Outcomes of the ICC Tall Wood Ad Hoc Committee: Mass Timber in the 2021 I Codes

Prepared by:
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The guidance provided herein is not a formal interpretation of any AF&PA/AWC standard. Interpretations of AF&PA/AWC standards are only available through a formal process outlined in AF&PA’s standards development procedures.
The American Wood Council (AWC) provides wood design and construction information to assist building industry professionals, develops structural and fire performance data on a wide range of traditional and engineered wood products, and engages in long-term research.

AWC is an ANSI accredited standards developer.

**Code assistance – AWC field staff**

![Code assistance map]

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**Course Description**

In early 2016, the ICC Board of Directors approved the creation of an ad hoc committee to explore the building science of tall wood buildings with the scope being to investigate the feasibility of and take action to develop code changes for tall wood buildings. Since that time, the Tall Wood Building (TWB) Ad Hoc Committee has reviewed voluminous materials regarding tall wood buildings, including results of various testing around the world, as well as studies domestically in support of the TWB charge to conduct a thorough review of the science of tall wood.
The TWB developed its own test scenario(s) to substantiate any code change proposals (testing was carried out at ATF labs); and worked to develop a comprehensive set of technically-substantiated code changes for consideration during the 2018 Group A code development process. The intensive research performed by the Committee was submitted under the ICC Code Development Process, along with the resulting proposals developed by Committee consensus. All of the Group A TWB proposals have been approved. The TWB has also developed a set of Group B proposals, submitted in January 2019.

Learning Objectives

Upon completion, participants will be able to:

1. **TWB Ad Hoc Committee**
   - Identify the make-up of the TWB Ad Hoc Committee and the process used to reach consensus on proposed code changes.

2. **IBC Construction Types**
   - Recognize how the new types of construction compare with existing types of construction in the *International Building Code* and specify the inherent differences and conservative approaches the new types have.

3. **Building Sizes**
   - Understand the process by which the allowable heights, areas, and number of stories permitted for the proposed mass timber types of construction were developed and will be able to utilize the information for building design.

4. **Fire Resistance**
   - State the fire resistance requirements for mass timber building elements. Further distinguish when and where non-combustible protection can be omitted.

Outline

- History and Overview
- TWB Ad Hoc Committee and Testing
- Code Changes and Definitions
- IBC Construction Types
- Building Sizes
MASS TIMBER IBC TIMELINE SUMMARY: (Type IV and Heavy Timber)

- **2000 IBC**: Legacy code heavy timber combined to form IBC Type IV HT type of construction and exceptions.
- **2006 IBC**: Table 602.4 added with glulam sizes
- **2015 IBC**: Structural Composite Lumber (SCL) added to Table 602.4
- Cross Laminated Timber (CLT) and CLT product standard (PRG-320) added to IBC
- New provisions for CLT Type IV HT exterior walls
- **2018 IBC**: 602.4 and 2304.11 provisions consolidated and moved to 2304.11 along with Table 602.4 (no technical changes)

MASS TIMBER IBC TIMELINE SUMMARY: (Type IV and Heavy Timber)

- **2021 IBC (group A)**:
  - 3 New construction types: IVA, IVB and IVC developed by the ICC ad hoc Committee on Tall Wood Buildings (14 TWB code changes in this class)
  - 6 - 2021 IBC Type IV HT changes (non-TWB):
    - G81-18 corrects S-2 occupancy allowable area
    - G101-18 HT bearing walls 1 hour FRR supporting >2 floors
    - G102-18 Table 601 footnote c applies to roof primary frame
    - G109-18 allows protected concealed spaces in floor or roof
    - G110-18 correlates and clarifies Type IV HT exterior walls
    - G111-18 HT columns, beams & spandrels in exterior walls

Most Asked Questions:

**What is Mass Timber?**...

... and

**How different than HT?**
Answer:
Mass(ive) Timber is an umbrella term in the 2021 IBC for wood elements meeting the minimum dimensions and material types of Type IV-HT:
• sawn or mech laminated timber,
• glulam,
• structural composite lumber (SCL),
• cross laminated timber (CLT)

Question
How is Heavy Timber different than Mass Timber?

Answer
Heavy Timber typically (but not always) relies on the dimensions and detailing to provide an intrinsic but undetermined level of fire resistance....
Mass Timber or Heavy Timber FRR

Mass timber or heavy timber fire resistance rating may come from the wood, or noncombustible protection...

...or both

IBC principles for heavy timber and mass timber

- Mass Timber ≠ Conventional Light-Frame

Traditional Heavy Timber – Type IV HT

- 9 story
  Vancouver, BC
Sawn (Traditional) Heavy Timber:

Traditional Heavy Timber, Type IV HT:
- Montreal Original Fire Department Building out of Heavy Timber w/ housing above

Mechanically Laminated Decking
Nail-Laminated Timber

• 2304.8.3 Mechanically laminated decking.
• 2304.8.3.1 General.
• 2304.8.3.2 Nailing.
• 2304.8.3.3 Controlled random pattern.

Nail length_{min} = 2.5 x t_{lamination}
Nail spacing

< 30" o.c.* > 48" span
< 18" o.c.* > 48" span

*nail placement alternates between top and bottom
Other Innovations

Photos courtesy of StructureCraft

Dowel Laminated Timber

Photos provided by Structurecraft

Glulam

Photos provided by Truss Joist

Structural Composite Lumber (SCL)

Photos provided by Weyerhaeuser

Photos provided by Wood Solutions
**Structural Composite Lumber**

- Parallel Strand Lumber or other SCL

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**SCL in Type IV Heavy Timber**

- Structural Composite Lumber (SCL) as part of heavy timber in the 2015 IBC:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Width, inch</td>
<td>Depth, inch</td>
<td>Width, inch</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>6</td>
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<td>6</td>
<td>9</td>
<td>5</td>
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<tr>
<td>6</td>
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<td>5</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

- Minimum dimensions are established for SCL to qualify as Type IV or Heavy Timber in the 2015 IBC

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**2018 IBC, G 179 - G 180 602.4 Heavy Timber “reorganization”**

- Clarifies requirements for Type IV Construction and heavy timber elements
- Moves many heavy timber details to IBC Section 2304.11

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Cross Laminated Timber (CLT)

Photos provided by FPInnovations

CLT Definition & Product Standard

2015 IBC code change established the definition and product standard for CLT:

[B5] 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.

CLT is now a “material permitted by this code” in the 2015 IBC!

2015 IBC: CLT permitted uses:

- CLT is now a material permitted by the code:
- For Type I and II construction, CLT can be used for balcony and canopy or roof construction
- For Type III construction, CLT can be used for the interior building elements including:
  - Roof-ceiling assembly,
  - Floor-ceiling assembly
  - Interior walls
- For Type IV or V construction, CLT can be used for anything:
**CLT vs. GLT**

Cross Laminated Timber  
Glued Laminated Timber

![Thick Orthotropic Plate](image1)

Graphics provided by WoodWorks

Graphics provided by APA

**Typical Building Configurations**

Mass timber or heavy timber buildings may be of building frame type with: column and beam or slab; or platform with bearing walls

**Brock Commons: post and slab**
Detailing to address shrinkage...

Brock Commons: post and slab

IBC Section 2304.3.3

Shrinkage must be accounted for in platform construction:

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

Shake Table Tests on 7-story Building
• Conducted at E-Defense
• Building weight 270t
  • Self weight 120t
  • Added weight 150t
• Panel thickness
  • 140 mm (5.5") floors 1 and 2
  • 125 mm (4.9") floors 3 and 4
  • 85 mm (3.3") top 3 floors
• Wall panels length 2.3 m (7.5")

CLT – Soft Story Tests
1. 2’ CLT panels
2. Simpson HD8U
3. 5/8” A36 rod x 6 foot
4. 8” displacement
5. 1 inch rod elongation
6. Some angle damage

Google: CLT soft story test
CLT – Soft Story Tests

New testing of CLT shear wall system
Shake table testing at UCSD, August and Sept, 2017

• Steel fuse absorbs energy.

