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

T3 Minneapolis | Architects: Michael Green Architecture, DLR Group | Photo: Ema Peter

WHAT'S UNIQUE ABOUT MASS TIMBER?

IT'S (RELATIVELY) NEW

Photo: John Klein

Photo: John Stamets

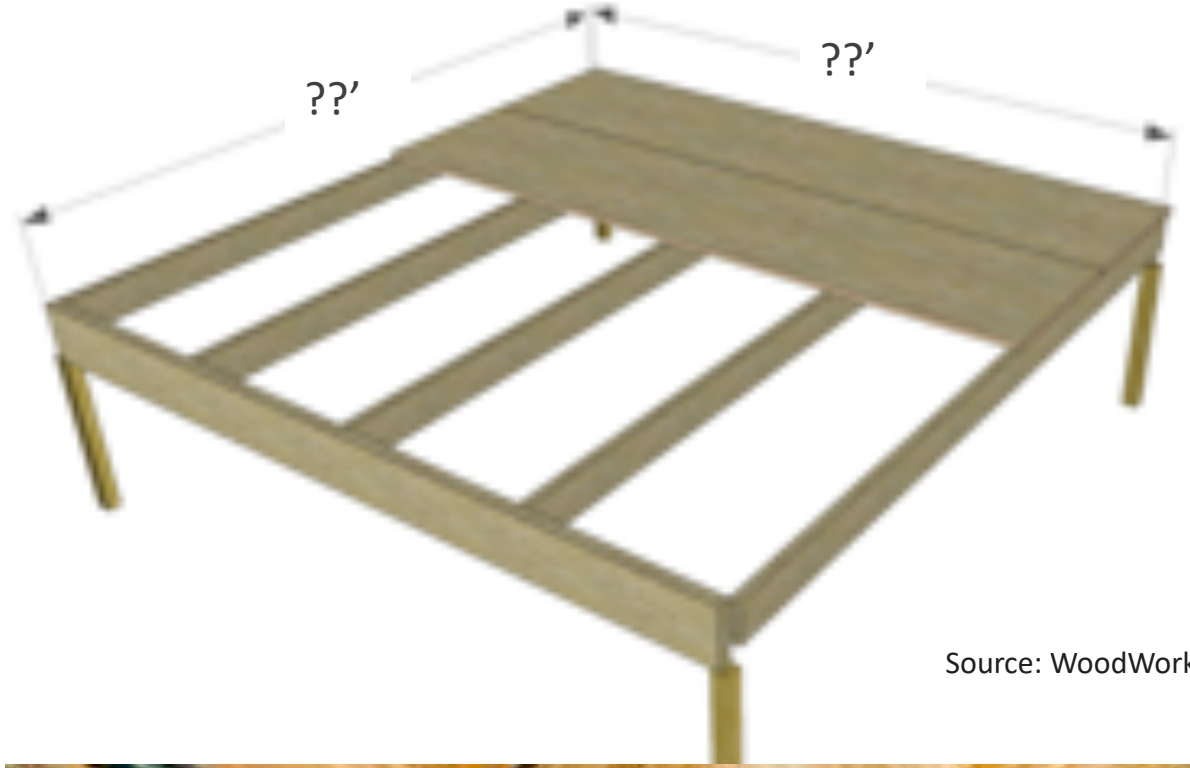
Photo: Alex Schreyer

NOT A COMMODITY PRODUCT (YET)

Photo: Marcus Kauffman

Photo: DR Johnson


Photo: Sauter Timber



Source: WoodWorks


Photo Credit: Josh Partee

STRUCTURE = FINISH = FIRE PROTECTION

Photo: Structurlam

Photo: Ema Peter Photography

COST OPTIMIZATION MUST ACCOUNT FOR MORE THAN COST (OF TIMBER)

Image: WoodWorks

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

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

Mass Timber Cost & Design Optimization Checklists

Overview

Pre-Design Checklist:

- ☑ **Design & Builder Team**
- ☑ **Cost Estimating Considerations**
- ☑ **Contractual Considerations**
- ☑ Design Goals
- ☑ Contact WoodWorks

