

Mass Timber Construction Management:
Design through Project Close Out

Structural Mass Timber Design

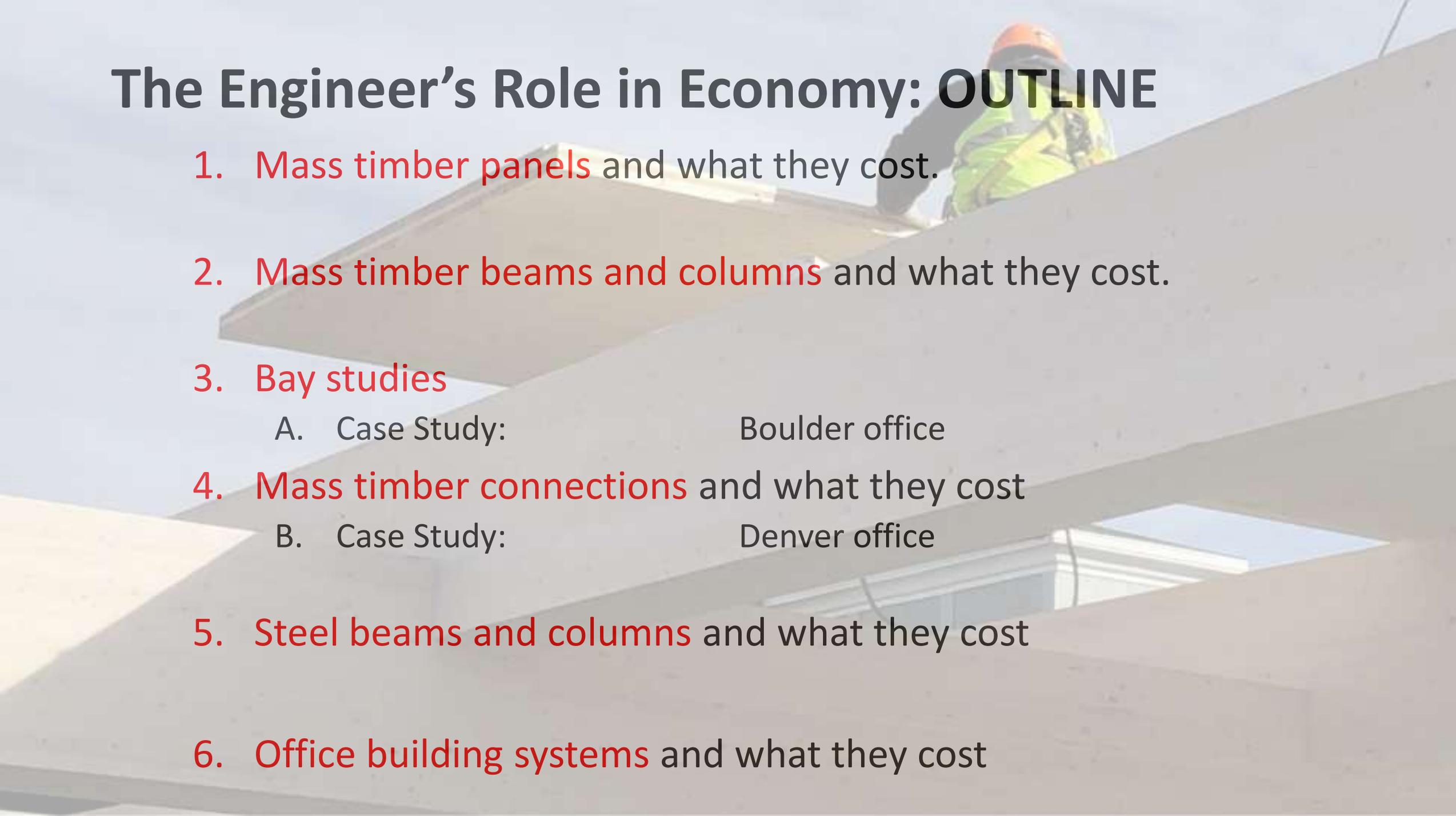
The Engineer's Role in
Optimization



Presented by Chris Kendall, PE



Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.



The Engineer's Role in Economy: **OUTLINE**

1. **Mass timber panels** and what they cost.
2. **Mass timber beams and columns** and what they cost.
3. **Bay studies**
 - A. Case Study: Boulder office
4. **Mass timber connections** and what they cost
 - B. Case Study: Denver office
5. **Steel beams and columns** and what they cost
6. **Office building systems** and what they cost

WHAT DO MASS TIMBER PANELS COST?



NLT



MPP

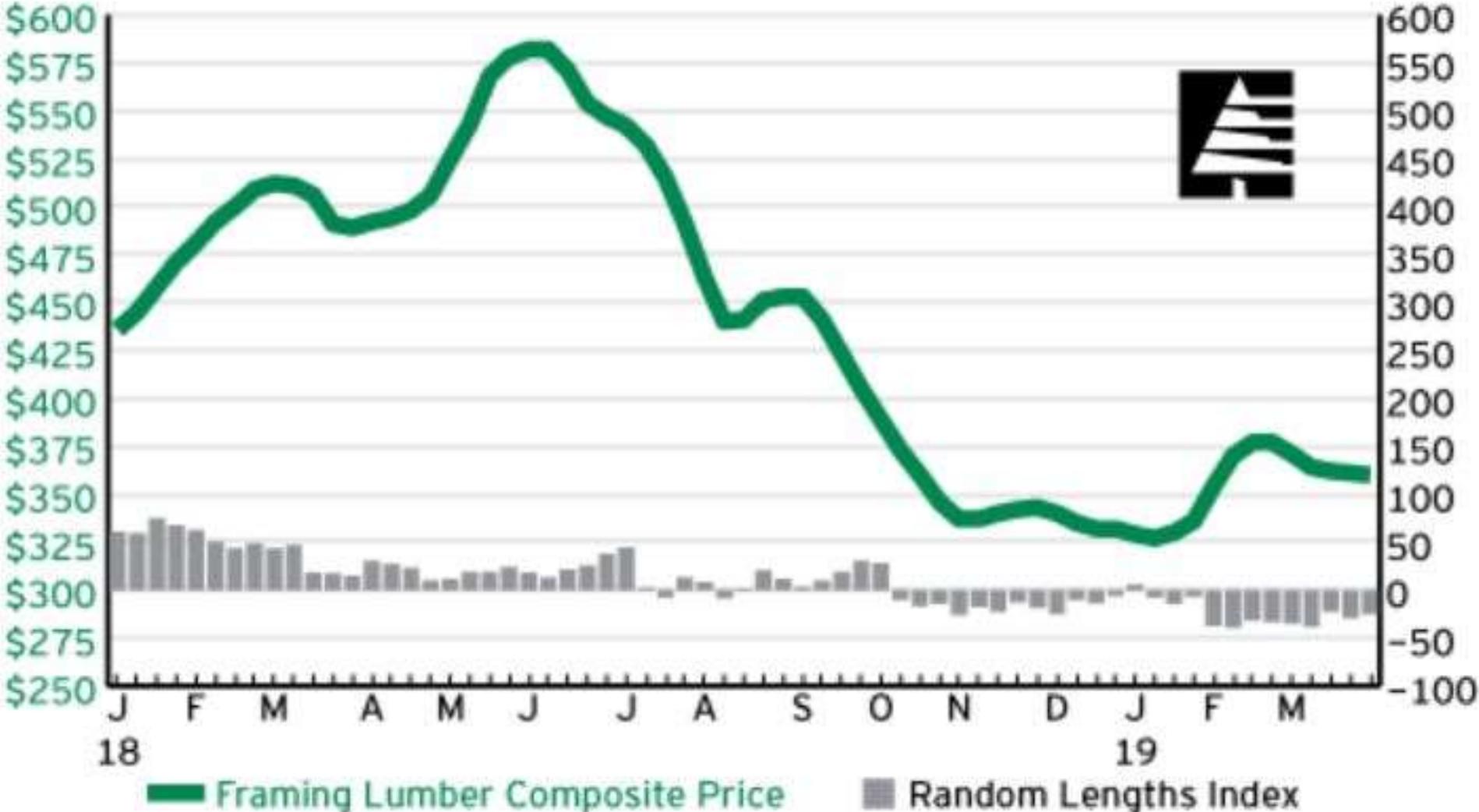


GLT



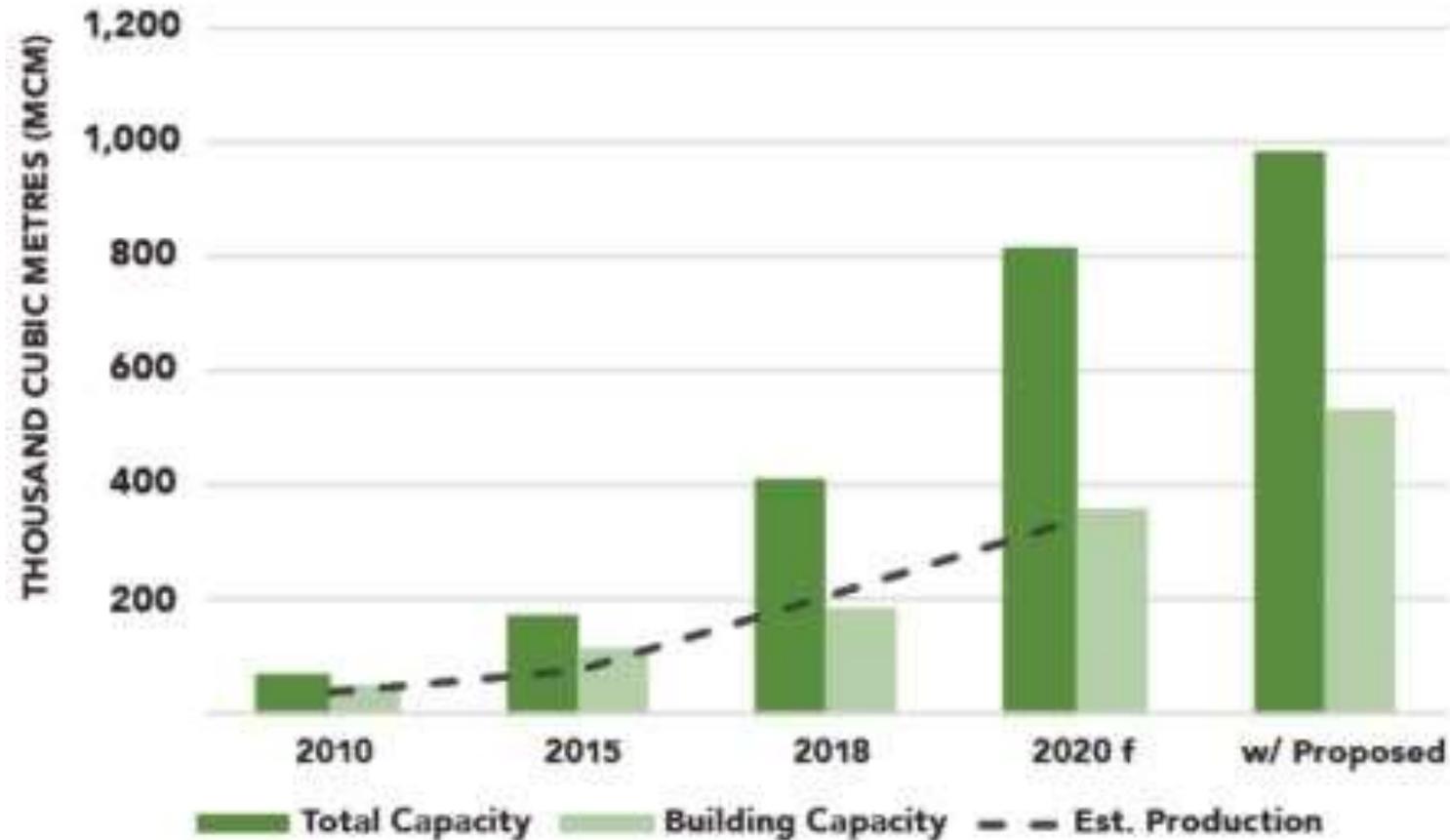
CLT

CLT COST DEPENDS ON THE PRICE OF LUMBER



CLT COST DEPENDS ON SUPPLY

... and North American supply is increasing



North American Mass Timber Panel Manufacturing Capacity

Source: 2019 State of the Industry: North American Mass Timber

CLT COST DEPENDS ON THE MANUFACTURER

Mass timber panels are not a commodity!



- Panel width
- Panel length
- Lamination thickness
- E-rated and V-rated
- Species
- Special finishes

CLT COST DEPENDS ON WOOD VOLUME!

