TAKING WOOD TO THE NEXT LEVEL – CLT AS A FLOOR OR ROOF ELEMENT

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DESCRIPTION

An overview of 2018 International Building Code (IBC) and 2018 National Design Specification® (NDS®) for Wood Construction provisions related to the use of cross-laminated timber (CLT) will be provided that includes a step-by-step structural and fire design example for a roof and floor application. Additionally, the WoodWorks® Design Office's Sizer program, version 12 (release date: January 2019) which enables CLT floor and roof design, will be used to demonstrate the structural design. Innovative wood products such as CLT are leading to a resurgence in heavy timber (Type IV) design and construction. These innovations are also making it possible for wood to be designed and built to taller heights and larger areas than what current codes permit. This has led to code change proposals for the 2021 IBC, expanding Type IV construction for tall "mass timber" buildings. Participants should find this presentation useful for current and future applications utilizing CLT in horizontal assemblies.

LEARNING OBJECTIVES

1. Discuss relevant CLT product manufacturing and design standards and identify where these standards are recognized in the IBC.

2. Consider the relevant structural design properties of CLT for floor and roof applications.

3. Discover how to design CLT floors to achieve serviceability goals related to deflection and creep.

4. Identify applications for using CLT and develop solutions using the highlighted resources.
**POLLING QUESTION**

1. What is your profession?
   a. Architect
   b. Engineer
   c. Code Official
   d. Fire Service
   e. Builder/Manufacturer/Other

2. Where are you located given the map below?
   a. West (purple)
   b. North Central (green)
   c. Northeast (brown)
   d. Southeast (teal)
   e. South Central (yellow)
POLLING QUESTION

3. How familiar are you with CLT?
   a) Guru-design or plan reviewed many CLT projects and can teach this course.
   b) Craftsman-designed or plan reviewed many projects with CLT.
   c) Apprentice-familiar with CLT but no design/review of projects.
   d) Novice-just started learning about CLT
   e) CLT whaaat?

OUTLINE

- CLT Building Examples
- CLT - IBC, NDS, ANSI/APA PRG-320
- CLT Floor & Roof Design Example
  - WoodWorks® Ex.
- Current Code Happenings
- Resources

Taking Wood to the Next Level
CONTEMPORARY STICK FRAMED CONSTRUCTION

STADHAUS, LONDON, UK
CANADIAN PROJECTS

Brock Commons

Vancouver, British Columbia, Canada

• 18 Stories (17 over 1)
• Mixed use student housing
• Completed Sept. 2017
CANADIAN PROJECTS

The Arbora
Québec, Canada
- (3) 8 Stories
- 434 Residential condo, townhouse and rental units
CANADIAN PROJECTS

The Arbora

US PROJECTS

Elementary School, Franklin, West Virginia – completed 2015

Taking Wood to the Next Level
US PROJECTS

Private Army Hotel
Redstone Arsenal Huntsville, AL
Completed 2016

Four stories 58,000 sq ft
Architect: Lend Lease

US PROJECTS

Albina Yard
Portland, Oregon
4 Story (3 over 1)
Office, Retail
16,000SF
Completed Summer 2016

Client/Owner: Albina Yard LLC
Architect: Lever Architecture
General Contractor: Reworks
Structural Engineer: KPFF Consulting Engineers
US PROJECTS

Carbon 12
Portland, Oregon
8 Story (85 feet)
Condominiums/commercial
42,000SF
Completed Summer 2018

Developer: Ben Kaiser
Architect: PATH Architecture
General Contractor: Kaiser Group Inc.
Structural Engineer: DCI Engineers
US PROJECTS

OUTLINE

CLT Building Examples

**CLT - IBC, NDS, ANSI/APA PRG-320**

CLT Floor & Roof design

Resources
BUILDING CODE

CROSS-LAMINATED TIMBER (CLT)

Photo provided by FPInnovations.
**MASS TIMBER CONCEPT - HISTORY OF CLT**

1985 1<sup>st</sup> CLT patent - France
1993 1<sup>st</sup> CLT projects - Switzerland and Germany
1995-1996 Improved press technology
1998 1<sup>st</sup> multi-story res building - Austria

Early 2000’s
- CLT use (Europe) increased significantly
- Green building movement driven
- Better efficiencies, product approvals, improved marketing and distribution channels
- Over 500 CLT buildings in England

Recent - US and Canadian use of CLT

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**CLT VS. GLT**

**Glued Laminated Timber**
- Beam-like member

**Cross Laminated Timber**
- Thick Orthotropic Plate

Graphics provided by APA

Graphics provided by WoodWorks
Taking Wood to the Next Level

Hasslacher Norica Timber, Austria

FIRE TESTS


FIRE TEST

American Wood Council
ASTM E119 Fire Endurance Test
• 5-Ply CLT (approx. 7” thick)
• 5/8” Type X GWB each side
• Sought 2 hour rating
• RESULTS: 3 hours 6 minutes

WHERE IS CLT ALLOWED IN IBC 2018?

Type IV Construction

2015 IBC
602.4 Type IV. Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. The details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Minimum solid sawn nominal dimensions are required for structures built using Type IV construction (HT). For glued-laminated members and structural composite lumber (SCL) members, the equivalent net finished width and depths corresponding to the minimum nominal width and depths of solid sawn lumber are required as specified in Table 602.4. Cross-laminated timber (CLT) dimensions used in this section are actual dimensions.

NEW: CLT and SCL

2018 IBC
602.4 Type IV. Type IV construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid wood, laminated wood, heavy timber (HT) or structural composite lumber (SCL) without concealed spaces. The minimum dimensions for permitted materials including solid timber, glued-laminated timber, structural composite lumber (SCL), and cross-laminated timber and details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Interior walls and partitions not less than 1-hour fire-resistance rating or heavy timber complying with Section 2304.11.2.2 shall be permitted.
WHERE IS CLT ALLOWED IN IBC 2018?

**Relocated from Ch. 6**

**TYPE IV CONSTRUCTION**

All structural elements can be CLT

*Exterior walls*

*Floor*

*Roof*

*Interior walls*

**NLT structural elements:**

*Floor*

*Roof*
WHERE IS CLT ALLOWED IN IBC 2018?

Type III Construction –

602.3 Type III. Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code. Fire-retardant-treated wood framing and sheathing complying with Section 2303.2 shall be permitted within exterior wall assemblies of a 2-hour rating or less.

• So where could CLT go?  
  • Almost anywhere!
• Exterior Walls need to be non-combustible or FRT Wood (2 hour or less)
• Interior any material permitted by code
• Roof
WHERE IS CLT ALLOWED IN IBC 2018?

Type V Construction –

602.5 **Type V.** Type V construction is that type of construction in which the structural elements, *exterior walls* and interior walls are of **any materials permitted** by this code.

WHERE IS CLT ALLOWED IN IBC 2018?

