Understanding Mass Timber and Cold-Formed Steel Hybrid Construction

MASS TIMBER+ SM

OFFSITE CONSTRUCTION CONFERENCE

PRODUCED BY WOODWORKS WOOD PRODUCTS COUNCIL

FEA Forest Economic Advisors

Credits: 1.0 AIA/CES HSW LUs, 1.0 PHD credit, 0.10 ICC credit

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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.

Incorporating Mass Timber in Hybrid Structures

Bunker Hill Housing Redevelopment – Stellata

Development Vision

- To fast track the replacement of public housing units with pre-fabricated assemblies.
- To create a kit of parts model for sustainable urban design development.
- To be at the forefront of Sustainability with all buildings **committed to Passive House prior to Energy Code updates.**

Masterplan Program

- Residential, retail and community uses
- **15 Residential Buildings**
- **Replacement of 1,010 existing public housing units** with the addition of market rate units
- Total of **2,699 units**
- 37% affordable unit ratio
- 7 acres of open space
- 50,000 SF of retail space

Defining Design Targets

Rent-to-cost optimized product

- Limited unit, kitchen and bath types

Building forms and facades optimized for energy performance

- Early energy modeling to set design parameters

Structural system optimized for tall mid-rise (6-12+ stories)

Phase 1: Stellata

- Building M
- 6 Story Building
- 120,000 Gross SF
- **102 units – 100% affordable**
- Passive House
- **2021 IBC IV-C**

Partners

Design Team

Stantec
Copley Wolff
Lam Partners
McNAMARA·SALVIA
ACENTECH
integrated ecostrategy
HOWE ENGINEERS
Nitsch Engineering