Photos Courtesy of Katerra
New testing of CLT shear wall system
Shake table testing at UCSD, August and Sept, 2017

Photos Courtesy of NHERI Tall Wood Project, Photo by Dr. Shiling Pei at Colorado School of Mines

New testing of CLT shear wall system
Shake table testing at UCSD, August and Sept, 2017

• Bent plate fuse absorbs energy.

Photos Courtesy of Washington State University

New testing of CLT shear wall system
Shake table testing at UCSD, August and Sept, 2017

• P695 Testing –platform framed wall with light gage clips between segments control drift and absorb energy.
Seismic systems with mass timber
Other lateral systems: buckling restrained brace system

Mass Plywood

Wood-Concrete Composites
Wood-Concrete Composites

Wood (LSL) - Concrete composite panels (4” conc., 1” insulation, over 3-1/2” LSL)

Wood-Concrete Composites

CrossLam Panel tight-fit tool

Photos courtesy of Structurecraft

Slide Courtesy of Structurlam
Outline

- History and Overview
- TWB Ad Hoc Committee and Testing
- Code Changes and Definitions
- IBC Construction Types
- Building Sizes

ICC TALL WOOD AD HOC COMMITTEE

Illustration courtesy Susan Jones
**ICC TALL WOOD AD HOC COMMITTEE**

**Project Scope**

In December 2015, the ICC Board established the ICC Ad Hoc Committee on Tall Wood Buildings noting the purpose of the ad hoc committee is to

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.

This scope will require further refinement by the committee.

**ICC TALL WOOD AD HOC COMMITTEE**

**Membership**

The Board has determined that the effort is to be undertaken by the newly formed Ad Hoc Committee on Tall Wood Buildings (AH-TWB). In making the committee appointments, the Board recognized the need to have a consensus committee comprised of the necessary balance of stakeholders including:

- Representatives from building construction material industries
- Building and Fire Officials
- Architects and engineers
- Fire protection experts
- Other construction related stakeholders

Photo courtesy Susan Jones
TWB Committee

- 4 Work Groups appointed
  - Definitions and Standards
  - Fire
  - Structural
  - Codes
- 82 major issues identified, assigned to specific work groups, and investigated
- Hundreds of reports reviewed and collected via ICC TWB webpage
- Performance Objectives discussed and listed
**TWB Ad Hoc Objectives**

TWB identified performance objectives to be met:

- No collapse under reasonable scenarios of complete burn-out of fuel without automatic sprinkler protection being considered
- 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

**TWB Ad Hoc Objectives (cont’d)**

TWB identified performance objectives to be met:

- No unusual fire department access issues
- Egress systems designed to protect building occupants during design escape time, plus a factor of safety
- Highly reliable fire suppression systems to reduce risk of failure during reasonably expected fire scenarios. Degree of reliability proportional to evacuation time (height) and risk of collapse.

**The TWB has determined that its comprehensive package of proposals meet these performance objectives**
## Mass Timber Fire Testing:

<table>
<thead>
<tr>
<th>Year</th>
<th>Test Sponsor and Location</th>
<th>Test Description</th>
<th>Fire Test Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>FPInnovations (FPI); National Research Council of Canada (NRC)</td>
<td>Protected Cross-Laminated Timber (CLT) Floor and Wall Tests</td>
<td>E 119</td>
</tr>
<tr>
<td>2012</td>
<td>American Wood Council (AWC); NGC Testing Services</td>
<td>5 ply CLT wall with 8700 PLF load protected with 1 layer of 5/8&quot; type X gypsum wallboard (GWB) each side</td>
<td>E 119</td>
</tr>
<tr>
<td>2014</td>
<td>WPC, Western Fire Center (WFC)</td>
<td>5 ply CLT wall with 8700 PLF load protected with 1 layer of 5/8&quot; type X gypsum wallboard (GWB) each side</td>
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<td>Nail Laminated Timber (NLT) and CLT compartments; 2 hour FRR fire stops</td>
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<td>2017</td>
<td>AWC, WFC</td>
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<tr>
<td>2018</td>
<td>AWC, SwRI</td>
<td>Development of a Fire Performance Assessment Methodology for CLT Adhesives</td>
<td>New PRG 320, Annex B standard</td>
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### “Non-Standard Fire” not in the code

Typical “non-standard” TT curve

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<td>LEVER Architecture, ARUP; SwRI</td>
<td>2 Hour exposed beam and column test with CLT deck</td>
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“Non-Standard Fire” not in the code
Behavior of Fire and Materials

- Fire needs three things:
  - Heat
  - Oxygen
  - Fuel

Source: AWC Staff

Behavior of Fire and Materials

- Phases of Fire
  - Ignition
  - Growth
  - Fully Developed
  - Decay

Source: AWC Staff

Behavior of Fire and Materials

Char layer
- tends to insulate the wood from heat sources

The updated version of AWC publication TR-10 is available free: www.awc.org
# Mass Timber Fire Testing:

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<td>GWB-Protected Beam Tests, Protected Structural Composite lumber (SCC) Tests</td>
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<td></td>
</tr>
<tr>
<td>2017</td>
<td>FPRF, NRC; NIST</td>
<td>Clad Timber Fire Tests</td>
<td>Non-Standard</td>
</tr>
<tr>
<td>2018</td>
<td>NRC</td>
<td>Fire Testing of Rooms with Exposed Second Generation PUR adhesive CLT</td>
<td>Non-Standard</td>
</tr>
</tbody>
</table>

## Adhesive qualification tests

Direction provided by ICC-TWB Ad-Hoc Committee

- Need test protocol capable of identifying heat-delaminating adhesives
- Code-referenced standards governing CLT should require adhesive qualification using this protocol
Qualification tests performed on other adhesives

- Fire re-growth observed with PUR
- No fire re-growth observed with
  - Melamine formaldehyde resin
  - Improved PUR
- Test identifies acceptable performance

2018 NRC, CNRC  Fire Testing of Rooms with Exposed Second Generation PUR adhesive CLT
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<td>CLT Compartment Fire Tests</td>
<td>Non-Standard</td>
</tr>
<tr>
<td>2017</td>
<td>UNLV, ENZ and ABA; SwRI, NSF, IIT lab</td>
<td>Wood species tests, two story Mass Timber Building</td>
<td>Non-Standard</td>
</tr>
</tbody>
</table>

### Non-combustible protection

FRR of mass timber element = time assigned to the exposed wood + time assigned to the added protection (usually gypsum)

### Ch 7: Fire & Smoke Protection Features

#### 703 Fire-Resistance Ratings and Standardized Fire Tests

Building elements are tested under a standardized test fire exposure for a given duration to:

1. Prevent passage of flame and temperature rise from one side to the other
2. Continue to provide vertical structural support when exposed to fire and elevated temperatures

- **How do calculations work to duplicate structural E119 fire test results?**
Technical Report 10 includes more details, background and commentary on the methods found in NDS chapter 16.