All structural elements can be combustible construction
- Exterior walls
- Floor
- Roof
- Interior walls
POLLING QUESTION

4. Which of the following is correct:
   a) 2015 IBC included CLT for the first time
   b) CLT can be used in Type III, IV and V Construction
   c) Heavy timber construction includes GLT, CLT and SCL.
   d) All of the above
   e) a) and b)

OUTLINE

CLT Building Examples

CLT - IBC, NDS, ANSI/APA PRG-320

CLT Floor & Roof Design Example
   WoodWorks® Ex.

Current Code Happenings

Resources
GOVERNING CODES FOR WOOD DESIGN

2018 IBC references in 2018 NDS

Product Chapters
• Ch. 4 Sawn Lumber
• Ch. 5 Structural Glued Laminated Timber
• Ch. 8 Structural Composite Lumber
• Ch. 10 Cross-Laminated Timber (new in 2015 NDS)
CHAPTER 10 – CROSS-LAMINATED TIMBER

10.1 General

10.1.1 Application

10.1.2 Definition

Cross-Laminated timber (CLT) – a prefabricated engineered wood product consisting of at least 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.

10.1.3 Standard Dimensions

10.1.3.1 The net thickness of a lamination for all layers at the time of gluing shall not be less than 5/8 inch or more than 2 inches.

10.1.3.2 The thickness of cross-laminated timber shall not exceed 20 inches.

10.1.4 Specification

All required reference design values shall be specified in accordance with Section 10.2.

10.1.5 Service Conditions

Reference design values reflect dry service conditions, where the moisture content in service is less than
MANUFACTURING STANDARDS

CLT- ANSI/APA PRG 320-2017 references ANSI/AITC 405-2013

CLT- ANSI/APA PRG 320-2018 references ANSI/AITC 405-2018
**PRODUCT MARKING**

Marks contain the following:

a) CLT grade qualified
b) CLT thickness or identification
c) Mill name or identification number
d) Approved agency name or logo
e) “ANSI/APA PRG 320”
f) Manufacturer’s designation
g) “Top” stamped on top face (only for unbalanced layup)

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**CHAPTER 10 – CROSS-LAMINATED TIMBER**

Single or multiple surface layers

1, 2, 3, 4 transverse layers

Laminations: 5/8”-2” sawn lumber or SCL
Panel thickness: 20” max
In-Service MC: 16%

Graphics provided by FPInnovations
CHAPTER 10 – CROSS-LAMINATED TIMBER

10.2 Reference Design Values

10.2.1 Reference Design Values

Reference design values for cross-laminated timber shall be obtained from the cross-laminated timber manufacturer’s literature or code evaluation report.

10.2.2 Design Section Properties

Reference design values shall be used with design section properties provided by the cross-laminated timber manufacturer based on the actual poplar used in the manufacturing process.

10.3 Adjustment of Reference Design Values

10.3.1 General

Reference design values: \( F_{u}(S_s), F_{v}(A_{wet}), F_{u}^{0}, F_{w}(A_{wet}), F_{u}(A), \sigma_{Ed}, \text{ and } \sigma_{Edd}. \) provided in 10.2 shall be multiplied by the adjustment factors specified in Table 10.3.1 to determine adjusted design values: \( F_{u}(S_s), F_{v}(A_{wet}), F_{u}^{0}, F_{w}(A_{wet}), F_{u}(A), \sigma_{Ed}, \text{ and } \sigma_{Edd}. \)

10.3.2 Load Duration Factor, \( c_0 \) (ASD only)

All reference design values except stiffness, \( \sigma_{Ed}, \) and \( \sigma_{Edd} \) shall be multiplied by load duration factor, \( c_0 \), as specified in 2.3.2

CLT PRODUCT REPORTS

https://www.apawood.org/cross-laminated-timber
CHAPTER 10 – CROSS-LAMINATED TIMBER

Table 10.3.1 Applicability of Adjustment Factors for Cross-Laminated Timber

<table>
<thead>
<tr>
<th></th>
<th>ASD only</th>
<th>ASD and LRFD</th>
<th>LRFD only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Load Factor</td>
<td>Serviceability</td>
<td>Ultimate Factor</td>
</tr>
<tr>
<td>$F_d(S_t)$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_I$</td>
</tr>
<tr>
<td>$F_d(A_{ptwG})$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_I$</td>
</tr>
<tr>
<td>$F_d(A_{ptw})$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_I$</td>
</tr>
<tr>
<td>$F_d(A_{ptw}Q)$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_I$</td>
</tr>
<tr>
<td>$F_d(A_{ptw})$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_I$</td>
</tr>
<tr>
<td>$F_d(A_{ptw})$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_I$</td>
</tr>
<tr>
<td>$E_d(\lambda_{pp})$</td>
<td>$C_D$</td>
<td>$C_M$</td>
<td>$C_I$</td>
</tr>
</tbody>
</table>
POLLING QUESTION

5. Cross-laminated timber has:
   a) Laminations of 5/8"-2" thick
   b) Laminations of sawn lumber or SCL
   c) Laminations all oriented in one direction
   d) All of the above
   e) a) and b)

NDS – CHAPTER 12

Include CLT Connections
SEISMIC DESIGN OPTIONS

ASCE 7 Minimum Design Loads for Buildings and Other Structures

Response Modification Coefficient, R

CLT not recognized system in ASCE 7 Table 12.2-1

Options

- Performance-based design procedure per ASCE 7
- Demonstrating equivalence to an existing ASCE 7 system
- ASCE 7-10, FEMA P695, and FEMA P795 Quantification of Building Seismic Performance Factors; Component Equivalency Methodology

CHAPTER 16 – FIRE (ASD)

- Fire resistance up to two hours
  - Columns
  - Beams
  - Tension Members
  - ASD only
- Products
  - Lumber
  - GLT
  - SCL
  - Decking
  - CLT

SECTION 722
CALCULATED FIRE RESISTANCE
722.1 General. The provisions of this section contain procedures by which the fire resistance of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used. The calculated fire resistance of concrete, concrete masonry and clay masonry assemblies shall be permitted in accordance with ACI 216.1/TMS 0216. The calculated fire resistance of steel assemblies shall be permitted in accordance with Chapter 5 of ASCE 29. The calculated fire resistance of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AWC National Design Specification for Wood Construction (NDS).
HEAVY TIMBER FIRE RESISTANCE RATING

Photo by Structure Magazine

FIRE PERFORMANCE GLULAM VS. STEEL

Photo by Structure Magazine
NDS CHAPTER 16 – CALCULATED RESISTANCE

Fire resistance of exposed wood members may be calculated using the provisions of NDS Chapter 16.

