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

Photo courtesy of Seagate Structures

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on behalf of Canadian Wood Council

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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

**POLLING QUESTION**

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
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
US PROJECTS

Private Army Hotel
Redstone Arsenal Huntsville, AL
Completed 2016

Four stories 58,000 sq ft
Architect: Lend Lease

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
MASS TIMBER CONCEPT - HISTORY OF CLT

1985 1st CLT patent - France
1993 1st CLT projects - Switzerland and Germany
1995-1996 Improved press technology
1998 1st 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

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

**TABLE 2304.11**

<table>
<thead>
<tr>
<th>SUPPORTING</th>
<th>HEAVY TIMBER STRUCTURAL ELEMENTS</th>
<th>MINIMUM NOMINAL SAWN SIZE</th>
<th>MINIMUM ILLEG- LAMINATED NET SIZE</th>
<th>MINIMUM STRUCTURAL COMPOSITE LUMBER NET SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor loads only or combined floor and roof loads</td>
<td>Column(s) or glued-laminated timber arches that spring from the floor line; Framed timber trusses</td>
<td>8</td>
<td>8</td>
<td>6²/₈₈</td>
</tr>
<tr>
<td>Roof loads only</td>
<td>Column(s) (roof and ceiling loads); Lower half of: wood-frame or glued-laminated arches that spring from the floor line or from grade</td>
<td>6</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Roof loads only</td>
<td>Upper half of: wood-frame or glued-laminated arches that spring from the floor line or from grade</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Frame timber trusses and other roof framing</td>
<td>Framed timber trusses and other roof framing</td>
<td>6²</td>
<td>6</td>
<td>3²</td>
</tr>
</tbody>
</table>

For SI: 1 in = 25.4 mm.

a. Splice members shall be permitted to be composed of two or more pieces not less than 3 inches nominal in thickness where thicknesses do not exceed 7/₈ in. Nominal thickness of splice members shall be no less than 7/₈ in. and not more than 2 in. nominal thickness secured to the underside of the members. Splice plates shall be not less than 3 inches nominal in thickness.

b. Where protected by approved automatic sprinklers under the roof deck, framing members shall be not less than 3 inches nominal in width.

**TYPE IV CONSTRUCTION**

All structural elements can be CLT

- Exterior walls
- Floor
- Roof

NLT structural elements:

- Interior walls
- 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.

TYPE III CONSTRUCTION

• 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)
GOVERNING CODES FOR WOOD DESIGN

2018 IBC references in 2018 NDS

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

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 3/8 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
**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**

1, 2, 3, 4 transverse layers  
Single or multiple surface 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 lap joint used in the manufacturing process.

10.3 Adjustment of Reference Design Values

10.3.1 General

Reference design values: \( F_{u}^{*}(A_{nmd}), F_{c}(V_{A}), F_{c}(V_{A/nmd}), F_{c}(A), \text{ and } E_{LM} \), provided in 10.2 shall be multiplied by the adjustment factors specified in Table 10.3.1 to determine adjusted design values: \( F_{u}^{*}(A_{nmd}), F_{c}(V_{A}), F_{c}(A), \text{ and } E_{LM} \).

