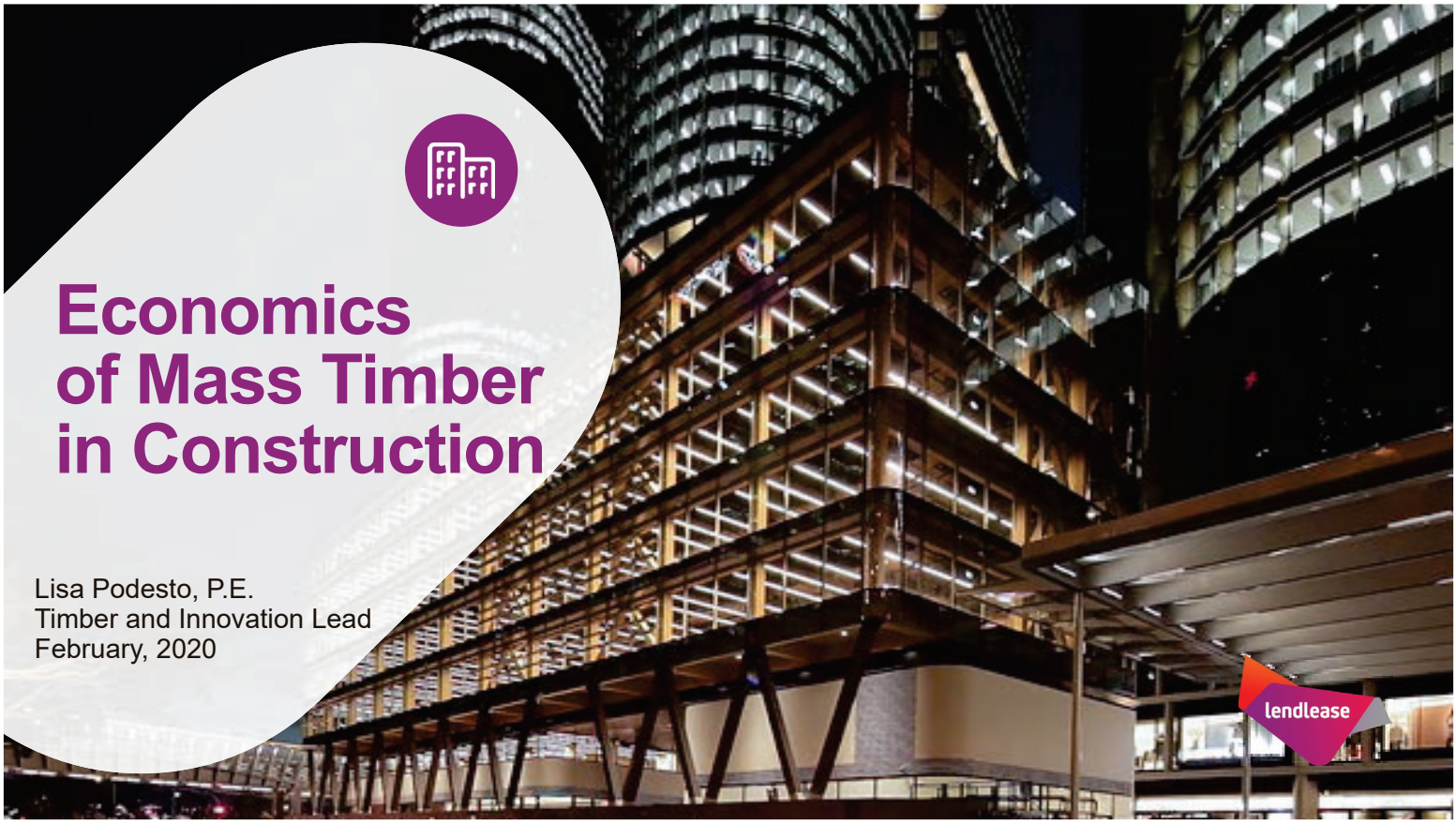
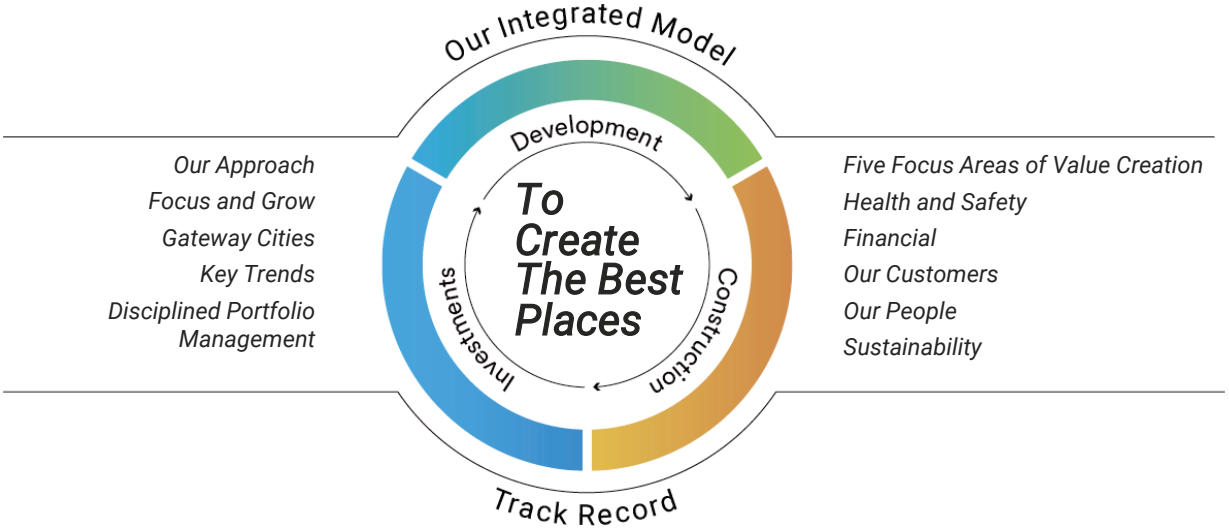
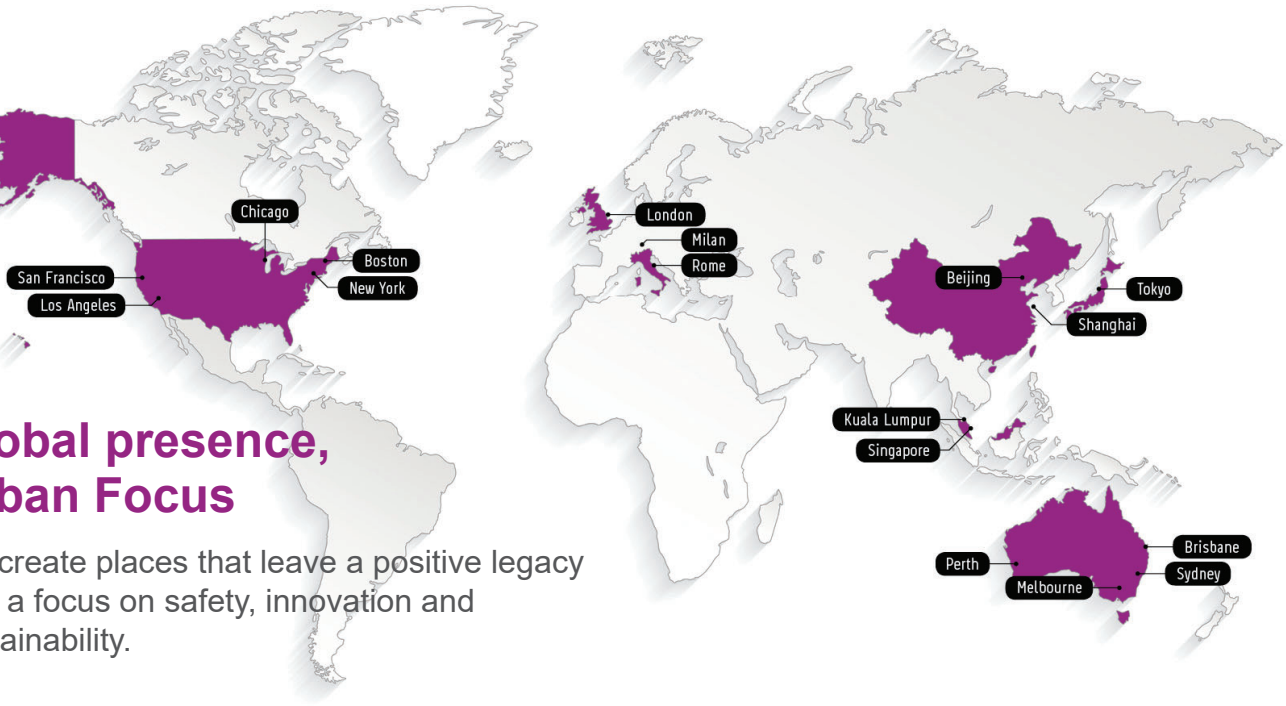