### NDS Ch 16 and TR-10, Beam, Column

#### Table 16.2.3A

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Effective Char Rate, ( R_{ch} ) (in/hr)</th>
<th>Effective Char Depth, ( R_{ch} ) (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hour</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>1 1/2 Hour</td>
<td>1.67</td>
<td>2.5</td>
</tr>
<tr>
<td>2 Hour</td>
<td>1.58</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Calculated Fire Resistance – NDS Ch 16

#### Table 16.2.2 Adjustment Factors for Fire Design

<table>
<thead>
<tr>
<th>Factor</th>
<th>ASD</th>
<th>( J_{fd} )</th>
<th>( J_{fr} )</th>
<th>( J_{nd} )</th>
<th>( J_{ns} )</th>
<th>( J_{efr} )</th>
<th>( J_{efn} )</th>
<th>( J_{ef} )</th>
<th>( J_{efn} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Strength ( F_b )</td>
<td>( x )</td>
<td>2.85</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Beam Buckling Strength ( F_{bd} )</td>
<td>( x )</td>
<td>2.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tensile Strength ( F_t )</td>
<td>( x )</td>
<td>2.85</td>
<td>( C_T )</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Compressive Strength ( F_c )</td>
<td>( x )</td>
<td>2.88</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Column Buckling Strength ( F_{cd} )</td>
<td>( x )</td>
<td>2.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1. \( F_{fr} \) and \( F_{efr} \) shall be multiplied by adjustment factors for specific products.
2. Factor shall be based on initial connection arrangement.
3. Factor shall be based on cross-sectional characteristics.
Fire Design of Exposed Wood Members

CLT manufactured with laminations of equal thickness

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Effective Char Depths, ( t_{\text{char}} ) (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3/4</td>
</tr>
<tr>
<td>1/2-hour</td>
<td>2.3</td>
</tr>
<tr>
<td>1-hour</td>
<td>3.4</td>
</tr>
<tr>
<td>2-hour</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Determination of effective residual cross-section

- Assume 5-plies @ 1.5” each ply = 7.5”
- Determine thickness for 1-hour rating
  - \( t_{\text{char}} = 1.8” \) (NDS Table 16.2.1B)
  - \( d = 7.5” – 1.8” = 5.7” \)
- Could conservatively assume 3-ply panel for design

Example Floor Calculation

Calculation on wall:
Non-combustible protection

FS5-18
IC: 702.8 (New)
Proposers: Stephen DiGiovanni, representing ICC Ad Hoc Committee on Tall Wood Buildings (TWB)

702.8 Determination of non-combustible protection time contribution. The time, in minutes, contributed to the fire resistance rating by the non-combustible protection of mass timber building elements, components, or assemblies, shall be determined through a comprehensive examination using appropriate tests in accordance with Sections E 119 and E 128. The test assemblies shall be typical of construction, loading, and exposure, other than the non-combustible protection. The test time shall be based on the same criteria as outlined below:
1. Test Assembly 1 shall be without protection.
2. Test Assembly 2 shall include the representative non-combustible protection. The protection shall be fully detailed in terms of configuration details, attachment details, and sealing details, accessories and all other relevant details.

The non-combustible protection time contribution shall be determined by subtracting the fire resistance time in minutes from Test Assembly 1 from the fire resistance time in minutes of Test Assembly 2.

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2011 FPInnovations (FPI); National Research Council of Canada (NRC)

E 119

3.7.1 NRC Protected CLT Floor and Wall Tests

As discussed in 2.8, in 2011, FPInnovations (FPI), in collaboration with the National Research Council of Canada (NRC), conducted a series of 8 full-scale fire resistance tests of CLT floors and walls [30]. All tests followed the ULC S101 fire exposure curve. A fire exposure comparable to the ASTM E119 time-temperature curve. Three of the CLT floors and one of the CLT walls were protected with GWB.

As reported in Section 2.8 for unprotected CLT floor and wall tests, loading of the floors and walls was based on Canadian standards. For purposes of this analysis, allowable stress design (ASD) values were determined using relevant grade levels from the CLT product standard, PRG-320 (51). Structural fire resistance was then calculated using NDS design provisions and appropriate ASD design values from PRG-320.

NRC Test #1 - Protected Floor:
NRC Test #2 - Protected Wall:
NRC Test #5 - Protected Floor:
NRC Test #6 - Protected Floor:

---

2014 AWC; Western Fire Center (WFC)

E 119

GWB-Protected Beam Tests, Protected Structural Composite Lumber (SCL) Tests

<table>
<thead>
<tr>
<th>Table 16b: Added Contribution of Optimum Wallboard Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>SCL - 2x6, 2x8, 2x10, 2x12</td>
</tr>
<tr>
<td>GAC - 2x6, 2x8, 2x10, 2x12</td>
</tr>
<tr>
<td>SCL - 2x6, 2x8, 2x10, 2x12</td>
</tr>
</tbody>
</table>
*Gypsum wallboard cores were not tested, resulting in empirical values.

When tested in accordance with ASTM E119, all ten SCL beams lasted longer in the fire tests than the calculated fire resistance corresponding to the actual applied load level. Accordingly, test results support the use of the calculation procedure as NDS Chapter 16 and TR10 for SCL.
Non-combustible protection

FS81-18

TABLE 722.7.1(1)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Protection Required (Min., per Foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
</tr>
</tbody>
</table>

TABLE 722.7.1(2)

<table>
<thead>
<tr>
<th>Non-combustible Protection</th>
<th>Description</th>
<th>Protection Required (Min., per Foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch Type X gypsum board</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1/2 inch Type X gypsum board</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 722.7.1(a) Protection Required From Noncombustible Covering Material

<table>
<thead>
<tr>
<th>Fire Resistance Rating of Building Elements (Per Tables 601 and 602) (hours)</th>
<th>Minimum Protection Required from Noncombustible Protection (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
</tr>
<tr>
<td>3 or More</td>
<td>120</td>
</tr>
</tbody>
</table>

Table 722.7.1(b) Protection Provided by Noncombustible Covering Material

<table>
<thead>
<tr>
<th>Noncombustible Protection</th>
<th>Protection Contribution (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch Type X Gypsum Board</td>
<td>30</td>
</tr>
<tr>
<td>5/8 Type X Gypsum Board</td>
<td>40</td>
</tr>
</tbody>
</table>

Noncombustible protection

Attachment of Type X Gypsum Board Used as Noncombustible Protection:

- Screws shall penetrate ≥1" into mass timber
- Screws shall be spaced no more than 12" o.c. in each direction
- Screws at panel edges shall be between 1" and 2" from the edge
- Panel edges shall be offset 18" from those of adjacent layers
- Stair-step profile required at wall-to-wall & wall-to-ceiling intersections
- Screw heads and panel joints shall be covered with joint compound

Other testing of NC protection:

Photo Courtesy of ROCKWOOL
Other testing of NC protection:

Objective: Quantify contribution of other non-combustible protection in addition to gypsum on Mass Timber