10.3.2 Load Duration Factor, \( C_{d} \) (ASD only)

All reference design values except stiffness, \( E_{LM} \), \( E_{LS} \), \( V_{A/nmd} \), rolling shear, \( V_{LM} \), and compression perpendicular to grain, \( F_{c}(A) \), shall be multiplied by load duration factors, \( C_{d} \), 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>
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<td>ASD only</td>
<td>ASD and LRFD</td>
<td>LRFD only</td>
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<tr>
<td>Fd(S) = Fd(Sad)</td>
<td>x</td>
<td>C_D</td>
<td>C_D</td>
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<tr>
<td>Fd(Applied) = Fd(Applied)</td>
<td>x</td>
<td>C_M</td>
<td>C_M</td>
</tr>
<tr>
<td>Fd(B) = Fd(B)</td>
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<tr>
<td>Fd(B) = Fd(B)</td>
<td>x</td>
<td>C_M</td>
<td>C_M</td>
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<tr>
<td>Fd(B) = Fd(B)</td>
<td>x</td>
<td>C_T</td>
<td>C_T</td>
</tr>
<tr>
<td>Fd(B) = Fd(B)</td>
<td>x</td>
<td>C_P</td>
<td>C_P</td>
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<tr>
<td>Fd(A) = Fd(A)</td>
<td>x</td>
<td>C_M</td>
<td>C_M</td>
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<tr>
<td>Fd(A) = Fd(A)</td>
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<tr>
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<td>C_T</td>
<td>C_T</td>
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<td>x</td>
<td>C_P</td>
<td>C_P</td>
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<tr>
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<td>C_D</td>
<td>C_D</td>
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<td>x</td>
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<td>C_M</td>
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<td>Fd(A) = Fd(A)</td>
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<td>C_T</td>
<td>C_T</td>
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<td>C_D</td>
<td>C_D</td>
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<td>x</td>
<td>C_M</td>
<td>C_M</td>
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<td>Fd(A) = Fd(A)</td>
<td>x</td>
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<td>C_T</td>
</tr>
<tr>
<td>Fd(A) = Fd(A)</td>
<td>x</td>
<td>C_P</td>
<td>C_P</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)

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**NDS – CHAPTER 12**

- Dowel-Type Fasteners
- Include CLT Connections

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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
HEAVY TIMBER FIRE RESISTANCE RATING

Photo by Structure Magazine

FIRE PERFORMANCE GLULAM VS. STEEL

Taking Wood to the Next Level
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>Structure Type</th>
<th>ASD Design Stress to Allowable Stress 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>2.85 x</td>
<td>C_F</td>
<td>C_V</td>
<td>C_M</td>
<td>C_L</td>
<td>-</td>
</tr>
<tr>
<td>Beam Buckling Strength</td>
<td>2.03 x</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>2.85 x</td>
<td>C_F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>2.58 x</td>
<td>C_F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>C_P</td>
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<tr>
<td>Column Buckling Strength</td>
<td>2.03 x</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

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

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

\[ t_{\text{gl}} = \text{time for char front to reach glued interface (hr.)} \]

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

\[ n_{\text{lam}} = \frac{t}{t_{\text{gl}}} \]

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

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

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

---

**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.}/\text{hr.})**

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Effective Char Depths, } a_{\text{eff}} \text{ (in.)</th>
<th>Required Fire Resistance (hr.)</th>
<th>Effective Char Depths, } a_{\text{eff}} \text{ (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lamination thicknesses, } h_{\text{lam}} \text{ (in.)</td>
<td></td>
<td>lamination thicknesses, } h_{\text{lam}} \text{ (in.)</td>
</tr>
<tr>
<td>5/8</td>
<td>3/4</td>
<td>7/8</td>
<td>1</td>
</tr>
<tr>
<td>1-Hour</td>
<td>2.2</td>
<td>2.2</td>
<td>2.0</td>
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<tr>
<td></td>
<td>2.1</td>
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<tr>
<td></td>
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<td>1.8</td>
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<tr>
<td>1½-Hour</td>
<td>3.4</td>
<td>3.4</td>
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<td>3.9</td>
<td>3.6</td>
<td>3.6</td>
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</table>
CHAR DEPTH

Table 16.2.1A  Char Depth and Effective Char Depth (for $\beta_0 = 1.5 \text{ in.}/\text{hr.}$)

<table>
<thead>
<tr>
<th>Required Fire Resistance (hr.)</th>
<th>Char Depth, $a_{\text{char}}$ (in.)</th>
<th>Effective Char Depth, $a_{\text{eff}}$ (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, $\beta_0 = 1.5 \text{ in.}/\text{hr.}$, the char depth, $a_{\text{char}}$, and effective char depth, $a_{\text{eff}}$, are shown in Table 16.2.1A.

