Mass Timber Construction Management:
Design through Project Close Out

Structural Mass Timber Design

The Engineer's Role in Optimization

Presented by Greg Kingsley, PhD, PE

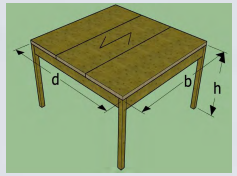
KL&A
Engineers & Builders

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

OUTLINE

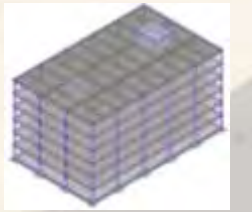
Dollar Cost of:

1. Elements (Panels, beams, and columns)



2. Bays (Timber, and steel/timber hybrid)

3. Timber Building Types (III-A, III-B, IV-HT, IV-C, IV-B, IV-A)



4. Building Archetypes (Timber, steel, and concrete)

MASS TIMBER ELEMENTS

Photo Credit: KL&A

MASS TIMBER ELEMENTS

NLT

MPP

GLT

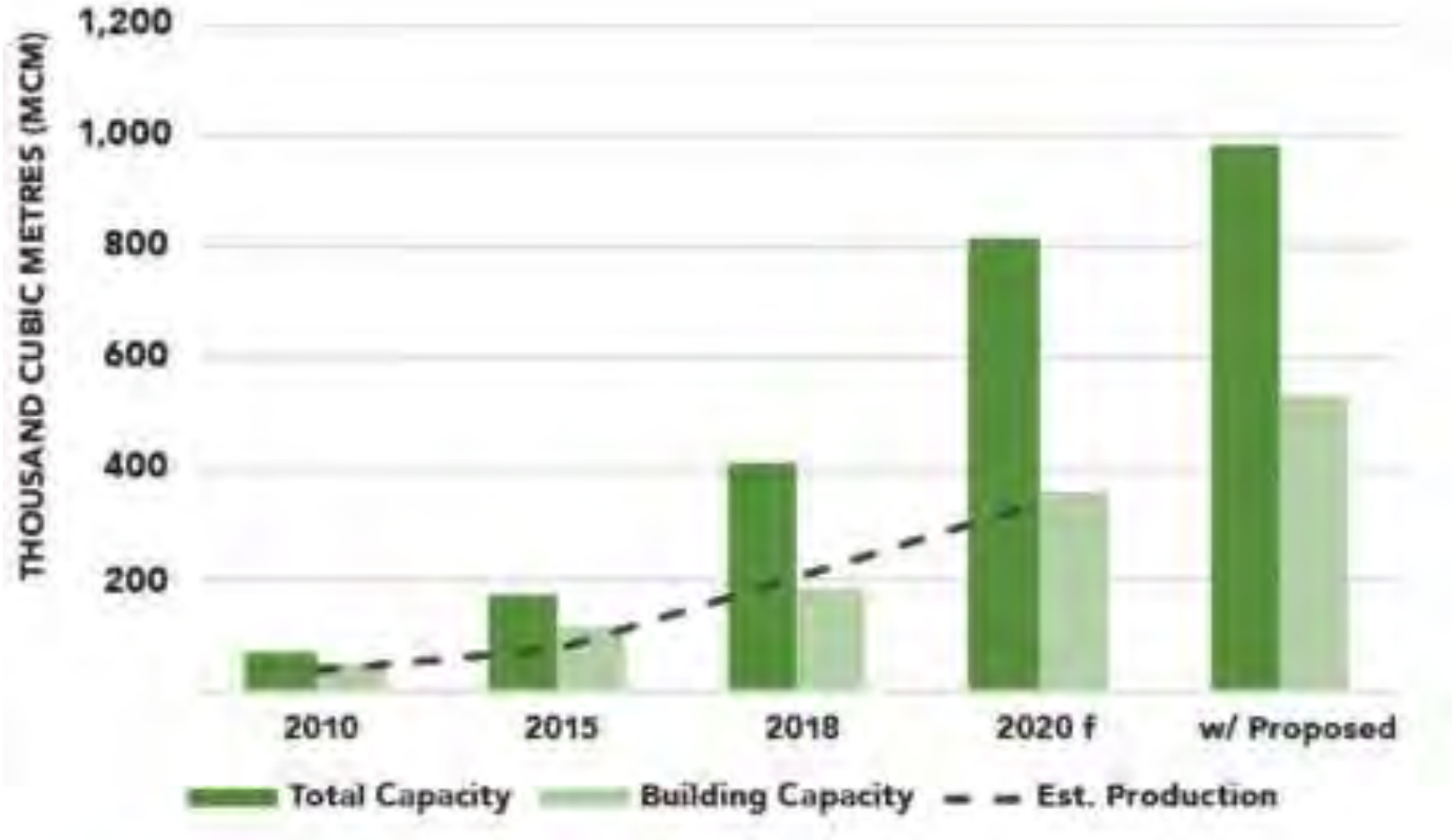
CLT

DLT

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 WOOD VOLUME!

3-ply 3-layer
(3.43”- 4.14”)

5-ply 5-layer
(5.47”- 6.90”)

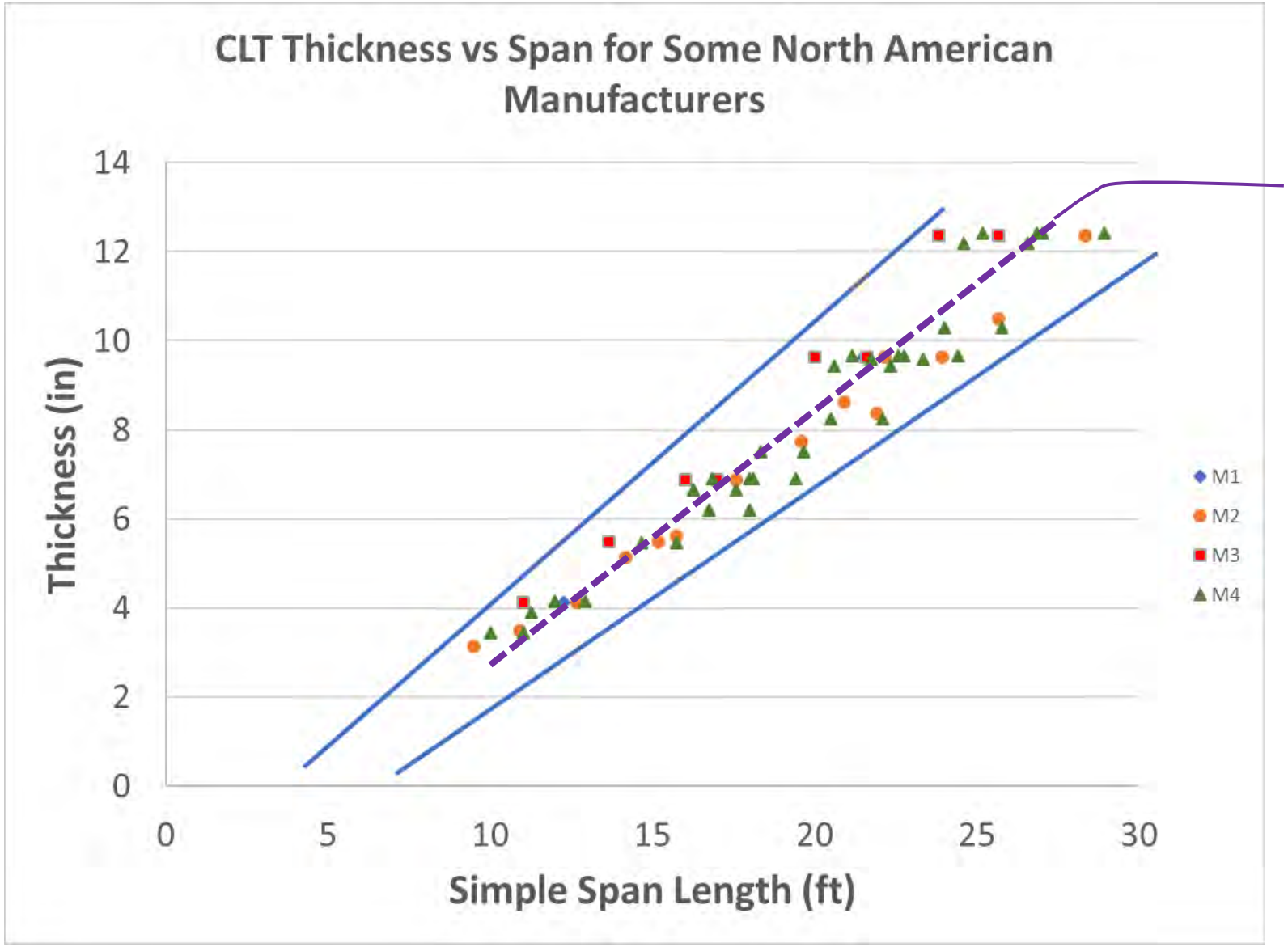
7-ply 7-layer
(7.52”- 9.66”)

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 THE MANUFACTURER

Mass timber panels are not a commodity!

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

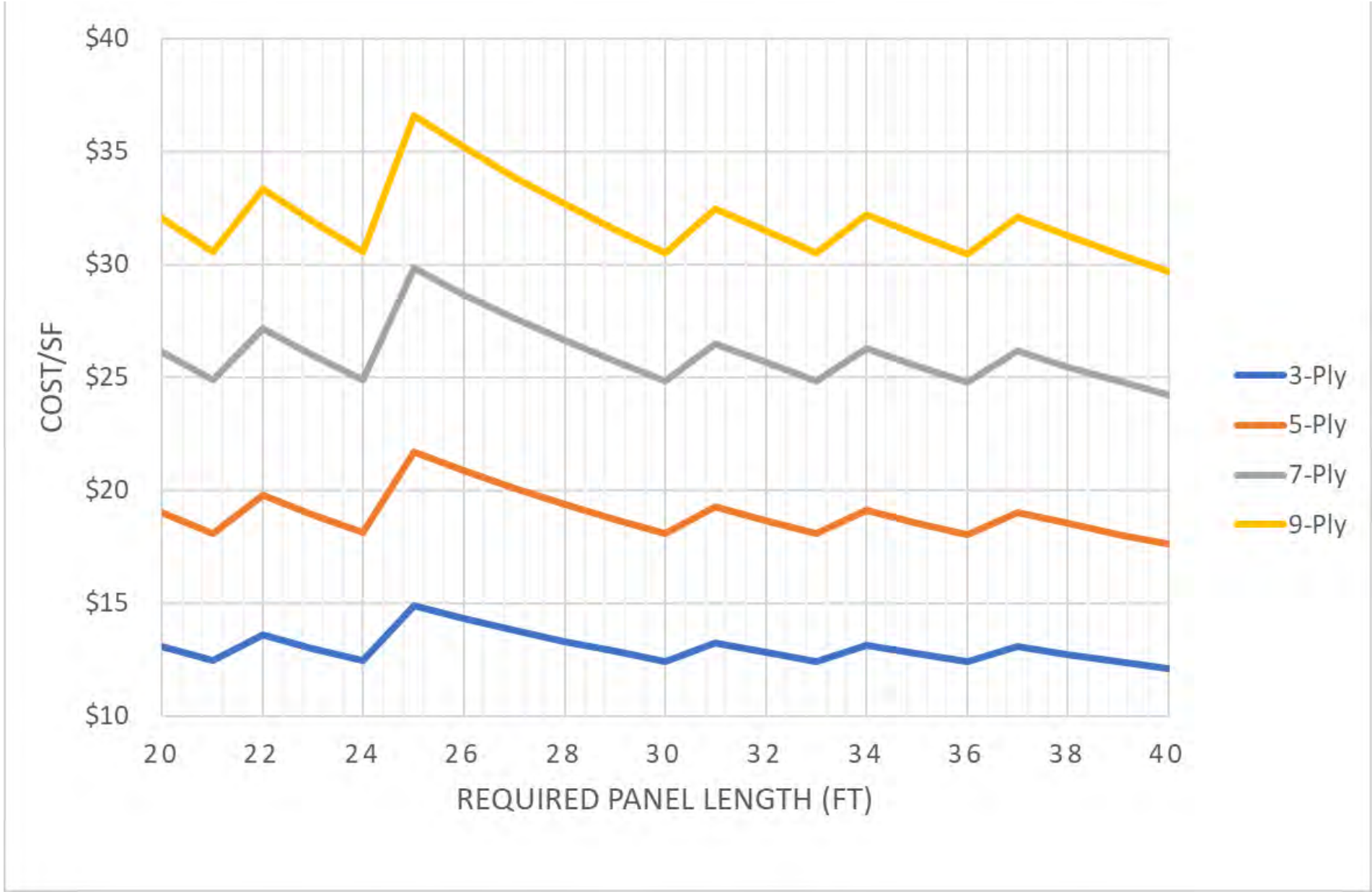
CLT COST DEPENDS ON NUMBER OF PLIES AND DROP

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

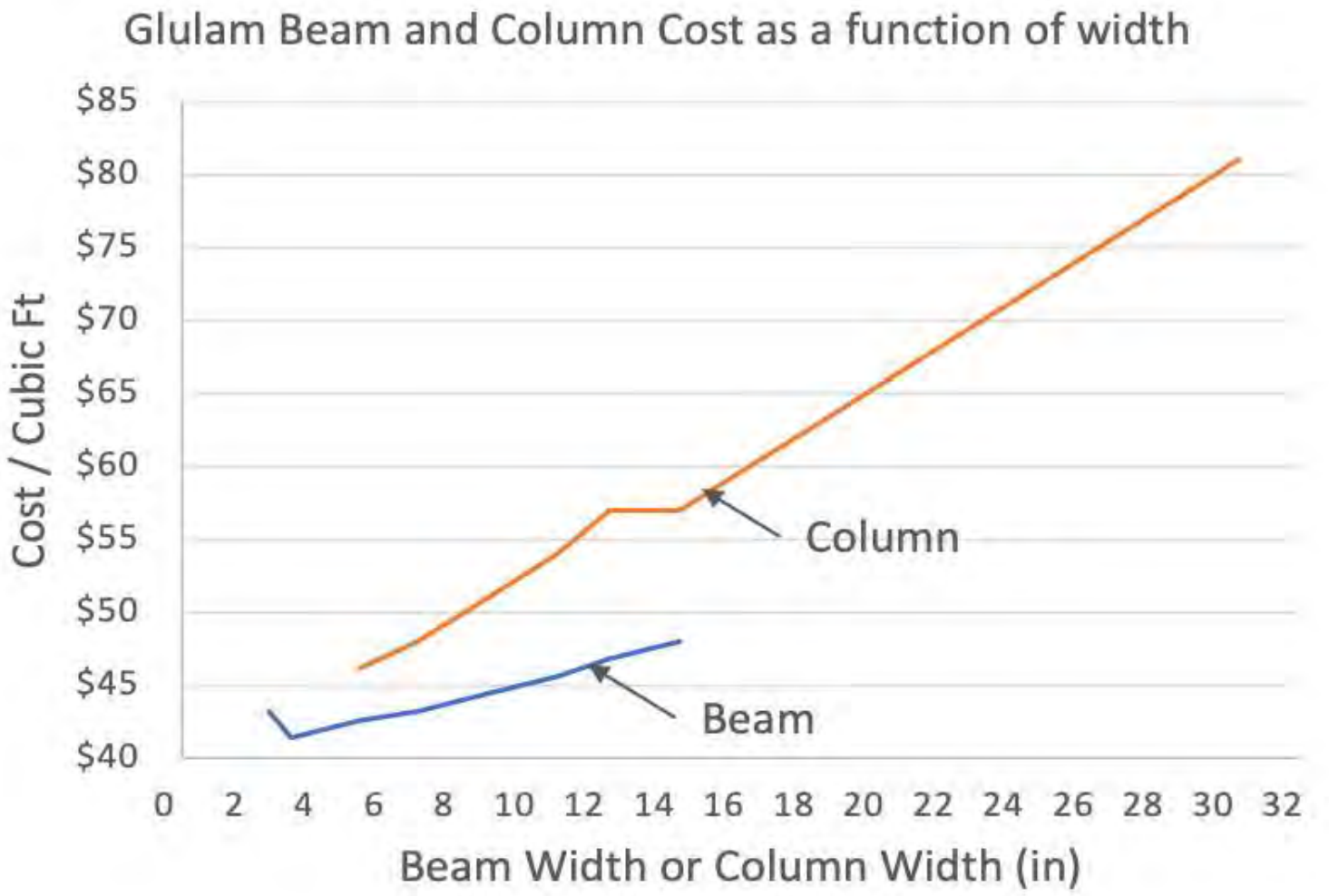
- CLT
- Shop fab
- Sanding
- Delivered
- Screws

but does **not** include:

- Finishes

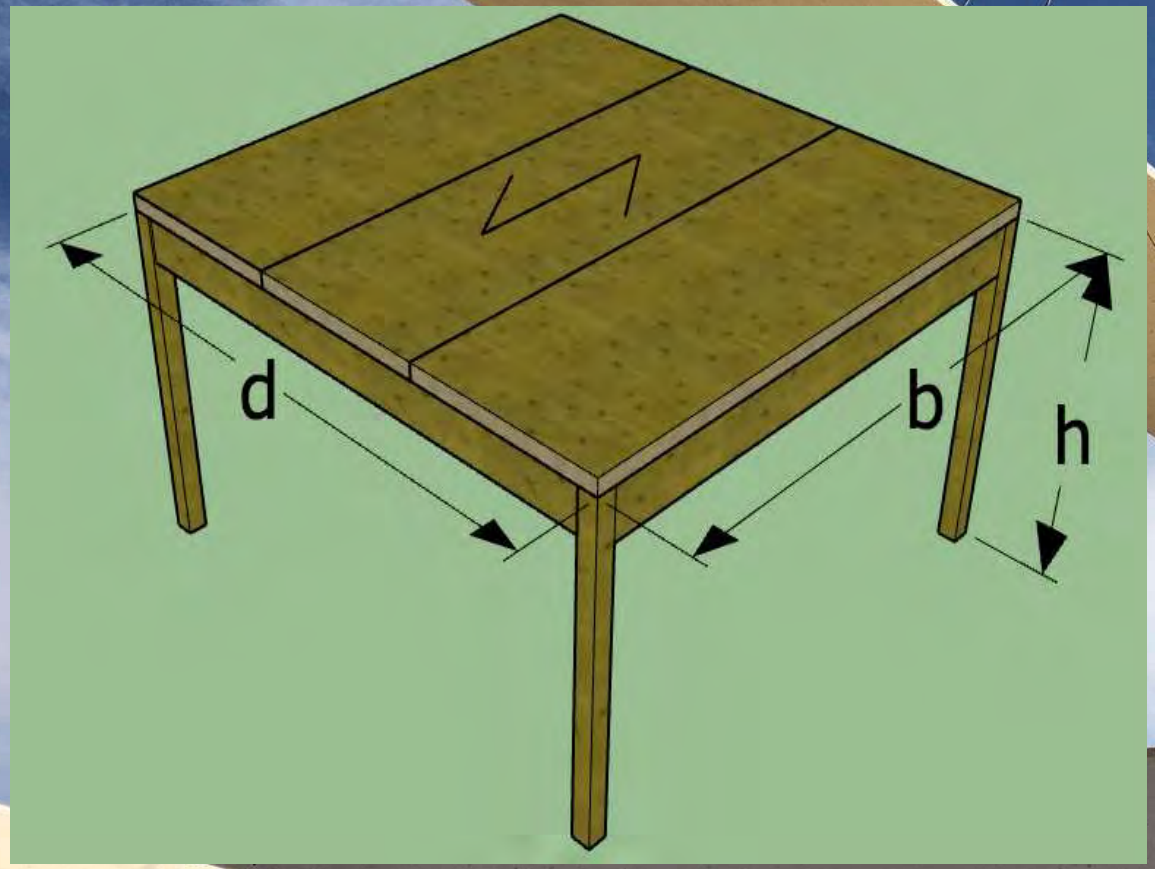


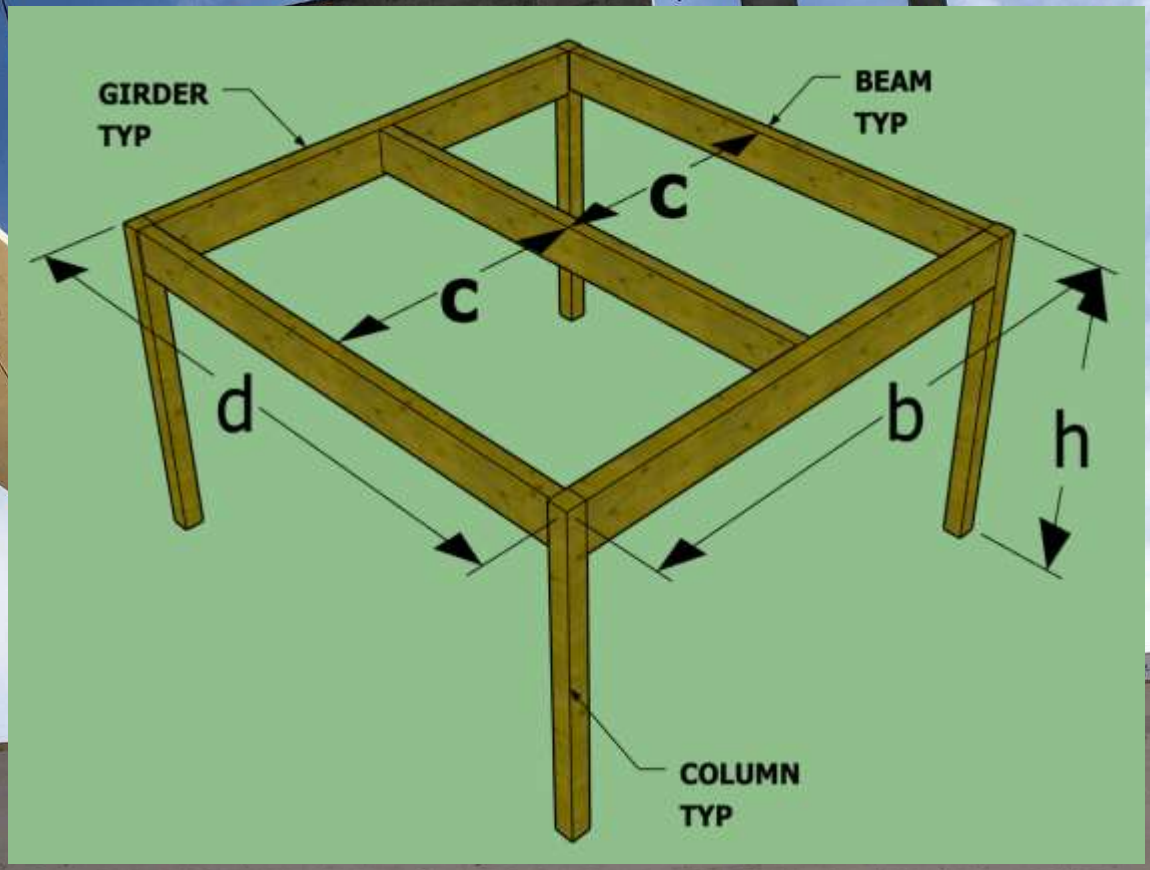
Glulam Beam and Column Cost



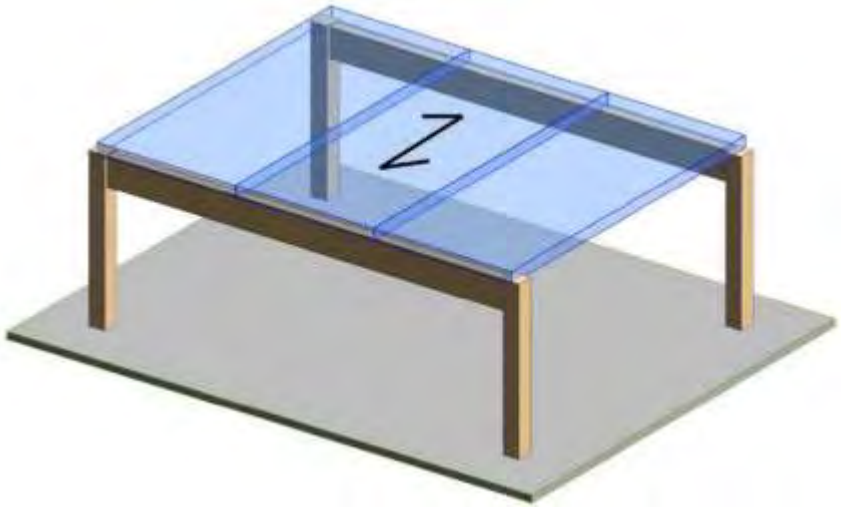
MASS TIMBER BAYS

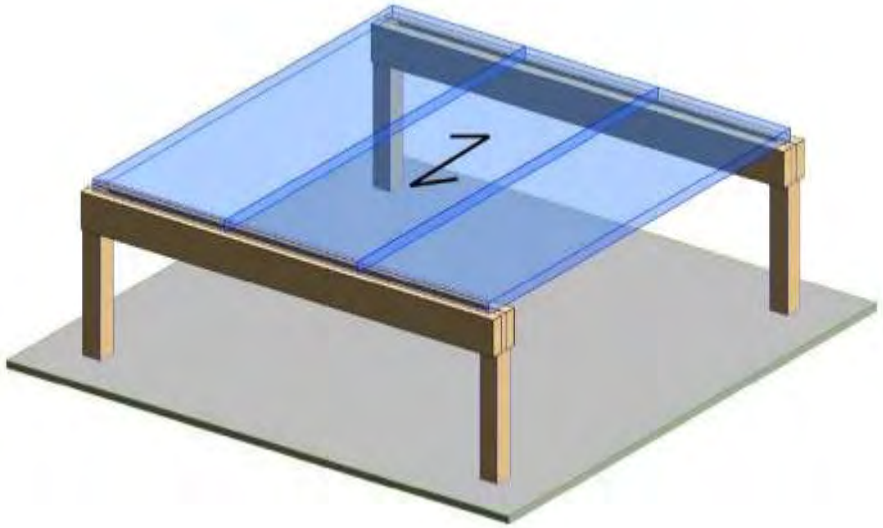
MASS TIMBER **BAYS**

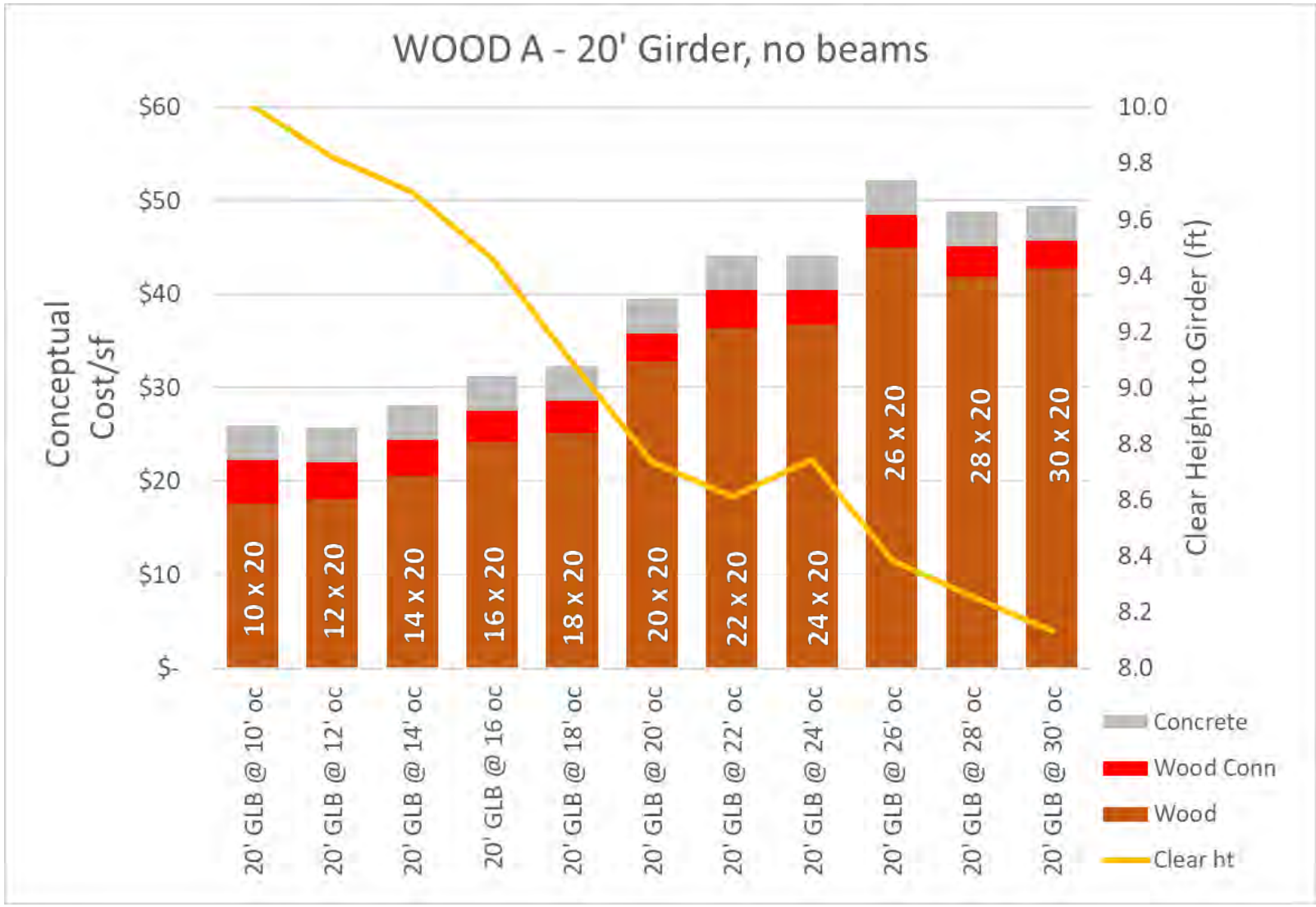




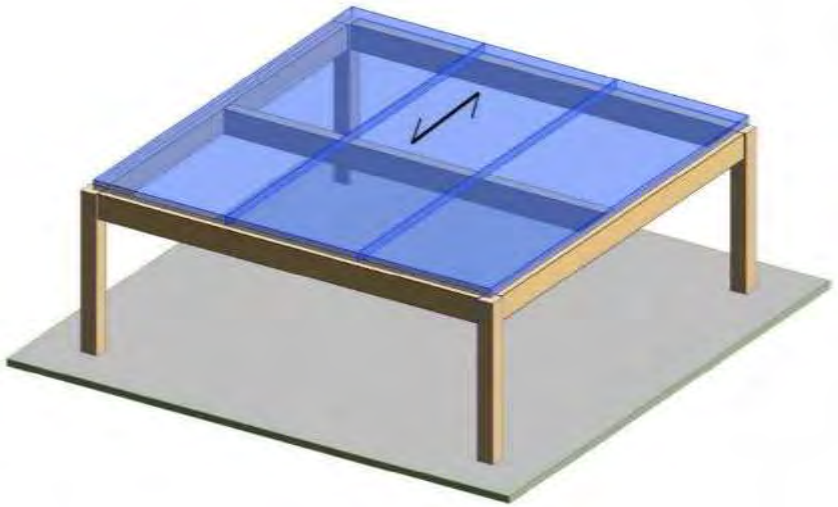
20 ft timber bents, no beams, CLT of varying span