2018 NDS METHODOLOGY

Chapter 16 – Fire Design of Wood Members
Mechanics Based Model
Supported by empirical data
NLT, GLT & CLT
FIRE DESIGN OF EXPOSED WOOD MEMBERS

Allowable Stress Design

Table 16.2.2 Adjustment Factors for Fire Design

<table>
<thead>
<tr>
<th></th>
<th>ASD</th>
<th>Design Stress to Allowable Strength Factor</th>
<th>Size Factor</th>
<th>Volume Factor</th>
<th>Fire Use Factor</th>
<th>Beam Stability Factor</th>
<th>Column Stability Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending Strength</td>
<td>Fb</td>
<td>2.85</td>
<td>C_F</td>
<td>C_v</td>
<td>C_m</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Beam Buckling Strength</td>
<td>F_{bb}</td>
<td>2.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>F_t</td>
<td>2.85</td>
<td>C_F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>F_c</td>
<td>2.58</td>
<td>C_F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>C_p</td>
</tr>
<tr>
<td>Column Buckling Strength</td>
<td>F_{cb}</td>
<td>2.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1. See 4.3, 5.3, 8.3, and 10.3 for applicability of adjustment factors for specific products.
2. Factor shall be based on initial cross-section dimensions.
3. Factor shall be based on reduced cross-section dimensions.

CHAPTER 16 – FIRE (ASD)

Technical Report No. 10
- Background on NDS provisions
- Design examples
- CLT provisions
FIRE DESIGN OF EXPOSED WOOD MEMBERS

Revised

Cross-laminated
Timber-Effective
Char Depth

$a_{\text{char}} = n_{\text{lam}} h_{\text{lam}} + \beta \left( t - \left( n_{\text{lam}} t_{\beta_n} \right) \right)^{0.813} \quad (16.2-3)$

$t_{\beta_n} = \left( \frac{h_{\text{lam}}}{\beta_n} \right)^{1.23}$

$t_{\beta_n} = \text{time for char front to reach glued interface (hr.)}$

$h_{\text{lam}} = \text{lamination thickness (in.)}$

$n_{\text{lam}} = \frac{t}{t_{\beta_n}}$

$n_{\text{lam}} = \text{number of laminations charred (rounded to lowest integer)}$

$t = \text{exposure time (hr.)}$

$a_{\text{eff}} = 1.2a_{\text{char}} \quad (16.2-4)$

---

FIRE DESIGN OF EXPOSED WOOD MEMBERS

CLT manufactured with laminations of equal thickness

---

Table 16.2.1B  Effective Char Depths (for CLT with $\beta_n = 1.5\text{in./hr.}$)

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Effective Char Depths, $a_{\text{eff}}$ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5/8</td>
</tr>
<tr>
<td>1-Hour</td>
<td>2.2</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>3.4</td>
</tr>
<tr>
<td>2-Hour</td>
<td>4.4</td>
</tr>
</tbody>
</table>
**CHAR DEPTH**

**Table 16.2.1A** Char Depth and Effective Char Depth (for $\beta_c = 1.5$ in./hr.)

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Char Depth, $a_{char}$ (in.)</th>
<th>Effective Char Depth, $a_{eff}$ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Hour</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>2-Hour</td>
<td>2.6</td>
<td>3.2</td>
</tr>
</tbody>
</table>

For sawn lumber, structural glued laminated softwood timber, laminated veneer lumber, parallel strand lumber, and laminated strand lumber, assuming a nominal char rate, $\beta_c = 1.5$ in./hr., the char depth, $a_{char}$, and effective char depth, $a_{eff}$, are shown in Table 16.2.1A.

For cross-laminated timber manufactured with laminations of equal thickness and assuming a nominal char rate, $\beta_c$ of 1.5 in./hr., the effective char depth, $a_{eff}$, for each exposed surface is shown in Table 16.2.1B.

**CONNECTIONS**

**Figure 9**
CLT panel-to-panel half-flapped joint detail

Source: U.S. CLT Handbook
16.3 Wood Connections
Where fire endurance is required, connectors and fasteners shall be protected from fire exposure
- Wood
- Fire-rated gypsum board

OUTLINE
CLT Building Examples
CLT - IBC, NDS, ANSI/APA PRG-320
CLT Floor & Roof Design Example
WoodWorks® Ex.
Current Code Happenings
Resources
**NDS-CLT DESIGN**

**10.1.1 Application**

10.1.1.1 Chapter 10 applies to engineering design with performance-rated cross-laminated timber.

10.1.1.2 Design procedures, reference design values and other information provided herein apply only to performance-rated cross-laminated timber produced in accordance with ANSI/APA PRG-320.

**10.2.1 Reference Design Values**

Reference design values for cross-laminated timber shall be obtained from the cross-laminated timber manufacturer’s literature or code evaluation report.

**10.2.2 Design Section Properties**

Reference design values shall be used with design section properties provided by the cross-laminated timber manufacturer based on the actual layup used in the manufacturing process.

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**TR-10 CLT FLOOR DESIGN EXAMPLE**

**4.6 Exposed CLT Floor Example (Allowable Stress Design)**

Simply-supported cross-laminated timber (CLT) floor spanning L=18 ft in the strong-axis direction. The design loads are \( q_{\text{live}} = 80 \text{ psf} \) and \( q_{\text{dead}} = 30 \text{ psf} \) including estimated self-weight of the CLT panel.

Floor decking, nailed to the unexposed face of CLT panel, is spaced to restrict hot gases from venting through half-lap joints at edges of CLT panel sections. Calculate the required section dimensions for a two-hour fire resistance time when subjected to an ASTM E119 fire exposure.

Use design provisions from 2018 National Design Specification (NDS)

Adhesive in accordance with ANSI/PRG 320-18 requirements.

Panels connected using a half-lapped joint
TR-10 CLT FLOOR DESIGN EXAMPLE

Given (cont.):

Adjustment factors:

Load duration factor $C_D = 1.0$

Moisture factor $C_M = 1.0$

Temperature factor $C_T = 1.0$

Beam stability factor $C_L = 1.0$

For the structural design of the CLT panel, calculate the maximum induced moment.

Calculate panel load (per foot of width):

$W_{load} = (q_{dead} + q_{live}) = (30 \text{ psf} + 80 \text{ psf})(1\text{ft width}) = 110 \text{ plf/ft of panel width}$

Calculate shear due to support reaction (per foot of width):

$V_{max} = W_{load} L / 2 = (110)(18)/2 = 990 \text{ lbs/ft of width}$

Calculate maximum induced moment (per foot of width):

