As interest in and use of mass timber in the U.S. has grown, so too has interest in pushing these timber structures to greater heights. Using international examples of successful tall wood buildings as precedent, some designers have proposed tall wood projects in the states using a project-specific performance-based design approach. In order to provide a uniform set of code provisions for these tall wood buildings, the International Code Council established an ad hoc committee on tall wood buildings that proposed a set of code changes allowing up to 18 stories of mass timber construction. Those code changes were announced as approved in January 2019 and will become part of the 2021 International Building Code. Following a brief discussion of history and motivators, this presentation will introduce the new tall wood code provisions and construction types, as well as the technical research and testing that supported their adoption.

Learning Objectives

1. Review the global history of tall wood construction and highlight the mass timber products used in these structures.
2. Explore the work and conclusions of the ICC Ad Hoc Committee on Tall Wood Buildings in establishing 14 new code provisions for the 2021 IBC that address tall wood construction.
3. Discuss differences between the new tall wood mass timber construction types and existing construction types.
4. Identify the key passive fire-resistance construction requirements and active systems that enable taller wood buildings to be built safely.

Questions we’ll answer:
• What is tall wood?
• How tall is tall?
• What has been done?
• What wood products are used in tall wood?
• What does the code allow now?
• How did we arrive at the proposed tall wood code changes?
• What are the new tall wood code provisions?
GLOBAL TALL WOOD CIRCA 2015
7-14 STORIES

GLOBAL TALL WOOD CIRCA 2019
18-24 STORIES

TALL WOOD IN THE US CIRCA 2019
8 STORIES

HEAVY TIMBER
Federal Center South, Seattle, WA
Photo: Benjamin Berenschneider

MASS TIMBER
Bullitt Center, Seattle, WA
Photo: John Stamets

GLULAM
CROSS-LAMINATED TIMBER (CLT)
NAIL-LAMINATED TIMBER (NLT)

DOMEL-LAMINATED TIMBER (ULT)
MASS PLYWOOD PANELS (MPP)

DECKING
WHY TALL WOOD?

GLOBAL POPULATION BOOM

Global Population
7.6 billion now
9.8 billion by 2050
30% increase

Source: United Nations Department of Economic and Social Affairs

US URBAN POPULATION BOOM

<table>
<thead>
<tr>
<th>Year</th>
<th>Urban (M)</th>
<th>Rural (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>271.4 M</td>
<td>57.7 M</td>
</tr>
<tr>
<td>2030</td>
<td>301 M</td>
<td>53.7 M</td>
</tr>
<tr>
<td>2050</td>
<td>347.3 M</td>
<td>42.2 M</td>
</tr>
</tbody>
</table>
Reduced Embodied Carbon

Brock Commons, Vancouver, BC

Photo Credit: UBC

Market Drivers for Mass Timber

**Primary Drivers**
- Construction Efficiency & Speed
- Construction site constraints – Urban Infill
- Innovation/Aesthetic

**Secondary Drivers**
- Carbon Reductions
- Structural Performance – Lightweight

Market Opportunity by Project Type

Forecast: Mass Timber “Type” Projects

All stories (not just tall wood)

~1 Billion SF per Year

Forecast: Mass Timber “Type” Projects

Looking Back: What could have used the new tall wood construction types?

2021 IBC Construction Types

<table>
<thead>
<tr>
<th>Type</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>19+</td>
<td>5%</td>
<td>6%</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>IV-A</td>
<td>3%</td>
<td>4%</td>
<td>5%</td>
<td>6%</td>
</tr>
<tr>
<td>IV-B</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>IV-C</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>III, IV, V</td>
<td>92%</td>
<td>91%</td>
<td>90%</td>
<td>89%</td>
</tr>
</tbody>
</table>

Estimated construction types calculated using building stories and occupancy

Looking Back: Which of the new tall wood construction types is there the largest market for?

