Acoustics, Floor Vibration, MEP Integration, Enclosure and Moisture Protection

March 27, 2023

Presented by Jessica Scarlett, Mark Bartlett and Jason Bahr
Noise  Acoustics  Sound Pollution

Whatever you call it, it all comes down to one thing: **Occupant Comfort**
Acoustical Design

Types of noise to control: Exterior to interior
Aoustical Design

Types of noise to control: Noise within a space
Room Acoustics

**What is Sound Absorption?**
All materials absorb sound energy to some degree. Whenever sound waves strike a material, part of the acoustical energy in the wave is absorbed and/or transmitted, and the remainder is reflected.

Arena Stage, Washington, DC
Photo: Nic Lehoux, Bing Thom Architects
Noise Reduction Coefficients (NRC) for Common Building Materials:

- Wood
- Terrazzo
- Steel
- Sprayed Cellulose Fibers (1" thick on concrete)
- "Soundboard" (1/2" thick)
- Rubber on Concrete
- Polyurethane Foam (1" thick, open cell, reticulated)
- Plywood
- Plaster
- Marble
- Linoleum on Concrete
- Gypsum
- Glass
- Fiberglass, 1" Semi-rigid
- Cork, wall tiles (1" thick)
- Cork, floor tiles (3/4" thick)
- Concrete (block), unpainted
- Concrete (block), painted
- Concrete (smooth), unpainted
- Concrete (smooth), painted
- Carpet, heavy on foam rubber
- Carpet, heavy on concrete
- Carpet, indoor-outdoor
- Brick, unpainted
- Brick, painted
Room Acoustics

NRC of exposed wood panels like NLT & DLT can be improved with inset absorbing materials.

**Acoustic Square with Wood Fibre (NRC = 0.55-0.65)**

**Acoustic Square with Wood Fibre & Felt (NRC = 0.75-0.80)**

**Acoustic Round (NRC = 0.10-0.25)**

Figure 2.16: Alternating 2x4 and 2x6 lumber with and without sound absorbing material.

Key
1. Concrete topping
2. Acoustic mat
3. Plywood/OSB
4. NLT
5. Sound absorbing material
Acoustical Design

Types of noise to control: **Interior to interior**

- **Air-Borne Sound**: Sound Transmission Class (STC)
  Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other. Applies to walls and floor/ceiling assemblies.
Acoustical Design

Types of noise to control: **Interior to interior**

- **Structure-borne sound: Impact Insulation Class (IIC)**
  
  Evaluates how effectively an assembly blocks impact sound from passing through it. Only applies to floor/ceiling assemblies.
# Acoustical Criteria

## Acoustical Isolation Between Units – Airborne (STC) / Impact (IIC)

<table>
<thead>
<tr>
<th>Class Designation</th>
<th>Airborne Sound Isolation (STC)</th>
<th>Floor Ceiling Impact Isolation (IIC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry level</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Market rate</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Luxury</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>
Acoustical Detailing

Mass Timber Wall Acoustics: STC

Photo: Pam Wean, MSES Architects

Photo: Lend Lease & Schaefer
### Acoustical Detailing

#### Sound Insulation of Bare CLT Floors and Walls

<table>
<thead>
<tr>
<th>Number of layers</th>
<th>Thickness (in.)</th>
<th>Wall or Floor</th>
<th>STC</th>
<th>IIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3-3/4 to 4-1/2</td>
<td>Wall</td>
<td>32-34</td>
<td>N.A.</td>
</tr>
<tr>
<td>5</td>
<td>5-1/3</td>
<td>Floor</td>
<td>39</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>5-3/4</td>
<td>Floor</td>
<td>39</td>
<td>24</td>
</tr>
</tbody>
</table>

Measured on field bare CLT wall and floor

<table>
<thead>
<tr>
<th>Number of layers</th>
<th>Thickness in.</th>
<th>Assembly type</th>
<th>FSTC</th>
<th>FIIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4-1/8</td>
<td>Wall</td>
<td>28</td>
<td>N.A.</td>
</tr>
<tr>
<td>7</td>
<td>8-1/5</td>
<td>Floor</td>
<td>N.A.</td>
<td>25-30</td>
</tr>
</tbody>
</table>

Credit: US CLT Handbook
Acoustical Detailing

Design Examples for >50 STC Walls

**STC 50:**
1 and 3 = 4-1/2 in. CLT;
2 = 1-1/8 in. Mineral wool in the gap

**STC 55:**
Add 5/8 in. gypsum board directly to both sides

**STC 60:**
Gypsum boards plus double the thickness of the gap and mineral wool

**STC 58:**
1 and 7 = 5/8 in. gypsum boards
3 and 5 = 2 in. by 3 in. wood studs at least 16 in. o.c.
2 and 6 = 2.5 in. mineral wool
4 = 4-1/2 in. CLT

Credit: US CLT Handbook
Main difference between light frame wood floors and mass timber floors is that mass timber floors are usually left exposed on ceiling side.