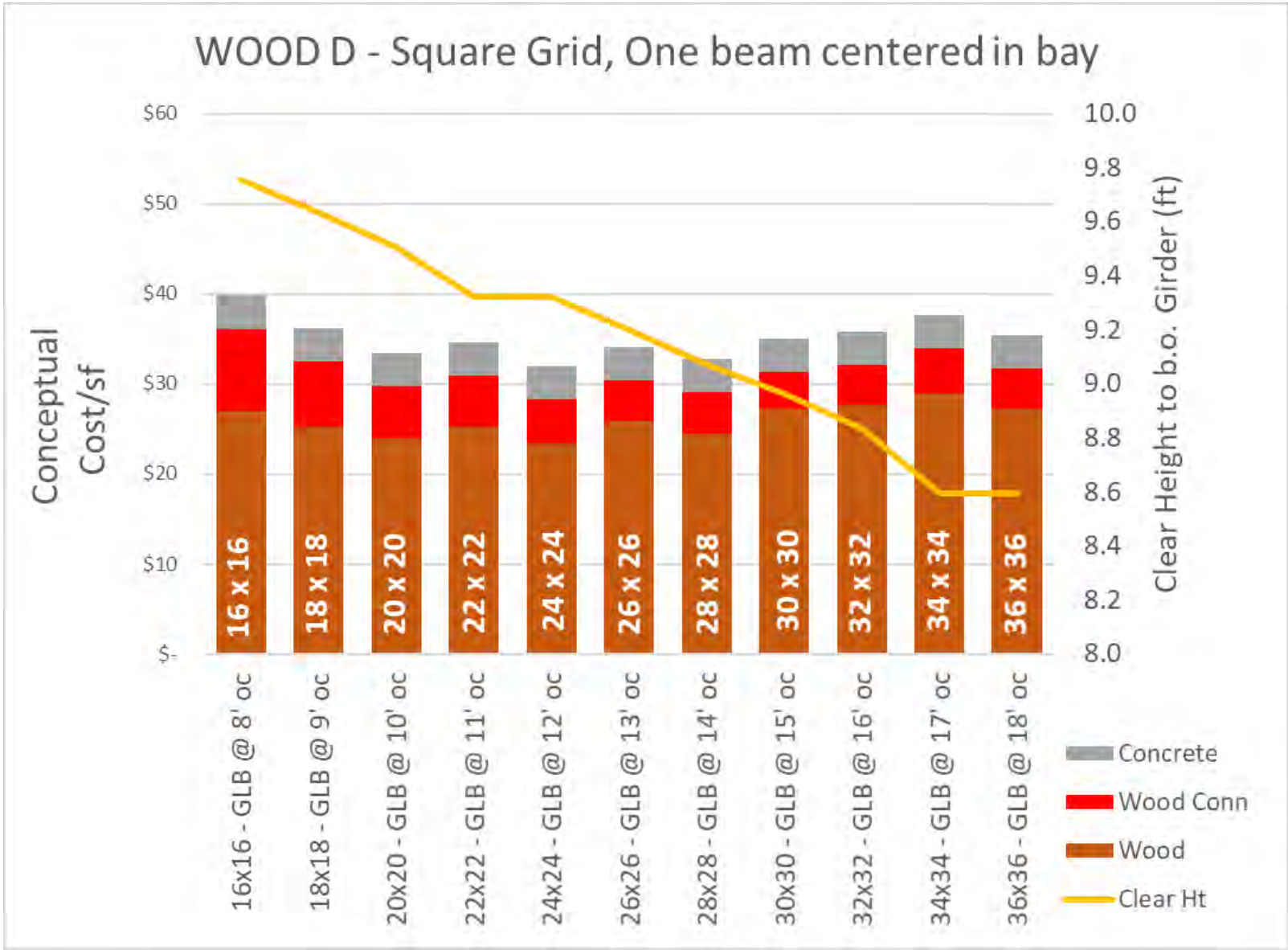




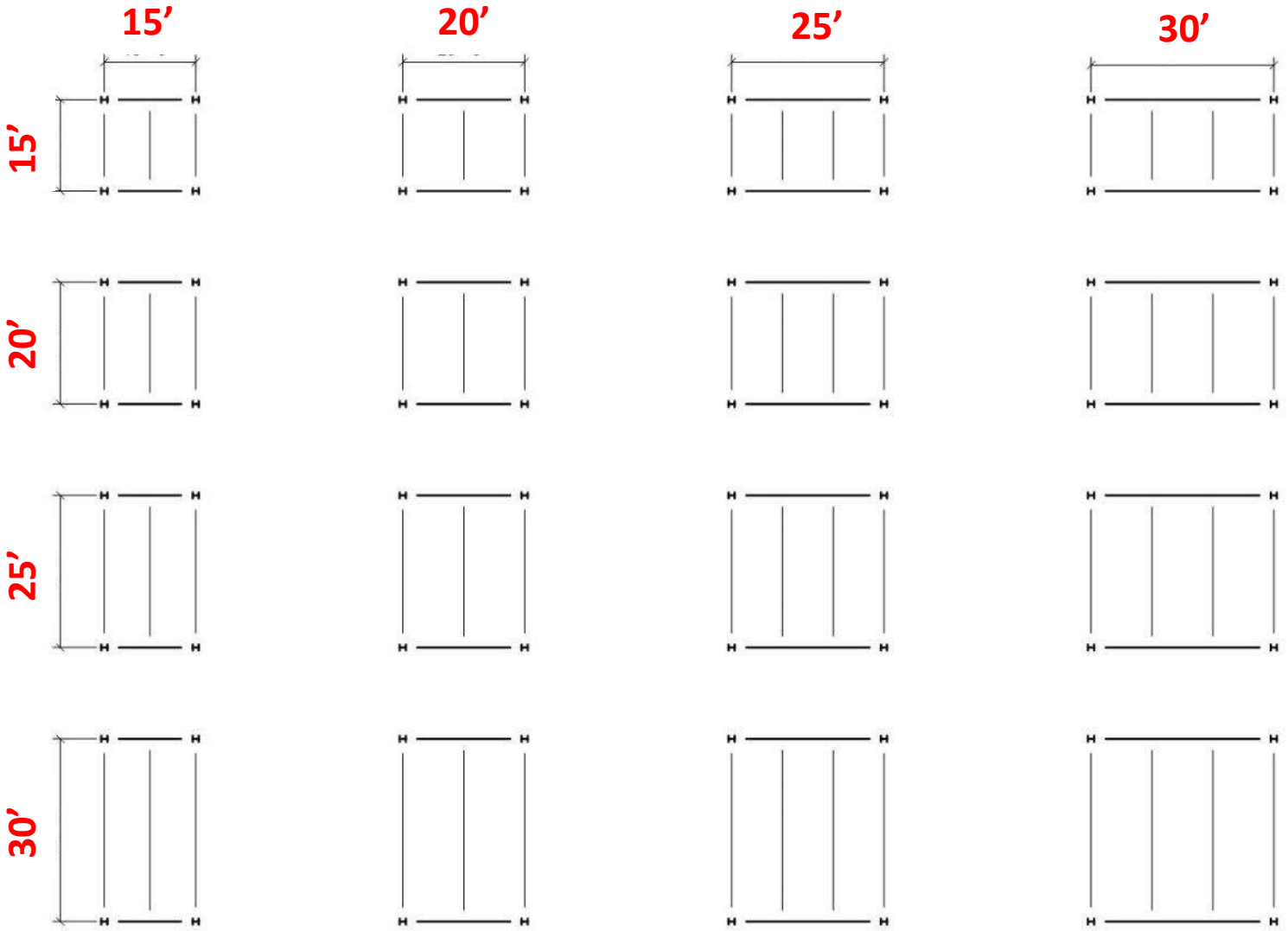


Square bay, CLT with 2 equal (varying) spans

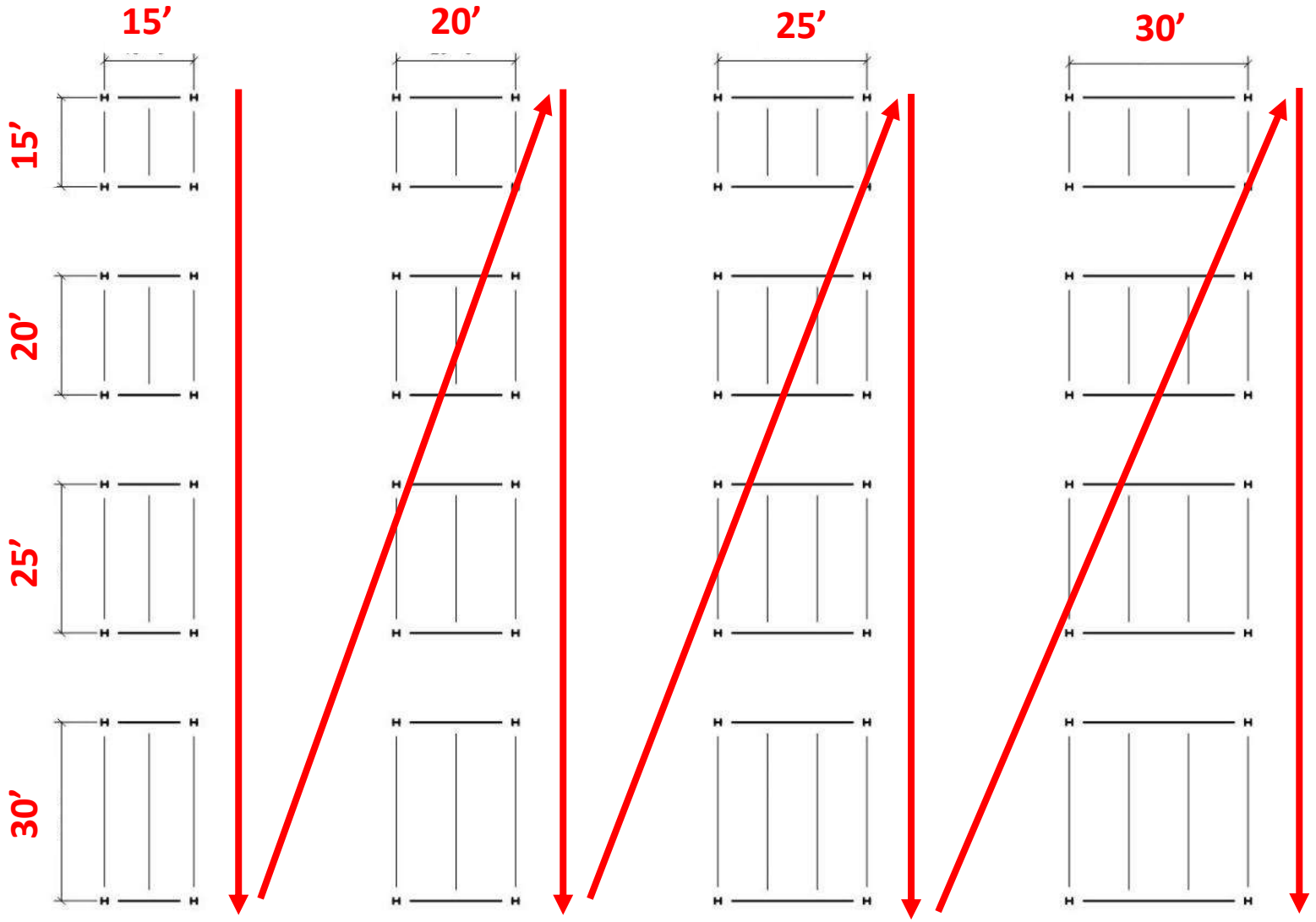




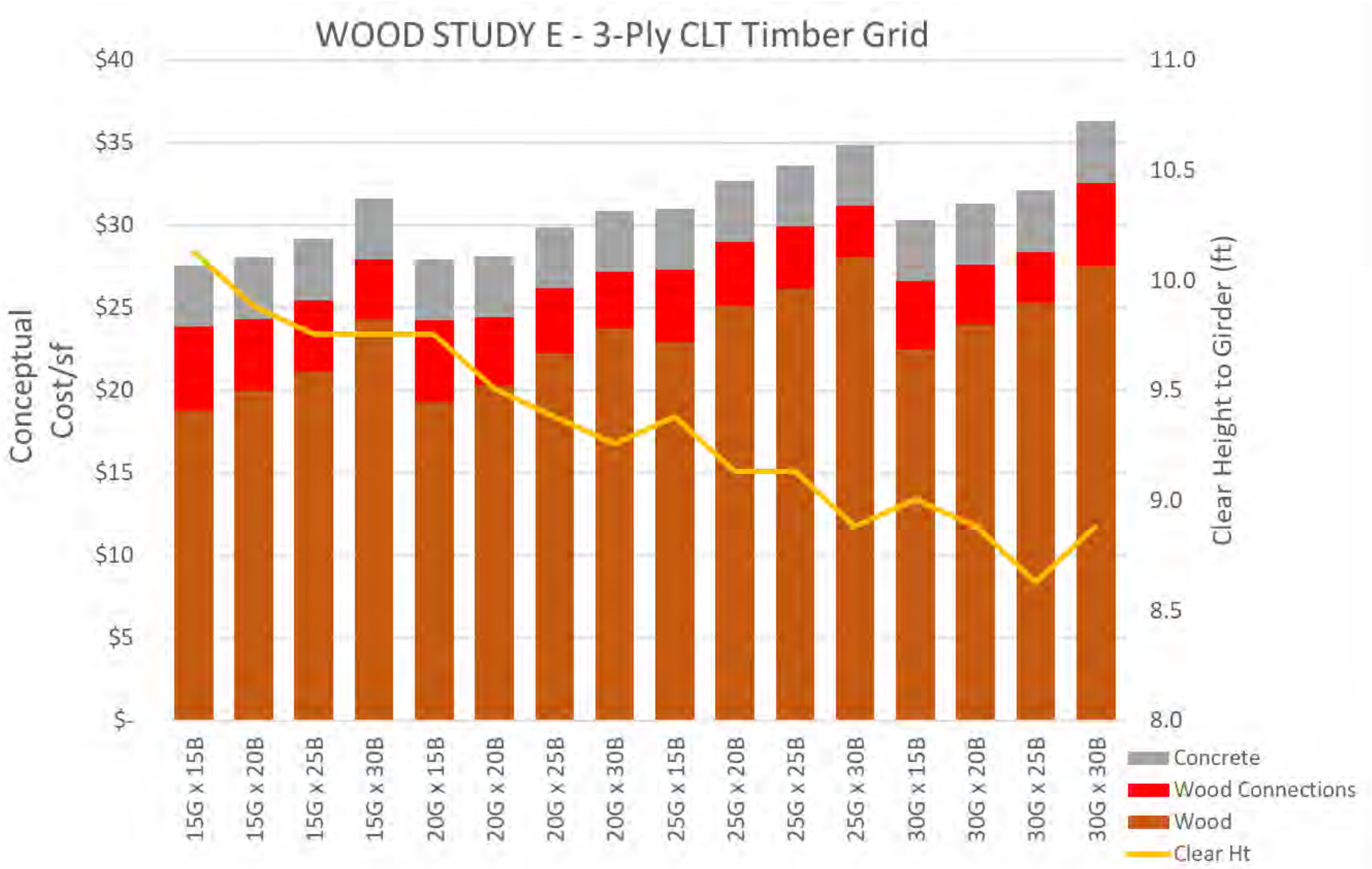
Wood Bay Study: 15x15 up to 30x30

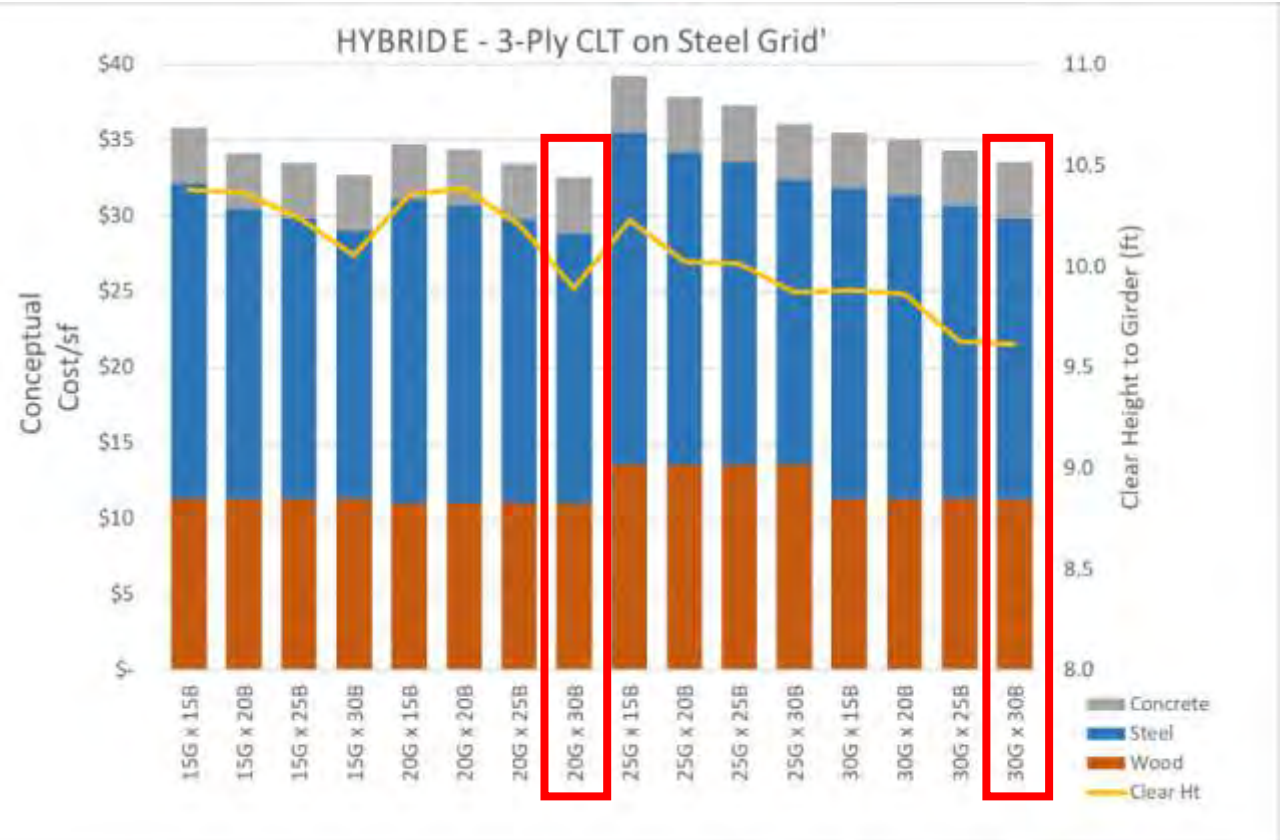


