Key to Success: Early Design Decisions for Mass Timber

Presented By:

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Photo: Michael Green Architecture
KEY EARLY DESIGN DECISIONS

What is the Single Most Important Early Design Decision on a Mass Timber Project? Is it:

- Exposed Timber (where & how much)
- Acoustics
- Concealed Spaces
- Connections
- Penetrations
- Construction Type
- Fire-Resistance Ratings
- Member Sizes
- Grids & Spans
- MEP Layout

The Answer is...They All Need to Be Weighed (Plus Others)
KEY EARLY DESIGN DECISIONS

Mass Timber Projects Are Most Efficient When Key Decisions and Coordination are Shifted to Earlier in Design

General geometry and grid finalized
All loads validated and finalized
Preliminary MEP/FP routing and penetration sizing
Section optimization
Review and Validation (50% CD)

Edge of deck/slab finalized
MEP openings with reinforcing
Review and approval (100% CD)

SHOP DRAWINGS
3D Modeling
Connection details and design
Coordination Drawings
AoR/ EoR coordination review
Coordination/approval drawings
AoR/ EoR review and approval
Fabrication drawings
Grids & Spans

- Consider Efficient Layouts
- Repetition & Scale
- Manufacturer Panel Sizing
- Transportation
KEY EARLY DESIGN DECISIONS

Grids & Spans

- Consider Efficient Layouts
- Repetition & Scale
- Manufacturer Panel Sizing
- Transportation
## KEY EARLY DESIGN DECISIONS

### Construction Type

<table>
<thead>
<tr>
<th>Occupancies</th>
<th>Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)</th>
<th>Allowable Number of Stories above Grade Plane (IBC Table 505.4)</th>
<th>Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)</th>
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<tbody>
<tr>
<td>A, B, R</td>
<td><strong>270</strong></td>
<td><strong>180</strong></td>
<td><strong>85</strong></td>
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<tr>
<td>A-2, A-3, A-4</td>
<td>18</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>18</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>R-2</td>
<td>18</td>
<td>12</td>
<td>8</td>
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<table>
<thead>
<tr>
<th>Occupancies</th>
<th>Allowable Building Height above Grade Plane, Feet (IBC Table 504.3)</th>
<th>Allowable Number of Stories above Grade Plane (IBC Table 505.4)</th>
<th>Allowable Area Factor (At) for SM, Feet² (IBC Table 506.2)</th>
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<tr>
<td>A-2, A-3, A-4</td>
<td><strong>135,000</strong></td>
<td><strong>90,000</strong></td>
<td><strong>56,250</strong></td>
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<tr>
<td>B</td>
<td>324,000</td>
<td>216,000</td>
<td>135,000</td>
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<tr>
<td>R-2</td>
<td>184,500</td>
<td>123,000</td>
<td>76,875</td>
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KEY EARLY DESIGN DECISIONS

Fire-Resistance Ratings

- Driven Primarily By Construction Type
- Rated Structure or Not?
- Rating achieved through timber alone or non-com protection required?

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
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<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>HT</td>
</tr>
<tr>
<td>Primary structural frame (see Section 202)</td>
<td>3(^{a, b})</td>
<td>2(^{a, b, c})</td>
<td>1(^{b, c})</td>
<td>0(^{c})</td>
<td>1(^{b, c})</td>
</tr>
<tr>
<td>Bearing walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior(^{a, f})</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Interior</td>
<td>3(^{a})</td>
<td>2(^{a})</td>
<td>1</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Nonbearing walls and partitions</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Exterior</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Nonbearing walls and partitions</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Floor construction and associated secondary structural members (see Section 202)</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Roof construction and associated secondary structural members (see Section 202)</td>
<td>1(^{1/2})</td>
<td>1(^{b, c})</td>
<td>1(^{b, c})</td>
<td>0(^{c})</td>
<td>1(^{b, c})</td>
</tr>
</tbody>
</table>

See Table 705.5
KEY EARLY DESIGN DECISIONS

Penetrations & Connections
• Impact of FRR
• Size & Configuration
• Exposed or Not (Aesthetics)

Figure 1: Detailing of fire-stops through CLT wall [3]
KEY EARLY DESIGN DECISIONS