All acoustical products applied on top of assembly
Acoustical Detailing

Concrete Slab:
- 6" Thick
- 80 PSF
- STC 53

CLT Slab:
- 6-7/8" Thick
- 18 PSF
- STC 41
Aoustical Detailing

Common mass timber floor assembly:
» Finish floor (if applicable)
» Underlayment (if finish floor)
» 1.5” to 3” thick concrete/gypcrete topping
» Acoustical mat
» WSP (if applicable)
» Mass timber floor panels
Acoustical Detailing

Options without concrete topping:
- Gypsum/cement board (Fermacell, Permabase, etc.)
- Proprietary products
Mass Timber Acoustics
Mass Timber Acoustics

Mass Timber Acoustics

Table 1: CLT Floor Assemblies with Concrete/Gypsum Topping, Ceiling Side Exposed

<table>
<thead>
<tr>
<th>CLT Panel</th>
<th>Concrete/Gypsum Topping</th>
<th>Acoustical Mat Product Between CLT and Topping</th>
<th>Finish Floor</th>
<th>STC</th>
<th>IC</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1/2&quot; Gyp-Crete®</td>
<td></td>
<td>Massmin Acousti-Mat® 3/4</td>
<td>4P ASRC</td>
<td>49 P AIC</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1 1/2&quot; Gyp-Crete®</td>
<td></td>
<td>Massmin Acousti-Mat® % Premium</td>
<td>4P ASRC</td>
<td>45 P AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLT 5-ply (6.67&quot;)</td>
<td></td>
<td>LSG SMM N/25 Ultra</td>
<td>48</td>
<td>49</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>LSG SMM N/73 Ultra</td>
<td>48</td>
<td>49</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: CLT Floor Assemblies with Concrete/Gypsum Topping, Ceiling Side Exposed

Following is a list of mass timber assemblages that have been acoustically tested as of January 23, 2015. Sources are noted at the end of the document. For free technical assistance on any questions related to the acoustical design of mass timber assemblies, or free technical assistance related to any aspect of the design, engineering or construction of a commercial or multi-family wood building in the U.S., email tech@woodworks.org or contact the WoodWorks Regional Director nearest you: http://www.woodworks.org/project-assistance

Contents:

- Table 1: CLT Floor Assemblies with Concrete/Gypsum Topping, Ceiling Side Exposed
- Table 2: CLT Floor Assemblies without Concrete/Gypsum Topping, Ceiling Side Exposed
- Table 3: CLT Floor Assemblies without Concrete/Gypsum Topping, with Wood Slopers, Ceiling Side Exposed
- Table 4: NLT, CLT & T&B Decking Floor Assemblies, Ceiling Side Exposed
- Table 5: Mass Timber Floor Assemblies with Ceiling Side Concealed
- Table 6: Single CLT Wall
- Table 7: Single NLT Wall
- Table 8: Double CLT Wall

Sources...

Disclaimer...

https://www.woodworks.org/resources/inventory-of-acoustically-tested-mass-timber-assemblies/
“One might almost say that strength is essential and otherwise unimportant”

- Hardy Cross
US Building Code Requirements for Vibration

None

» Barely discussed in IBC, NDS, etc.
» ASCE 7 Commentary Appendix C has some discussion, no requirements
Floor Vibration Dynamics

Undamped Free Response

Period $T = 1 / f_n$ Frequency

Natural Frequency

$$f_n = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$
Walking Frequency $f_w$

<table>
<thead>
<tr>
<th>Walking Speed</th>
<th>Walking Frequency</th>
<th>Steps Per Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Slow</td>
<td>1.25 Hz</td>
<td>75 SPM</td>
</tr>
<tr>
<td>Slow</td>
<td>1.6 Hz</td>
<td>95 SPM</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.85 Hz</td>
<td>110 SPM</td>
</tr>
<tr>
<td>Fast</td>
<td>2.1 Hz</td>
<td>126 SPM</td>
</tr>
<tr>
<td>Running</td>
<td>Up to 4.0 Hz</td>
<td>240 SPM</td>
</tr>
</tbody>
</table>

