Mass Timber Cost Optimization: How the Details Influence the Big Picture

Bruce Lindsey, Regional Director, WoodWorks – Wood Products Council

Photo: Texas Timber Frames
WHAT'S UNIQUE ABOUT MASS TIMBER?
IT’S (RELATIVELY) NEW
NOT A COMMODITY PRODUCT

Photo: Marcus Kauffman
STRUCTURE = FINISH = FIRE PROTECTION
COST OPTIMIZATION MUST ACCOUNT FOR MORE THAN COST (OF TIMBER)
Mass Timber Construction Types
3-4 Story Building Options

111 East Grand, Neumann Monson Architects, photo Mike Sinclair
# Mass Timber Construction Types

## 3-4 Story Building Options

<table>
<thead>
<tr>
<th></th>
<th>Type IIIB</th>
<th>Type VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable Building Height</td>
<td>4 stories / 75 ft</td>
<td>4 stories / 70 ft</td>
</tr>
<tr>
<td>Allowable Area</td>
<td>57k SF / 171k SF</td>
<td>54k SF / 162k SF</td>
</tr>
<tr>
<td>Interior FRR</td>
<td>0 HR</td>
<td>1 HR</td>
</tr>
<tr>
<td>Interior materials</td>
<td>Any material</td>
<td>Any material</td>
</tr>
<tr>
<td>Interior partitions</td>
<td>0 HR non-brng</td>
<td>0 HR non-brng</td>
</tr>
<tr>
<td>Exterior Bearing Walls</td>
<td>FRTW or Non-com, 2 HR</td>
<td>Any material, 1 HR</td>
</tr>
<tr>
<td>Concealed Spaces</td>
<td>Permitted</td>
<td>Permitted</td>
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</tbody>
</table>

### Floor and Wall Options
- **3-ply Floors**
  - No CLT ext. walls
  - Connections/Penetrations not rated
- **5-ply Floors**
  - CLT ext. walls
  - Connections/Penetrations rated
MT Fire Resistance Ratings (FRR)

Mass Timber Fire Design Resource
- Code compliance options for demonstrating FRR
- Construction type considerations
- Free download at woodworks.org

Credit: WoodWorks
Table 1: North American Fire Resistance Tests of Mass Timber Floor / Roof Assemblies

<table>
<thead>
<tr>
<th>CLT Panel</th>
<th>Manufacturer</th>
<th>CLT Grades or Major x Minor Grades</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>
</tr>
</thead>
<tbody>
<tr>
<td>5-ply CLT 114mm x 4.048 in.</td>
<td>Nordic</td>
<td>SYP 15.50 ft x 15.00 MBR x SPF #5</td>
<td>2 layers 3/4&quot; Type X Gypsum</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 10% Moment Capacity</td>
<td>1</td>
<td>NRC Fire Laboratory</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT 114mm x 4.113 in.</td>
<td>Stavanger</td>
<td>SYP #1-92</td>
<td>None</td>
<td>None</td>
<td>Reduced 7% Moment Capacity</td>
<td>1</td>
<td>NRC Fire Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-ply CLT 177mm x 4.113 in.</td>
<td>Nordic</td>
<td>SYP #1-92 x SPF #1-92</td>
<td>1 layer 5/8&quot; Type X Gypsum</td>
<td>Topside Splice</td>
<td>2 staggered layers of 1/2&quot; cement board</td>
<td>Laminated, 30% Metal factor</td>
<td>2</td>
<td>NRC Fire Laboratory, March 2014</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT 177mm x 4.113 in.</td>
<td>Nordic</td>
<td>SYP #1-92 x SPF #1-92</td>
<td>None</td>
<td>Topside Splice</td>
<td>2 staggered layers of 1/2&quot; cement board</td>
<td>Laminated, 30% Metal factor</td>
<td>3</td>
<td>NRC Fire Laboratory, Nov. 2014</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT 177mm x 4.113 in.</td>
<td>Nordic</td>
<td>SYP #1-92 x SPF #1-92</td>
<td>1 layer 5/8&quot; normal gypsum</td>
<td>Topside Splice</td>
<td>3/4 in proprietary gypsum over Mason panel and proprietary sound board</td>
<td>Reduced 10% Moment Capacity</td>
<td>3</td>
<td>UL</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT 177mm x 4.113 in.</td>
<td>Nordic</td>
<td>SYP #1-92 x SPF #1-92</td>
<td>1 layer 5/8&quot; Type X Gypsum under 2 layers of 1/2&quot; cement board</td>
<td>Topside Splice</td>
<td>3/4 in proprietary gypsum over Mason panel and proprietary sound board</td>
<td>Reduced 10% Moment Capacity</td>
<td>4</td>
<td>UL</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT 254mm x 4.048 in.</td>
<td>DR Johnson</td>
<td>SYP #2</td>
<td>None</td>
<td>Half-Lap</td>
<td>None</td>
<td>Reduced 10% Moment Capacity</td>
<td>2</td>
<td>Interlock, 6/24/2012</td>
<td></td>
</tr>
<tr>
<td>5-ply CLT 254mm x 4.113 in.</td>
<td>Stavanger</td>
<td>SPF #1-78 x SPF #1-92</td>
<td>None</td>
<td>Topside Splice</td>
<td>1 1/2&quot; Mercer Type C Gypal 500 or Mercer Reinforcing Mesh</td>
<td>Interlock, 2/22/2016</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-ply CLT 254mm x 4.113 in.</td>
<td>Stavanger</td>
<td>SPF #1-92 x SPF #1-92</td>
<td>None</td>
<td>Topside Splice</td>
<td>1 1/2&quot; Mercer Type C Gypal 500 or Mercer Reinforcing Mesh</td>
<td>Interlock, 2/22/2016</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Credit: WoodWorks
New Tall Mass Timber Types