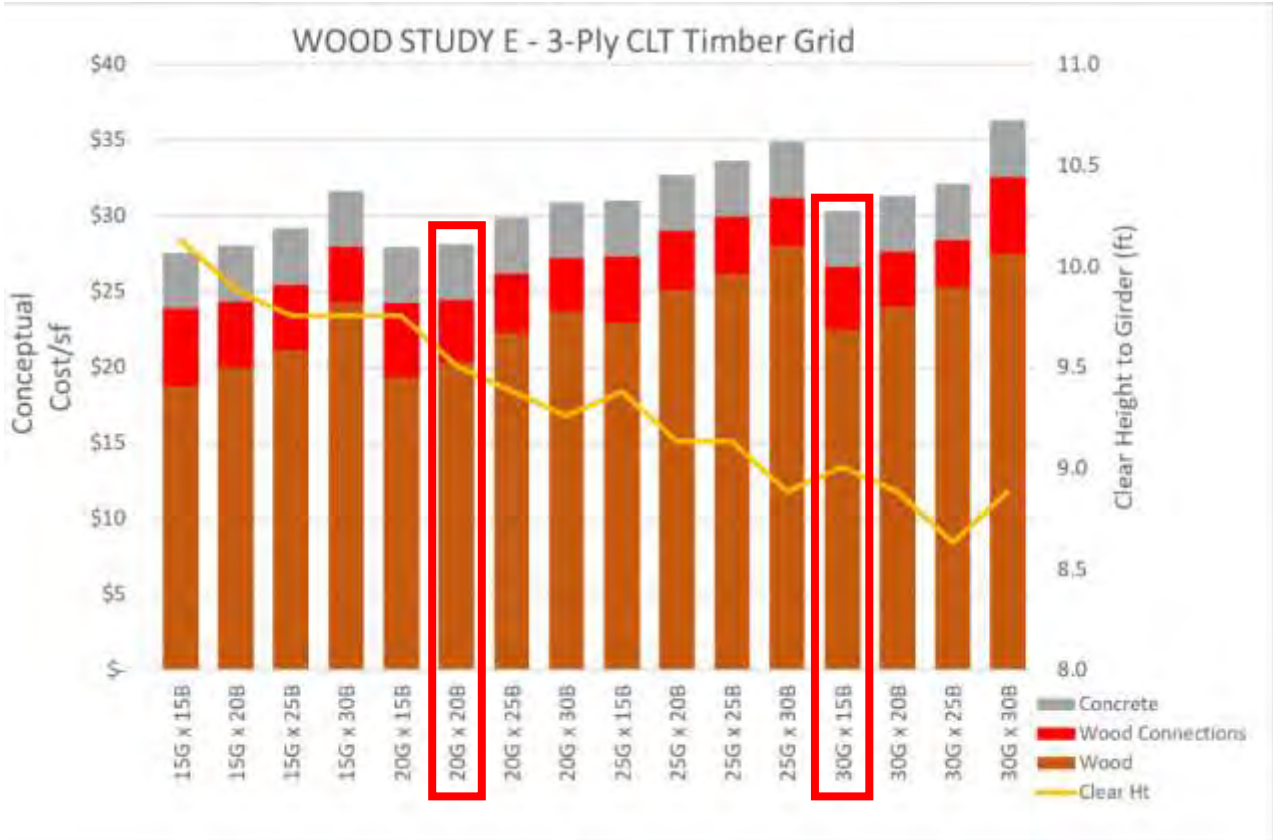
Wood Bay Study: 15x15 up to 30x30



Wood Bay Study

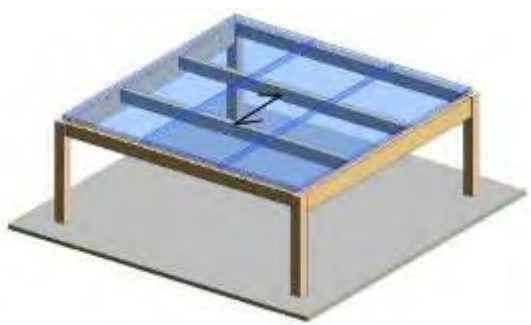






Steel beams and columns:
Labor dominates cost

Timber beams and columns:
Material volume dominates cost



WHAT DO MASS TIMBER CONNECTIONS COST?