Economics of Mass Timber in Construction

Lisa Podesto, P.E.
Timber and Innovation Lead
February, 2020

Our Approach



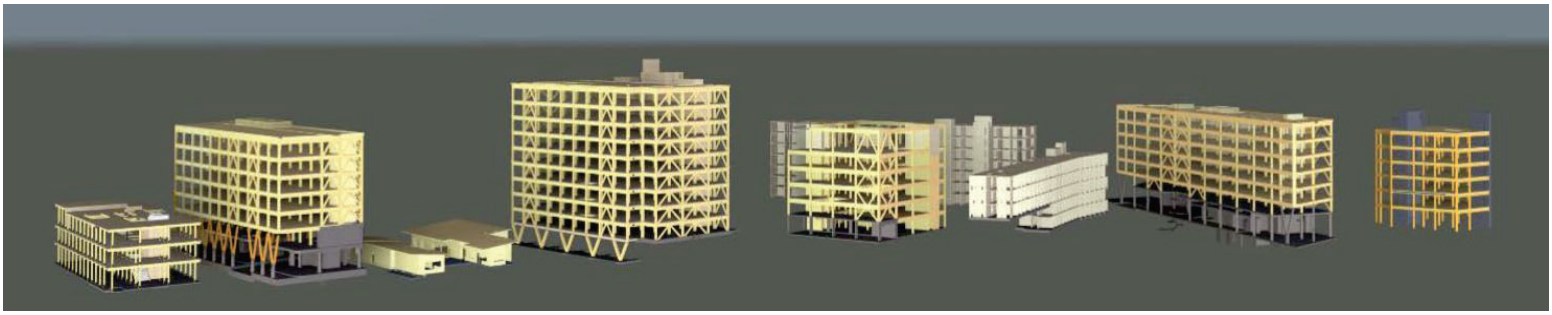


Global presence, Urban Focus

We create places that leave a positive legacy with a focus on safety, innovation and sustainability.