Options, Comparisons, Studies

Pre-Design Contractual Considerations

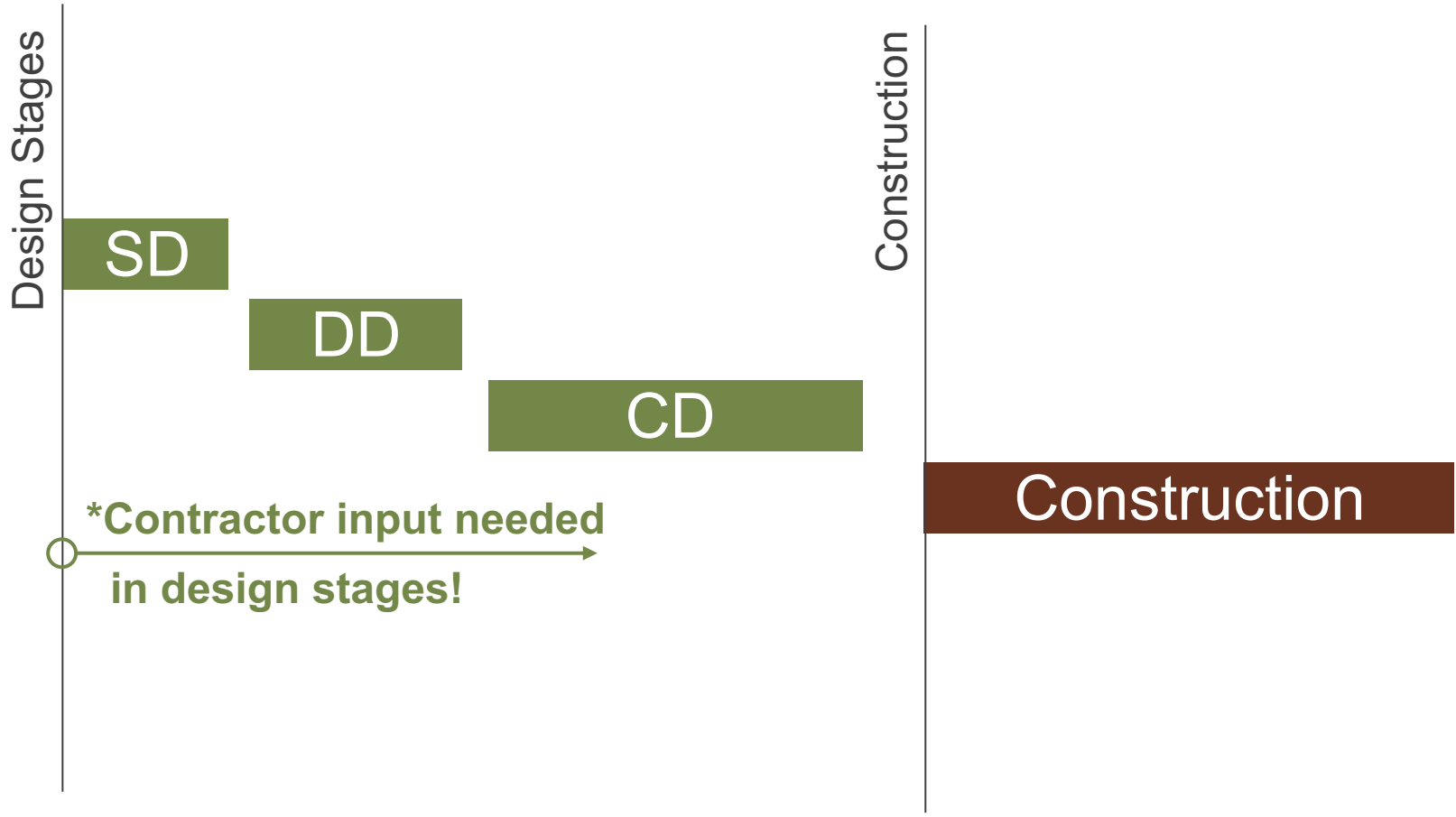
Prefabricated Approach

Avoid:

- Design-bid-build

Consider:

- CM at risk
- Design-assist
- IPD
- Design-build



Mass Timber Cost & Design Optimization Checklists

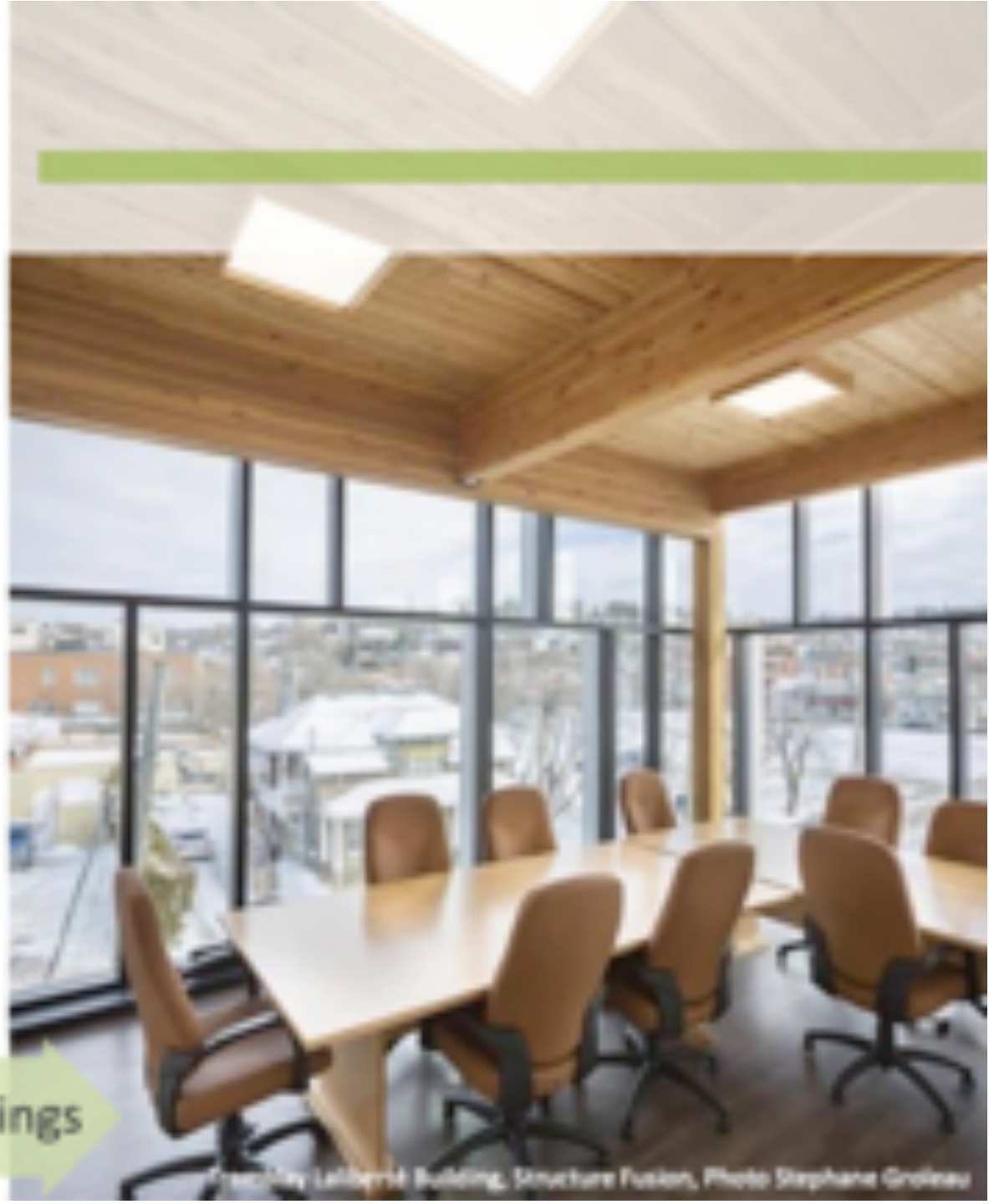
Overview

Pre-Design Checklist:

- ☑ Design & Builder Team
- ☑ Cost Estimating Considerations
- ☑ Contractual Considerations
- ☑ **Design Goals**
- ☑ Contact WoodWorks

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

Potential Benefits	Project Goal ✓	Value Add ✓
Fast construction		
Aesthetic Value (Leasing velocity/ premiums) Healthy Building / Biophilia		
Lightweight structure		
Labor shortage solution • small crews • entry level workers		
Just-in-time delivery (ideal for dense urban sites)		
Environmentally friendly (low carbon footprint)		
Healthy forests/ wildfire resiliency & support rural economies		

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[1]

Download Case Study:

http://www.fastepp.com/wp-content/uploads/181109-Seattle-Mass-Timber-Tower-Book.pdf

Seattle Mass Timber Tower

Fast Construction

Construction Schedule:

Mass Timber
5 months
(25%) faster

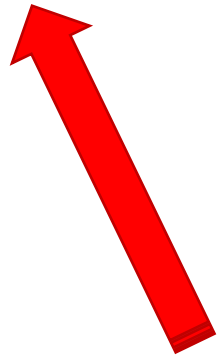
How can faster construction increase your ROI?

Source: Tall With Timber
A Seattle Mass Timber Tower Case Study by DLR Group[1]

Seattle Mass Timber Tower

Faster Construction + Higher Material Costs = Cost Competitive

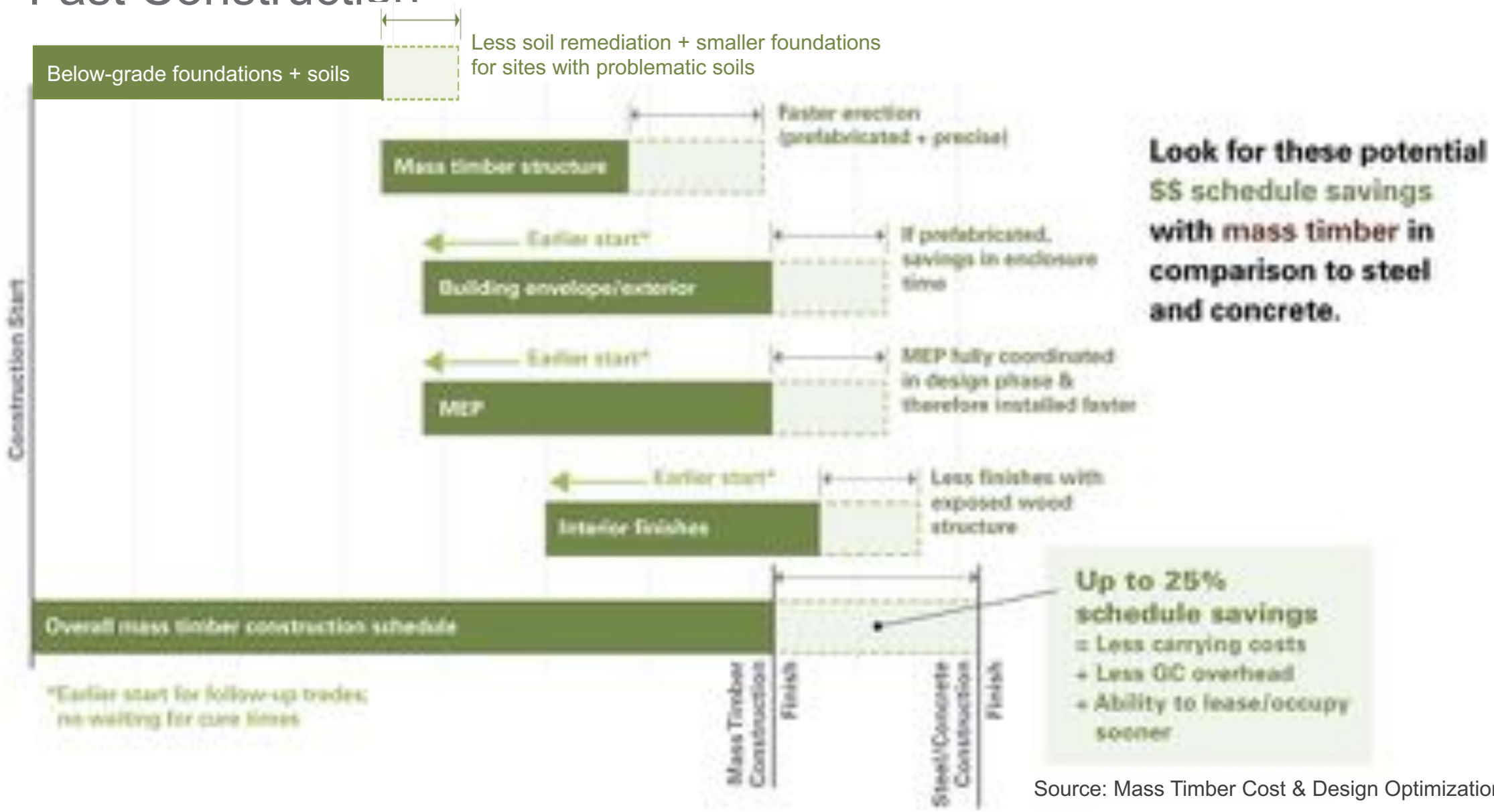
System	Mass Timber Design	PT Concrete Design	Mass Timber Savings
Direct Cost of Work	$86,997,136	$85,105,091	2.2%
Project Overhead	$ 9,393,750	$11,768,750	-20.2%
Add-Ons	$ 8,387,345	$ 8,429,368	-0.5%
Total	**$104,778,231**	**$105,303,209**	**-0.5%**