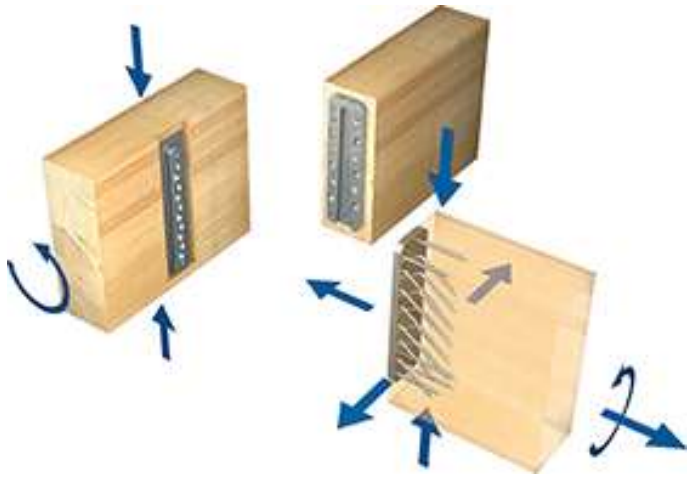
Slide credit: WoodWorks

Simple connections are economical

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

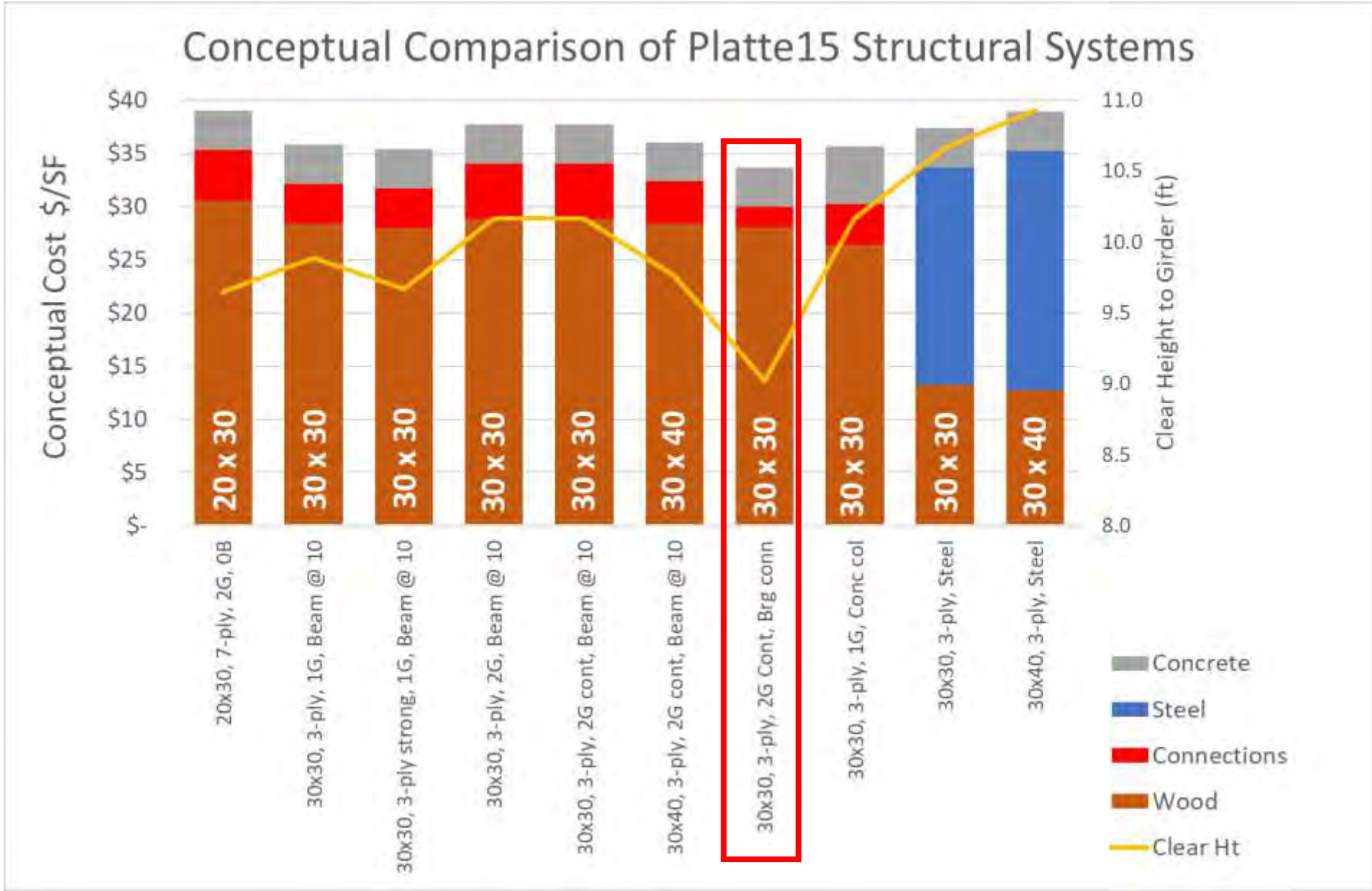
Adolfson & Peterson Construction

KL&A & Nordic

PLATTE 15

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

Platte Fifteen Bay Study

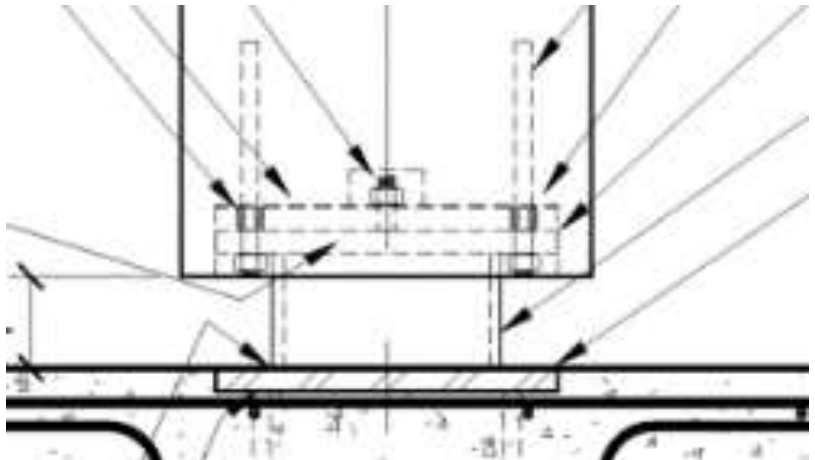


PLATTE 15

PLATTE 15

PLATTE 15

- DIFFERENT MATERIAL
- DIFFERENT TOLERANCE
- DESIGN FOR IT

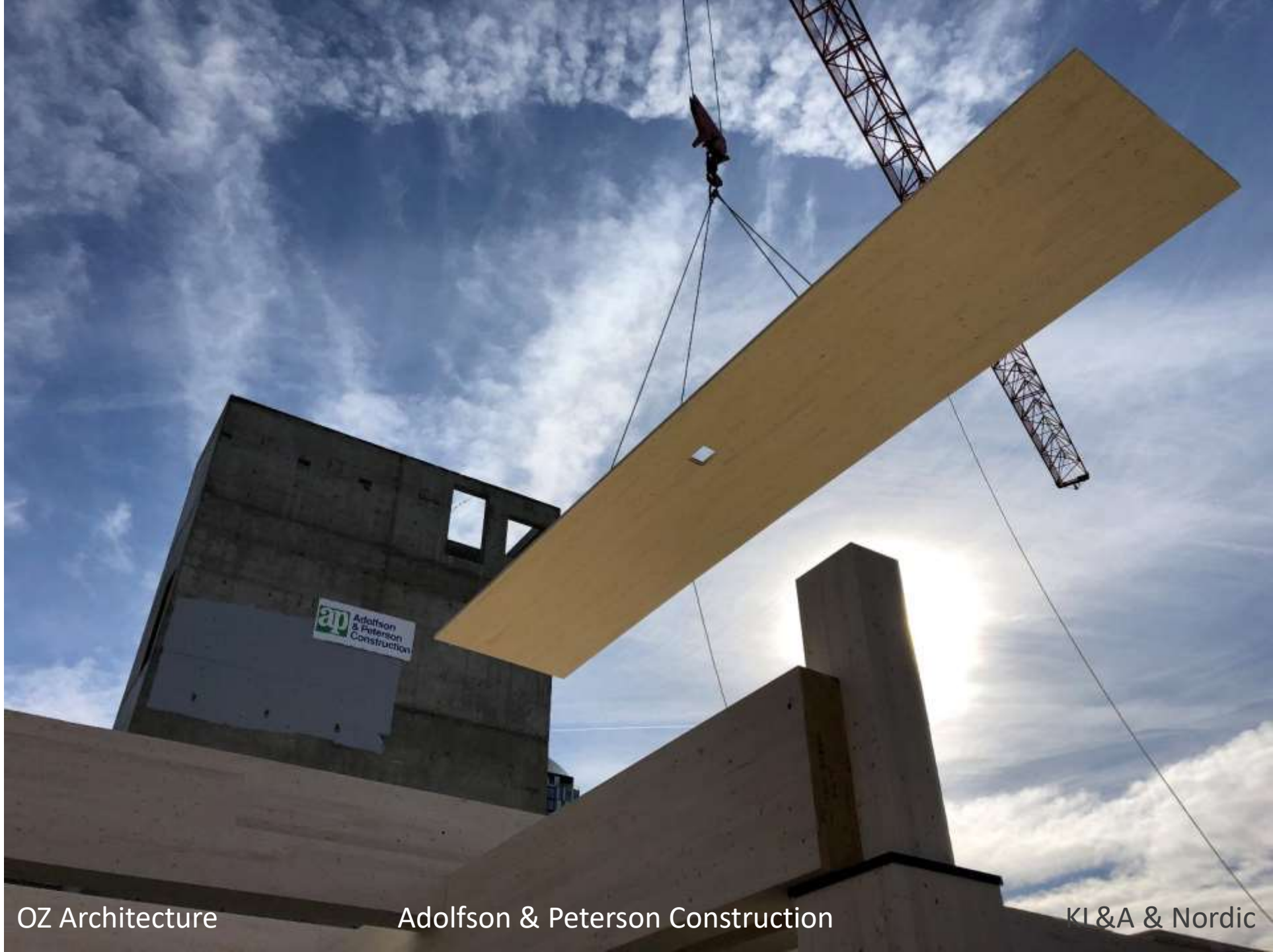


CONNECTION DESIGN:

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

PLATTE 15

50+ ft panels span five 10 ft bays



OZ Architecture

Adolfson & Peterson Construction

KL&A & Nordic

PLATTE 15

MASS TIMBER BUILDING TYPES

III-B

III-A

IV-HT

IV-C

IV-B

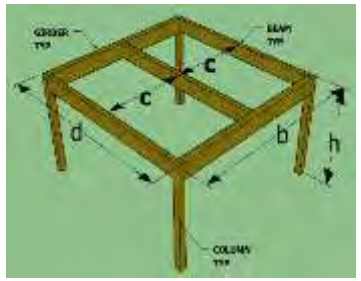
IV-A

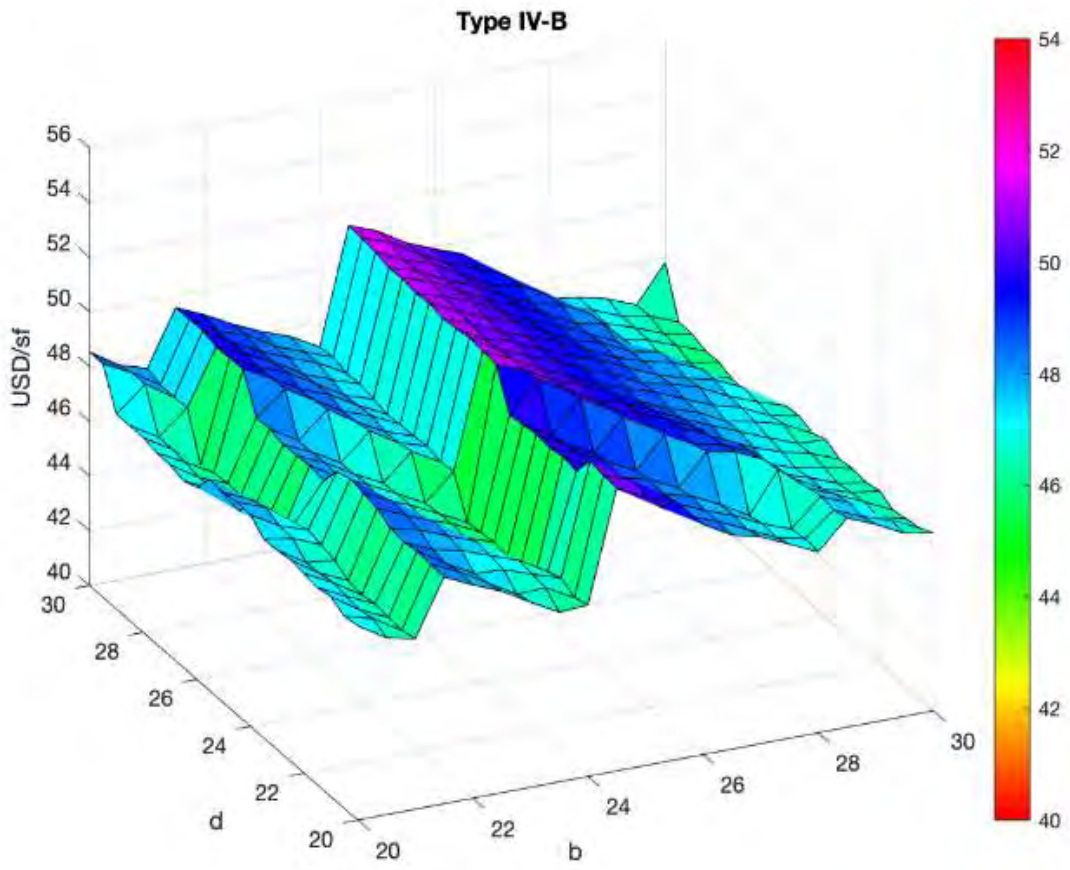
Fire Resistance Requirements for Mass Timber Buildings

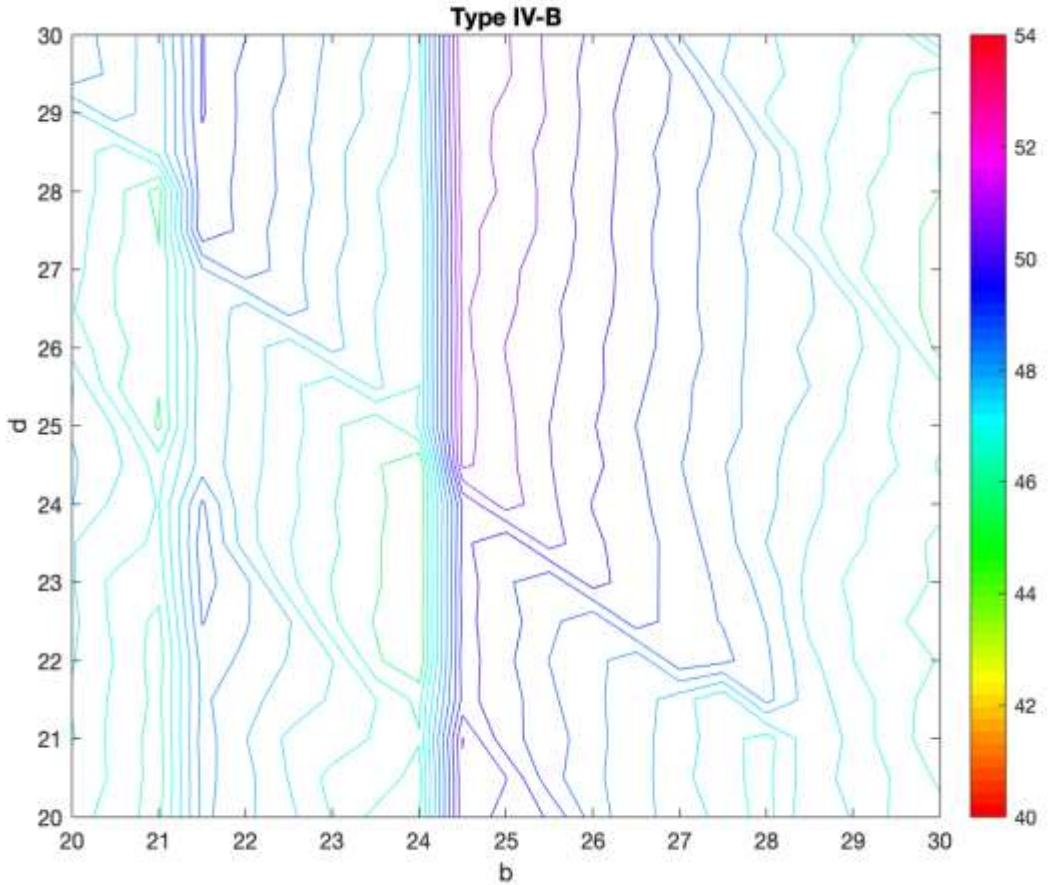
Construction Type	FRR (hours)			Non-combustible Protection	Story Limit	Maximum Height (ft)
	Primary Structural Frame	Floor	Roof			
III-A	1	1	1	Not Required	6	85
III-B	0	0	0	Not Required	4	75
IV-A	3	2	1.5	Fully Covered	18	270
IV-B	2	2	1	Partially Covered	12	180
IV-C	2	2	1	Not Required	9	85
IV-HT	HT[a]	HT[a]	HT[a]	Not Required	6	85

From: Chaggaris, Pei, Kingsley, Kinder, *Sensitivity on Cost of Mass Timber Beam-Column Gravity Systems*, Journal of Architectural Engineering