Practical Tip - walk to a metronome too understand the range

The range of walking frequencies considered is an important consideration of vibration analysis.
Vibration Design Methods

- Rules of Thumb
- Empirical Methods
- Simplified Analytical
- FEM/Modal Superposition
- FEM/Time History

Canadian CLT Handbook 2nd Ed., 2019
FPInnovations
# CLT Handbook Base Span Limit

## For PRG 320-2019 Basic CLT Grades and Layups from Solid Sawn Lumber

<table>
<thead>
<tr>
<th>Grade</th>
<th>Layup</th>
<th>Thickness</th>
<th>Base Span Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>13.1</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>18.2</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>22.7</td>
</tr>
<tr>
<td>E2</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>21.6</td>
</tr>
<tr>
<td>E3</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>20.9</td>
</tr>
<tr>
<td>E4</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>17.6</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>22.1</td>
</tr>
<tr>
<td>E5</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>21.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade</th>
<th>Layup</th>
<th>Thickness</th>
<th>FPI Span Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>17.6</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>22.0</td>
</tr>
<tr>
<td>V1(N)</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>17.6</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>22.0</td>
</tr>
<tr>
<td>V2</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>21.5</td>
</tr>
<tr>
<td>V3</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>20.9</td>
</tr>
<tr>
<td>V4</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>20.4</td>
</tr>
<tr>
<td>V5</td>
<td>3ply</td>
<td>4 1/8&quot;</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td>5ply</td>
<td>6 7/8&quot;</td>
<td>16.8</td>
</tr>
<tr>
<td></td>
<td>7ply</td>
<td>9 5/8&quot;</td>
<td>21.0</td>
</tr>
</tbody>
</table>

New Mass Timber Floor Vibration Design Guide

Covers simple and complex methods for bearing wall and frame supported floor systems

Worked office, lab and residential Examples

https://www.woodworks.org/publications-media/solution-papers/
Parameters of Modal Superposition Methods

Excitation Force(s) \( \rightarrow \) Structure \( \rightarrow \) Vibration Response

Walking Frequency, \( f_w \)  
...  
Walking Location  
Walking Path

Stiffness  
Mass/Weight  
Damping  
Boundary Conditions

Performance Targets
Details of U.S. Mass Timber Floor Vibration Design Guide

Vibration Design Examples

- Residential Bearing Wall Building with CLT
- Open Office with NLT on Glulam Frame
- High Performance Lab Space with CLT on Glulam Frame

https://www.woodworks.org/publications-media/solution-papers/
MEP DESIGN CONSIDERATIONS

INTRO, Cleveland, OH. Credit: Harbor Bay Real Estate Advisors
MEP Layout & Integration

Key considerations:
• Level of exposure desired
• Floor-to-floor structure depth & desired head height
• Building occupancy and configuration (i.e. central core vs. double loaded corridor)
• Grid layout and beam orientations
• Need for future tenant reconfiguration
• Impact on fire & structural design
• Concealed spaces
• Penetrations
Exposed MEP
MEP items often left exposed on the ceiling side of floor assembly

Photo credit: WoodWorks
MEP Layout & Integration

Set Realistic Owner Expectations About Aesthetics
• MEP fully exposed with MT structure, or limited exposure?
MEP Layout & Integration

Smaller grid bays at central core (more head height)
- Main MEP trunk lines around core, smaller branches in exterior bays
MEP Layout & Integration

Grid impact: one-way beam layout.

Columns/beams spaced at panel span limits in one direction.

Beam penetrations are minimized/eliminated.

Recall typical panel span limits:

<table>
<thead>
<tr>
<th>Panel</th>
<th>Example Floor Span Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-ply CLT (4-1/8&quot; thick)</td>
<td>Up to 12 ft</td>
</tr>
<tr>
<td>5-ply CLT (6-7/8&quot; thick)</td>
<td>14 to 17 ft</td>
</tr>
<tr>
<td>7-ply CLT (9-5/8&quot;)</td>
<td>17 to 21 ft</td>
</tr>
<tr>
<td>2x4 NLT</td>
<td>Up to 12 ft</td>
</tr>
<tr>
<td>2x6 NLT</td>
<td>10 to 17 ft</td>
</tr>
<tr>
<td>2x8 NLT</td>
<td>14 to 21 ft</td>
</tr>
<tr>
<td>5&quot; MPP</td>
<td>10 to 15 ft</td>
</tr>
</tbody>
</table>
 MEP Layout & Integration