OVER 20 CLT BUILDINGS IN 8 YEARS

AUSTRALIA – DESIGN MAKE

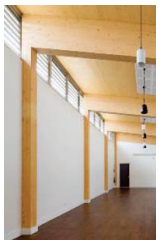


2014 | 2016 | 2017 | 2018 | 2019 | 2020

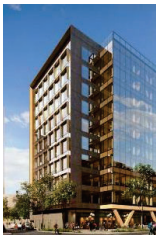
FORTE APARTMENTS, VIC

LIBRARY AT THE DOCK, VIC

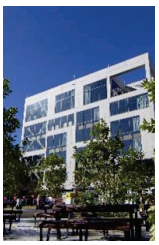
INTERNATIONAL HOUSE ,NSW



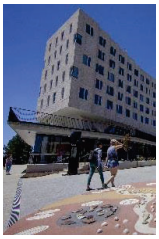
JORDAN SPRINGS, COMMUNITY CENTRE, NSW



25 KING ST, QLD



MARIE REAY CENTRE, ACT

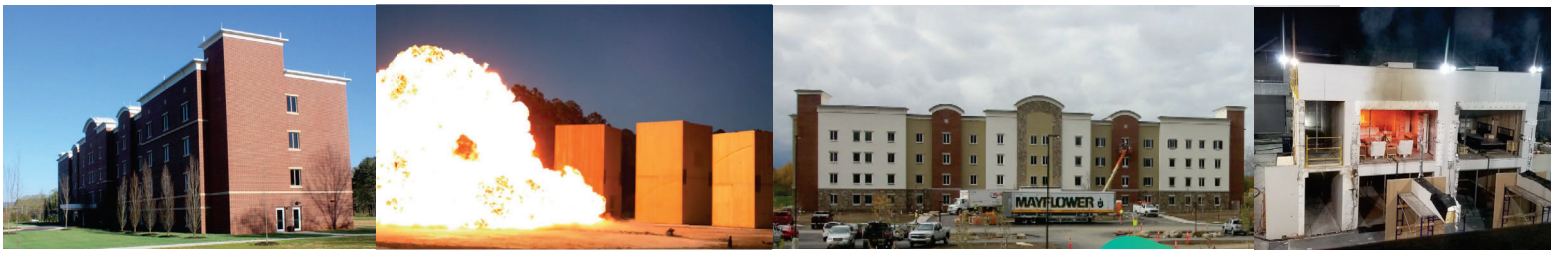


FENNER HALL, ACT

DARAMU HOUSE, NSW

MELBOURNE CONNECT, VIC

UNITIED STATES – DESIGN BUILD



2015 | 2016/2018 | 2017

2018 | 2019 | 2019 | 2020

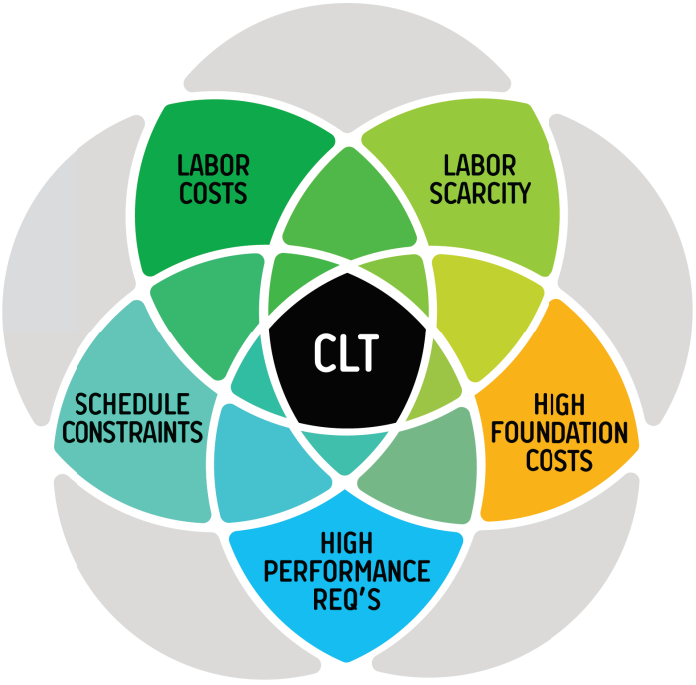
UNITED KINGDOM – DESIGN BUILD/CM

2015 | 2015 | 2018 | 2021

WHERE IS THE SWEET SPOT?

Variables that affect CLT's ability to be cost competitive include:

- The dominant structural system(s) CLT is competing against which is typically determined by
  - Regional availability of competing materials and labor
  - Market Segment norms
- Specific market/project conditions that CLT can address
  - high cost of labor
  - labor shortage
  - schedule constraints
  - poor soil conditions



FILLING IN THE HEIGHT SPECTRUM

I-A IV-A I-B IV-B IV-C II/III

STRUCTURAL TYPOLOGIES

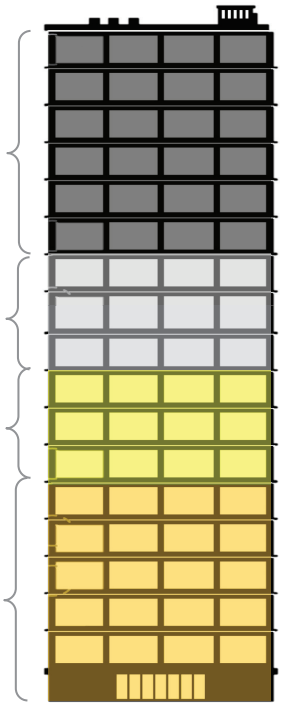
2021 CODE CONST. TYPE

18 STORY R/ 20 STORY B
- Type IV-A
- Completely protected in sheet rock

12 STORY R & B
- Type IV-B
- Exposed surfaces limited to 40% wall area and 20% ceiling area
- Concealed spaces area to be fully protected by non-combustible

9 STORY R & B
- Type IV-C
- Exposed surfaces unlimited
- Concealed spaces area to be fully protected by non-combustible

5 STORY R/ 6 STORY B
- Type IV
  - Exposed surfaces unlimited
  - No concealed spaces for IV
- Type III
  - Exposed surfaces permitted with FRR
  - Concealed spaces permitted



GRAVITY TYPOLOGY

HIGH RISE
- Open flat plate
- Hybrid post and beam gravity system

MID-HIGH RISE
- CLT Bearing wall
- Open flat plate
- Wood or Hybrid post and beam
- Perimeter/ interior frame

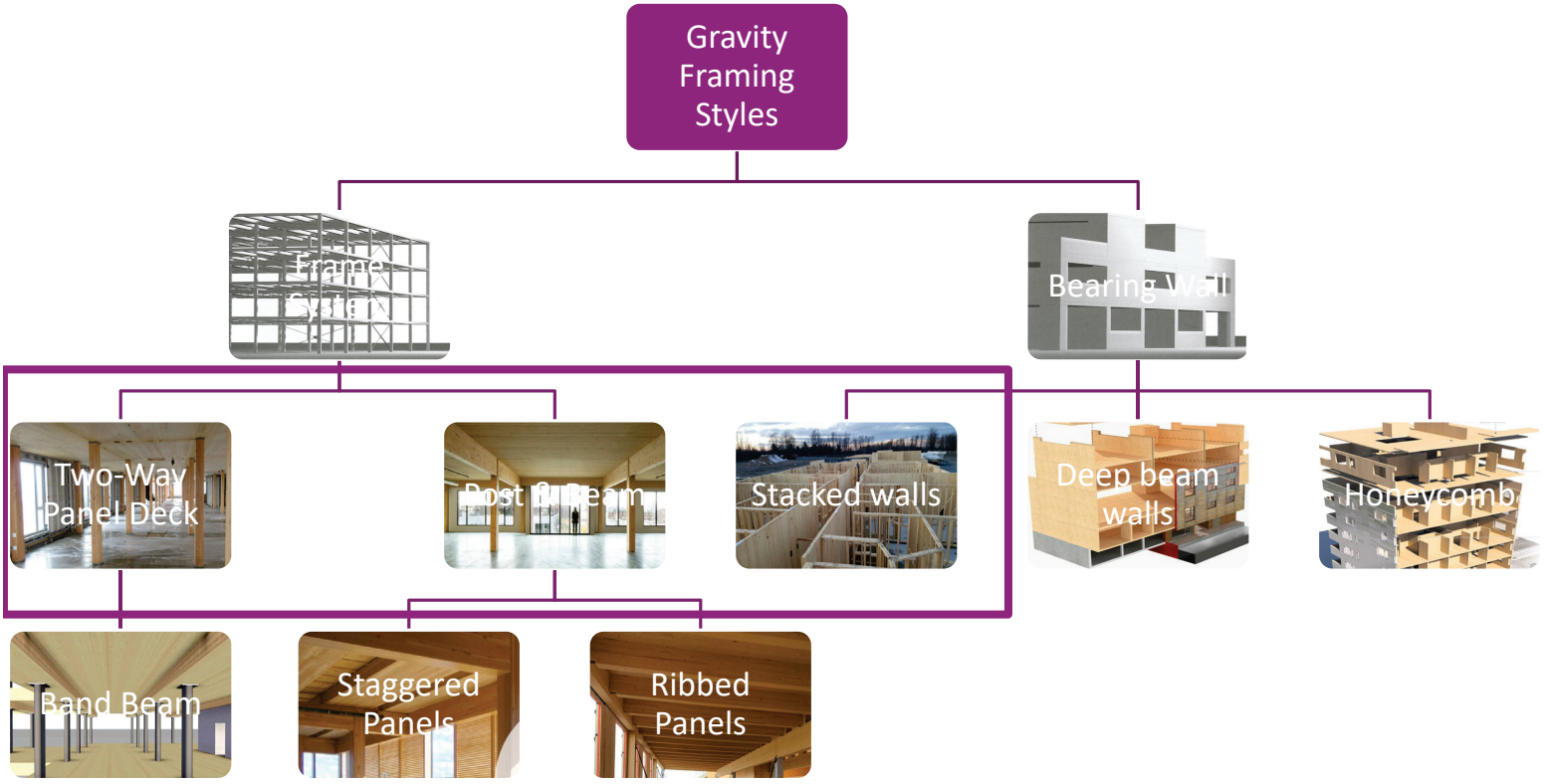
MID-LOW RISE
- CLT Bearing wall
- Mixed Light frame/CLT bearing wall
- Wood or Hybrid post and beam gravity system