Source: DLR Group | Fast + Epp | Swinerton Builders

Compressing the Typical Schedule

Fast Construction

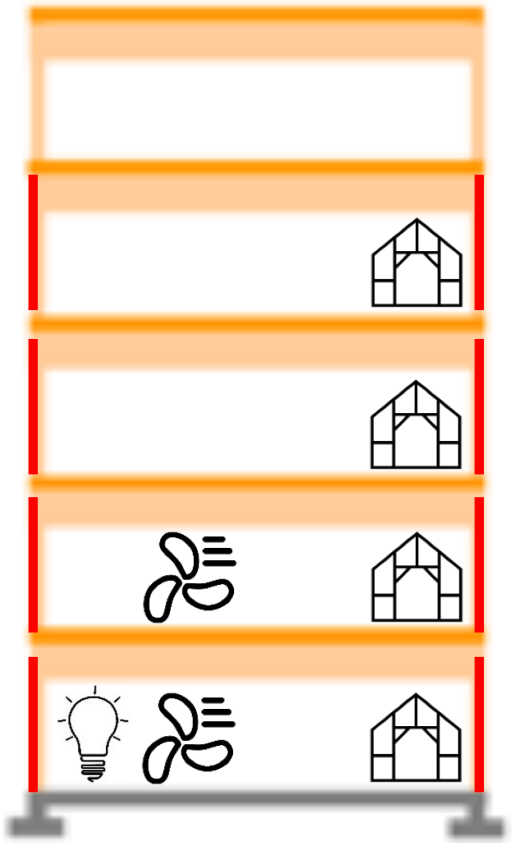


Look for these potential $$ schedule savings with mass timber in comparison to steel and concrete.

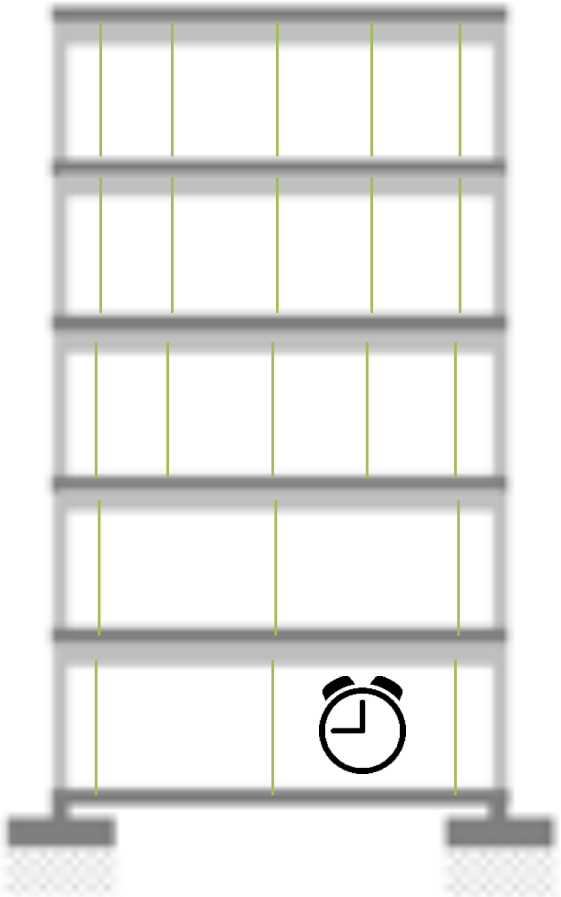
Source: Mass Timber Cost & Design Optimization, WoodWorks[2]

Schedule Savings for Rough-In Trades

Fast Construction



NO curing
(mass timber)



Curing & maze of shores (concrete)

Candlewood Suites: Military Hotels
Labor Shortage Solutions

Redstone Arsenal:
- 37% faster overall[2]
- 40% fewer construction workers[2]
- 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**."

2018 Report

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)

The Hudson
Mackenzie | Photo: Christian Columbres

Attracting Top Talent

Exposed timber offices create market distinction

Microsoft Campus

Image: Microsoft | WRNS Studio

Sidewalk Labs, Toronto

Image: Picture Plane for Heatherwick Studio for Sidewalk Labs

Google HQ, UK

Image: Google | Lendlease HayesDavidson for BIG & Heatherwick Studios

Carbon Storage: Wood = 50% Carbon (dry weight)
Environmental Impact


Image: Kaiser + Path


Image: Lever Architecture

MASS TIMBER APPEAL
Reduced Embodied Carbon

Volume of wood products used:
818,736 board feet (equivalent)

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

Carbon stored in the wood:
1,014 metric tons of CO_2

Avoided greenhouse gas emissions:
2,155 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
3,169 metric tons of CO_2

EQUIVALENT TO:

605 cars off the road for a year

Energy to operate a home for 269 years

Source: US EPA

...From one school

Estimated by the Wood Carbon Calculator for Buildings, based on research by Sarthre, R. and J. O'Connor, 2010, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations. Note: CO_2 on this chart refers to CO_2 equivalent.