Credit: Susan Jones, atelierjones
Tall Wood Buildings in the 2021 IBC
Up to 18 Stories of Mass Timber

In January 2018, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (IBC). Based on these proposals, the 2021 IBC will include three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber or noncombustible materials. These new types are based on the previous Heavy Timber construction type (renamed Type IV-HT) but with additional fire-resistance ratings and levels of required noncombustible protection. The code will include provisions for up to 18 stories of Type IV-A construction for Business and Residential Occupancies.

Based on information first published in the Structural Engineers Association of California (SEAOC) 2018 Conference Proceedings, this paper summarizes the background to these proposals, technical research that supported their adoption, and resulting changes to the IBC and product-specific standards.

Background: ICC Tall Wood Building Ad Hoc Committee

Over the past 10 years, there has been a growing interest in tall buildings constructed from mass timber materials (Breneman 2013, Timmera 2015). Around the world there

WoodWorks Tall Wood Design Resource

Demonstrating Fire-Resistance Ratings for Mass Timber Elements in Tall Wood Structures

Richard McLerie, PE, SE | Senior Technical Director – Tall Wood, WoodWorks

Changes to the 2021 International Building Code (IBC) have created opportunities for wood buildings that are much larger and taller than prescriptively allowed in past versions of the code. Occupant safety, and the need to ensure fire performance in particular, was a fundamental consideration as the changes were developed and approved. The result is three new construction types—Type IV-A, IV-B, and IV-C—which are based on the previous Heavy Timber construction type (renamed Type IV-H1), but with additional fire protection requirements.

One of the main ways to demonstrate that a building will meet the required level of passive fire protection, regardless of structural materials, is through hourly fire-resistance ratings (FRRs) of its elements and assemblies. The IBC defines an FRR as the period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703.

FRRs for the new construction types are similar to those required for Type I construction, which is primarily steel and concrete. (See Table 1.) They are found in IBC Table 601, which includes FRR requirements for all construction types and building elements; however, other code sections should be checked for overriding provisions (e.g., occupancy separation, shaft enclosures, etc.) that may alter the requirement.