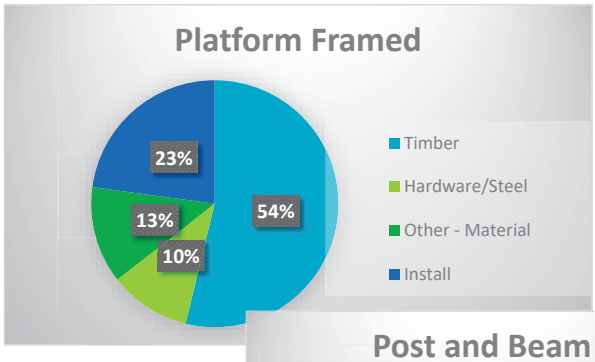
LATERAL TYPOLOGY

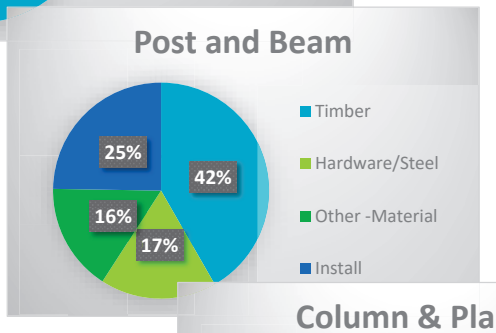
HIGH RISE
- Traditional Lateral core
- Perimeter/Interior frame
- Link beam*

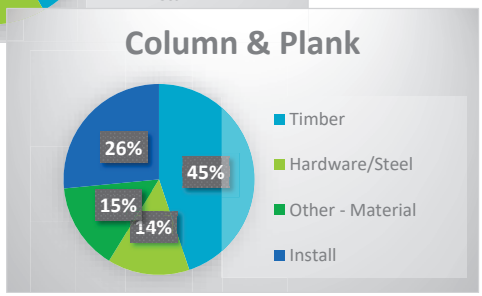
MID-HIGH RISE
- Honeycomb*
- Rocking wall
- Lateral core
- Perimeter/ interior frame
- CLT shear wall

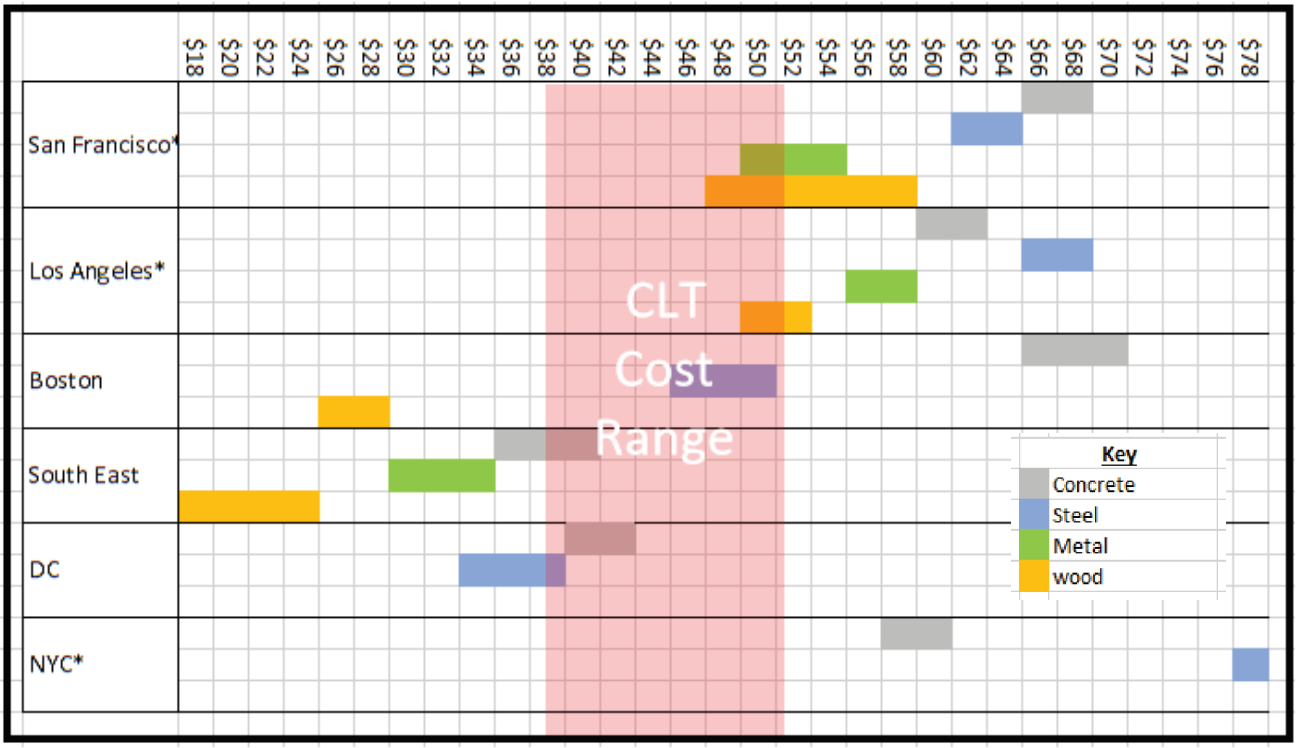
MID-LOW RISE
- CLT shear wall
- Light frame shear wall
- Perimeter/ interior frame