MEP Integration: Set Realistic Owner Expectations About Aesthetics
KEY EARLY DESIGN DECISIONS

MEP Integration

• Consider Level of Exposure & Owner Expectations
• Floor to Floor, Structure Depth & Desired Head Height
• Need for Future Tenant Reconfiguration
• Concealed Spaces, Penetrations
KEY EARLY DESIGN DECISIONS

MEP Integration: Smaller Bay at Central Core, Branches in Exterior Bays

Credit: Blaine Brownell

Credit: WoodWorks
KEY EARLY DESIGN DECISIONS

MEP Integration: Dropped Below MT Framing
KEY EARLY DESIGN DECISIONS

MEP Integration: Penetrations Through MT Framing
KEY EARLY DESIGN DECISIONS

MEP Integration: Under Slab, Through Chases
KEY EARLY DESIGN DECISIONS

MEP Integration: In RAF Above MT Panels

Credit: BOKA Powell
KEY EARLY DESIGN DECISIONS

Member Sizes
• Impact of FRR on Sizing
• Impact of Sizing on Efficient Spans
• Consider connections – can drive member sizing

0 HR FRR: Consider 3-ply Panel
• Efficient Spans of 10-12 ft
• Grids of 20x20 (1 purlin) to 30x30 (2 purlins) may be efficient

Albina Yard, Portland, OR
20x20 Grid, 1 purlin per bay
3-ply CLT
Image: Lever Architecture
KEY EARLY DESIGN DECISIONS

Member Sizes
• Impact of FRR on Sizing
• Impact of Sizing on Efficient Spans
• Consider connections – can drive member sizing

0 HR FRR: Consider 3-ply Panel
• Efficient Spans of 10-12 ft
• Grids of 20x20 (1 purlin) to 30x30 (2 purlins) may be efficient

Platte Fifteen, Denver, CO
30x30 Grid, 2 purlins per bay
5-ply CLT
Image: JC Buck
KEY EARLY DESIGN DECISIONS

Member Sizes

- Impact of FRR on Sizing
- Impact of Sizing on Efficient Spans
- Consider connections – can drive member sizing

1 or 2 HR FRR: Likely 5-ply Panel
- Efficient spans of 14-17 ft
- Grids of 15x30 (no purlins) to 30x30 (1 purlin) may be efficient

First Tech Credit Union, Hillsboro, OR
12x32 Grid, One-Way Beams
5-ply (5.5”) CLT
Image: Swinerton
KEY EARLY DESIGN DECISIONS

Member Sizes
• Impact of FRR on Sizing
• Impact of Sizing on Efficient Spans
• Consider connections – can drive member sizing

1 or 2 HR FRR: Likely 5-ply Panel
• Efficient spans of 14-17 ft
• Grids of 15x30 (no purlins) to 30x30 (1 purlin) may be efficient

Clay Creative, Portland, OR
30x30 Grid, 1 purlin per bay
2x6 NLT
Image: Mackenzie
KEY EARLY DESIGN DECISIONS

Mass Timber Fire Design Resource

- Code compliance options for demonstrating FRR
- Updated as new tests are completed
- Free download at woodworks.org
### KEY EARLY DESIGN DECISIONS