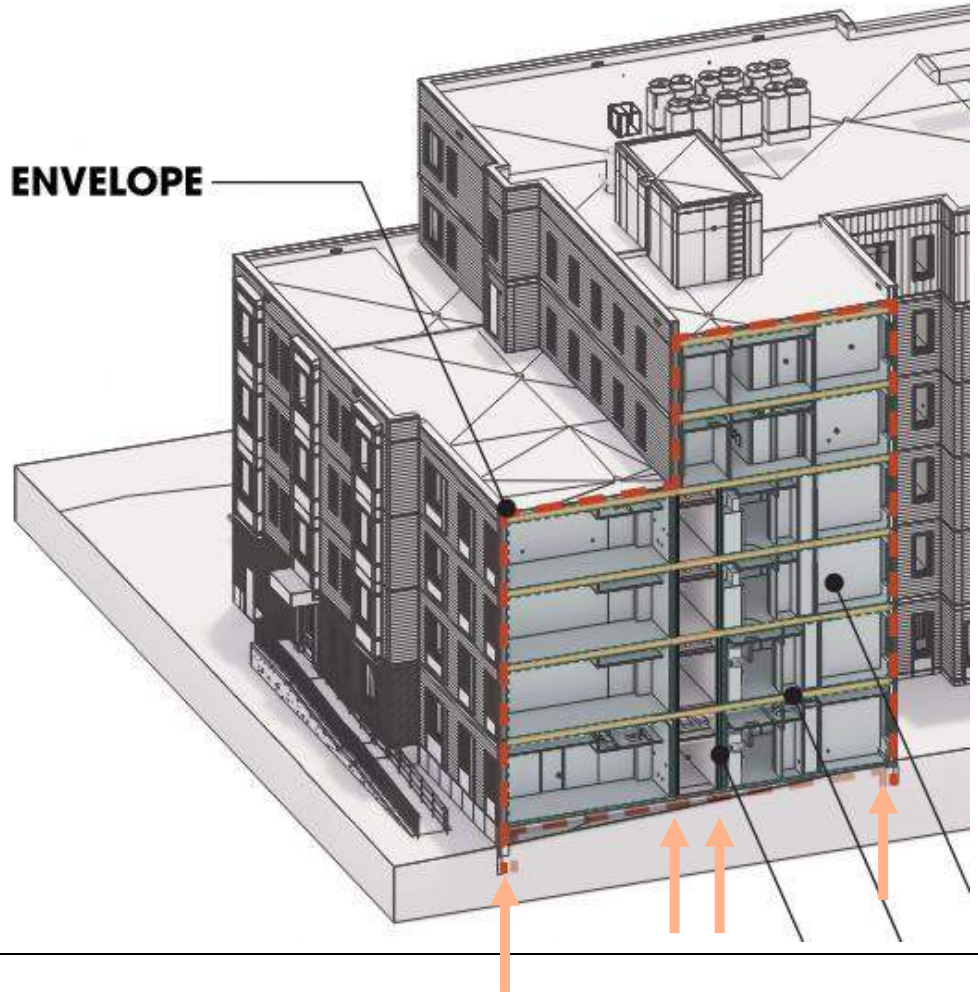
Construction Team

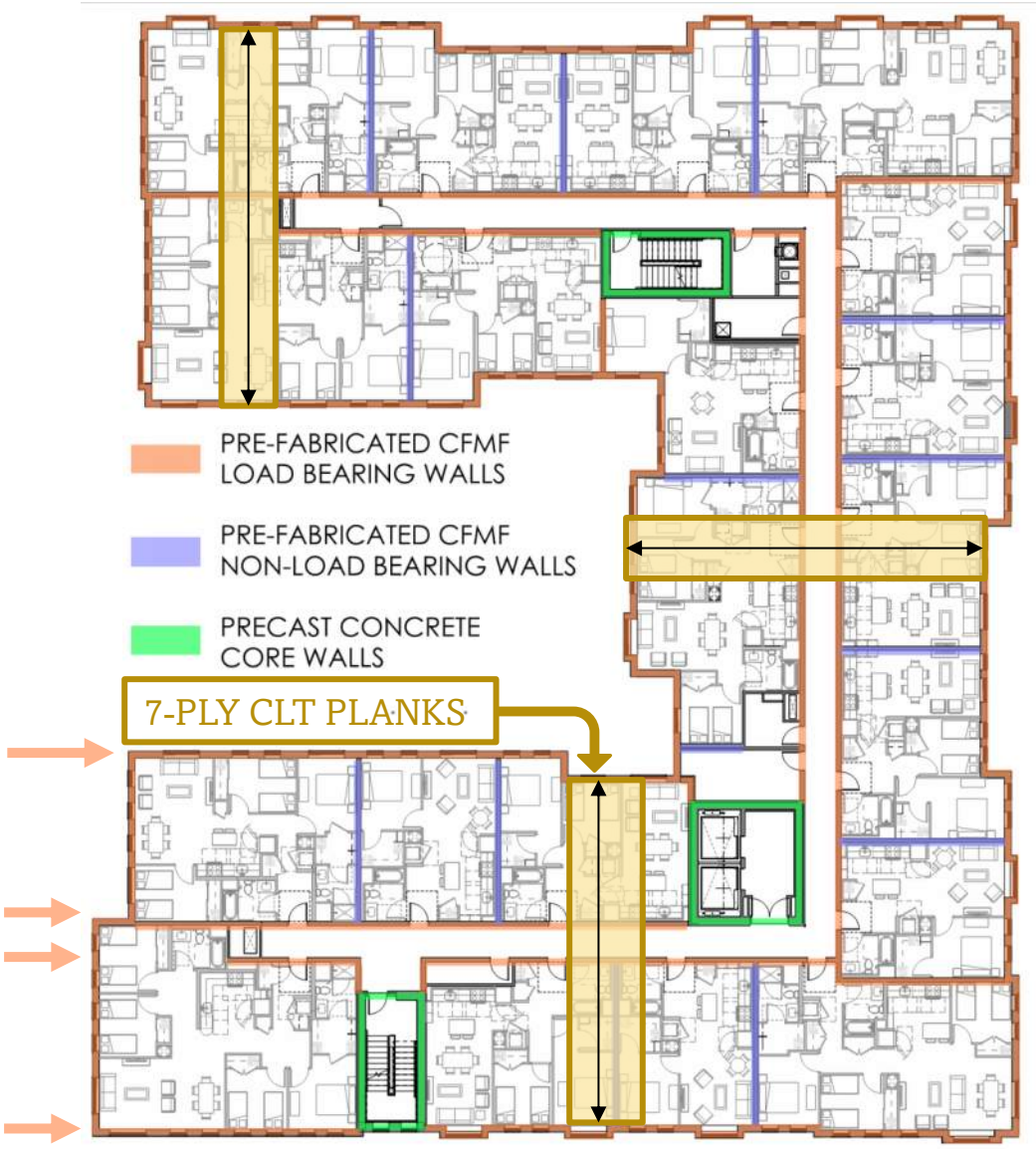
SUFFOLK

Passive House Team

- CPHC: PE Petersen Engineering
- CPHV: RDH BUILDING SCIENCE

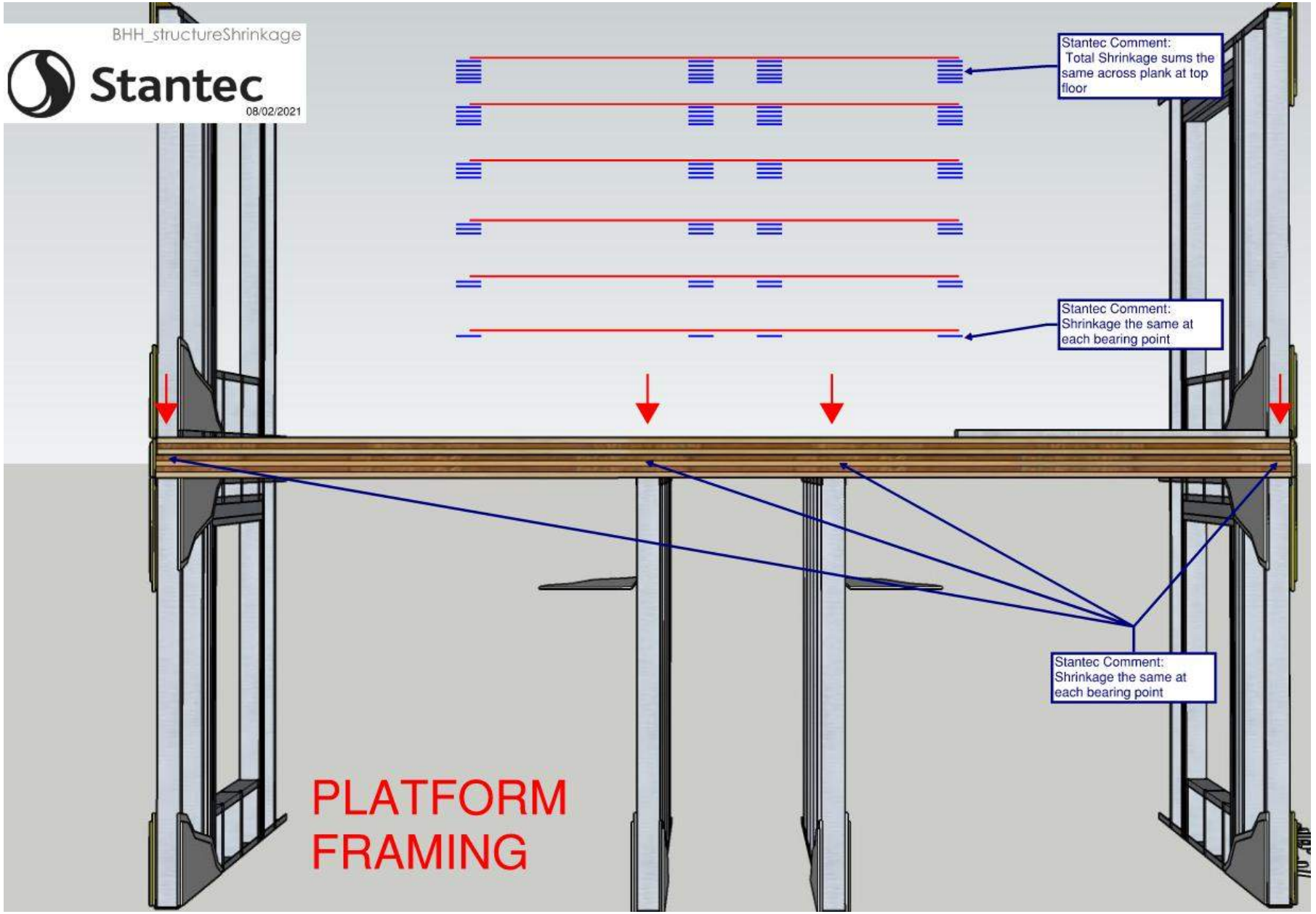
Component Construction





BUNKER HILL HOUSING

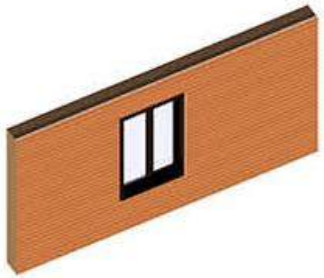
Platform Framing

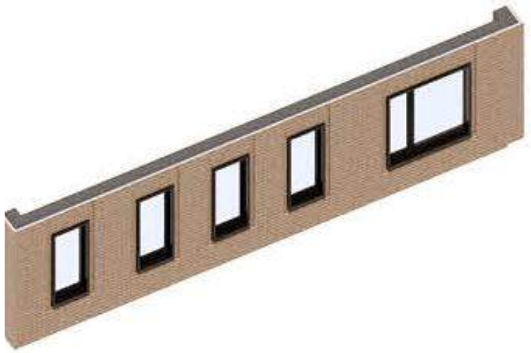


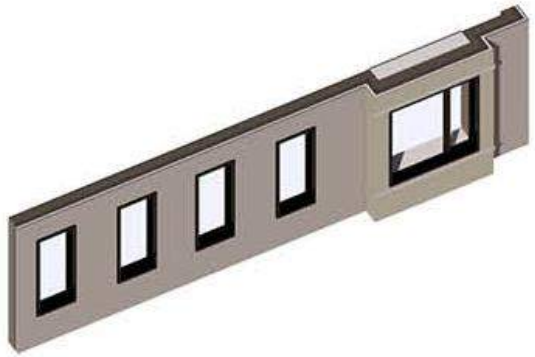
Leggat McCall PROPERTIES

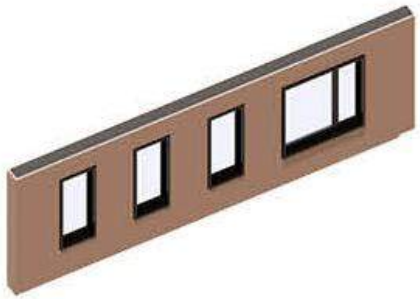
COMPONENT CONSTRUCTION ANIMATION

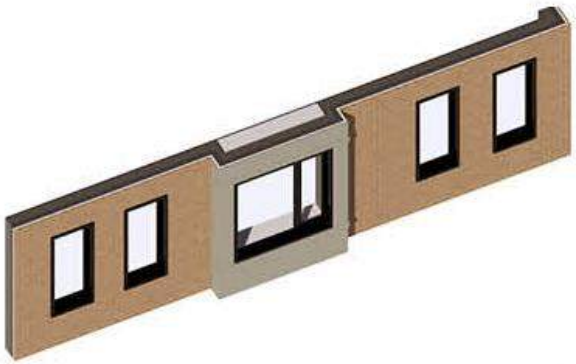
FOUNDATIONS

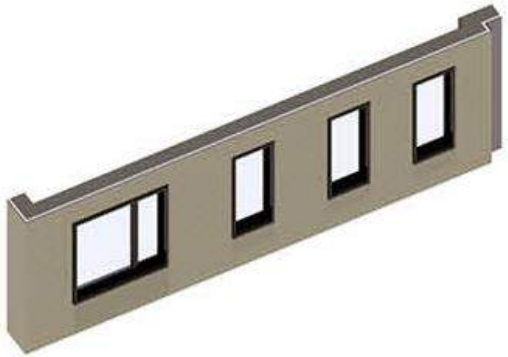


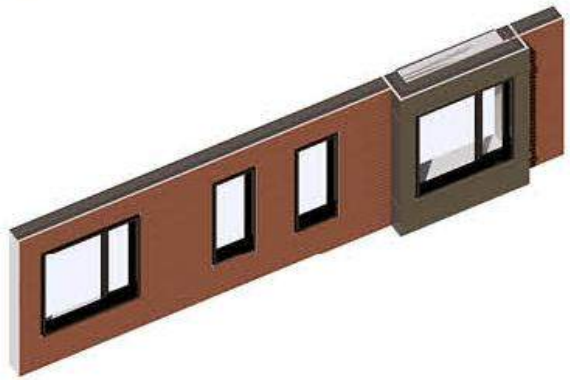






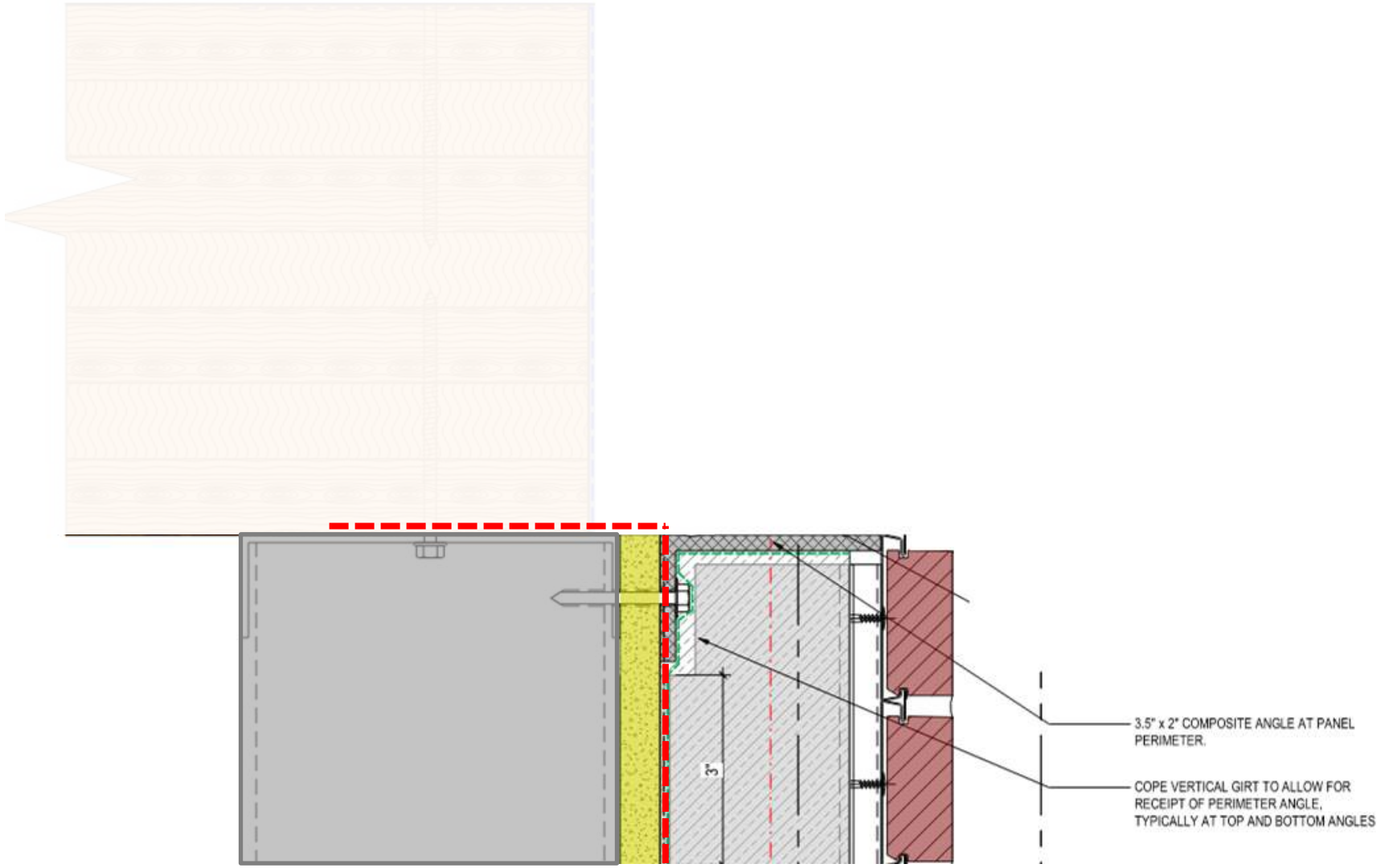






New Constructability Approach

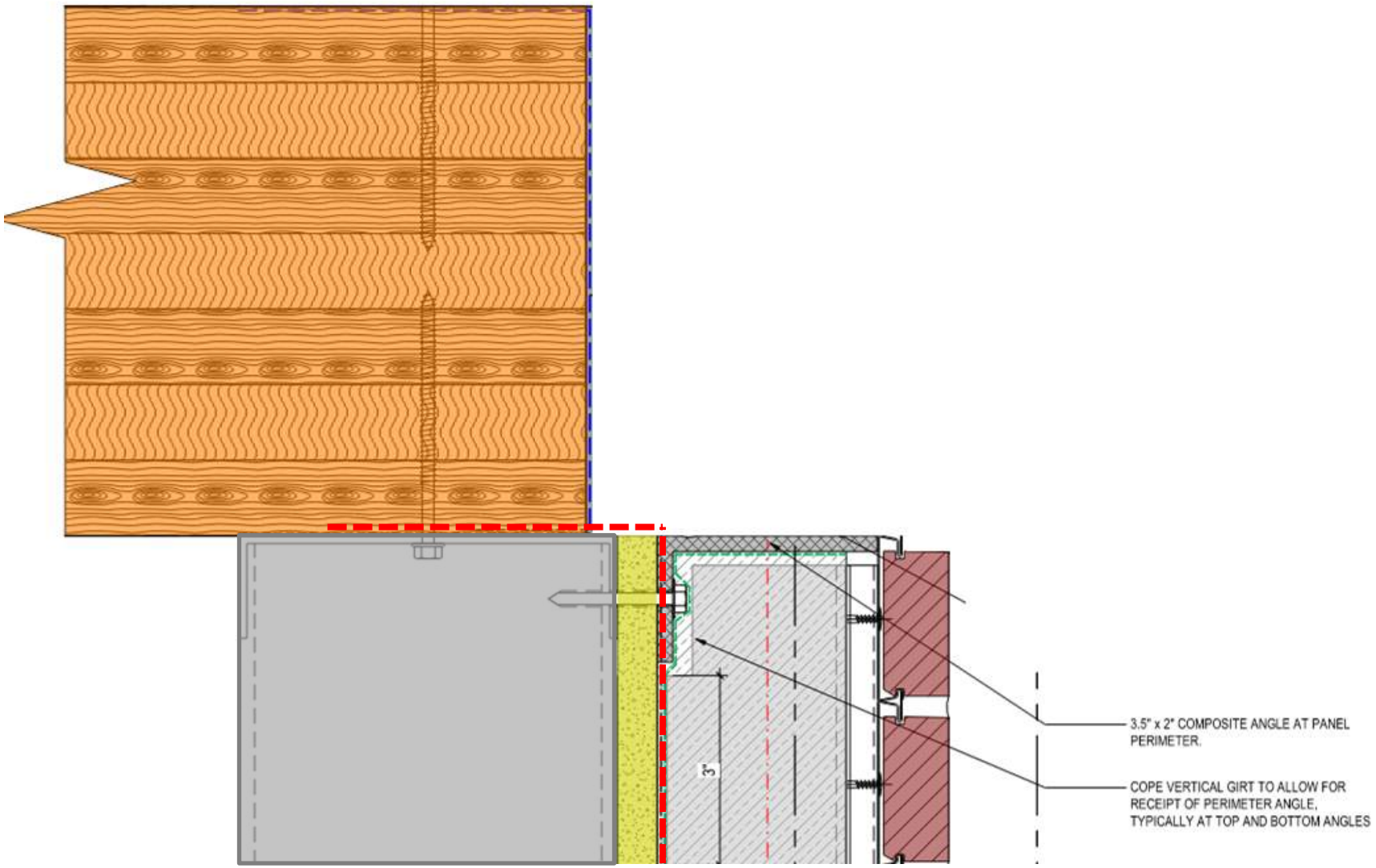
Prefabricated exterior walls with cladding installed at the factory.



New Constructability Approach

7 ply CLT (62’)

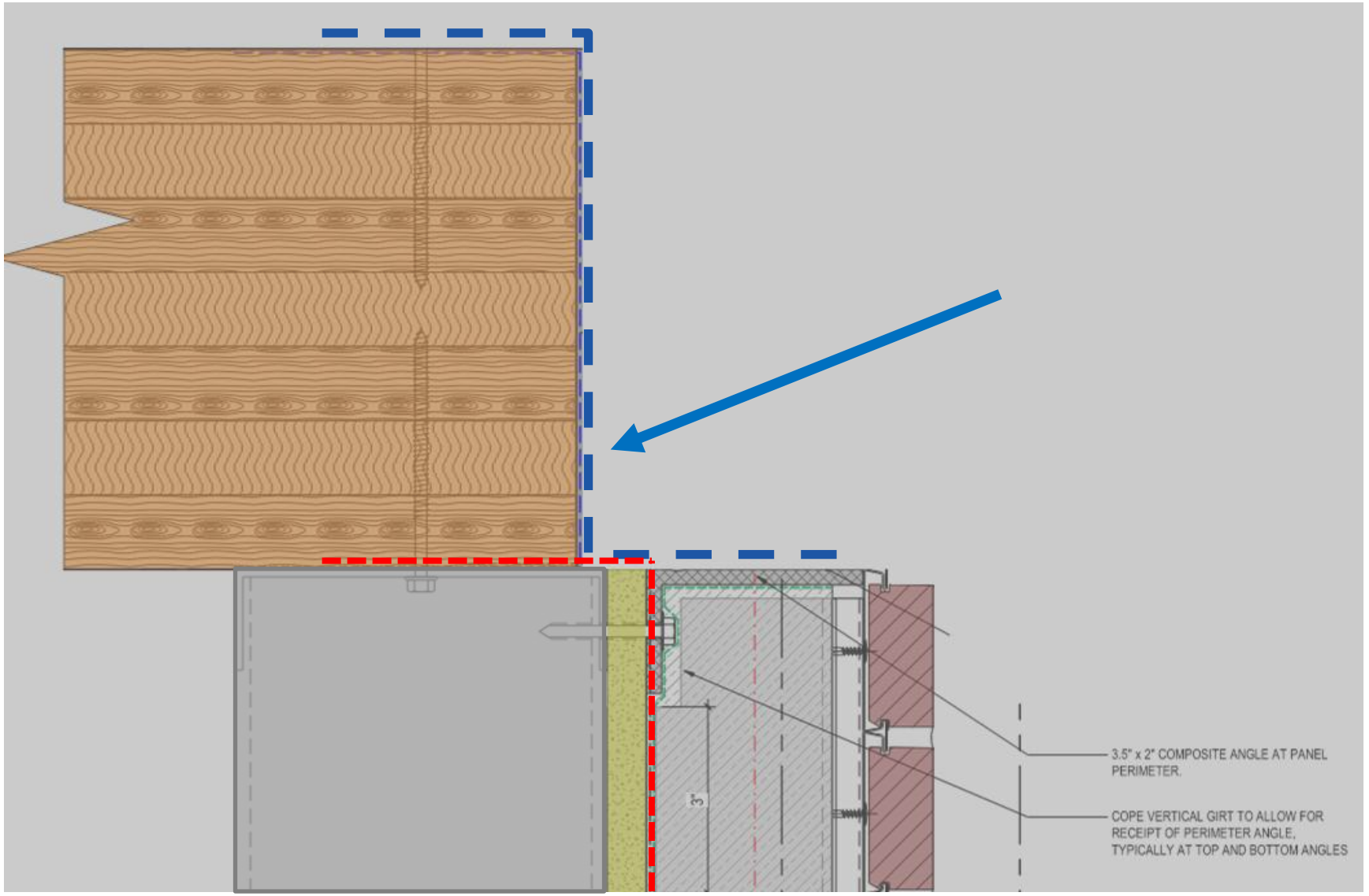
Bearing on exterior and corridor walls.



