Understanding Mass Timber and Cold-Formed Steel Hybrid Construction

Presented by:

Hercend Mpidi Bita, P.E.
Principal
Timber Engineering Inc.

TIMBER ENGINEERING

Bryan Maltais, P.E.
Associate
McNamara · Salvia

McNAMARA · SALVIA
STRUCTURAL ENGINEERS

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Bunker Hill Housing Redevelopment – Stellata / Stantec / McNamara - Salvia / Leggat McCall Properties / Photo courtesy McNamara Salvia

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

AIA Approved Continuing Education

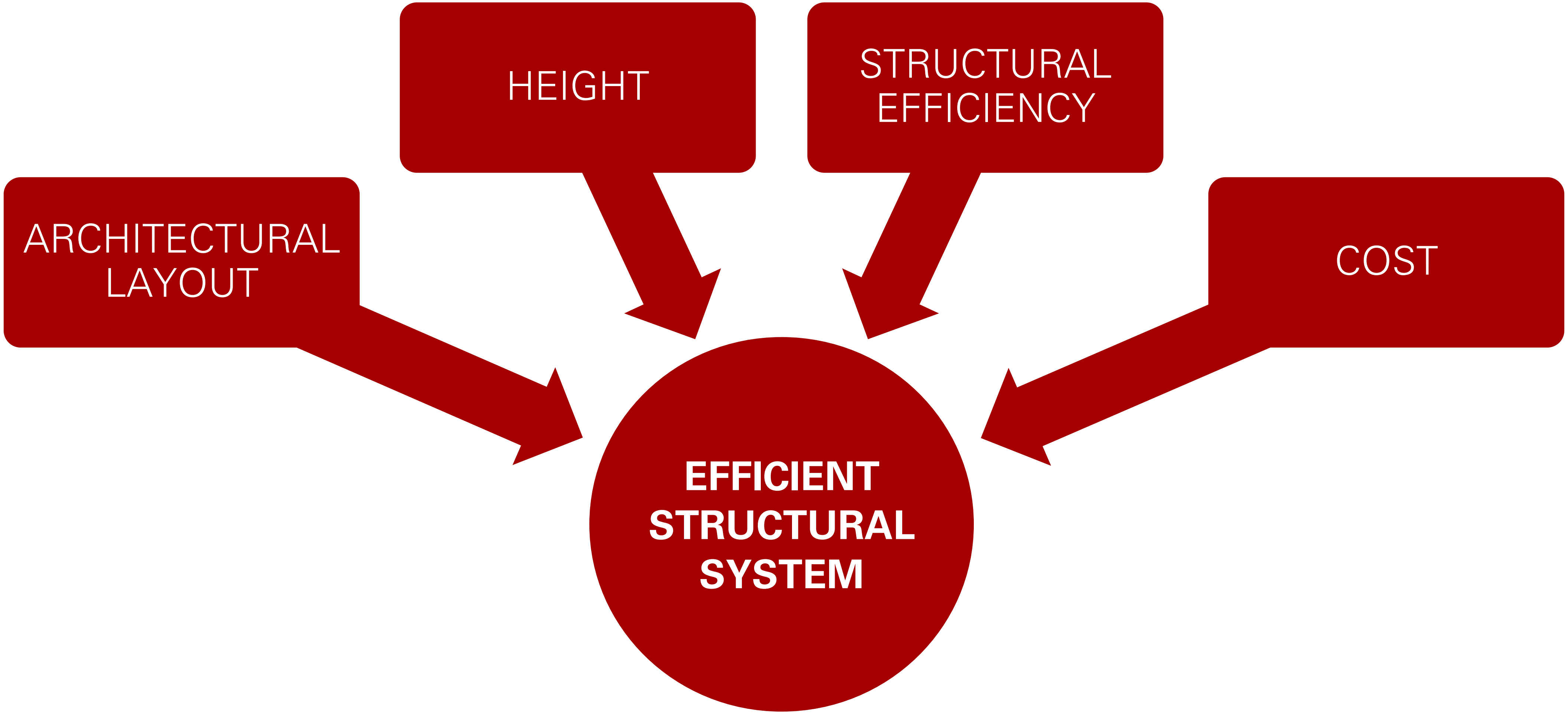
Course Description

This seminar explores the emerging hybrid construction method combining mass timber and cold-formed steel (CFS) to optimize structural performance and cost-effectiveness. We will examine structural, fire, and acoustic performance benefits, prefabrication advantages, and construction efficiencies. The presentation will also feature a detailed case study of the Bunker Hill Housing Redevelopment project in Boston, MA, showcasing a groundbreaking application of mass timber-CFS hybrid construction in an urban setting. Participants will gain insights into the design considerations, construction sequencing, benefits, and challenges associated with this hybrid structural system.

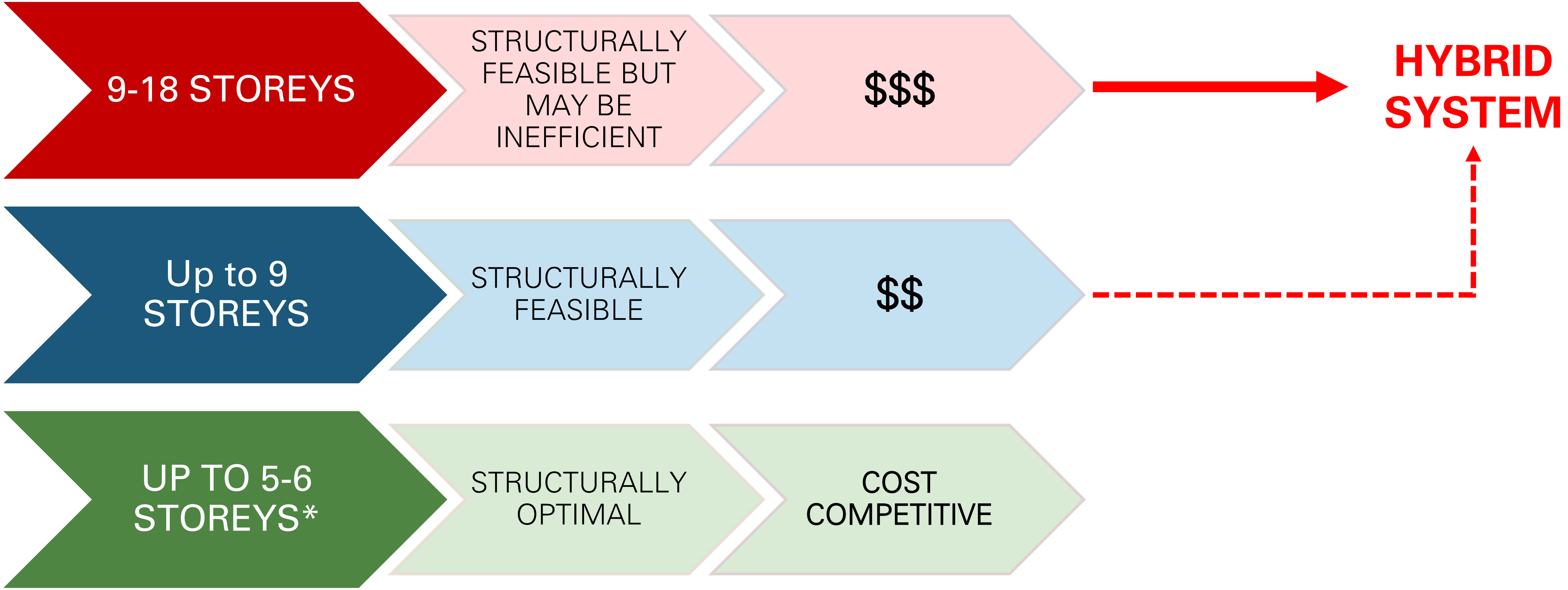
Learning Objectives

1. Assess the structural efficiency, fire safety, acoustic performance, and sustainability advantages of integrating cross-laminated timber (CLT) and cold-formed steel (CFS) in mid-rise buildings.
2. Examine how the thermal performance of mass timber and cold-formed steel contributes to energy-efficient building envelopes and reduces operational carbon.
3. Compare the cost-effectiveness of CLT-CFS hybrid construction with conventional building systems, focusing on material efficiency, labor savings, and lifecycle costs.
4. Explain the gravity and lateral load-resisting strategies of mass timber and CFS hybrid systems, including platform-type construction and connection detailing.

EFFICIENT STRUCTURAL SYSTEM

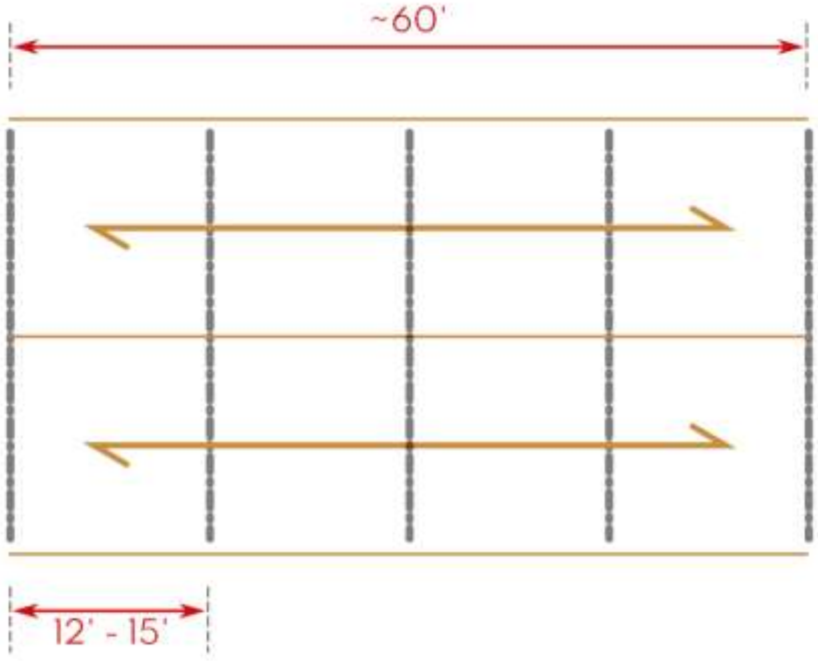


WOOD BEARING WALLS – WHEN IS IT VIABLE?



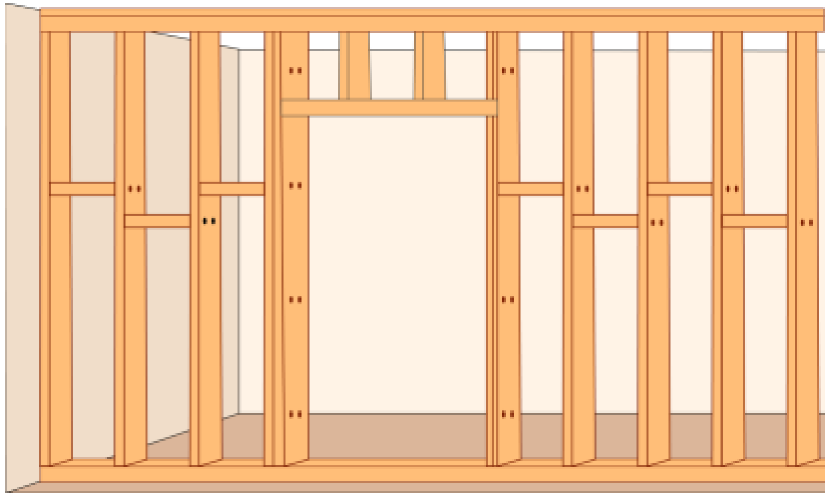
*UP TO 60FT SHEAR WALLS NO SPLICE

MASS TIMBER FLOOR SYSTEM – EFFICIENT SPAN



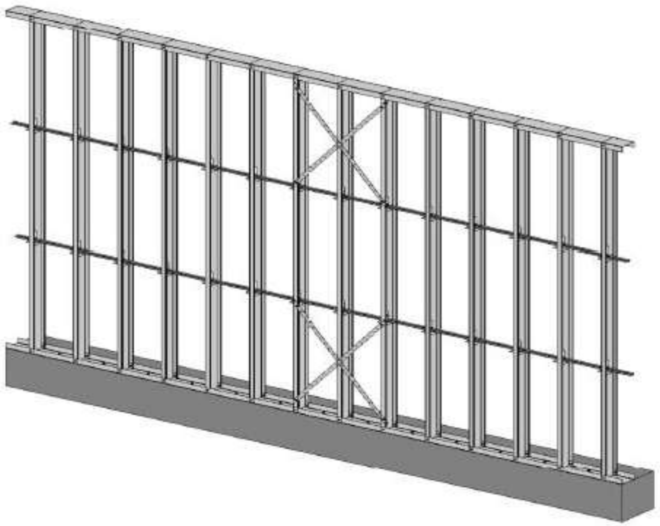
LOADBEARING WALL SYSTEMS – PLATFORM-TYPE

LOADBEARING LIGHTWOOD FRAMING
≤ 5-6 STOREYS



LOADBEARING CLT PLATFORM-TYPE
UP TO 8-9 STOREYS

LOADBEARING CFS FRAMING
UP TO 18 STOREYS



EFFICIENT HYBRID SYSTEM FOR TALLWOOD– NEW APPROACH

UP TO 18 STOREYS

+

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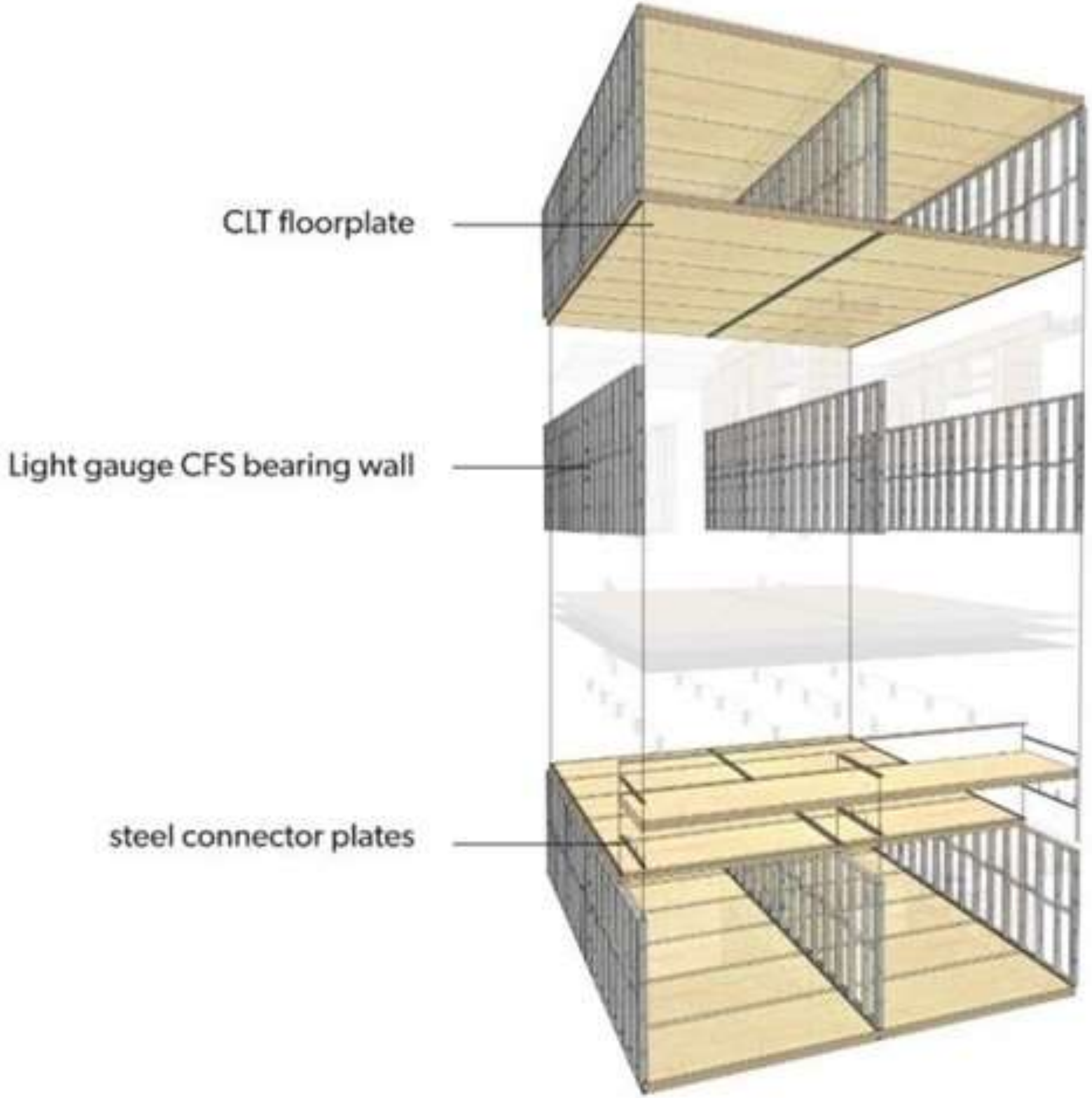
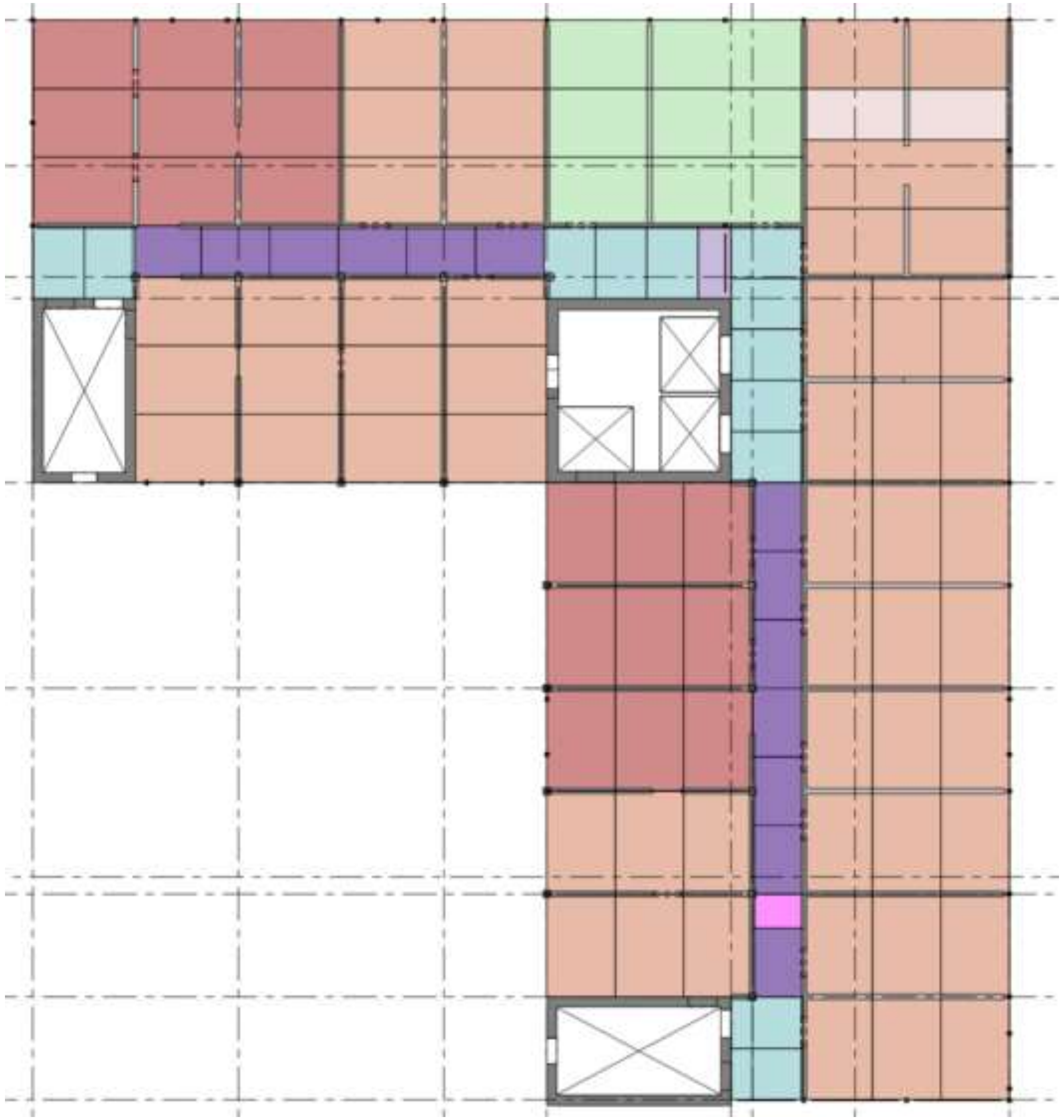
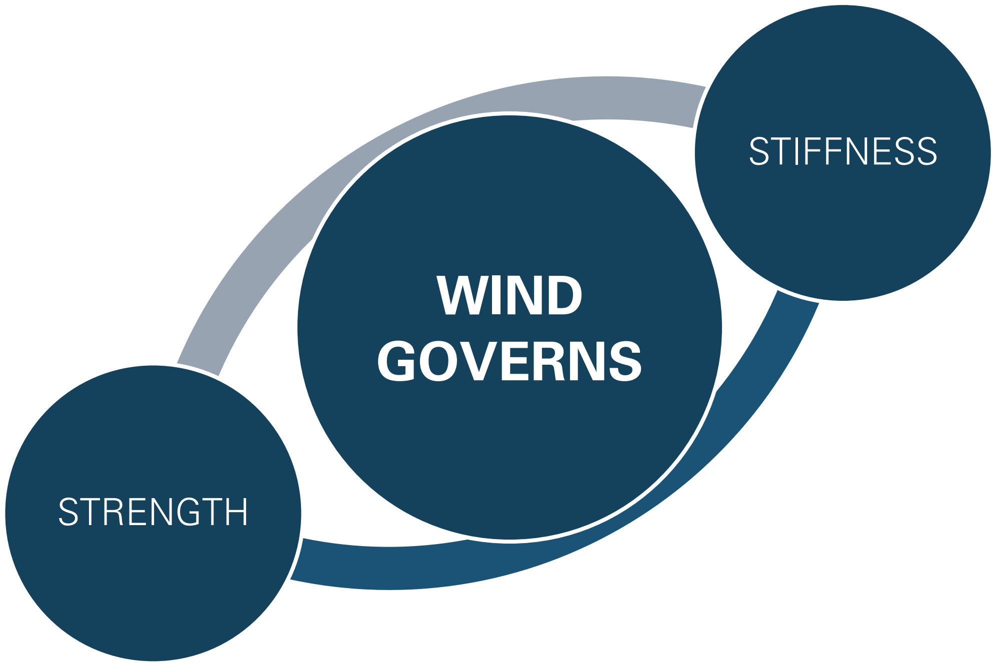