$M_{max} = W_{load} L^2 / 8 = (110)(18^2)/8 = 4,455 \text{ ft-lb/ft of width}$

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CLT MANUFACTURING STANDARD

<table>
<thead>
<tr>
<th></th>
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</thead>
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<tr>
<td>E1</td>
<td>1,950</td>
<td>1.7</td>
<td>1,375</td>
<td>1,800</td>
<td>135</td>
<td>45</td>
<td>500</td>
<td>1.2</td>
<td>250</td>
</tr>
<tr>
<td>E2</td>
<td>1,650</td>
<td>1.5</td>
<td>1,020</td>
<td>1,700</td>
<td>180</td>
<td>60</td>
<td>525</td>
<td>1.4</td>
<td>325</td>
</tr>
<tr>
<td>E3</td>
<td>1,200</td>
<td>1.2</td>
<td>600</td>
<td>1,400</td>
<td>110</td>
<td>35</td>
<td>350</td>
<td>0.9</td>
<td>150</td>
</tr>
<tr>
<td>E4</td>
<td>1,950</td>
<td>1.7</td>
<td>1,375</td>
<td>1,800</td>
<td>135</td>
<td>45</td>
<td>450</td>
<td>1.3</td>
<td>250</td>
</tr>
<tr>
<td>V1</td>
<td>900</td>
<td>1.6</td>
<td>575</td>
<td>1,350</td>
<td>180</td>
<td>60</td>
<td>525</td>
<td>1.4</td>
<td>325</td>
</tr>
<tr>
<td>V2</td>
<td>875</td>
<td>1.4</td>
<td>450</td>
<td>1,150</td>
<td>135</td>
<td>45</td>
<td>500</td>
<td>1.2</td>
<td>250</td>
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<tr>
<td>V3</td>
<td>750</td>
<td>1.4</td>
<td>450</td>
<td>1,250</td>
<td>175</td>
<td>55</td>
<td>450</td>
<td>1.3</td>
<td>250</td>
</tr>
</tbody>
</table>

For SI: 1 psi = 0.006895 MPa
a. See Section 4 for symbols.
b. Tabulated values are ASD reference design values and not permitted to be increased for the lumber size and flat use adjustment factors in accordance with the NDS. The design values shall be used in conjunction with the section properties provided by the CLT manufacturer based on the actual layup used in manufacturing the CLT panel (see Table A2).
c. Custom CLT layups that are not listed in this table shall be permitted in accordance with 7.2.1.
d. The tabulated $E$ values are published $E$ for lumber. For calculating the CLT design properties shown in Table A2, the transverse $E$ of the lamina is assumed to be $E/30$, the longitudinal $G$ of the lamina is assumed to be $E/16$, and the transverse $G$ of the lamina is assumed to be longitudinal $G/10$. 

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### TR-10 CLT FLOOR DESIGN EXAMPLE

See CLT manufacturer or ER for design values!
Assume for this ex. PRG 320 design values

<table>
<thead>
<tr>
<th>CLT Layup</th>
<th>CLT Thickness (in.)</th>
<th>ASD Reference Design Values for CLT (for use in the U.S.)</th>
<th>Major Strength Direction (ksi)</th>
<th>Minor Strength Direction (ksi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10^6 Laminar Strength (ksi)</td>
<td>10^3 Laminar Stress (ksi)</td>
<td>V_L (kips/lin ft)</td>
</tr>
<tr>
<td>4 1/8</td>
<td>12/8 13/8 13/8 13/8</td>
<td>5,455 115 0.46 0.130 160 3.1 0.61 495</td>
<td>4,675 363 0.91 1.970 1.370 81 1.0 1.430</td>
<td></td>
</tr>
<tr>
<td>6 1/8</td>
<td>13/8 13/8 13/8 13/8</td>
<td>10,400 440 0.92 1.970 1.370 81 1.0 1.430</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 5/8</td>
<td>13/8 13/8 13/8 13/8</td>
<td>18,375 1,089 1.4 2.490 3,125 309 1.8 1,960</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 1/8</td>
<td>13/8 13/8 13/8 13/8</td>
<td>3,825 102 0.53 1.910 1.65 3.6 0.56 660</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### CLT MANUFACTURING STANDARD

**CLT Grades:**

- **E1:** 1950-1.7E Spruce-pine-fir MSR lumber in all longitudinal layers and No. 3 Spruce-pine-fir lumber in all transverse layers
- **E2:** 1650-1.5E Douglas fir-Larch MSR lumber in all longitudinal layers and No. 3 Douglas fir-Larch lumber in all transverse layers
- **E3:** 1200-1.2E Eastern Softwoods, Northern Species, or Western Woods MSR lumber in all longitudinal layers and No. 3 Eastern Softwoods, Northern Species, or Western Woods lumber in all transverse layers
- **E4:** 1950-1.7E Southern pine MSR lumber in all longitudinal layers and No. 3 Southern pine lumber in all transverse layers
- **V1:** No. 2 Douglas fir-Larch lumber in all longitudinal layers and No. 3 Douglas fir-Larch lumber in all transverse layers
- **V2:** No. 1/No. 2 Spruce-pine-fir lumber in all longitudinal layers and No. 3 Spruce-pine-fir lumber in all transverse layers
- **V3:** No. 2 Southern pine lumber in all longitudinal layers and No. 3 Southern pine lumber in all transverse layers
TR-10 CLT FLOOR DESIGN EXAMPLE

- From PRG 320-18 select 7-ply CLT floor panel made from 1 3/8 in. x 3 1/2 in. lumber boards (CLT thickness of 9 5/8 in.)

- V2 CLT grade per ANSI/PRG 320-18 of width (Table A2):
  \[
  (F_b S)_{eff,f,0} = 8,275 \text{ ft-lb/ft of width} \\
  (E I)_{eff,f,0} = 898 \times 10^6 \text{ lbf-in.}^2/\text{ft of width} \\
  (G A)_{eff,f,0} = 1.4 \times 10^6 \text{ lbf/ft of width} \\
  V_{s,0} = 2,490 \text{ lbf/ft of width}
  \]

Structural Check:

- Calculate the allowable design shear:
  \[
  V_s' = V_{s,0}(C_D)(C_M)(C_t) = 2,490(1.0)(1.0)(1.0) = 2,490 \text{ lbf/ft of width (NDS 10.3.1)}
  \]
  \[
  V_s' > V_{\text{max}} \quad 2,490 \text{ lbf/ft} > 990 \text{ lbf/ft}
  \]

TR-10 CLT FLOOR DESIGN EXAMPLE

Structural Check (cont.):

- Calculate the allowable design moment:
  \[
  M_s' = F_b(S_{eff})(C_D)(C_t)(C_L) = 8,275(1.0)(1.0)(1.0)(1.0) = 8,275 \text{ ft-lb/ft of width (NDS 10.3.1)}
  \]
  \[
  M_s' > M_{\text{max}} \quad 8,275 \text{ ft-lb/ft} > 4,455 \text{ ft-lb/ft}
  \]

- Deflection and Creep:
  \[
  K_s = 11.5 \quad \text{(pinned) Shear deformation adjustment factor (NDS Table 10.4.1.1)}
  \]
  \[
  K_c = 2.0 \quad \text{Creep Factor (NDS 3.5.2)}
  \]
  \[
  \frac{E I_{app}}{1 + \frac{K_s E I_{eff}}{G A_{eff} L^2}} = 775 \times 10^6 \text{ lbs-in.}^2/\text{ft.}
  \]

Structural Check (cont.):

**IBC Table 1604.3**

**Long-Term DL (Creep Deflection) + Short-Term LL (Live Deflection)**

Deflection criteria L/360 for short term loading, L/240 for creep deflection.

