Optimizing the Cost of Mass Timber Buildings Pre-design Through CDs

Ricky McLain, PE, SE, Senior Technical Director – Tall Wood, WoodWorks – Wood Products Council

Photo: Kaiser+Path
Mass Timber Cost Optimization = Mass Timber Success
WHAT’S UNIQUE ABOUT MASS TIMBER?
IT’S (RELATIVELY) NEW

Photo: John Klein
NOT A COMMODITY PRODUCT (YET)
STRUCTURE = FINISH = FIRE PROTECTION

Photo: Structurlam
COST OPTIMIZATION MUST ACCOUNT FOR MORE THAN COST (OF TIMBER)
Mass Timber Cost & Design Optimization Checklists

Optimize Costs

- Aid in design & cost optimization of mass timber projects
- Guiding discussions between:
  - Designers (architects & engineers)
  - Builders (general contractors, estimators, fabricators & installers)
  - Owners (developers & construction managers)

Download Checklists at www.woodworks.org

Mass Timber Cost & Design Optimization Checklists

Overview

Pre-Design Checklist:

- Design & Builder Team
- Cost Estimating Considerations
- Contractual Considerations
- Design Goals
- Contact WoodWorks
Pre-Design Contractual Considerations
Prefabricated Approach

Avoid:
• Design-bid-build

Consider:
• CM at risk
• Design-assist
• IPD
• Design-build

*Contractor input needed in design stages!
Mass Timber Cost & Design Optimization Checklists

Overview

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- Contractual Considerations
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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>
</tr>
</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>
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<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>
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:
How can faster construction increase your ROI?

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

Mass Timber 5 months (25%) faster
# 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)

Building envelope/exterior

Earlier start*

If prefabricated, savings in enclosure time

MEP

Earlier start*

MEP fully coordinated in design phase & therefore installed faster

Earlier start*

Less finishes with exposed wood structure

Interior finishes

Overall mass timber construction schedule

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

Mass Timber Construction

Fleisch

Steel/Concrete Construction

Fleisch

Look for these potential $ savings with mass timber in comparison to steel and concrete.

Up to 25% schedule savings
= Less carrying costs + Less GC overhead + Ability to lease/occupy sooner

Source: Mass Timber Cost & Design Optimization, WoodWorks²
Schedule Savings for Rough-In Trades

Fast Construction

NO curing (mass timber) vs. Curing & maze of shores (concrete)
Candlewood Suites: Military Hotels
Labor Shortage Solutions

Redstone Arsenal:
• 37% faster overall
• 40% fewer construction workers
• Trained unemployed veterans

Prefab Assemblies:
• Bathroom Pods
• Facades
• MEP Racks

Developer, Asset Manager, Design Builder: Lendlease
Location: Redstone Arsenal, Huntsville, Alabama
ULI Report: The Business Case for Healthy Buildings

Healthy Building/ Biophilia

Global Wellness Real Estate Industry:
- $134 billion industry in 2017
- 6.4% annual increase since 2015
- $180 billion industry by 2022

Healthy Bldgs ROI (Survey of 200 Canadian Bldg Owners):
- 46% easier to lease
- 28% command premium rents
- 38% of those who reported value in healthy bldgs said they are worth 7% more than conventional ones

Millennials:
- 78% say workplace quality is important
- 69% would trade other benefits for good workplace

“Health and wellness-focused environments…can help reduce company operating costs and increase revenues and profits.”
Employee Retention
Healthy Building/ Biophilia

Cost of losing an employee (assume: $33/hr):

- $1,000 termination
- $9,000 replacement
- $15,875 lost productivity

$25,875 total

Sources by Terrapin Bright Green:
- Economics of Biophilia, 2012
- 14 Patterns of Biophilic Design, 2014
  (includes list of testing citations)
Attracting Top Talent

Exposed timber offices create market distinction

Sidewalk Labs, Toronto

Microsoft Campus

Google HQ, UK.
Carbon Storage: Wood = 50% Carbon (dry weight)
Environmental Impact
Volume of wood products used: 816,736 board feet (equivalent)

U.S. and Canadian forests grow this much wood in: 4 minutes

Carbon stored in the wood: 1,054 metric tons of CO₂

Avoided greenhouse gas emissions: 2,155 metric tons of CO₂

TOTAL POTENTIAL CARBON BENEFIT: 3,169 metric tons of CO₂

Source: US EPA

605 cars off the road for a year

Energy to operate a home for 269 years

...From one school

Leading Developer Embraces Mass Timber Offices

T3 = Timber, Transit & Technology

Location: Minneapolis, MN
Architect: Michael Green Architecture, DLR Group
Structural Engineer: Magnusson Klemencic Associates
Mass Timber Engineer: StructureCraft

- 6 stories wood over podium
- 220,000 sf
- Finance & Commerce reports:
  - $25 to 50 million project cost (2016 completion)
  - $87 million purchase price (May 2018 sold to LaSalle)

Photos: Ema Peter, MGA
Leading Developer Embraces Mass Timber Offices
T3 Minneapolis