EFFICIENT GRAVITY SYSTEM
WHAT CREATES FORMS?

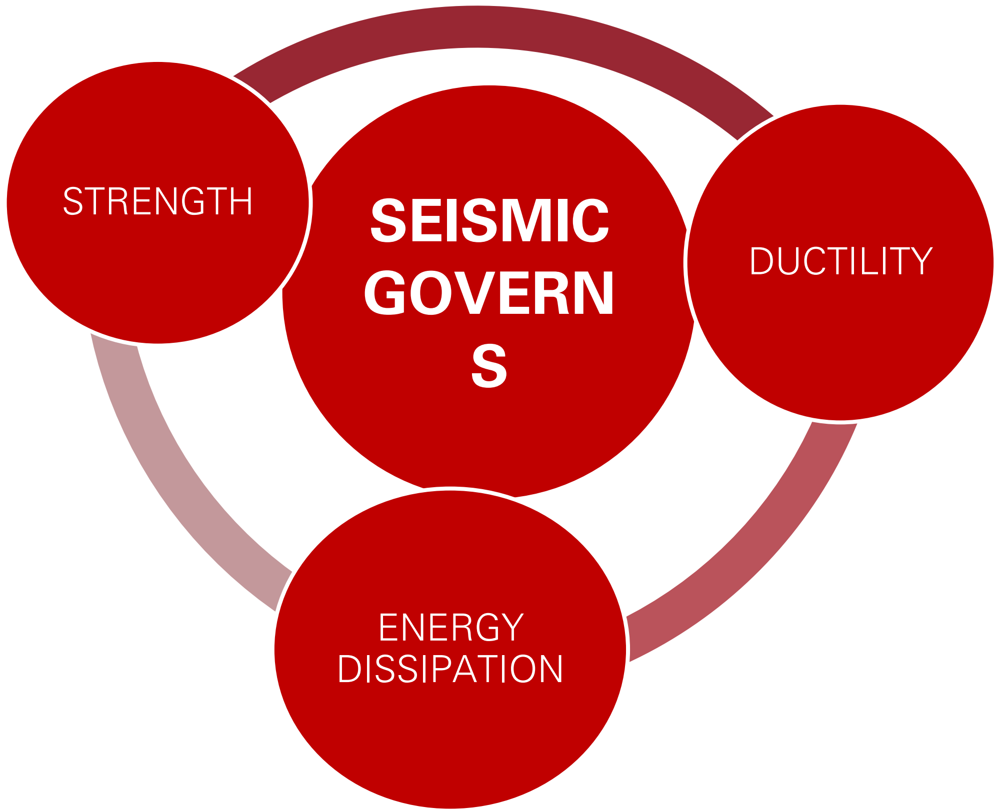
- → EFFICIENT STRUCTURAL LAYOUT
- → PANEL UTILISATION & EFFICIENCY
- → PANEL THICKNESS
- → WALL SPACINGS
- → ERECTION SPEED & OPTIMISATION
- → PREFAB.



EFFICIENT LATERAL SYSTEM
WHAT CREATES FORMS?



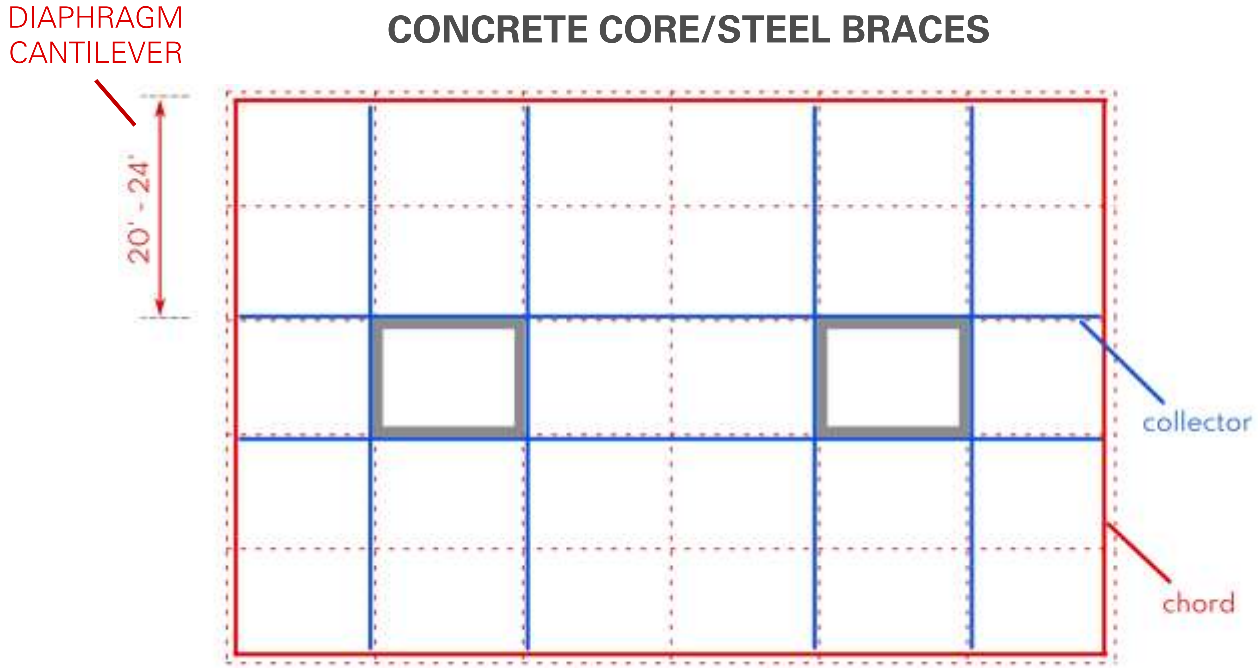
WOOD LLRS VIABLE UP TO~9 STOREY



HYBRID LLRS REQUIRED

EFFICIENT LATERAL SYSTEM – WHERE?

CONCRETE CORE/STEEL BRACES



→ ELEVATION FLEXIBILITY

SHEAR WALLS/BRACES

→ PLAN LAYOUT FLEXIBILITY

NEW APPROACH – CLT+CFS

→ CONCRETE PODIUM – PARKING & COMMERCIAL

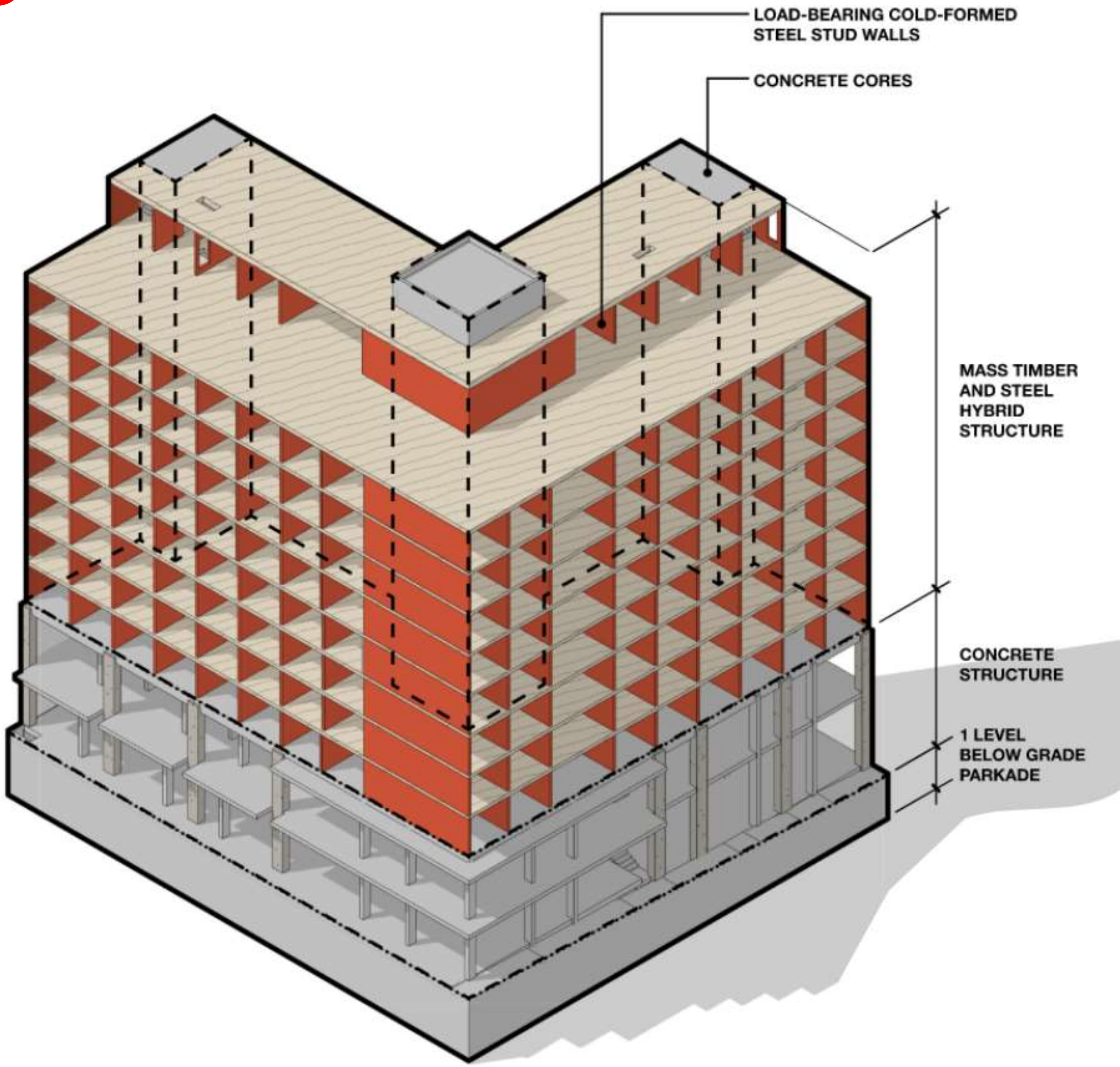
→ CLT+CFS – RESIDENTIAL/OFFICE

PLATFORM TYPE CONSTRUCTION

✓ CFS LOAD BEARING WALLS

✓ CLT FLOOR PANELS

→ REPETITIVE + LIGHTWEIGHT + PREFAB



Credit – MA+HG ARCHITECTURE

PROJECT TEAM

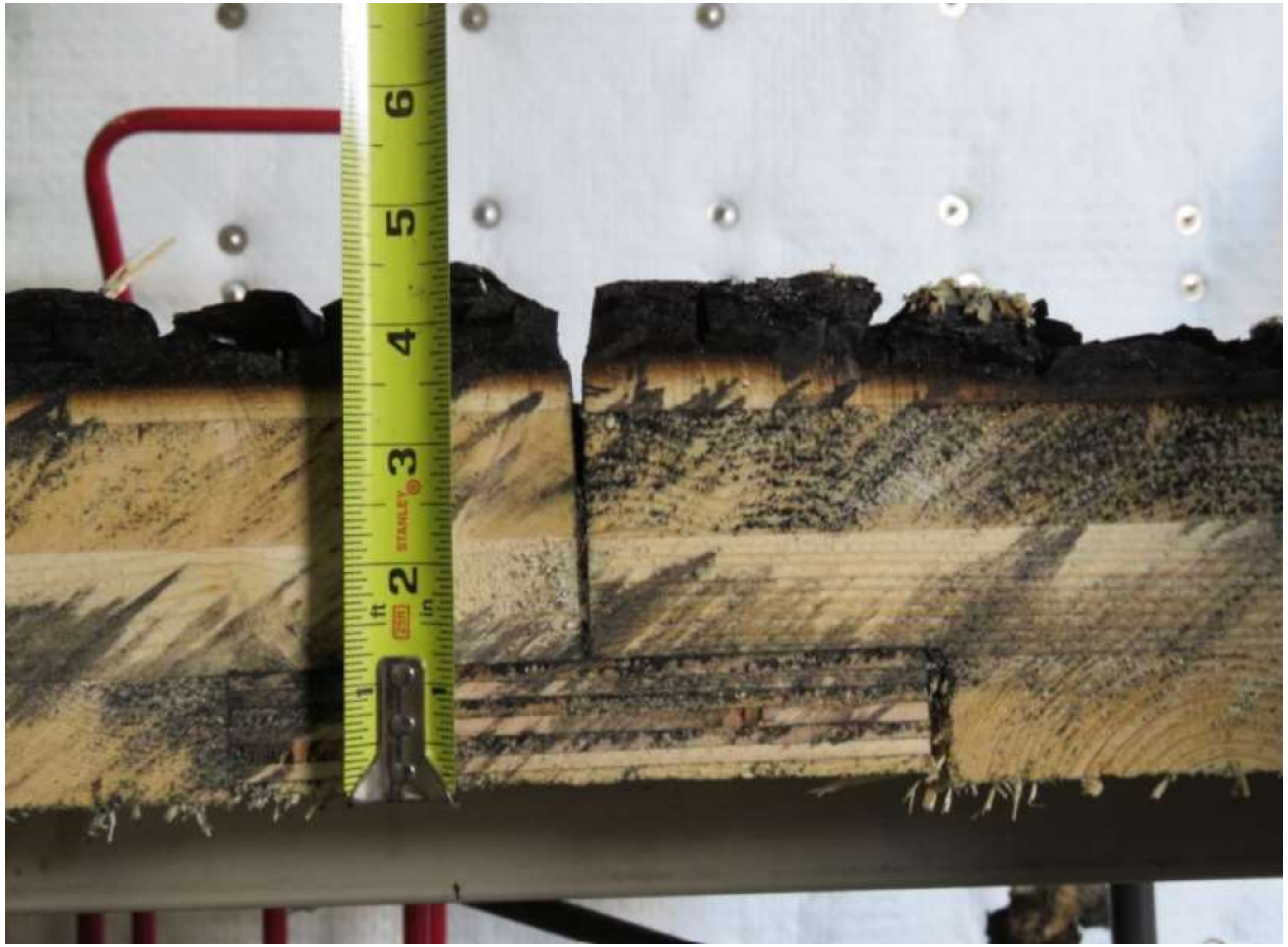
Owner	Tomo Spaces
Architectural	MA+HG
Consulting Arch	Eskew+Dumez+Ripple
Structural	Timber Engineering
CP/Code	GHL Consultants
Mechanical	Rocky Point Engineering
Fire Suppression	Rocky Point Engineering
Electrical	Nemetz (S/A) & Associates
Landscape	Hapa Collaborative
Envelope/Energy	Evoke Buildings
Civil	Creus Engineering
Geotech	Geopacific Consultants
Acoustic	BLK Consultants
Heritage Consultant	Donald Luxton & Associates, John Atkin
Indigenous Consultant	snəw̓eyəɬ

