass timber code change proposals. The proposals create three new types of construction (Types IV-A, IV-B and IV-C), which set fire safety requirements, and allowable heights, areas and number of stories for tall mass timber buildings. Official results are expected to be announced during the first quarter of 2019. The new provisions will be included in the 2021 International Building Code (IBC).

“Mass timber has been capturing the imagination of architects and developers, and the ICC result means they can now turn sketches into reality. ICC’s rigorous study, testing and voting process now
SO WHAT’S CHANGED??

Since its debut, IBC has contained 9 construction type options
5 Main Types (I, II, III, IV, V) with all but IV having sub-types A and B

<table>
<thead>
<tr>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>HT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>
2021 IBC Introduces 3 new tall wood construction types:
IV-A, IV-B, IV-C
Previous type IV renamed type IV-HT
New Building Types

<table>
<thead>
<tr>
<th>TYPE IV-A</th>
<th>TYPE IV-B</th>
<th>TYPE IV-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBC 2021</td>
<td>IBC 2021</td>
<td>IBC 2015</td>
</tr>
</tbody>
</table>

BUSINESS OCCUPANCY [GROUP B]

*Building floor-to-floor heights are shown at 12'-0" for all examples for clarity in comparison between 2015 to 2021 IBC codes.*

Credit: Susan Jones, atelierjones
Type IV-C

Credit: Susan Jones, atelierjones

Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman
Type IV-C Protection vs. Exposed

All Mass Timber surfaces may be exposed

Exceptions: Shafts, concealed spaces, outside face of exterior walls

Credit: Susan Jones, atelierjones
### Type IV-C Height and Area Limits

<table>
<thead>
<tr>
<th>Occupancy</th>
<th># of Stories</th>
<th>Height</th>
<th>Area per Story</th>
<th>Building Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2</td>
<td>6</td>
<td>85 ft</td>
<td>56,250 SF</td>
<td>168,750 SF</td>
</tr>
<tr>
<td>B</td>
<td>9</td>
<td>85 ft</td>
<td>135,000 SF</td>
<td>405,000 SF</td>
</tr>
<tr>
<td>M</td>
<td>6</td>
<td>85 ft</td>
<td>76,875 SF</td>
<td>230,625 SF</td>
</tr>
<tr>
<td>R-2</td>
<td>8</td>
<td>85 ft</td>
<td>76,875 SF</td>
<td>230,625 SF</td>
</tr>
</tbody>
</table>

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

Credit: Susan Jones, atelierjones  
Credit: LEVER Architecture
**Type IV-B Protection vs. Exposed**

**NC protection on all surfaces of Mass Timber except limited exposed areas**

~20% of Ceiling or ~40% of Wall can be exposed, see code for requirements
**Type IV-B Height and Area Limits**

<table>
<thead>
<tr>
<th>Occupancy</th>
<th># of Stories</th>
<th>Height</th>
<th>Area per Story</th>
<th>Building Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2</td>
<td>12</td>
<td>180 ft</td>
<td>90,000 SF</td>
<td>270,000 SF</td>
</tr>
<tr>
<td>B</td>
<td>12</td>
<td>180 ft</td>
<td>216,000 SF</td>
<td>648,000 SF</td>
</tr>
<tr>
<td>M</td>
<td>8</td>
<td>180 ft</td>
<td>123,000 SF</td>
<td>369,000 SF</td>
</tr>
<tr>
<td>R-2</td>
<td>12</td>
<td>180 ft</td>
<td>123,000 SF</td>
<td>369,000 SF</td>
</tr>
</tbody>
</table>

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

Credit: Susan Jones, atelierjones

Photos: Structurlam, naturally:wood, Fast + Epp, Urban One
Type IV-A Protection vs. Exposed

100% NC protection on all surfaces of Mass Timber

Credit: Susan Jones, atelierjones
Type IV-A Height and Area Limits

<table>
<thead>
<tr>
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<th># of Stories</th>
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<th>Building Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-2</td>
<td>18</td>
<td>270 ft</td>
<td>135,000 SF</td>
<td>405,000 SF</td>
</tr>
<tr>
<td>B</td>
<td>18</td>
<td>270 ft</td>
<td>324,000 SF</td>
<td>972,000 SF</td>
</tr>
<tr>
<td>M</td>
<td>12</td>
<td>270 ft</td>
<td>184,500 SF</td>
<td>553,500 SF</td>
</tr>
<tr>
<td>R-2</td>
<td>18</td>
<td>270 ft</td>
<td>184,500 SF</td>
<td>553,500 SF</td>
</tr>
</tbody>
</table>

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

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

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 (Breneman 2013, Timmers 2015). Around the world there

WoodWorks Tall Wood Design Resource
TALL TIMBER CODE ADOPTION
Resources for Developers/Owners

www.woodworks.org/learn/mass-timber-clt/mass-timber-business-case/
Released on 20 October 2021

https://www.woodworks.org/mass-timber-construction-management-program/

The Loading Dock, OZ Architecture, KL&A, photo Joe Anastasi
Questions? Ask us anything.

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