<table>
<thead>
<tr>
<th>CLT Type/Grade</th>
<th>Single-Layer Protection</th>
<th>Triple-Layer Protection</th>
<th>Mineral Wool Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-Layer V4 (Smartlam)</td>
<td>75% of ASD moment (including self-weight)</td>
<td>75% of ASD moment (including self-weight)</td>
<td>75% of ASD moment (including self-weight)</td>
</tr>
<tr>
<td>CLT Panel Size</td>
<td>Two 7’x18’ panels per test, joined together for an overall size of 14’x18’</td>
<td>Two 7’x18’ panels per test, joined together for an overall size of 14’x18’</td>
<td>Two 7’x18’ panels per test, joined together for an overall size of 14’x18’</td>
</tr>
<tr>
<td>Loading</td>
<td>24 sand-filled barrels, uniformly-distributed for an applied load of 60 psf</td>
<td>24 sand-filled barrels, uniformly-distributed for an applied load of 60 psf</td>
<td>24 sand-filled barrels, uniformly-distributed for an applied load of 60 psf</td>
</tr>
<tr>
<td>Span</td>
<td>17’-10”</td>
<td>17’-10”</td>
<td>17’-10”</td>
</tr>
<tr>
<td>Load Ratio</td>
<td>75% of ASD moment (including self-weight)</td>
<td>75% of ASD moment (including self-weight)</td>
<td>75% of ASD moment (including self-weight)</td>
</tr>
<tr>
<td>Noncombustible protection</td>
<td>1 layer of 5/8” Type X gypsum wallboard</td>
<td>3 layers of 5/8” Type X gypsum wallboard</td>
<td>2” thick; 8 pcf mineral wool</td>
</tr>
</tbody>
</table>
| GWB attachment | None | Type S screws @ 12” o.c. both directions, staggered 4” each layer, 1” penetration into CLT, 1.5” edge distance | Type S screws and 1.5” fender washers at CLT edges

| Deflection at End of Test | 0.15” | 0.15” | 0.15” |
| Test duration | 149.4 minutes | 189.7 minutes | 276.8 minutes |
| Noncomparable contribution | 40.3 minutes | 127.4 minutes | 113 minutes |
| Time attributed to each layer | 40.3 min/layer | 42.5 min/layer | 113 minutes |

Behavior of Fire and Materials

- Wood exposed to high temperature:
  - low thermal conductivity
  - dimensionally stable
  - inner portion remains cool
  - does not lose strength
  - **Contributes to the Fire!**

Fire Behavior Depends on:

Fire behavior depends in part on:

- Amount of exposed wood
- Arrangement of exposed wood
- Thermal performance of adhesive
MASS TIMBER: FRR & NC PROTECTION CHECKLIST:

- Mass timber material meets heavy timber minimum dimension requirements found in IBC 2304.11?
- Exposed MT meets limits for area and separation between exposed locations?
- NC Protection meets 2/3 FRR of Table 601 and other specific requirements?
- Overall FRR of building elements (either exposed or protected) meet the minimum FRR requirements of Table 601 (calculated or tested)?

Additional NC Protection of CLT:

All have 3 hour or more fire resistance rating:

- 1 layer
- Limited protection
- Complete protection

Is the behavior the same?

Behavior of Fire and Materials

Protection of mass timber construction:
Mass Timber Fire Testing:

<table>
<thead>
<tr>
<th>Year</th>
<th>Test sponsor (Location)</th>
<th>Test Description</th>
<th>Fire Test Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>FPInnovations (FPI); National Research Council of Canada (NRC)</td>
<td>Protected Cross-Laminated Timber (CLT) Floor and Wall Tests</td>
<td>E 119</td>
</tr>
<tr>
<td>2012</td>
<td>American Wood Council (AMC); NGC Testing Services</td>
<td>5 ply CLT wall with 8700 PLF load protected with 1 layer of 5/8&quot; type X gypsum wall board (GWB)</td>
<td>E 119</td>
</tr>
<tr>
<td>2014</td>
<td>ASC; Western Wood Products Association (WWPA)</td>
<td>Wood-Fiber Reinforced Plastics (WFRP) Fire Tests</td>
<td>E 119</td>
</tr>
<tr>
<td>2015</td>
<td>ASC; Southwest Research Institute (SWRI)</td>
<td>Nail-laminated wood-frame wall</td>
<td>Non-standard; E 814</td>
</tr>
<tr>
<td>2016</td>
<td>ASC; Southwest Research Institute (SWRI)</td>
<td>2 hour unprotected structure wall</td>
<td>Non-standard</td>
</tr>
<tr>
<td>2017</td>
<td>Lever Architecture, ARUP; SwRI</td>
<td>Non-standard; E 119</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>NRC, CNRC Fire Testing of Rooms with Exposed Second Generation PUR adhesive CLT</td>
<td>Non-standard</td>
<td></td>
</tr>
</tbody>
</table>

- Purpose: Perform tests of realistic fire scenarios applicable to tall wood construction in order to evaluate occupant and firefighter tenability for egress and suppression efforts, and to provide data necessary to guide further development of relevant code and standard provisions.
- Conducted at U.S. government facilities (ATF).
- Supervised by U.S. Forest Product Laboratory staff.
Compartment Fire Tests, Non-Standard

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Date</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>All mass timber surfaces protected with 2 layers of 5/8&quot; Type X GWB</td>
<td>5/23/17</td>
<td>3 hours</td>
</tr>
<tr>
<td>Test 2</td>
<td>10% of CLT ceiling area in living room and bedroom exposed</td>
<td>5/31/17</td>
<td>4 hours</td>
</tr>
<tr>
<td>Test 3</td>
<td>Two opposing CLT walls exposed – one in bedroom and one in living room (there is a partition wall)</td>
<td>6/20/17</td>
<td>4 hours</td>
</tr>
<tr>
<td>Test 4</td>
<td>All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – normal activation</td>
<td>6/27/17</td>
<td>6 minutes</td>
</tr>
<tr>
<td>Test 5</td>
<td>All mass timber surfaces fully exposed in bedroom and living room (except bathroom). Sprinklered – 23 min delayed activation</td>
<td>6/29/17</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

- Tests 1 through 3: unlikely scenario in which automatic sprinklers fail to activate and fire service unable to respond
- Test 4: normal sprinkler activation
- Test 5: automatic sprinklers fail to activate, but are later manually charged by fire service

Two stories, one apartment per level
- Each apartment: 30 ft x 30 ft
- Ceiling height: 9 ft
- 5-ply CLT
  - Douglas fir-Larch species group
  - Lamination Thickness: 1.375 inches
  - CLT Thickness: 6.875 inches
  - Polyurethane Adhesive
- Corridor around each apartment and a 2 hour stair enclosure
• Partitions used unrated ½" gypsum wallboard
• Kitchen & Living Room: 15 ft x 30 ft
• Bedroom & Bath: 15 ft x 30 ft
• 20-min rated door between compartment and corridor
• 90-min rated door between corridor and stairwell
• Fuel load ~570 MJ/m²
ATF fire Test #1 - All Mass Timber Protected
All mass timber surfaces protected with 2 layers of 5/8" Type X GWB

ATF fire Test #2 – 20% of Dwelling Unit CLT Ceilings Exposed
30% of CLT ceiling area in living room and bedroom exposed
Live load applied using water barrels
Atf fire Test #2 – 20% of Dwelling Unit
CLT Ceilings Exposed

Post-Fire Condition of Glulam
After Gypsum Removal

- Fire intensity decreased subsequent to consumption of furnishings and contents (known as decay phase)
- Exposed mass timber surfaces self-extinguished in the decay phase
- Mass timber surfaces protected with 2 layers of 5/8” Type X GWB remained mostly uncharred

Section of exposed ceiling (90º angle)
Two opposing CLT walls exposed one in bedroom and one in living room

ATF fire Test #3 – Exposed Walls

Atf Fire Test #3  40% of Dwelling Unit Floor Area Walls Exposed

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

ATF fire Test #4 – Sprinklers, Exposed
Test #5 – delayed Sprinklers

All mass timber surfaces fully exposed in bedroom and living room.

