# Design Strategies for Affordable Mass Timber Multi-Family Housing


Presented by

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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 webinar will explore the essential design decisions for achieving cost-effective and sustainable solutions in mass timber multi-family housing projects. Our expert panel will explain the fundamental principles behind successful mass timber housing project design, from structural innovations to efficient material utilization. Starting with a review of how mass timber multi-family projects can approach strategic design decisions related to fire-resistance, acoustics, construction type, unit sizing, structural grid and floor slab spans, building science and enclosure, MEPF integration, and more, the webinar will then delve into an in-depth case study of the groundbreaking Dixwell project in New Haven, CT. This four-story all-mass timber passive house project will create 69 units in total, providing much-needed housing for New Haven, most of which will be for those at 60% AMI or lower. The design team will demonstrate how they applied strategic design considerations and utilized design iterations to turn vision into reality. Whether you are new to mass timber, an experienced architect, developer, engineer, contractor, or simply passionate about sustainable construction, this webinar promises to be a stimulating and enlightening journey into the world of cost-effective mass timber design.

# Learning Objectives

1. Understand the critical design decisions and principles that underpin cost-effective mass timber multi-family housing projects, including material selection and structural efficiency.

2. Gain insights into how the Dixwell project in New Haven, CT, successfully implemented these design considerations and overcame challenges specific to their context.

3. Identify key strategies to optimize construction costs and timelines while maintaining sustainability and design integrity in mass timber multi-family housing projects.

4. Acquire knowledge of best practices and innovative approaches in mass timber design, enabling participants to apply these principles in future projects for greater cost-effectiveness and sustainability.

# **340+ Dixwell**
Case Study

Design Strategies for Affordable Mass Timber Multi-Family Housing

September 20, 2023

# 340+ Dixwell
## Overview + Project Team

340+ Dixwell is a mass timber, Passive House, and LIHTC-funded affordable housing development in New Haven, Connecticut. The development includes 69 residential units with 1, 2, and 3 bedroom apartments. 80% of the units will be reserved for residents at 60% AMI or lower, while 20% will be market-rate rentals.

| | |
|---|---|
| Developer | Beulah Land Development Corporation<br>HELP Development Corporation<br>Spiritos Properties |
| Architect | Gray Organschi Architecture<br>Schadler Selnau Associates |
| Structural Engineer | Odeh Engineers |
| MEP Engineer | Acorn Engineers |
| Construction Manager | LaRosa Building Group |
| Funding Sources | Connecticut Housing Finance Authority (CHFA)<br>Connecticut Department of Housing<br>Connecticut DECD<br>City of New Haven<br>National Equity Fund<br>TD Bank |