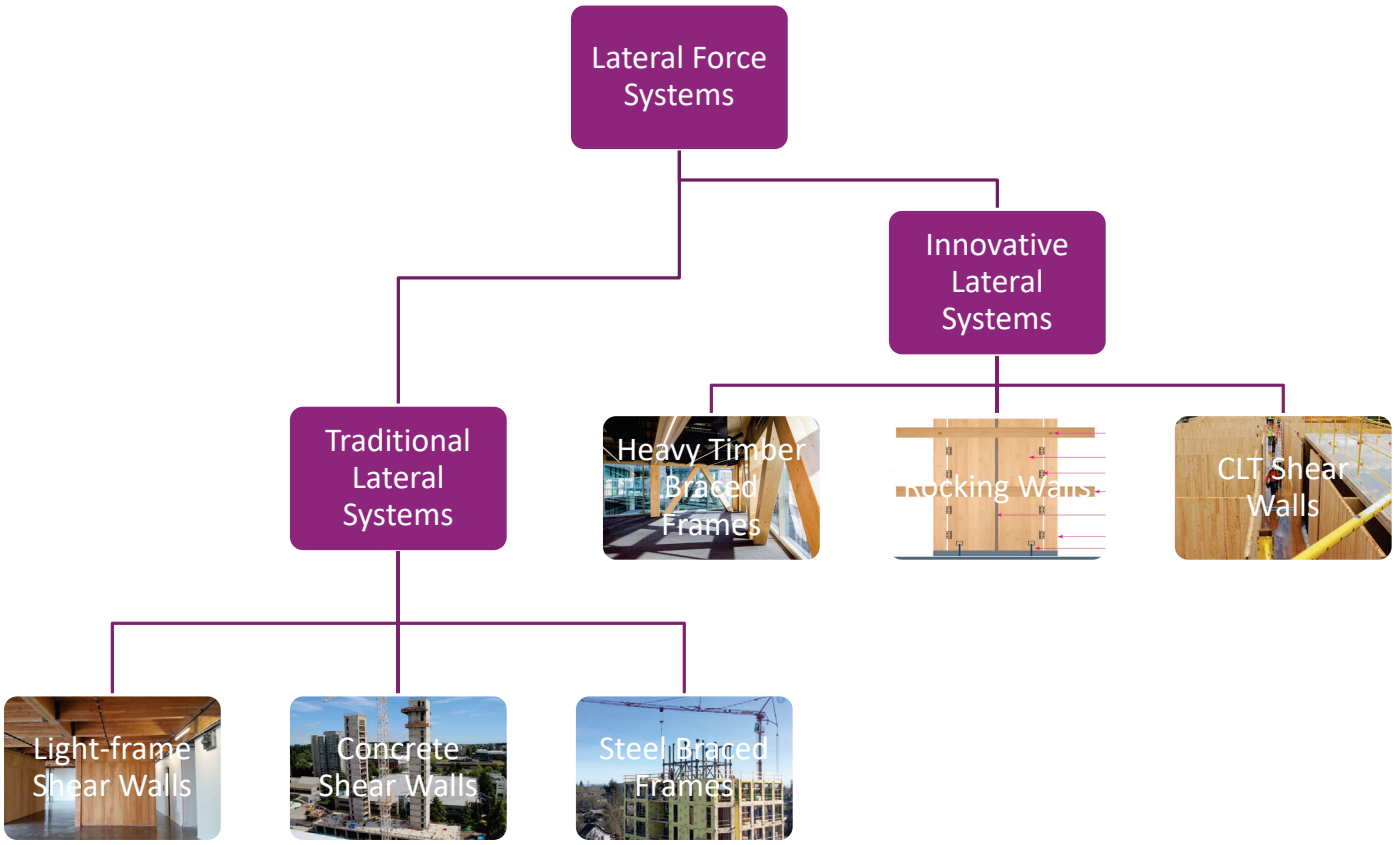

Gravity Framing Styles
Frame System
Bearing Wall
Two-Way Panel Deck
Post & Beam
Stacked walls
Deep beam walls
Honeycomb
Band Beam
Staggered Panels
Ribbed Panels


Platform Framed
23%
54%
13%
10%
Timber
Hardware/Steel
Other - Material
Install


Post and Beam
25%
42%
16%
17%
Timber
Hardware/Steel
Other -Material
Install


Column & Plank
26%
45%
15%
14%
Timber
Hardware/Steel
Other - Material
Install


$18 $20 $22 $24 $26 $28 $30 $32 $34 $36 $38 $40 $42 $44 $46 $48 $50 $52 $54 $56 $58 $60 $62 $64 $66 $68 $70 $72 $74 $76 $78
San Francisco*
Los Angeles*
Boston
South East
DC
NYC*
CLT Cost Range
Key
Concrete
Steel
Metal
wood


Lateral Force Systems
Innovative Lateral Systems
Traditional Lateral Systems
Heavy Timber Braced Frames
Rocking Walls
CLT Shear Walls
Light-frame Shear Walls
Concrete Shear Walls
Steel Braced Frames

PLATFORM FRAMED

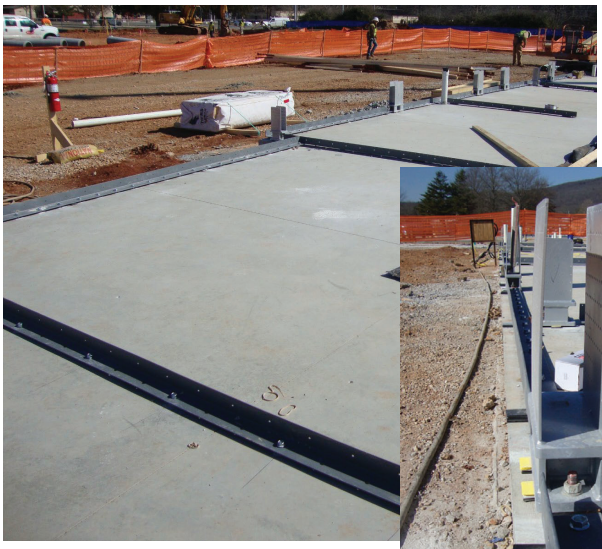
CLT Light

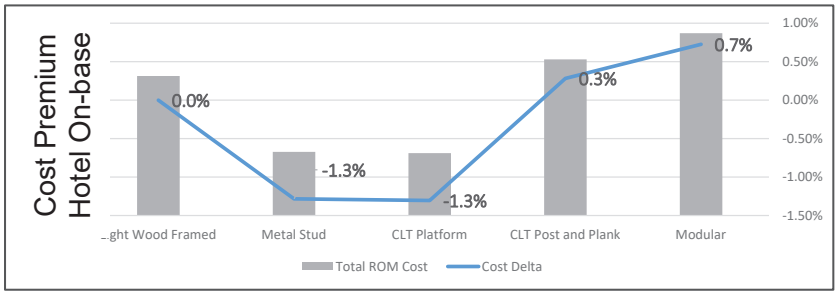
PAL PORTFOLIO	TYPICAL NEW PAL HOTEL (ACTUAL*)	FT. DRUM (ACTUAL)	DIFFERENCE
Gross SF	54,891	65,776	+20%
Average # of Employees	18 (Peak 26)	10	-44%
Structural Duration (Days)	123	93	-24%
Structural Man Hours	14,735	9,715	-34%
Structural Production Rate/Day (SF)	460 SF/day	708 SF/day	+54%

