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.
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</th>
<th>Rural</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>

Construction Traffic & Noise
Material Stockpiles
Labor Costs
Labor Availability
Weather Risks

Resiliency
Sustainability
Fire & Life Safety
MARKET DRIVERS FOR MASS TIMBER

PRIMARY DRIVERS
- Construction Efficiency & Speed
- Construction site constraints – Urban Infill
- Innovation/Aesthetic

SECONDARY DRIVERS
- Carbon Reductions
- Structural Performance – lightweight

Forecast: Mass Timber “Type” Projects
All stories (not just tall wood)
≈1 Billion SF per Year

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

Estimated construction types calculated using building stories and occupancy

2021 IBC Construction Types
- 19+
- IV-A
- IV-B
- IV-C
- III, IV, V

Opportunity for Tall Wood (various building types): 200 million sqft per year

Estimated construction types calculated using building stories and occupancy
TALL WOOD IN THE U.S.

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

Light-Frame Wood

Mass Timber

U.S. BUILDING CODE STATUS

3 YEAR CODE CYCLE
Seen as the catalyst for the mass timber revolution, CLT first recognized in US codes in the 2015 IBC.

Interest in tall wood projects in the US was rapidly increasing. Some building officials were reluctant to approved 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,
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

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

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.

- No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios.
- 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.
- No unusual fire department access issues
- 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

Test Description Construction
Test 1 All mass timber surfaces protected with 2 layers of 5/8” Type X Gypsum. No Sprinklers. IV-A
Test 2 30% of CLT ceiling area in living room and bedroom exposed. No Sprinklers. IV-B
Test 3 Two opposing CLT walls exposed – one in bedroom and one in living room. No Sprinklers. IV-B
Test 4 All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – normal activation IV-C
Test 5 All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – 20 minute delayed activation IV-C

Tests on exposed mass timber, gypsum-covered mass timber; normal sprinkler protection, delayed sprinkler protection. Majority of flames seen are from contents, not structure.

Images: AWC
TEST 1

Decay Phase

Photos provided by U.S. Forest Products Laboratory, USDA

Source: AWC

TEST 2

Photos provided by U.S. Forest Products Laboratory, USDA

Source: AWC

TEST 3

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 activation delayed for 20 minutes after smoke detector activation...approximately 23-1/2 minutes from ignition

Source: AWC

TEST 5

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:

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 (B. 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

ICC Public Comment Hearing Voting Results on Tall Wood Changes, October 2018
TALL WOOD APPROVED!
Unofficial results posted Dec 19, 2018
Final votes ratified Jan 31, 2019

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

U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

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 Construction 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

New Building Types
Credit: Susan Jones, atelierjones

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
**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

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**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>18</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

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**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>12</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-C Protection vs. Exposed

All Mass Timber surfaces may be exposed

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

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>115,000 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

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>V-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>120</td>
<td>120</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Allowable Number of Stories above Grade Plane (IBC Table 505.4)</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>18</td>
<td>18</td>
<td>12</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)</td>
<td>Unlimited</td>
<td>Unlimited</td>
<td>90,000</td>
<td>90,000</td>
<td>56,250</td>
<td>56,250</td>
<td>56,250</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>IV-A</td>
<td>2 HR</td>
<td>1 HR</td>
<td>1 HR</td>
<td></td>
</tr>
<tr>
<td>IV-B</td>
<td>2 HR</td>
<td>1 HR</td>
<td>1 HR</td>
<td></td>
</tr>
<tr>
<td>IV-C</td>
<td>2 HR</td>
<td>1 HR</td>
<td>No protection req’d</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 3 layers 5/8&quot; type X gyp</td>
<td>Mass Timber or NC</td>
<td>Permitted, requires NC protection on MT surfaces</td>
<td>All MT permitted may be exposed except as noted</td>
</tr>
<tr>
<td>Permitted, requires NC protection on MT surfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All MT is protected</td>
<td>3 HR: 3 layers 5/8&quot; type X gyp</td>
<td>2 HR or less: 3 layers 5/8&quot; type X gyp</td>
<td></td>
</tr>
</tbody>
</table>
| 3 layers 5/8" type X gyp on outside face | 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
EARLY TALL WOOD CODE ADOPTION

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