2021 IBC Construction Types

<table>
<thead>
<tr>
<th>Type</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV-A</td>
<td>12%</td>
<td>13%</td>
<td>14%</td>
<td>15%</td>
</tr>
<tr>
<td>IV-B</td>
<td>8%</td>
<td>9%</td>
<td>10%</td>
<td>11%</td>
</tr>
<tr>
<td>IV-C</td>
<td>5%</td>
<td>6%</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>III, IV, V</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Estimated construction types calculated using building stories and occupancy

Opportunity for Tall Wood (various building types):

200 million sqft per year
Current 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

Type III construction, Residential occupancy: 5 stories

U.S. Building Code Status

3 Year Code Cycle
**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 timber or structural composite timber 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 timber shall be manufactured and identified in accordance with ANSI/APA PRG 320.

**U.S. BUILDING CODES 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.

**Timeline:**
Submission of code changes for the 2018 Group A Cycle (IBC) in January 2018 – changes for 2021 IBC

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

**U.S. BUILDING CODES DEVELOPMENT AND CHANGES**

Fire resistance of mass timber for low- to mid-rise structures well understood, codified
Taller wood buildings create new set of challenges to address:

AHC established 6 performance objectives:

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.

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.

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

<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>
TEST 1

Ignition
Living Room / Kitchen Flashover
Bedroom Flashover

Decay Phase
Living Room / Kitchen
Bedroom

Photos provided by U.S. Forest Products Laboratory, USDA
Source: AWC

TEST 2

Ignition
Living Room / Kitchen Flashover
Bedroom Flashover

Decay Phase
Living Room Ceiling
Bedroom Ceiling

Photos provided by U.S. Forest Products Laboratory, USDA
Source: AWC

TEST 3

Ignition
Living Room / Kitchen Flashover
Bedroom Flashover

Decay Phase
Wall
Wall

Photos provided by U.S. Forest Products Laboratory, USDA
Source: AWC

TEST 4

All mass timber surfaces fully exposed in bedroom and living room.
Sprinkler – normal activation

Source: AWC
Photos provided by U.S. Forest Products Laboratory, USDA

TEST 5

All mass timber surfaces fully exposed in bedroom and living room.
Sprinkler – activation delayed for 20 minutes after smoke detector activation...approximately 23-1/2 minutes from ignition

Source: AWC
Although not directly affiliated with the TWB AHC, other mass timber and tall wood testing & research was occurring, the results of which the AHC included in their final decisions.
U.S. BUILDING CODES
DEVELOPMENT AND CHANGES

ICC TWB Ad Hoc Committee Group A proposals consisted of the following 14 parts:

- ICC Section 602.4 – Type of Construction (G36-18)
- ICC Section 602.8 – Performance Method for Fire Resistance from Noncombustible Protection (F35-18)
- ICC Section 722.7 – Prescriptive Fire Resistance from Noncombustible Protection (F35-18)
- ICC Section 703.9 – Seams at Edges (F56-18)
- ICC Section 718.2.1 – Fire and Smoke Protection (G173-18)
- ICC Section 403.3.2 – High-Rise Sprinkler Water Supply (G29-18)
- ICC Section 701.6 – Owners’ Responsibility (F96-18)
- ICC Section 506.4 – Fire Safety During Construction (F369-18)

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

Housekeeping changes:
- ICC Section 3105 – Special Construction (G148-18)
- ICC Appendix H – Fire Districts (G152-18)
- ICC Section 506.4 and 509.4 – Fire Barriers (G389-18)

2018 TIMELINE:
Step 1: January 8 – Final Proposed Language submitted to ICC
Step 2: February 28 – Changes are posted for Public Viewing
Step 3: April 15–25 – Committee Action Public Hearing – Columbus, OH

2018 (& BEYOND) TIMELINE:
Step 4: May 30 – Committee Action Hearing results posted
Step 5: June 1 – July 16 – Public Comments Sought on Committee Action Hearing Results
Step 6: August 31 – Public Comments Posted
Step 7: October 24–31 – Public Comment Hearing and Vote
Step 8: November 19 – December 7 Final Online Vote
Step 9: Fall 2020 – New Edition is Published