New Constructability Approach

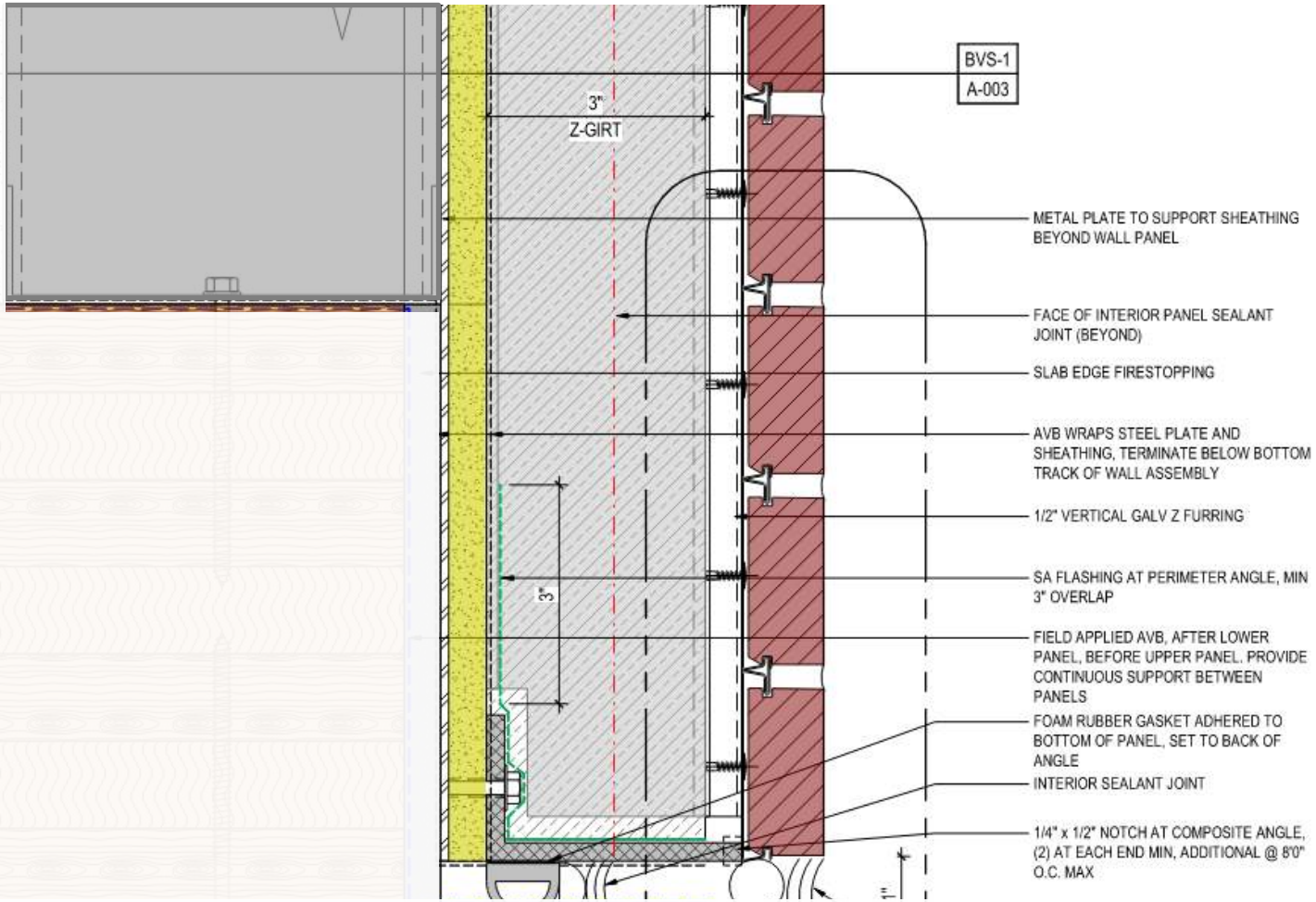
AVB “Z” dual purpose:

- CLT Moisture protection
- Air and water seal at the exterior wall panels 4-joint