**Table 1:**

<table>
<thead>
<tr>
<th>Building Type</th>
<th>I-A</th>
<th>IV-A</th>
<th>I-B</th>
<th>IV-B</th>
<th>I-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfactored load</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Fire resistance</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
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</table>

Tall Timber Fire-Resistance Design
Mass Timber: Structure Often is Finish

Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman | Architect: PATH Architecture
But by Itself, Not Adequate for Acoustics
# Mass Timber Acoustics

## TABLE 1: Examples of Acoustically-Tested Mass Timber Panels

<table>
<thead>
<tr>
<th>Mass Timber Panel</th>
<th>Thickness</th>
<th>STC Rating</th>
<th>IIC Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-ply CLT wall</td>
<td>3.07&quot;</td>
<td>33</td>
<td>N/A</td>
</tr>
<tr>
<td>5-ply CLT wall</td>
<td>6.875&quot;</td>
<td>38</td>
<td>N/A</td>
</tr>
<tr>
<td>5-ply CLT floor</td>
<td>5.1875&quot;</td>
<td>39</td>
<td>22</td>
</tr>
<tr>
<td>5-ply CLT floor</td>
<td>6.875&quot;</td>
<td>41</td>
<td>25</td>
</tr>
<tr>
<td>7-ply CLT floor</td>
<td>9.65&quot;</td>
<td>44</td>
<td>30</td>
</tr>
<tr>
<td>2x4 NLT wall</td>
<td>3-1/2&quot; bare NLT</td>
<td>24 bare NLT</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>4-1/4&quot; with 3/4&quot; plywood</td>
<td>29 with 3/4&quot; plywood</td>
<td>N/A</td>
</tr>
<tr>
<td>2x6 NLT wall</td>
<td>5-1/2&quot; bare NLT</td>
<td>22 bare NLT</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>6-1/4&quot; with 3/4&quot; plywood</td>
<td>31 with 3/4&quot; plywood</td>
<td>N/A</td>
</tr>
<tr>
<td>2x6 NLT floor + 1/2&quot; plywood</td>
<td>6&quot; with 1/2&quot; plywood</td>
<td>34</td>
<td>33</td>
</tr>
</tbody>
</table>

Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks
One of the main reasons is “mass”
Recall the three ways to increase acoustical performance:

1. Add Mass
2. Add noise barriers
3. Add decouplers
Concrete Slab:
6” Thick
80 PSF
STC 53

CLT Slab:
6-7/8” Thick
18 PSF
STC 41
There are three main ways to improve an assembly’s acoustical performance:

1. Add mass
2. Add noise barriers
3. Add decouplers
Mass Timber Acoustics

Acoustics and Mass Timber: Room-to-Room Noise Control

The growing availability and code acceptance of mass timber—via large solid wood panel products such as engineered laminated timber (CLT) and Nail-Embedded timber (NLT)—for floor, wall, and roof construction has given designers a low-carbon alternative to steel, concrete, and masonry when applying mass timber as floors, roofs, and walls. While higher acoustic performance has been achieved in traditional building assemblies, such as light-steel and concrete, solid wood construction lacks the long history of success and is more costly without mass timber panels. Additionally, one of the most desired aspects of mass timber construction is the ability to have a building plan that supports the structure, which reduces the need for interior supports. With careful design and detailing, mass timber buildings can meet the acoustic performance expectations of mass timber buildings.

Mass Timber Assembly Options

Walls can also be used for interior and exterior walls—both bearing and non-bearing. For interior walls, the need for concealed services such as electrical and plumbing is an added consideration. Common approaches include placing a chase wall in front of the mass timber wall or installing partition walls 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 chase walls also function as acoustical improvements. For example, a 3-ply CLT wall panel with a thickness of 3.075 in has an STC rating of 51 in contrast. Figure 3 shows an interior CLT partition wall with chase walls on both sides. This assembly achieves an STC rating of 64, exceeding the IRC's acoustical requirements for multi-family construction. Other examples are included in the inventory of tested assemblies noted above.

Acoustical Differences between Mass Timber Panel Options

The majority of acoustically tested mass timber assemblies include CLT. However, tests have also been done on other mass timber panel options such as NLT and glued-laminated timber (GLT), as well as traditional heavy timber options such as tongue and groove. Most tests have concluded that CLT acoustic performance is slightly better than that of other mass timber options, largely because the cross-section of laminations in a CLT panel limits sound flanking. For those interested in comparing similar assemblies, one mass timber panel option that stands out above all others tested assemblies using CLT, NLT, glued-laminated timber panels (GLT), and tongue and groove.