MAC – VANCOUVER, BC

Credit – MA+HG ARCHITECTURE

CLT EFFICIENT SPAN – 2H FRR

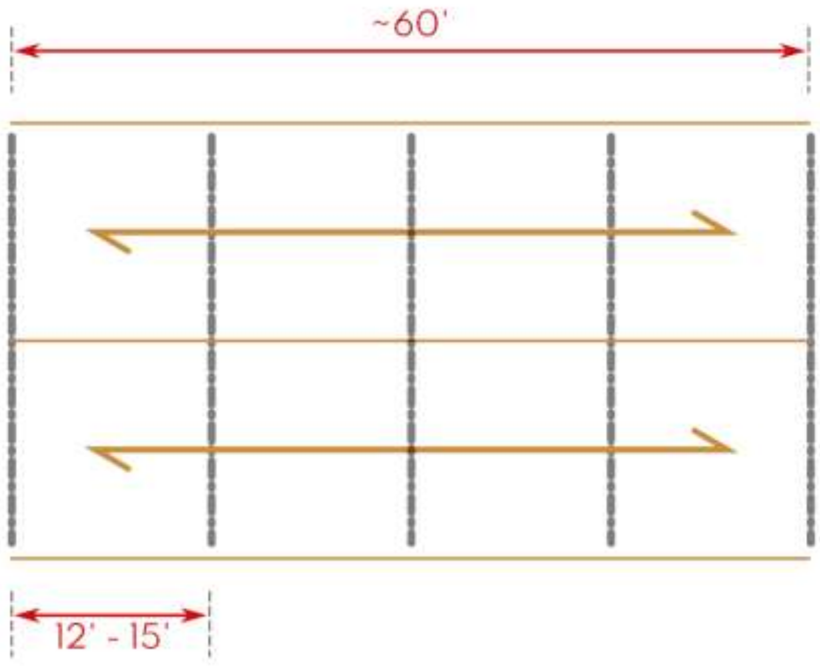
- → TALL MID-RISE WOOD = 8-12 STOREYS
- → 2H FRR
- → 12′ SPAN – GRID SYSTEM
- → 5PLY (175mm) V-GRADE CLT PANEL
- → DESIGN CHAR RATE
  0.65mm/Min

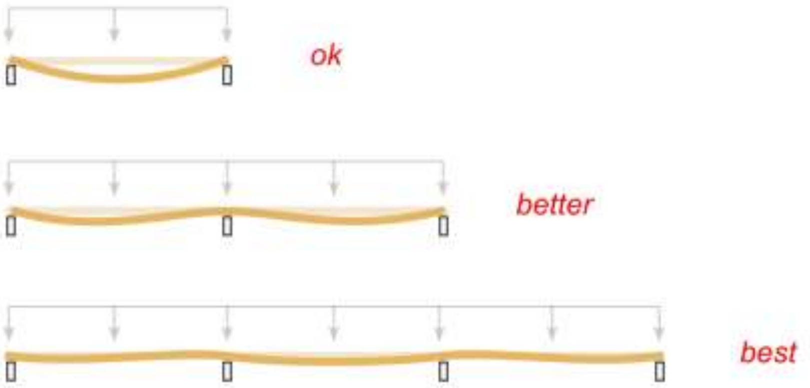


Credit – Katerra /Mercer

CLT EFFICIENT SPAN – PERFORMANCE

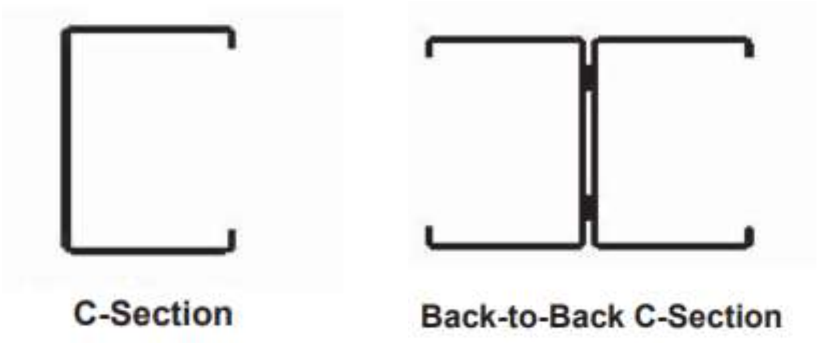
- → RESIDENTIAL LOADS
- → UP TO 2” CONCRETE TOPPING
- → MULTI-SPAN CONTINUOUS
  - ✓ DEFLECTION
  - ✓ VIBRATION
  - ✓ ACOUSTIC
  - ✓ FIRE

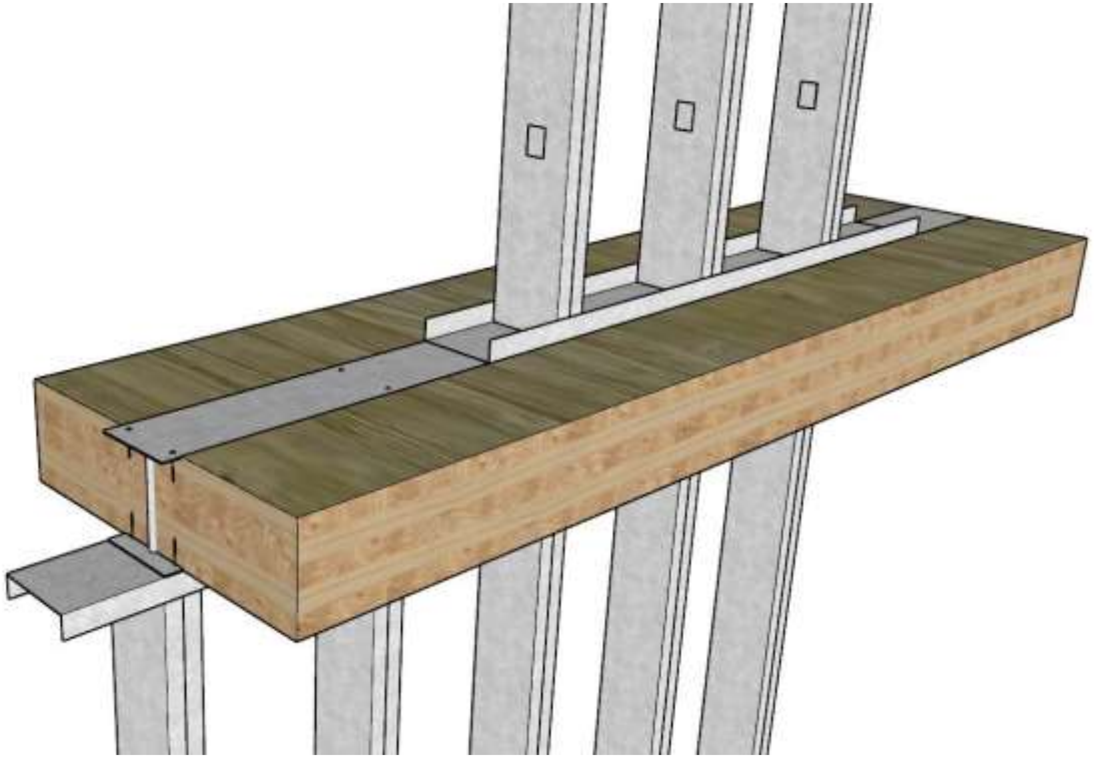




CFS WALLS EFFICIENT HEIGHT – UP TO 8-9 STOREYS

- WALL SPACING – OPTIMISE LOADS ON WALL
- STUD SPACING – OPTIMISE LOADS ON STUD
- HEAVY STUDS AT LOWER LEVEL

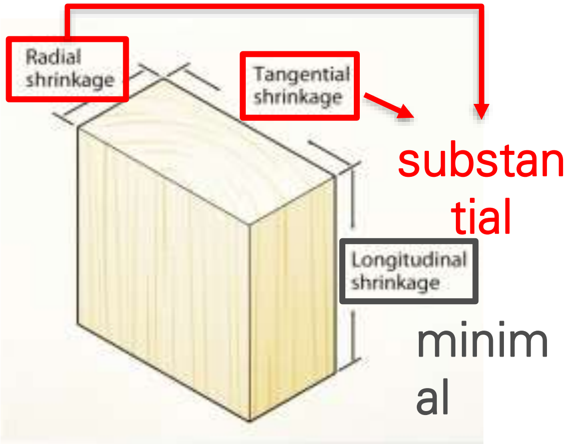




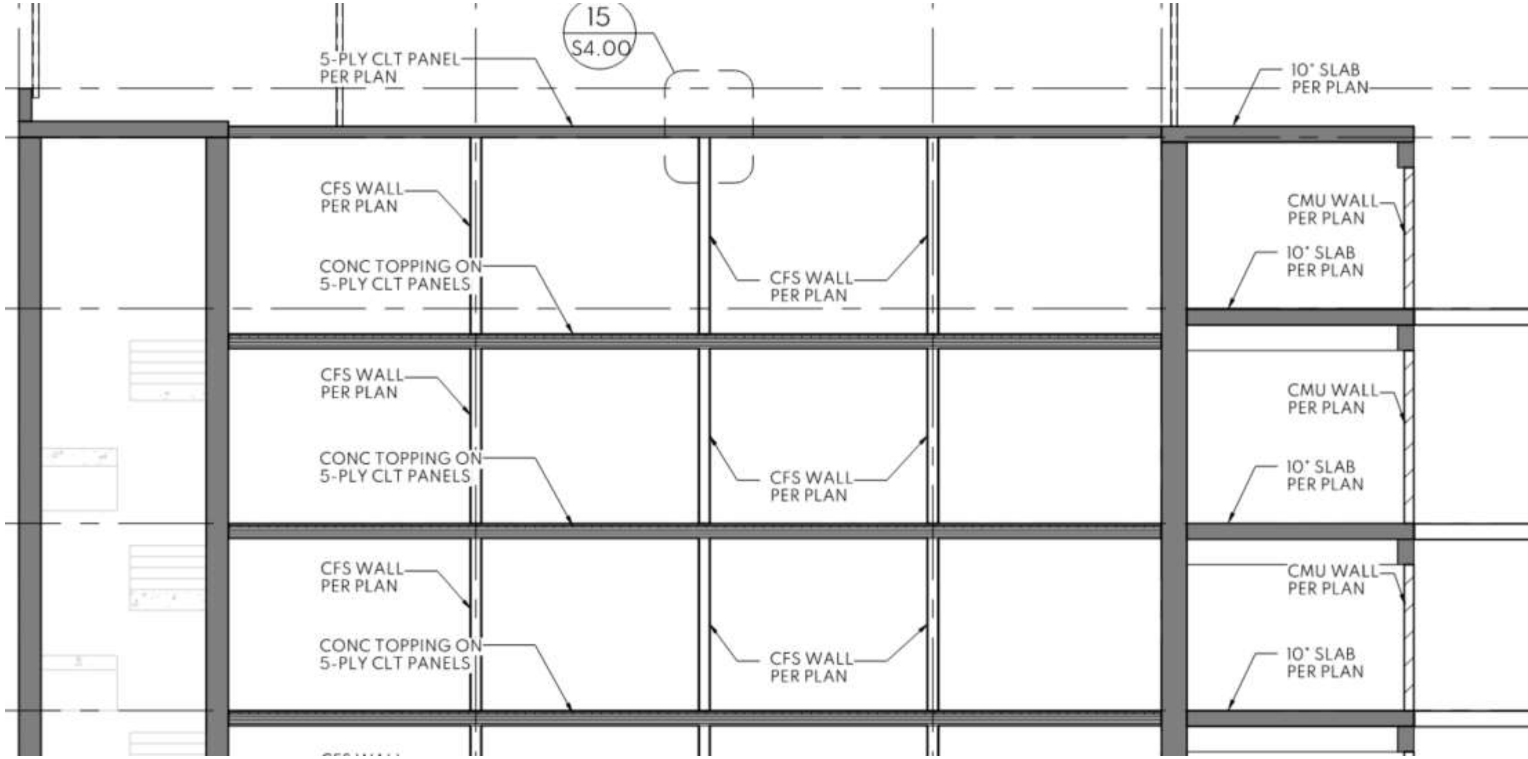
CFS STUD PACK vs HSS POSTS

- HIGH VERTICAL LOADS
- CONNECTIONS BTW COMPONENTS
- NUMBER OF TRADES
- PREFAB & CONSTRUCTION SEQUENCE

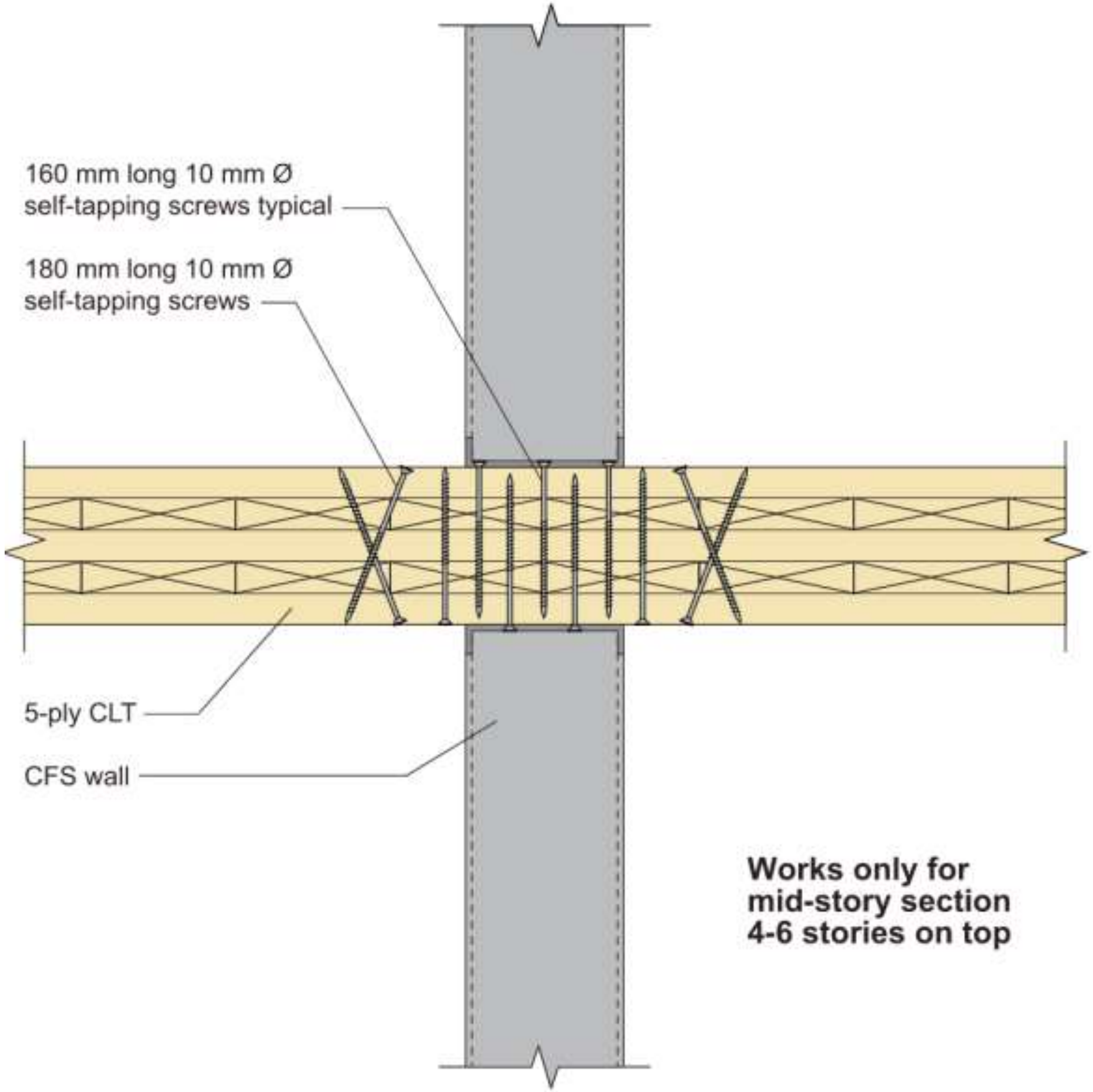
VERTICAL MOVEMENTS



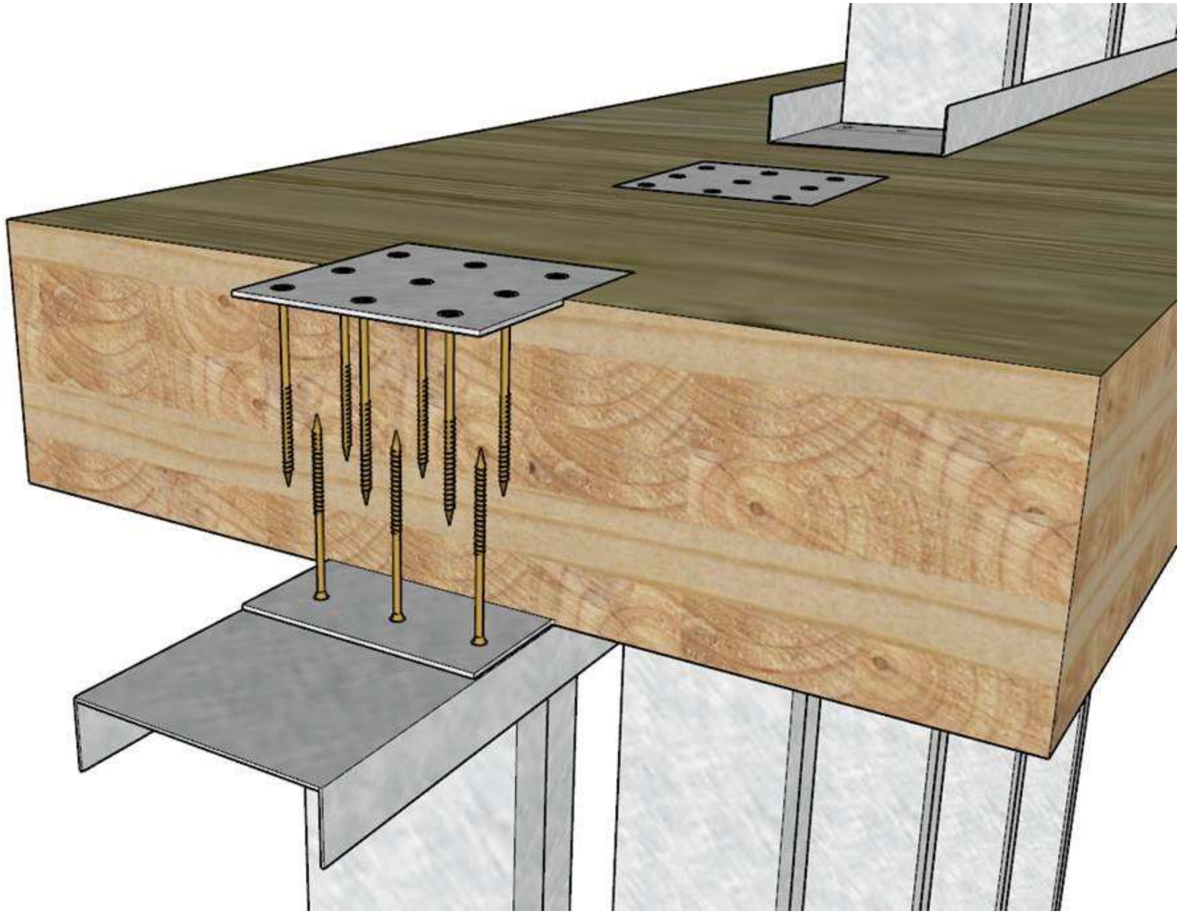
- → PLATFORM CONSTRUCTION
- → HYBRID SYSTEM – GRAVITY & LATERAL COMPATIBILITY
  - ✓ SHINKAGE
  - ✓ CREEP
  - ✓ COMPRESSION PERP
- → LOAD-PATH