For cross-laminated timber manufactured with laminations of equal thickness and assuming a nominal char rate, $\beta_0$ of 1.5 in./hr., the effective char depth, $a_{\text{eff}}$, for each exposed surface is shown in Table 16.2.1B.

CONNECTIONS

Figure 9  CLT panel-to-panel half-lapped 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
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-120.

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.

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 \( q_{\text{live}} = 80 \) psf and \( q_{\text{dead}} = 30 \) 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):

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

Calculate maximum induced moment (per foot of width):

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

---

**CLT MANUFACTURING STANDARD**

**TABLE A1**

<table>
<thead>
<tr>
<th>CLT Layup</th>
<th>$F_1$ (psi)</th>
<th>$F_2$ (psi)</th>
<th>$E_1$ (10$^3$ psi)</th>
<th>$F_3$ (psi)</th>
<th>$F_4$ (psi)</th>
<th>$E_2$ (10$^3$ psi)</th>
<th>$F_5$ (psi)</th>
<th>$F_6$ (psi)</th>
<th>$F_7$ (psi)</th>
<th>$F_8$ (psi)</th>
<th>$F_9$ (psi)</th>
</tr>
</thead>
<tbody>
<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>
<td>650</td>
<td>135</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>
<td>775</td>
<td>180</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>
<td>475</td>
<td>110</td>
</tr>
<tr>
<td>E4</td>
<td>1,950</td>
<td>1.7</td>
<td>1,375</td>
<td>1,800</td>
<td>175</td>
<td>55</td>
<td>450</td>
<td>1.3</td>
<td>250</td>
<td>725</td>
<td>175</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>
<td>775</td>
<td>180</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>
<td>650</td>
<td>135</td>
</tr>
<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>
<td>725</td>
<td>175</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 laminations is assumed to be $E/30$, the longitudinal $G$ of the lamimation is assumed to be $E/16$, and the transverse $G$ of the lamimation is assumed to be longitudinal $G/10$.  

---
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>E1</th>
<th>41/8 13/8 13/8 13/8 1/8 13/8 13/8 13/8</th>
<th>10,400 440 440 1,970 1,370 81.2 1.2 1,430</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E2</td>
<td>67/8 13/8 13/8 13/8 13/8 13/8 13/8 13/8</td>
<td>10,400 440 440 1,970 1,370 81.2 1.2 1,430</td>
</tr>
<tr>
<td></td>
<td>V1</td>
<td>67/8 13/8 13/8 13/8 13/8 13/8 13/8 13/8</td>
<td>8,000 1,027 1,121 1,320 1,121 1,121 1,121 1,121</td>
</tr>
<tr>
<td></td>
<td>V2</td>
<td>67/8 13/8 13/8 13/8 13/8 13/8 13/8 13/8</td>
<td>8,000 1,027 1,121 1,320 1,121 1,121 1,121 1,121</td>
</tr>
</tbody>
</table>

CLT Grades:

- E1: 1950-L7E Spruce-pine-fir MSR lumber in all longitudinal layers and No. 3 Spruce-pine-fir lumber in all transverse layers
- E2: 1650-L7E Douglasfir-Larch MSR lumber in all longitudinal layers and No. 3 Douglas fir-Larch lumber in all transverse layers
- E4: 1950-L7E 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 13/8 in. x 31/2 in. lumber boards (CLT thickness of 95/8 in.)