Dropped below MT framing
• Can simplify coordination (fewer penetrations)
• Bigger impact on head height
MEP Layout & Integration

In penetrations through MT framing
• Requires more coordination (penetrations)
• Bigger impact on structural capacity of penetrated members
• Minimal impact on head height
MEP Layout & Integration

In chases above beams and below panels
- Fewer penetrations
- Bigger impact on head height (overall structure depth is greater)
- FRR impacts: top of beam exposure
MEP Layout & Integration

In raised access floor (RAF) above MT
- Aesthetics (minimal exposed MEP)
MEP Layout & Integration

In raised access floor (RAF) above MT
- Impact on head height
- Concealed space code provisions
**MEP Layout & Integration**

**INTEGRATED SYSTEMS**

Credit: John Klein, Generate Architecture
Penetration Fire Protection

Although not a new code requirement or specific to tall wood, more testing & information is becoming available on firestopping of penetrations through MT assemblies.
Penetration Fire Protection

Most firestopping systems include combination of fire safing (eg. noncombustible materials such as mineral wool insulation) plus fire caulk.

Photos: AWC/FPInovations/Hilti
Penetration Fire Protection

Firestop systems tests on Mass Timber
Contact WoodWorks for information

FIRE PERFORMANCE OF FIRESTOPS, PENETRATIONS, AND FIRE DOORS IN MASS TIMBER ASSEMBLIES

Lindsay Ranger 1, Christian Dagenais 1, Corey Lum 1, Tony Thomas 1

ABSTRACT: Integrity and continuity must be maintained for fire separations required to provide fire protection of hot gases or increased temperature on the unexposed side. Vulnerable locations, what are introduced into mass timber systems, are susceptible to fire spread. Service and closure penetrations can cause a fire separation to fail. Many of the firestop systems were able to achieve 1-1/2-hr fire separation in accordance with CAN/ULC-S115, which would be required for 2-hr fire resistance rated assemblies. Smaller wood buildings and construction details are outlined which ensure adequate fire performance of these systems.

KEYWORDS: Firestop, through-penetrations, fire rated door, mass timber, cross-laminated timber, small wood buildings, fire resistance

1 INTRODUCTION

Many tall wood buildings using mass timber are planned or currently being designed for construction around the world. A few have been built in Canada, including the 18-storey cross-laminated timber (CLT) and glulam building in British Columbia. The prescriptive requirements in the National Building Code of Canada (NBCC) [1] do not (yet) permit the construction of wood buildings taller than six stories, however an alternative
## Penetration Fire Protection