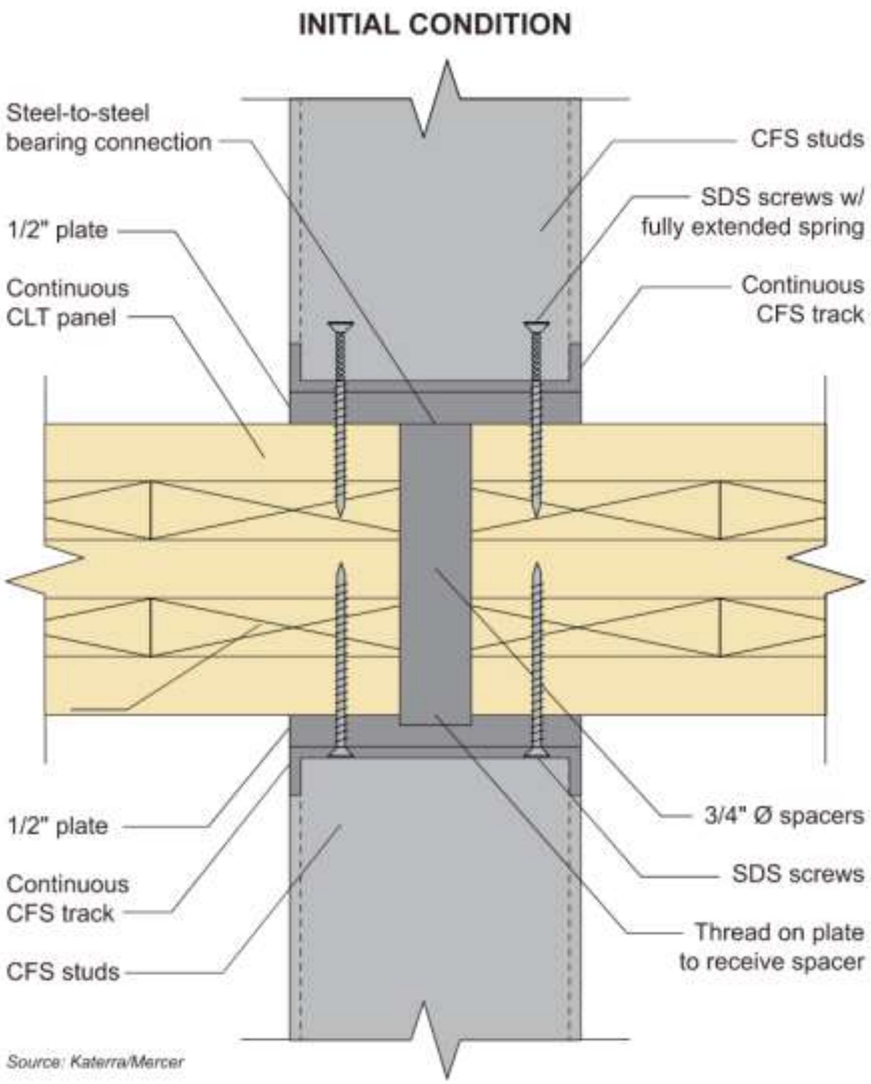
CONCEPT #1 – SCREW REINFORCEMENT



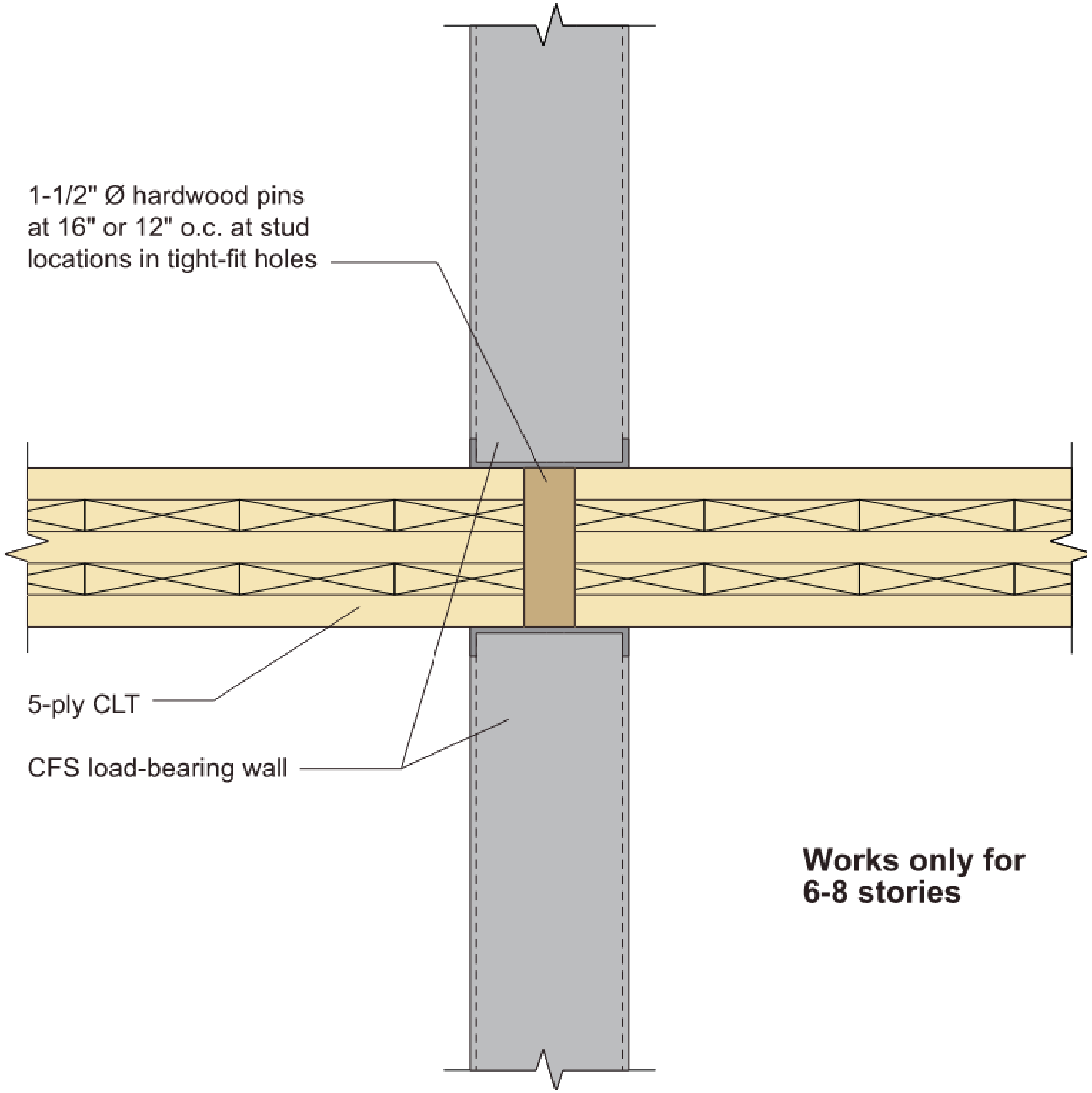
Works only for mid-story section 4-6 stories on top



CONCEPT #2– DOWEL THROUGH CLT



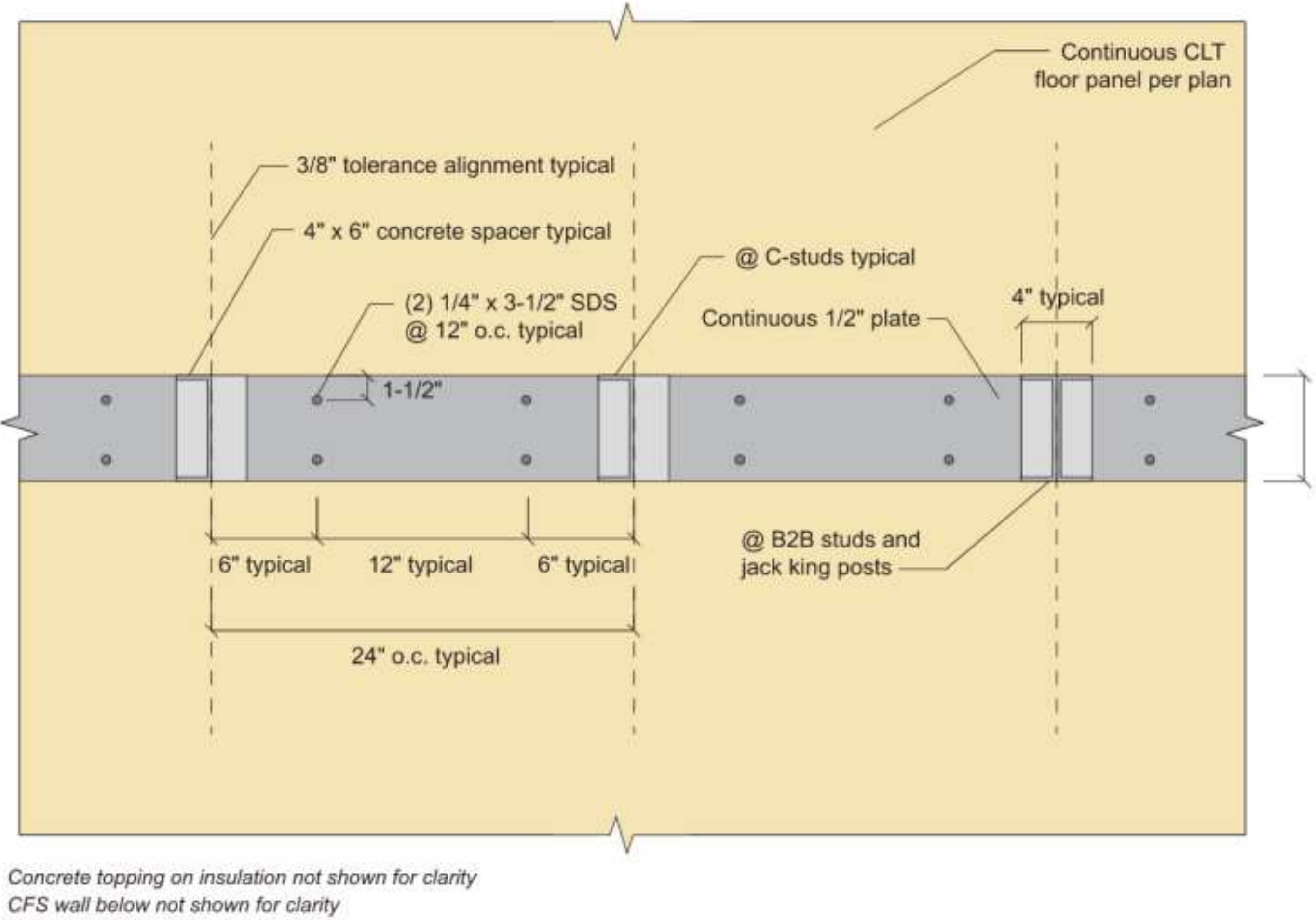
STEEL SPACERS (credit Katerra/Mercer)