Sprinkler – water delayed for 20 minutes after sprinkler activation within the test compartment…approximately 23 minutes from ignition

- Flashover conditions were reached in the kitchen, and the bedroom was very near reaching flashover
- The sprinkler system effectively suppressed the fire

TWB Committee Fire Testing Summary:

Fire Work Group created fire test scenarios to study and validate the TWB code change proposals

- Test structure represented multi-story condo
- 30 ft x 30 ft interior dimensions
- Corridor and stair included in the structure
- UL “modern furnishings” fuel load imposed → 570 MJ/m²
  - fuel load was approximately 85th percentile of Group R fuel loads from survey of Group R’s

ATF Fire Test Results – Event Log

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Time After Ignition (min):</th>
<th>Flashover (600°C) Bedroom</th>
<th>Flashover (600°C) Living Room</th>
<th>Flames in Hallway</th>
<th>Compartment door fails</th>
<th>Sprinkler Activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1st Floor</td>
<td>13:27</td>
<td>17:20</td>
<td>26:51</td>
<td>57:46</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>2nd Floor</td>
<td>11:42</td>
<td>17:20</td>
<td>30:38</td>
<td>63:59</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>2nd Floor</td>
<td>12:37</td>
<td>17:00</td>
<td>29:42</td>
<td>57:46</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>3rd Floor</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2:37</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>4th Floor</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>23:00</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Tests 2 and 3 terminated at 4 hours with no re-growth
ATF Fire tests


Fire Test Videos on AWC Website: www.awc.org/tallmasstimber

Repair in Place?

Repair of CLT?
## Mass Timber Fire Testing:

<table>
<thead>
<tr>
<th>Year</th>
<th>Test Sponsor and Location</th>
<th>Test Description</th>
<th>Fire Test Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>FPInnovations (FPI); National Research Council of Canada (NRC)</td>
<td>Protected Cross-Laminated Timber (CLT) Floor and Wall Tests, E 119</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>American Wood Council (AWC); NGC Testing Services</td>
<td>5 ply CLT wall with 2 hour protected with 1 layer of 5/8&quot; type X gypsum wallboard (GWB) each side, E 119</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>AWC, Western Fire Center (WFC)</td>
<td>GWB-Protected Beam Tests, Protected Structural Composite Lumber (SCL) Tests, E 119</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>AWC, Southwest Research Institute (SwRI)</td>
<td>Nail Laminated Timber (NLT) and CLT compartments; 2 hour FRR fire stops, Non-Standard; E 814</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>LEVER Architecture, ARUP; AWC, SwRI</td>
<td>2 Hour exposed beam and column test with CLT deck, E 119</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>FPRF, NRC; NIST National Fire Research Lab</td>
<td>Non-Standard; CLT Compartments Fire Tests (w/ first generation PUR adhesive CLT)</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>AWC, SwRI; US FPL, ICC Tall Wood Ad Hoc (TWB), AWC, ATF lab</td>
<td>Non-Standard; CLT Compartments Fire Tests, Non-Standard; Two story Mass Timber Building</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>AWC, SwRI</td>
<td>Development of an Experimental Assessment &amp; Methodology for CLT Adhesives, Non-Standard; E 814</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>AWC, SwRI</td>
<td>Non-Standard; CLT Compartments Fire Tests, Non-Standard; CLT Adhesives</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>NWRI, NR Can.</td>
<td>Fire testing of modern mass timber evaluated with second generation PUR adhesive CLT, Non-Standard</td>
<td></td>
</tr>
</tbody>
</table>

## “Non-Standard Fire” not in the code

Typical “non-standard” TT curve

[![Compartiment Temperature](image)](image)
Nail Laminated Timber (NLT) and CLT compartments; 2 hour FRR fire stops

Non-Standard; E 814

Figure 4.2: Sample after 2-h Exposure.

2016 LEVER Architecture, ARUP; SwRI
2 Hour exposed beam and column test with CLT deck
E 119

Slide Courtesy of Arup
Outline

• History and Overview
• TWB Ad Hoc Committee and Testing
• Code Changes and Definitions
• IBC Construction Types
• Building Sizes

TWB Committee Proposals

TWB Group A Work Product:

• 14 code change proposals to-date; hundreds of code sections reviewed
• 3 new types of construction
• New entries in Height (feet), Height (stories) and Area for the IBC
• Multiple new requirements for safety while under construction
• Existing exterior wall test standard still required (currently NFPA 285 per IBC)
TWB Committee Group A Proposals –
ALL APPROVED as submitted OR as modified.

- G108 New types of construction and definitions
- G75 Height in feet
- G80 Height in stories
- G84 Allowable area per floor
- G89 Fire barriers
- G146 Membrane structures with mass timber
- G152 Appendix
- G28 Redundant water supply
- FS5 Performance based noncombustible protection
- FS6 Sealing of Splices and intersections
- FS73 Mass timber as fire blocking
- FS81 Prescriptive noncombustible protection
- IFC F88 Owners responsibility
- IFC F266 Fire safety during construction

SO LET'S LOOK AT SOME OF THOSE NEW CODE SECTIONS...

Definitions: G108-18

**Mass Timber**. Structural elements of Type IV construction primarily of solid, built-up, panelized or engineered wood products that meet minimum cross section dimensions of Type IV construction.

**Noncombustible Protection (FOR MASS TIMBER)**: Noncombustible material, in accordance with Section 703.5, designed to increase the fire-resistance rating and delay the combustion of mass timber.

**[BS] Wall, Load Bearing.** Any wall meeting either of the following classifications:

1. Any metal or wood stud wall that supports more than 100 pounds per linear foot (1459 N/m) of vertical load in addition to its own weight.
2. Any masonry, or concrete, or mass timber wall that supports more than 200 pounds per linear foot (2919 N/m) of vertical load in addition to its own weight.
Definitions: G108-18

**Mass Timber**: Structural elements of Type IV construction primarily of solid, built-up, panelized or engineered wood products that meet minimum cross section dimensions of Type IV construction.

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Outline

• History and Overview
• TWB Ad Hoc Committee and Testing
• Code Changes and Definitions
• IBC Construction Types
• Building Sizes

Key considerations in Chapter 6:

• Allowed Materials
• Structural FRR (Table 601)
• Amount and location of non-combustible protection
• NC protection of concealed spaces
• NC protection of other features
602.4 Type IV. Type IV construction is that type of construction in which the building elements are mass timber or noncombustible materials and have fire resistance ratings in accordance with Table 601. Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both and shall be determined in accordance with Section 703.2 or 703.3. The minimum dimensions and permitted materials for building elements shall comply with the provisions of this section and Section 2304.11. Mass timber elements of Types IV A, IV B and IV C construction shall be protected with noncombustible protection applied directly to the mass timber in accordance with Sections 602.4.1 through 602.4.3. The time assigned to the noncombustible protection shall be determined in accordance with Section 703.8 and comply with 722.7.