### Inventory of Fire Tested Penetrations in MT Assemblies

**Table 3: North American Fire Tests of Penetrations and Fire Stops in CLT Assemblies**

<table>
<thead>
<tr>
<th>CLT Panel</th>
<th>Exposed Side Protection</th>
<th>Penetrating Item</th>
<th>Penetration Centered or Offset in Hole</th>
<th>Firestopping System Description</th>
<th>F Rating</th>
<th>T Rating</th>
<th>Stated Test Protocol</th>
<th>Source</th>
<th>Testing Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-ply (76mm 3.07&quot;)</td>
<td>None</td>
<td>1.5&quot; diameter d-cable bunch</td>
<td>Centred</td>
<td>3.5&quot; in diameter hole. Mineral wool was installed in the 1/16&quot; annular space around the data cables to a total depth of approximately 2 - 3/4 in. The remaining 1/16&quot; annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>1 hour</td>
<td>0.5 hour</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>3-ply (76mm 3.07&quot;)</td>
<td>None</td>
<td>2&quot; copper pipe</td>
<td>Centred</td>
<td>4.375&quot; in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 2 - 3/4 in. The remaining 1/16&quot; annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>1 hour</td>
<td>N/A</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>3-ply (76mm 3.07&quot;)</td>
<td>None</td>
<td>2.5&quot; sched. 40 pipe</td>
<td>Centred</td>
<td>4.92&quot; in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 2 - 3/4 in. The remaining 1/16&quot; annular space starting at the top of the pipe to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>1 hour</td>
<td>N/A</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>3-ply (76mm 3.07&quot;)</td>
<td>None</td>
<td>6&quot; cast iron pipe</td>
<td>Centred</td>
<td>8.35&quot; in diameter hole. Mineral wool was installed in the 1/16&quot; annular space around the cast iron pipe to a total depth of approximately 2 - 3/4 in. The remaining 1/16&quot; annular space starting at the top of the pipe to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>1 hour</td>
<td>N/A</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>3-ply (76mm 3.07&quot;)</td>
<td>None</td>
<td>Hilti 6 in drop in device System No: F-B-2649</td>
<td>Centred</td>
<td>9.01&quot; diameter hole. Mineral wool was installed in the 1/32&quot; annular space around the drop-in device to a total depth of approximately 1 - 7/8 in. and the remaining 1/32&quot; annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>1 hour</td>
<td>0.75 hour</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>5-ply CLT (31.1 mm 5.16&quot;)</td>
<td>None</td>
<td>1.5&quot; diameter d-cable bunch</td>
<td>Centred</td>
<td>3.5&quot; in diameter hole. Mineral wool was installed in the 1/32&quot; annular space around the data cables to a total depth of approximately 4 - 3/2 in. The remaining 1/32&quot; annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>2 hours</td>
<td>1.5 hours</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>5-ply CLT (31.1 mm 5.16&quot;)</td>
<td>None</td>
<td>2&quot; copper pipe</td>
<td>Centred</td>
<td>4.375&quot; in diameter hole. Pipe wrap was installed around the copper pipe to a total depth of approximately 4 - 3/2 in. The remaining 1/32&quot; annular space starting at the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>2 hours</td>
<td>N/A</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>5-ply CLT (31.1 mm 5.16&quot;)</td>
<td>None</td>
<td>2.5&quot; sched. 40 pipe</td>
<td>Centred</td>
<td>4.92&quot; in diameter hole. Pipe wrap was installed around the schedule 40 pipe to a total depth of approximately 4 - 3/2 in. The remaining 1/32&quot; annular space starting at the top of the pipe to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>2 hours</td>
<td>0.5 hour</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>5-ply CLT (31.1 mm 5.16&quot;)</td>
<td>None</td>
<td>6&quot; cast iron pipe</td>
<td>Centred</td>
<td>8.35&quot; in diameter hole. Mineral wool was installed in the 1/32&quot; annular space around the cast iron pipe to a total depth of approximately 4 - 3/2 in. The remaining 1/32&quot; annular space starting at the top of the pipe to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>2 hours</td>
<td>N/A</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>5-ply CLT (31.1 mm 5.16&quot;)</td>
<td>None</td>
<td>Hilti 6 in drop in device System No: F-B-2649</td>
<td>Centred</td>
<td>9.01&quot; diameter hole. Mineral wool was installed in the 1/32&quot; annular space around the drop-in device to a total depth of approximately 1 - 7/8 in. and the remaining 1/32&quot; annular space from the top of the mineral wool to the top of the floor assembly was filled with Hilti FS-One Max caulking.</td>
<td>2 hours</td>
<td>1.5 hours</td>
<td>CANULC SI15</td>
<td>26</td>
<td>Untertrek March 30, 2016</td>
</tr>
<tr>
<td>5-ply CLT (31.1 mm 5.16&quot;)</td>
<td>None</td>
<td>1&quot; nominal PVC pipe</td>
<td>Centred</td>
<td>4.21&quot; in diameter at a 3/4&quot; plywood nicker flush with the top of the slab reducing the opening to 2.28 in. Two wraps of Hilti CP CL65-E W55/1-3/4&quot; Fasten on strip in two locations in the 3/16&quot; steel sheet with nail placed at the top of the slab to 1 in below the slab. The first location was with the bottom of the strip to flush with the bottom of the steel sheet and the second was with the bottom of the strip 3 in from the bottom of the slab. The voids between the steel shelf and the CLT and between the steel shelf and pipe at the top of the assembly was filled with WoodSafe mineral wool using a 3/4&quot; deep wood at the top of the assembly. Hilti FS-One Max Int.unc mask was applied to a depth of 3/4 in on the top of the assembly between the plywood and steel sheet as well as the steel sheet and pipe.</td>
<td>2 hours</td>
<td>2 hours</td>
<td>ASIM E814</td>
<td>24</td>
<td>QA-Laboratories March 3, 2017</td>
</tr>
</tbody>
</table>
New for GCs and installers:

Download free at woodworks.org
New for GCs and installers:


19. US Department of Labor, Occupational Safety and Health Administration (OSHA). OSHA Requirements Related to Leading Hazards at Construction Sites.
   https://www.osha.gov/complianceassistance/quickstarts/construction#step1

20. OSHA. Other OSHA Requirements That May Apply to Your Jobsite.
    https://www.osha.gov/complianceassistance/quickstarts/construction#step2