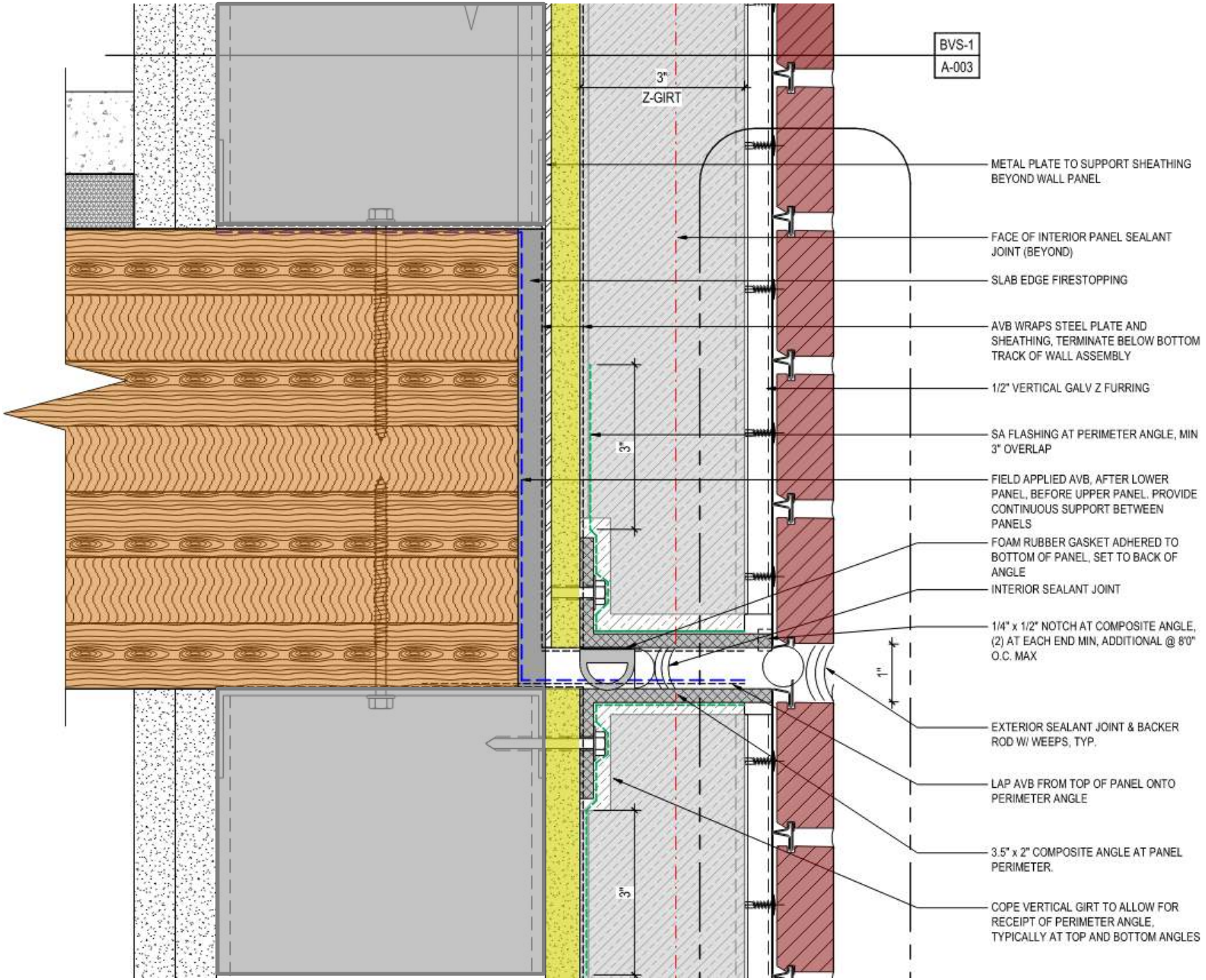
New Constructability Approach

Upper Panel



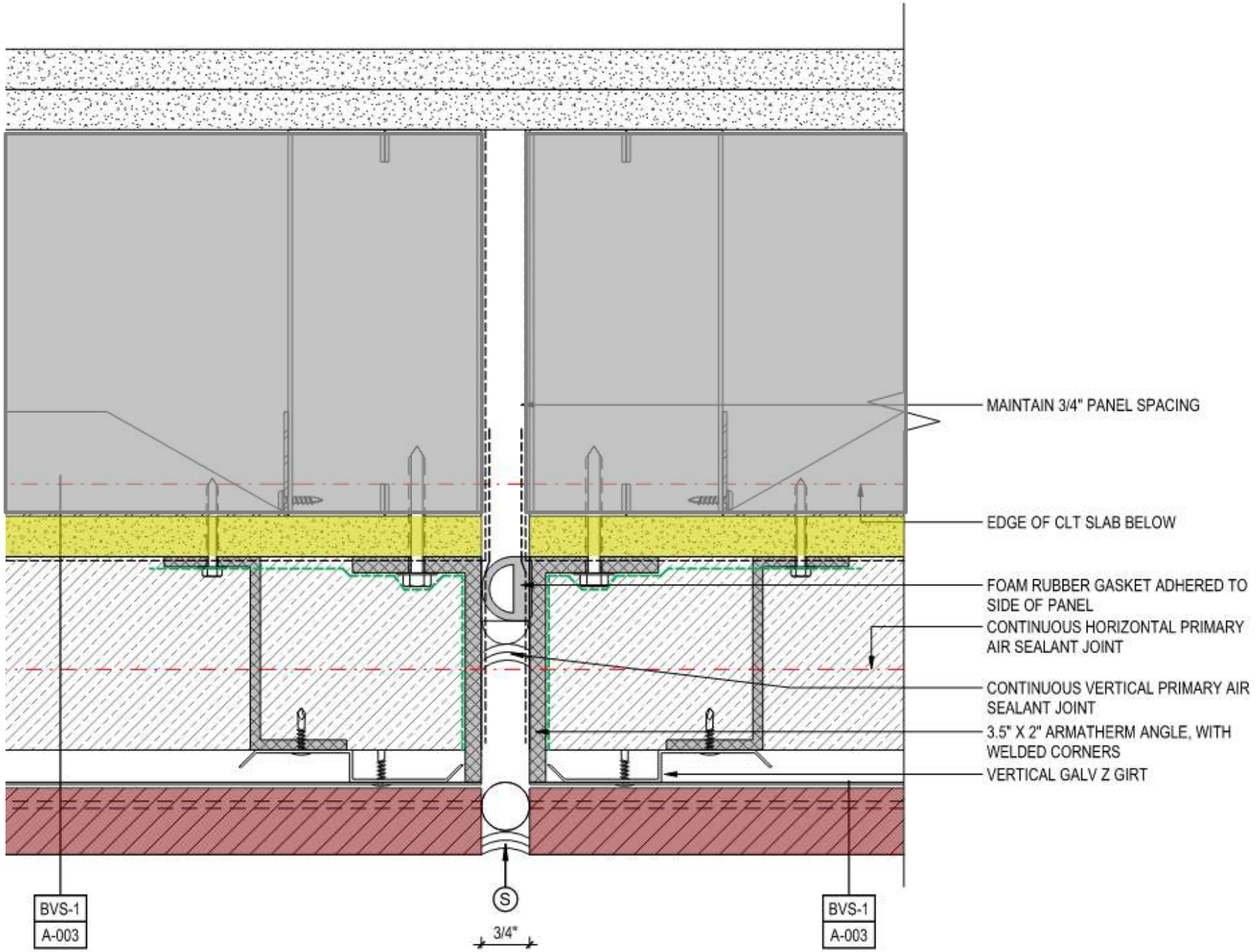
New Constructability Approach

Horizontal Joint



New Constructability Approach

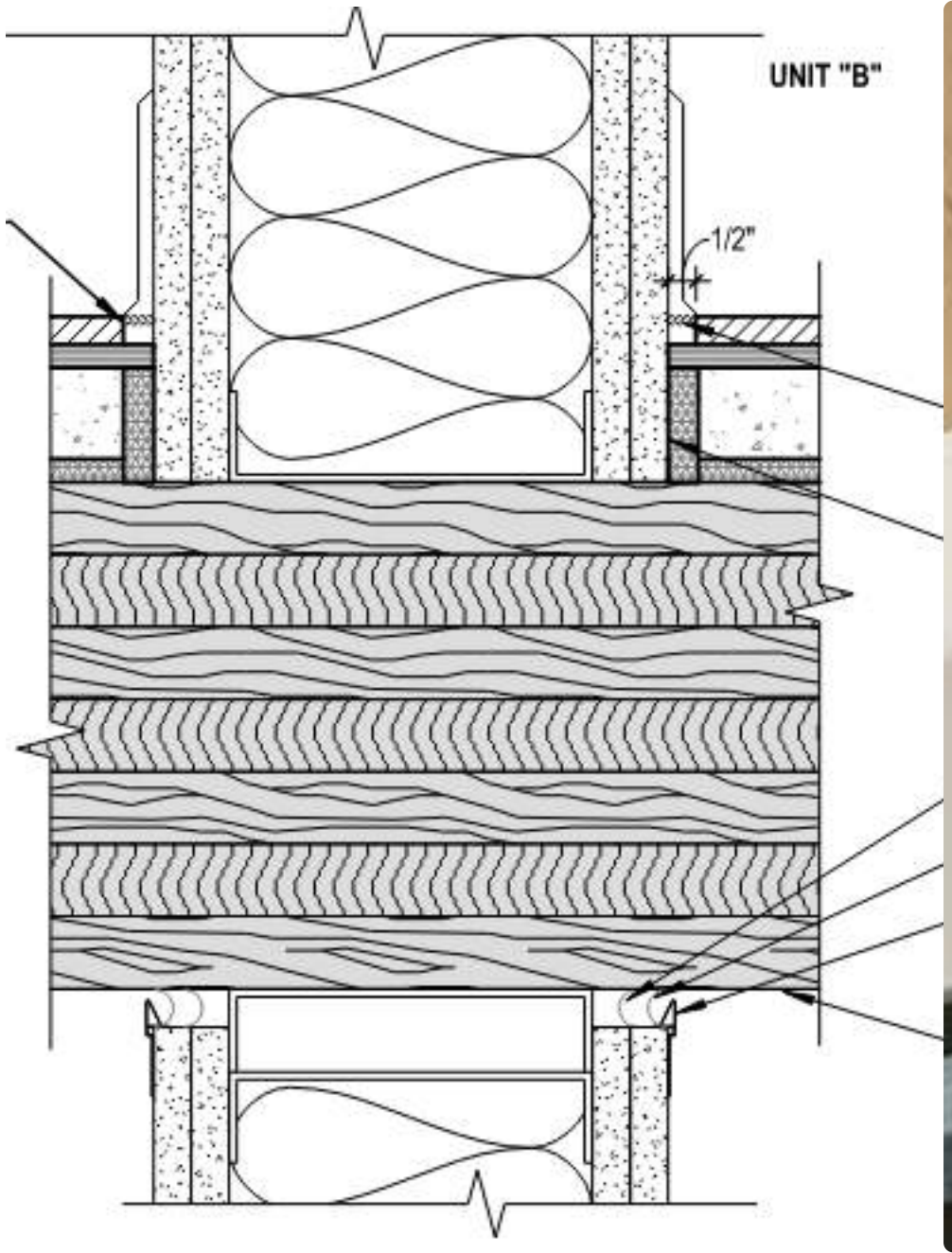
Vertical joint



Deflection

Deflection bead at areas where demising wall met exposed CLT ceilings

App 5/8” deflection at floors and roof



Acoustics

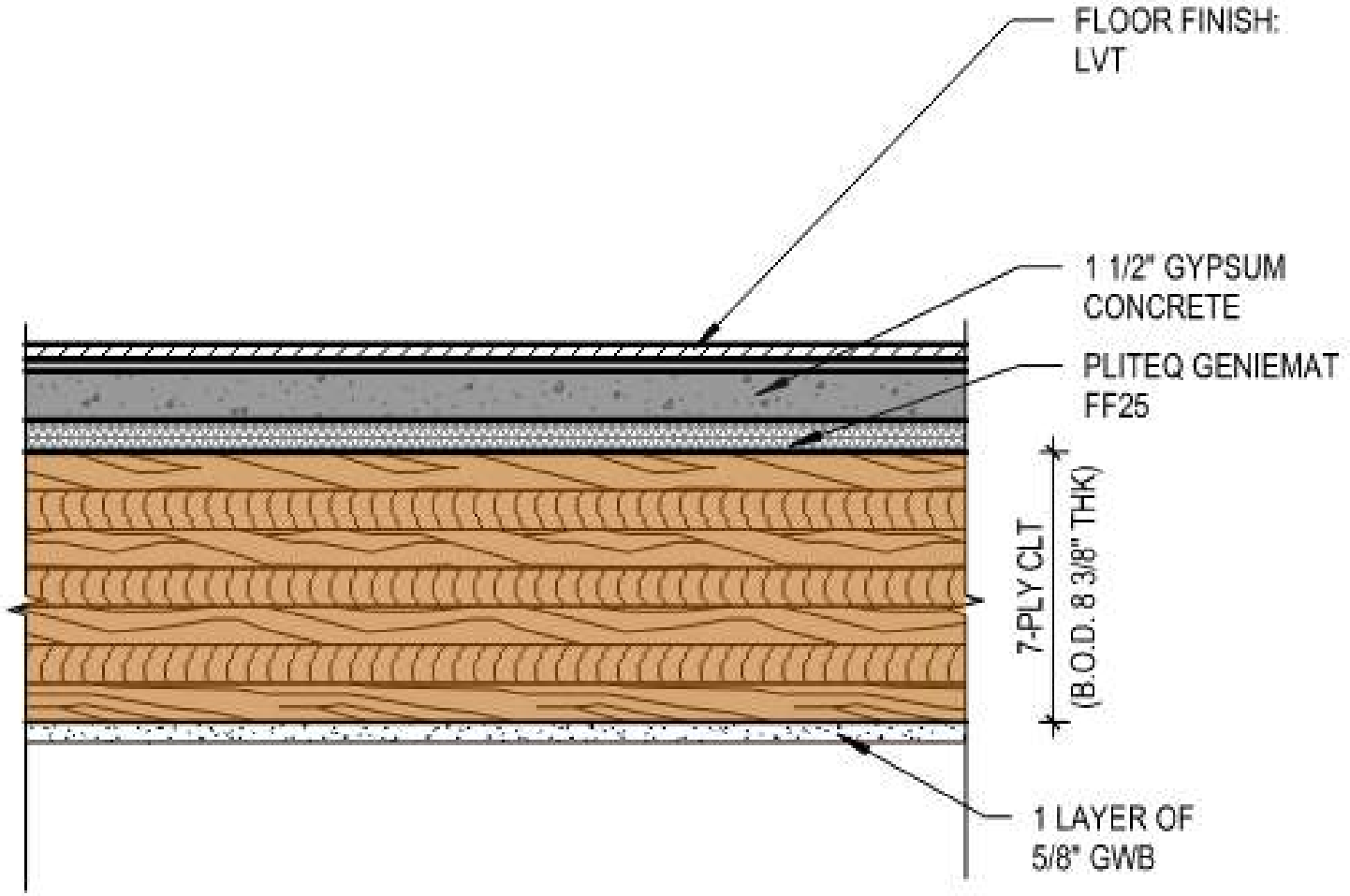
Tested assemblies that meet the project goals using 7-ply CLT

Lab Results:

STC 55 / IIC 50

Field Test Results:

STC: 57 / IIC: 49



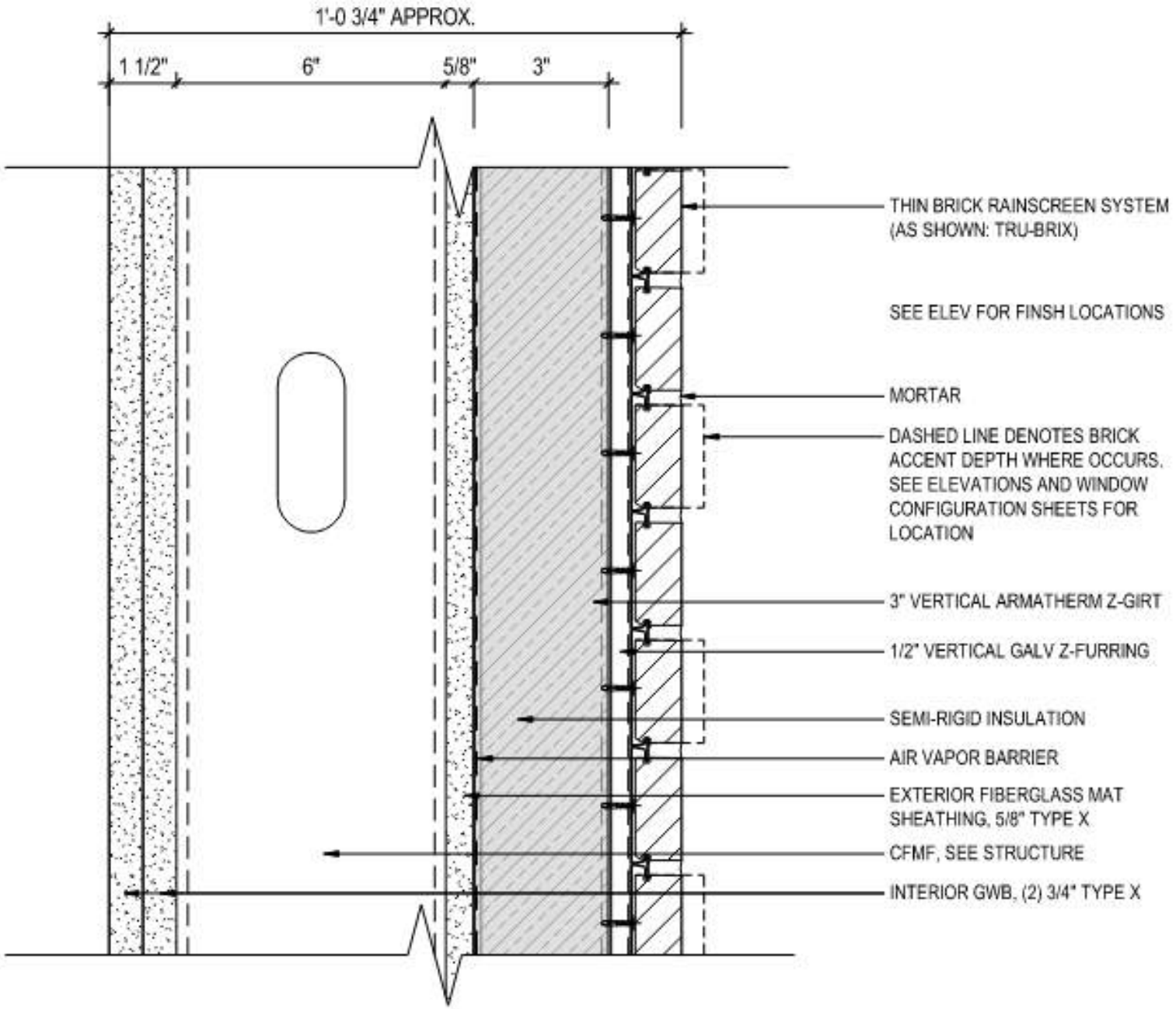
PENETRATIONS IN FLOOR:
1.FIRESTOP PENETRATIONS IN THE FLOOR.

MIN. STC 50
MIN. IIC 50

FLOOR TYPE	CLT FLOOR ASSEMBLY 2HR RATED (BASIS OF DESIGN)

Fire Rating

- **2HR rated exterior walls**: UL 425
- **2021 Type IV-C: Variance at the time of permitting**



2HR BEARING WALL : UL# - U425 R VALUE = 14

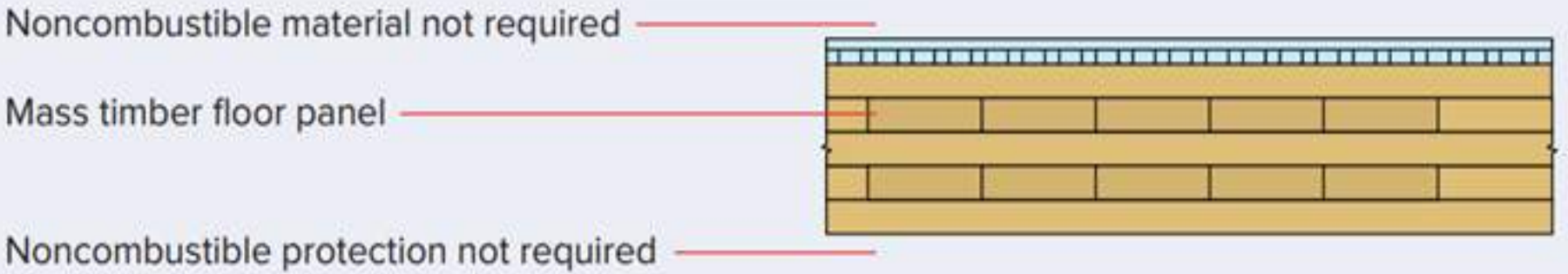
Concealed Spaces

Combustible material protection required in concealed spaces under 2021 IBC Type IV-C

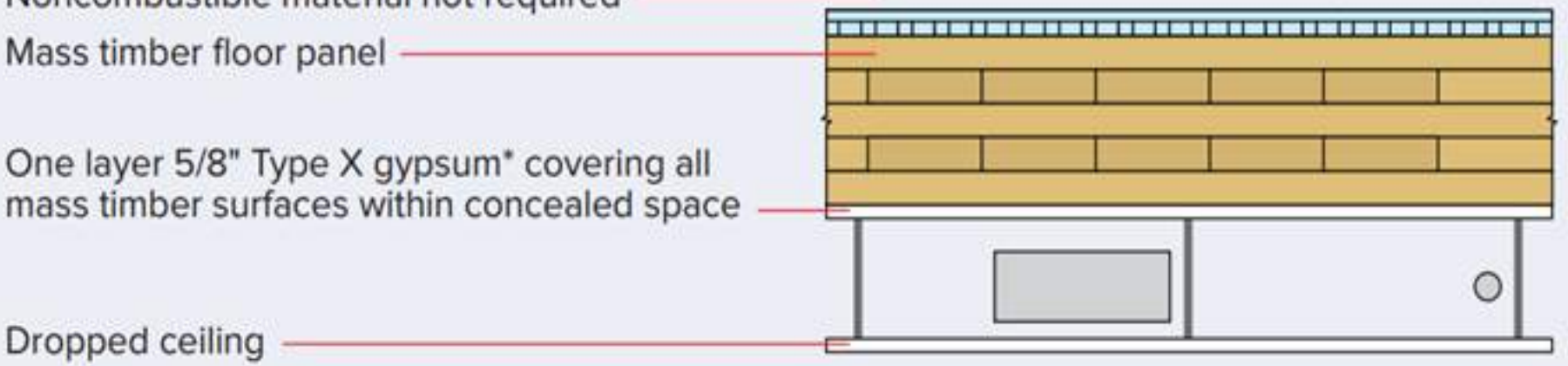
Taping and sealing of GWB joints, challenge sequence