U.S. BUILDING CODES
DEVELOPMENT AND CHANGES

Tall Mass Timber Building Code Changes Pass First Hurdle
The highly anticipated International Code Council (ICC) Tall Mass Timber Building code changes passed a first hurdle in April with approval by the ICC code changes committee responsible for this part of the process. By wide margins a series of 14 proposals was each approved. The hearings brought together researchers, architects, engineers, builders, and other construction professionals as part of the first step in approving code change proposals for the International Code Council (ICC) code. The proposals submitted by ICC’s Ad Hoc Committee on Tall Wood Buildings (TWBs) would allow mass timber buildings to be constructed up to 18 stories in height. A small but significant number of testimonials at the hearings spoke in support of the Ad Hoc Committee proposals. For more information see www.icc.org/tallmass timber.

U.S. BUILDING CODES
DEVELOPMENT AND CHANGES

2018 TIMELINE:
Step 1: January 8 – Final Proposed Language submitted to ICC
Step 2: February 28 – Changes are posted for Public Viewing
Step 3: April 15–25 – Committee Action Public Hearing – Columbus, OH

ICC Public Comment Hearing Voting Results on Tall Wood Changes, October 2018

<table>
<thead>
<tr>
<th>Proposal</th>
<th>Support</th>
<th>Oppose</th>
</tr>
</thead>
<tbody>
<tr>
<td>F5S-18</td>
<td>68.6%</td>
<td>31.4%</td>
</tr>
<tr>
<td>G106-18</td>
<td>68.1%</td>
<td>31.9%</td>
</tr>
<tr>
<td>G28-18</td>
<td>67.3%</td>
<td>32.7%</td>
</tr>
<tr>
<td>G64-18</td>
<td>68.2%</td>
<td>31.8%</td>
</tr>
</tbody>
</table>

Photo: LendLease
Credit: AWC

Photo: AWC
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 14 tall mass timber code change proposals. The proposals create three new types of construction (Types IV-A, IV-B and IV-C), which set the safety requirements, and allocate 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).

"Tall mass timber has been capturing the imaginations 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 lead to the inclusion of heavy/reinforced mass timber buildings in the nation’s model building code."

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>A</td>
<td>A</td>
<td>HT</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>

U.S. BUILDING CODES
Tall Wood Construction Types

2021 IBC Introduces 3 new tall wood construction types:
IV-A, IV-B, IV-C
Previous type IV renamed type IV-HT

U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

ICC Online Governmental Consensus Voting Results, Ratified January 2019

Tall Wood Code Changes as submitted by TWB Ad Hoc Committee

% of Vote in Favor of Code Change
% of Vote Req’d for Code Change Approval

U.S. BUILDING CODES
New Building Types

Three Main Categories:
1. Noncombustible (Types I and II)
2. Light-Frame (Types III and V)
3. Heavy/Mass Timber (Type IV)

Although use of mass timber products in low- to mid-rise in types III and V is very common

Credit: Susan Jones, atelierjones
Type IV-A 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>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>

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

Areas exclude potential frontage increase

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>

In most cases, Type IV-B height & story allowances = Type I-B height & story allowances
Type IV-B area = 2 * Type IV-HT area

Areas exclude potential frontage increase

Type IV-A Protection vs. Exposed

100% NC protection on all surfaces of Mass Timber

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-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>9</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>8</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 include potential frontage increase.

In most cases, Type IV-C height allowances = Type IV-HT height allowances, but additional stories permitted due to enhanced FRR.