Effect of grid on cost/sf – Type IV-B







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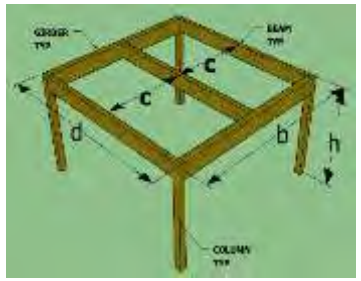
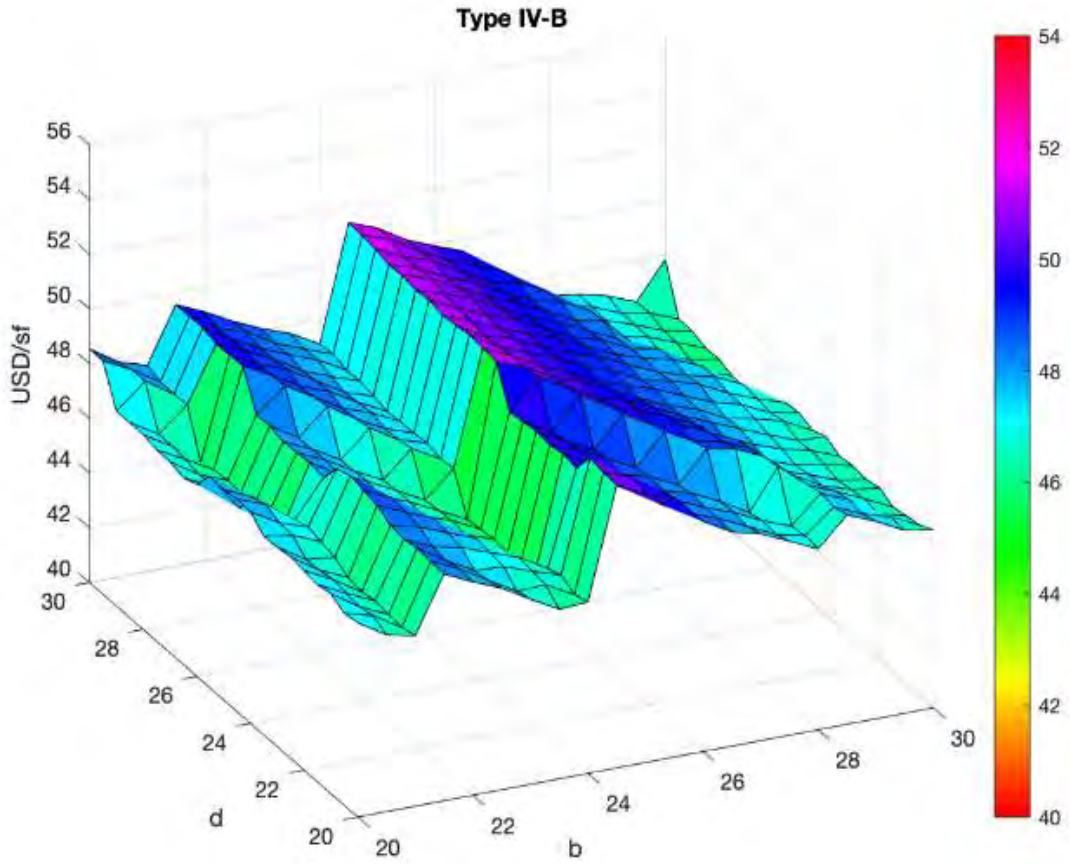
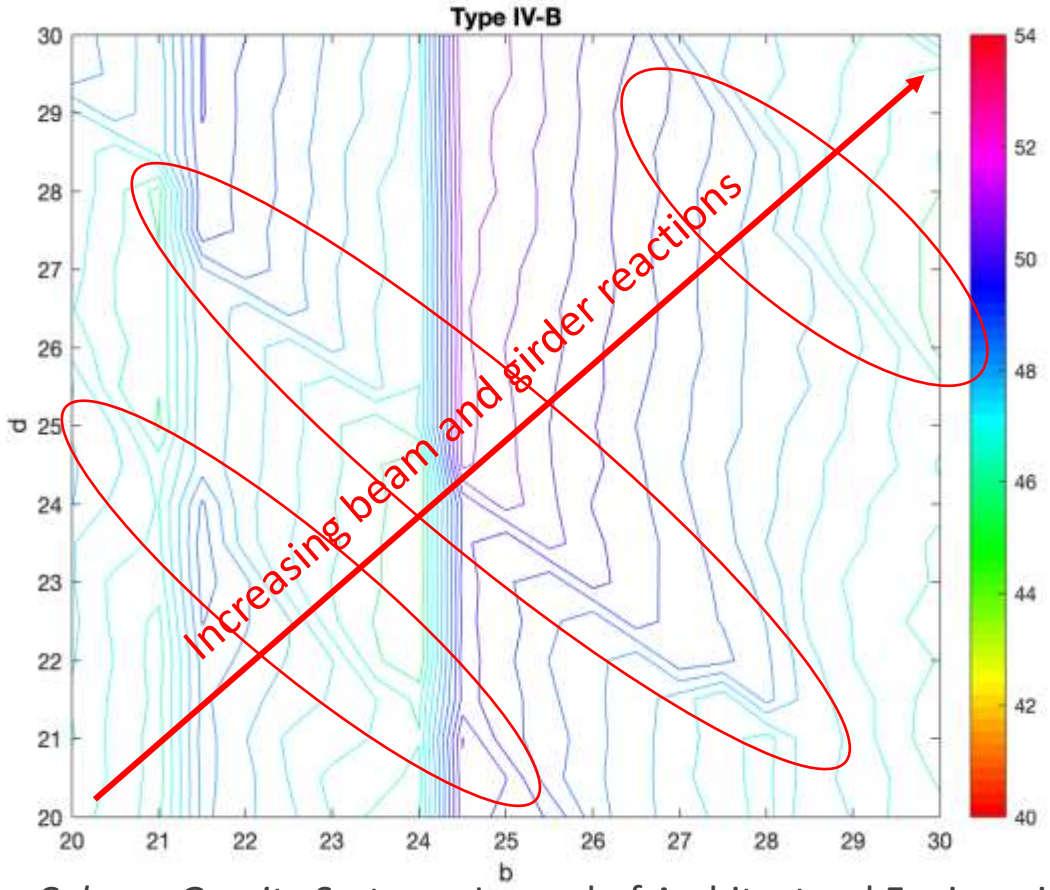
Longer spans = higher connection cost

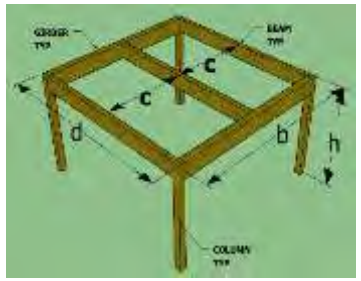


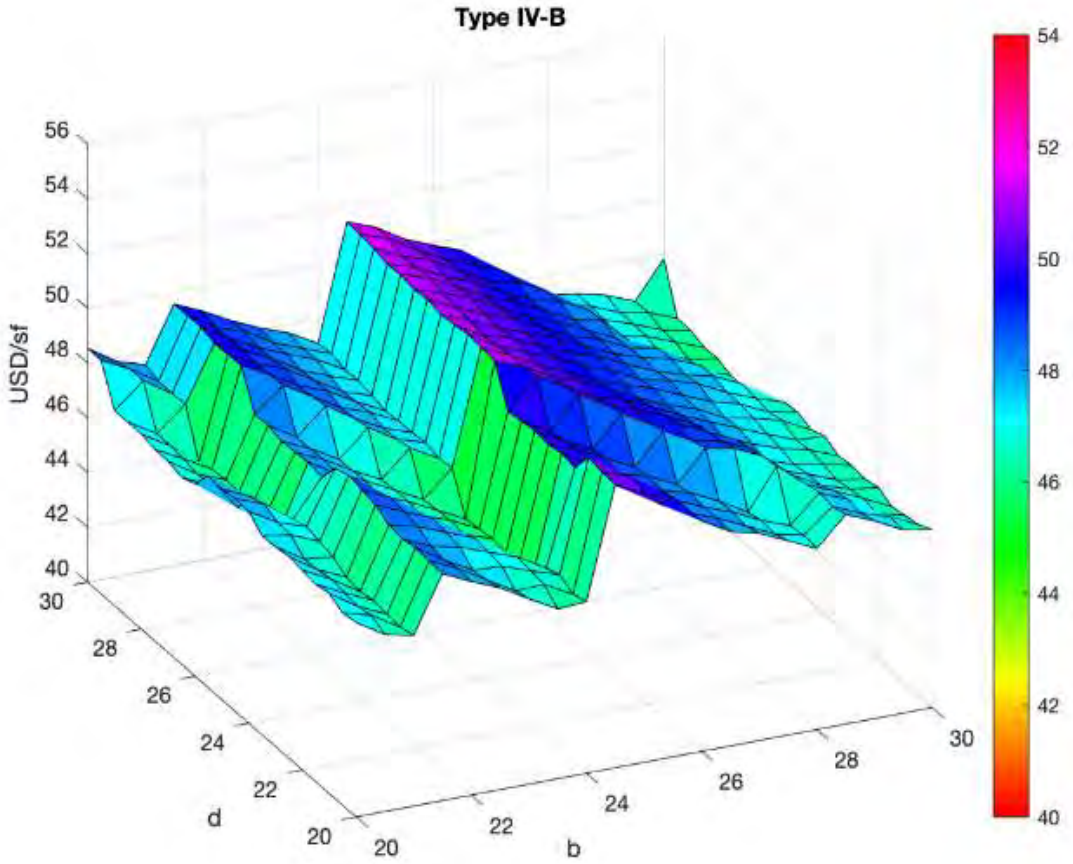


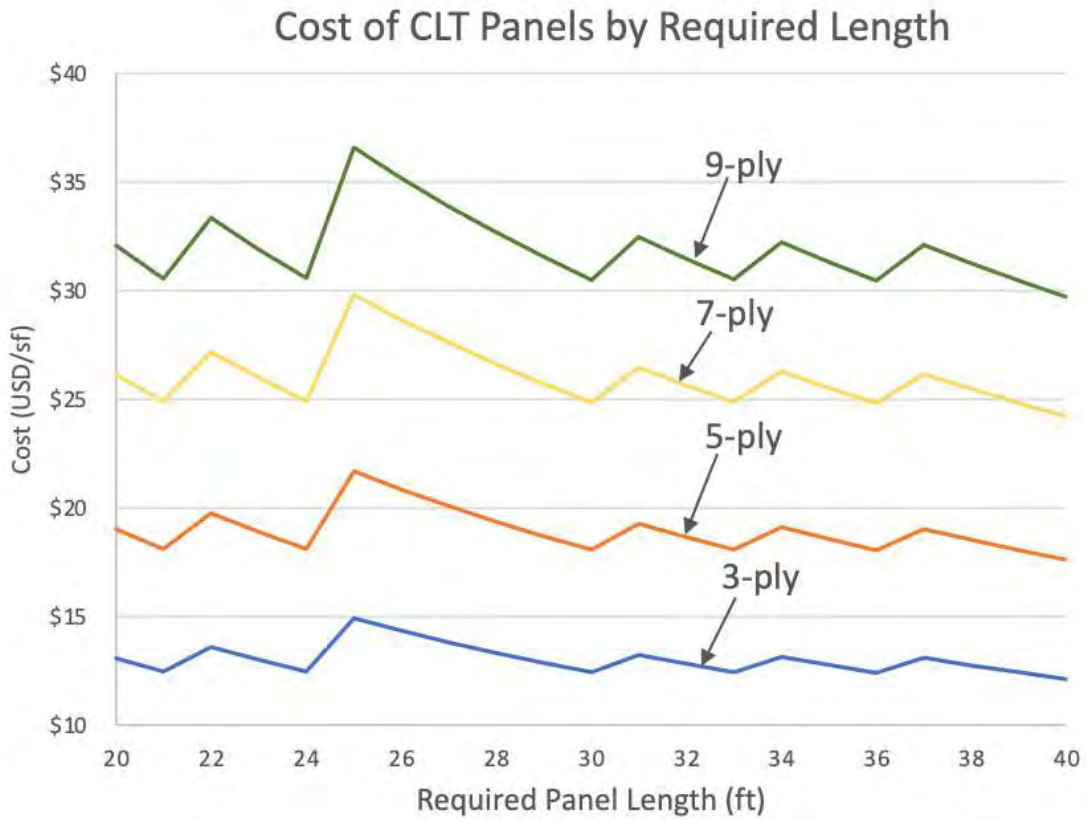


From: Chaggaris, Pei, Kingsley, Kinder, *Sensitivity on Cost of Mass Timber Beam-Column Gravity Systems*, Journal of Architectural Engineering

CLT press length efficiency affects cost







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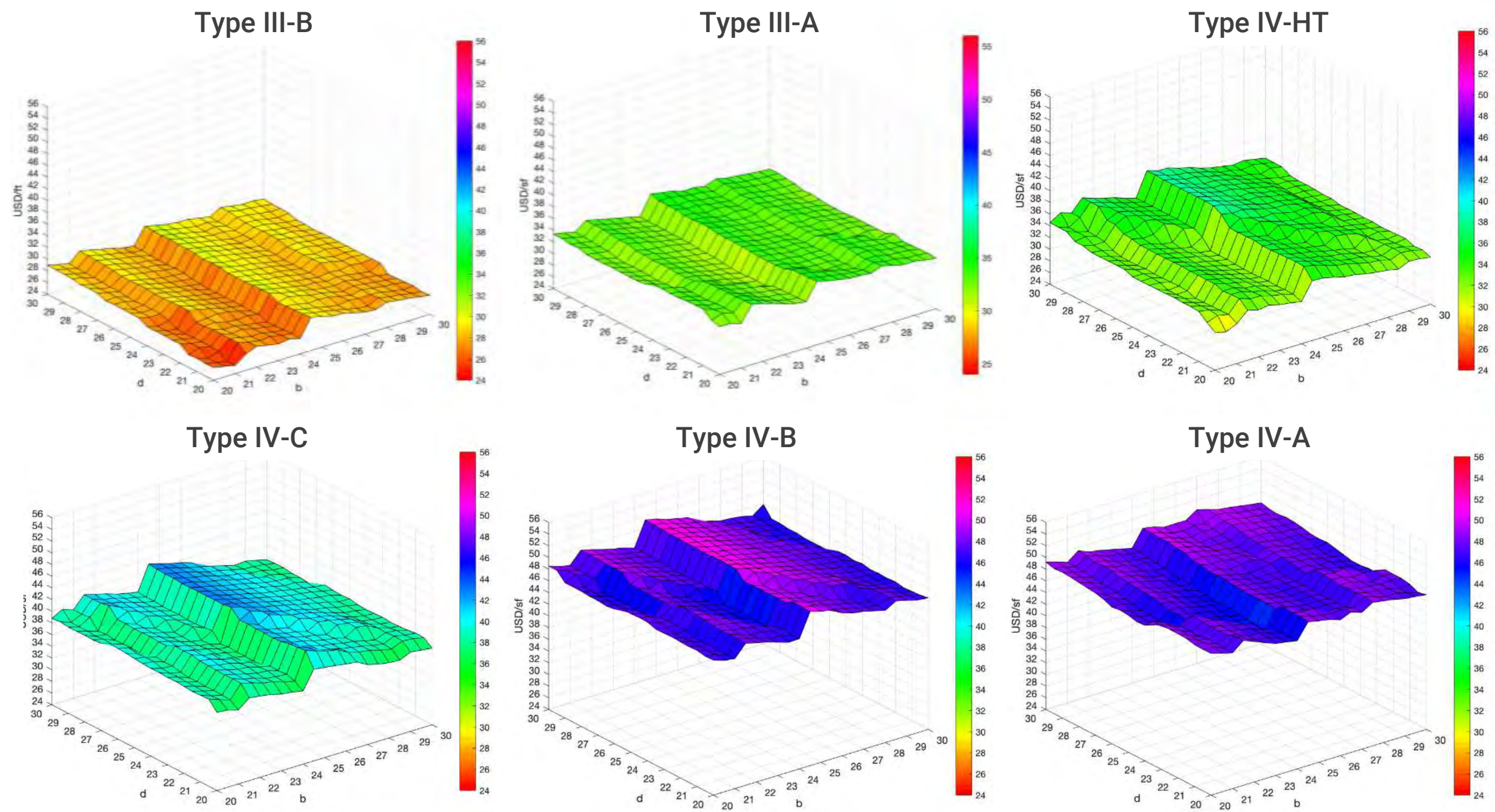