CONCEALED SPACES: TYPE IV-C

Without Dropped Ceiling



With Dropped Ceiling



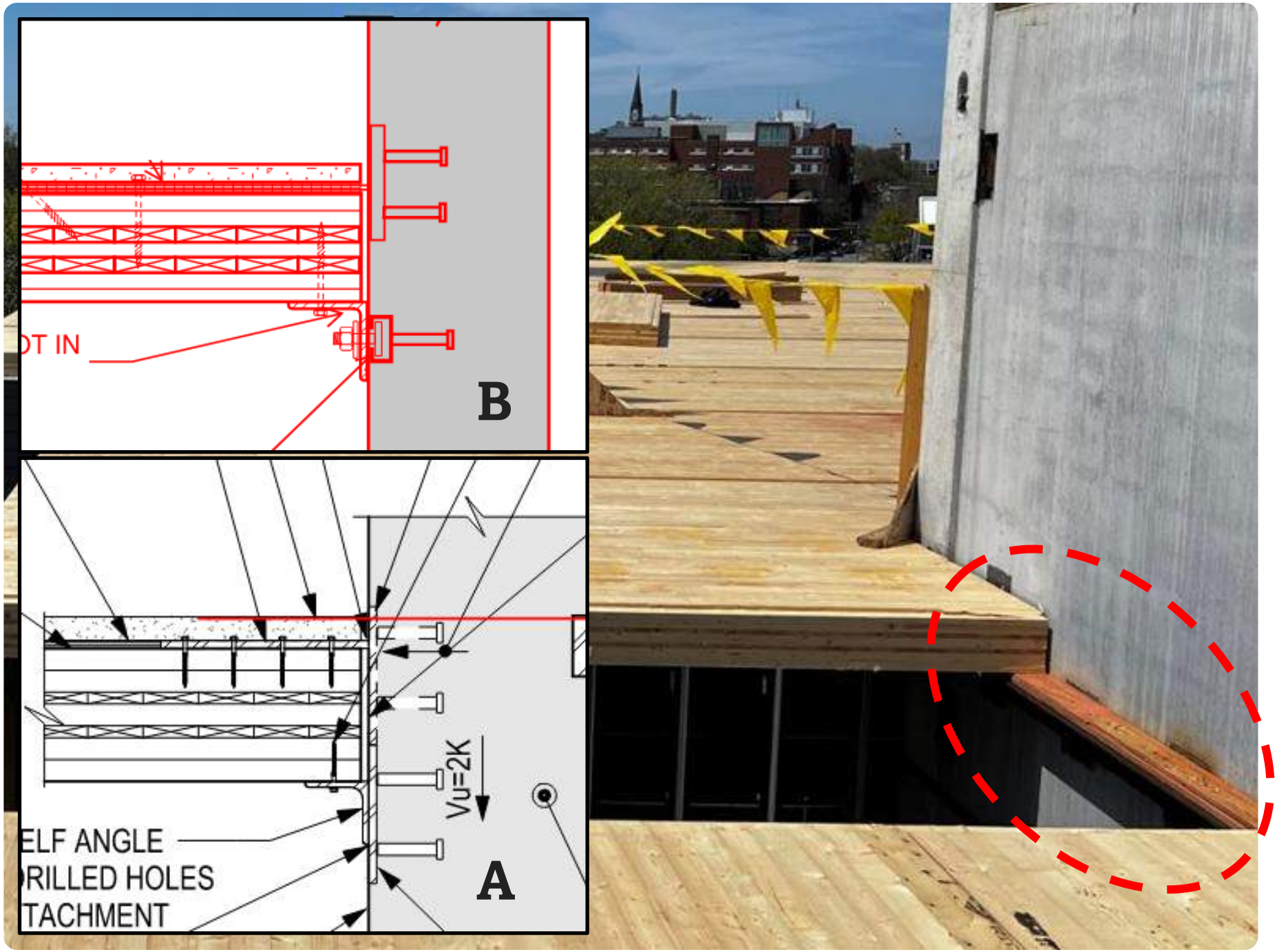
SOURCE: WOODWORKS

Challenge: Concealed Spaces

Combustible material protection required in concealed spaces under 2021 IBC Type IV-C

Lessons Learned

- Connection of CLT to precast concrete walls.
- Welded Connection vs Bolted slotted connection



Lessons Learned

- Oversize door frame openings

Lessons Learned

- L-Shape plate at top of exterior wall panel, exposed.

Benefits

Decreased Construction Timeframe

- 7K SF floor structure/day
- 21K SF exterior walls/6 days
- Building M: **102 units**, **16 months vs. 20+ mo.**
- 20%+ Reduction of Onsite Labor Hours
- 6-Man carpentry crew [CLT/Wall erection]

Reduced Temporary Construction Items

- No construction hoist or operator – materials preloaded during erection
- No exterior scaffolding – exterior walls glazed & finished
- No tower crane foundation
- Reduced winter weather mitigation

Benefits

CLT's single span across building

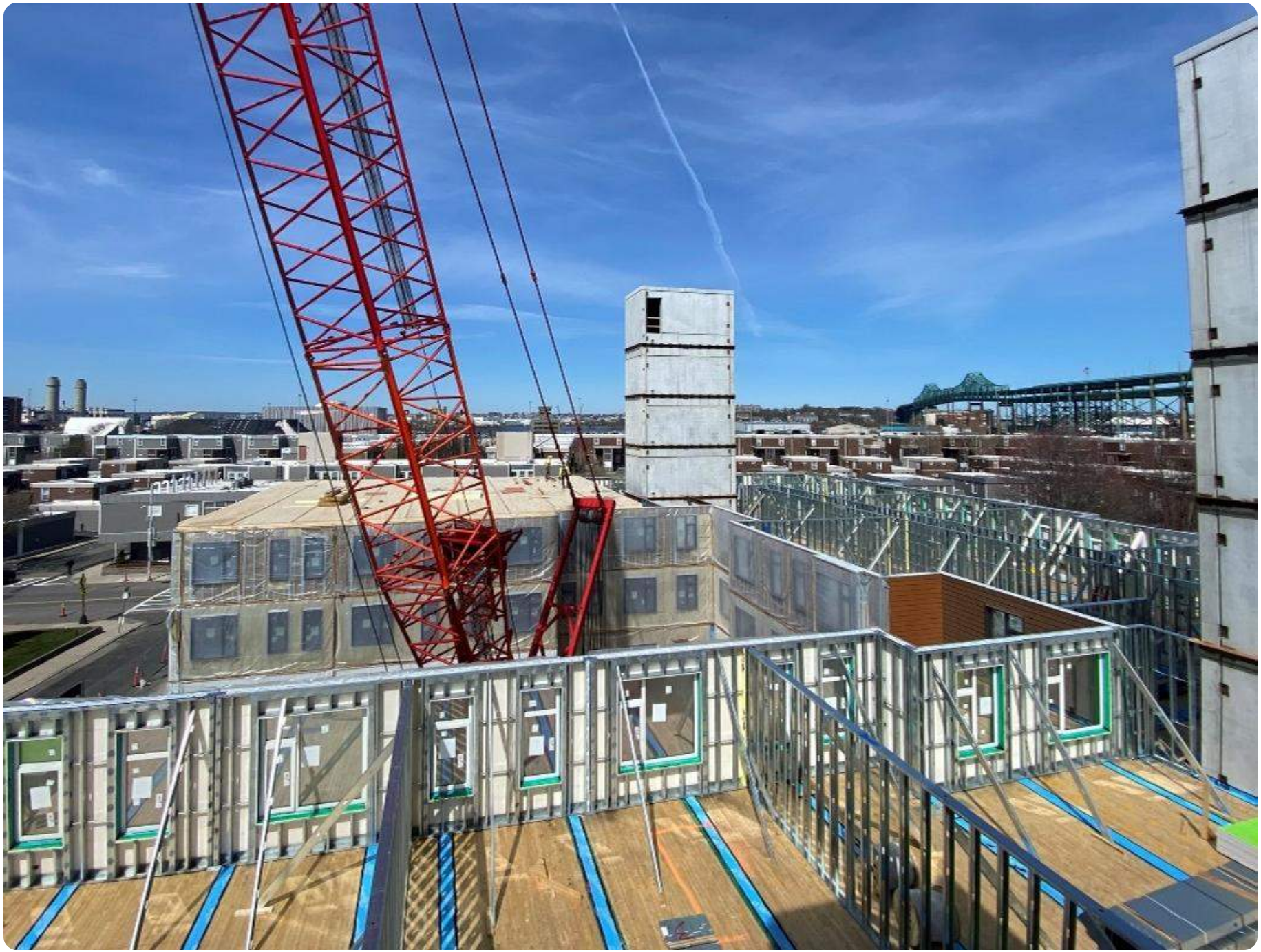
- Less crane picks – faster erection
- Maximizes fabrication efficiency

CLT's light weight

- Reduced foundation impact

Fire Resistance

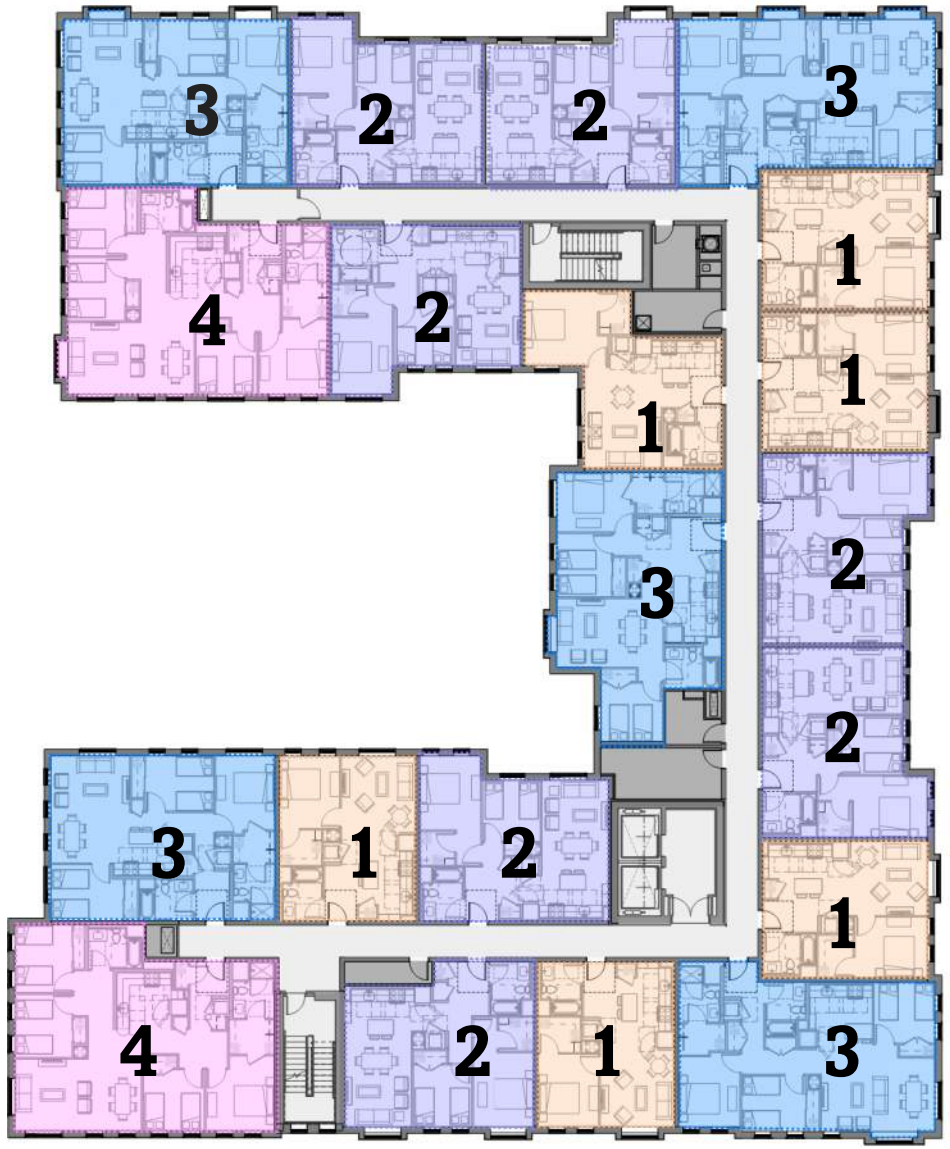
- Inherent 2HR fire resistance



Design Flexibility

Average Unit Size: 914 SF

Unit Type	%	Unit Size
1 Bedroom	32%	600 - 650 SF
2 Bedroom	35%	750 - 920 SF
3 Bedroom	23%	980 - 1,060 SF
4 Bedroom	10%	1,300 - 1,320 SF