\[ \Delta_{\text{live}} = L_{\text{panel}} \left( \frac{12 \text{ in/ft}}{360} \right) = \frac{18(12)}{360} = 0.60 \text{ in.} \]

Max. allowable live load (short term) deflection

\[ \Delta_{\text{max}} = L_{\text{panel}} \left( \frac{12 \text{ in/ft}}{240} \right) = \frac{18(12)}{240} = 0.90 \text{ in.} \]

Max. allowable total load deflection

**Short Term LL (Live Deflection)**

\[
\Delta_{\text{ST}} = \frac{5 \left( \frac{W_{\text{live}}}{12} \right) (L_{\text{panel}})^2}{384 E I_{\text{app}}}
\]

\[
= \frac{5 \left( \frac{80}{12} \right) (18 \times 12)^2}{384 (775 \times 106)} = 0.244 \text{ in.} < 0.60 \text{ in.}
\]

Live load deflection (short term)
TR-10 CLT FLOOR DESIGN EXAMPLE

Structural Check (cont.):

Long Term DL (for use with IBC 1604.3)

\[
\Delta_{DL} = \frac{5 \left( \frac{W_{dead}}{12} \right) (L_{panel} \ 12)^4}{384 \ EI_{app}}
\]

\[
= \frac{5 \left( \frac{30}{12} \right) (18 \times 12)^4}{384 \ (775 \times 106)} = 0.092 \text{ in.}
\]

\[
\Delta_T = \Delta_{DL} + \Delta_{ST}
\]

\[
= 0.092'' + 0.244'' = 0.336'' < 0.90 \text{ in.}
\]

Long term deflection

---

TR-10 CLT FLOOR DESIGN EXAMPLE

Structural Check (cont.):

NDS Deflection per 3.5

Short-Term DL (Dead Deflection) + Long-Term DL (Creep Deflection) + Short-Term LL (Live Deflection)

\[
\Delta_T = K_c \Delta_{LT} + \Delta_{ST} \quad (3.5-1)
\]

Short Term LL Deflection (Live Deflection)

\[
\Delta_{ST} = \frac{5 \left( \frac{W_{live}}{12} \right) (L_{panel} \ 12)^4}{384 \ EI_{app}}
\]

\[
= \frac{5 \left( \frac{80}{12} \right) (18 \times 12)^4}{384 \ (775.4 \times 106)} = 0.244 \text{ in.} \quad \text{Live load deflection (short term)}
\]
TR-10 CLT FLOOR DESIGN EXAMPLE

**Structural Check (cont.):**

**NDS Deflection per 3.5**

**Short-Term DL (Dead Deflection) + Long-Term DL (Creep Deflection)**

\[
\Delta_{LT} = \Delta_{DL} = \frac{5 \left( \frac{W_{\text{dead}}}{12} \right) (L_{\text{panel}} 12)^4}{384 \, EI_{\text{app}}}
\]

\[
= \frac{5 \left( \frac{30}{12} \right) (18 \times 12)^4}{384 \, (775.4 \times 106)} = 0.092 \text{ in.}
\]

\[
\Delta_T = Kc_r \Delta_{LT} + \Delta_{ST} = 2.0 \times 0.092 + 0.244 = 0.428 \text{ in.}
\]

TR-10 CLT FLOOR DESIGN EXAMPLE

**Fire Check:**

For the fire design of the CLT panel, mass loss due to charring is conservatively neglected so the loading is unchanged. Therefore, the maximum induced moment is unchanged. The fire resistance must be calculated.

Determine the effective char depth, \(a_{\text{eff}}\)

In this example, the effective char depth, \(a_{\text{eff}}\), has penetrated through the first face lamination, the second lamination and partially into the third lamination. The contribution of the partially charred lamination is neglected and the fourth cross-ply lamination is neglected. Therefore, the resisting moment is calculated using the tabulated bending moment of a 3-ply CLT.

**Table 16.2.1B Effective Char Depths (for CLT with \(\beta_m = 1.5\text{in./hr.}\))**

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Effective Char Depths, (a_{\text{eff}}) (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(h_{\text{app}}) (in.)</td>
</tr>
<tr>
<td>1-Hour</td>
<td>2.2</td>
</tr>
<tr>
<td>1½-Hour</td>
<td>3.4</td>
</tr>
<tr>
<td>2-Hour</td>
<td>4.4</td>
</tr>
</tbody>
</table>
**TR-10 CLT FLOOR DESIGN EXAMPLE**

**Fire Check (cont.):**

Net section 3-ply $F_{bseff} = 2030$ ft-lb/ft of width.

$$M_{\text{max}} = \frac{w_{\text{load}} L^2}{8} = \frac{(110)(182)}{8} = 4,455 \text{ ft-lb/ft of width}$$

Calculate the resisting moment (assuming $C_D = N/A$: $C_M = N/A$: $C_t = N/A$: $C_L = 1.0$).

$$M_f' = (2.85) F_b(S_{\text{eff}})(C_L) = 2.85(2,030)(1.0) = 5,785 \text{ ft-lb/ft of width} \quad \text{(NDS 16.2.2)}$$

Fire Check: $M_f' \geq M_{\text{max}}$ 5,785 ft-lb/ft $> 4,455$ ft-lb/ft

---

**TR-10 CLT FLOOR DESIGN EXAMPLE**

**Thermal Separation:**

ASTM E119 also requires floor assemblies to be checked for thermal separation wherein transmission of heat through the test specimen during the fire exposure period does not raise the average temperature on the unexposed surface more than 250°F (139°C) above its initial temperature. If the CLT is used as an unbacked fire barrier, the estimated time to burn-through, $t_{\text{bt}}$, is calculated using TR10 Section 4.4.1.1:

$$t_{\text{bt}} = 60 \left( \frac{d-0.6}{1.5} \right)^{1.23} + 17 = 60 \left( \frac{9.625-0.6}{1.5} \right)^{1.23} + 17 = 562 \text{ minutes}$$

(estimated time to burn-through)

From TR10 Section 4.4.1.2, the time assigned for thermal separation, $t_{\text{ts}}$, is calculated as: $t_{\text{ts}} = 0.85 \ t_{\text{bt}}$

$t_{\text{ts}} = 0.85 \times 562 = 478 \text{ minutes}$

Thermal Separation Check: $t_{\text{ts}} \geq \text{FRR}$ 478 minutes $> 120$ minutes
POLLING QUESTION

6. Which of the following is true for CLT floor or roof systems:
   a) Manufacturer or code ER provide ref. design values
   b) The deflection criteria in the IBC is the same as the NDS
   c) Exposed CLT may be designed for 2 hrs. of fire-resistance
   d) All of the above
   e) a) and c)

OUTLINE

CLT Building Examples
CLT - IBC, NDS, ANSI/APA PRG-320
CLT Floor & Roof Design Example

WoodWorks® Ex.