Leading Developer Embraces Mass Timber Offices

T3 = Timber, Transit & Technology

Photos: Ema Peter; MGA

IV (HT)

- 6 stories wood over podium
- 220,000 sf
- *Finance & Commerce* reports:

  $25 to 50 million project cost[3] (2016 completion)

  $87 million purchase price (May 2018 sold to LaSalle)[4]

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

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

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[5]

Austin's 1st CLT Office: Built to Attract Millennial Talent

901 E 6th Street

Location: Austin, TX
Architect: Thoughtbarn / Delineate Studio
Engineer: LEAP! Structures

IIIA

- 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**."[9]

Tenant Build Outs – Potentially Lower Costs

Starting with Aesthetic Value of Structure

T3 Minneapolis | Architects: Michael Green Architecture, DLR Group | Photo: Ema Peter

55 Southbank: Add Vertical Density over Existing Bldgs
Lightweight

Location: Melbourne, Australia
Architect: Bates Smart
Engineer: Vistek

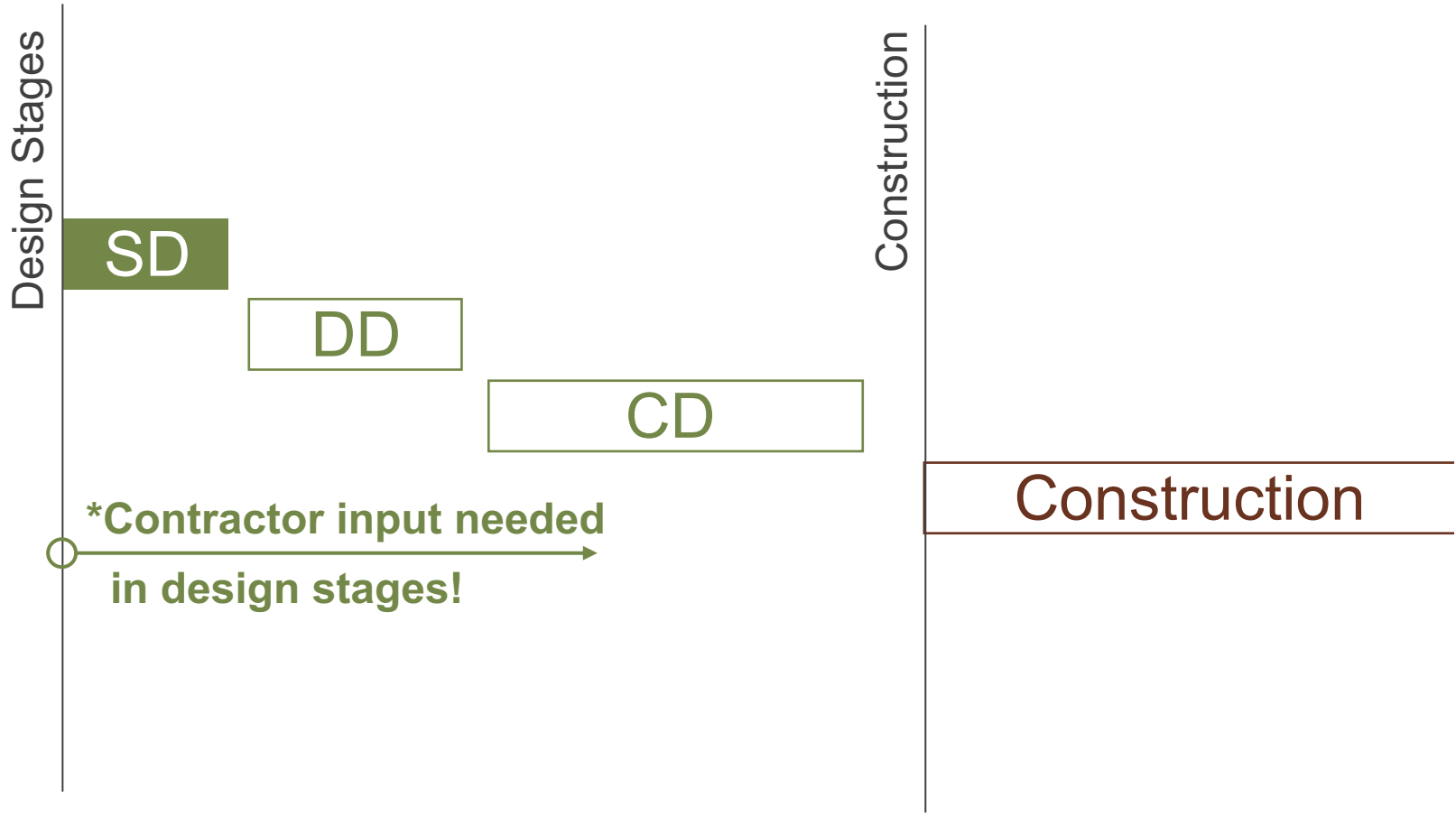
- Existing building constructed to accommodate future 6-story concrete addition
- Owner wanted 220 key hotel addition:
  6-stories conc = no deal
  10-stories wood = deal[6]
- Research shows ¼ of urban buildings in the world are strong enough to carry additional floors of wood[7]
- Low embodied carbon footprint

Schematic Design (SD) Phase

Prefabricated Mass Timber

- 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:

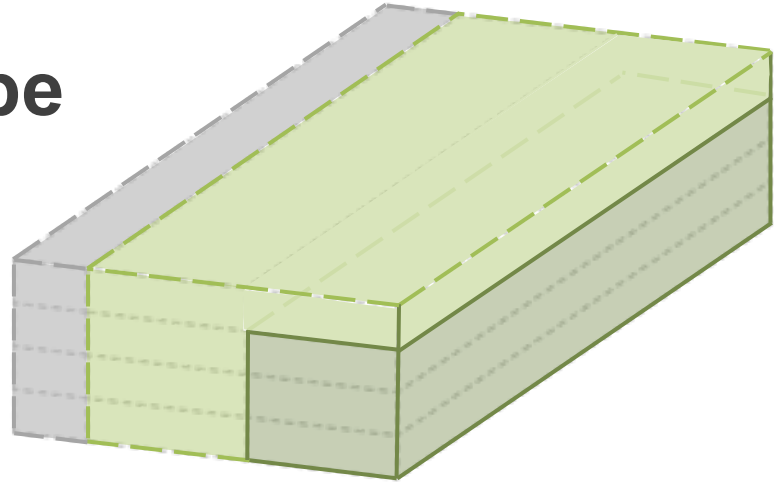
- ☑ Material Optimization/ Grids
- ☑ System Coordination
  - Structural
  - Acoustics/ Vibration
  - Fire Resistance
- ☑ Finish Quality

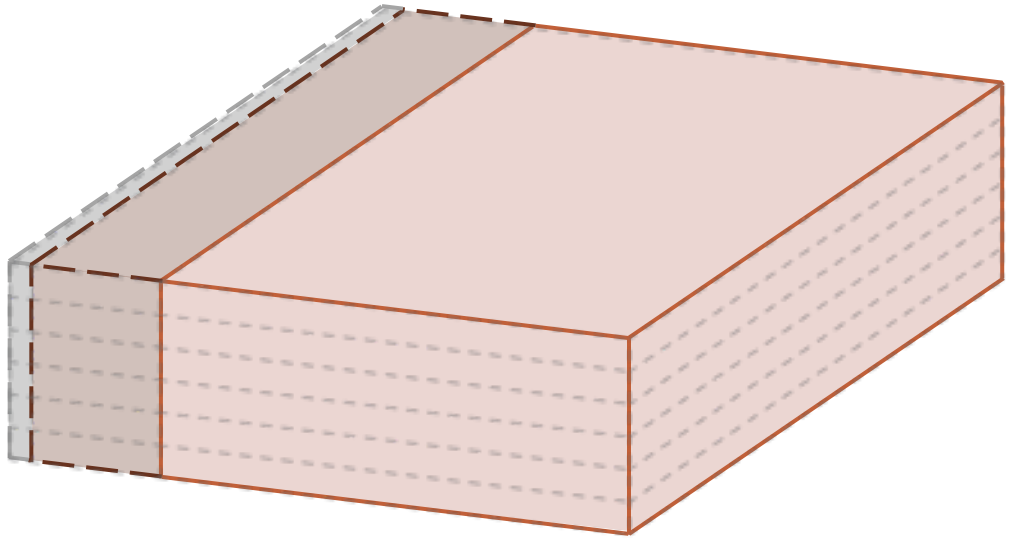
SD Cost Optimization Checklist:

- ☑ 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





	3 to 4 Stories				5 to 6 Stories		
	Steel/ Conc	Wood			Steel/ Conc	Wood	
Heights & Areas	IIB	IIIB	VA	VB	IIA	IIIA	IV (HT)
Stories[1]	4	4	4	3	6	6	6
Height[1] (ft)	75	75	70	60	85	85	85
Max Story Area[2] (ft^2)	69 k	57 k	54 k	27 k	112 k	85 k	108 k
Total Bldg Area[3] (ft^2)	207 k	171 k	162 k	81 k	337 k	256 k	324 k

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)

Denver University, Burwell Center for Career Achievement
Photo: WoodWorks

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

WoodWorks™
WOOD PRODUCTS COUNCIL

PROJECT ASSISTANCE | UPCOMING EVENTS | CONTACT US | Search

EDUCATION | GALLERY & AWARDS | DESIGN & TOOLS | PUBLICATIONS & MEDIA | WHY WOOD? | ABOUT

Home > All Expert Tips

LinkedIn | Twitter | Facebook | Email

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.

Mast 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/round 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

http://www.woodworks.org/experttip/2019-efficient-structural-grid/

The following considerations are based on a post-and-beam frame for occupancies such as offices,

View All Expert Tips

Project Assistance

Our technical experts offer free project support from design through construction, on issues ranging from allowable heights and areas to structural design, lateral systems and fire- or acoustical-rated assemblies.

Get Assistance »

Ask an Expert

Q: What design and detailing considerations exist when splicing shear wall top plates at wall discontinuities?

A: Disruption of shear wall top plates can occur for many reasons—e.g., the presence of a continuous structural steel column within the wall, installation of plumbing vents, change in wall widths, or a slight jog in wall position. In some cases, a shear wall's top plates are used as chords and/or collectors for a diaphragm, meaning that discontinuities in the top plates create discontinuities in lateral load

PREFABRICATION & COORDINATION

Architect: HACKER
Image: Structurlam

Fully Prefabricated: North America's First DLT Office

111 East Grand

Image: Neumann Monson Architects courtesy of Ryan Companies

IIIB

- 4 Story
- 64,000 sf
- First DLT office in the US
- 1st spec office in Des Moines in over a decade[8]
- 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

Fully Prefabricated: North America's First DLT Office

111 East Grand

IIIB

- 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?