Construction Progress


STELLAR

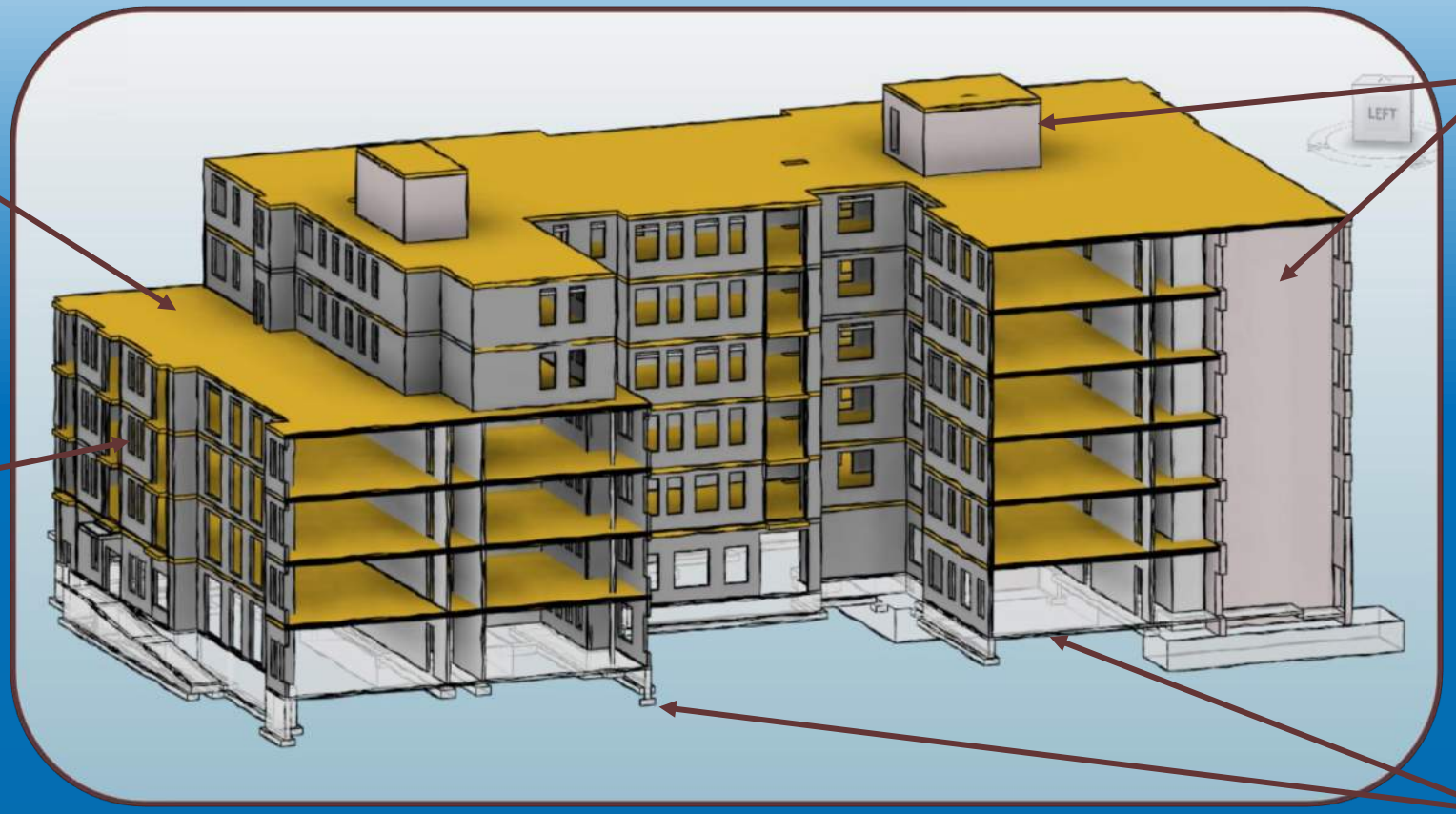
BUNKER HILL HOUSING

QUESTIONS?

BHH – BUILDING M
STRUCTURAL OVERVIEW

CLT floor panels

CFMF bearing walls



Precast Concrete stair/elev. cores

Concrete Slab-on-Grade & Spread Ftgs.

Credit: McNamara – Salvia

Presented by:
Bryan P. Maltais, P.E.
LiRo-Hill

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)

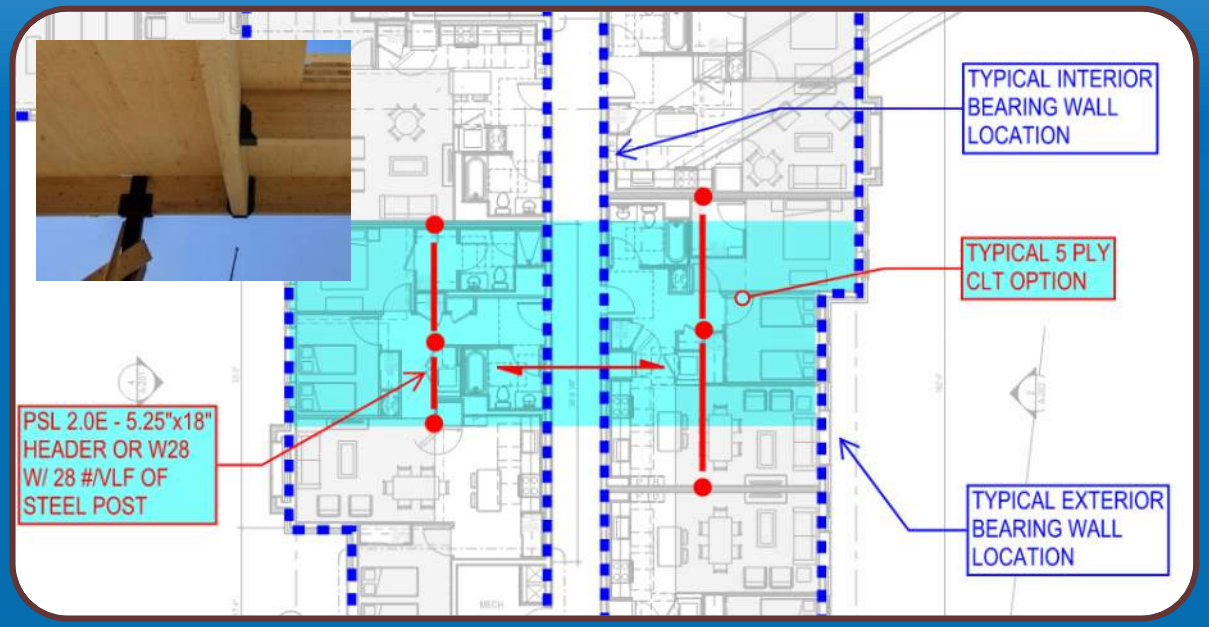
BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[b,c]	0
Bearing walls												
Exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[a]	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)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1½	1	1	HT	1[b,c]	0

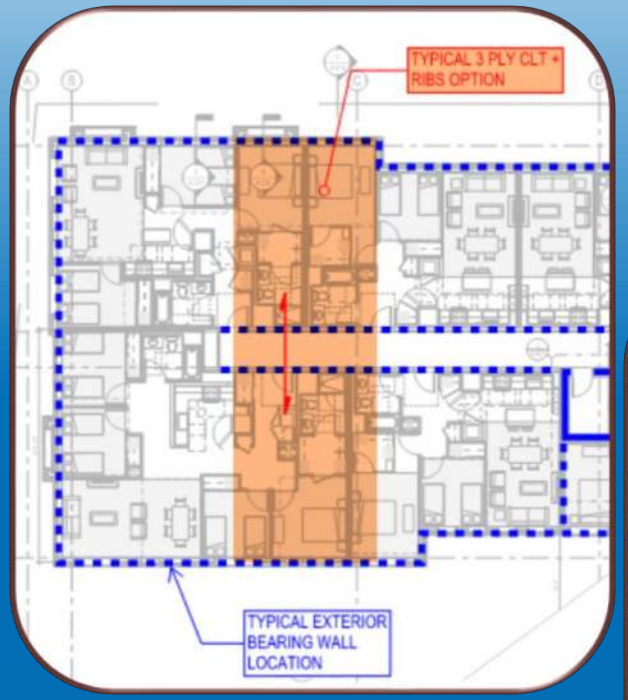
e. Not less than the fire-resistance rating based on fire separation distance (see Table 705.5).
f. Not less than the fire-resistance rating as referenced in Section 704.10.

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

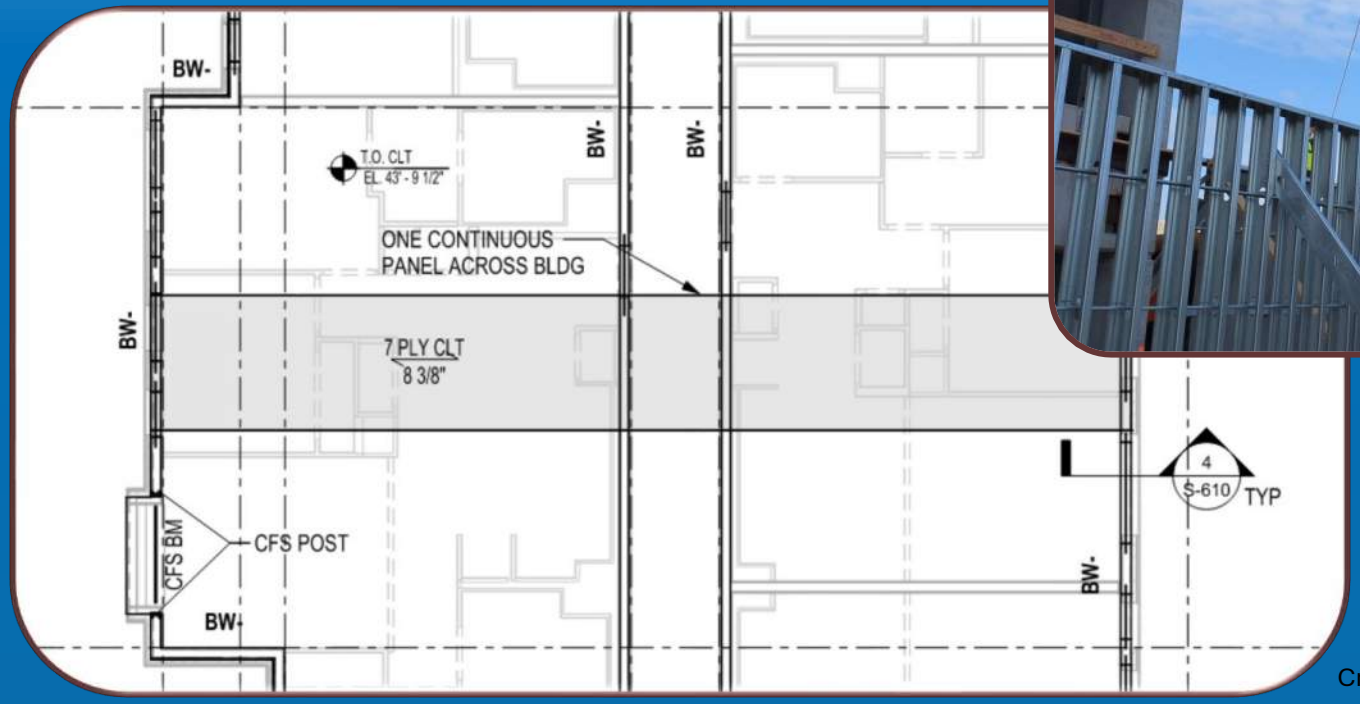




Credit: McNamara – Salvia

MATERIAL EXPLORATIONS: Why CLT?

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

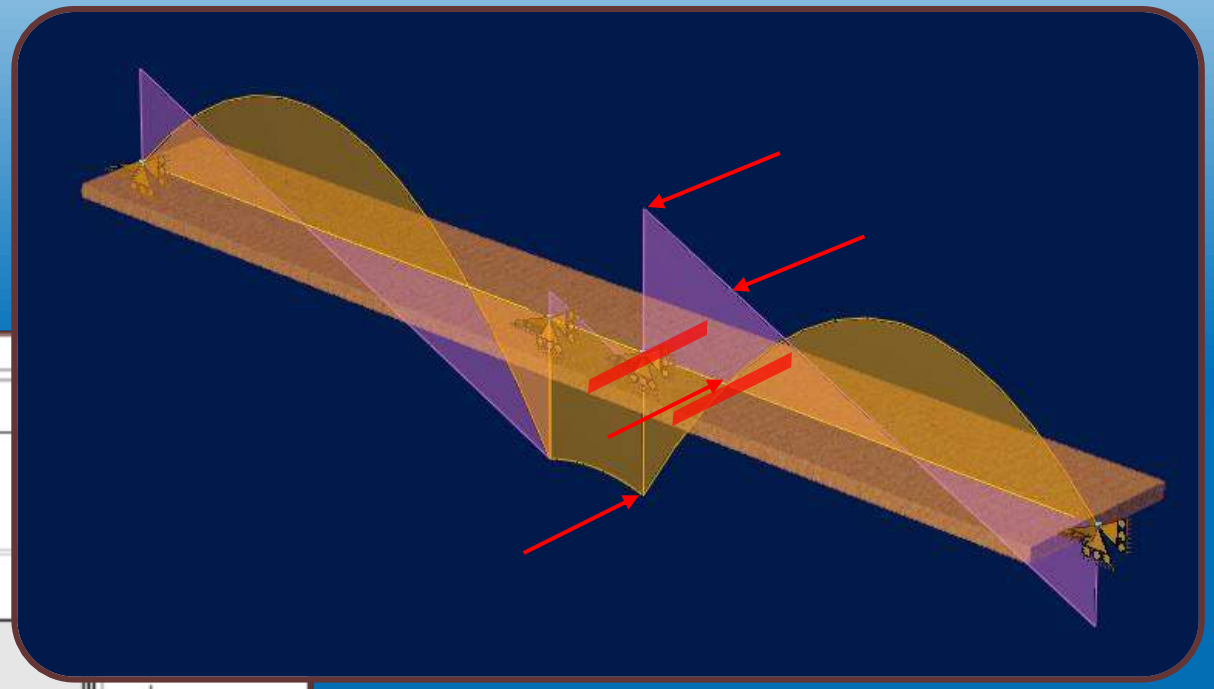


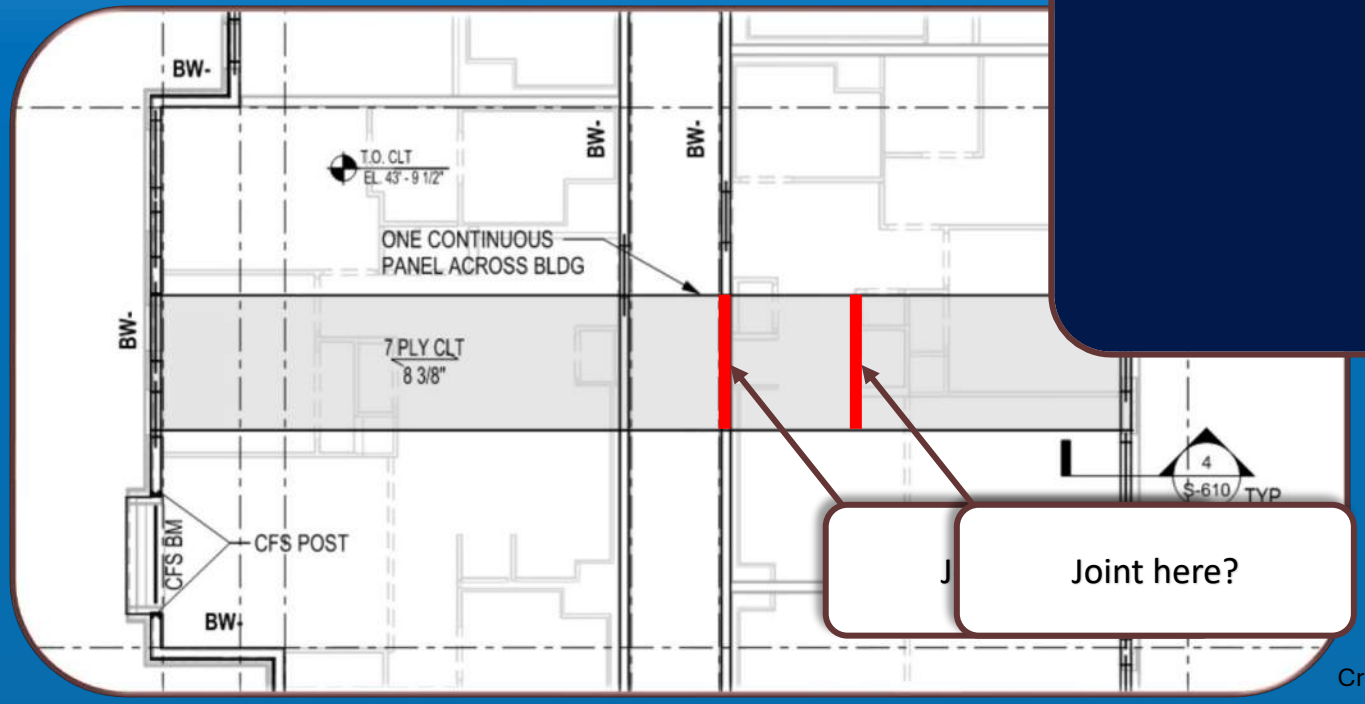
- Exposed CLT ceilings

Credit: McNamara – Salvia

DOES IT HAVE TO BE ONE PANEL?