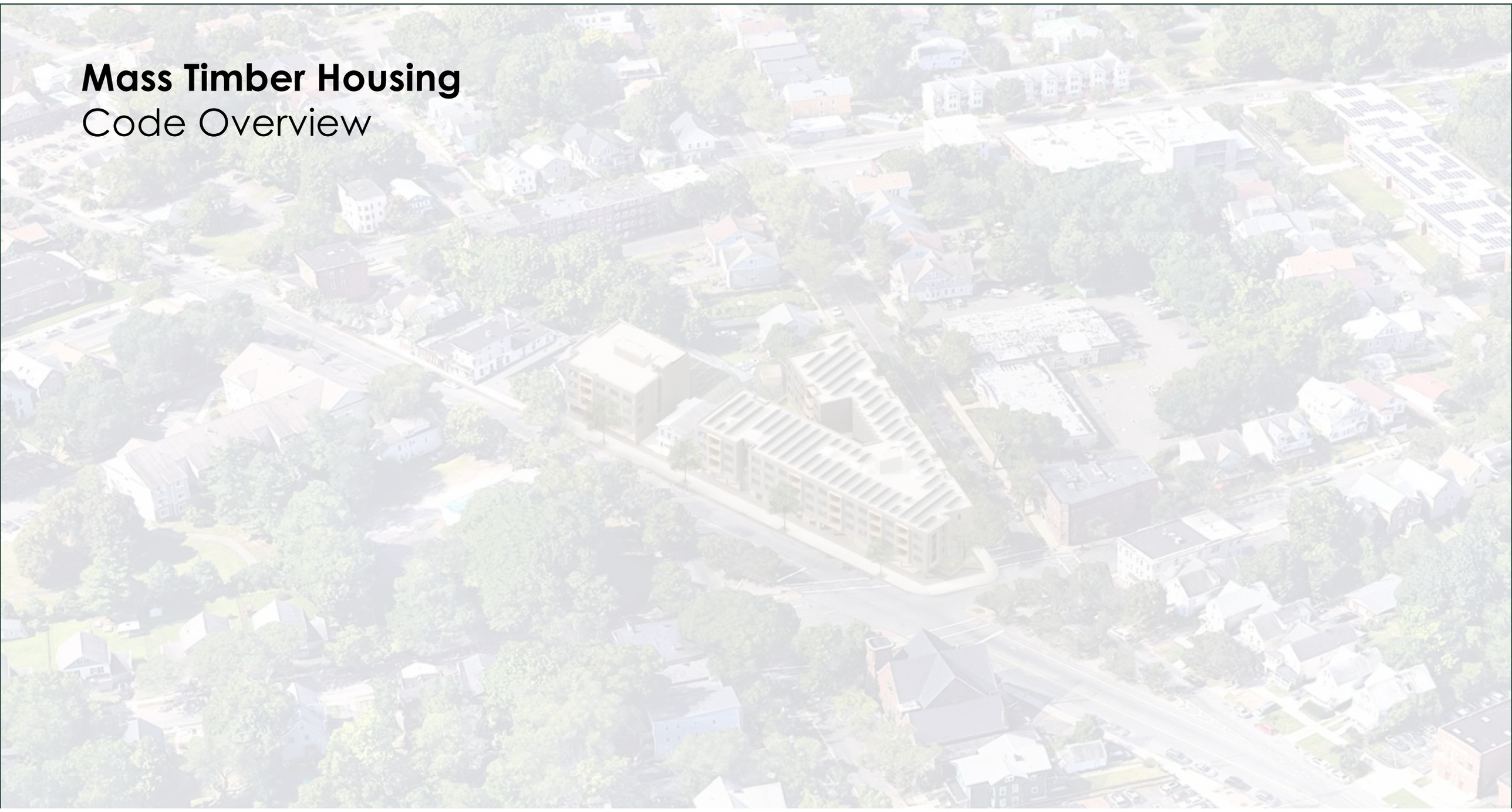
*Special thanks to the USDA Forest Service Wood Innovations Program for their support*


316 DIXWELL
340 DIXWELL

# 340+ Dixwell
## Project Information

| | |
|---|---|
| Location | New Haven, Connecticut, USA |
| Building Type | Mixed-use Multifamily (R-2) |
| Construction Type | Type V-A |
| Construction Material | Cross-laminated timber + glue-laminated timber with secondary structural steel frame |
| Building Code | 2018 Connecticut Building Code (2015 IBC) |
| Building Height | 49’ / 4 stories |
| Building Area | 79,813 sf  (65,766 sf + 14,047 sf) |

# **Mass Timber Housing**
# Code Overview



# **Mass Timber Housing**
# Construction Type

**2021 IBC**

602.3 Type III
Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of **any material permitted by this code**.

Fire-retardant-treated wood framing and sheathing complying with Section 2303.2 shall be permitted within exterior wall assemblies of a 2-hour rating or less.

602.3 Type V
Type V construction is that type of construction in which the structural elements, exterior walls and interior walls are of **any materials permitted by this code**.

**TABLE 504.3**

**ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE[a]**

| OCCUPANCY CLASSIFICATION | See Footnotes | TYPE OF CONSTRUCTION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Type I | | Type II | | Type III | | Type IV | | | | Type V | |
| | | A | B | A | B | A | B | A | B | C | HT | A | B |
| A, B, E, F, M, S, U | NS[b] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 270 | 180 | 85 | 85 | 70 | 60 |
| H-1, H-2, H-3, H-5 | NS[c, d] | UL | 160 | 65 | 55 | 65 | 55 | 120 | 90 | 65 | 65 | 50 | 40 |
| | S | | | | | | | | | | | | |
| H-4 | NS[c, d] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 140 | 100 | 85 | 85 | 70 | 60 |
| I-1 Condition 1, I-3 | NS[d, e] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 180 | 120 | 85 | 85 | 70 | 60 |
| I-1 Condition 2, I-2 | NS[d, e, f] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | | | | | | | | | |
| I-4 | NS[d, g] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 180 | 120 | 85 | 85 | 70 | 60 |
| R[h] | NS[d] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S13D | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 50 | 40 |
| | S13R | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 270 | 180 | 85 | 85 | 70 | 60 |

# **Mass Timber Housing**
# Construction Type

**2021 IBC**

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.