The Soto, San Antonio| Photo: StructureCraft

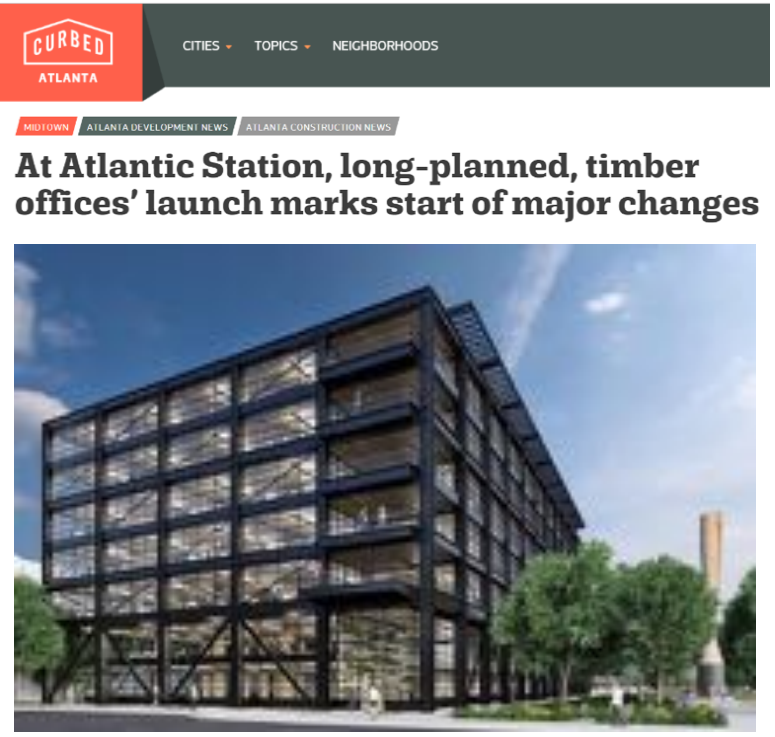

T3 Atlanta | Photo: StructureCraft

Image: WoodWorks

Image: Marcus Kauffman

Image: Alex Schreyer

Hines' Mass Timber Offices Rising in Southeast
T3 West Midtown, Atlanta



IV (HT)

- 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**

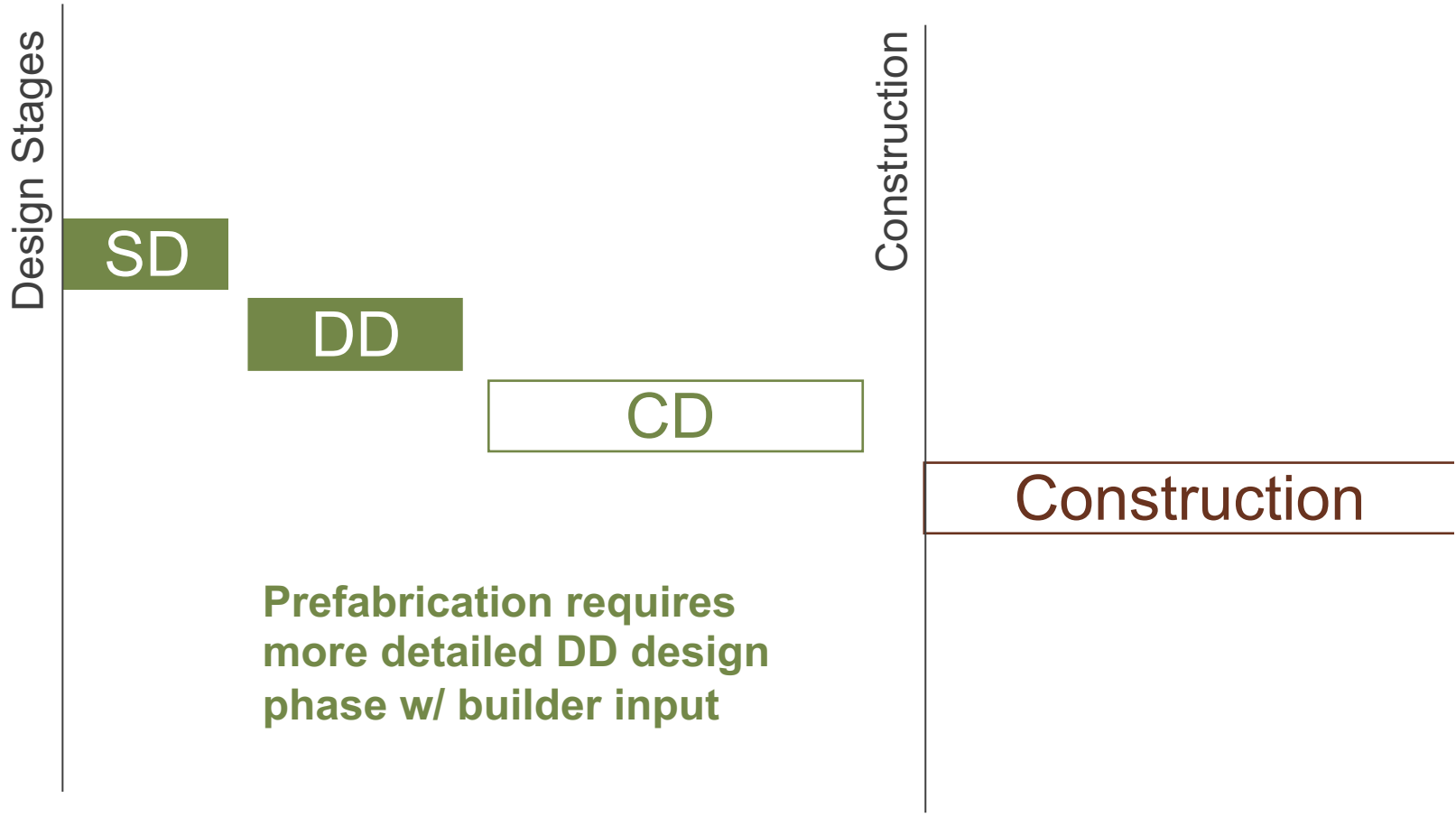
Location: Atlanta, GA
Architect: Hartshorne Plunkard Architects + DLR Group
Structural Engineer: Magnusson Klemencic Associates
Mass Timber Engineer: StructureCraft