- Splice the panels together?
  - Needs continuity for span/loads
  - Intensive connection & fire protection
  - Slows down erection time

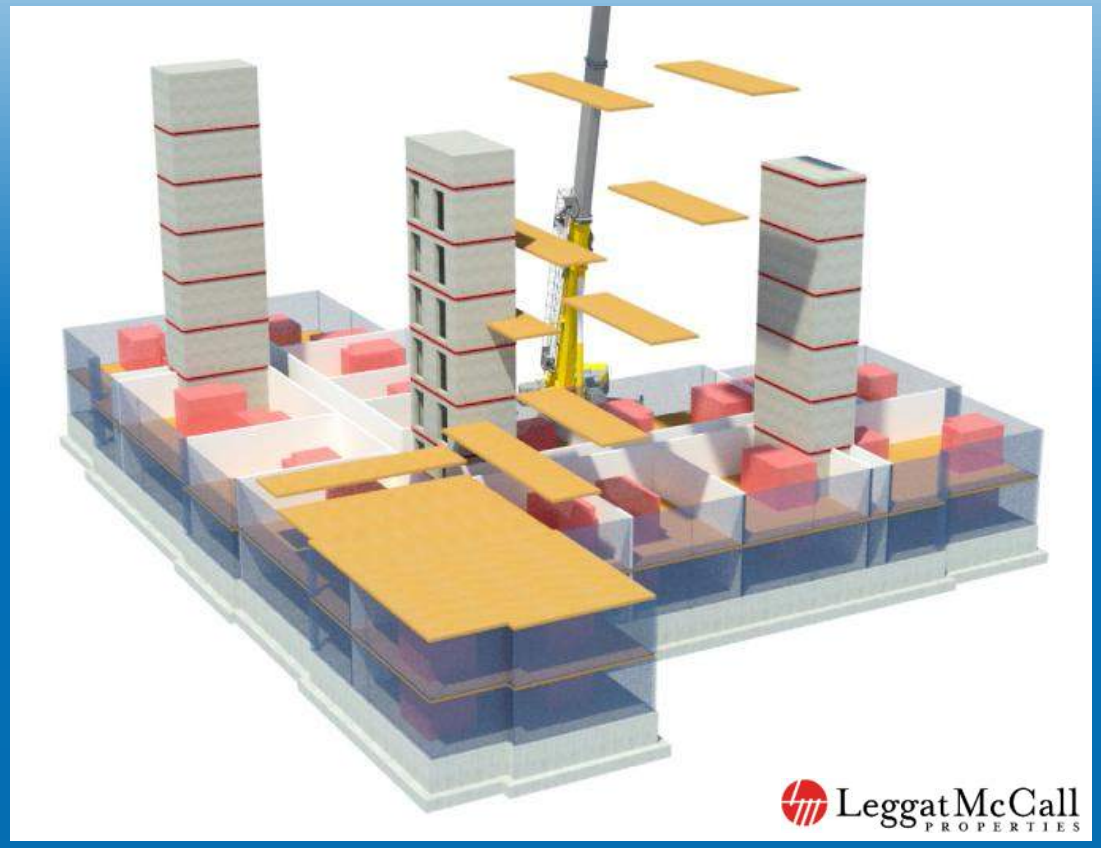




- Joint over interior wall?
- Joint at zero moment?

Credit: McNamara – Salvia

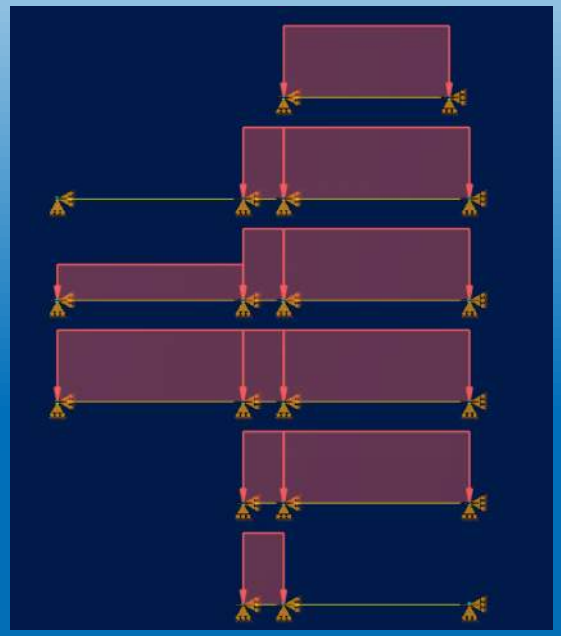
EFFECTIVE BUILDING TYPE

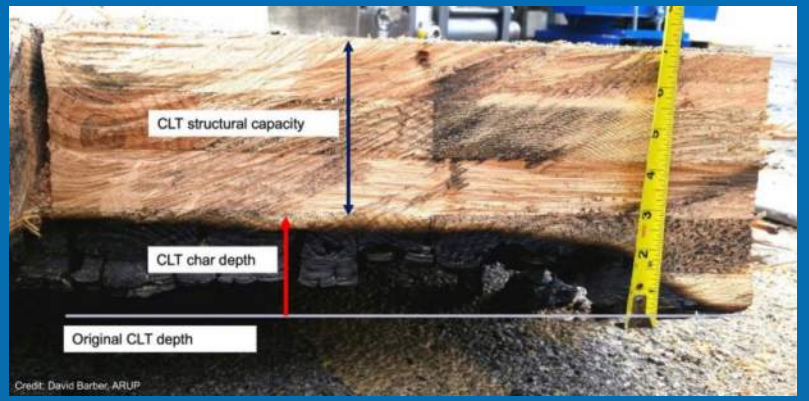


- GOAL = Speed of Erection: every load carrying element is pre-fabricated

DESIGN PARAMETERS

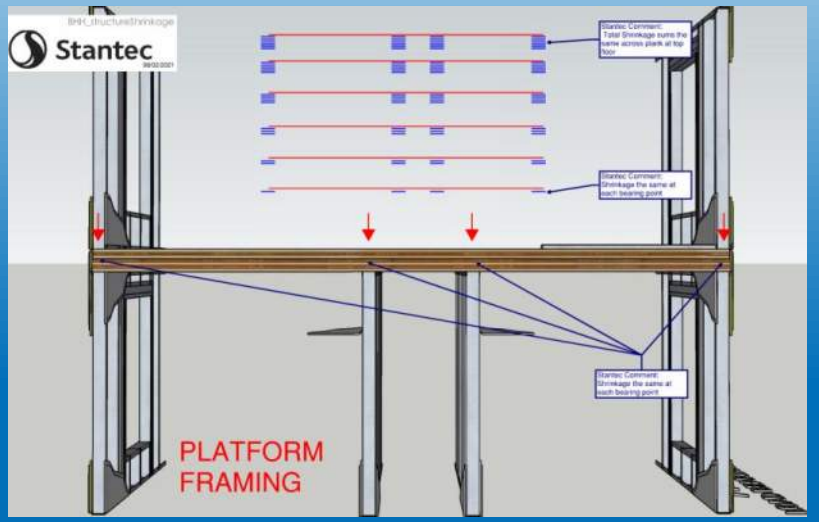
- Service loads
  - Varying span & skip load conditions
- Fire Resistance: Type IV-C
  - 2 Hour char time

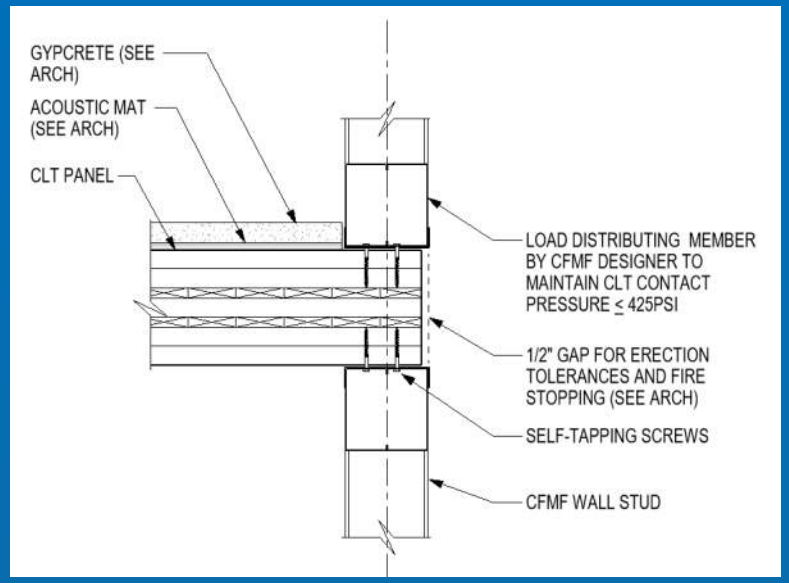


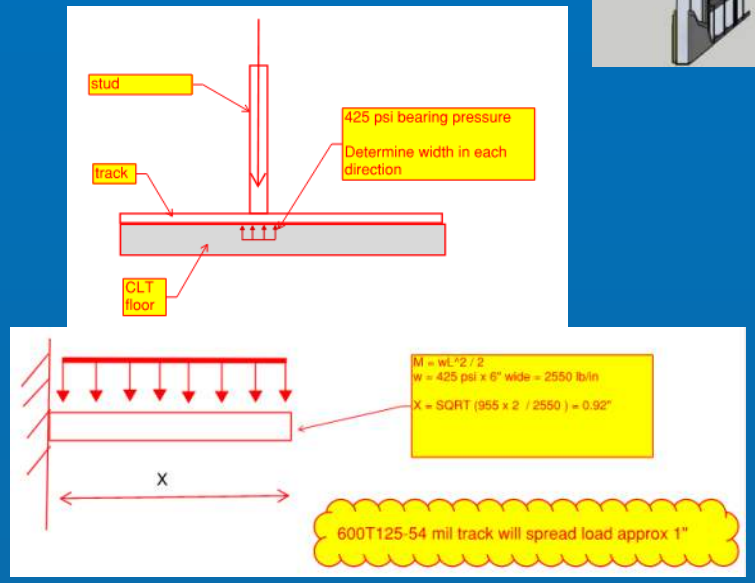


DESIGN PARAMETERS

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

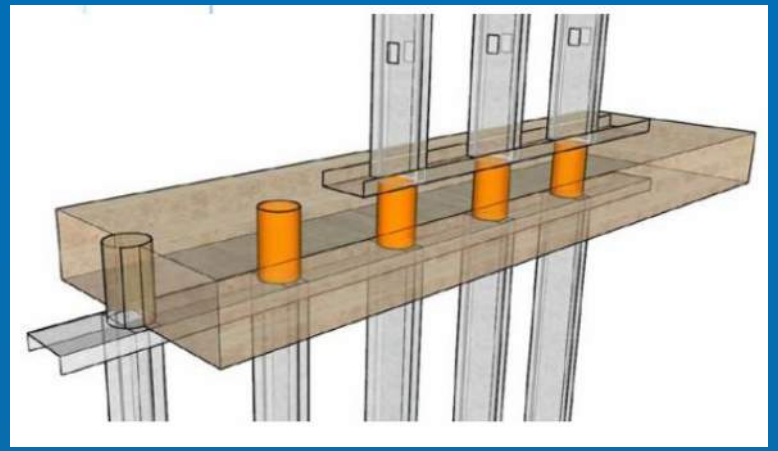


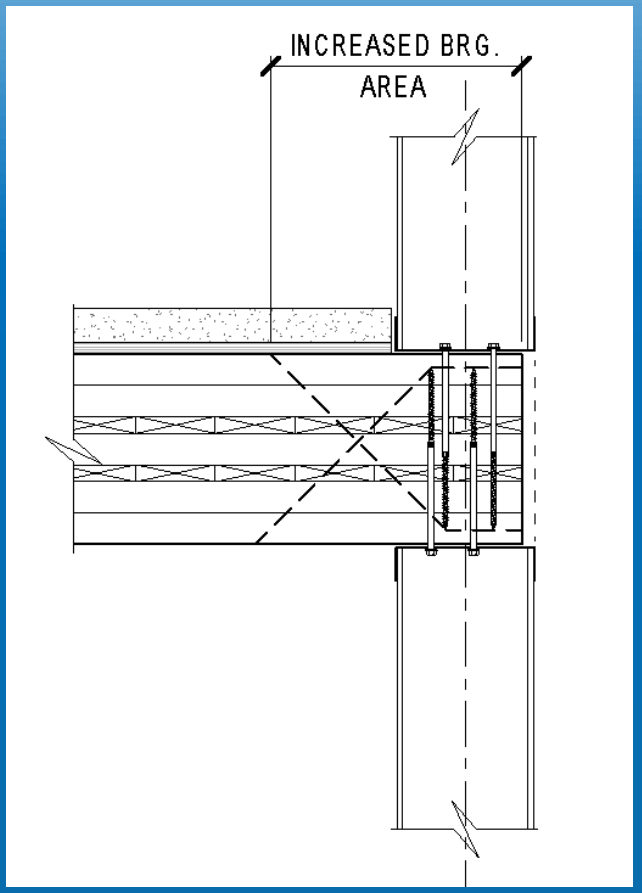




DESIGN PARAMETERS

- Taller building = higher crushing loads
- Expand on current detail?
  - Install the nested distribution element
    - Plate, HSS, CFMF box beam
  - Install vertical spacer/dowel
    - concrete, hardwood
  - Install full thread screws
    - Increased brng. area