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

Tall Wood Building Size Limits

<table>
<thead>
<tr>
<th>Construction Type (All Sprinklered Values)</th>
<th>I-A</th>
<th>I-B</th>
<th>IV-A</th>
<th>IV-B</th>
<th>IV-C</th>
<th>IV-HT</th>
<th>III-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable Building Height above Grade Plane (IBC Table 504.3)</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>120 ft</td>
<td>180 ft</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>270 ft</td>
</tr>
<tr>
<td>Allowable Number of Stories above Grade Plane (IBC Table 505.4)</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>12</td>
<td>18</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>24</td>
</tr>
</tbody>
</table>

Tall Wood Fire Resistance Ratings (FRR)

<table>
<thead>
<tr>
<th>Primary Frame or Brng Wall FRR</th>
<th>Floor Construction FRR</th>
<th>Roof Construction FRR</th>
<th>Floor Surface Protection</th>
<th>Roof Construction Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 HR (2 HR at Roof)</td>
<td>2 HR</td>
<td>2 HR</td>
<td>1.5 HR</td>
<td>1 HR</td>
</tr>
<tr>
<td>1 inch of NC protection</td>
<td>1 inch of NC protection</td>
<td>No protection req’d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 layers 5/8” type X gyp on inside face</td>
<td>2 layers 5/8” type X gyp on inside face</td>
<td>No protection req’d unless concealed space</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tall Wood Materials & Protection

<table>
<thead>
<tr>
<th>Exterior Walls</th>
<th>Structural Materials</th>
<th>Concealed Spaces</th>
<th>Gypsum Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Timber, exterior surface protected with 1 layer 5/8” type X gyp</td>
<td>Permitted, requires NC protection on MT surfaces</td>
<td>All MT permitted may be exposed except as noted</td>
<td>Permitted, requires NC protection on MT surfaces</td>
</tr>
<tr>
<td>Mass Timber or NC</td>
<td>All MT permitted</td>
<td>Limited exposed MT permitted, FRR still applies</td>
<td>3 HR: 3 layers 5/8” type X gyp</td>
</tr>
</tbody>
</table>

Credit: Susan Jones, atelierjones

Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman

Credit: Kaiser+PATH, Ema Peter

Occupancy

<table>
<thead>
<tr>
<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>65 ft</td>
<td>56,250 SF</td>
</tr>
<tr>
<td>B</td>
<td>9</td>
<td>85 ft</td>
<td>135,000 SF</td>
</tr>
<tr>
<td>M</td>
<td>6</td>
<td>85 ft</td>
<td>76,875 SF</td>
</tr>
<tr>
<td>R-2</td>
<td>8</td>
<td>85 ft</td>
<td>76,875 SF</td>
</tr>
</tbody>
</table>

All Mass Timber surfaces may be exposed. Exceptions: Shafts, concealed spaces, outside face of exterior walls.

Credit: Susan Jones, atelierjones

Areas exclude potential frontage increase.

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12/16/2019
EARLY TALL WOOD CODE ADOPTION

Washington state to allow mid and high-rise mass-timber buildings

State is first in the nation to allow building codes in support of a new generation of engineered wooden building materials with exciting properties of strength, durability and beauty. With mass timber, architects and builders acquire a new material to create with and rural areas gain the prospect of new high-skilled, high-paid jobs.

Statewide Alternate Method
No. 18-01 Tall Wood Buildings – Background

Statewide Alternate Method (SAM) No. 18-01 provides prescriptive path elements for Tall Wood Buildings of mass timber construction. This alternate path includes scientific conclusions established by the International Code Council’s Ad Hoc Committee on Tall Wood Buildings that were incorporated into fourteen national proposals and utilizes concrete, steel or masonry for the vertical elements of the seismic force-resisting system.

The provisions detailed in the SAM are crafted to coincide with the 2014 Oregon Structural Specialty Code (OSSC) when selected for use.

Three new types of construction are introduced under this method, all three of which are organized under Type IV construction, typically referred to as heavy timber.

The new types of construction are:

- Type IV A
- Type IV B
- Type IV C

SEATTLE MASS TIMBER TOWER

- 12 Stories
- 135,000 SF
- Type IV-B Construction – 2 HR FRR (1 HR at Roof)
- 14 ft Floor to Floor
- 12.5 ft x 42 ft Structural Grid
- Retail on 1st level; 5 floors of office; 192-key hotel
This concludes The American Institute of Architects Continuing Education Systems Course.

QUESTIONS?

Speaker name
Speaker organization
Speaker email address

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