• V2 CLT grade per ANSI/PRG 320-18 of width (Table A2):

  \[(F_bS)_{eff,f,0} = 8,275 \text{ ft-lb/ft of width}\]
  \[(EI)_{eff,f,0} = 898 \times 10^6 \text{ lbf-in.}^2/\text{ft of width}\]
  \[(GA)_{eff,f,0} = 1.4 \times 10^6 \text{ lbf/ft of width}\]
  \[V_{s,0} = 2,490 \text{ lbf/ft of width}\]

Structural Check:

• Calculate the allowable design shear:

  \[V_s' = V_{s,0}(C_D)(C_M)(C_t) = 2,490(1.0)(1.0)(1.0) = 2,490 \text{ lbf/ft of width (NDS 10.3.1)}\]

  \[V_s' > V_{max} \quad 2,490 \text{ lbf/ft} > 990 \text{ lbf/ft}\]

TR-10 CLT FLOOR DESIGN EXAMPLE

Structural Check (cont.):

• Calculate the allowable design moment:

  \[M_s' = F_b(S_{eff})(C_D)(C_M)(C_t)(C_L) = 8,275(1.0)(1.0)(1.0) = 8,275 \text{ ft-lb/ft of width (NDS 10.3.1)}\]

  \[M_s' > M_{max} \quad 8,275 \text{ ft-lb/ft} > 4,455 \text{ ft-lb/ft}\]

• Deflection and Creep:

  \[K_s = 11.5 \text{ (pinned) Shear deformation adjustment factor (NDS Table 10.4.1.1)}\]

  \[K_c = 2.0 \text{ Creep Factor (NDS 3.5.2)}\]

  \[EI_{app} = \frac{EI_{eff}}{1 + \frac{K_s EI_{eff}}{GA_{eff} L^2}} \text{ Apparent bending stiffness (NDS Eq. 10.4-1)}\]

  \[EI_{app} = \frac{898 \times 10^6}{1 + \frac{11.5(898 \times 10^6)}{1.4 \times 10^6(18)(12)^2}} = 775 \times 10^6 \text{ lbs-in.}^2/\text{ft.}\]
TR-10 CLT FLOOR DESIGN EXAMPLE

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.

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

Max. allowable live load (short term) deflection

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

Max. allowable total load deflection

**Short Term LL (Live Deflection)**

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

\[ = \frac{5 \times \left( \frac{80}{12} \right) \times (18 \times 12)^4}{384 \times (775 \times 106)} = 0.244 \text{ in.} < 0.60 \text{ in.} \]

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

Structural Check (cont.):

Long Term DL (for use with IBC 1604.3)

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

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

\[ = 0.092 \text{ in.} \]

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

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

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)

\[ \Delta_{ST} = \frac{5 \left( \frac{w_{live}}{12} \right)}{384 E_{I app}} \left( L_{panel} \cdot 12 \right)^4 \]

\[ = \frac{5 \left( \frac{80}{12} \right)}{384 (775.4 \times 106)} (18 \times 12)^4 \]

\[ = 0.244 \text{ in.} \]

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)**

\[
\Delta_{LT} = \Delta_{DL} = \frac{5 \left( \frac{w_{\text{dead}}}{12} \right) (L_{\text{panel}} 12)^4}{384 E I_{\text{app}}} \\
= \frac{5 \left( \frac{30}{12} \right) (18 \times 12)^4}{384 (775.4 \times 106)} = 0.092 \text{ in.}
\]

\[
\Delta_T = K c r \Delta_{LT} + \Delta_{ST} = 2.0 (0.092) + 0.244 = 0.428 \text{ in.}
\]

---

**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.
**TR-10 CLT FLOOR DESIGN EXAMPLE**

**Fire Check (cont.):**

Net section 3-ply $F_bS_{\text{eff},0} = 2030$ 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 $C_D = N/A; \; C_M = N/A; \; C_t = N/A; \; CL = 1.0$).