Location: Minneapolis, MN
Architect: MGA | Michael Green Architecture, DLR Group
Structural Engineer: Magnusson Klemencic Associates
Mass Timber Engineer: StructureCraft

Photo: WoodWorks

**IV (HT)**

- 20' x 25' grid
- 2x8 NLT spanning 20 ft
- MEP mains routed around core w/ a shorter bay spacing & shallower beam
- Timber erection:
  - 2.5 months total
  - 9 days per 30,000-sf floor
- **Foundation $ savings:**
  - **30% lighter** than steel
  - **60% lighter** than conc

Location: Minneapolis, MN
Architect: MGA | Michael Green Architecture, DLR Group
Structural Engineer: Magnusson Klemencic Associates
Mass Timber Engineer: StructureCraft
Austin’s 1st CLT Office: Built to Attract Millennial Talent
901 E 6th Street

- 5 Story
- 129,000 sf
- CLT & steel frame hybrid
- 14-ft Floor to ceiling heights w/ 9’ windows
- “Leasing broker feedback… CLT helped generate interest, assisted in faster leasing and helped support higher lease rates.”

Location: Austin, TX
Architect: Thoughtbarn / Delineate Studio
Engineer: LEAP! Structures
Tenant Build Outs – Potentially Lower Costs
Starting with Aesthetic Value of Structure
55 Southbank: Add Vertical Density over Existing Bldgs Lightweight

- Existing building constructed to accommodate future 6-story concrete addition
- Owner wanted 220 key hotel addition:
  - 6-stories conc = no deal
  - 10-stories wood = deal
- Research shows ¼ of urban buildings in the world are strong enough to carry additional floors of wood
- Low embodied carbon footprint

Location: Melbourne, Australia
Architect: Bates Smart
Engineer: Vistek
• Structural & MEP require more detailed input from engineers and builders
• Estimating: Not enough data for unit cost method; more detailed approaches req’d

Publicly-funded projects to be competitively bid, make the “go/no go” decision on mass timber by end of SD.
Mass Timber Cost & Design Optimization Checklists
Schematic Design (SD)

**SD Design Optimization Checklist:**
- Material Optimization/ Grids
- System Coordination
  - Structural
  - Acoustics/ Vibration
  - Fire Resistance
- Finish Quality

**SD Cost Optimization Checklist:**
- Schedule Savings = Cost Savings
- Aesthetic Value
- Less Weight = Cost Savings
- Fabrication
- Shipping/ Trucking
- Installation & Labor
## Building Size & Construction Type

**Multi-story, Business Occupancy (B)**

*IBC 2015/ 2018*

Tables 504.3, 504.4, 506.2 w/ allowable increases

### Heights & Areas

<table>
<thead>
<tr>
<th>3 to 4 Stories</th>
<th>5 to 6 Stories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steel/ Conc</strong></td>
<td><strong>Wood</strong></td>
</tr>
<tr>
<td><strong>Heights &amp; Areas</strong></td>
<td>IIB</td>
</tr>
<tr>
<td>Stories</td>
<td>4</td>
</tr>
<tr>
<td>Height (ft)</td>
<td>75</td>
</tr>
<tr>
<td>Max Story Area (ft²)</td>
<td>69 k</td>
</tr>
<tr>
<td>Total Bldg Area (ft²)</td>
<td>207 k</td>
</tr>
</tbody>
</table>

### Assumptions:

1. NFPA 13 sprinkler increase (IBC 504.2)
2. NFPA 13 sprinkler increase (IBC 506.3)
3. Stories 3 or more (IBC 506.4)
Office
Wythe Ave Buildings, NY | Flank Architecture + Development

Hospitality
Lark Hotel, Bozeman | Thinktank Design | Photo: Dan Armstrong

Multi-family
Carbon 12, Portland | Path Architecture | Photo: Andrew Pogue

Industrial
StructureCraft Plant, Abbotsford, BC
How can I create an efficient structural grid for a mass timber building?

Mass timber products such as cross-laminated timber (CLT), nail-laminated timber (NLT) and glue-laminated timber (glulam) are at the core of a revolution that is shifting how designers think about construction. At no time has materials selection been such an integral aspect of the building designer’s daily responsibilities. In addition to its sustainability and light carbon footprint, mass timber has benefits that include enhanced aesthetics, speed of construction and light weight, all of which can positively impact costs. However, to convince building owners and developers that a mass timber solution is viable, the structural design must also be cost competitive. This requires a full understanding of both material properties and manufacturer capabilities.

Mass timber is commonly seen in projects such as offices, schools and tall mixed-use buildings, which often have assumed structural grids. Intended to meet the need for tenant flexibility, these “default” grids align with the capabilities of materials historically used—i.e., steel and concrete. When it comes to laying out a structural grid for mass timber, the square peg/hole analogy is pertinent. Although a mass timber solution may work economically on many grids conducive to steel/concrete framing, some grid modification may be valuable. Trying to force a mass timber solution on a grid laid out for steel and concrete can result in member size inefficiencies while negating opportunities related to manufacturer capabilities. As such, it is critically important to design a mass timber building as a mass timber building from the start. This requires a thorough understanding of how to best lay out the structural grid, without sacrificing space functionality, to optimize member sizes—but there’s more to it than that.