3-ply 3-layer
(3.43" - 4.14")



5-ply 5-layer
(5.47" - 6.90")



7-ply 7-layer
(7.52" - 9.66")



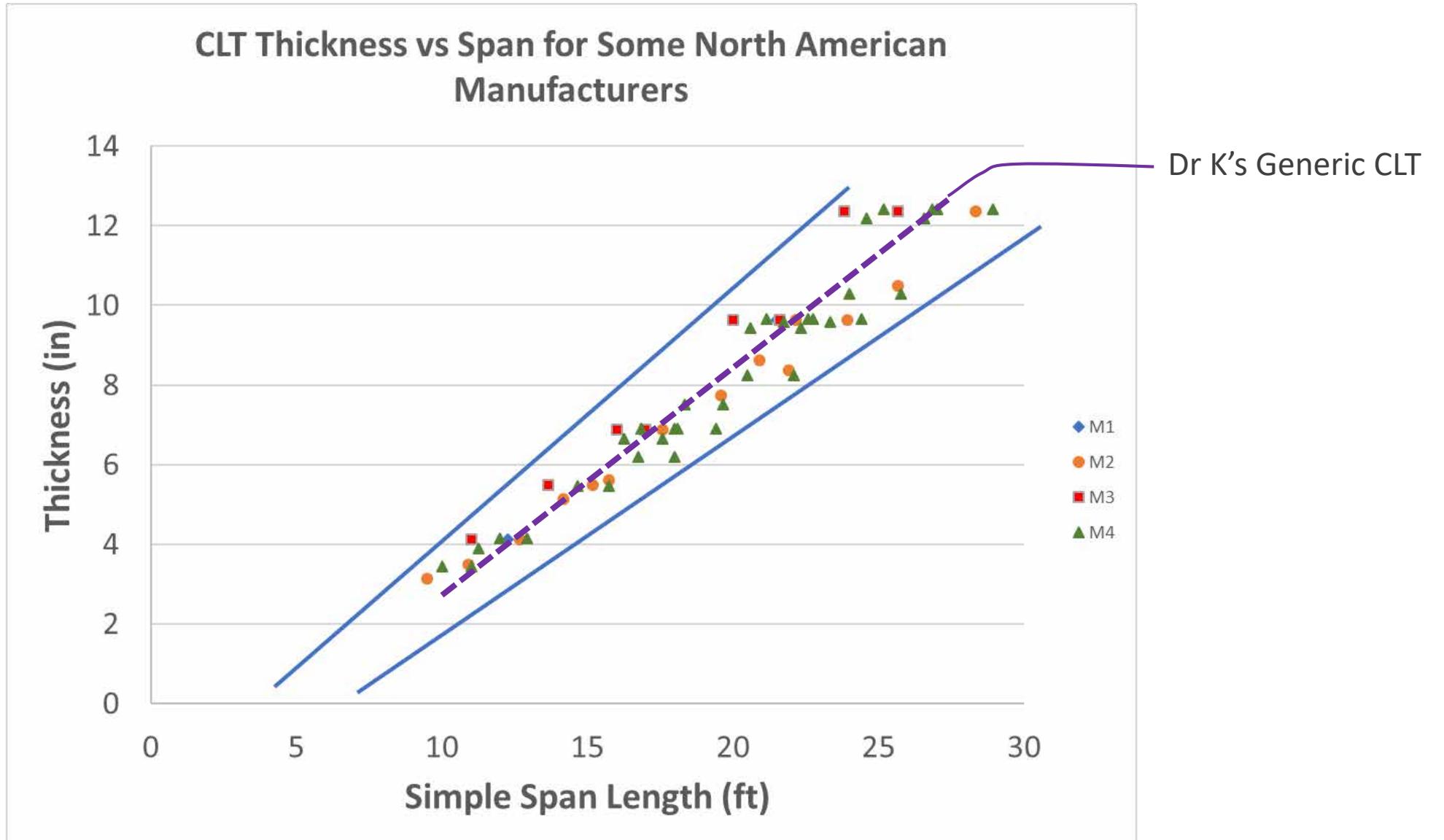
7-ply 5-layer

9-ply 9-layer
(9.57" - 12.42")



9-ply 7-layer

CLT COST DEPENDS ON WOOD VOLUME!



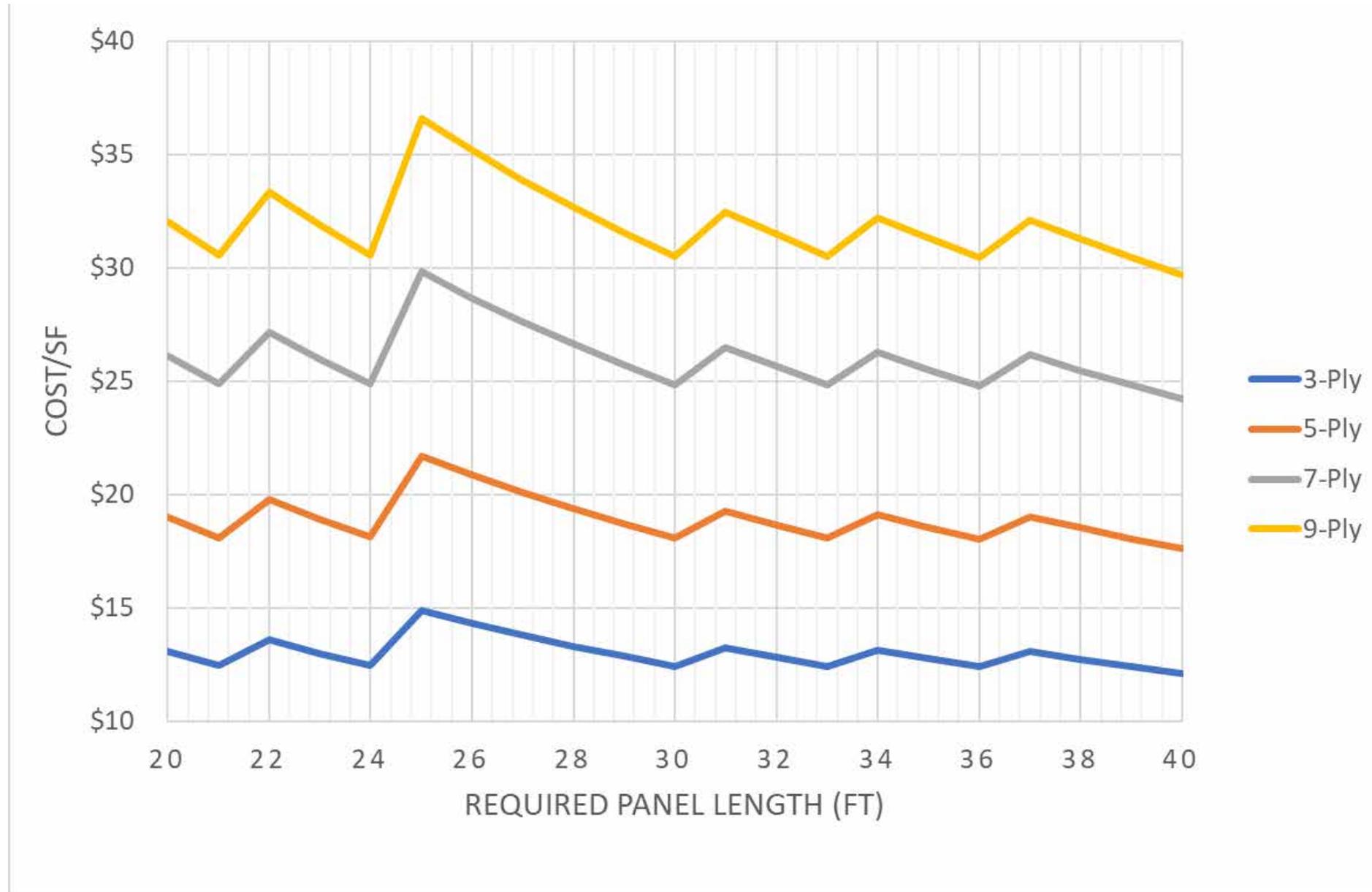
CLT COST DEPENDS ON NUMBER OF PLYS AND DROP

Conceptual cost of Dr K's Generic CLT is intended to include:

- CLT
- Shop fab
- Sanding
- Delivered
- Screws

but does **not** include:

- Finishes

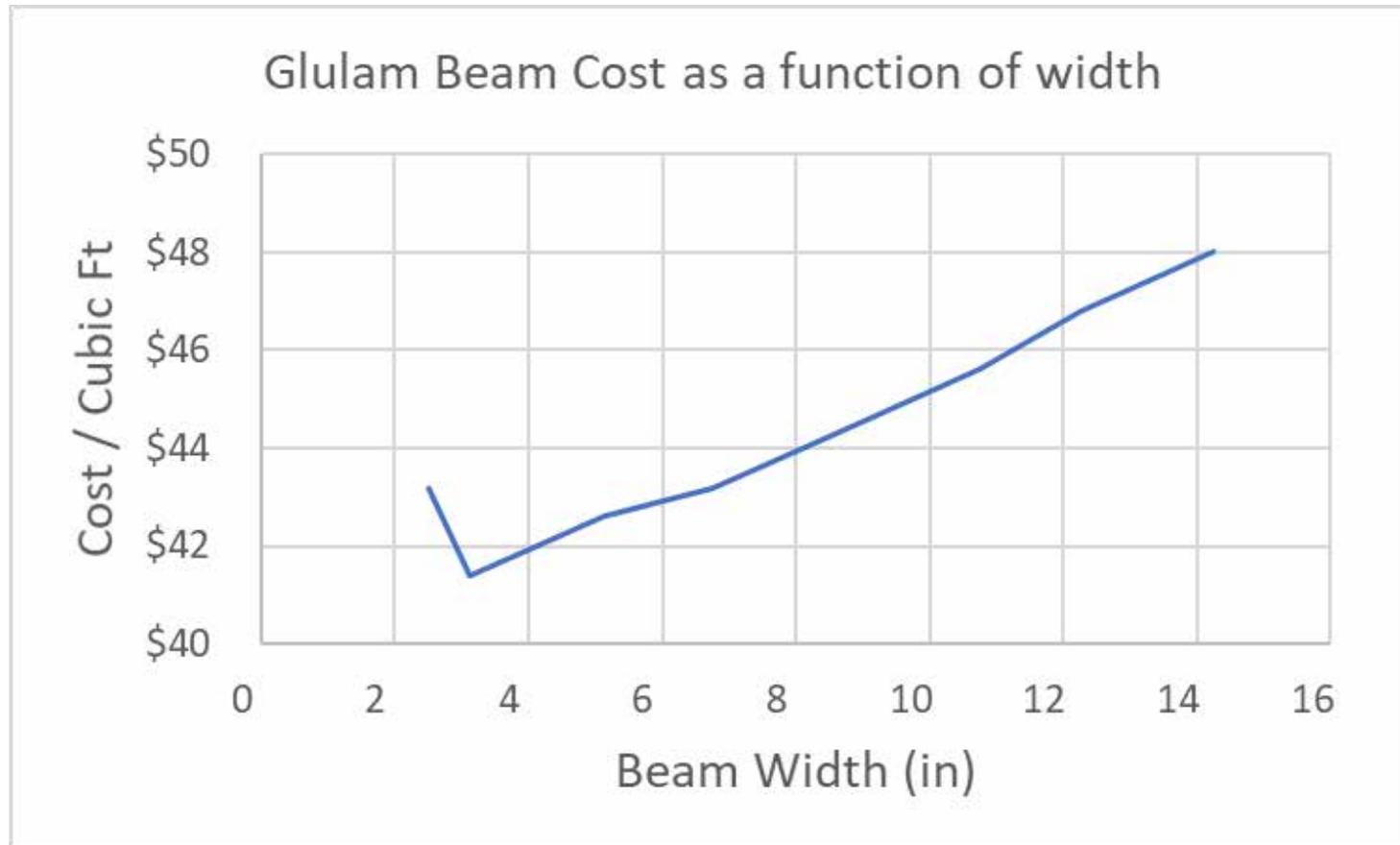


The image shows the interior of a modern building under construction or recently completed. The ceiling is composed of a grid of light-colored, horizontally-oriented timber beams. The walls are also made of similar timber panels. A series of large, floor-to-ceiling windows runs along the right side of the room, providing a view of an urban landscape with buildings and utility poles. The floor is a smooth, light-colored concrete. The overall atmosphere is bright and airy, with natural light streaming in from the windows.

WHAT DOES GLUE LAMINATED TIMBER COST?