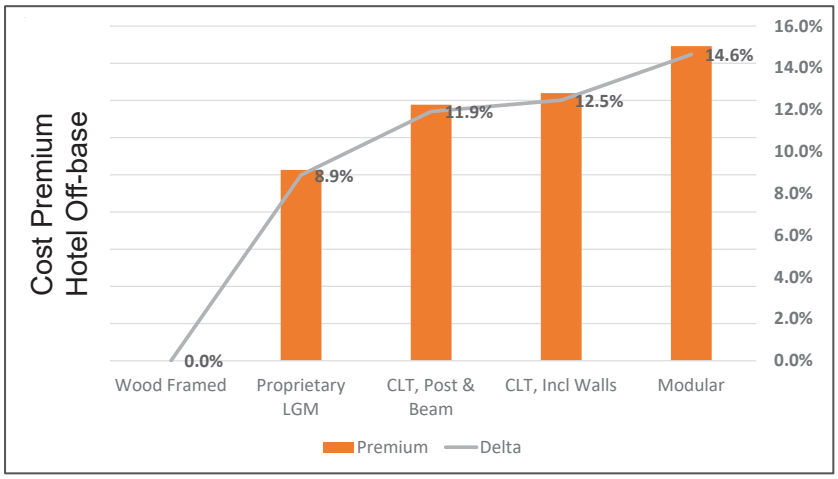
CLT Heavy

PAL PORTFOLIO	TYPICAL NEW PAL HOTEL (ACTUAL*)	REDSTONE ARSENAL (ACTUAL)	DIFFERENCE
Gross SF	54,891	62,688	+14%
Average # of Employees	18 (Peak 26)	10 (Peak 11)	-43%
Structural Duration (Days)	123	78	-37%
Structural Man Hours	14,735	8,203	-44%
Structural Production Rate/Day (SF)	460 SF/day	803 SF/day	+75%

** PAL New Build Hotel Historical Average w/ Light Gauge Metal*

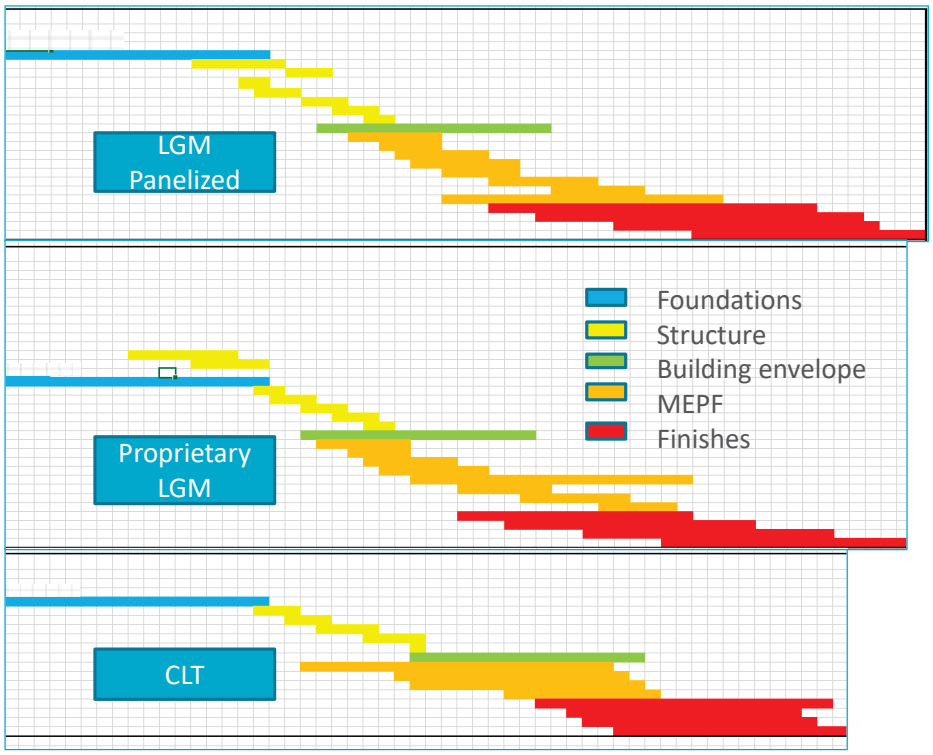



Cost Premium
Hotel On-base
1.00%
0.50%
0.00%
-0.50%
-1.00%
-1.50%
0.0%
-1.3%
-1.3%
0.3%
0.7%
ght Wood Framed
Metal Stud
CLT Platform
CLT Post and Plank
Modular
Total ROM Cost
Cost Delta


Cost Premium
Hotel Off-base
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
0.0%
8.9%
11.9%
12.5%
14.6%
Wood Framed
Proprietary LGM
CLT, Post & Beam
CLT, Incl Walls
Modular
Premium
Delta