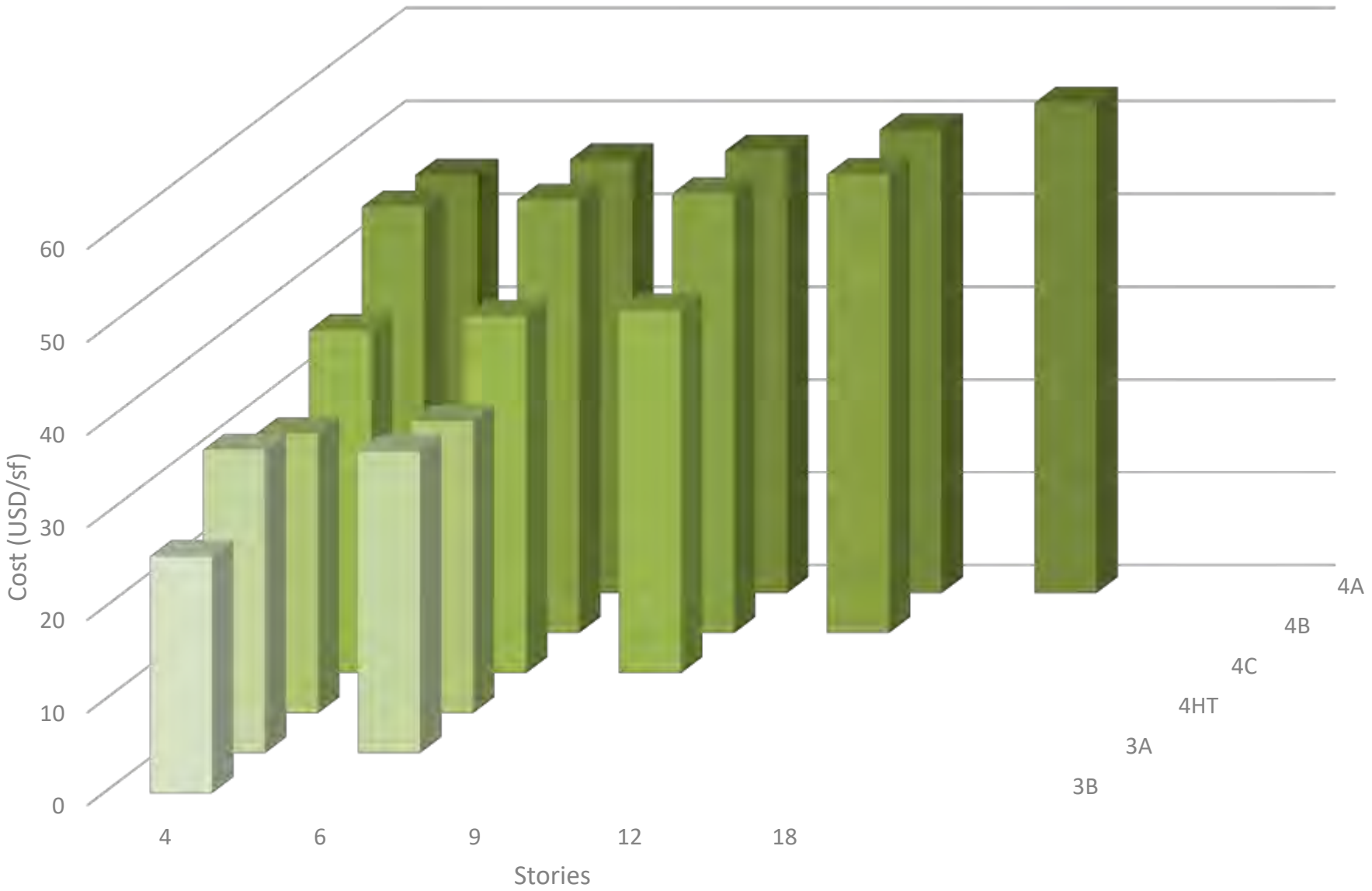
From: Chaggaris, Pei, Kingsley, Kinder, *Sensitivity on Cost of Mass Timber Beam-Column Gravity Systems*, Journal of Architectural Engineering

		Building Type						
Stories		**III-B**	**III-A (Gyp)**	**III-A (No Gyp)**	**IV-HT**	**IV-C**	**IV-B**	**IV-A**
4	Grid	21 x 20.5	30 x 27	24 x 22	20.5 x 20	24'x20'	24 x 24	24 x 22.5
	Cost	$25.53	$32.70	$32.10	$30.14	$36.97	$45.49	$45.04
6	Grid	--	24 x 23.5	20 x 20	20.5 x 20	24 x 24.5	24 x 24	24 x 22
	Cost	--	$32.56	$33.33	$31.50	$38.47	$46.68	$46.72
9	Grid	--	--	--	--	24 x 24.5	24 x 24	24 x 22.5
	Cost	--	--	--	--	$39.16	$47.37	$47.64
12	Grid	--	--	--	--	--	24 x 24	24 x 22
	Cost	--	--	--	--	--	$49.44	$49.93
18	Grid	--	--	--	--	--	--	24 x 22
	Cost	--	--	--	--	--	--	$52.81

The most economical option for each building type for each number of stories. Bay size in feet.
Most economical system at each heigh shaded in blue

From: Chaggaris, Pei, Kingsley, Kinder, *Sensitivity on Cost of Mass Timber Beam-Column Gravity Systems*, Journal of Architectural Engineering

The cost of the most economical bay option for each viable building type for a given number of stories

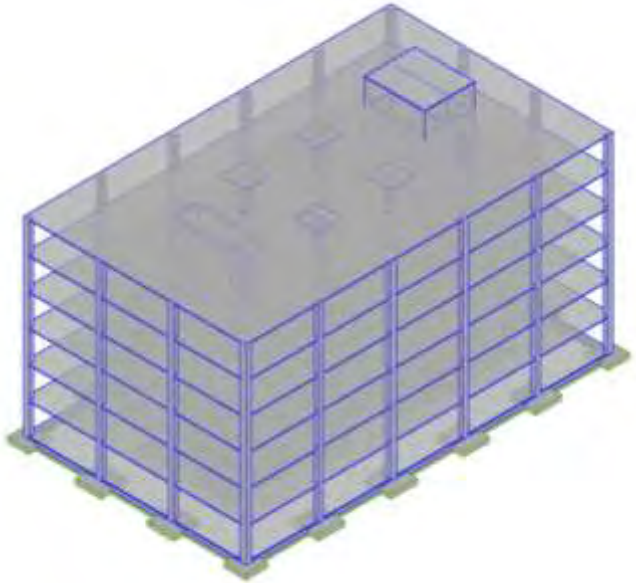


From: Chaggaris, Pei, Kingsley, Kinder, *Sensitivity on Cost of Mass Timber Beam-Column Gravity Systems*, Journal of Architectural Engineering

BUILDING ARCHETYPES

Photo Credit: KL&A

TYPE III A 6-STORY



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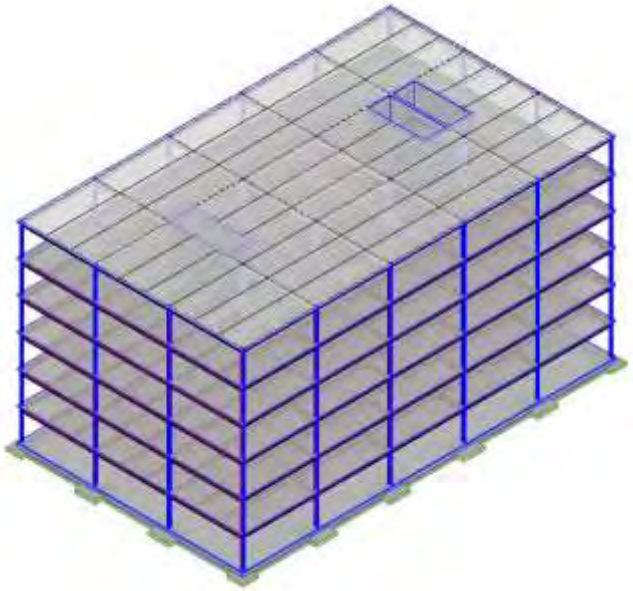
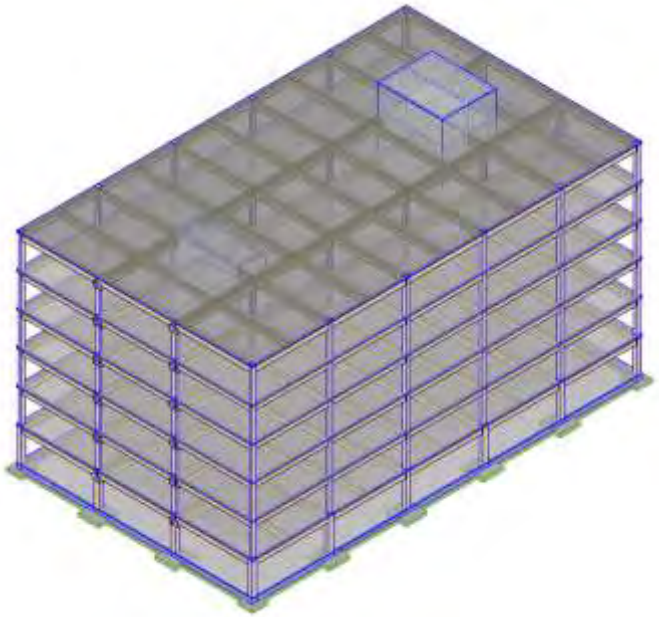
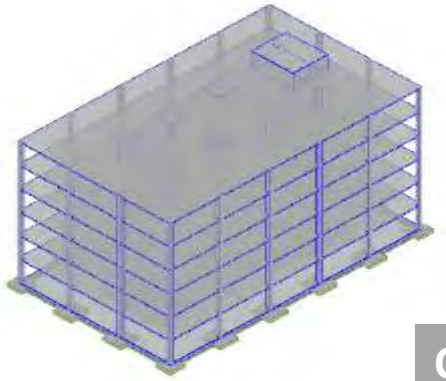


STEEL



MASS TIMBER

TYPE III A 6-STORY



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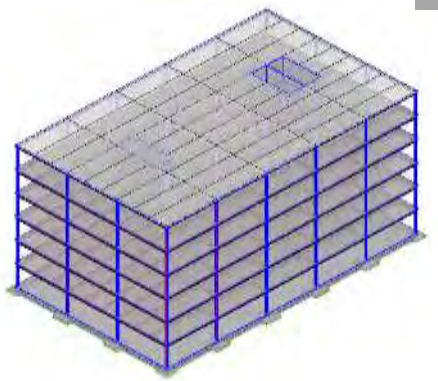

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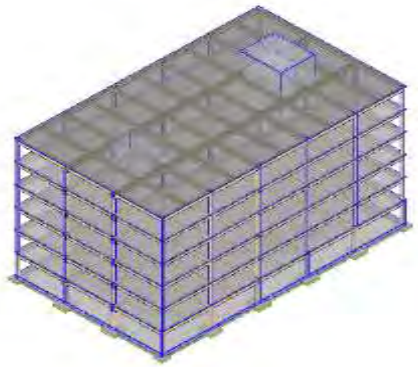
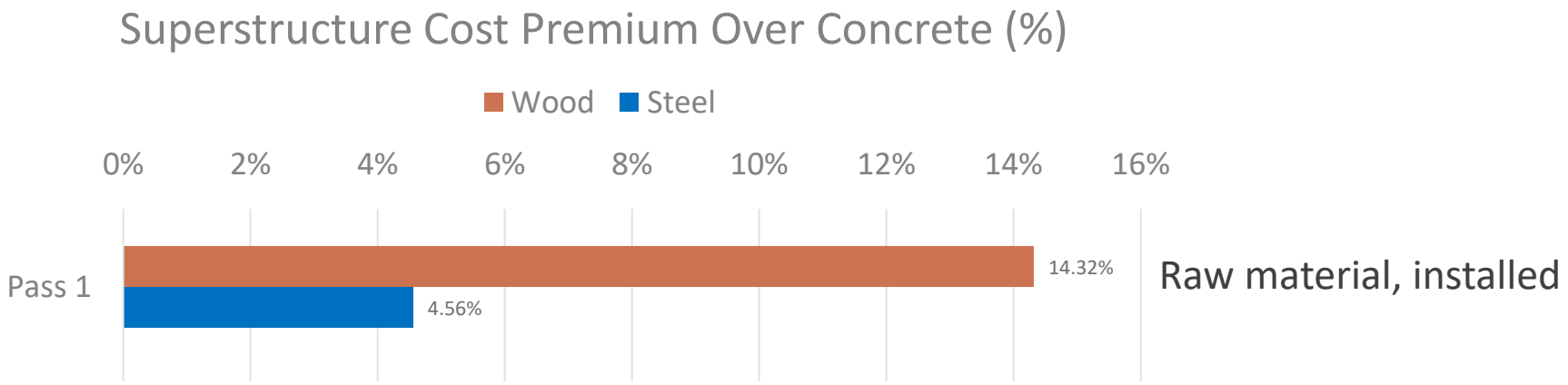


WOOD



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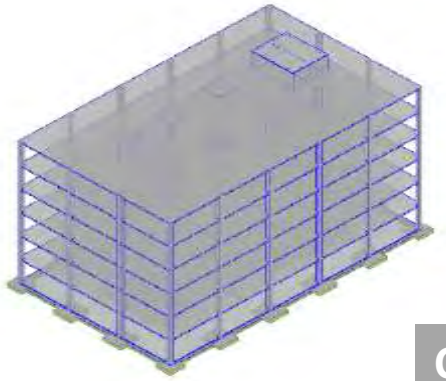

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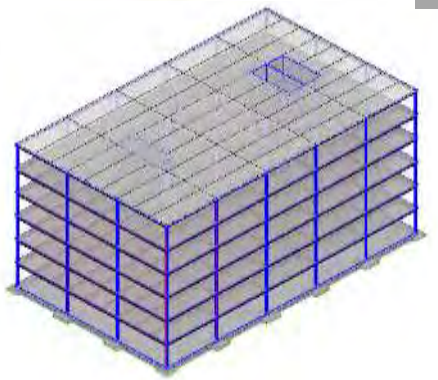
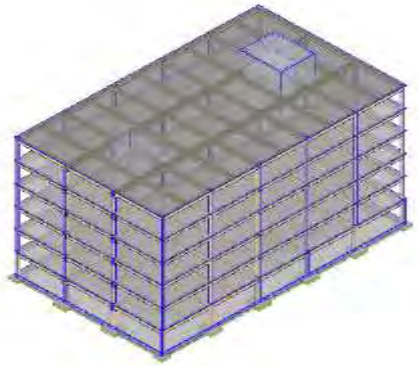