Dr K's Glulam Beam Cost

Unit cost per cubic ft is a function of beam width





BAY STUDIES

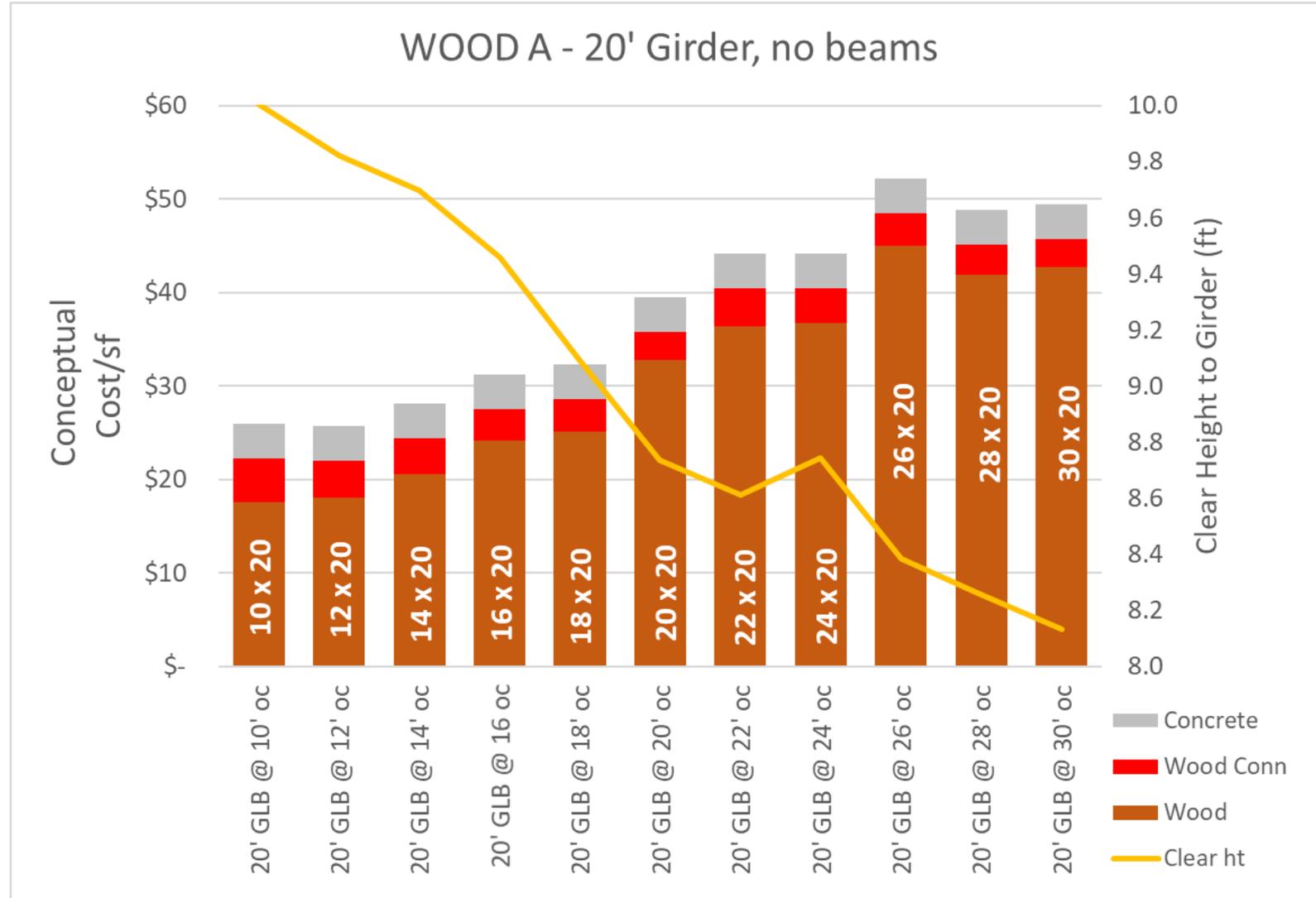
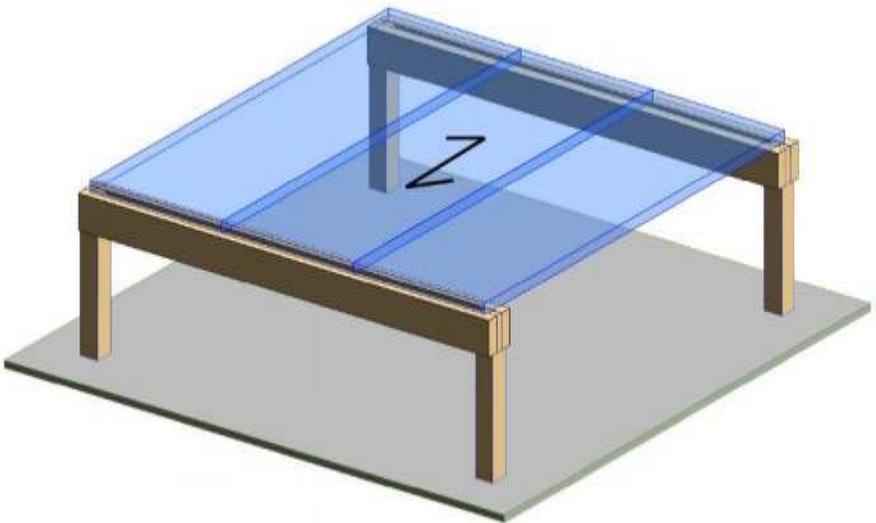
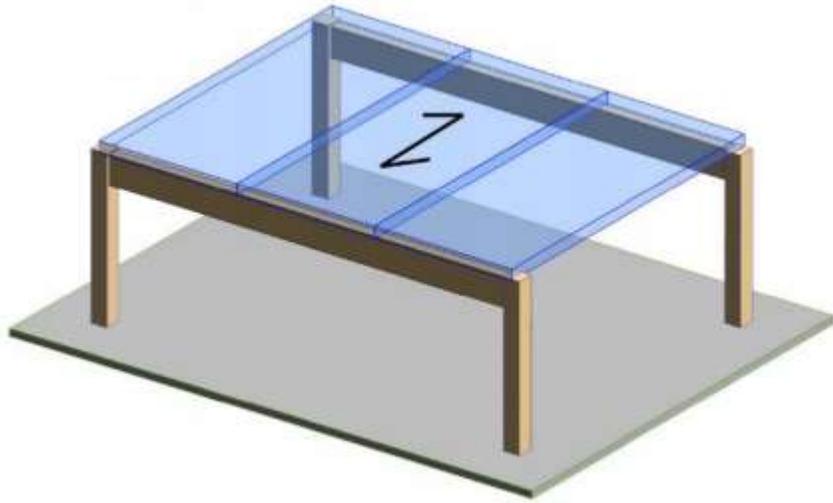
Estimating the “Conceptual Cost” of a structural bay

- CLT Cost
- Wood Beams and Girders
- Wood Columns
- Wood connections
 - Beams, Girders, Columns
- Steel Beams and Girders
- Steel Columns
- Concrete (NC topping)

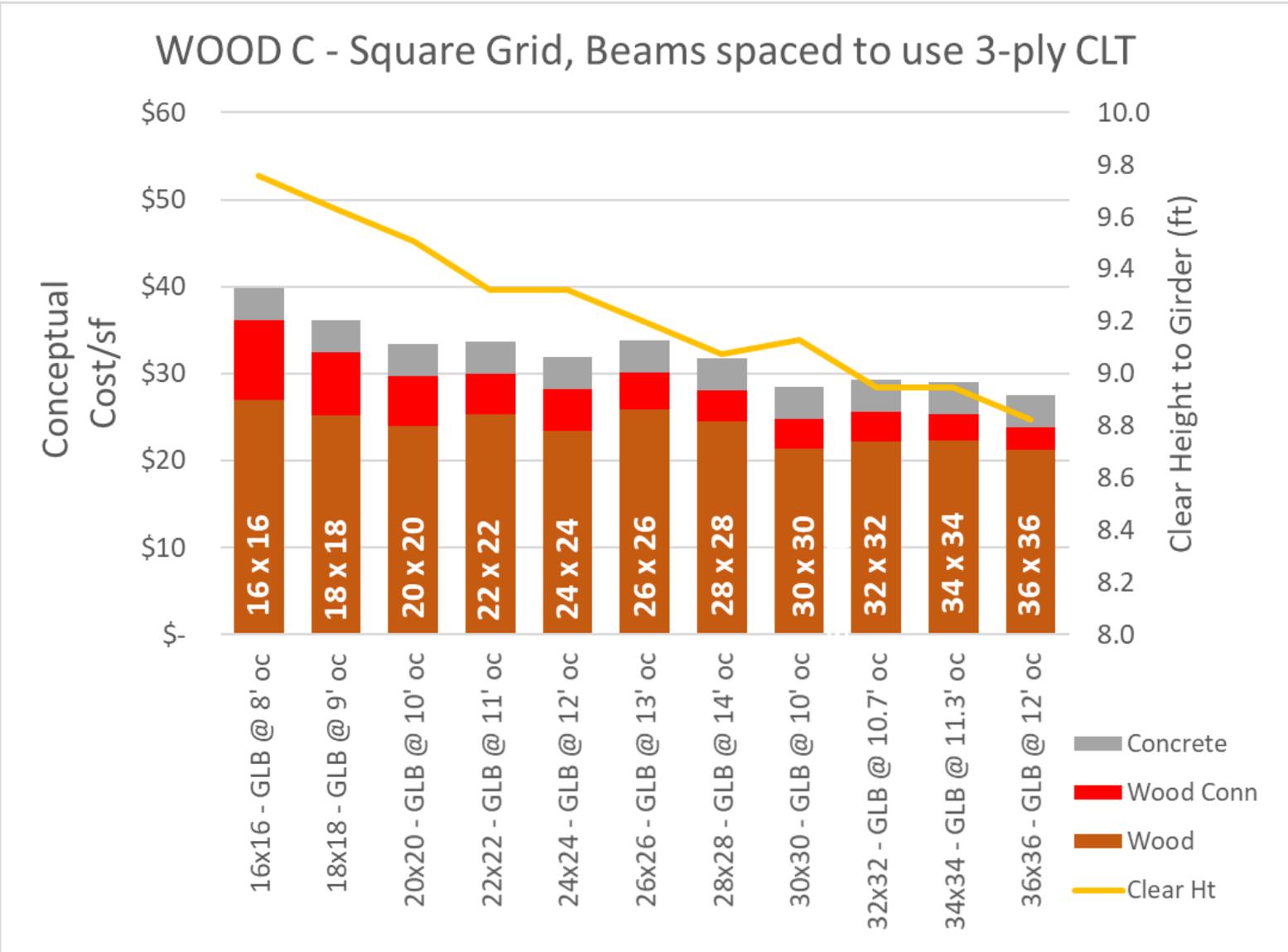
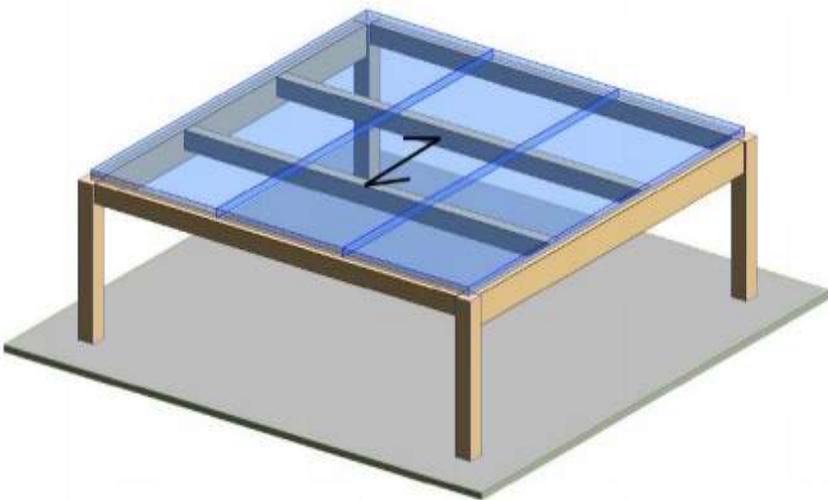
Conceptual cost estimates that follow are appropriate only for illustrating the relative difference between similar systems.

They are not accurate enough to compare steel vs concrete vs mass timber systems

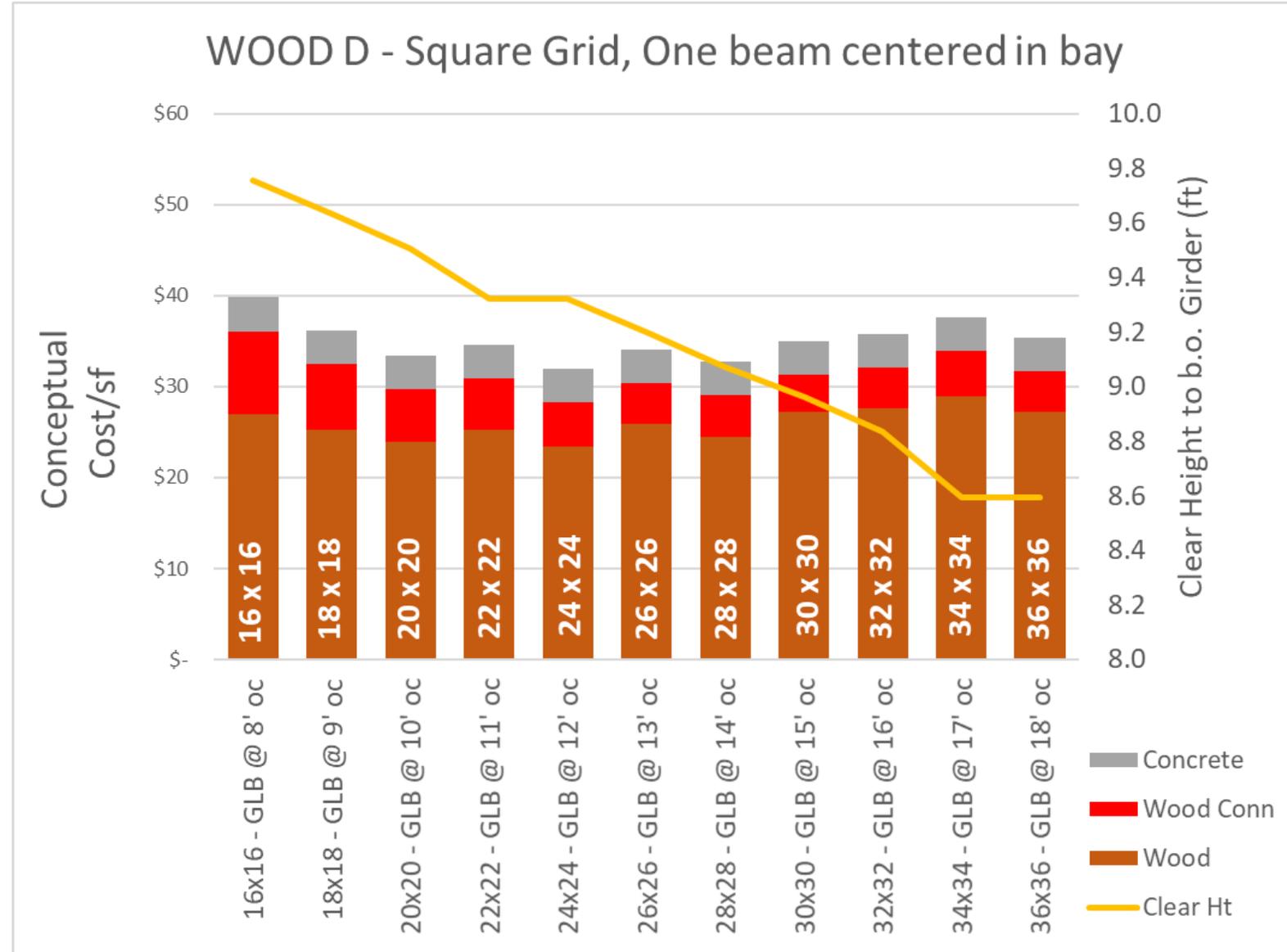
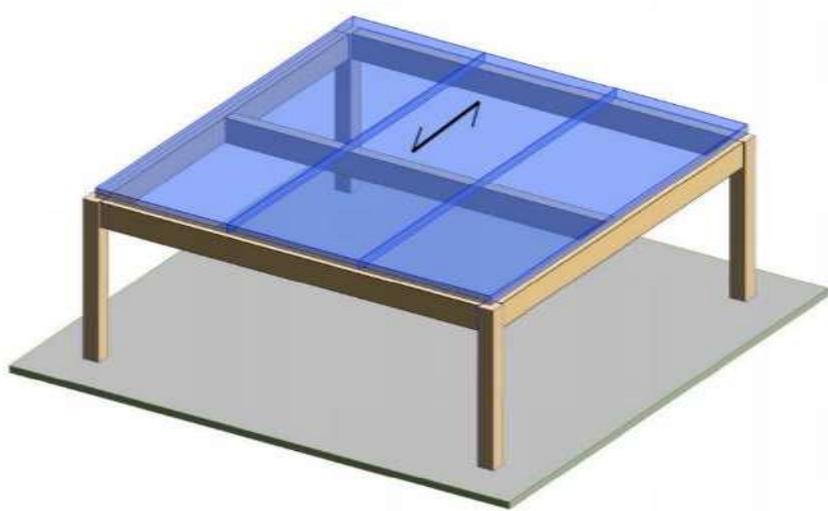
20 ft timber bents, no beams, CLT of varying span