PROJECT SCHEDULE COMPRESSION -Critical Path

Idealized 4-story Hotel Schedule Comparison

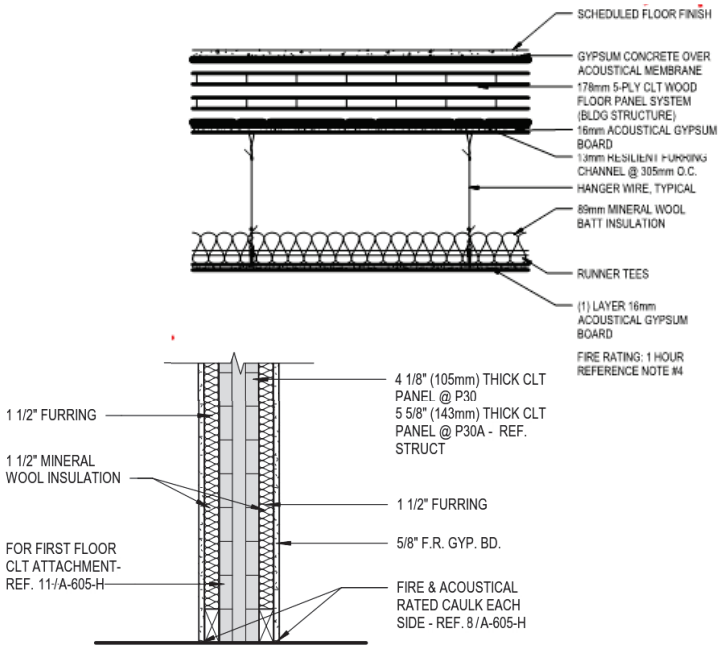


Structure – 4250 sf/wk
Baseline

Structure – 6780 sf/wk*
Overall – 1-2% reduction

Structure – 4900 sf/wk
Overall – 8-9% reduction

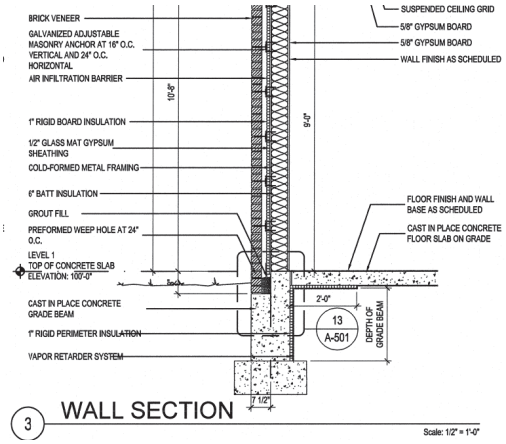
ACOUSTIC PERFORMANCE

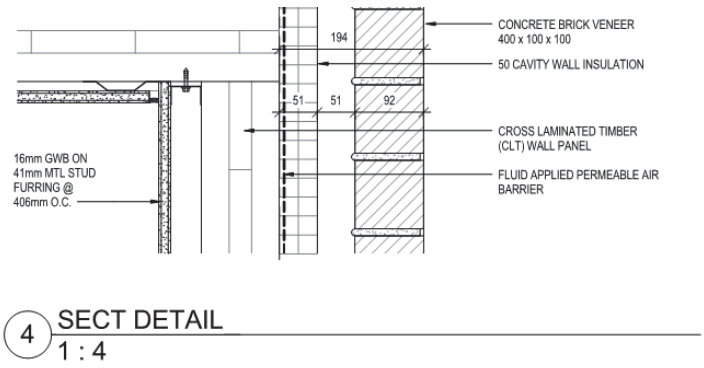


Summary of Test Results			
Test Area	**Test Area Description**	**FIIC**	**ASTC**
1	Demising Wall between Kitchen/Living Areas of Units 220 and 222	---	55
2	Demising Wall between Kitchen/Living Areas of Units 224 and 222	---	54
3	Floor/Ceiling assembly between Kitchen/Living Area of Units 222 and 322	---	54
4	Floor/Ceiling assembly between Kitchen/Living Areas of Units 322 and 222 (LVT plank)	56	---
5	Floor/Ceiling assembly between Kitchen/Living Areas of Units 322 and 222 (carpet with pad)	74	---
6	Floor/Ceiling assembly between Bathroom Areas of Units 322 and 222	60	---

ENERGY PERFORMANCE

Building Shell	Wall Assembly R-Value	Roof Assembly R-Value	Annual Energy Use (kBtu/yr)	Energy Use
Steel Frame 6" Batt	15.7	41.7	484,407	100.00%
CLT Panel	21.5	42.6	306,400	63.25%



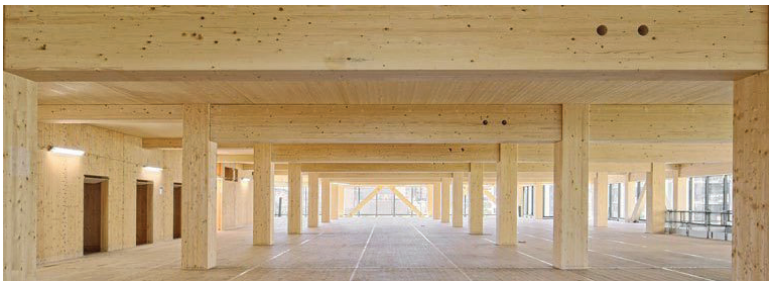


IN HIGH SEISMIC REGIONS

PERSCRIPTIVE CLT SHEARWALLS ARE PROBLEMATIC…..

1. High Aspect Ratio requirements defeat the schedule and/or labor advantage
2. Connections are prescribed as conventional
3. Non shear walls still have to conform to detailing
4. R-values are low
5. Height is limited

POST AND BEAM



20’ X 30’ OR 20’ X 26’ PRIMARY BEAM & FLAT SLAB

FLOOR: 40’ (L) x 7.5’ (W)

DELIVERY: 8x floors per standard truck

30’ X 30’ OR 24’ X 24’ PRIMARY BEAM RIB DECK SLAB

RIBDECK: ~32’ (L) X 10’ (W)

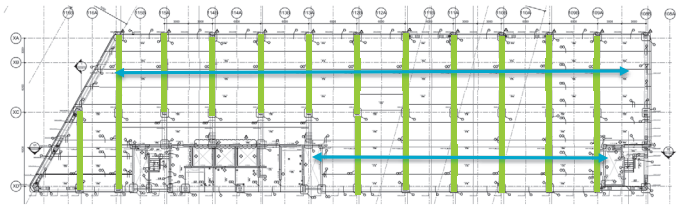
DELIVERY: ~ 3X RIBDECKS PER OVERSIZE TRUCK

GRID SYSTEMS COMPARISON

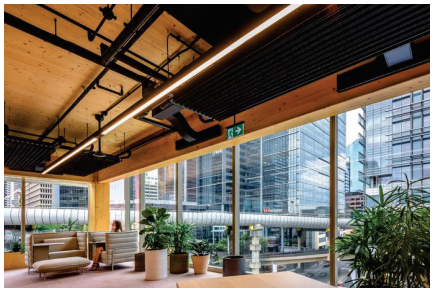
GRID	ADVANTAGES	DISADVANTAGES
20’x26’& 20’x30’	• Volume reduction in glulam beams • Simple floor slab processing • Flat soffit • Less penetration co-ordination in floor	• Smaller grid • Volume increase in glulam columns • Slower install
24’x24’& 30’x30’	• Volume reduction in glulam columns • Decrease in CLT panel thickness • Greater services distribution. • Faster install	• Volume increase in glulam beams • More penetration co-ordination in floor. • Pre-assembly required, transport inefficiency as a result

SERVICES

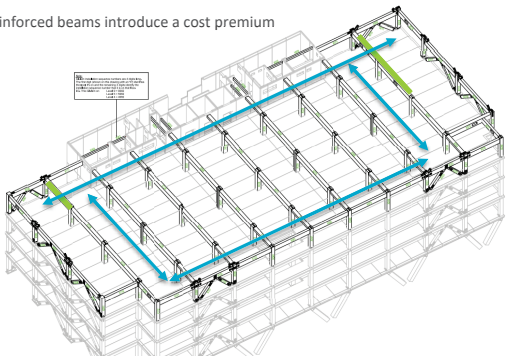
20’X30’ GRID
INTERNATIONAL HOUSE
COLUMN/BEAM/SLAB