602.4 Type IV (cont’d)

All cross-laminated timber shall be labeled as conforming to the heat performance requirements of Section 6.1.3.4 of DOC PRG 320-18 as referenced in Section 2303.1.4 and have no delamination in any specimen, except when occurring at a localized characteristic when permitted in the product standard.

Exterior load-bearing walls and nonload-bearing walls shall be mass timber construction, or shall be of noncombustible construction.

Exception: Type IV-HT Construction in accordance with Section 602.4.4.

The interior building elements, including nonload-bearing walls and partitions, shall be of mass timber construction or of noncombustible construction.

Exception: Type IV-HT Construction in accordance with Section 602.4.4.

Combustible concealed spaces are not permitted except as otherwise indicated in Sections 602.4.1 through 602.4.4. Combustible stud spaces within light frame walls of Type IV-HT construction shall not be considered concealed spaces, but shall comply with Section 718.

602.4.1.6 Shafts. Shafts shall be permitted in accordance with Sections 713 and Section 718. Both the shaft side and room side of mass timber elements shall be protected in accordance with Section 602.4.1.2.
Exit and Hoistway Enclosures:

**Key considerations in Chapter 6:**

- Allowed Materials
- **Structural FRR (Table 601)**
- Amount and location of non-combustible protection
- NC protection of concealed spaces
- NC protection of other features

**TWB proposed Text**

602.4 Type IV. Type IV construction is that type of construction in which the building elements are mass timber or noncombustible materials and have fire resistance ratings in accordance with Table 601. Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both and shall be determined in accordance with Section 703.2 or 703.3. The minimum dimensions and permitted materials for building elements shall comply with the provisions of this section and Section 2304.11. Mass timber elements of Types IV A, IV B and IV C construction shall be protected with noncombustible protection applied directly to the mass timber in accordance with Sections 602.4.1 through 602.4.3. The time assigned to the noncombustible protection shall be determined in accordance with Section 703.8 and comply with 722.7.
Type of construction

**Table 601 (comparison)**

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>HFT</td>
<td>HT</td>
<td>HT</td>
</tr>
<tr>
<td>Columns</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Primary Frame</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Interior Bearing Walls</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Floor Assembly</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>reduce 1 hour</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NC protection reductions</strong>:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* reduce 1 hour (except for F-1, H-2, H-3, H-4, M and S-1 occupancies)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key considerations in Chapter 6:

- Allowed Materials
- Structural FRR (Table 601)
- **Amount and location of non-combustible protection**
- NC protection of concealed spaces
- NC protection of other features

**TWB proposed Text**

602.4 Type IV. Type IV construction is that type of construction in which the building elements are mass timber or noncombustible materials and have fire resistance ratings in accordance with Table 601. Mass timber elements shall meet the fire resistance rating requirements of this section based on either the fire resistance rating of the noncombustible protection, the mass timber, or a combination of both and shall be determined in accordance with Section 703.2 or 703.3. The minimum dimensions and permitted materials for building elements shall comply with the provisions of this section and Section 2304.11. Mass timber elements of Types IV A, IV B and IV C construction shall be protected with noncombustible protection applied directly to the mass timber in accordance with Sections 602.4.1 through 602.4.3. The time assigned to the noncombustible protection shall be determined in accordance with Section 703.8 and comply with 722.7.
Brock Commons: IVA NC Protection:

Noncombustible protection in Type IV-B

Type IV-B
602.4.2.2 Protected Area. All interior faces of all mass timber elements shall be protected in accordance with Section 602.4.2.2.1, including the inside faces of exterior mass timber walls and mass timber roofs.

Exceptions: Unprotected portions of mass timber ceilings and walls complying with Section 602.4.2.2.4 and the following:

1. Unprotected portions of mass timber ceilings, including attached beams, shall be permitted and shall be limited to an area equal to 20% of the floor area in any dwelling unit or fire area; or

2. Unprotected portions of mass timber walls, including attached columns, shall be permitted and shall be limited to an area equal to 40% of the floor area in any dwelling unit or fire area; or

3. Unprotected portions of both walls and ceilings of mass timber, including attached columns and beams, in any dwelling unit or fire area shall be permitted in accordance with section 602.4.2.2.3.

ATF Test: IVB NC Protection:
TWB Committee proposals

602.4.2.2.3 Mixed Unprotected Areas. In each dwelling unit or fire area, where both portions of ceilings and portions of walls are unprotected, the total allowable unprotected area shall be determined in accordance with Equation 6-1.

\[(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1 \quad \text{(Equation 6-1)}\]

where:

- \(U_{tc}\) = Total unprotected mass timber ceiling areas
- \(U_{ac}\) = Allowable unprotected mass timber ceiling area conforming to Section 602.4.2.2, exception item 1
- \(U_{tw}\) = Total unprotected mass timber wall areas
- \(U_{aw}\) = Allowable unprotected mass timber wall area conforming to Section 602.4.2.2, exception item 2

TWB Committee proposals

602.4.2.2.4 Separation Distance Between Unprotected Mass Timber Elements. In each dwelling unit or fire area, unprotected portions of mass timber walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.

Key considerations in Chapter 6:

- Allowed Materials
- Structural FRR (Table 601)
- Amount and location of non-combustible protection
- **NC protection of concealed spaces**
- NC protection of other features
TWB proposed Text

602.4 Type IV (cont’d)

All cross-laminated timber shall be labeled as conforming to the heat performance requirements of Section 6.1.3.4 of DOC PS1-PRG 320-18 as referenced in Section 2303.1.4 and have no delamination in any specimen, except when occurring as a localized characteristic when permitted in the product standard.

Exterior load-bearing walls and nonload-bearing walls shall be mass timber construction, or shall be of noncombustible construction.

Exception: Type IV-HT Construction in accordance with Section 602.4.4.

The interior building elements, including nonload-bearing walls and partitions, shall be of mass timber construction or of noncombustible construction.

Exception: Type IV-HT Construction in accordance with Section 602.4.4.

Combustible concealed spaces are not permitted except as otherwise indicated in Sections 602.4.1 through 602.4.4. Combustive stud spaces within light frame walls of Type IV-HT construction shall not be considered concealed spaces, but shall comply with Section 718.

Concealed Spaces

No exposed combustibles other than plenum exception permitted in concealed space

G108-18

G108-18

Proposed: Stephen Gilbreath, representing ICC Ad Hoc Committee on Tall Wood Buildings (tallwoodcrafts.org)

Key considerations in Chapter 6:

- Allowed Materials
- Structural FRR (Table 601)
- Amount and location of non-combustible protection
- NC protection of concealed spaces
- NC protection of other features
TWB Committee proposals

602.4 Type IV (cont’d)
In buildings of Type IV-A, B, and C, construction with an occupied floor located more than 75 feet above the lowest level of fire department access, up to and including 12 stories or 180 feet above grade plane, mass timber interior exit and elevator hoistway enclosures shall be protected in accordance with Section 602.4.1.2.

In buildings greater than 12 stories or 180 feet above grade plane, interior exit and elevator hoistway enclosures shall be constructed of non-combustible materials.

602.4.1.6 Shafts. Shafts shall be permitted in accordance with Sections 713 and Section 718. Both the shaft side and room side of mass timber elements shall be protected in accordance with Section 602.4.1.2.