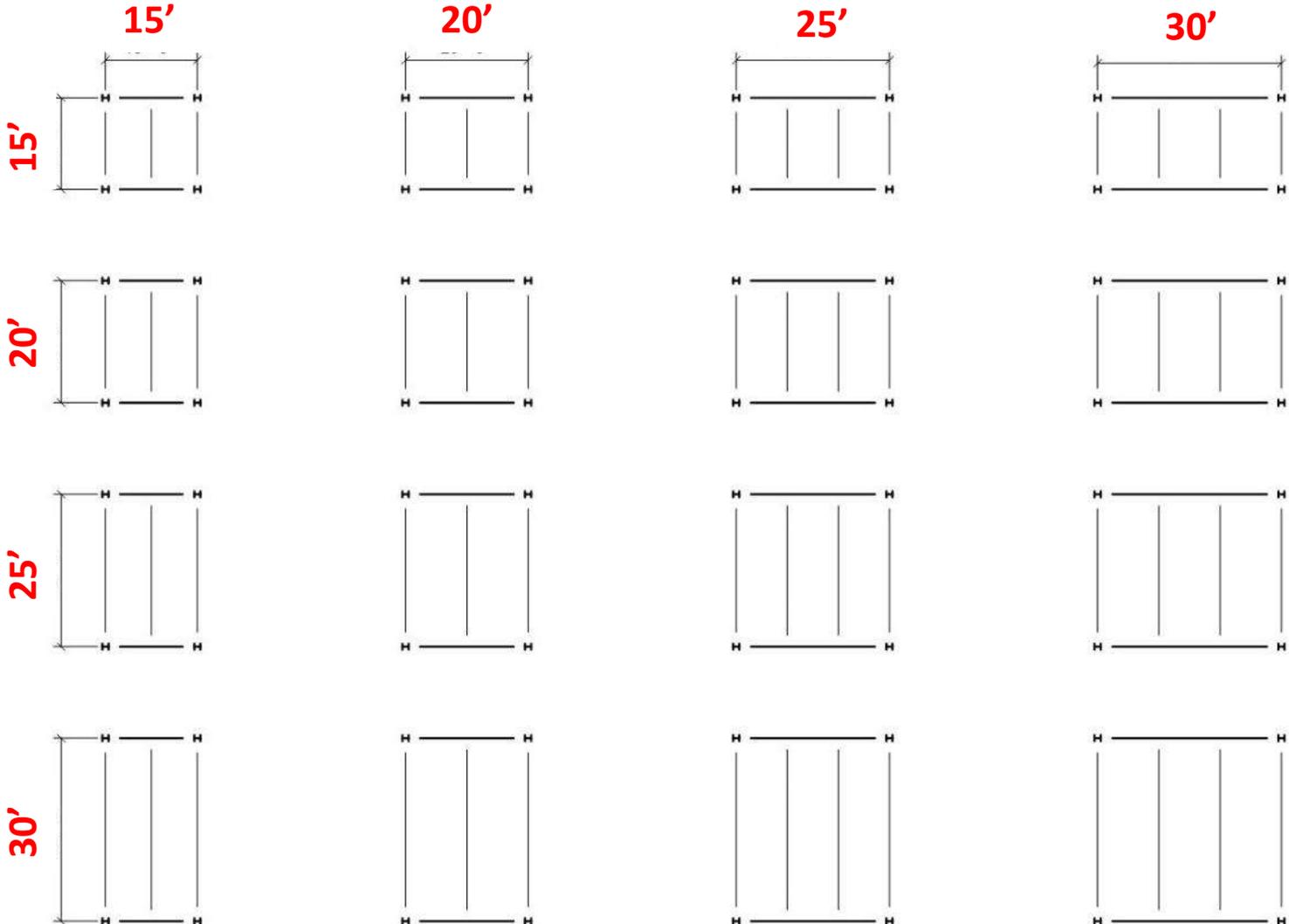
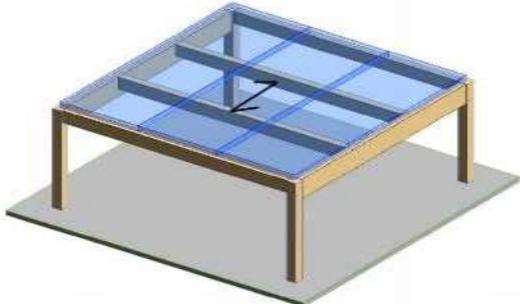
Square bay w/ secondary beams, 3-ply CLT of varying span



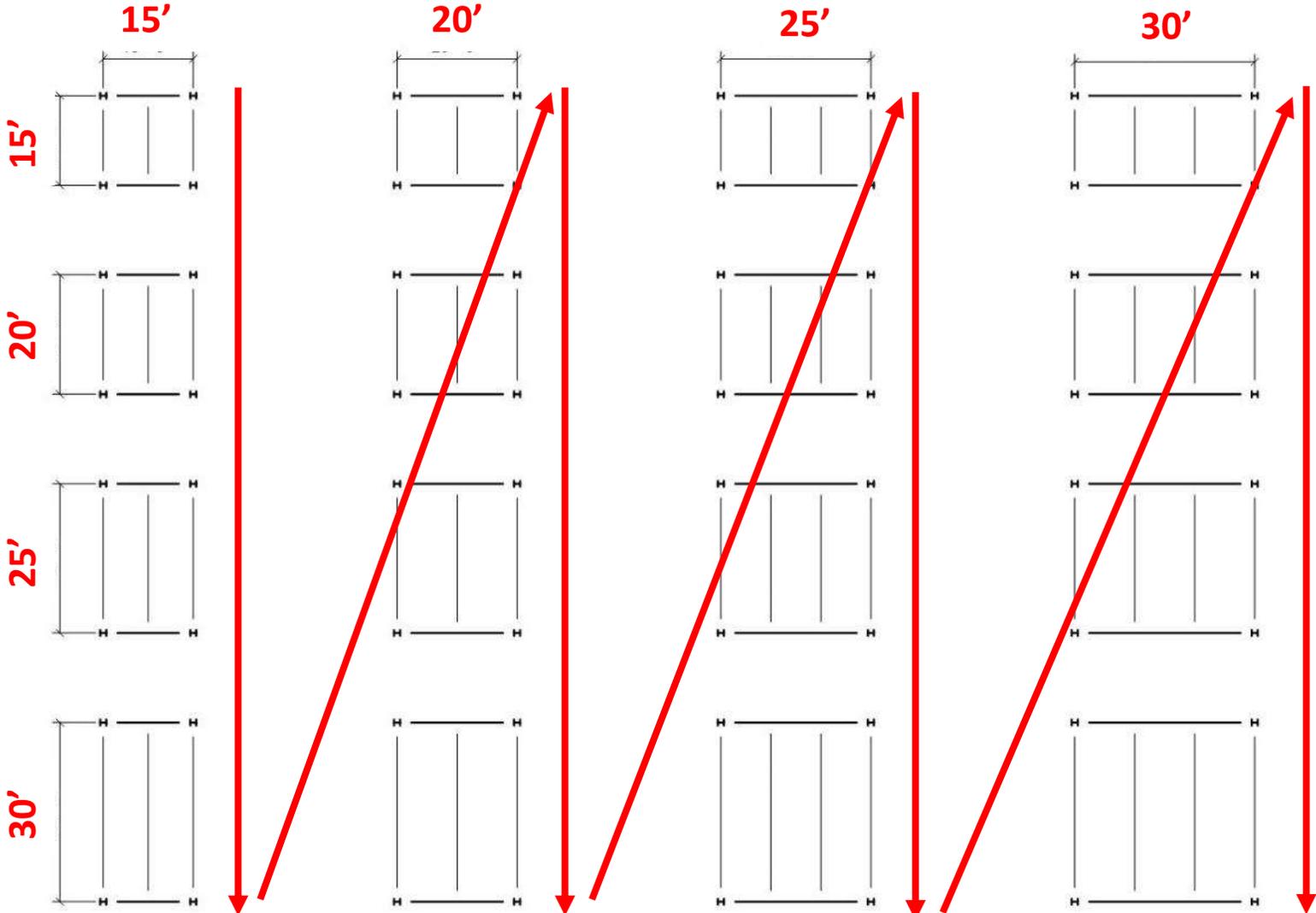
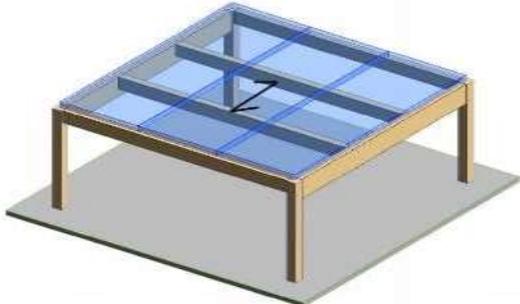
Square bay, CLT with 2 equal (varying) spans