Current Code Happenings
Resources
WOODWORKS® DESIGN OFFICE 12 SOFTWARE

SIZER
Gravity Design
- Concept mode
- Beam mode
- Column mode

SHEARWALLS
Lateral Design (Wind and Seismic)

CONNECTIONS
Fasteners

DATABASE EDITOR
Add proprietary products

woodworks-software.com

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CLT Floor Example – Panel Inputs

Deflection Limits

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**CLT Floor Example – Bearing Design**

### Supports for Bearing Design

![Supports for Bearing Design](image)

### Bearing Design Input

![Bearing Design Input](image)

---

**Type of Support**

- Beam
- Hanger
- Other non-wood material
- Beam
- Wall
- Wall panel

**Applies to..**

- All supports
- Right end
- Left end
WOODWORKS® SIZER

CLT Floor Example – Bearing Design

Bearing Design Input

Material, Species, Grade

Supports for bearing design

Applies to: All supports

Type: Beam

Material: Timber-soft

Species: D.Fir-L

Grade: No.2

Bearing length*: (unknown) in

Bearing width*: Same as b* in

Bearing at support end

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CLT Floor Example – Load Input

Loads Input

Type

Distribution

Magnitude Width

Name Type Distribution psf ft

Load1 Dead Full Uniform Area 30 1

Load2 Live Full Uniform Area 80 psf 1

Type

Distribution

Dead

Live

Snow

Wind

Roof live

Impact

Earthquake
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**CLT Floor Example – Structural Analysis Diagrams**

- **Reactions**
- **Shear**
- **Bending**
- **Total Deflection**

**WOODWORKS® SIZER**

**CLT Floor Example – Structural Design Results**

**Panel Description**

**Analysis vs. Allowable Stress and Deflection**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Analysis Value</th>
<th>Design Value</th>
<th>Unit</th>
<th>Analysis/Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear</td>
<td>V = 899</td>
<td>Vr = 3465</td>
<td>lbs</td>
<td>V/Vr = 0.26</td>
</tr>
<tr>
<td>Bending(+)</td>
<td>H = 4655</td>
<td>Nr = 6266</td>
<td>lbs-ft</td>
<td>H/Nr = 0.75</td>
</tr>
<tr>
<td>Live Defl’n</td>
<td>0.41 = L/8.883</td>
<td>0.40 = L/8.60</td>
<td>in</td>
<td>0.41</td>
</tr>
<tr>
<td>Total Defl’n</td>
<td>0.43 = L/8.04</td>
<td>1.20 = L/180</td>
<td>in</td>
<td>0.36</td>
</tr>
<tr>
<td>Vibration</td>
<td>Lmax = 18.000</td>
<td>Lv = 66.313</td>
<td>ft</td>
<td>Lmax/Lv = 0.27</td>
</tr>
<tr>
<td>Fire</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bending(+)</td>
<td>M = 4655</td>
<td>Nr = 6697</td>
<td>lbs-ft</td>
<td>M/Nr = 0.65</td>
</tr>
</tbody>
</table>
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CLT Floor Example – Structural Design Results

Panel Description

Analysis vs. Allowable Stress and Deflection

Modification Factors

Material Properties

Taking Wood to the Next Level

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CLT Floor Example – Bearing Design Results

Bearing Design Summary

Support Description

Taking Wood to the Next Level
## WOODWORKS® SIZER

### CLT Floor Example – Fire Design

**Description**
- **Description**: CLT Floor Panel, V2, 244-7 9-5/8" (12" Width)
- **Typical 1’ Cross-Section**

### Required Resistance

- **Fire Exposure**: 2h
- **Protection**: None

### Deflection Limits

- **Material**: CLT
- **Gliares**: Stress class

### Service Conditions

- **Environmental Conditions**: Dry

### Treatment

- **Fire resistance**: 2h

### Dimensions

- **Width**: 12 in
- **Depth**: 5-5/8 in

### Fire Design

- **Required Resistance**: 2h
- **Protection**: None

### Typical 1’ Cross-Section

- **CLT Floor Panel, V2, 244-7 9-5/8” (12” Width)**

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CLT Floor Example – Fire Design

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CLT Floor Example – Vibration Design Procedure (CSA O86-14, Update 1)

A.8.5.3 Vibration performance of CLT floors

The allowable span for the control of floor motions caused by walking on a CLT floor may be calculated using the following equation:

\[
I_v \leq 0.11 \left( \frac{(EI)_{\text{eff}}}{10^6} \right)^{0.29} \frac{m}{0.12}
\]

where

- \( I_v \) = vibration-controlled span limit, m
- \( m \) = linear mass of CLT for a 1 m wide panel, kg/m
- \((EI)_{\text{eff}}\) = effective bending stiffness for a 1 m wide panel, N⋅mm² (see Clause 8.4.3.2)

**Note:** The above equation assumes the floor

- (a) has a single span with both ends simply supported (for CLT supported on beams refer to the CWC Commentary on CSA O86 for additional guidance);
- (b) is bare with no topping material.

For multiple-span floors with a non-structural element that is considered to provide enhanced vibration effect, the calculated vibration controlled span may be increased by up to 20%, provided it is not greater than 8 m.

---

**WOODWORKS® SIZER**

**CLT Floor Example – Vibration Design Results**

**Analysis vs. Allowable Stress and Deflection**

**Vibration Design Summary**
### WOODWORKS® SIZER

#### CLT Floor Example – Maximum Panel Span

<table>
<thead>
<tr>
<th>Description</th>
<th>Span</th>
<th>Centerline</th>
<th>Type</th>
<th>Ply Panel</th>
<th>Design</th>
<th>Span</th>
<th>Live</th>
<th>Total</th>
<th>Deflection Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L/360</td>
<td>L/240</td>
<td>Left support</td>
</tr>
</tbody>
</table>

Analysis vs. Allowable Stress and Deflection using NDS 2018:

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Analysis Value</th>
<th>Design Value</th>
<th>Unit</th>
<th>Analysis/Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear V</td>
<td>1115 lbs</td>
<td>3465 lbs</td>
<td>lbs</td>
<td>V/Vr = 0.32</td>
</tr>
<tr>
<td>Bending (+)</td>
<td>M = 6655 lbs-ft</td>
<td>M = 8264 lbs-ft</td>
<td>lbs-ft</td>
<td>M/Nr = 0.81</td>
</tr>
<tr>
<td>Live Defl'n</td>
<td>L/507 in</td>
<td>0.73 L/360 in</td>
<td>in</td>
<td>0.71</td>
</tr>
<tr>
<td>Total Defl'n</td>
<td>L/289 in</td>
<td>1.10 L/240 in</td>
<td>in</td>
<td>0.83</td>
</tr>
<tr>
<td>Vibration Lmax</td>
<td>22,000 ft</td>
<td>66,313 ft</td>
<td>ft</td>
<td>Lmax/Lv = 0.33</td>
</tr>
<tr>
<td>Fire Bending (+)</td>
<td>M = 6655 lbs-ft</td>
<td>M = 6897 lbs-ft</td>
<td>lbs-ft</td>
<td>M/Nr = 0.96</td>
</tr>
</tbody>
</table>