Exterior Wall Section

All material outboard of the Mass Timber MUST BE NONCOMBUSTIBLE

Except: water resistive barrier

1 layer 5/8 in. Type X GWB (or equivalent)

Required on outside of exterior walls for Type IV-A, B and C

Exterior Wall Section
### In Summary: Type of Construction IV-A

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Maximum Height</th>
<th>270’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Stories</td>
<td>18 maximum</td>
<td></td>
</tr>
<tr>
<td>Exposed Mass Timber?</td>
<td>No exposed MT, full NC protection including floors</td>
<td></td>
</tr>
<tr>
<td>Sprinklers</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Primary Frame FRR</td>
<td>3 hours</td>
<td></td>
</tr>
<tr>
<td>Floor FRR</td>
<td>2 hours</td>
<td></td>
</tr>
<tr>
<td>Primary Frame FRR coming from NC protection</td>
<td>120 minutes</td>
<td></td>
</tr>
<tr>
<td>Stair Towers (if over 120 feet)</td>
<td>Non-combustible</td>
<td></td>
</tr>
<tr>
<td>Concealed Spaces</td>
<td>Permitted but protected</td>
<td></td>
</tr>
</tbody>
</table>

### In Summary: Type of Construction IV-B

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Maximum Height</th>
<th>180’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Stories</td>
<td>12 maximum</td>
<td></td>
</tr>
<tr>
<td>Exposed Mass Timber?</td>
<td>Up to 20% ceiling or 40% of floor area for walls, floors protected</td>
<td></td>
</tr>
<tr>
<td>Sprinklers</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Primary Frame FRR</td>
<td>2 hours</td>
<td></td>
</tr>
<tr>
<td>Floor FRR</td>
<td>2 hours</td>
<td></td>
</tr>
<tr>
<td>Fire Resistance from Non-core</td>
<td>80 minutes</td>
<td></td>
</tr>
<tr>
<td>Stair Towers</td>
<td>Mass Timber or NC</td>
<td></td>
</tr>
<tr>
<td>Concealed Spaces</td>
<td>Permitted but protected</td>
<td></td>
</tr>
</tbody>
</table>

### In Summary: Type of Construction IV-C

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Maximum Height</th>
<th>85’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Stories</td>
<td>9 maximum</td>
<td></td>
</tr>
<tr>
<td>Exposed Mass Timber?</td>
<td>Fully exposed (except both sides of stair and shaft enclosures, outside of exterior walls protected)</td>
<td></td>
</tr>
<tr>
<td>Sprinklers</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Primary Frame FRR</td>
<td>2 hours</td>
<td></td>
</tr>
<tr>
<td>Floor FRR</td>
<td>2 hours</td>
<td></td>
</tr>
<tr>
<td>Stair Tower</td>
<td>Mass Timber or NC</td>
<td></td>
</tr>
<tr>
<td>Concealed Spaces</td>
<td>Permitted but protected</td>
<td></td>
</tr>
</tbody>
</table>
TWB Committee Group A Proposals –
ALL APPROVED as submitted OR as modified.

- G108 New types of construction
- G75 Height in feet
- G80 Height in stories
- G84 Allowable area per floor
- G89 Fire barriers
- G146 Membrane structures with mass timber
- G152 Appendix
- G28 Redundant water supply
- FS5 Performance based noncombustible protection
- FS6 Sealing of Splices and intersections
- FS73 Mass timber as fire blocking
- FS81 Prescriptive noncombustible protection
- IFC F88 Owners responsibility
- IFC F266 Fire safety during construction

SO LET'S LOOK AT SOME OF THOSE NEW CODE SECTIONS...

Outline

- History and Overview
- TWB Ad Hoc Committee and Testing
- Code Changes and Definitions
- IBC Construction Types
- Building Sizes
Height and area

Table 504.3, Allowable Height (G75-18):

- Type IV B set based on equivalence with Type I B: 180 feet for occupancy groups A, B, E, F, M, S, U and R
- Reduced ½ to 1/3 for other occ groups
- Type IV A = IV B x 1.5 instead of UL
- Type IV C = IV HT with no increase

ALLOWABLE HEIGHTS – feet

<table>
<thead>
<tr>
<th>OCCUPANCY CLASSIFICATION</th>
<th>TYPE OF CONSTRUCTION</th>
<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, B, E, F, M, S, U</td>
<td>TYPE IV B</td>
<td>180</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-1, H-2, H-3, H-5</td>
<td>TYPE IV B</td>
<td>180</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-8</td>
<td>TYPE IV B</td>
<td>180</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-1 Condition 1, 1.12</td>
<td>TYPE IV B</td>
<td>180</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-1 Condition 2, 1.12</td>
<td>TYPE IV B</td>
<td>180</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H-4</td>
<td>TYPE IV B</td>
<td>180</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Height and area

Table 504.4, Allowable Stories (G80-18):

- Type IV B set based on equivalence with Type I B: 12 stories for occupancy groups A-2, A-3, A-4, B, and R; 6 stories for A-1, E and U
- Reduced for F, I, M, H-4 and S occ groups; and other H occ groups = IV HT
- Type IV A = IVB x 1.5 (not UL); H=IV HT
- Type IV C = IV HT x 1.5 for A 2-4, B, R
ALLOWABLE HEIGHTS – stories

Height and area

Table 506.2, Allowable Area (G84-18):

- Type IV C based on IV HT x 1.25 (with some exceptions)
- Type IV B based on IV HT x 2.0 (with some exceptions)
- Type IV A based on IV HT x 3.0 (with some exceptions)

IVA and IVB much more conservative than UL (taller = smaller fire area, floor)
### ALLOWABLE areas – square feet

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Fire Area (square feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>Type II</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>100,000</td>
<td>125,000</td>
</tr>
<tr>
<td>200,000</td>
<td>250,000</td>
</tr>
<tr>
<td>300,000</td>
<td>375,000</td>
</tr>
<tr>
<td>400,000</td>
<td>500,000</td>
</tr>
</tbody>
</table>

### Comparison of Fire Area:

**EACH Type IV A, B or C FLOOR IS A SEPARATE FIRE AREA FOR:**

- A, B, E, F-2, H-4, H-5, I, M, R, & S-2 occ groups

### Comparison of Fire Area (5 story - R)

<table>
<thead>
<tr>
<th>Building # of Stories</th>
<th>Assembly Occupancy</th>
<th>Office Occupancy</th>
<th>Residential Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>U/L</td>
<td>U/L</td>
<td>U/L</td>
</tr>
<tr>
<td>2</td>
<td>U/L</td>
<td>U/L</td>
<td>90,000</td>
</tr>
<tr>
<td>3</td>
<td>U/L</td>
<td>U/L</td>
<td>120,000</td>
</tr>
<tr>
<td>4</td>
<td>U/L</td>
<td>U/L</td>
<td>162,000</td>
</tr>
<tr>
<td>5</td>
<td>U/L</td>
<td>U/L</td>
<td>210,000</td>
</tr>
<tr>
<td>6</td>
<td>U/L</td>
<td>U/L</td>
<td>262,000</td>
</tr>
<tr>
<td>7</td>
<td>U/L</td>
<td>U/L</td>
<td>325,000</td>
</tr>
<tr>
<td>8</td>
<td>U/L</td>
<td>U/L</td>
<td>390,000</td>
</tr>
<tr>
<td>9</td>
<td>U/L</td>
<td>U/L</td>
<td>460,000</td>
</tr>
<tr>
<td>10</td>
<td>U/L</td>
<td>U/L</td>
<td>535,000</td>
</tr>
</tbody>
</table>