Wood Bay Study: 15x15 up to 30x30

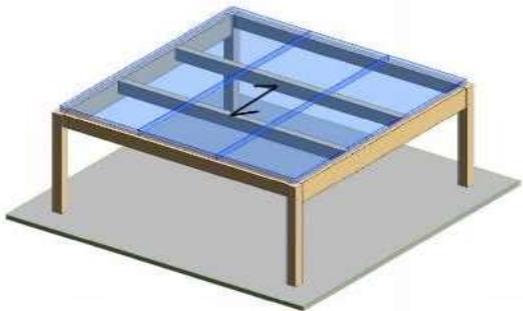
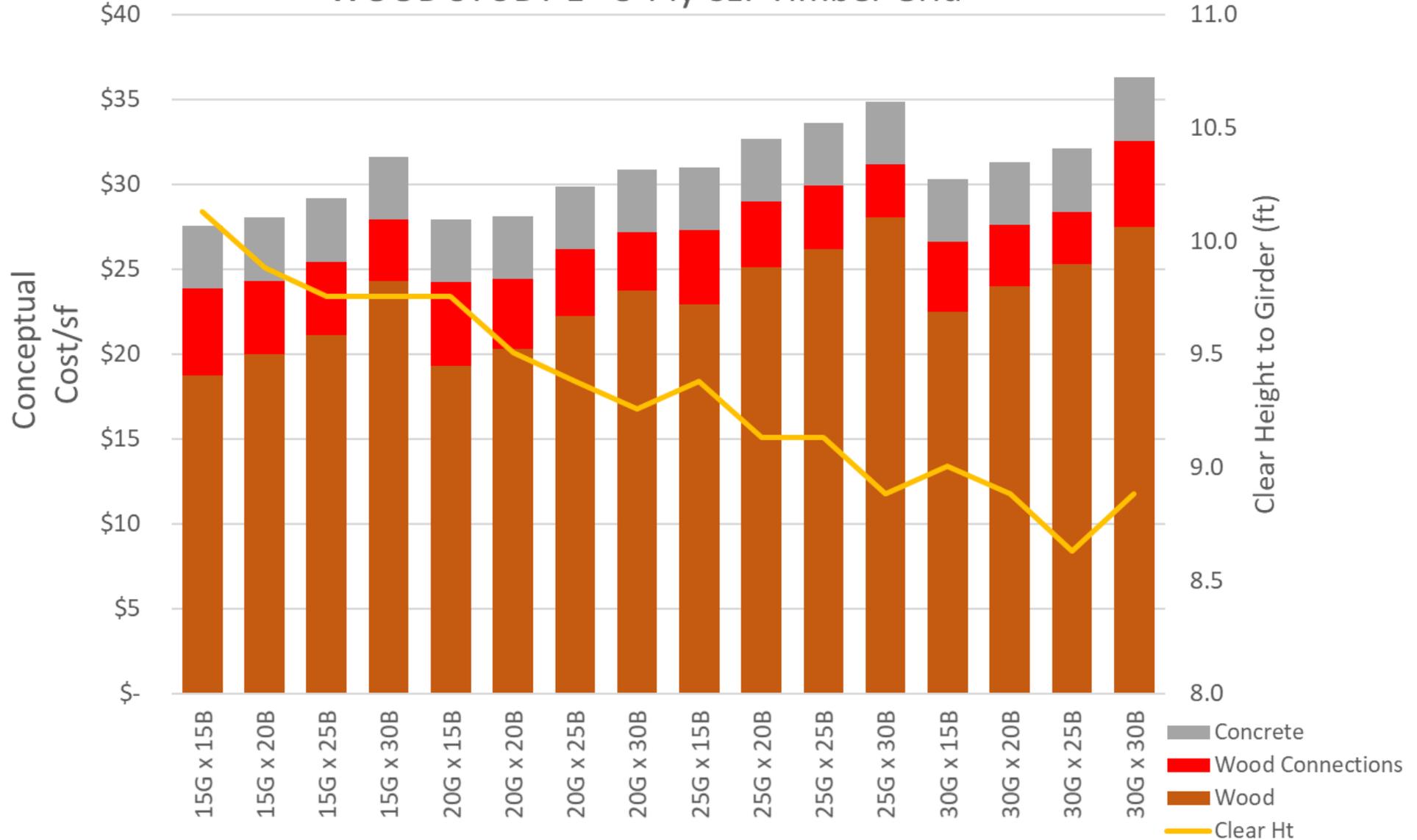


Wood Bay Study: 15x15 up to 30x30



Wood Bay Study

WOOD STUDY E - 3-Ply CLT Timber Grid



BOULDER LOADING DOCK



BOULDER LOADING DOCK



- Type IV, Sprinklered Construction
- 2-story
- 2012 IBC
- 7-ply 5-layer CLT Floors
- 5-ply CLT roof
- 3-ply CLT shear walls
- Stora Enso and Ligna Terra
- 25 x 30 Grid

BOULDER LOADING DOCK

- 25 x 30 Grid
- 7-ply 5-layer CLT Floors
- 5-ply CLT roof
- 3-ply CLT shear walls

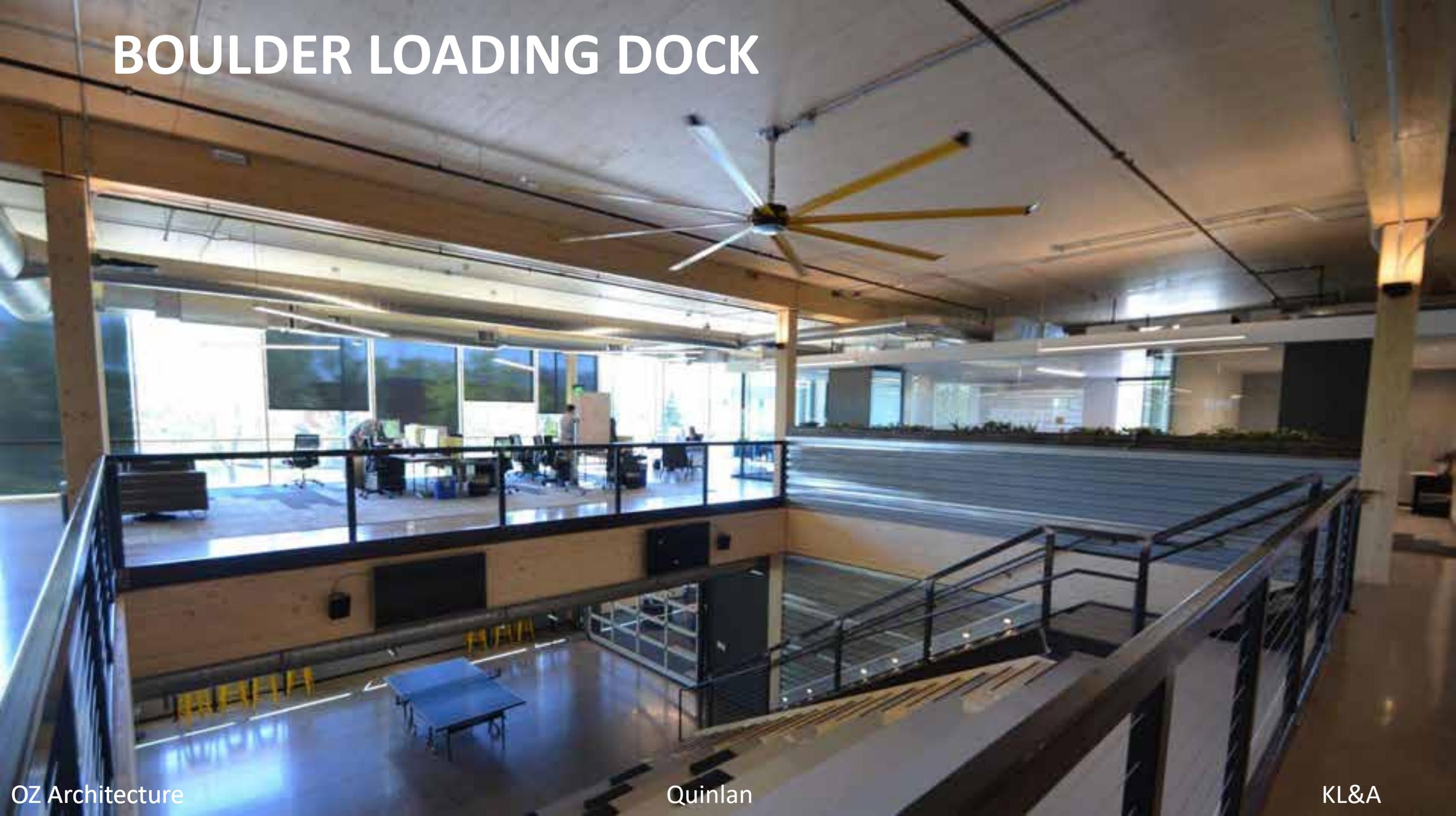
BOULDER LOADING DOCK



BOULDER LOADING DOCK



BOULDER LOADING DOCK



BOULDER LOADING DOCK

Simple connections

WHAT DO MASS TIMBER CONNECTIONS COST?



Mass timber design

connections

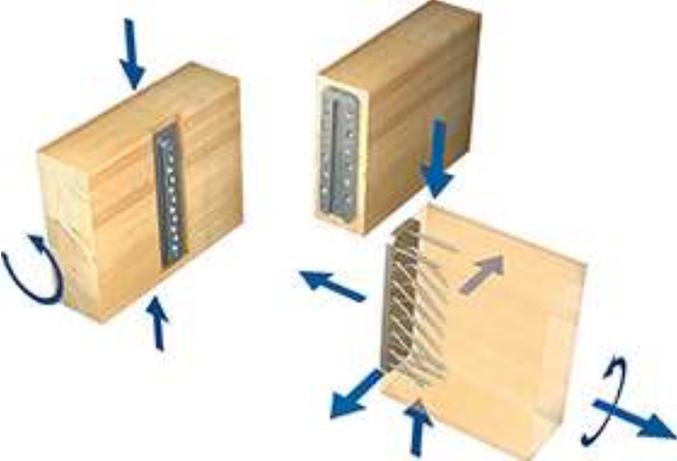


Photo Credit: myticon



Panel to beam connections

Connection Cost – Different Connection “Classes”



Connection Cost based on “Connection Class”

Cost for each class is based on ...

- Connection material
- Screws and bolts
- Beam end fabrication
- Girder fabrication
- Field Installation

Cost increases with ...

- Connection “Class”
 - Simple screws
- 
- Complex hidden custom connector
 - **Reaction carried**

PLATTE FIFTEEN

Office / Retail

Type III-B over IA Construction

2 floors concrete below grade

1 floor concrete above grade

3 floors + roof in mass timber

Concrete cores

30' x 30' grid



OZ Architecture

Adolfson & Peterson Construction

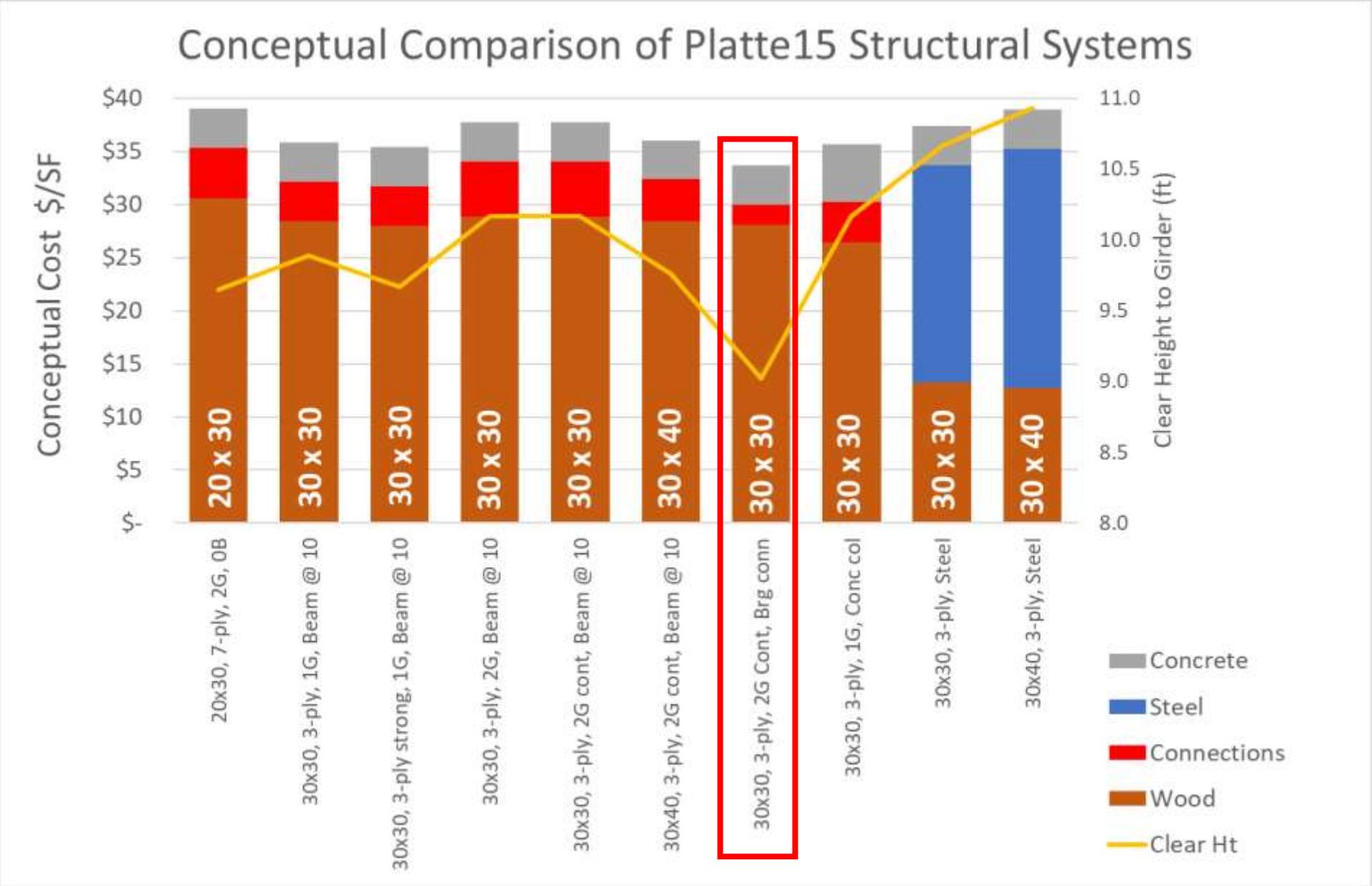
KL&A & Nordic

PLATTE 15

Office / Retail
Type III-B Construction
30' x 30' grid



Platte Fifteen Bay Study



PLATTE 15



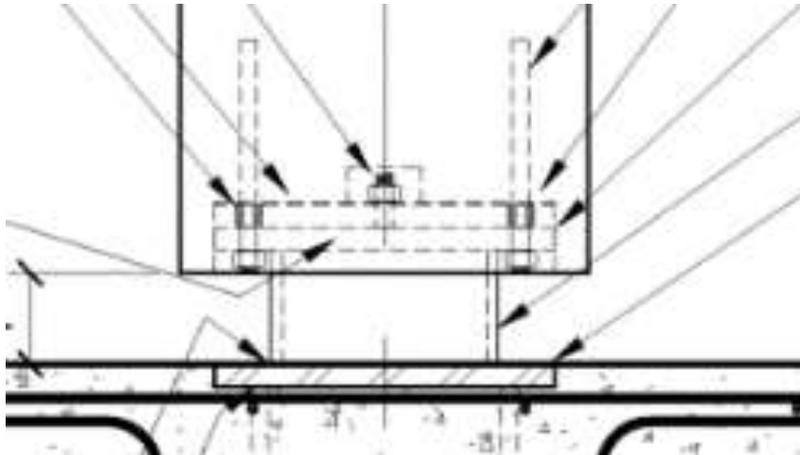
PLATTE 15



PLATTE 15



- DIFFERENT MATERIAL
- DIFFERENT TOLERANCE
- DESIGN FOR IT



PLATTE 15



CONNECTION DESIGN:

- CONNECTION MATERIAL
- CONSIDERATION OF MATERIAL INTERFACE
- TIME IS MONEY

PLATTE 15

50+ ft panels
span five 10 ft
bays



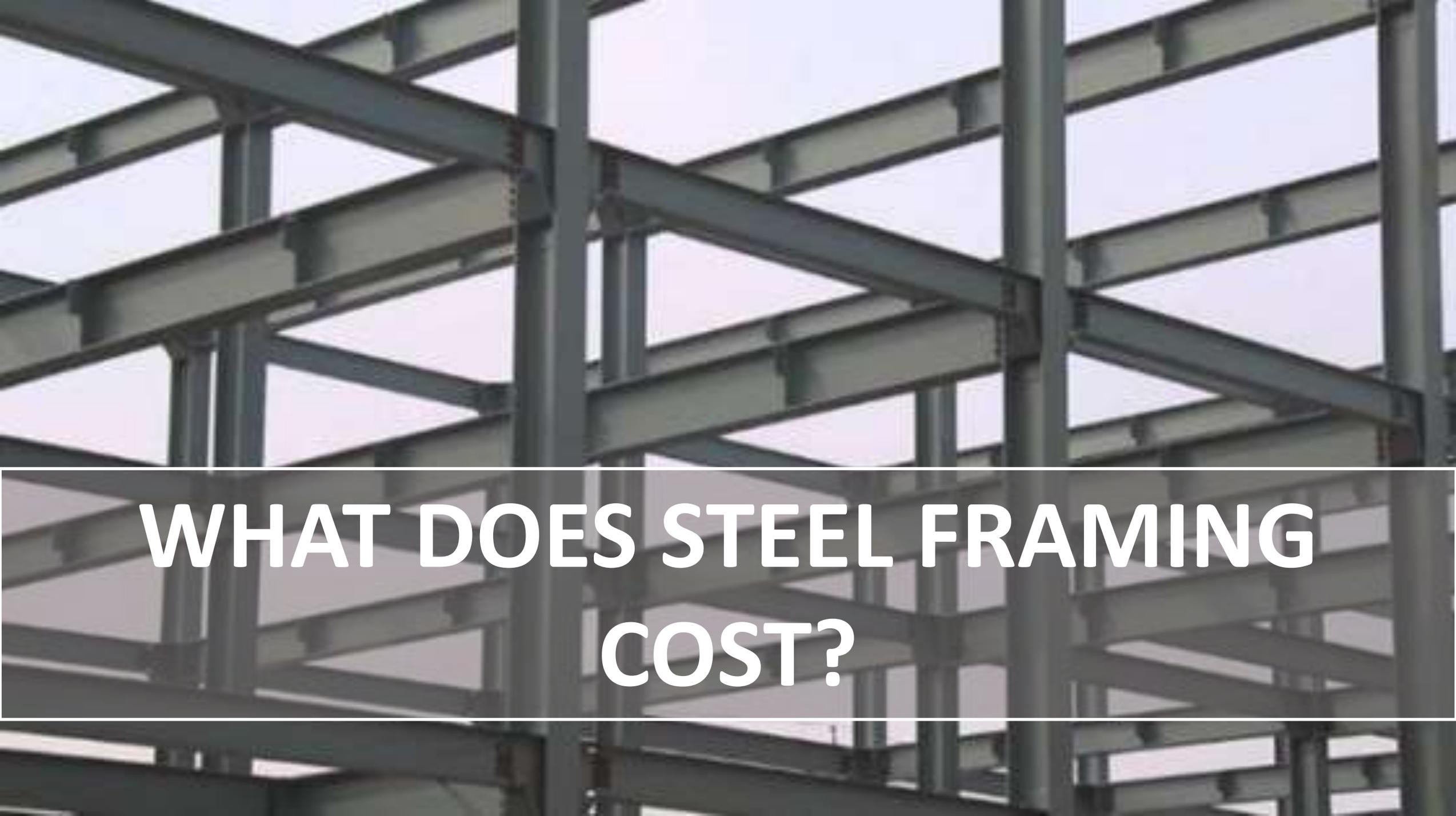
OZ Architecture

Adolfson & Peterson Construction

KI&A & Nordic

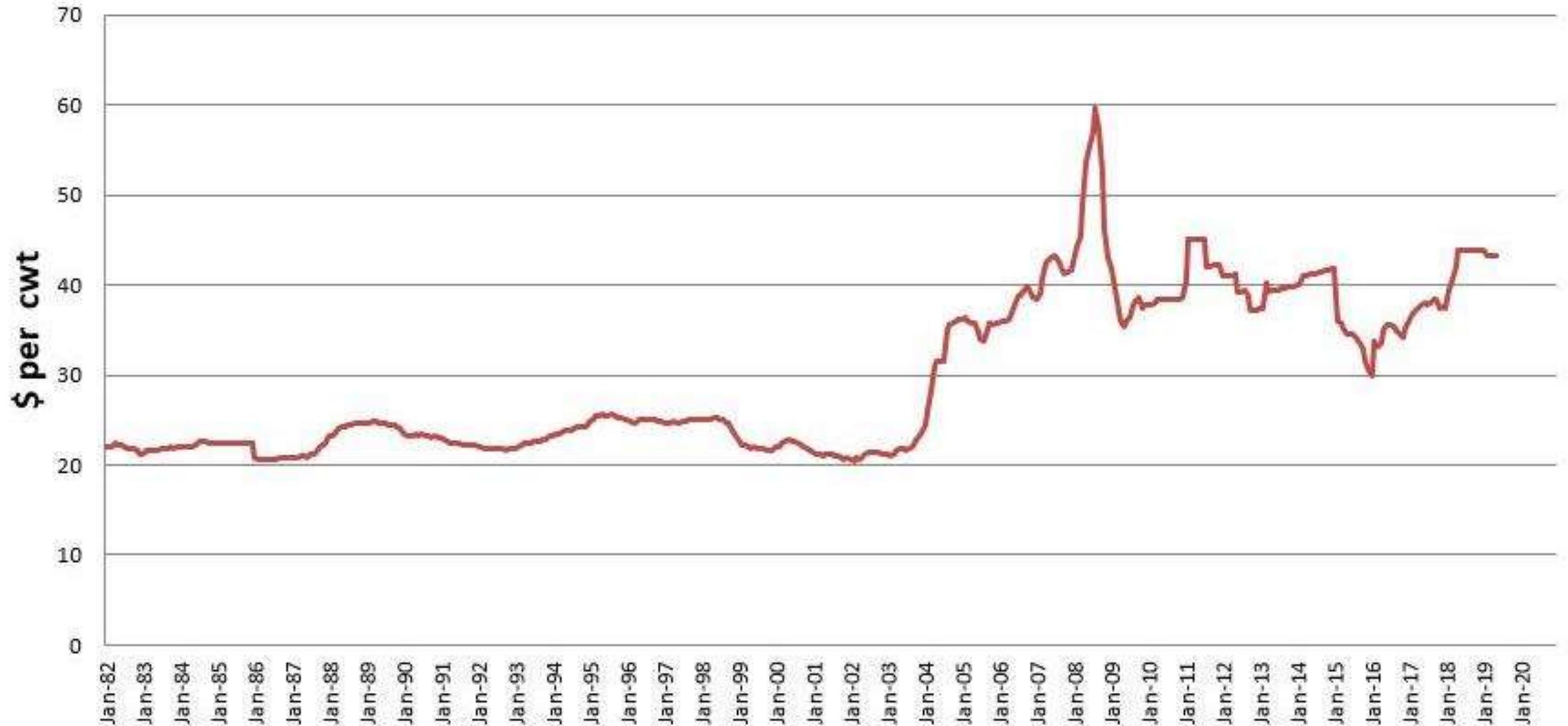
PLATTE 15



A photograph of a steel framing structure, showing a grid of vertical columns and horizontal beams. The structure is made of dark metal, likely steel, and is set against a light, overcast sky. The perspective is from a low angle, looking up at the structure.

**WHAT DOES STEEL FRAMING
COST?**

Steel Mill Base Price



Steel Pricing

Material Cost +
Detailing and Fabrication Cost +
Erection Cost
Total Cost



Approximately 2/3 of cost is labor and handling, not material

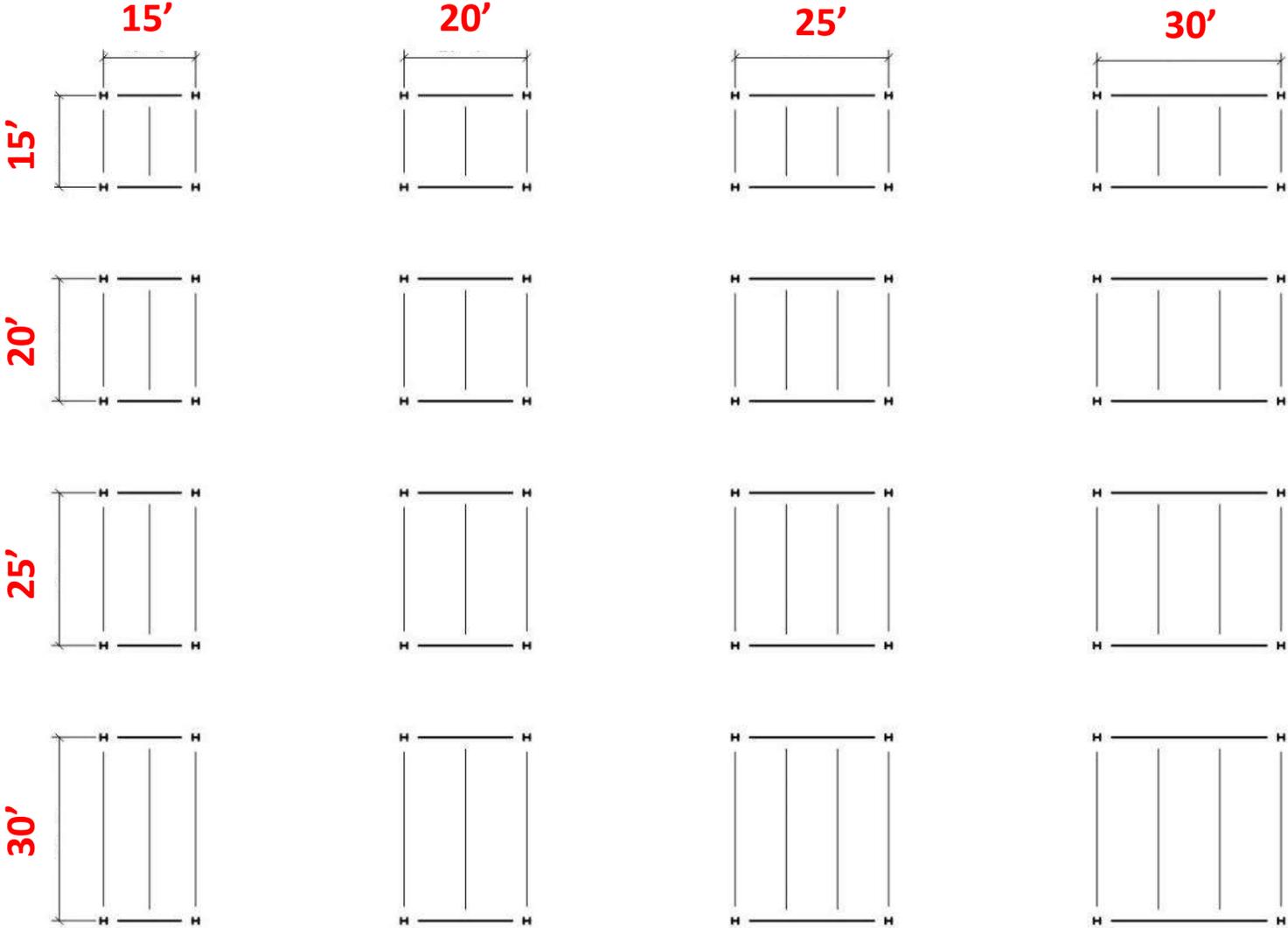
So ...