### WOODWORKS® SIZER

#### CLT Floor Example – Maximum Loading Conditions

<table>
<thead>
<tr>
<th>Load</th>
<th>Name</th>
<th>Type</th>
<th>Distribution</th>
<th>Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis vs. Allowable Stress and Deflection using NDS 2018:

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Analysis Value</th>
<th>Design Value</th>
<th>Unit</th>
<th>Analysis/Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear V</td>
<td>1399 lbs</td>
<td>3465 lbs</td>
<td>lbs</td>
<td>V/Vr = 0.39</td>
</tr>
<tr>
<td>Bending (+)</td>
<td>M = 6653 lbs-ft</td>
<td>M = 8264 lbs-ft</td>
<td>lbs-ft</td>
<td>M/Nr = 0.81</td>
</tr>
<tr>
<td>Live Defl’n</td>
<td>L/523 in</td>
<td>0.60 L/360 in</td>
<td>in</td>
<td>0.69</td>
</tr>
<tr>
<td>Total Defl’n</td>
<td>L/362 in</td>
<td>0.60 L/240 in</td>
<td>in</td>
<td>0.66</td>
</tr>
<tr>
<td>Vibration Lmax</td>
<td>18,000 ft</td>
<td>66,313 ft</td>
<td>ft</td>
<td>Lmax/Lv = 0.27</td>
</tr>
<tr>
<td>Fire Bending (+)</td>
<td>M = 6653 lbs-ft</td>
<td>M = 6897 lbs-ft</td>
<td>lbs-ft</td>
<td>M/Nr = 0.97</td>
</tr>
</tbody>
</table>
WOODWORKS® SIZER

CLT Floor Example – Database Editor

**Database Type**
- Custom
- Standard
- Custom

**Member Type**
- Panels (*.cws)
- Joists (*.cws)
- Columns (*.cwc)
- Wall Studs (*.cws)
- Lapped Shear (main)
- Lapped Shear (side)
- Panel (*cws)
- Wall Panels (*.cws)

**Material Properties**
- Member Type: Wall Panels
- Material Name: CLT
- File Name: ucl.cws

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WOODWORKS® SIZER

CLT Floor Example – Database Editor

Section Properties

Panel Dimensions

POLLING QUESTION

7. The WoodWorks® Software performs which of the following design
   a) Vibration Design
   b) Structural Design
   c) Fire Design
   d) All of the above
   e) (b) and (c) only
OUTLINE
CLT Building Examples
CLT - IBC, NDS, ANSI/APA PRG-320
CLT Floor & Roof Design Example
    WoodWorks® Ex.
Current Code Happenings
Resources

OUTCOMES OF ICC TALL WOOD AD HOC COMMITTEE: PROPOSALS AND DISCUSSION

Taking Wood to the Next Level
Mass timber ≠ conventional frame

Mass timber ≠ traditional heavy timber
TWB PROJECT & 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 explore the building science of tall wood buildings and investigate the feasibility of and take action on developing code changes for tall wood buildings.

AD HOC COMMITTEE

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

TWO-STOREY FIRE TESTS

• 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
### 14 TALL MASS TIMBER CODE CHANGES

- IBC Section 602.4 Type IV construction (G108-18)
- IBC Section 703.8 Tested noncombustible protection contribution (F55-18)
- IBC Section 722.7 Calculated noncombustible protection contribution (F581-18)
- IBC Section 703.9 Sealing of adjacent mass timber elements (F56-18)
- IBC Section 718.2.1 Fireblocking materials (F573-18)
- IBC Section 403.3.2 High rise sprinkler water supply (G28-18)
- IFC Section 701.6 Owner's responsibility (F88-18)
- IFC Section 3314.7 Fire safety during construction (F266-18)
- IBC Table 504.3 (G75-18)
- IBC Table 504.4 (G80-18)
- IBC Table 506.2 (G84-18)
- IBC Section 3102.3 Special construction (G146-18)
- IBC Appendix D Fire Districts (G152-18)
- IBC Sections 508.4.4.1 and 509.4.1.1 Fire barriers at separated occupancies and incidental uses (G89-18)

[www.awc.org/tallmasstimber](http://www.awc.org/tallmasstimber)

### TYPE OF CONSTRUCTION IV-C

<table>
<thead>
<tr>
<th>Building Element</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Height</td>
<td>85'</td>
</tr>
<tr>
<td>Number of Stories</td>
<td>≤9</td>
</tr>
<tr>
<td>Exposed Mass Timber</td>
<td>Fully Exposed</td>
</tr>
<tr>
<td>Sprinklers</td>
<td>Yes</td>
</tr>
<tr>
<td>Primary Frame FRR</td>
<td>2 hours</td>
</tr>
<tr>
<td>Floor FRR</td>
<td>2 hours</td>
</tr>
<tr>
<td>Stairs Tower</td>
<td>Mass Timber</td>
</tr>
<tr>
<td>Concealed Spaces</td>
<td>Permitted but must have protection</td>
</tr>
</tbody>
</table>

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### TYPE OF CONSTRUCTION IV-B

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Height</td>
<td>180’</td>
</tr>
<tr>
<td>Number of Stories</td>
<td>≤12</td>
</tr>
<tr>
<td>Exposed Mass Timber</td>
<td>YES - Partially</td>
</tr>
<tr>
<td>Sprinklers</td>
<td>Yes</td>
</tr>
<tr>
<td>Primary Frame FRR</td>
<td>2 hours</td>
</tr>
<tr>
<td>Floor FRR</td>
<td>2 hours</td>
</tr>
<tr>
<td>Fire Resistance from Non-com</td>
<td>80 minutes</td>
</tr>
<tr>
<td>Stairs Tower</td>
<td>Mass Timber</td>
</tr>
<tr>
<td>Concealed Spaces</td>
<td>Permitted but must have protection</td>
</tr>
</tbody>
</table>

### TYPE OF CONSTRUCTION IV-A

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Height</td>
<td>270’</td>
</tr>
<tr>
<td>Number of Stories</td>
<td>≤18</td>
</tr>
<tr>
<td>Exposed Mass Timber</td>
<td>NONE - Fully Protected</td>
</tr>
<tr>
<td>Sprinklers</td>
<td>Yes</td>
</tr>
<tr>
<td>Primary Frame FRR</td>
<td>3 hours</td>
</tr>
<tr>
<td>Floor FRR</td>
<td>2 hours</td>
</tr>
<tr>
<td>Fire Resistance from Non-com</td>
<td>120 minutes</td>
</tr>
<tr>
<td>Stairs Tower</td>
<td>Non-combustible</td>
</tr>
<tr>
<td>Concealed Spaces</td>
<td>Permitted but must have protection</td>
</tr>
</tbody>
</table>
TALL MASS TIMBER TYPE OF CONSTRUCTION