Inventory of Tested Assemblies

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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A Few Notes About the Inventory


<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>RC</th>
<th>Source</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Maxson Acousti-Mat® 3/4</td>
<td>None</td>
<td>47¹ ASTC</td>
<td>47¹ AIIIC</td>
<td>1</td>
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<tr>
<td></td>
<td></td>
<td>Maxson Acousti-Mat® % Premium</td>
<td>LVT</td>
<td>49¹ AIIIC</td>
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<td></td>
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<tr>
<td>3-1/2&quot; Gyp-Crete*</td>
<td></td>
<td>Maxson Acousti-Mat® 3/4</td>
<td>Carpet + Pad</td>
<td>75¹ AIIIC</td>
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<td>Maxson Acousti-Mat® % Premium</td>
<td>LVT on Acousti-Top*</td>
<td>52¹ AIIIC</td>
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<td></td>
<td></td>
<td>Maxson Acousti-Mat® % Premium</td>
<td>Tag Wood on Acousti-Top*</td>
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<tr>
<td>CLT 5-ply (6.875&quot;)</td>
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<td>USG SAM N25 Ultra</td>
<td>None</td>
<td>45² ASTC</td>
<td>45² AIIIC</td>
<td></td>
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<tr>
<td></td>
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<td>Maxson Acousti-Mat® % Premium</td>
<td>LVT</td>
<td>47² AIIIC</td>
<td></td>
<td></td>
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<tr>
<td>1-1/2&quot; Le伏rotok®</td>
<td>Brand 2500</td>
<td>Soventra® Insonamat</td>
<td>LVT Plus</td>
<td>47² AIIIC</td>
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<td>Maxson Acousti-Mat® % Premium</td>
<td>LVT on Acousti-Top*</td>
<td>50² AIIIC</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td>Maxson Acousti-Mat® % Premium</td>
<td>Tag Wood</td>
<td>47² AIIIC</td>
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<tr>
<td></td>
<td></td>
<td>Maxson Acousti-Mat® % Premium</td>
<td>Carpet + Pad</td>
<td>45² AIIIC</td>
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<td>Maxson Acousti-Mat® % Premium</td>
<td>Ceramic Tile</td>
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<td>45² AIIIC</td>
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<td></td>
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<td></td>
<td>Maxson Acousti-Mat® % Premium</td>
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<td>47² AIIIC</td>
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<td>Tag Wood</td>
<td>47² AIIIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maxson Acousti-Mat® % Premium</td>
<td>LVT</td>
<td>47² AIIIC</td>
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</tr>
</tbody>
</table>

¹: STC = Sound Transmission Class
²: RC = Rating Class

Source: WoodWorks

Mass Timber Assemblies

Without Dropped Ceiling

Two layers 5/8" Type X gypsum
*Applicable to most locations; limited exposed mass timber permitted in IV-B
Mass timber floor panel
Minimum 1" noncombustible material

With Dropped Ceiling

Two layers 5/8" Type X gypsum
Mass timber floor panel
Minimum 1" noncombustible material
Dropped ceiling

LVT on 2” Concrete

Effect of Timber Thickness

<table>
<thead>
<tr>
<th>CLT Thickness</th>
<th>STC</th>
<th>IIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-ply CLT</td>
<td>53</td>
<td>48</td>
</tr>
<tr>
<td>5-ply CLT</td>
<td>53</td>
<td>52</td>
</tr>
</tbody>
</table>
**Without Dropped Ceiling**

Minimum 1” noncombustible material  
Mass timber floor panel  
Two layers 5/8” Type X gypsum*  
*Applicable to most locations; limited exposed mass timber permitted in IV-B

**With Dropped Ceiling**

Minimum 1” noncombustible material  
Mass timber floor panel  
Two layers 5/8” Type X gypsum

---

**Effect of Gypsum Ceiling**

STC 51  
IIC 43  
STC 52  
IIC 48  
STC 63  
IIC 63
MASS TIMBER WHY’S

- Innovation and Aesthetic Appeal
- Speed of Construction
- Construction Site Constraints – Urban Infill
- Labor Shortages
- Structural Performance - Lightweight
- Business Case for Healthy Buildings
KNOW YOUR WHY
<table>
<thead>
<tr>
<th>Potential Benefits</th>
<th>Project Goal</th>
<th>Value Add</th>
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</thead>
<tbody>
<tr>
<td>Fast construction</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Aesthetic Value (Leasing velocity/ premiums)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy Building / Biophilia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightweight structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Labor shortage solution</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>• small crews</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• entry level workers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Just-in-time delivery (ideal for dense urban sites)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmentally friendly (low carbon footprint)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy forests/ wildfire resiliency &amp; support rural economies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reduce Risk
Optimize Costs