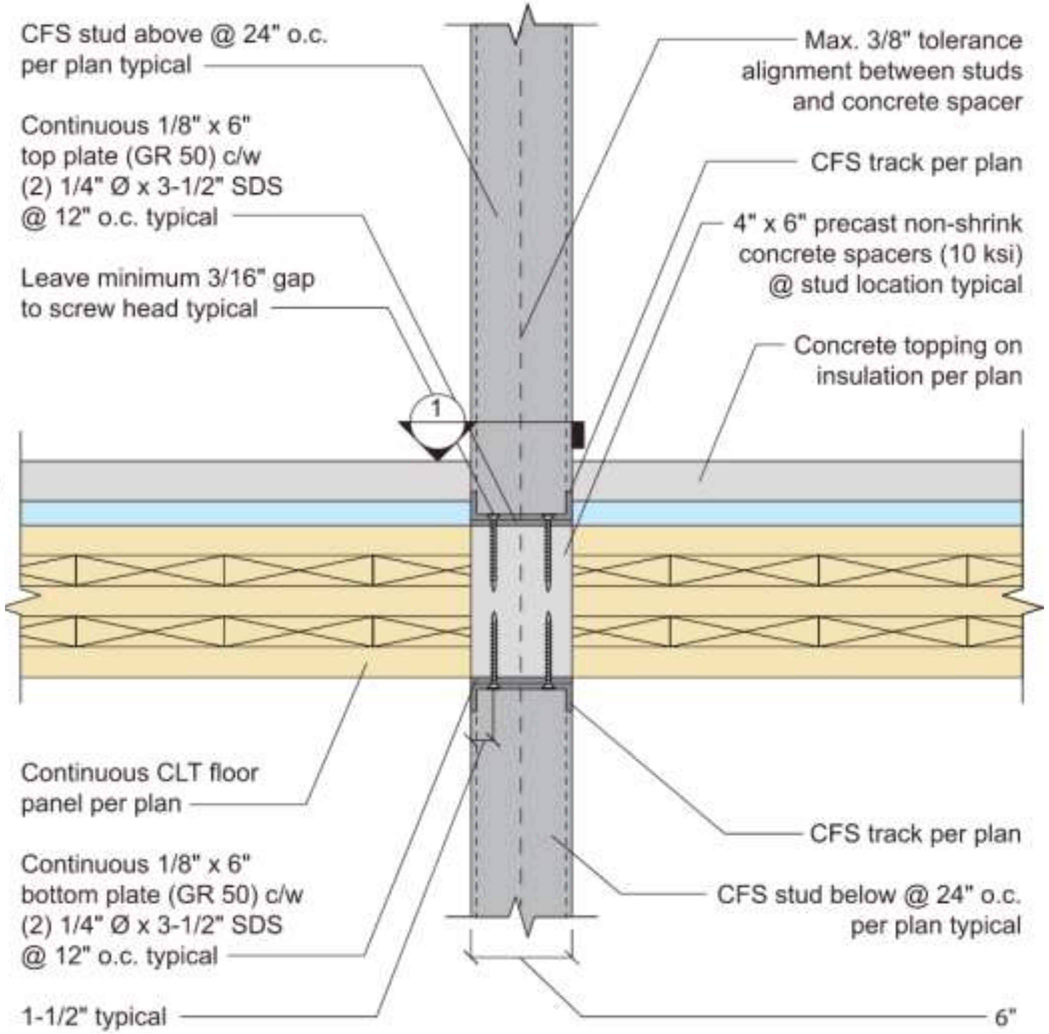
Works only for 6-8 stories

HARDWOOD SPACERS

CONCEPT #3– PRECASE CONCRETE SPACER



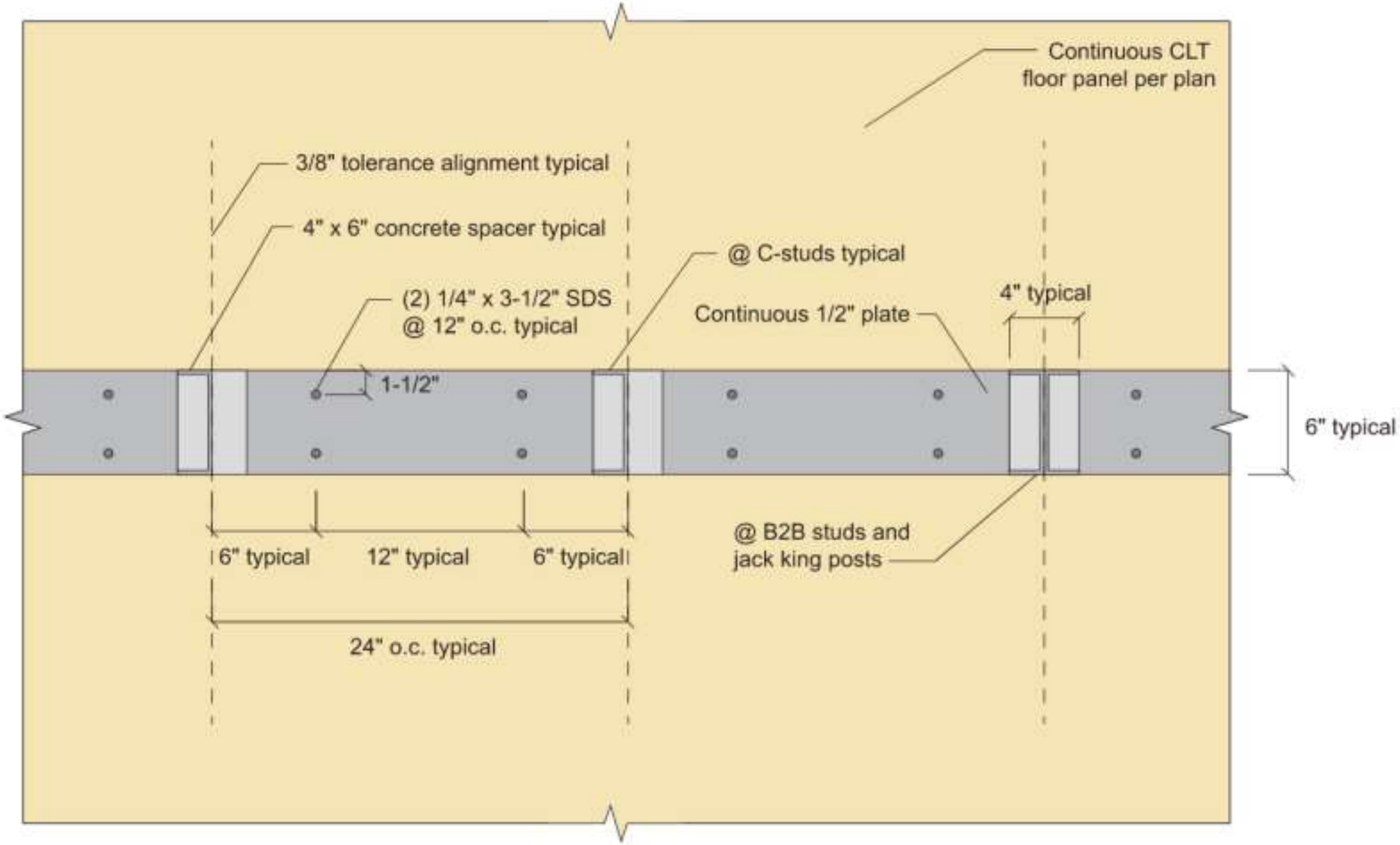
PLAN VIEW 1



SECTION VIEW

CLT DIAPHRAGM & STRUCTURAL INTEGRITY

- STUD SPACING - @ 24” O.C.
- CONCRETE SPACERS – 6” DIAM.
- CLT CUTS
- TIE FORCES & STRUCTURAL INTEGRITY

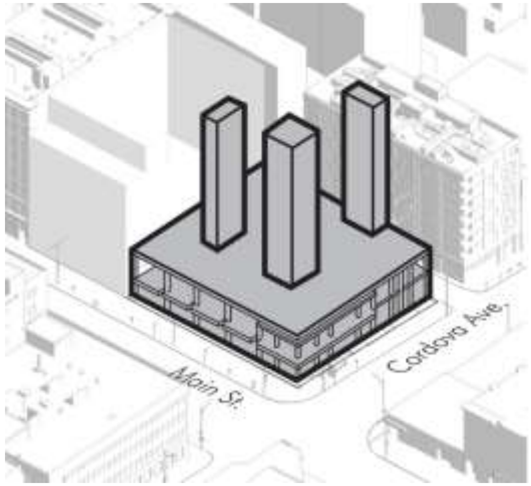


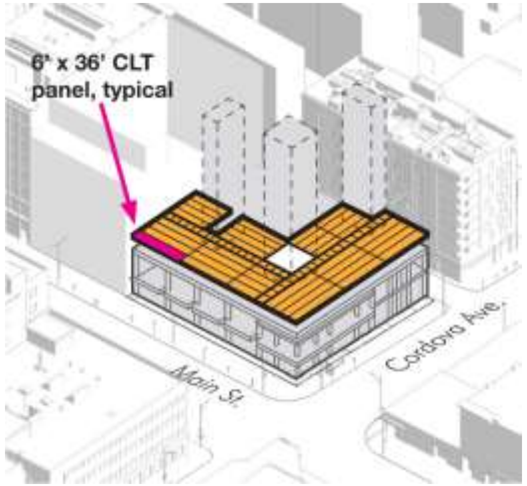
Concrete topping on insulation not shown for clarity
CFS wall below not shown for clarity

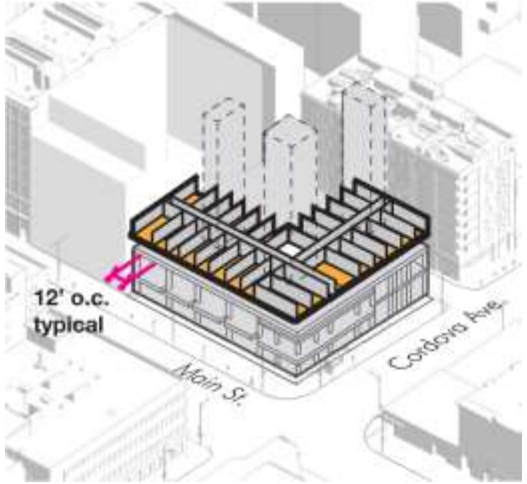
PLAN VIEW 1

EFFICIENT MATERIAL CHOICES

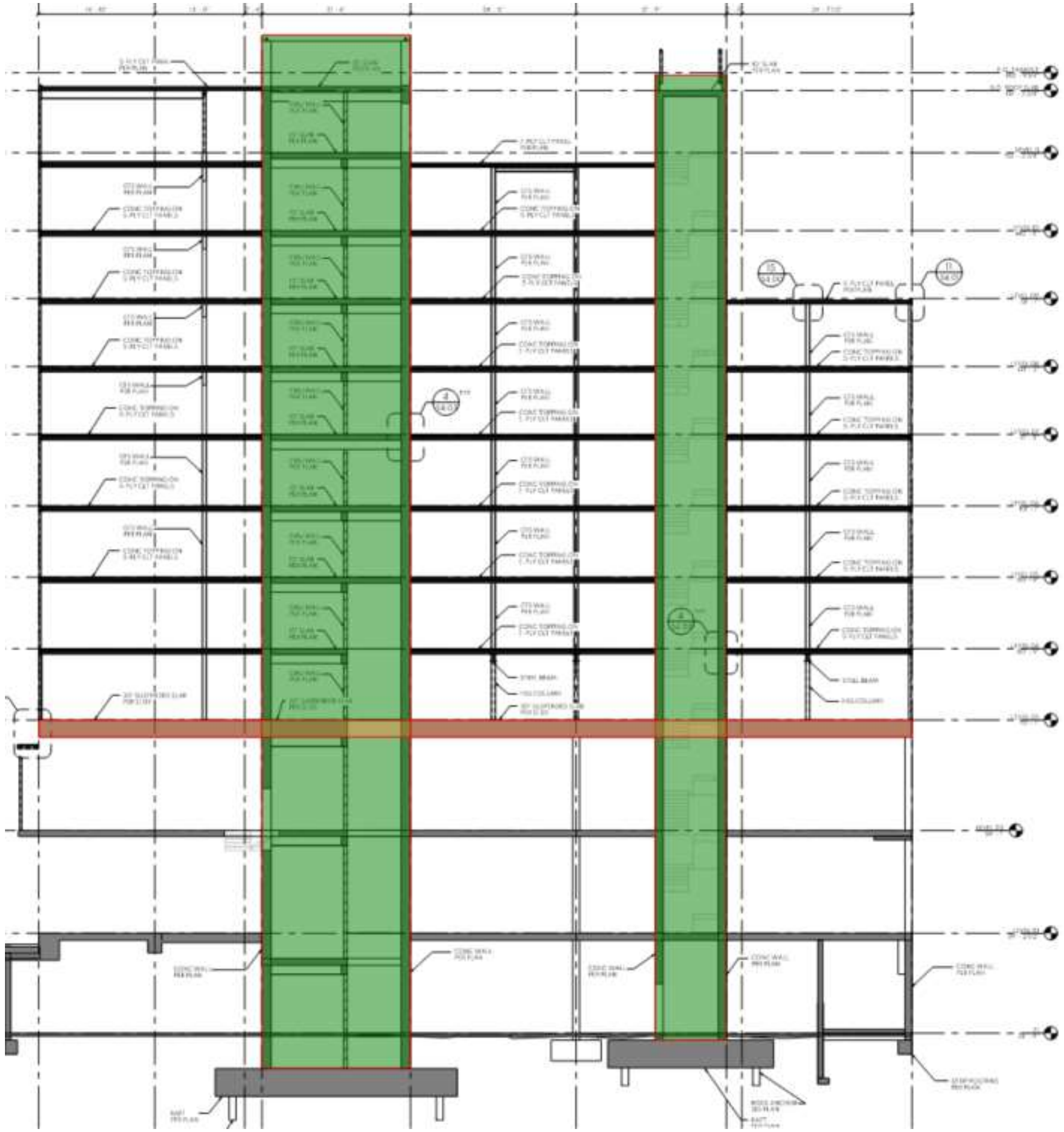
SPEED OF CONSTRUCTION
CONSTRUCTION SEQUENCE
CONNECTIONS AND DETAILING
PREFAB.