Inventory of Fire Tested MT Assemblies

<table>
<thead>
<tr>
<th>CLT Panel</th>
<th>Manufacturer</th>
<th>CLT Grade or Major x Minor Grade</th>
<th>Ceiling Protection</th>
<th>Panel Connection in Test</th>
<th>Floor Topping</th>
<th>Load Rating</th>
<th>Fire Resistance Achieved (Hours)</th>
<th>Source</th>
<th>Testing Lab</th>
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<tbody>
<tr>
<td>3-ply CLT (114mm 4.488 in)</td>
<td>Nordic Inc</td>
<td>SPF 1550 FB 1.5 LFSM x SPF 93</td>
<td>2 layers 1/2&quot; Type X gypsum</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 34% Moment Capacity</td>
<td>1</td>
<td>1 (Test 2)</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>2 staggered layers of 1/2&quot; cement boards</td>
<td>Loaded, See Manufacturers</td>
<td>2</td>
<td>2 (Test 3)</td>
<td>NRC Fire Laboratory March 2016</td>
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<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>2 staggered layers of 1/2&quot; cement boards</td>
<td>Loaded, See Manufacturers</td>
<td>2</td>
<td>5 (Test 4)</td>
<td>NRC Fire Laboratory Nov 2014</td>
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<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>3/4 in. proprietary gypsum over Maxon acoustical mat</td>
<td>Reduced 50% Moment Capacity</td>
<td>1.5</td>
<td>3 (Test 5)</td>
<td>UL</td>
</tr>
<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>3/4 in. proprietary gypsum over Maxon acoustical mat or proprietary sound board</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>4 (Test 6)</td>
<td>UL</td>
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<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>1 layer 5/8&quot; normal gypsum</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>2 (Test 7)</td>
<td>Interlock 8/24/2012</td>
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<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>3/4 in. proprietary gypsum over Maxon acoustical mat or proprietary sound board</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>2 (Test 8)</td>
<td>Interlock, 2/22/2016</td>
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<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>2&quot; gypsum batt</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>3 (Test 9)</td>
<td>SwRI (May 2016)</td>
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<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>1-1/2&quot; Monax Gyp-Cote 7000 over Maxon Reinforcing Mesh</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>4 (Test 10)</td>
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<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>2&quot; gypsum batt</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>5 (Test 11)</td>
<td>NRC Fire Laboratory</td>
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<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>3/4 in. proprietary gypsum over Maxon acoustical mat or proprietary sound board</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>6 (Test 12)</td>
<td>NRC Fire Laboratory</td>
</tr>
<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>2&quot; gypsum batt</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>7 (Test 13)</td>
<td>SwRI (May 2016)</td>
</tr>
<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>3/4 in. proprietary gypsum over Maxon acoustical mat or proprietary sound board</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>8 (Test 14)</td>
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<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
<td>None</td>
<td>Topside Spline</td>
<td>2&quot; gypsum batt</td>
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<td>2</td>
<td>9 (Test 15)</td>
<td>SwRI (May 2016)</td>
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<tr>
<td>5-ply CLT (153mm 6.05 in)</td>
<td>Nordic Inc</td>
<td>E1 SPF #1/2 x SPF #1/2</td>
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<td>Topside Spline</td>
<td>3/4 in. proprietary gypsum over Maxon acoustical mat or proprietary sound board</td>
<td>Reduced 50% Moment Capacity</td>
<td>2</td>
<td>10 (Test 16)</td>
<td>SwRI (May 2016)</td>
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</table>
KEY EARLY DESIGN DECISIONS

NEW MASS TIMBER
FLOOR VIBRATION
DESIGN GUIDE

U.S. Mass Timber
Floor Vibration

Design Guide

Worked office, lab and residential Examples

Covers simple and complex methods for bearing wall and frame supported floor systems
KEY EARLY DESIGN DECISIONS

MASS TIMBER CONNECTIONS INDEX
A library of commonly used mass timber connections with designer notes and information on fire resistance, relative cost and load-carrying capacity.

WoodWorks Index of Mass Timber Connections
Acoustics and Mass Timber: Room-to-Room Noise Control

Richard Mcke, PE, SE • Senior Technical Director • WoodWorks

The growing availability and code acceptance of mass timber—i.e., large-scale wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction has given designers a low-cost alternative to steel, concrete, and masonry for many applications. However, the use of mass timber in multifamily and commercial buildings presents unique acoustic challenges.

While laboratory measurements of the impact and airborne sound isolation of traditional building assemblies such as light wood-framed, steel and concrete are widely available, few acoustical data exist that quantify the acoustical performance of mass timber assemblies. Additionally, one of the most desired aspects of mass timber construction is the ability to frame a building’s structure expressed as finish, which creates the need for partition, assemblies. With careful design and detailing, mass timber buildings can meet the acoustical performance expectations of most building codes.

Mass Timber Assembly Options: Walls
Mass timber panels are often used for interior and exterior walls—both framed and solid wood framing. For interior walls, the need for a stud wall has been eliminated. Common uses include building a base wall in front of the mass timber wall or installing gypsum board on resilient channels that are attached to the mass timber wall. As with bare mass timber floor panels, bare mass timber walls don’t typically provide adequate noise control, and these walls also function as acoustical improvements. For example, a 3 ply CLT wall panel with a thickness of 3.00” has an STC rating of 32. In contrast, Figure 3 shows a single CLT panel partition wall with a thickness of 3.00” that has a STC rating of 55. The same applies for the use of mass timber wall panels. The use of mass timber panels can achieve the same STC ratings as those achieved with traditional wall assemblies.