Design Development (DD) Phase

Prefabricated Mass Timber

- 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



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)

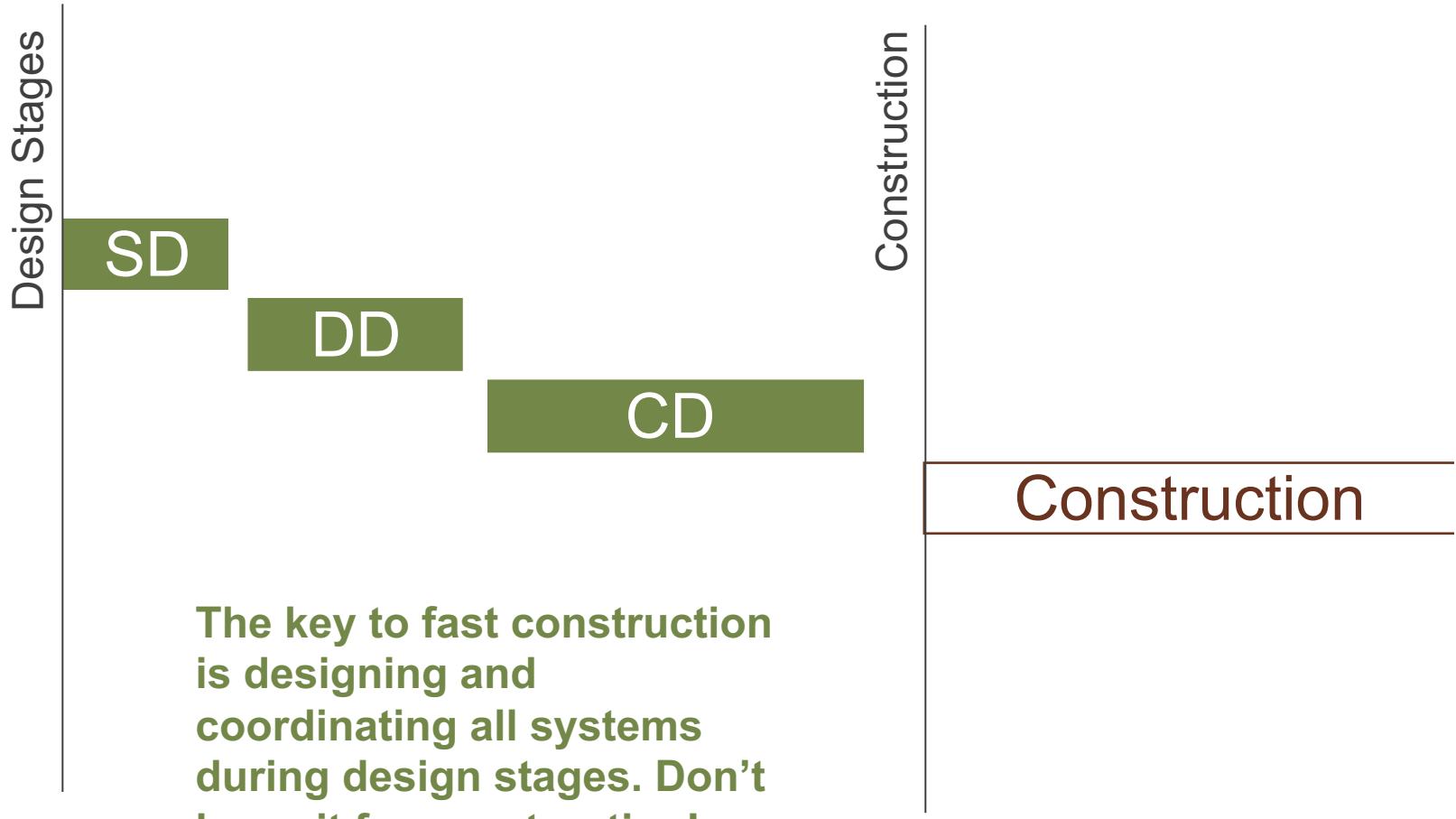
- Prefabricated panels
- Coordinate all MEP & fire protection penetrations
- Tolerances for wood tighter than steel, conc, & other materials
- Structural connections
- Schedule steel shops so they don’t delay mass timber fabrication
- Plan now to reduce on-site labor

Photo: Lever Architecture

Construction Document (CD) Phase

Prefabricated 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:

https://www.thinkwood.com/products-and-systems/mass-timber/nltguide

https://info.thinkwood.com/nlt-design-and-construction-guide-u.s.-version-think-wood-0

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:

https://www.bchousing.org/publications/Wood-Construction-Moisture-Management-Guide.pdf

https://www.bchousing.org/publications/Wood-Construction-Moisture-Management-Guide.pdf

Remove Moisture ASAP

Photo: Lendlease

Panels protected until needed

Photo: Alex Schreyer

Finish Quality: Exposed Structure

Protect the Investment

- Industrial grade appearance, save $
- Surface coatings
- Temporary Protection
  - Moisture
  - Construction trades


Photo: Christian Columbres


The Hudson | Vancouver, WA | Mackenzie | Turner Construction

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

Images: Korb & Associates

Questions?

Ricky McLain, PE, SE
Senior Technical Director,
WoodWorks
Ricky.mclain@woodworks.org
802.498.3310

T3 Atlanta | Architects: Hartshorne Plunkard Architects, DLR Group | Photo: StructureCraft

Copyright Materials