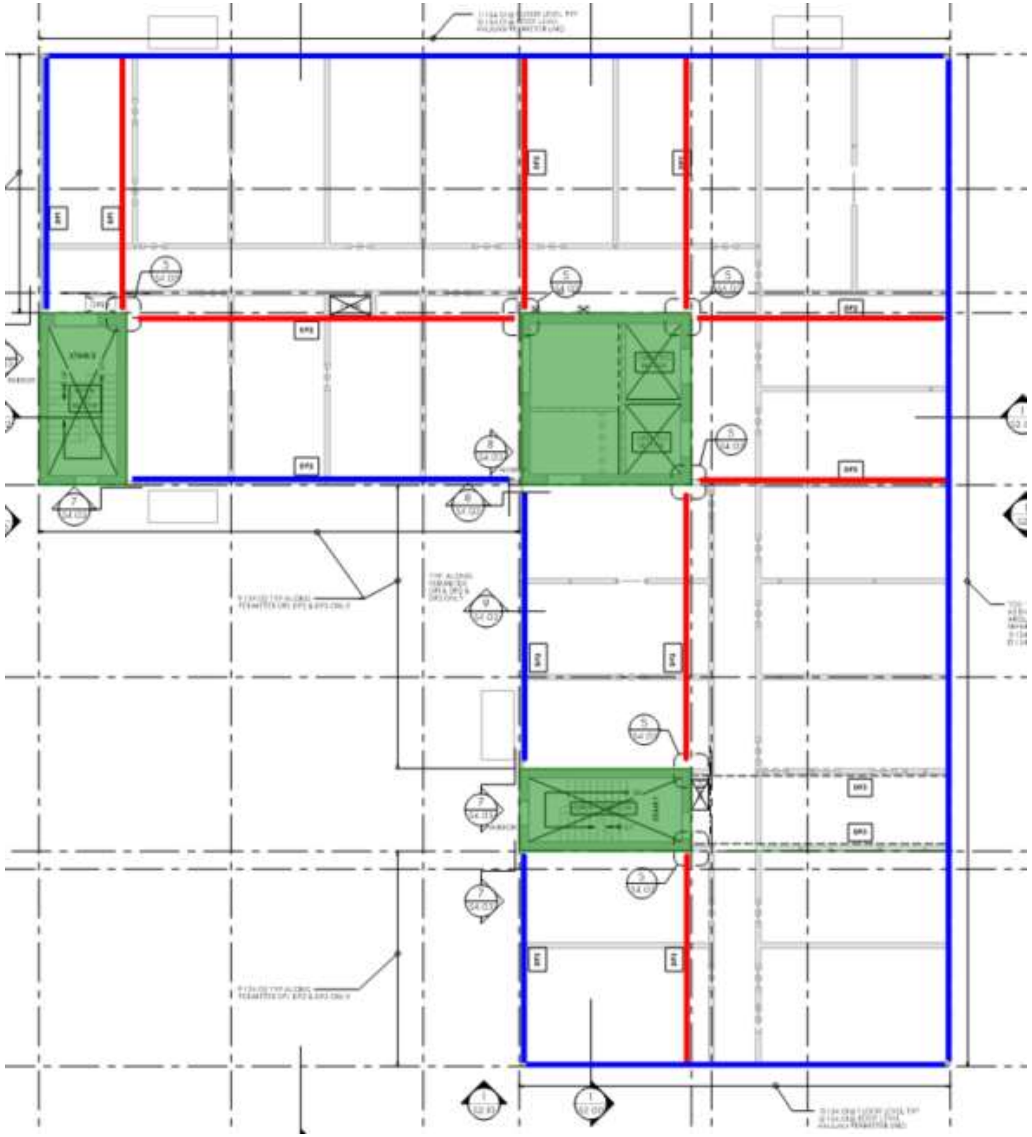






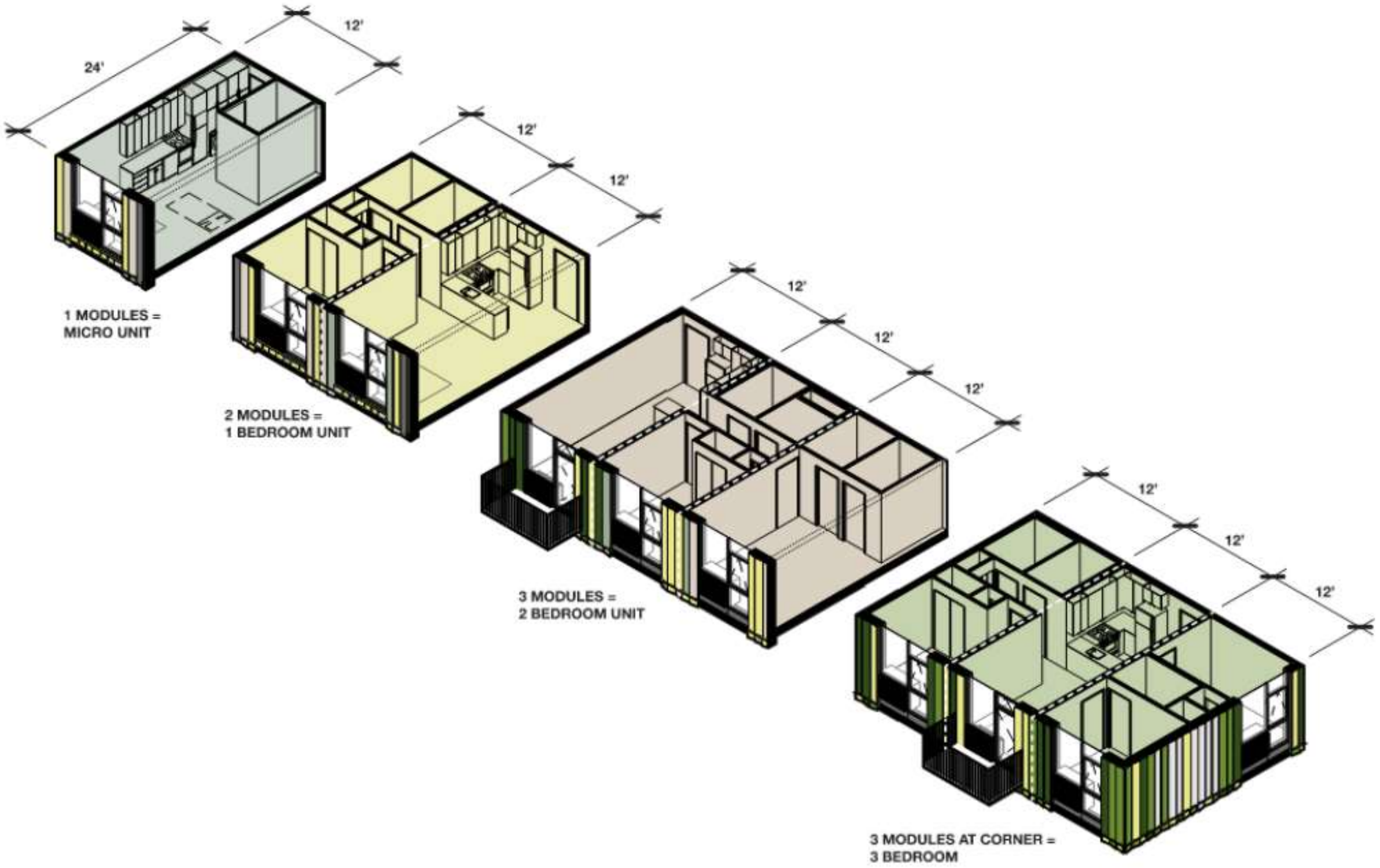
SIMPLICITY + REGULARITY = EFFICIENCY





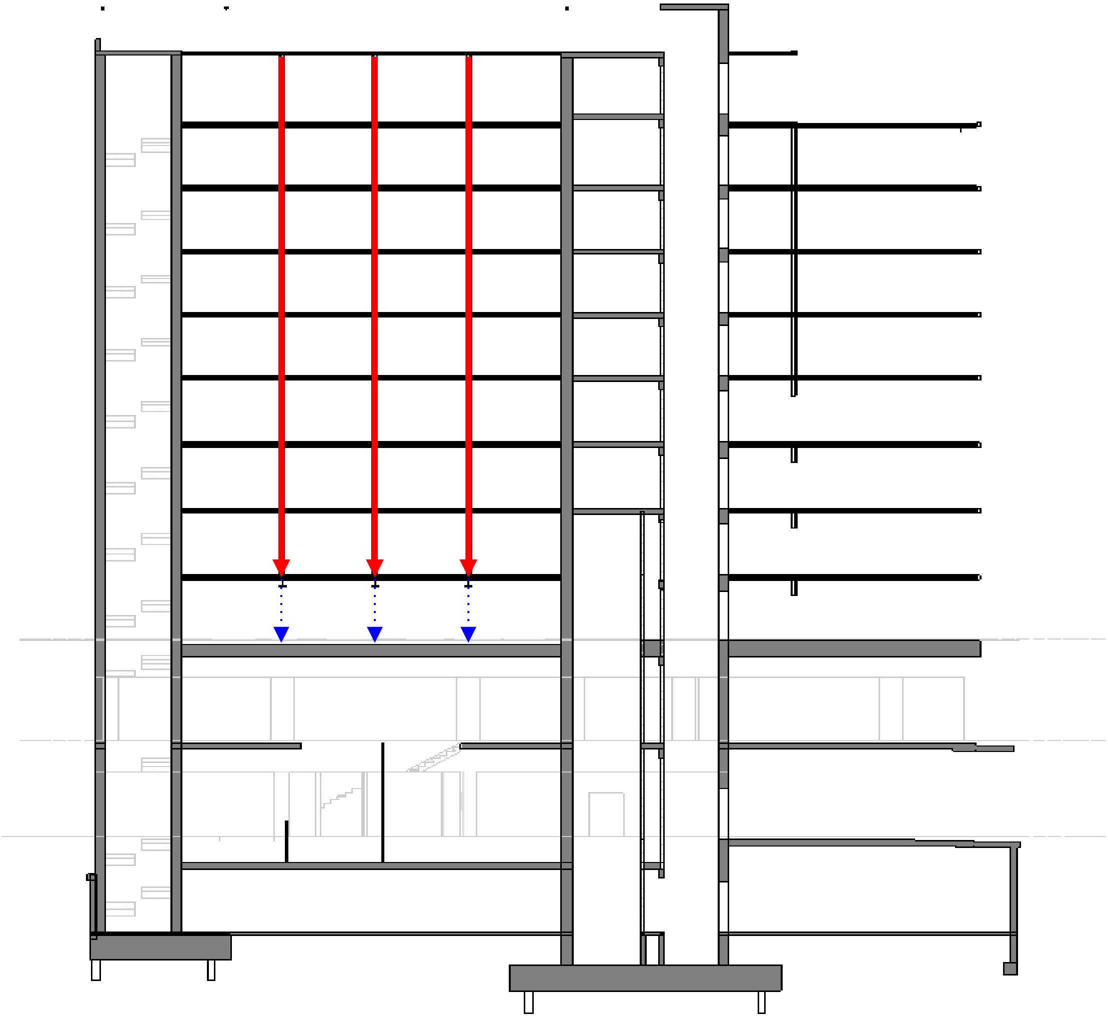
UNDERSTAND OPTIMIZATION

- EARLY ARCHITECT INTEGRATION
- EARLY ARCHITECT INTEGRATION
- CONDO MODULES
- WITH OPTIMAL CLT SIZING
- PREFAB.

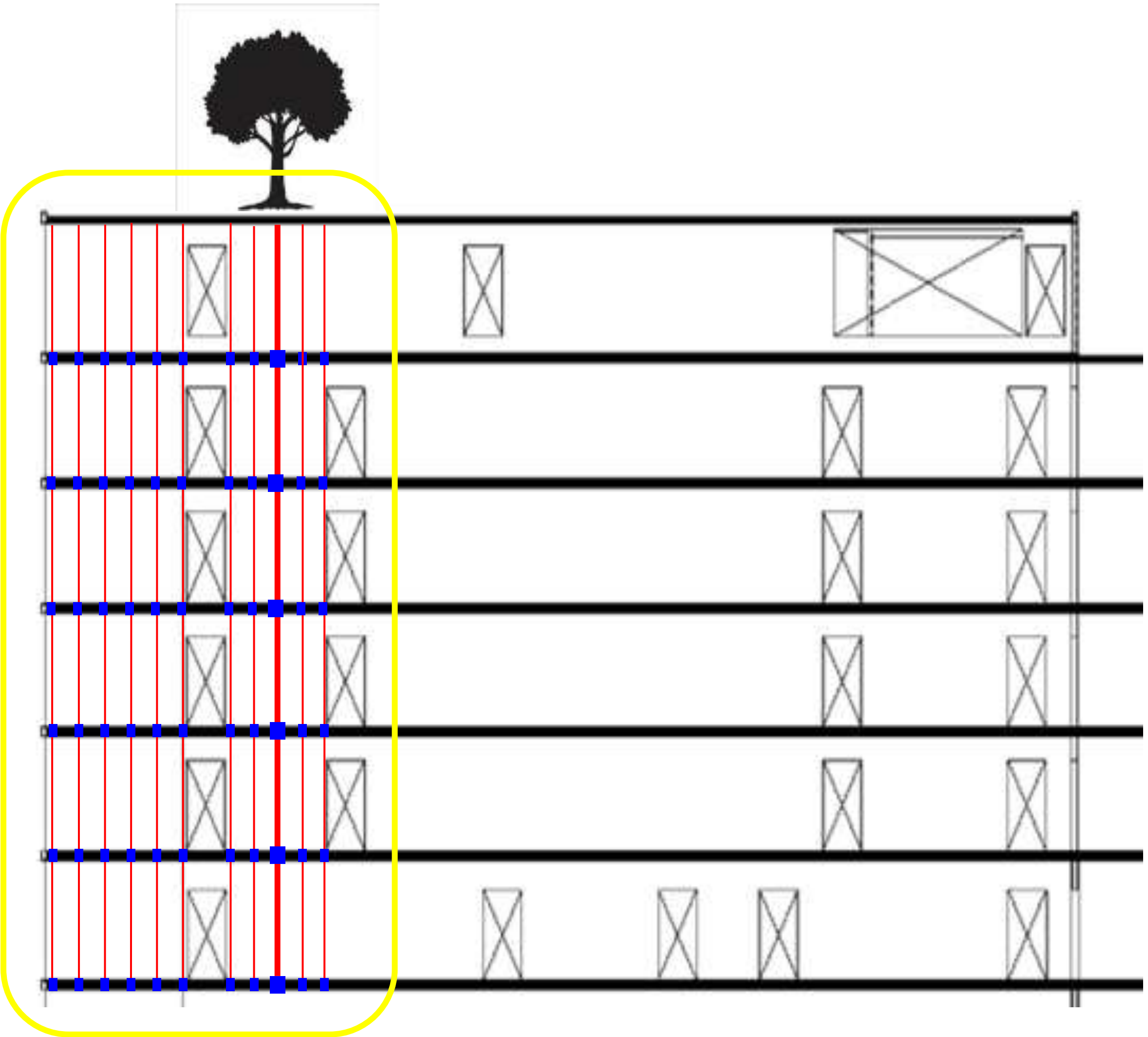


AMENITY SPACE & OPENINGS

TRANSFER STEEL POSTS AND BEAMS



ALIGNMENT OF OPENINGS



CLT+CFS SYSTEM FOR TALL MID-RISE 5-9 STOREYS

→ CLT THICKNESSES AND SPANS

→ STUD SPACINGS

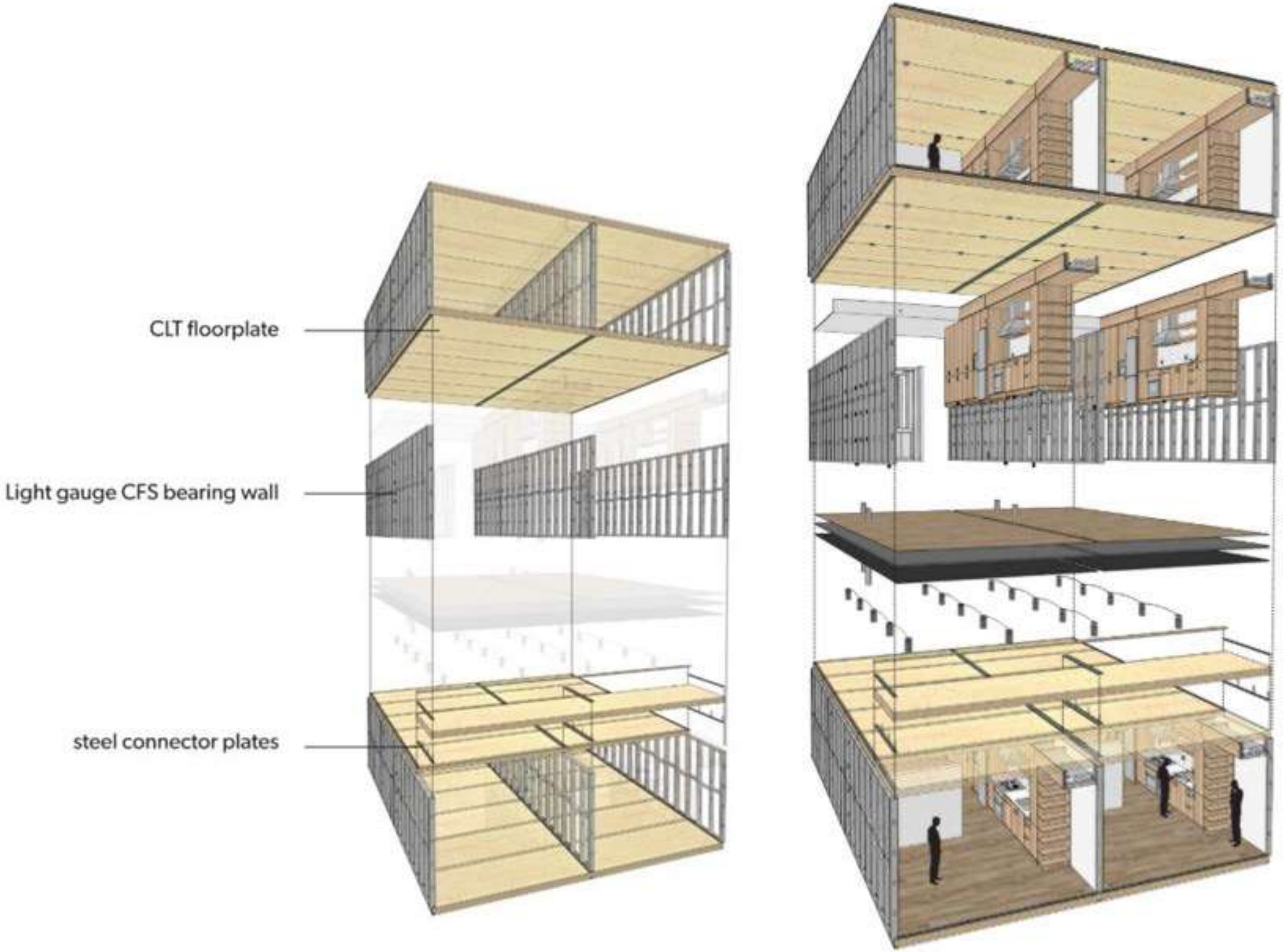
→ SPACERS vs NO SPACERS

→ TYPE & SIZE OF SPACERS

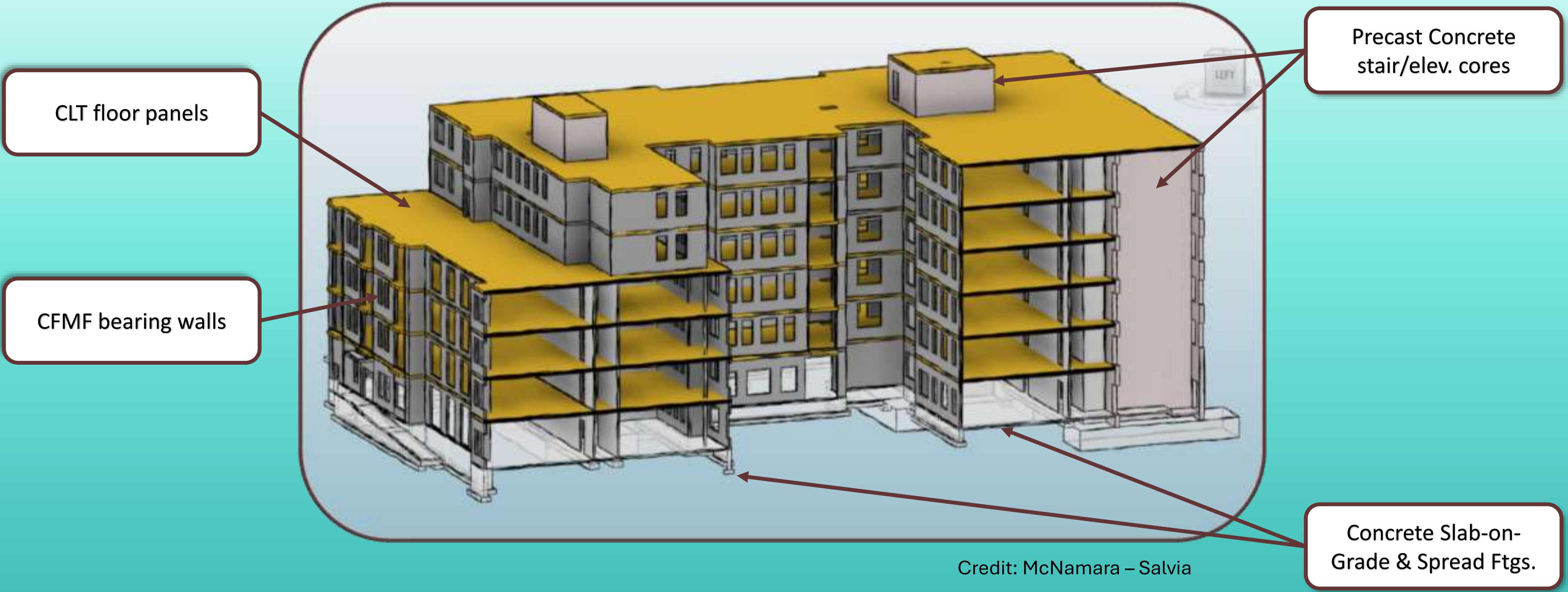
→ STUD PACKS vs HSS POSTS

→ NUMBER OF TRADES

→ TRANSFERS & OPENINGS



BUNKER HILL HOUSING STRUCTURAL OVERVIEW



Credit: McNamara – Salvia

MATERIAL EXPLORATIONS: Why CFMF?

- Construction Type IV-C
  - Non-combustible bearing walls
  - Panelized CFMF walls: non-combustible, strong, fast erection time

602.4 Type IV. Type IV construction is that type of construction in which the *building elements* are *mass timber* or noncombustible materials and have *fire-resistance ratings* in accordance with Table 601. *Mass timber* elements shall meet the *fire-resistance-rating* requirements of this section based on either the *fire-resistance rating* of the *noncombustible protection*, the *mass timber*, or a combination of both and shall be determined in accordance with Section 703.2. The minimum dimensions and permitted materials for *building elements* shall comply with the provisions of this section and Section 2304.11. *Mass timber* elements of Types IV-A, IV-B and IV-C construction shall be protected with *noncombustible protection* applied directly to the *mass timber* in accordance with Sections 602.4.1 through 602.4.3. The time assigned to the *noncombustible protection* shall be determined in accordance with Section 703.6 and comply with Section 722.7.

Cross-laminated timber shall be labeled as conforming to ANSI/APA PRG 320 as referenced in Section 2303.1.4.

Exterior *load-bearing walls* and *nonload-bearing walls* shall be *mass timber* construction, or shall be of noncombustible construction.

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

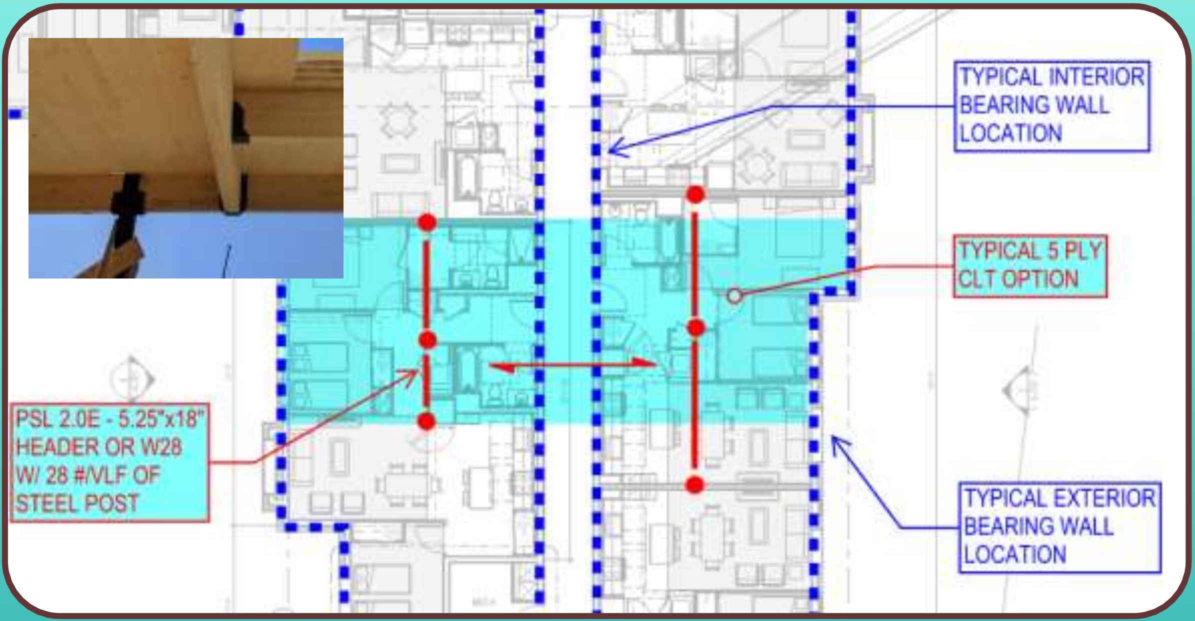
BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a, b]	2[a, b, c]	1[b, c]	0[c]	1[b, c]	0	3[a]	2[a]	2[a]	HT	1[b, c]	0
Bearing walls												
Exterior[e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	$1\frac{1}{2}$[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	$1\frac{1}{2}$	1	1	HT	1[b,c]	0

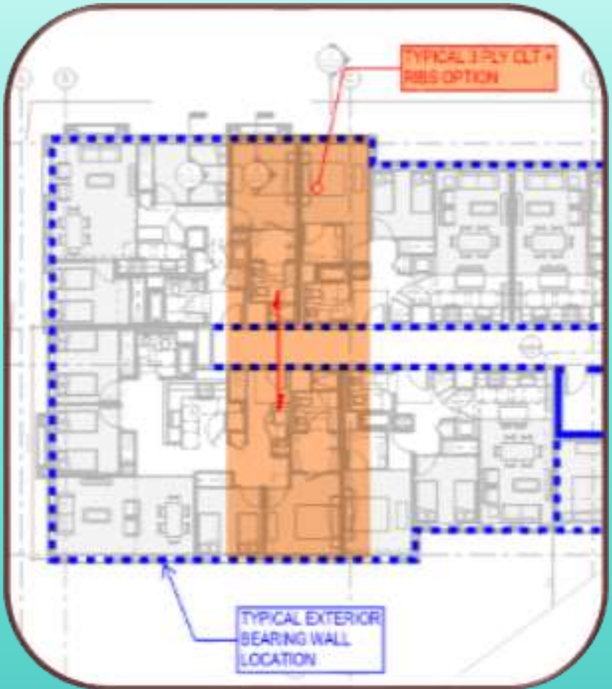
e. Not less than the fire-resistance rating based on fire separation distance (see Table 705.5).
f. Not less than the fire-resistance rating as referenced in Section 704.10.