Credit: Timber Engineering Inc

OTHER DESIGN CONSIDERATIONS

- Vibrations: analytical review

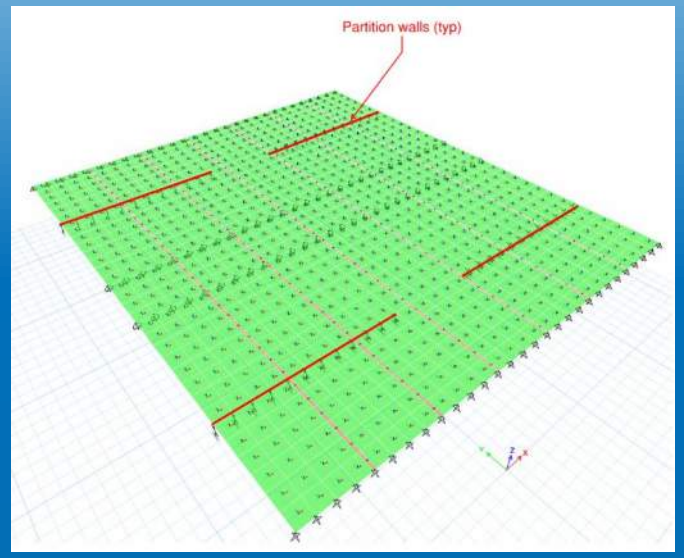
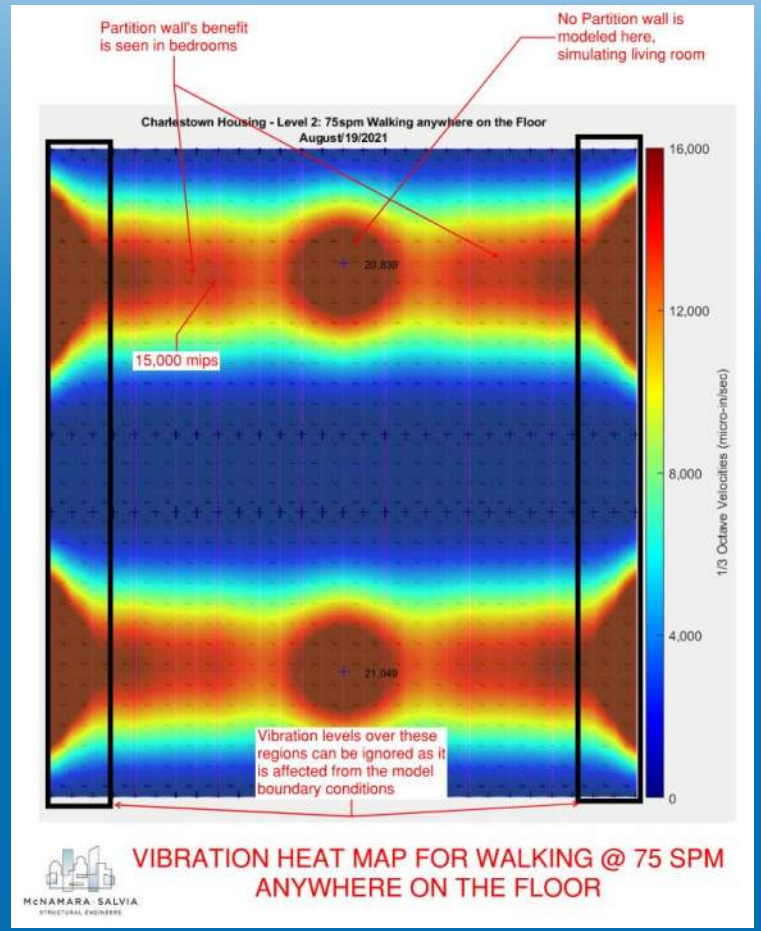


TABLE 3-13: Suggested performance targets

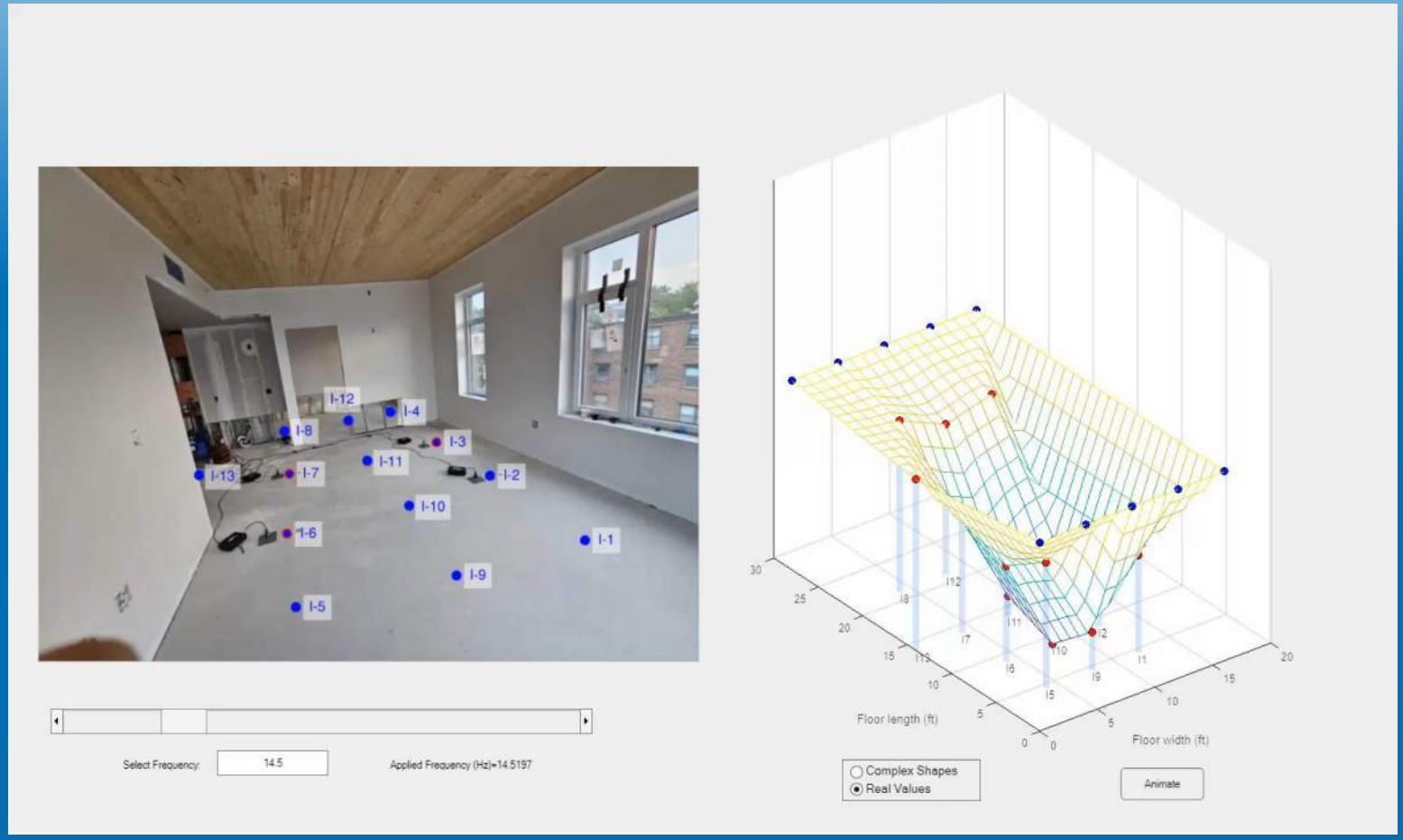
Place	Peak Acceleration Target	RMS Velocity Target
Offices or residences	0.5% g	16,000 - 32,000 mips
Premium offices or luxury residences	0.3% g	8,000 - 16,000 mips

Source: WoodWorks – Vibration Design Guide



OTHER DESIGN CONSIDERATIONS

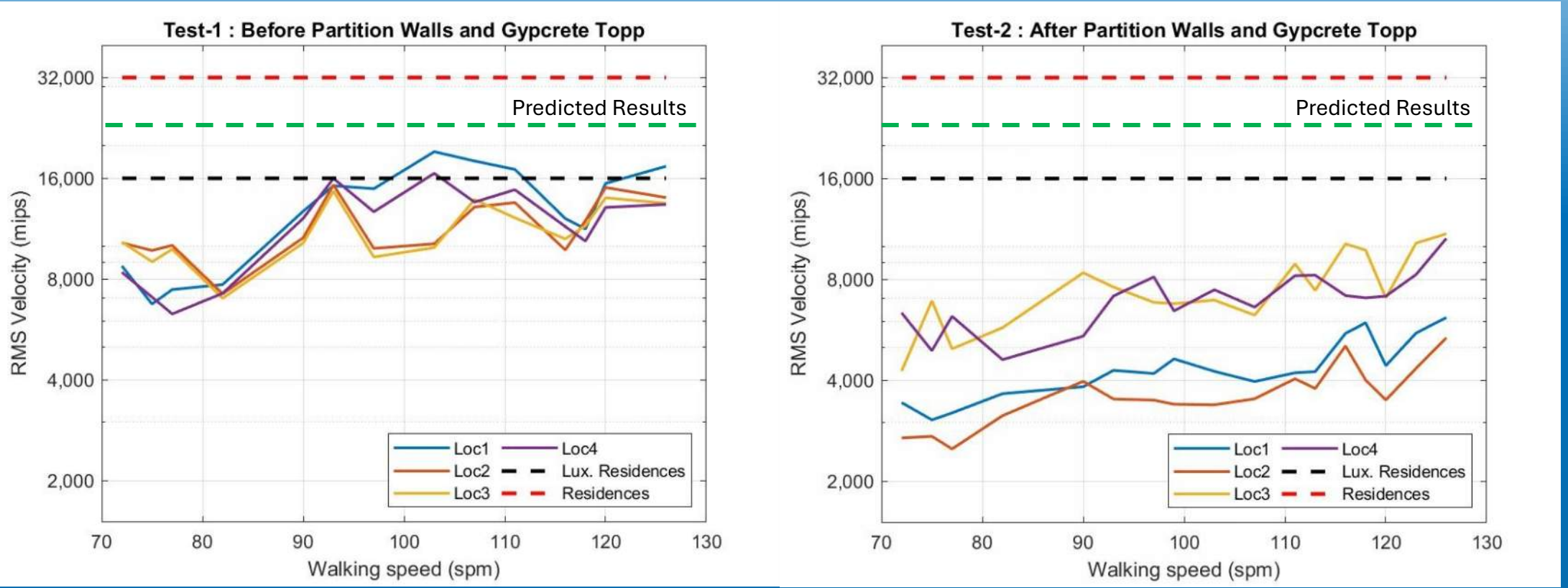
- Vibrations: in-situ results



Credit: McNamara – Salvia

OTHER DESIGN CONSIDERATIONS

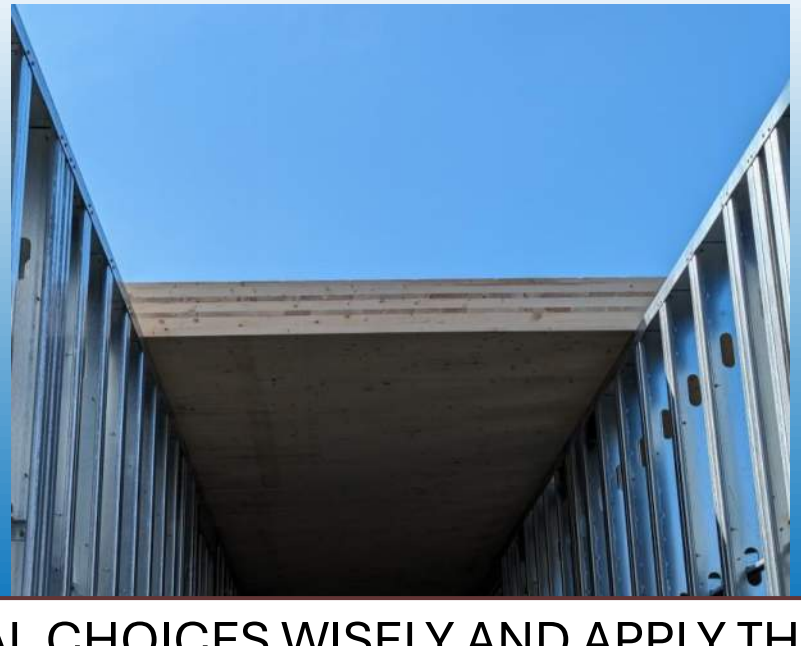
- Walking test results



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

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