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

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

---

**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 $250^\circ\text{F} \; (139^\circ\text{C})$ above its initial temperature. If the CLT is used as an unbacked fire barrier, the estimated time to burn-through, $t_{bt}$, is calculated using TR10 Section 4.4.1.1:

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

(estimated time to burn-through)

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

\[ t_{ts} = 0.85 \; t_{bt} = 0.85 \times 562 = 478 \text{ minutes} \]

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

This portion of the presentation was developed by a 3rd party and is not funded by AWC or Softwood Lumber Board.
WOODWORKS® DESIGN OFFICE 12 SOFTWARE

- **SIZER**
  - Concept mode
  - Beam mode
  - Column mode

- **SHEARWALLS**
  - Lateral Design (Wind and Seismic)

- **CONNECTIONS**
  - Fasteners

- **DATABASE EDITOR**
  - Add proprietary products

woodworks-software.com

---

WOODWORKS® SIZER

CLT Floor Example – Panel Inputs

<table>
<thead>
<tr>
<th>Description</th>
<th>Cantilevers</th>
<th>Type</th>
<th>Material</th>
<th>Species</th>
<th>Grade</th>
<th>Width (b)</th>
<th>Depth (d)</th>
<th>Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>18'</td>
<td>None</td>
<td>Floor Panel</td>
<td>CLT</td>
<td>S-P-F</td>
<td>V2</td>
<td>12 in.</td>
<td>9-5/8 in.</td>
<td>7</td>
</tr>
<tr>
<td>16'</td>
<td>None</td>
<td>Floor Panel</td>
<td>CLT</td>
<td>S-P-F</td>
<td>V2</td>
<td>12 in.</td>
<td>9-5/8 in.</td>
<td>7</td>
</tr>
</tbody>
</table>

Deflection Limits

- Deflection limits:
  - Live: L/360
  - and ≤ 1.00 in.
  - Total: L/240

Taking Wood to the Next Level
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CLT Floor Example – Bearing Design

Bearing Design Input

Material, Species, Grade

Material, Species, Grade

WOODWORKS® SIZER
CLT Floor Example – Load Input

Type

Distribution

Load Input

Name | Type | Distribution | Magnitude | Width
--- | --- | --- | --- | ---
Load 1 | Dead | Full Uniform Area | 30 | 1
Load 2 | Live | Full Uniform Area | 30 psf | 1
WOODWORKS® SIZER

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

### Panel Description

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

- Supports: All - Timber-soft Beam, No. 2
- Total length: 18.04”, Clear span: 17.958”, volume = 47.5 cu ft.; Panel orientation: Longitudinal axis
- Exposed on one b-face;
- Required performance: standard demands

This section PASSES the design code check.

### 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</td>
<td>V = 899</td>
<td>Vz = 3465</td>
<td>lbs</td>
<td>V/Vz = 0.26</td>
</tr>
<tr>
<td>Bending(+)</td>
<td>H = 4655</td>
<td>Hz = 6266</td>
<td>lbs-ft</td>
<td>H/Hz = 0.74</td>
</tr>
<tr>
<td>Live Defl’n</td>
<td>0.47 = L/360</td>
<td>0.47 = L/360</td>
<td>in</td>
<td>0.41</td>
</tr>
<tr>
<td>Total Defl’n</td>
<td>0.43 = L/504</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>Bending(+)</td>
<td>M = 4655</td>
<td>Hz = 6266</td>
<td>0.65</td>
</tr>
</tbody>
</table>

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CLT Floor Example – Structural Design Results

Panel Description

Modification Factors

Analysis vs. Allowable Stress and Deflection

Material Properties

Taking Wood to the Next Level

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CLT Floor Example – Bearing Design Results

Support Description

Bearing Design Summary

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CLT Floor Example – Fire Design

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

Typical 1' Cross-Section

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CLT Floor Example – Fire Design

Taking Wood to the Next Level

Analysis vs. Allowable Stress and Deflection

Critical Load Combination

Fire Design Summary

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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:

\[
l_v \leq \frac{(E/\text{eff})^{0.29}}{10^6 m^{0.12}}
\]

where

- \(l_v\) = vibration-controlled span limit, m
- \(m\) = linear mass of CLT for a 1 m wide panel, kg/m
- \((E/\text{eff})\) = effective bending stiffness for a 1 m wide panel, \(\text{N}\cdot\text{mm}^2\) (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); and
- (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