Reference: IBC 2021

MATERIAL EXPLORATIONS: Why CLT?

- Short span 5 Ply CLT, Glulam/PSL beams, HSS posts
- Medium span 3 Ply CLT + Glulam Prefabbed Tee
- Long span 8” Precast Hollow-core Concrete plank

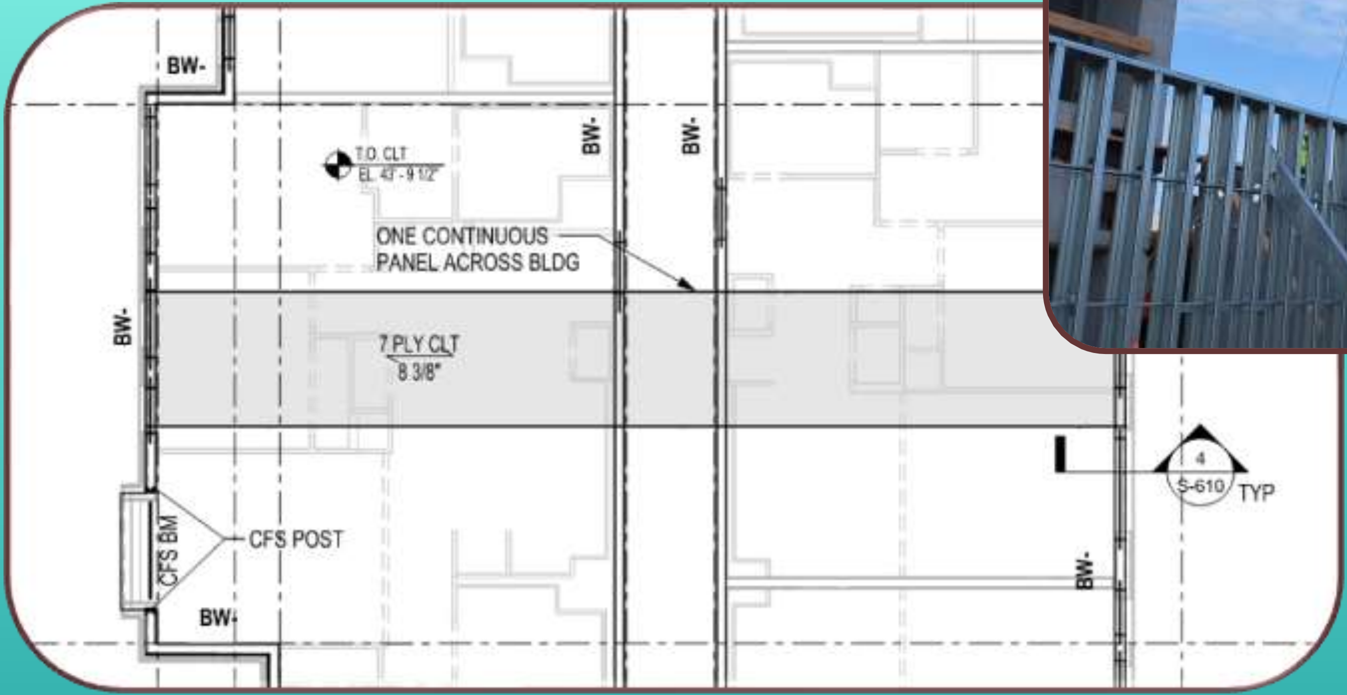




Credit: McNamara – Salvia

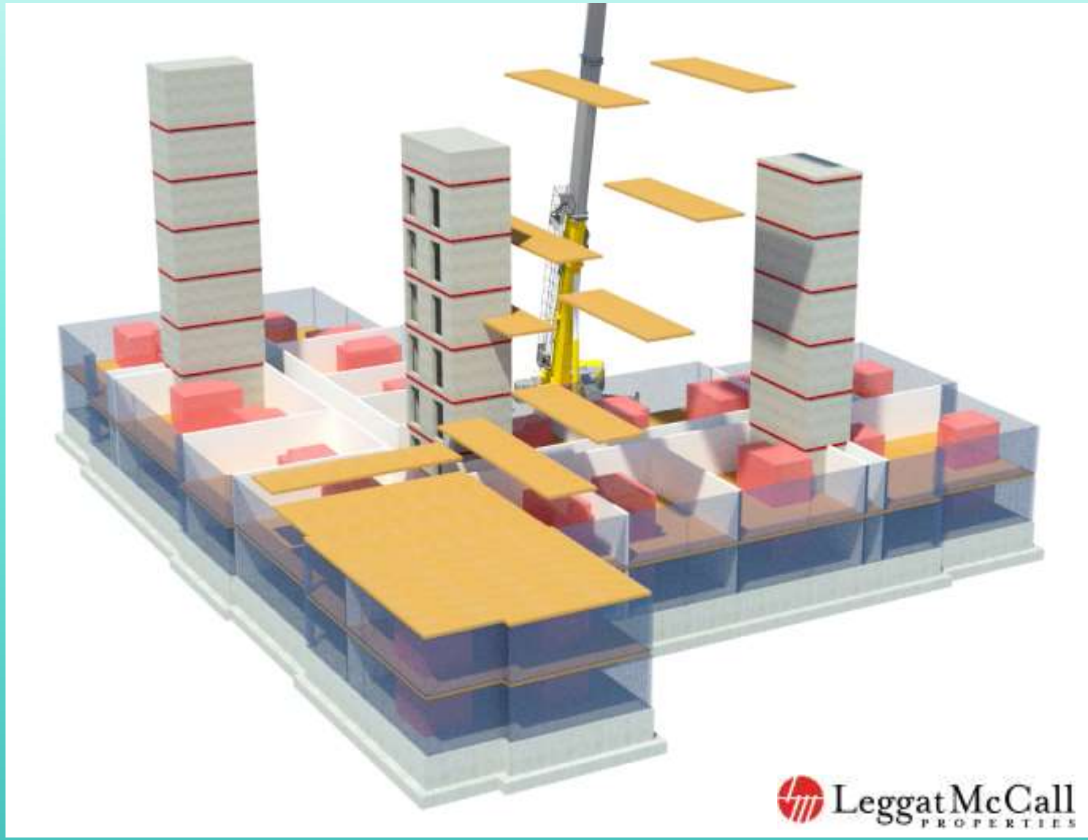
MATERIAL EXPLORATIONS: Why CLT?

- Long span 7 Ply CLT
  - 1 Piece
  - Lightweight floor panel



Credit: McNamara – Salvia

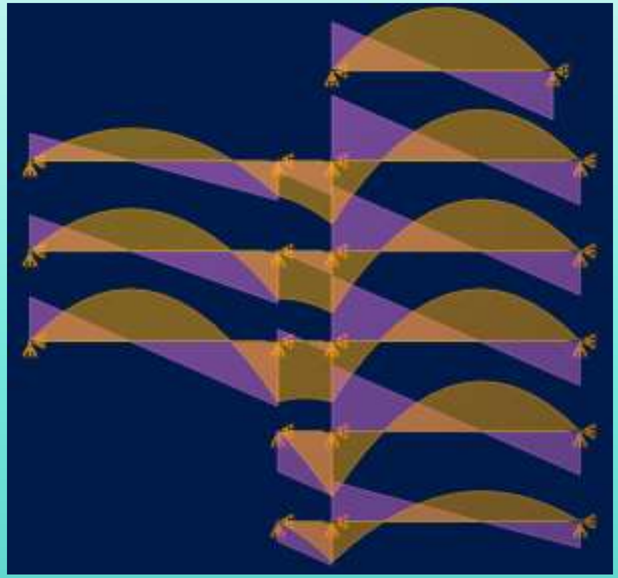
EFFECTIVE BUILDING TYPE

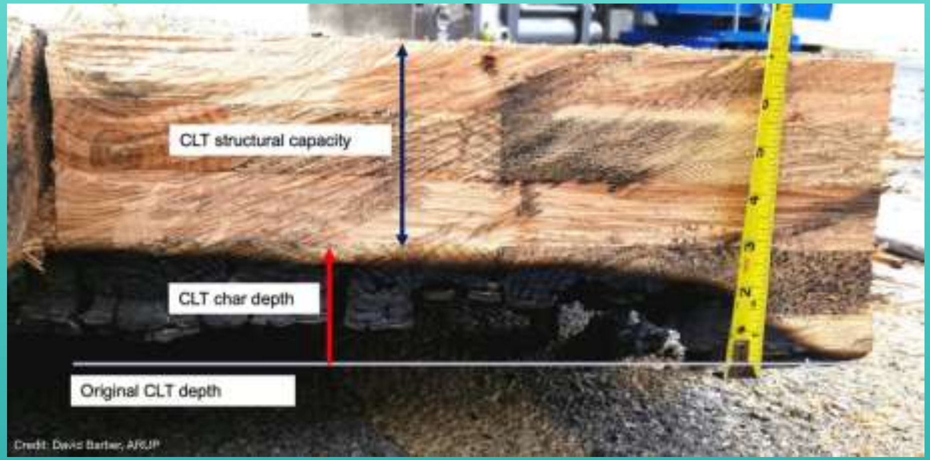


- Speed of Erection: every load carrying element is pre-fabricated

DESIGN PARAMETERS

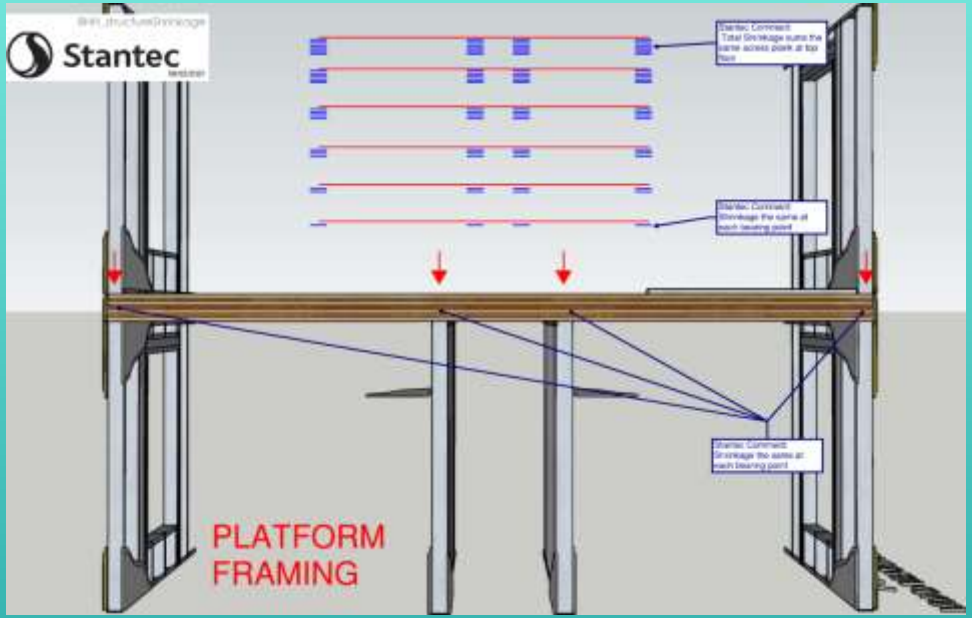
- Service loads
  - Varying span & skip load conditions
- Fire Resistance: Type IV-C
  - 2 Hour char time

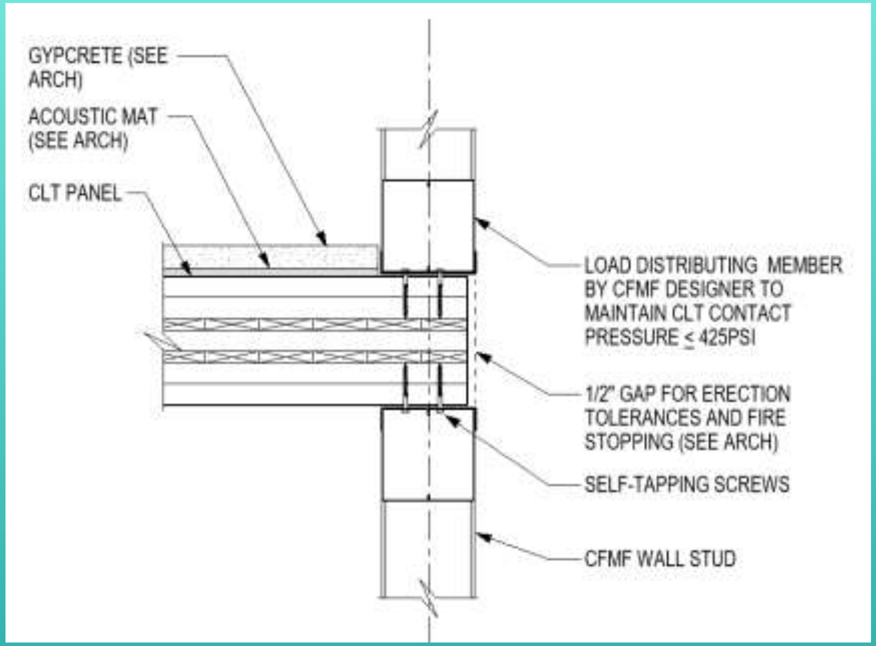




DESIGN PARAMETERS

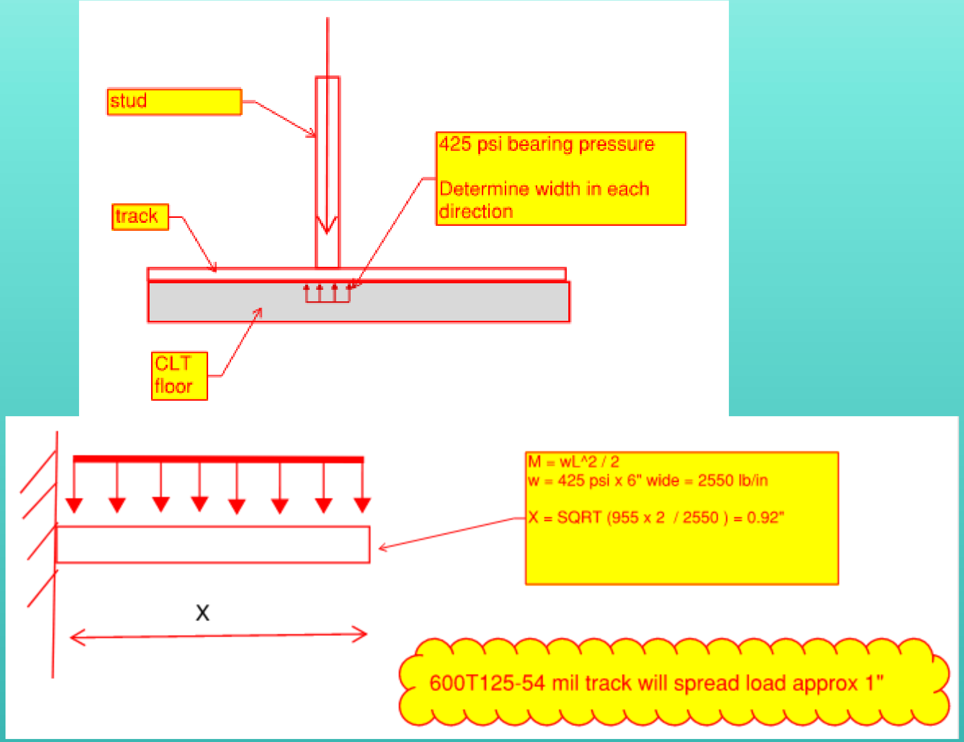
- Wood shrinkage of CLT
  - Platform style construction
- Crushing of timber perpendicular to grain
  - CFMF studs bearing on CLT