<table>
<thead>
<tr>
<th>Feature</th>
<th>Type IV-A</th>
<th>Type IV-B</th>
<th>Type IV-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of new Type IV-B</td>
<td>MT or NC</td>
<td>MT or NC</td>
<td>MT or NC</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>MT or NC</td>
<td>MT or NC</td>
<td>MT or NC</td>
</tr>
<tr>
<td>Fire Resistance</td>
<td>MT or NC</td>
<td>MT or NC</td>
<td>MT or NC</td>
</tr>
<tr>
<td>Noncombustible Materials</td>
<td>MT or NC</td>
<td>MT or NC</td>
<td>MT or NC</td>
</tr>
</tbody>
</table>

8-Step I-Code Development Cycle 2018

1. January 8 (ext. Jan. 11) - Code Changes Submitted
2. February 28 - Code Changes Posted
3. April 15-23 - Committee Action Hearing (Public Hearing)
4. May 15 - Committee Action Hearing Results Posted
5. June 1-July 16 - Public Comments Sought on Committee Action Hearing Results
6. August 31 - Public Comments Posted
7. Oct 24-31 - Public Comment Hearing
8. Nov.-Dec.-online voting
9. Fall 2020 - New Edition is Published


Taking Wood to the Next Level
ICC PUBLIC COMMENT HEARINGS

AWC: Tall Mass Timber code proposals approved at ICC public comment hearings

Oct 24, 2018

LEESBURG, VA. — American Wood Council’s (AWC) Vice President of Codes & Regulations Kenneth Bland, P.E., issued the following statement regarding the approval of the 14 tall mass timber code change proposals during the International Code Council (ICC) public comment hearings today in Richmond, Va. The proposals will now be subject to ICC’s online voting, which is scheduled to begin in November. The final outcome of the tall mass timber code change proposals is expected in December.

The proposals create three new types of construction: Types IV-A, IV-B and IV-C.

"ICC’s Ad hoc Committee on Tall Wood Buildings studied mass timber construction for two years prior to introducing these code change proposals, including conducting numerous fire performance tests. The result of that rigorous process is that each of the new proposed construction types has had its fire and life safety performance confirmed, resulting in a robust building performance.

"Other nations have already seen the benefits of tall wood construction – from the low carbon footprint, ease of construction and reduced construction time. The tremendous support of tall mass timber construction seen at the ICC public comment hearings; and the positive outcome, is one more important step toward advancement of tall wood in the United States."

###

AWC ECOURSE

Outcomes of ICC Tall Wood Ad Hoc Committee: Proposals and Discussion

DES605

Sam Francis, C.B.O.
Senior Director, National Programs
American Wood Council

Paul Coats, P.E., C.B.O.
Southwest Regional Manager
American Wood Council


Taking Wood to the Next Level
OREGON APPROVED ICC MASS TIMBER CODE CHANGE


SAMPLE OF MASS TIMBER PROJECTS

- Carbon 12
  - 8 stories
  - Portland, OR
  - 2018
- Framework
  - 5 stories
  - Portland, OR
  - 2015
- Biomass Boiler
  - 1 story
  - Quincy, CA
  - 2018
- Bullitt Center
  - 6 stories
  - Seattle, WA
  - 2013
- The Long Hall
  - 1 Story
  - Whitefish MT
  - 2011
- T3
  - 7 stories
  - Minneapolis, MN
  - 2016
- Design Building
  - 4 stories
  - Amherst, MA
  - 2017
- West Virginia ES
  - 2 story
  - Franklin, WV
  - 2015
- Duke Lower & Middle Schools
  - 1 story
  - Durham, NC
  - 2009
- Redstone Arsenal
  - 4 stories
  - Huntsville, AL
  - 2016
CLT

McDonald's
600 N Clark St.
Chicago, IL
TALL WOOD

http://awc.org/tallwood

Taking Wood to the Next Level
RESOURCES

https://www.rethinkwood.com/node/1114/done?sid=10589

RESOURCES

RESOURCES

www.awc.org
- Print versions
- PDF versions

RESOURCES

Structure Magazine
2018 NDS
2015 SDPWS
July 2015
www.awc.org

What's Changed?
TR-10 CLT WALL DESIGN EXAMPLE

Example 6: Exposed CLT Wall - Allowable Stress Design

Cross-laminated timber (CLT) wall with an unbraced height of L=120 inches and loaded in compression in the strong-axis direction. The design loads are W_{live}=14,000 lbf and W_{dead}=6,150 lbf including estimated self-weight of the CLT panel. Walls above are supported on a CLT floor slab and aligned with a CLT wall below. Sealing of wall joints with fire-rated caulking restricts hot gases from venting through half-lap joints at edges of CLT panel sections. Calculate the required section dimensions for a 2-hr structural fire resistance time when subjected to an ASTM E119 fire exposure.

Calculate column load:

\[ P_{col} = P_{dead} + P_{snow} = 6,150 \text{ lbf} + 14,000 \text{ lbf} = 20,150 \text{ lb/foot of width}. \]

From PRG 320, select a 7-ply CLT panel made from 1-3/8 in x 3-1/2 in. lumber boards (CLT thickness of 9-5/8 inches). For CLT grade E1, tabulated properties are:

- Reference compression stress, \( f_{c,ref} = 1800 \text{ psi} \) (PRG 320 Annex A, Table A1)
- Reference bending moment, \( f_{b,ref} = 18,375 \text{ ft-lb/ft of width} \) (PRG 320 Annex A, Table A2)
- Reference bending stiffness, \( E_{i,ref} = 1.085 \times 10^6 \text{ lb-in}^2/\text{ft of width} \) (PRG 320 Annex A, Table A2)
- Reference shear stiffness, \( G_{a,ref} = 1.4 \times 10^6 \text{ lb/ft of width} \) (PRG 320 Annex A, Table A2)

BUILDING CODES AND STANDARDS EDUCATION

Live Presentations

Experienced, qualified AWC staff can provide training nation-wide. Seminar attendees receive special discounts on publications, a comprehensive seminar materials package, and a certificate upon seminar completion.

Some of the most popular topics are listed here. Each topic can be combined into a more comprehensive package. Live courses can typically be provided to groups providing for a minimum of 200 contact hours (e.g. 50 people for 4 hours). For smaller audiences, a webinar might be arranged. AWC can provide Continuing Education Certificates for each course. Additionally, AWC has partnered with the following organizations to provide continuing education credits:

- International Code Council (ICC) Education Preferred Provider Program
- American Institute of Architects (AIA) CES Program
- National Council of Structural Engineers Associations (NCSEA) Diamond Review Program

Please note that AWC, AIA, ICC, and NCSEA do not warrant that a program complies with the continuing education requirements in all jurisdictions.

AWC’s seminars are ideally suited as continuing education for code officials (building and fire officials) and design professionals (architects, engineers, and building designers). To arrange a live presentation for your state or local chapter, complete the Request Form outlining which courses you are interested in, the expected size of your group, and an approximate date. For upcoming seminar events, see our calendar.

https://www.awc.org/education/liverepresentations/requestform
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