Acoustical Differences between Mass Timber Panel Options
The majority of acoustically rated mass timber assemblies include CLT. However, tests have also been done on other mass timber panel options such as NLT and glue-laminated timber (GLT), as well as coupled heavy timber options such as solid tongue and groove decking. Most tests have concluded that CLT has the most performance results, but the results are not significantly better than that of other mass timber options. Different mass timber options, largely because of the cross-vibration of laminations in a CLT panel face sound flanking.

Improving Performance by Minimizing Flanking
Even when the assemblies are not in contact, high acoustical performance can be achieved. Consideration of flanking paths, in areas such as assembly intersections, beam-to-column/wall connections, and MEP penetrations is necessary for a building to resist overall acoustical performance objectives.

One way to minimize flanking paths is to use resilient connections and interfaces to reduce resilient connection isolation and wall-to-wall direct connections between members. In the context of the three methods of improving acoustical performance tested above, these are the preferred solutions. With sound insulation, connections, and penetrations, there is a much greater chance that the acoustical performance of a mass timber building will meet expectations.

Acoustically-Tested Mass Timber Assemblies

Following is a list of mass timber assemblies that have been acoustically tested as of January 23, 2019. Sources are noted at the end of this 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 help@woodworks.org or contact the WoodWorks Regional Director nearest you: http://www.woodworks.org/project-assistance

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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>STC¹</th>
<th>IIC²</th>
<th>Source</th>
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</thead>
<tbody>
<tr>
<td>1-1/2” Gyp-Crete*</td>
<td>Maxxon Acousti-Mat* 3/4</td>
<td>None</td>
<td>LVT</td>
<td>-</td>
<td>47⁵</td>
<td>47⁵ AILC</td>
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<tr>
<td></td>
<td></td>
<td>Maxxon Acousti-Mat* ¾ Premium</td>
<td>None</td>
<td>LVT</td>
<td>-</td>
<td>47⁵</td>
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<tr>
<td>CLT 5-ply (6.875&quot;)</td>
<td>USG SAM N25 Ultra</td>
<td>None</td>
<td>LVT</td>
<td>-</td>
<td>47⁵</td>
<td>47⁵ AILC</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>LVT Plus</td>
<td>-</td>
<td>47⁵</td>
<td>47⁵ AILC</td>
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<td></td>
<td></td>
<td></td>
<td>Eng Wood</td>
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<td>47⁵</td>
<td>47⁵ AILC</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Carpet + Pad</td>
<td>45⁵</td>
<td>47⁵</td>
<td>73⁵ AILC</td>
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<td></td>
<td></td>
<td></td>
<td>Ceramic Tile</td>
<td>50⁶</td>
<td>46⁵</td>
<td>61⁶</td>
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<tr>
<td></td>
<td>Suprema® Insular</td>
<td>None</td>
<td>LVT</td>
<td>-</td>
<td>42⁴</td>
<td>42⁴</td>
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<td></td>
<td></td>
<td></td>
<td>LVT Plus</td>
<td>-</td>
<td>42⁴</td>
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<td></td>
<td>Eng Wood</td>
<td>47⁵</td>
<td>45⁵</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Carpet + Pad</td>
<td>45⁵</td>
<td>47⁵</td>
<td>73⁵ AILC</td>
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<tr>
<td></td>
<td></td>
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<td>Ceramic Tile</td>
<td>50⁶</td>
<td>46⁵</td>
<td>61⁶</td>
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<tr>
<td></td>
<td>USG SAM N75 Ultra</td>
<td>None</td>
<td>LVT</td>
<td>-</td>
<td>36⁶</td>
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<td>Eng Wood</td>
<td>47⁵</td>
<td>49⁴</td>
<td>49⁴</td>
</tr>
</tbody>
</table>

¹ STC: Sound Transmission Class
² IIC: Impact Isolation Class

Note: The values in the table represent the acoustic properties of the floor assemblies, with higher numbers indicating better sound insulation and impact resistance.