21. OSHA. Survey Your Workplace for Additional Hazards.
    https://www.osha.gov/complianceassistance/quickstarts/construction#step3

22. OSHA. Develop a Jobsite Safety and Health Program.
    https://www.osha.gov/complianceassistance/quickstarts/construction#step4
Material Protection

» Moisture
» UV rays
» Damage
Moisture Management

Keep wood as dry as possible to avoid:

» Stains and dirt
» Shrinkage and swelling
» Damage from prolonged moisture exposure

Mass timber can get wet—and will get wet on most projects. That is not a problem, provided an effective moisture management plan is in place.
Moisture Management Plan

Planning starts at the earliest stage and is collaborative.

Construction team responsibilities include:

» Construction phase plan; on-site strategies based on risk evaluation
  » Coverings
  » Deflection/diversion
  » Ventilation/drying

» Anticipating and troubleshoots issues
» Monitoring

<table>
<thead>
<tr>
<th>Type and Extent of Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Decision by architect/contractor</td>
</tr>
<tr>
<td>- Appearance requirements</td>
</tr>
<tr>
<td>- Extent and cost of protection methods</td>
</tr>
<tr>
<td>- Protection in fabrication plant and/or on jobsite</td>
</tr>
<tr>
<td>- Capability of fabricator</td>
</tr>
<tr>
<td>- Capability of installer/moisture protection subcontractor</td>
</tr>
<tr>
<td>- Schedule protection plan</td>
</tr>
<tr>
<td>- Protection prior to installation</td>
</tr>
<tr>
<td>- Protection during installation</td>
</tr>
<tr>
<td>- Protection after installation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moisture Management Responsibility and Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Responsibility for managing and cost of the plan</td>
</tr>
<tr>
<td>- Contractor and/or fabricator</td>
</tr>
<tr>
<td>- Conditions to be considered</td>
</tr>
<tr>
<td>- Schedule delays and revisions</td>
</tr>
<tr>
<td>- Construction weather conditions (worst case)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitoring Moisture Before, During and After Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Coordination with concrete topping activities</td>
</tr>
<tr>
<td>- Roofing material</td>
</tr>
<tr>
<td>- Columns, beams and floor/wall panels</td>
</tr>
</tbody>
</table>
Factory-Applied Sealants & Coatings
Membranes can be spray-applied, sheet product (adhesive or non), or board/sheathing product.
Transportation & Storage
Panel Joint Treatment

INTRO
Harbor Bay Ventures / Hartshorne Plunkard Architecture / Forefront Structural Engineers / Fast + Epp / Panzica Construction
Photos WoodWorks
Deflection & Diversion

Coverings

INTRO / Photos WoodWorks
Moisture Monitoring

Monitor the moisture content (MC) of wood materials throughout construction.

» When materials are received
» Regular intervals
» After rainfall
» Before drying in

<table>
<thead>
<tr>
<th>Product</th>
<th>MC at Manufacture</th>
<th>Desired MC at Project Close-in with Direct-Applied Concrete Toppings</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLT</td>
<td>12% +/- 3%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt;16%</td>
</tr>
<tr>
<td>GLT</td>
<td>12-16%&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;16%</td>
</tr>
<tr>
<td>NLT</td>
<td>&lt;19%&lt;sup&gt;c&lt;/sup&gt;</td>
<td>&lt;16%</td>
</tr>
<tr>
<td>DLT</td>
<td>15-19%&lt;sup&gt;d&lt;/sup&gt;</td>
<td>&lt;16%</td>
</tr>
</tbody>
</table>

Sources: <sup>a</sup>PRG-320 standard, <sup>b</sup>ANSI A190.1,
The best way to minimize exposure to moisture is to close in the project quickly.
MASS TIMBER APPEAL
Reduced construction time

1 Floor = 3 Days

17 Floors Erected in 9.5 Weeks

Brock Commons, Vancouver, BC
Source: naturally:wood
Cleaning Mass Timber

Sanding and cleaning solutions are the most common ways to remove stains.
Planning for Environmental Exposures

- Plan Early
- Risk Evaluation
- Develop Construction Phase Plan
- Execute the Design and Moisture Management Plan
- Monitor

RDH Moisture Management Guide 1st Ed
Applying Finishes

Below, glulam panels are coated in the controlled environment of a fabrication facility. On the right, a coating is being applied on the jobsite.
On Site Considerations
Onsite Considerations
Questions? Ask us anything.

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Ask us anything!