The following considerations are based on a gross-and-cream frame for occupancies such as offices, classrooms and offices, with some general recommendations:

1. **Grid Alignment**: The grid should be aligned with the building’s structural system to maximize efficiency.
2. **Span Efficiency**: Minimize the span of structural elements to reduce material usage and cost.
3. **Material Properties**: Utilize the unique properties of mass timber to optimize design.
4. **Cost Considerations**: Balance structural integrity with economic viability.

By considering these factors, designers can create efficient and cost-effective structural grids for mass timber buildings.
Fully Prefabricated: North America’s First DLT Office
111 East Grand

- 4 Story
- 64,000 sf
- First DLT office in the US
- 1st spec office in Des Moines in over a decade
- Superstructure all prefabricated for fast erection.
- Lateral system – precast concrete walls & core

Location: Des Moines, IA
Architect: Neumann Monson
Structural Engineer: Raker Rhodes
Mass Timber Engineer: StructureCraft

Image: Neumann Monson Architects courtesy of Ryan Companies
Fully Prefabricated: North America’s First DLT Office
111 East Grand

- 20’ x 25’ grid
- 2x8 DLT spanning 20 ft
- 40’ x 6’-4” DLT panels
- Glulam beams & cols

Just-in-time delivery ideal for tight sites and urban locations

Location: Des Moines, IA
Architect: Neumann Monson
Structural Engineer: Raker Rhodes
Mass Timber Engineer: StructureCraft
Design Phases
Schematic Design (SD)

- Select lateral system in SD
  - Compatibility w/ fast speed of mass timber
- Responsibility
  - design engineer
  - fabrication
- Installation
  - GC self install?
  - Subcontractor?
Hines’ Mass Timber Offices Rising in Southeast
T3 West Midtown, Atlanta

- 6 stories Type IV over podium
- 205,000 sf
- DLT floors, glulam frame
- T3 Atlanta replaces concrete with steel braced-frame lateral system to keep up with fast speed of mass timber erection

Location: Atlanta, GA
Architect: Hartshorne Plunkard Architects + DLR Group
Structural Engineer: Magnusson Klemencic Associates
Mass Timber Engineer: StructureCraft
Digital fabrication needs defined

- Structural & MEP require more detailed designs from engineers and builders
- More Key Details need to be developed

Publicly-funded projects to be competitively bid, early bid the mass timber supplier at end of DD or by 50% CD at latest

Prefabrication requires more detailed DD design phase w/ builder input
Mass Timber Cost & Design Optimization Checklists

Design Development

**DD Design Optimization Checklist:**
- ✔ Material Optimization/ Grids
- ✔ Hybrid Considerations
- ✔ System Coordination
- ✔ Fire Resistance
- ✔ MEP Systems
- ✔ Finish Quality
- ✔ Key Details

**DD Cost Optimization Checklist:**
- ✔ Less Weight = Cost Savings
- ✔ Schedule Savings = Cost Savings
- ✔ Cost & Value
- ✔ Fabrication
- ✔ Installation & Labor
- ✔ Protection
Digital Fabrication
Design Development (DD)

- Prefabricated panels
- Coordinate all MEP & fire protection penetrations
- Tolerances for wood tighter than steel, conc, & other materials
- Structural connections
- Schedule steel shops so they don’t delay mass timber fabrication
- Plan now to reduce on-site labor
Construction Document (CD) Phase
Prefabrecated Mass Timber

- Everything is in 3D Model: Structural, MEP, & Fire Protection
- Pay extra attention to material systems interaction: timber to concrete to steel including tolerances, timing of shop drawings & responsibility

The key to fast construction is designing and coordinating all systems during design stages. Don’t leave it for construction!
Moisture Management
Keep Wood Dry & Schedule on Track

• Just-in-time delivery, no storage - wood installed directly from trucks
• Protect connections/ connectors
• Moisture management plan

Reuse panel wraps for covering wood end grains & connections

Construction Phase Moisture Management, Section 7.6 NLT Guide (Good Tips for all MT)

Download:
Moisture Management
Keep Wood Dry & Schedule on Track

• Mass timber & light frame
• Design & Construction Moisture Mgmt Checklists in Appendix I & II
• Categorizes material
  • by wetting & drying potential
  • for on-site protection strategies

Moisture Management Guide
Download:
Finish Quality: Exposed Structure
Protect the Investment

• Industrial grade appearance, save $
• Surface coatings
• Temporary Protection
  • Moisture
  • Construction trades
Reduce Risk
Optimize Costs

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

Download Checklists at
www.woodworks.org

www.woodworks.org/wp-content/uploads/wood_solution_paper-
Mass-Timber-Design-Cost-Optimization-Checklists.pdf
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
Questions?

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