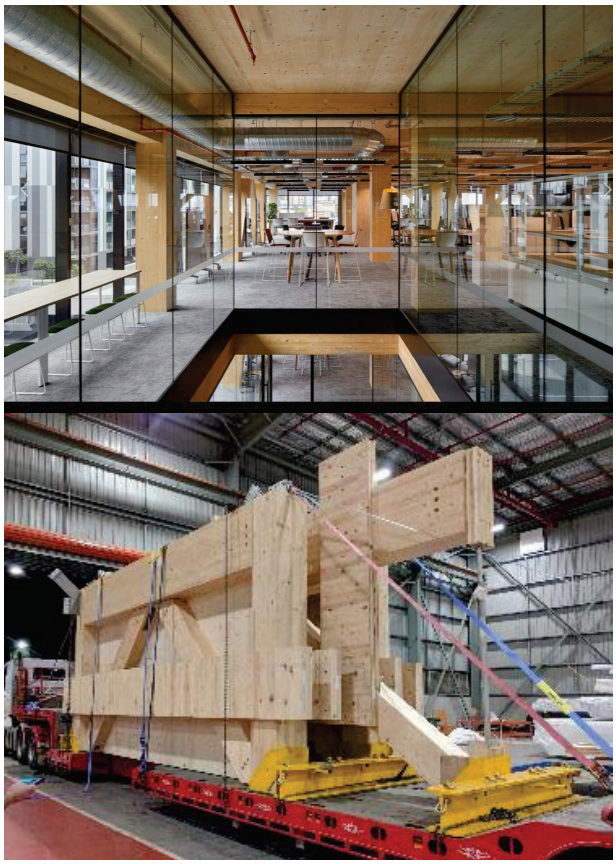
Hardwood LVL reinforced beams introduce a cost premium



20’X30’ GRID
25 KING
COLUMN/BEAM/SLAB



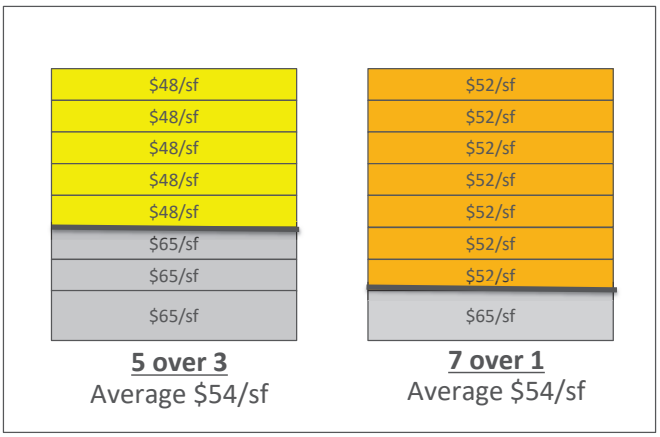
30’X30’ GRID
COLUMN/BEAM/RIBDECK



COLUMN & PLANK

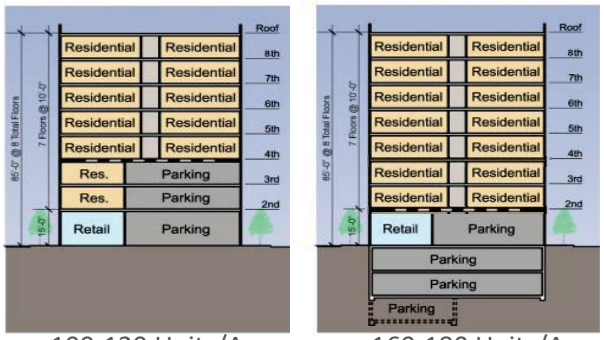
Rethinking Podium Typology

- Load transfer deck vs. 3hr fire separation
- Differences in where Assembly Occupancy is permitted
- Upper building offsets



5 over 3
Average $54/sf

7 over 1
Average $54/sf



100-120 Units/Ac

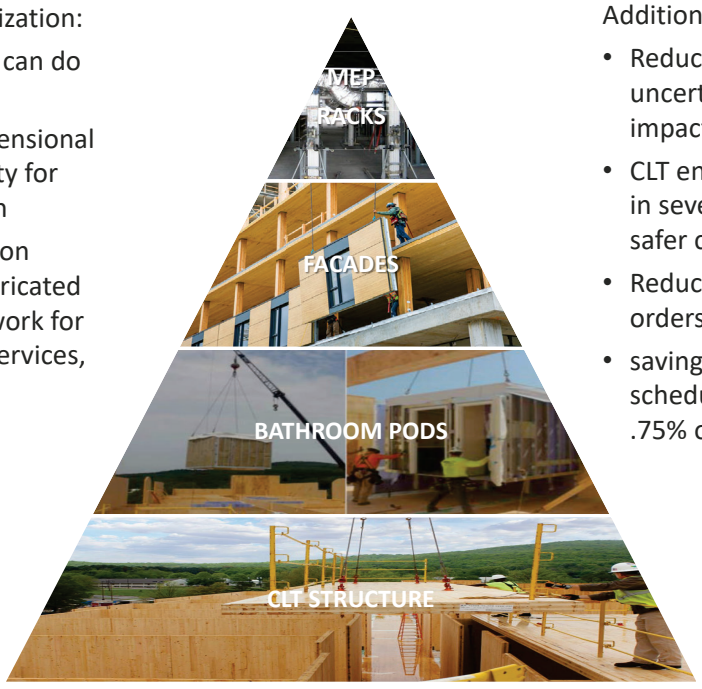
160-180 Units/Ac



Componentization of more than Structure

Synergy in further componentization:

- Same equipment and crew can do installation
- precision and installed dimensional reliability create opportunity for other offsite pre-fabrication
- preplanning and coordination required to design a prefabricated structure sets the ground work for coordinating of prefab'ed services, façades and finishes



Addition savings:

- Reducing the rate of schedule uncertainty can have a significant impact reducing project overruns
- CLT enables more work to carry on even in severe weather conditions AND in safer conditions
- Reductions in the number of change orders
- saving 10% off of the total project schedule has the potential to save .5-.75% off general conditions


25 King Street BNE

MAKING A COMPELLING COST COMPARISON

1. Consider the Cost Baseline
2. Be Material Efficient and Optimize Systems
3. Capitalize on the Labor Advantage
4. Amplify the Schedule Compression
5. Quantify of the Value Proposition
6. Compare TOTAL COST

Recommendations

Partner

Partner early.

Find experienced partners.

Commit

Study cost before starting.

Set a reasonable budget and design to it.

DO NOT run concurrent designs.

Prioritize

You can't have it all.

Limit your design objectives.

Be prepared to compromise on the others.

Invest

You won't solve it in one project.

Spend time educating.

Be prepared to do everything different.

Thank You