Fewer larger pieces are usually more economical than many small pieces

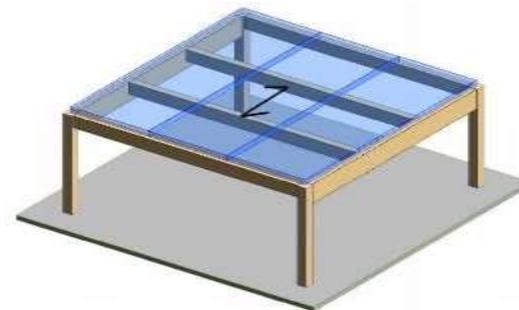
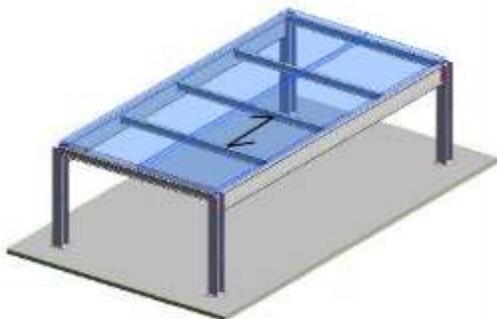
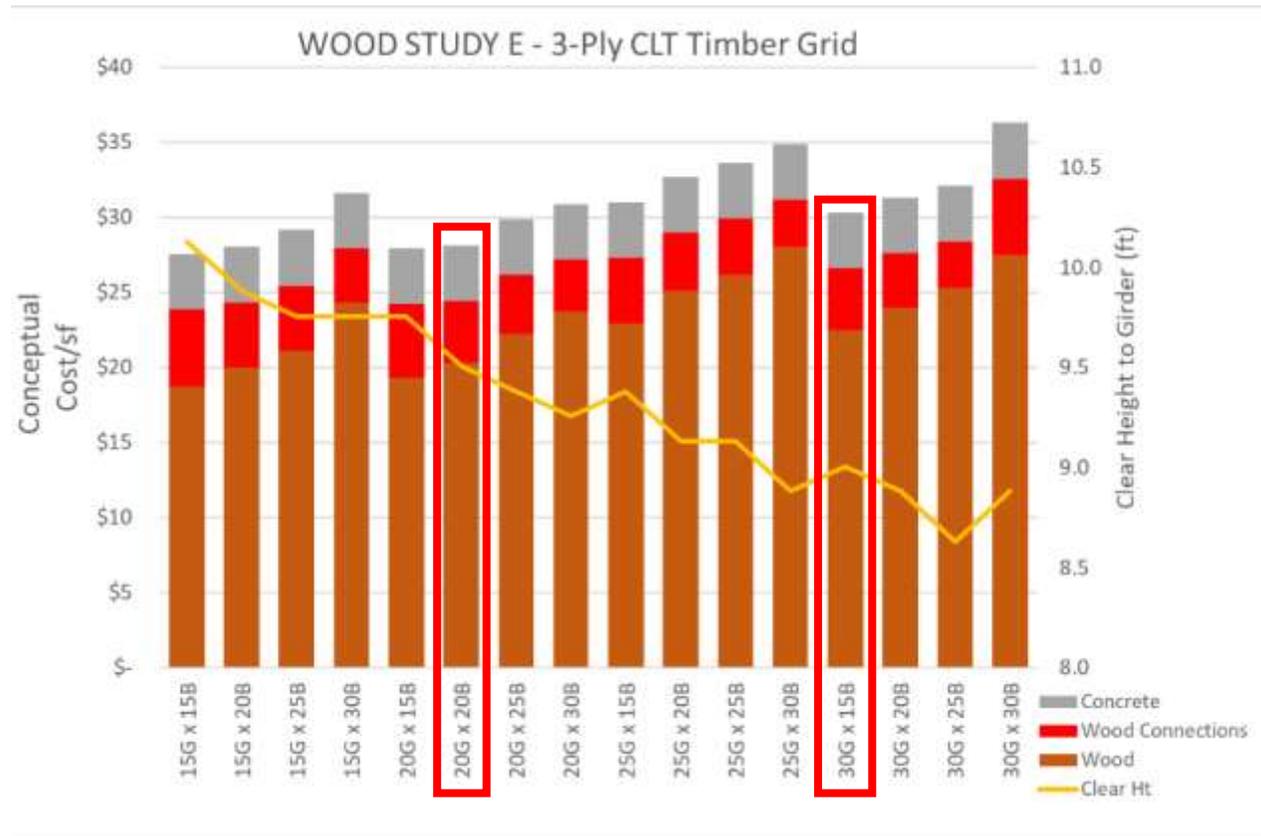
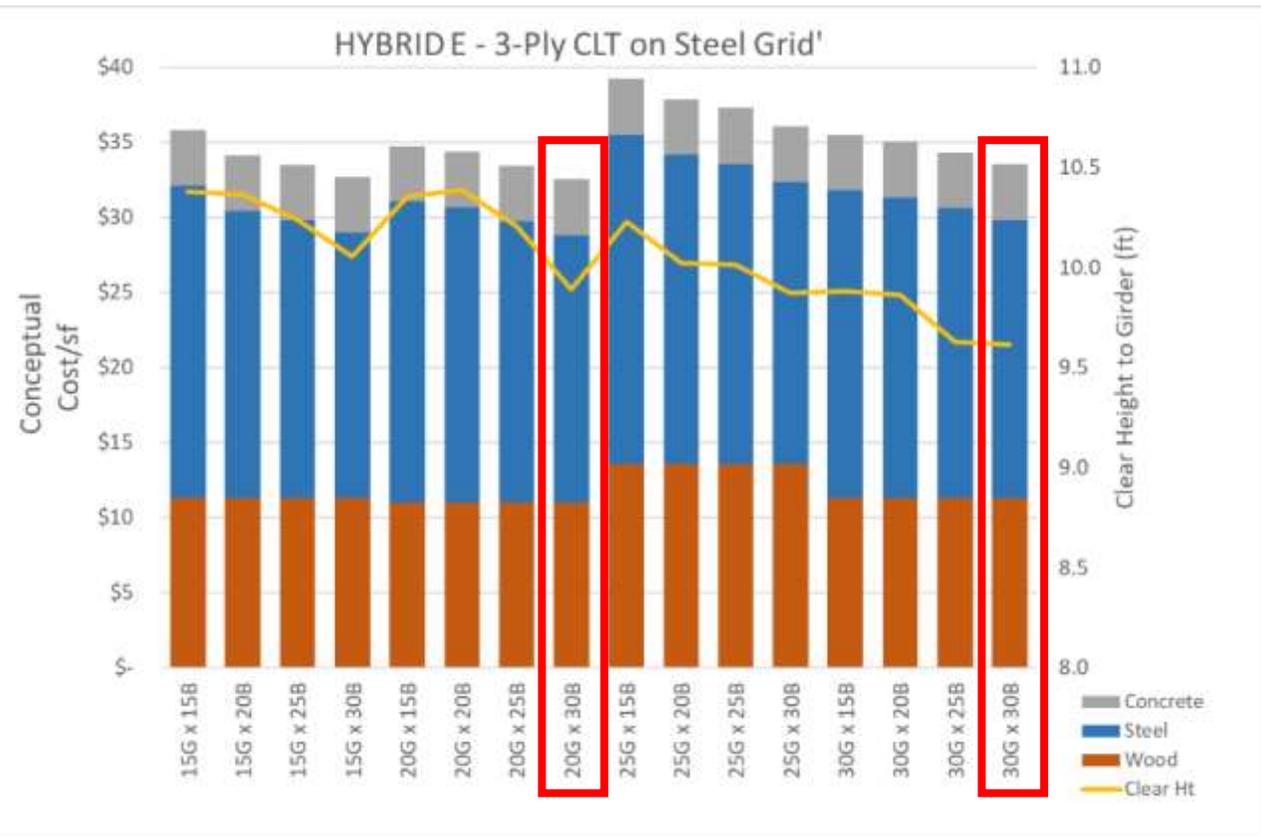


W10x26 spanning 20 ft	\$1,161 / pc	\$ 4,255 / ton
W16x40 spanning 30 ft	\$ 1,705 / pc	\$ 2,707 / ton
W24x84 spanning 50 ft	\$ 3,906 / pc	\$ 1,771 / ton

Hybrid Bay Study: 15x15 up to 30x30



Hybrid vs Wood Grid

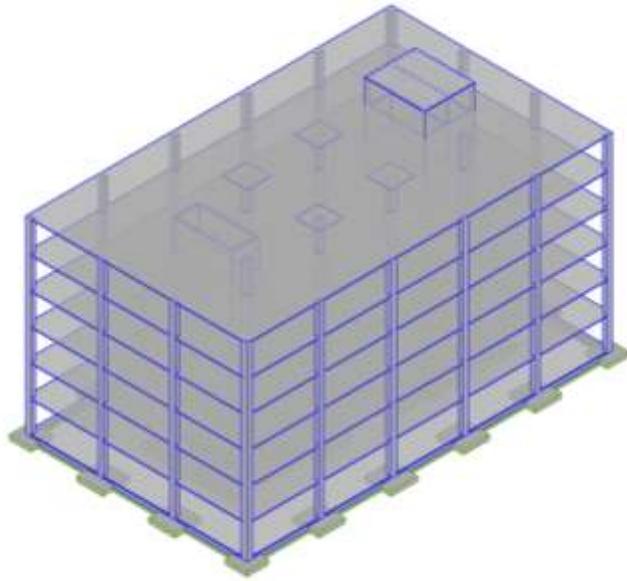




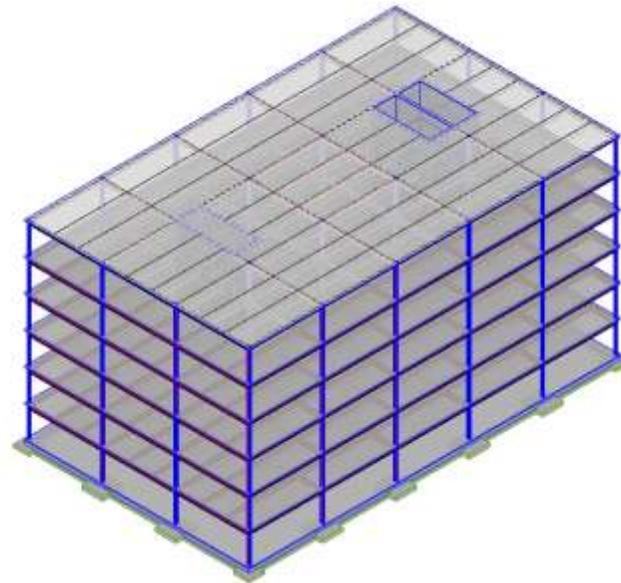
ARCHETYPE COST STUDY

MULTI-STORY OFFICE ARCHETYPE STUDY

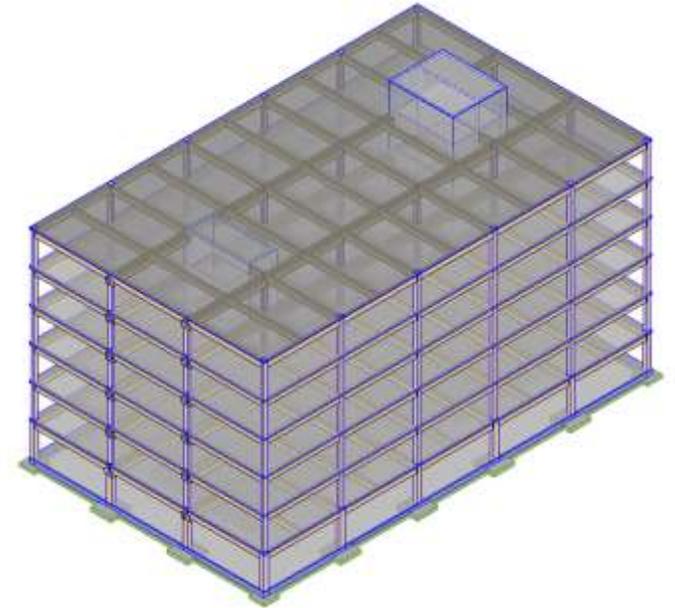
TYPE III A 6-STORY



CONCRETE



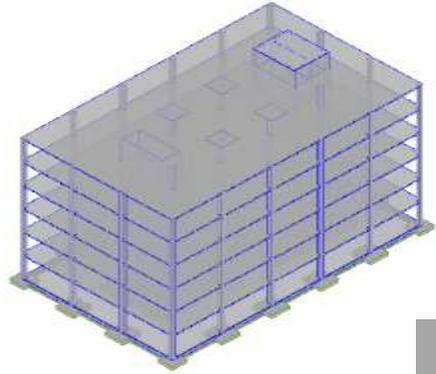
STEEL



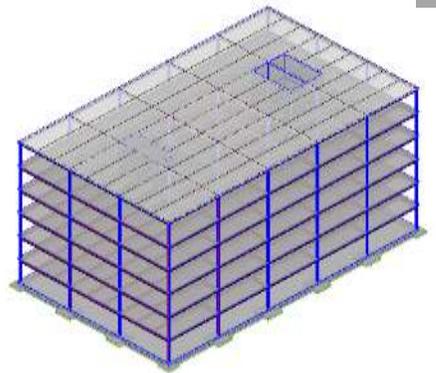
MASS TIMBER

MULTI-STORY OFFICE ARCHETYPE STUDY

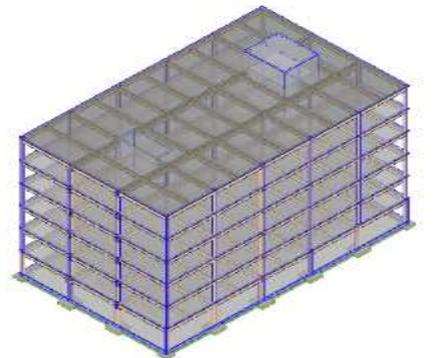
TYPE III A 6-STORY



CONCRETE



STEEL



WOOD

Superstructure Cost Premium Over Concrete (%)