STEEL



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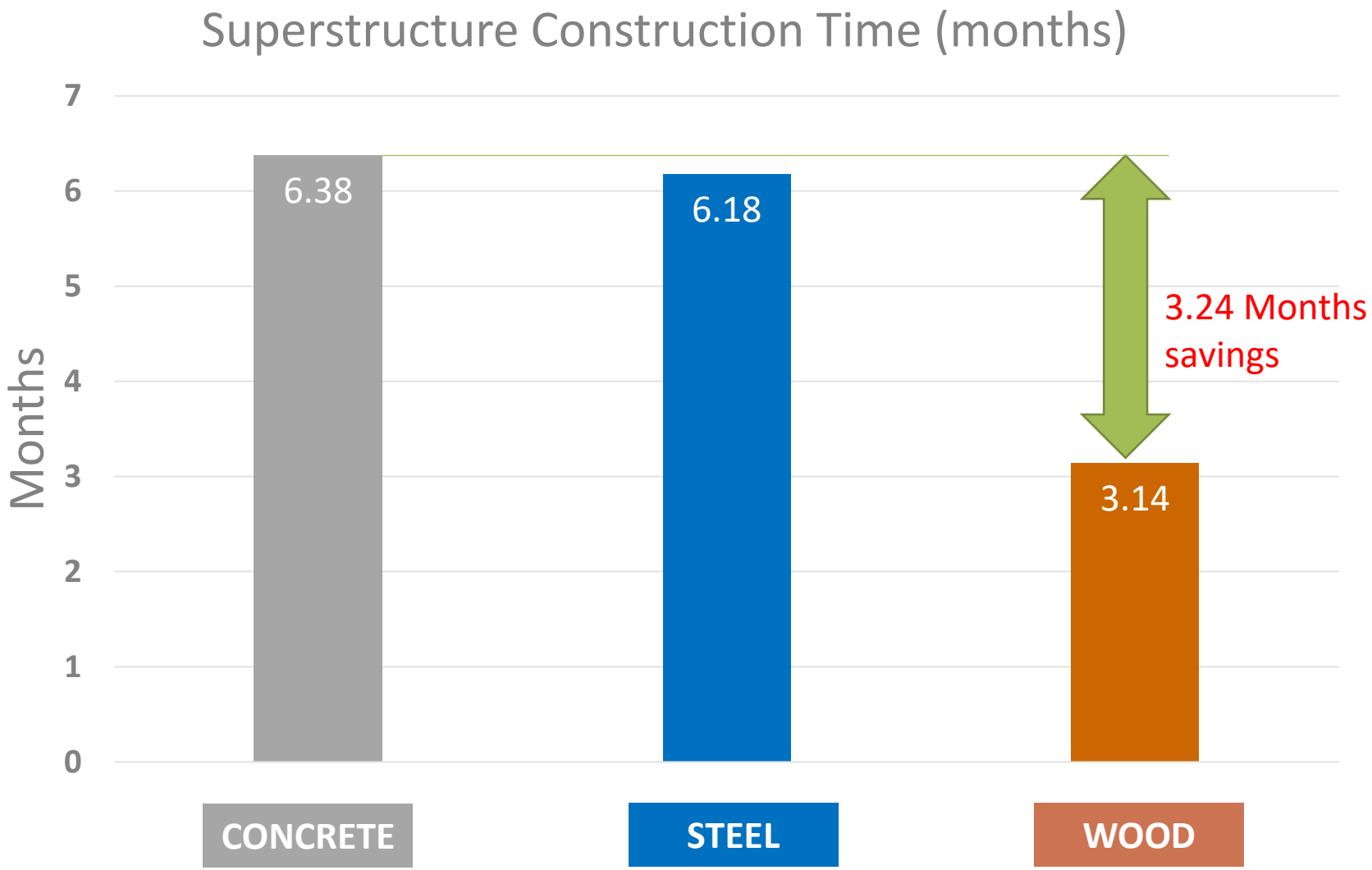

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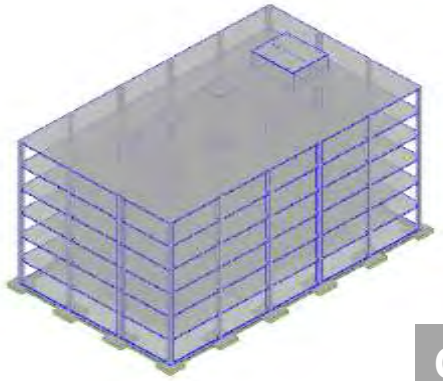

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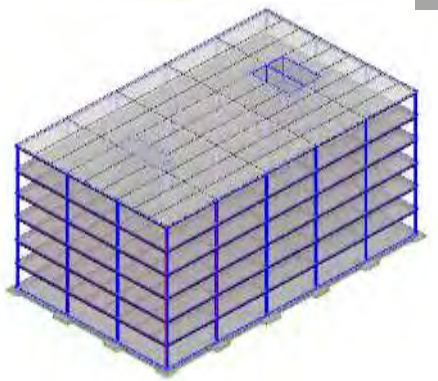
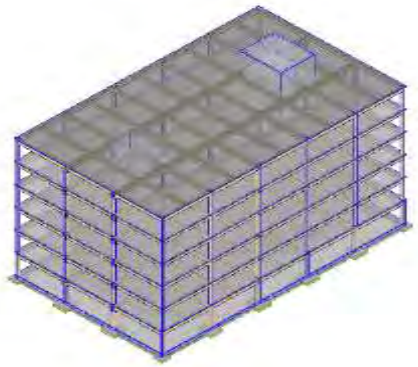
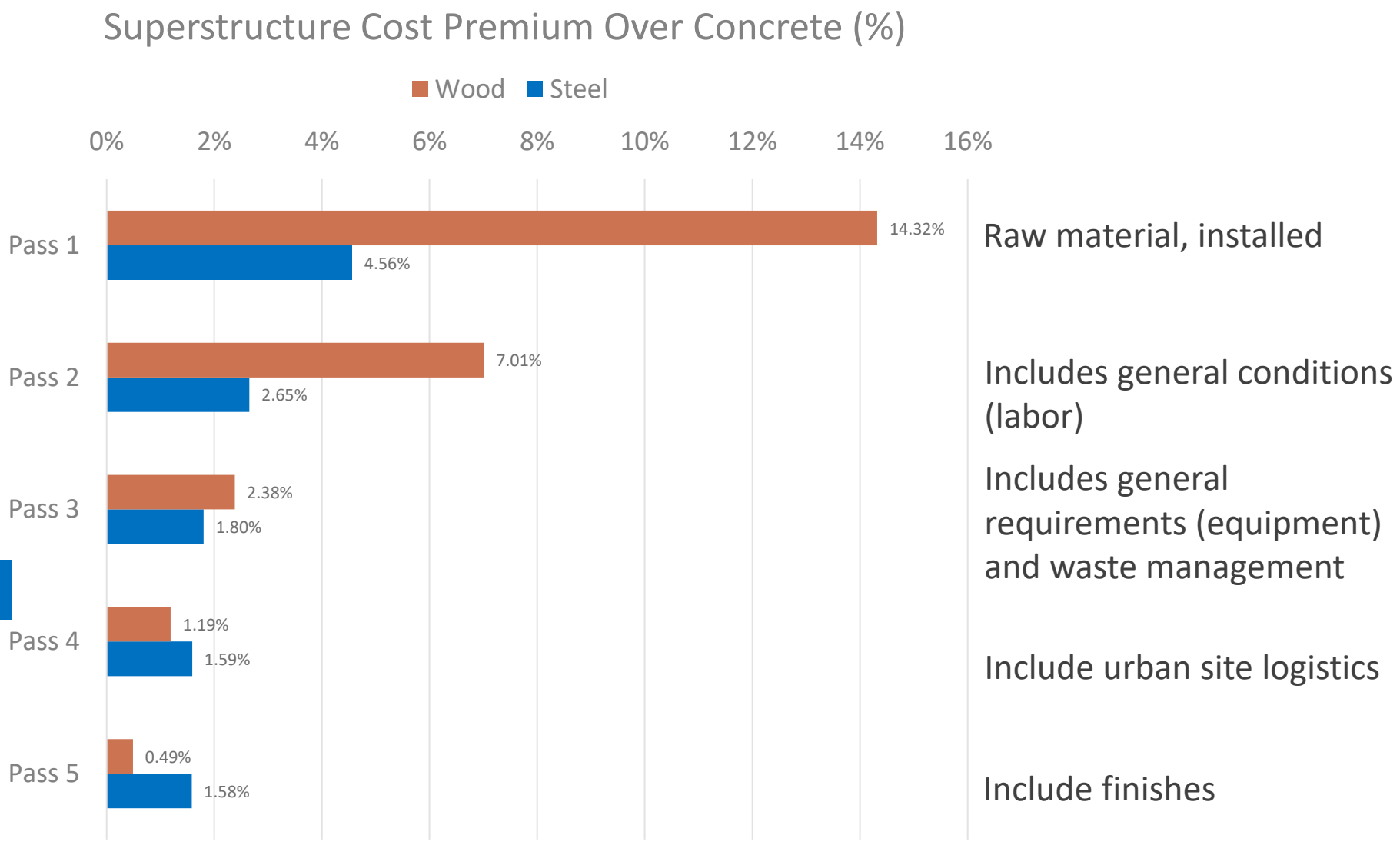


STEEL



WOOD



Raw material, installed

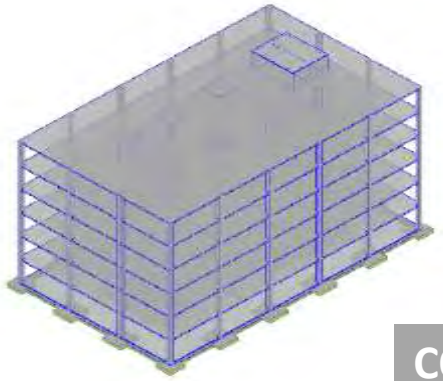
Includes general conditions (labor)

Includes general requirements (equipment) and waste management

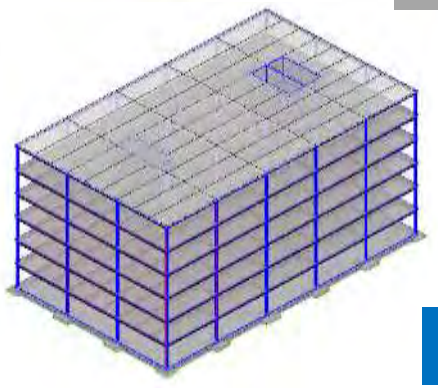
Include urban site logistics

Include finishes

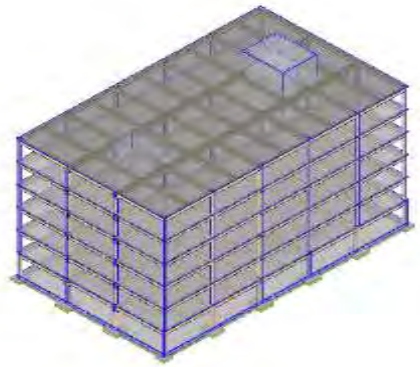
TYPE III A 6-STORY



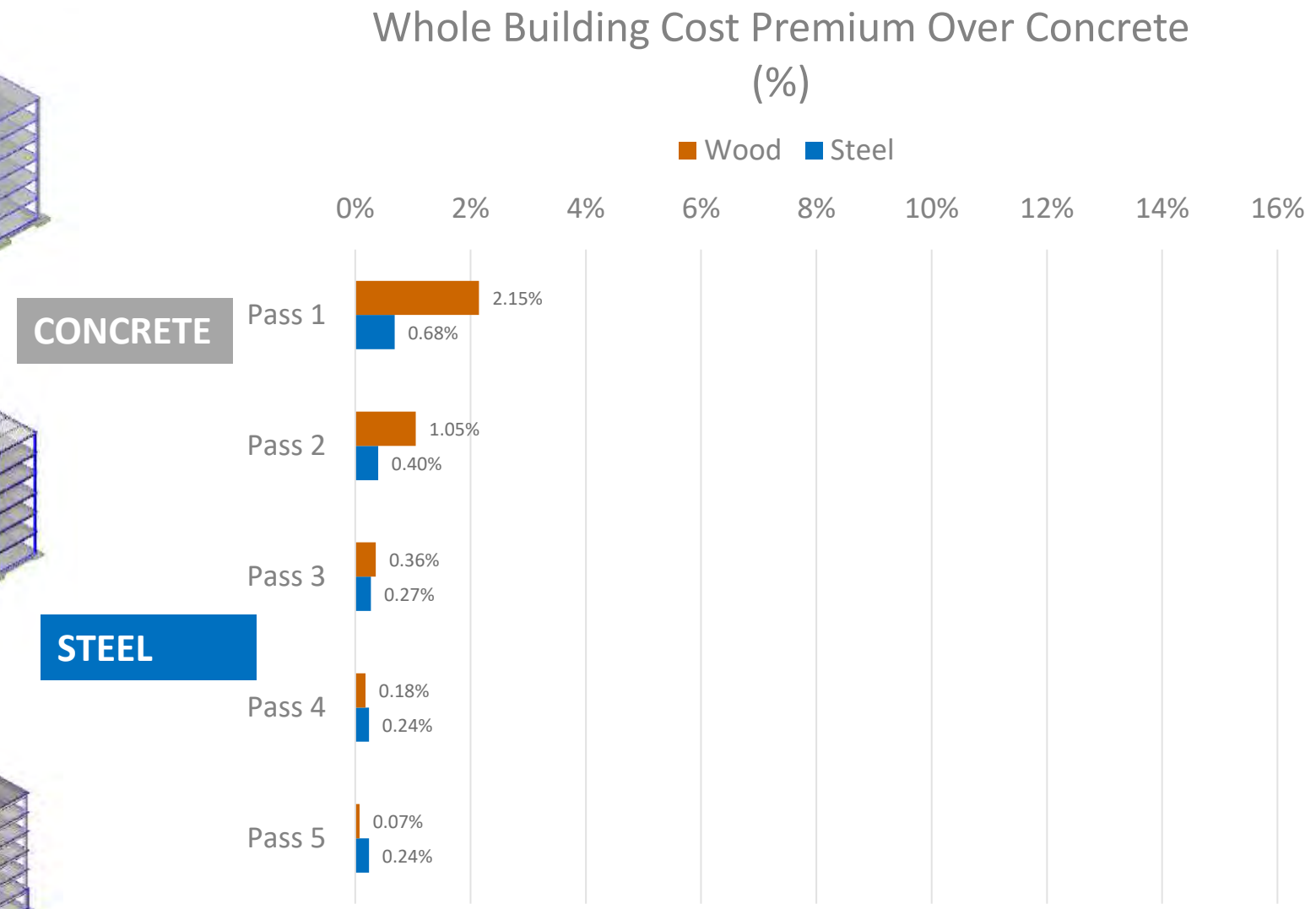
CONCRETE



STEEL



WOOD



Assuming Superstructure Cost = 15% of Whole Building Cost

Raw material, installed

Includes general conditions (labor)

Includes general requirements (equipment) and waste management

Include urban site logistics

Include finishes


Finally: MEP coordination. Consider it early to minimize cost
Photo Credit: JC Buck

Some conclusions

- 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

QUESTIONS?

KL&A Engineers & Builders

This concludes The American Institute of Architects Continuing Education Systems Course

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Photo Credit: JC Buck