**Vibration Design Summary**

Analysis vs. Allowable Stress and Deflection

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Design Value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress</td>
<td>(250 \text{ lb/ft})</td>
<td>270 psi</td>
</tr>
<tr>
<td>Deflection</td>
<td>0.05 in.</td>
<td>0.06 in.</td>
</tr>
</tbody>
</table>

---

Taking Wood to the Next Level
WOODWORKS® SIZER

CLT Floor Example – Maximum Panel Span

Maximum Design Span

Design Ratios

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</td>
<td>V = 1215</td>
<td>Vr = 3465</td>
<td>lbs</td>
<td>V/Vr = 0.32</td>
</tr>
<tr>
<td>Bending(+)</td>
<td>M = 6655</td>
<td>Mz = 8264</td>
<td>lbs-ft</td>
<td>M/Mz = 0.81</td>
</tr>
<tr>
<td>Live Defl’n</td>
<td>0.52 = L/507</td>
<td>0.73 = L/360</td>
<td>in</td>
<td>Lmax/Lv = 0.33</td>
</tr>
<tr>
<td>Total Defl’n</td>
<td>0.91 = L/289</td>
<td>1.10 = L/240</td>
<td>in</td>
<td>Lmax/Lv = 0.33</td>
</tr>
<tr>
<td>Vibration</td>
<td>Lmax = 22,000</td>
<td>Lv = 66.313</td>
<td>ft</td>
<td>Lmax/Lv = 0.33</td>
</tr>
<tr>
<td>Fire Bending(+)</td>
<td>M = 6655</td>
<td>Mz = 6897</td>
<td>lbs-ft</td>
<td>M/Mz = 0.86</td>
</tr>
</tbody>
</table>

Taking Wood to the Next Level

WOODWORKS® SIZER

CLT Floor Example – Maximum Loading Conditions

Live Load

Design Ratios

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</td>
<td>V = 1399</td>
<td>Vr = 3465</td>
<td>lbs</td>
<td>V/Vr = 0.39</td>
</tr>
<tr>
<td>Bending(+)</td>
<td>M = 6653</td>
<td>Mz = 8264</td>
<td>lbs-ft</td>
<td>M/Mz = 0.81</td>
</tr>
<tr>
<td>Live Defl’n</td>
<td>0.41 = L/523</td>
<td>0.60 = L/360</td>
<td>in</td>
<td>Lmax/Lv = 0.69</td>
</tr>
<tr>
<td>Total Defl’n</td>
<td>0.60 = L/362</td>
<td>0.90 = L/240</td>
<td>in</td>
<td>Lmax/Lv = 0.66</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 Bending(+)</td>
<td>M = 6653</td>
<td>Mz = 6897</td>
<td>lbs-ft</td>
<td>M/Mz = 0.97</td>
</tr>
</tbody>
</table>

Taking Wood to the Next Level
WOODWORKS® SIZER

CLT Floor Example – Database Editor

Database Type

- Custom
- Standard
- Custom

Member Type

- Panels (*.cws)
- Joists (*.cws)
- Columns (*.cwcw)
- Wall Studs (*.cws)
- Lapped Shear (main)
- Lapped Shear (side)
- Panels (cws)
- Wall Panels (*.cws)

Material Properties

- CLT

Taking Wood to the Next Level
**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
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-STORY 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 (FS81-18)
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 (G94-18)
IBC Section 3102.3 Special construction (G146-18)
IBC Appendix D Fire Districts (G152-18)
IBC Sections 508.4.1.1 and 509.4.1.1 Fire barriers at separated occupancies and incidental uses (G89-18)

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>
### TYPE OF CONSTRUCTION IV-B

<table>
<thead>
<tr>
<th>Building Element</th>
<th></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></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