- For the entire project team, not just builders
- Lots of reference documents

**Mass Timber Cost and Design Optimization Checklists**

WoodWorks has developed the following checklists to assist in the design and cost optimization of mass timber projects. The design optimization checklists are intended for building designers (architects and engineers), but many of the topics should also be discussed with the fabricators and builders. The cost optimization checklists will help guide coordination between designers and builders (general contractors, construction managers, estimators, fabricators, installers, etc.) as they are estimating and making cost-related decisions on a mass timber project.

Most resources listed in this paper can be found on the WoodWorks website. Please see the end notes for URLs.

**Download Checklists at**

[www.woodworks.org](http://www.woodworks.org)

Is Mass Timber Cost Competitive?
Risk: Cost Analysis of Structure Only

Source: GBD Architects
Seattle Mass Timber Tower: Detailed Cost Comparison
Fast Construction

- Textbook example done by industry experts
- Mass timber vs. PT conc
- Detailed cost, material takeoff & schedule comparisons

“The initial advantage of Mass Timber office projects in Seattle will come through the leasing velocity that developers will experience.”
- Connor Mclain, Colliers

Download Case Study:
Seattle Mass Timber Tower
Fast Construction

Construction Schedule:

- Site Selection, Due Diligence, & PSA: Jan 1 - May 17
- Master Use and Building Permits: May 20 - Jun 29
- Design Phase: Jan 29 - Oct 6
- Estimating and GMP Contract Phase: Mar 25 - Jan 12

Mass Timber:
- 5 months (25%) faster

How can faster construction increase your ROI?

Source: Tall With Timber
A Seattle Mass Timber Tower Case Study by DLR Group
# Seattle Mass Timber Tower

Faster Construction + Higher Material Costs = Cost Competitive

<table>
<thead>
<tr>
<th>System</th>
<th>Mass Timber Design</th>
<th>PT Concrete Design</th>
<th>Mass Timber Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Cost of Work</td>
<td>$86,997,136</td>
<td>$85,105,091</td>
<td>2.2%</td>
</tr>
<tr>
<td>Project Overhead</td>
<td>$ 9,393,750</td>
<td>$11,768,750</td>
<td>-20.2%</td>
</tr>
<tr>
<td>Add-Ons</td>
<td>$ 8,387,345</td>
<td>$ 8,429,368</td>
<td>-0.5%</td>
</tr>
<tr>
<td>Total</td>
<td>$104,778,231</td>
<td>$105,303,209</td>
<td>-0.5%</td>
</tr>
</tbody>
</table>

Source: DLR Group | Fast + Epp | Swinerton Builders
Compressing the Typical Schedule

Fast Construction

Below-grade foundations + soils

Less soil remediation + smaller foundations for sites with problematic soils

Mass timber structure

Faster erection (prefabricated + precise)

If prefabricated, savings in enclosure time

Early start*

Building envelope/interior

 MEP fully coordinated in design phase & therefore installed faster

Early start*

MEP

Early start*

Interior finishes

Less finishes with exposed wood structure

Overall mass timber construction schedule

*Earlier start for follow-up trades; no waiting for cure times

Up to 25% schedule savings

= Less carrying costs
  + Less GC overhead
  + Ability to lease/occupy sooner

Source: Mass Timber Cost & Design Optimization, WoodWorks®
Schedule Savings for Rough-In Trades
Fast Construction

NO curing (mass timber)

Curing & maze of shores (concrete)
Keys to Mass Timber Success:

Know Your **WHY**

Design it as Mass Timber From the Start

Leverage Manufacturer Capabilities

Understand Supply Chain

Optimize Grid

Take Advantage of Prefabrication & Coordination

Expose the Timber

Discuss Early with AHJ

Work with Experienced People

Let WoodWorks Help for Free

Create Your Market Distinction

Images: Korb & Associates
QUESTIONS?
This concludes The American Institute of Architects Continuing Education Systems Course

Bruce Lindsey
Regional Director - WoodWorks
bruce@woodworks.org
(704) 877-6255
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