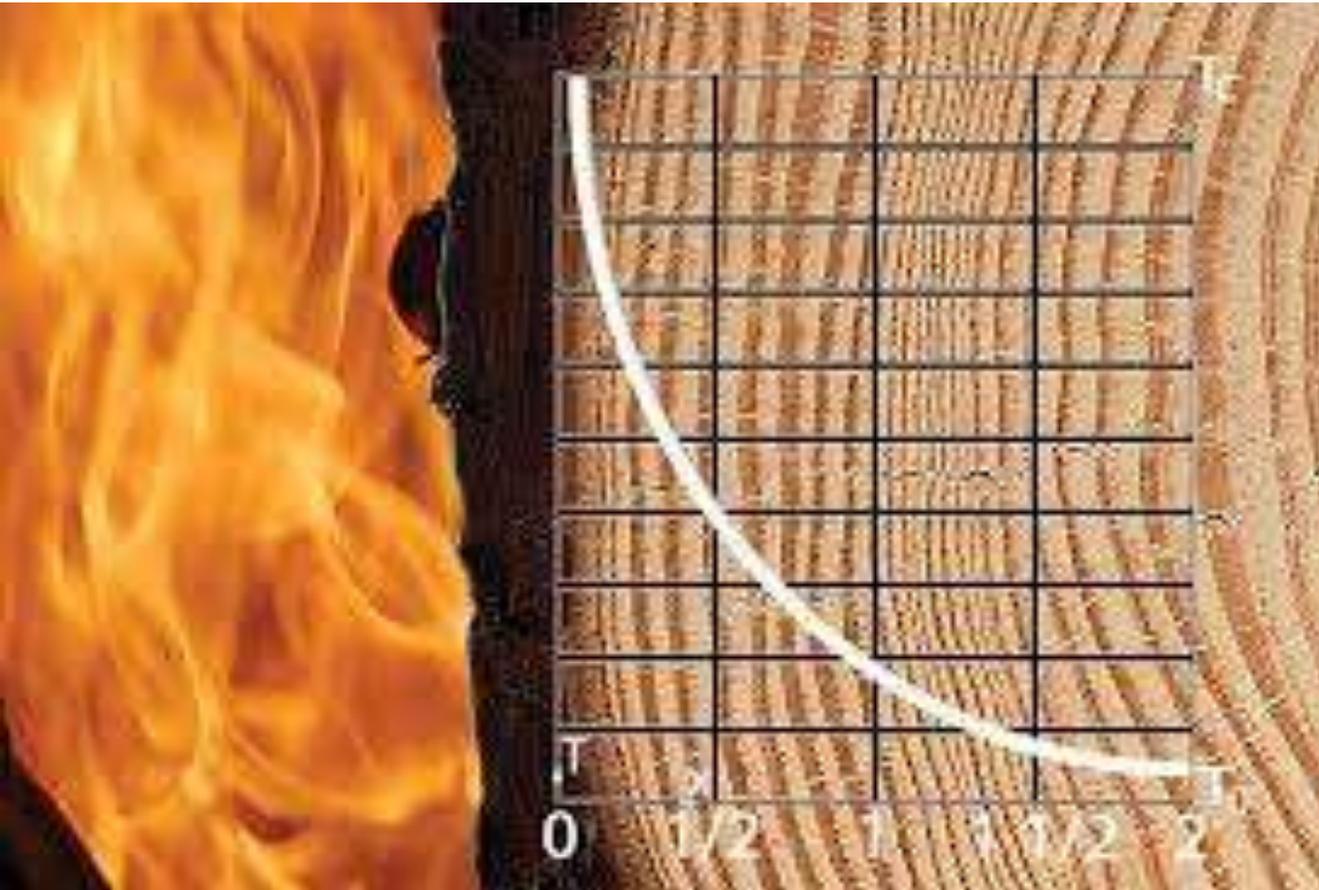


Some important design considerations that affect cost but not addressed here ...

Fire Rated Construction

MEP Coordination

Tall Wood requires design for fire rated assemblies



All case studies in this presentation were unrated construction

T3 - MEP

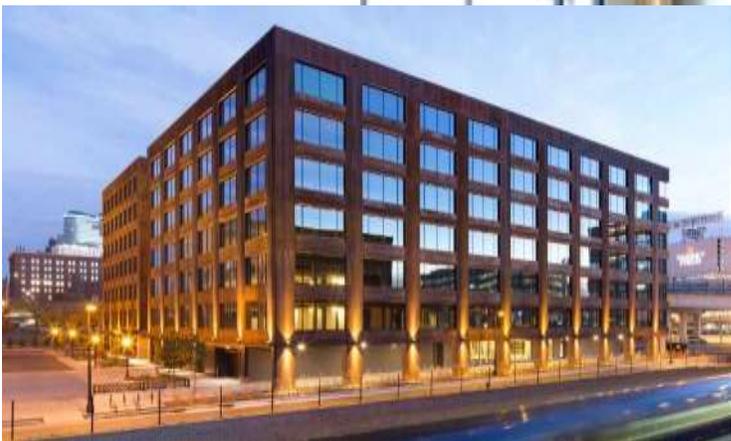
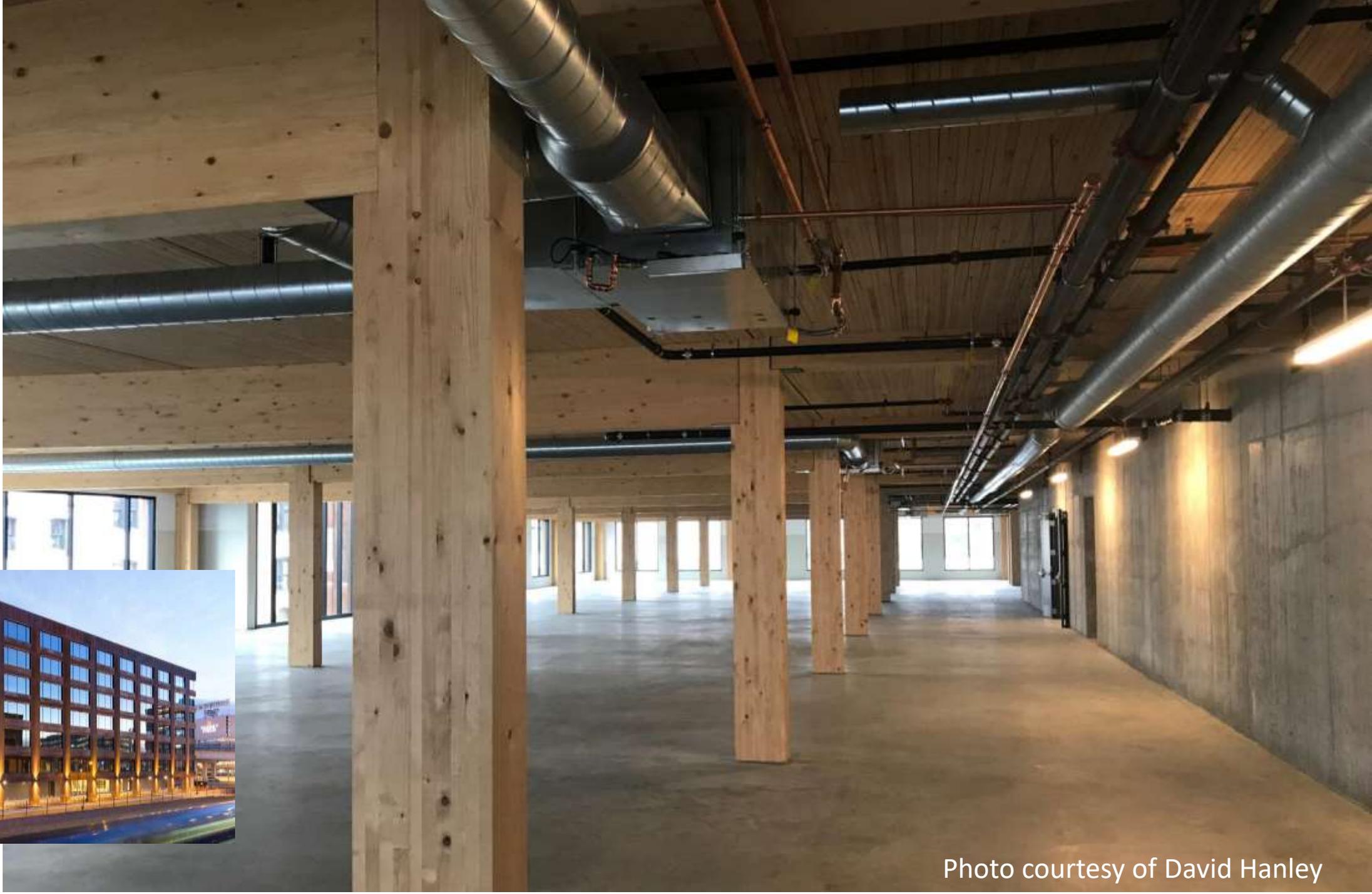
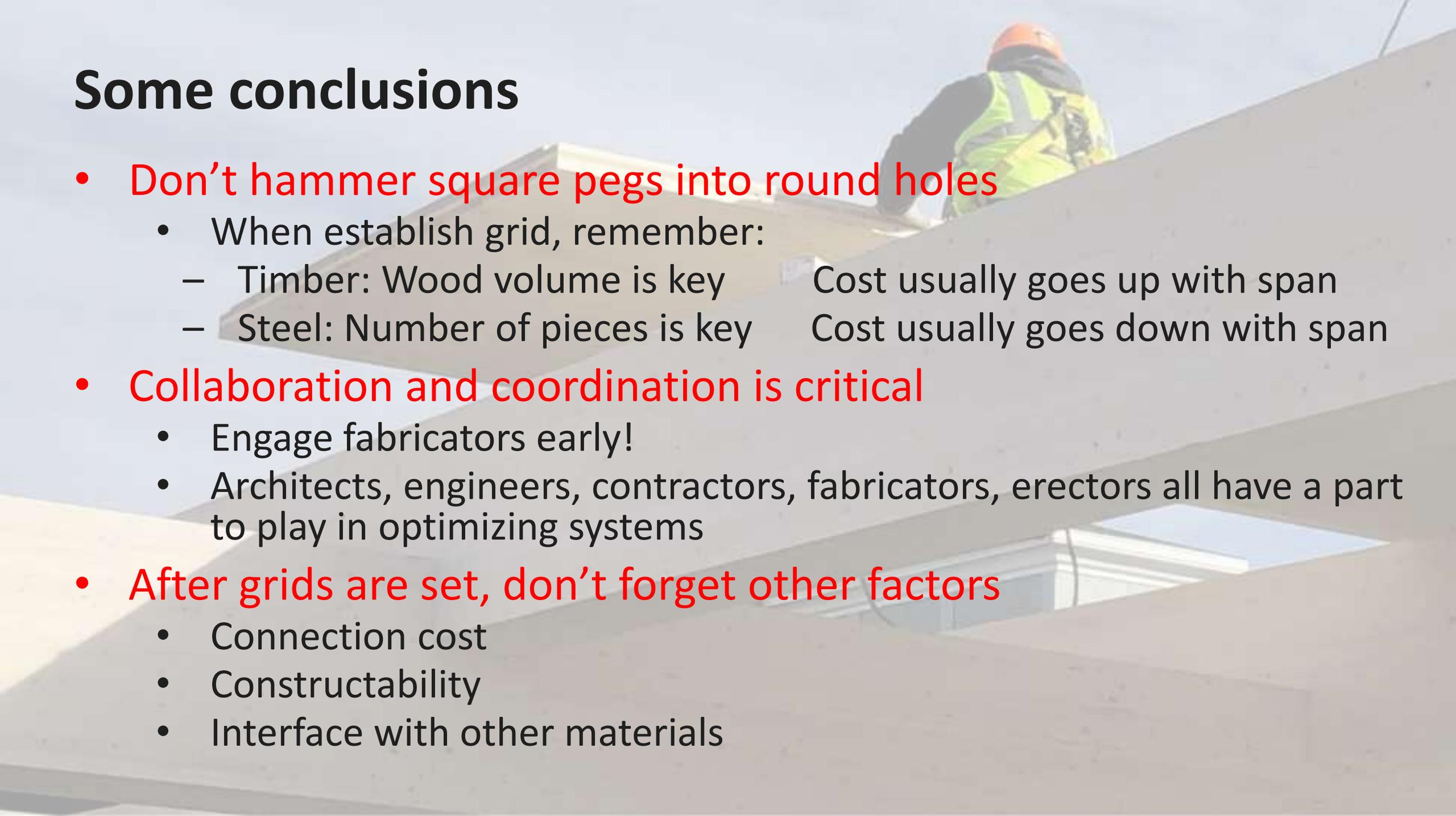


Photo courtesy of David Hanley

Some conclusions

A construction worker wearing a high-visibility yellow vest and an orange hard hat is seen from behind, working on a concrete structure. The worker is positioned on a ledge or roof edge, with a clear blue sky in the background. The structure appears to be part of a building under construction, with various concrete beams and surfaces visible.

- **Don't hammer square pegs into round holes**
 - When establish grid, remember:
 - Timber: Wood volume is key Cost usually goes up with span
 - Steel: Number of pieces is key Cost usually goes down with span
- **Collaboration and coordination is critical**
 - Engage fabricators early!
 - Architects, engineers, contractors, fabricators, erectors all have a part to play in optimizing systems
- **After grids are set, don't forget other factors**
 - Connection cost
 - Constructability
 - Interface with other materials



THANK YOU

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Photo Credit: JC Buck