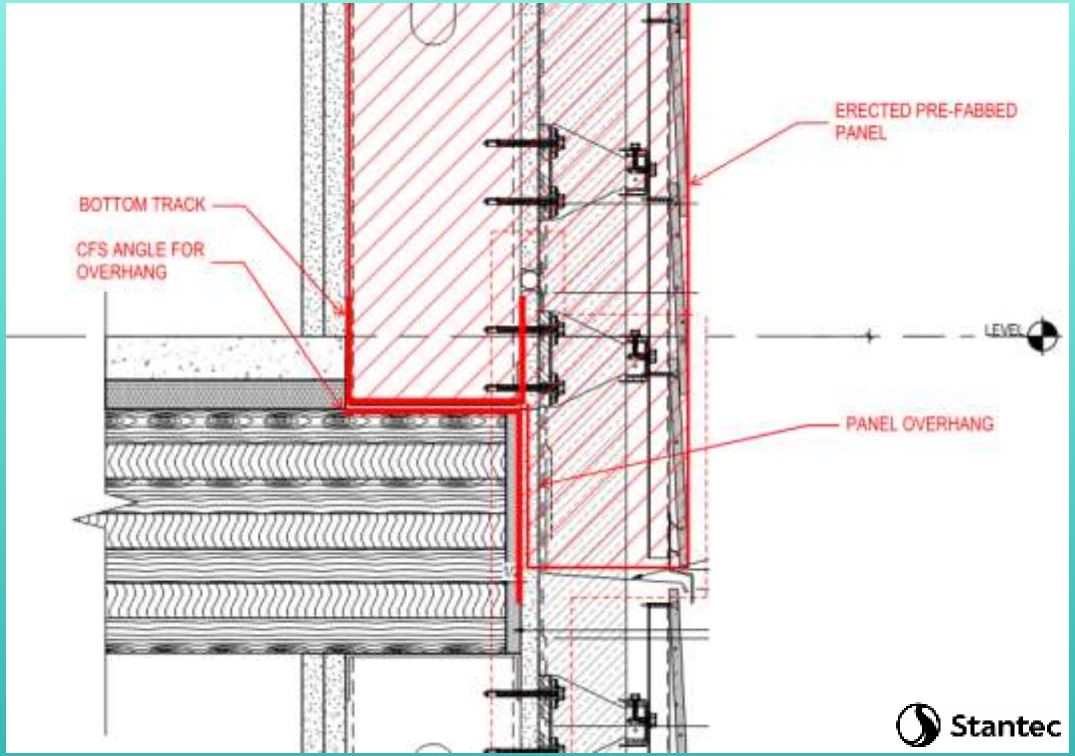




DESIGN PARAMETERS

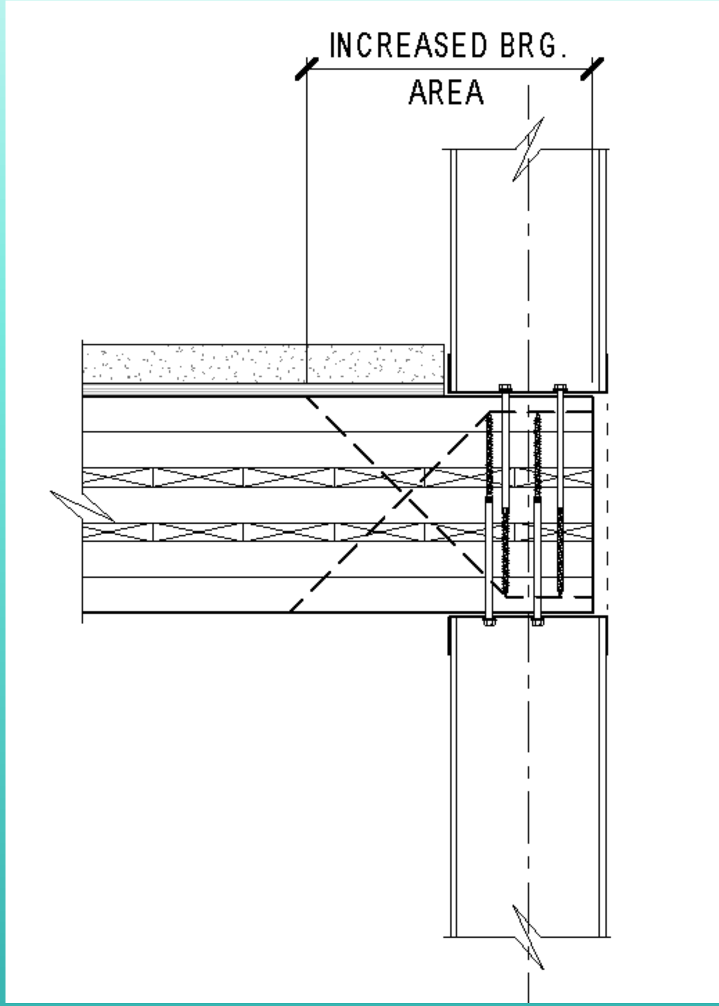
- Crushing of timber perpendicular to grain
  - Track acts like base plate
  - Added angle aids in overhang support





DESIGN PARAMETERS

- Taller building = higher crushing loads
- Expand on current detail?
  - Screws are owned for lateral chord loads
  - Make them longer for bearing area increase?



OTHER DESIGN CONSIDERATIONS

- Vibrations: analytical review

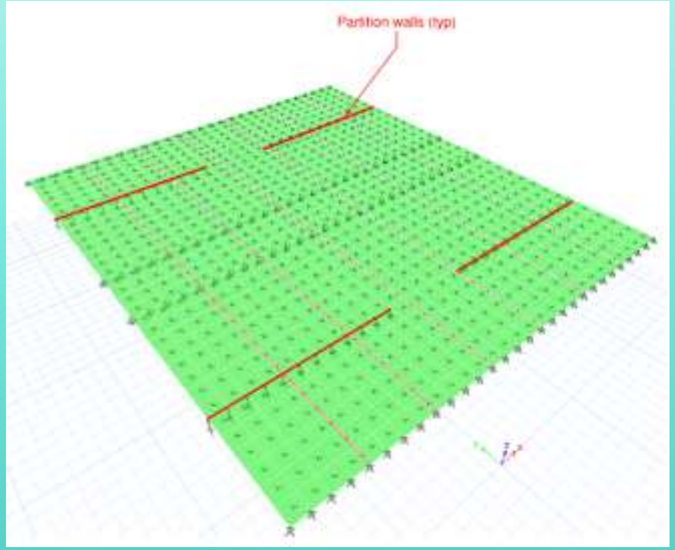
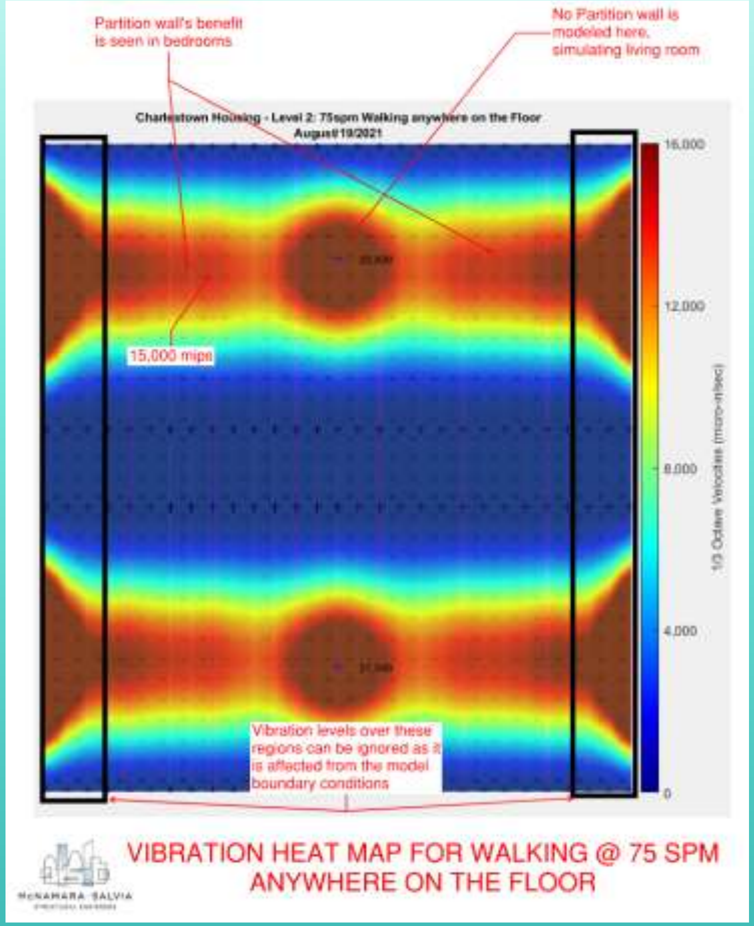


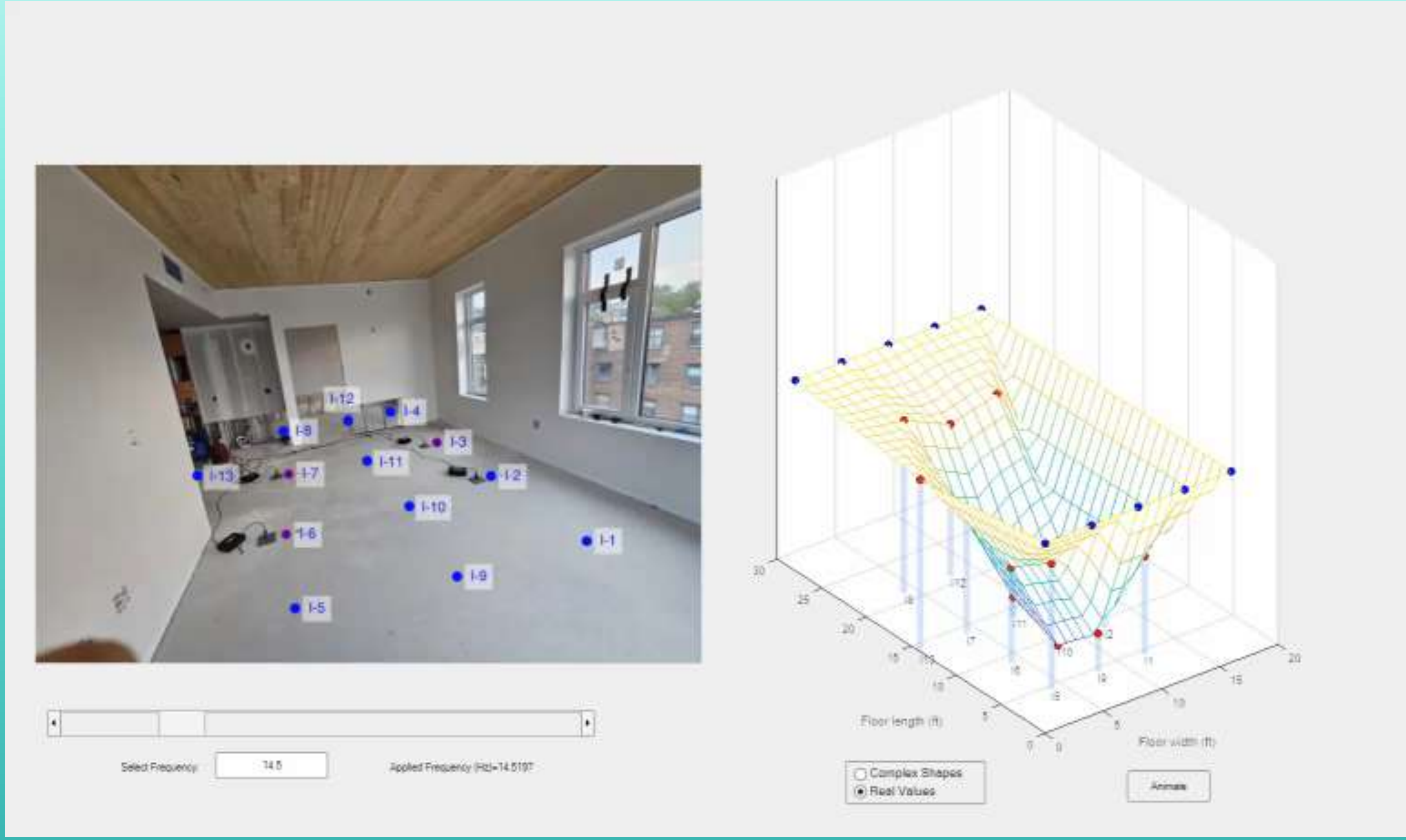
TABLE 3-13: Suggested performance targets		
Place	**Peak Acceleration Target**	**RMS Velocity Target**
Offices or residences	0.5% g	16,000 - 32,000 mips
Premium offices or luxury residences	0.3% g	8,000 - 16,000 mips

Source: WoodWorks – Vibration Design Guide



OTHER DESIGN CONSIDERATIONS

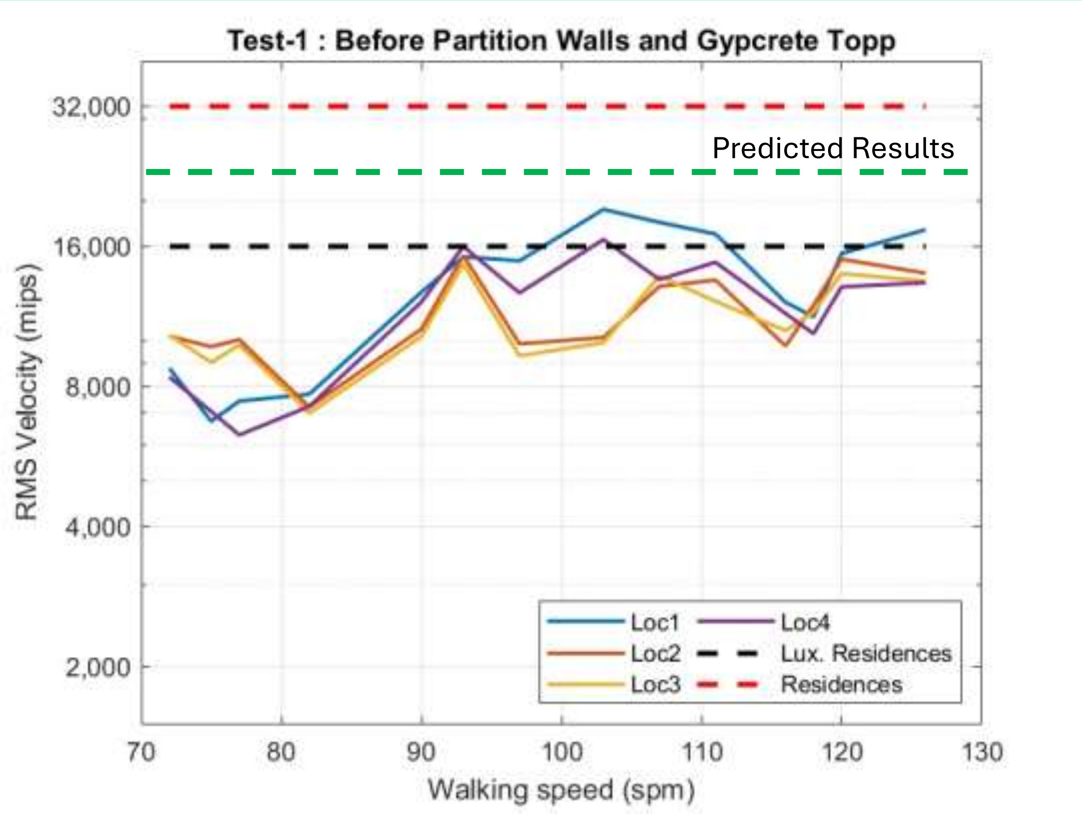
- Vibrations: in-situ results

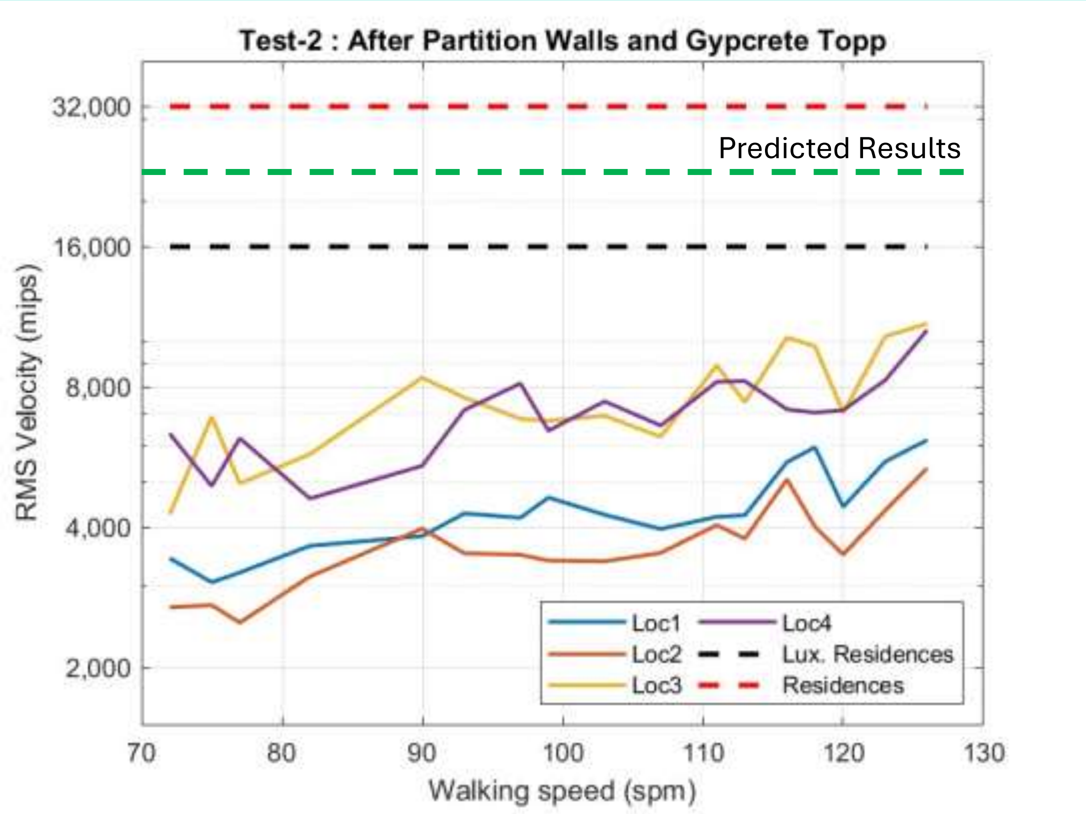


Credit: McNamara – Salvia

OTHER DESIGN CONSIDERATIONS

- Walking test results





Credit: McNamara – Salvia

CLT & CFMF BENEFITS

- CLT's single span across building
  - Less crane picks – faster erection
  - Maximizes fabrication efficiency
- CLT's light weight
  - Lower foundation impact
- Diaphragm strength
- CFMF's high load wall capacity
- CFMF's prefab – faster erection

USE MATERIAL CHOICES WISELY AND APPLY THEM WHERE THEIR STRENGTHS INCREASE THE VALUE OF YOUR PROJECT

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

HERCEND MPIDI BITA, Ph.D. P.Eng. P.E.
Principal
Timber Engineering Inc.
400-19 East 5th Avenue
Vancouver, BC V5T 1G7
C +1 778 903 4553
hercend.mpidibita@timberengineering.ca

TIMBER ENGINEERING

Bryan P. Maltais, P.E.
Associate
McNamara · Salvia
One Federal Street, Suite 3710
Boston MA 02110
C 617-850-4155
bmaltais@mcsal.com

McNAMARA · SALVIA STRUCTURAL ENGINEERS