### Tall Mass Timber Type of Construction Comparison

<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>Noncombustibility</td>
<td>MT or NC</td>
<td>MT or NC</td>
<td>MT or NC</td>
</tr>
<tr>
<td>Exposure Limitation for NC</td>
<td>MT or NC</td>
<td>MT or NC</td>
<td>MT or NC</td>
</tr>
<tr>
<td>Flow Resistance Requirement</td>
<td>20 lb/sq ft</td>
<td>20 lb/sq ft</td>
<td>20 lb/sq ft</td>
</tr>
<tr>
<td>Exposure to Fire</td>
<td>Pre-Engineered</td>
<td>Pre-Engineered</td>
<td>Pre-Engineered</td>
</tr>
<tr>
<td>Engineered Protection</td>
<td>3 layers of 1/8&quot; Type X</td>
<td>2 layers of 1/8&quot; Type X</td>
<td>2 layers of 1/8&quot; Type X</td>
</tr>
<tr>
<td>Finish Protection</td>
<td>Minimum of 4 layers of 1/4&quot; Type X</td>
<td>Minimum of 4 layers of 1/4&quot; Type X</td>
<td>Minimum of 4 layers of 1/4&quot; Type X</td>
</tr>
<tr>
<td>Roof Material</td>
<td>2 layers of 1/2&quot; Type X</td>
<td>2 layers of 1/2&quot; Type X</td>
<td>2 layers of 1/2&quot; Type X</td>
</tr>
<tr>
<td>Roof Construction</td>
<td>3 layers of 1/2&quot; Type X</td>
<td>3 layers of 1/2&quot; Type X</td>
<td>3 layers of 1/2&quot; Type X</td>
</tr>
<tr>
<td>Fire Resistance</td>
<td>No NC, accredited, 2 layers of 1/2&quot; Type X</td>
<td>Accredited, 2 layers of 1/2&quot; Type X</td>
<td>Accredited, 2 layers of 1/2&quot; Type X</td>
</tr>
<tr>
<td>Combustible Spaces</td>
<td>No exposed MT, interior spaces</td>
<td>No exposed MT, interior spaces</td>
<td>No exposed MT, interior spaces</td>
</tr>
<tr>
<td>Paint/Surface</td>
<td>fire-resistant paint</td>
<td>fire-resistant paint</td>
<td>fire-resistant paint</td>
</tr>
<tr>
<td>Fire Resistance Rating (ERR)</td>
<td>5.5 fire UL for interior use</td>
<td>5.5 fire UL for interior use</td>
<td>5.5 fire UL for interior use</td>
</tr>
<tr>
<td>Fire Resistance Rating (FRR)</td>
<td>5.5 fire UL for exterior use</td>
<td>5.5 fire UL for exterior use</td>
<td>5.5 fire UL for exterior use</td>
</tr>
<tr>
<td>Format Rating (FR)</td>
<td>5.5 fire UL for exterior use</td>
<td>5.5 fire UL for exterior use</td>
<td>5.5 fire UL for exterior use</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

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https://www.iccsafe.org/codes-tech-support/codes/code-development/current-code-develop ment-cycle/
 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

OREGON APPROVED ICC MASS TIMBER CODE CHANGE


SAMPLE OF MASS TIMBER PROJECTS

- Hudson
  - 3 stories
  - Vancouver, WA
  - 2016
- Carbon 12
  - 8 stories
  - Portland, OR
  - 2018
- Framework
  - 5 stories
  - Portland, OR
  - 2015
- Biomass Boiler
  - 1 stories
  - 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
CLT
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
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 psf and w_{dead}=6,150 psf 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 caulk 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:

\[ P_{load} = P_{live} + P_{snow} = 6,150 \text{ psf} + 14,000 \text{ psf} = 20,150 \text{ lb/foot of width}. \]

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, \( E_{bl,ref} = 1.085 \times 10^6 \text{ lb-in}^2/\text{ft of width} \) (PRG 320 Annex A, Table A2)
- Reference shear stiffness, \( G_{s,ref} = 1.4 \times 10^6 \text{ lb/ft of width} \) (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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