**Fire Area Comparison of IVB (unlimited) vs. IVB vs. IIIA:**

- Fire Area is each floor for Type IVB: 73,800 sf on one floor (147,600 sf if 2 floors open)
- Fire Area is entire building for Type IIIA: 3 x 72,000 = 216,000 sf for total building
**Comparison of Fire Area (5 story - R)**

Fire Area Comparison of IB (unlimited) vs. IVB vs. IIIA:
- Fire Area is each floor for Type IVB: 73,800 sf one floor (147,600 sf if 2 floors open)
- Fire Area is entire building for Type IIIA: 3 x 72,000 = 216,000 sf for total building

### IV B vs IIIA: group R Fire Area Comparison:

<table>
<thead>
<tr>
<th></th>
<th>Type IV-B</th>
<th>Type IV-B</th>
<th>Type IV-B</th>
<th>Type III-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 story</td>
<td>164,000</td>
<td>123,000</td>
<td>123,000</td>
<td>72,000</td>
</tr>
<tr>
<td>2 story</td>
<td>246,000</td>
<td>123,000</td>
<td>123,000</td>
<td>72,000</td>
</tr>
<tr>
<td>3 story</td>
<td>369,000</td>
<td>123,000</td>
<td>123,000</td>
<td>72,000</td>
</tr>
<tr>
<td>123,000</td>
<td>72,000</td>
<td>216,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### IV B vs IIIA: group R Fire Area Comparison (with no openings between floors):

<table>
<thead>
<tr>
<th></th>
<th>Type IV-B</th>
<th>Type IV-B</th>
<th>Type IV-B</th>
<th>Type III-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 story</td>
<td>164,000</td>
<td>123,000</td>
<td>123,000</td>
<td>216,000</td>
</tr>
<tr>
<td>2 story</td>
<td>246,000</td>
<td>123,000</td>
<td>123,000</td>
<td>216,000</td>
</tr>
<tr>
<td>3 story</td>
<td>369,000</td>
<td>123,000</td>
<td>123,000</td>
<td>216,000</td>
</tr>
<tr>
<td>123,000</td>
<td>216,000</td>
<td>216,000</td>
<td>216,000</td>
<td>216,000</td>
</tr>
</tbody>
</table>
IV B vs IIIA: group R Fire Area Comparison:

Fire Area (with openings between 2 floors)

1 story: 164,000
2 story: 246,000
3 story: 246,000
4 story: 216,000
5 story: 216,000
6 story: 216,000

IV B vs IIIA: group R Fire Area Comparison:

Fire Area (with openings between 2 floors)

1 story: 184,500
2 story: 147,600
3 story: 123,000
4 story: 216,000
5 story: 216,000
6 story: 216,000

IV B vs IIIA: group R Fire Area Comparison:

Fire Area (with openings between 2 floors)

1 story: 184,500
2 story: 147,600
3 story: 123,000
4 story: 216,000
5 story: 216,000
6 story: 216,000
**IV B vs IIIA: group R Fire Area Comparison:**

<table>
<thead>
<tr>
<th>Story</th>
<th>Type IV-B Group R</th>
<th>Type III-A Group R</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>369,000</td>
<td>105,428</td>
</tr>
<tr>
<td>8</td>
<td>369,000</td>
<td>92,250</td>
</tr>
<tr>
<td>9</td>
<td>369,000</td>
<td>82,000</td>
</tr>
<tr>
<td>5</td>
<td>216,000</td>
<td>52,714</td>
</tr>
</tbody>
</table>

**Area (with openings between 2 floors):**

<table>
<thead>
<tr>
<th>Story</th>
<th>Type IV-B Group R</th>
<th>Type III-A Group R</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>369,000</td>
<td>92,250</td>
</tr>
<tr>
<td>8</td>
<td>369,000</td>
<td>82,000</td>
</tr>
<tr>
<td>9</td>
<td>369,000</td>
<td>82,000</td>
</tr>
<tr>
<td>5</td>
<td>216,000</td>
<td>52,714</td>
</tr>
</tbody>
</table>

---

**IV B vs IIIA: Group R Fire Area Comparison:**

<table>
<thead>
<tr>
<th>Story</th>
<th>Type IV-B Group R</th>
<th>Type III-A Group R</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>369,000</td>
<td>105,428</td>
</tr>
<tr>
<td>11</td>
<td>369,000</td>
<td>92,250</td>
</tr>
<tr>
<td>12</td>
<td>369,000</td>
<td>82,000</td>
</tr>
<tr>
<td>5</td>
<td>216,000</td>
<td>52,714</td>
</tr>
</tbody>
</table>

**Area (with openings between 2 floors):**

<table>
<thead>
<tr>
<th>Story</th>
<th>Type IV-B Group R</th>
<th>Type III-A Group R</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>369,000</td>
<td>92,250</td>
</tr>
<tr>
<td>11</td>
<td>369,000</td>
<td>82,000</td>
</tr>
<tr>
<td>12</td>
<td>369,000</td>
<td>82,000</td>
</tr>
<tr>
<td>5</td>
<td>216,000</td>
<td>52,714</td>
</tr>
</tbody>
</table>

---

**IB vs IVB vs IIIA: group R Fire Area:**

<table>
<thead>
<tr>
<th>Type IB 1 HOUR BLDG. NO LIMIT ON FIRE AREA</th>
<th>Type IV-B 2 HOUR BLDG. 67,090 MAX FIRE AREA</th>
<th>Type III-A 1 HOUR BLDG. 216,000 MAX FIRE AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNLIMITED AREA</td>
<td>UNLIMITED AREA</td>
<td>UNLIMITED AREA</td>
</tr>
</tbody>
</table>

*1 HOUR PER IBC 403.2.1.1
TWB Committee Group A Proposals – ALL APPROVED as submitted OR as modified.

- G108 New types of construction
- G75 Height in feet
- G80 Height in stories
- G84 Allowable area per floor
  - G89 Fire barriers
  - G146 Membrane structures with mass timber
  - G152 Appendix
  - G28 Redundant water supply
- FS5 Performance based noncombustible protection
- FS6 Sealing of Splices and intersections
- FS73 Mass timber as fire blocking
- FS81 Prescriptive noncombustible protection
- IFC F88 Owners responsibility
- IFC F266 Fire safety during construction

SO LET'S LOOK AT SOME OF THOSE NEW CODE SECTIONS...

Tall Wood Code Changes are Conservative

IV A, IV B proposals more conservative than Type I A, I B:
- All material outboard of the CLT exterior wall must be non-combustible (except weather resistive barrier)
- No one hour reduction allowed in required FRR for supervised sprinkler valves as in IBC 403.2.1
- No combustible light frame walls, floors, shafts or roofs
- In addition to the NC protection (FRR of 2/3 of table 601 FRR), MT has it’s own redundant FRR based on size
- Limitations on height, area and number of stories (can not be unlimited area like Type I A and B)
- Minimum of 80 minutes of noncombustible protection also provided for roof construction
- Owner responsibilities for maintenance
- Limits on exposed combustible materials during construction

Questions?

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- info@awc.org
- (202) 463-4713
- Dennis Richardson
- (707) 538-2786
- drichardson@awc.org

Check out the AWC website:
Thankyou!

Thank You For Attending