**TABLE 504.3**

**ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE[a]**

| OCCUPANCY CLASSIFICATION | See Footnotes | TYPE OF CONSTRUCTION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Type I | | Type II | | Type III | | Type IV | | | | Type V | |
| | | A | B | A | B | A | B | A | B | C | HT | A | B |
| A, B, E, F, M, S, U | NS[b] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 270 | 180 | 85 | 85 | 70 | 60 |
| H-1, H-2, H-3, H-5 | NS[c, d] | UL | 160 | 65 | 55 | 65 | 55 | 120 | 90 | 65 | 65 | 50 | 40 |
| | S | | | | | | | | | | | | |
| H-4 | NS[c, d] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 140 | 100 | 85 | 85 | 70 | 60 |
| I-1 Condition 1, I-3 | NS[d, e] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 180 | 120 | 85 | 85 | 70 | 60 |
| I-1 Condition 2, I-2 | NS[d, e, f] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | | | | | | | | | |
| I-4 | NS[d, g] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 180 | 120 | 85 | 85 | 70 | 60 |
| R[h] | NS[d] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S13D | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 50 | 40 |
| | S13R | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 270 | 180 | 85 | 85 | 70 | 60 |

# **Mass Timber Housing**
# Construction Type

**2021 IBC**

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

***Exception:*** *Exterior load-bearing walls and nonload-bearing walls of Type IV-HT Construction in accordance with Section 602.4.4.*

The interior building elements, including nonload-bearing walls and partitions, shall be of mass timber construction or of noncombustible construction.

***Exception:*** *Interior building elements and nonload-bearing walls and partitions of Type IV-HT construction in accordance with Section 602.4.4.*

Combustible concealed spaces are not permitted except as otherwise indicated in Sections 602.4.1 through 602.4.4. Combustible stud spaces within light frame walls of Type IV-HT construction shall not be considered concealed spaces, but shall comply with Section 718.

**TABLE 504.3**

**ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE[a]**

| OCCUPANCY CLASSIFICATION | TYPE OF CONSTRUCTION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | See Footnotes | Type I | | Type II | | Type III | | Type IV | | | | Type V | |
| | | A | B | A | B | A | B | A | B | C | HT | A | B |
| A, B, E, F, M, S, U | NS[b] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 270 | 180 | 85 | 85 | 70 | 60 |
| H-1, H-2, H-3, H-5 | NS[c, d] | UL | 160 | 65 | 55 | 65 | 55 | 120 | 90 | 65 | 65 | 50 | 40 |
| | S | | | | | | | | | | | | |
| H-4 | NS[c, d] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 140 | 100 | 85 | 85 | 70 | 60 |
| I-1 Condition 1, I-3 | NS[d, e] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 180 | 120 | 85 | 85 | 70 | 60 |
| I-1 Condition 2, I-2 | NS[d, e, f] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | | | | | | | | | |
| I-4 | NS[d, g] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 180 | 120 | 85 | 85 | 70 | 60 |
| R[h] | NS[d] | UL | 160 | 65 | 55 | 65 | 55 | 65 | 65 | 65 | 65 | 50 | 40 |
| | S13D | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 50 | 40 |
| | S13R | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | S | UL | 180 | 85 | 75 | 85 | 75 | 270 | 180 | 85 | 85 | 70 | 60 |

# **Mass Timber Housing**
# Fire Rating

722.7 Fire-Resistance Rating for Mass Timber
The required fire resistance of mass timber elements in Section 602.4 shall be determined in accordance with Section 703.2. The fire-resistance rating of building elements shall be as required in Tables 601 and 705.5 and as specified elsewhere in this code. The fire-resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element added to the protection time of the noncombustible protection.

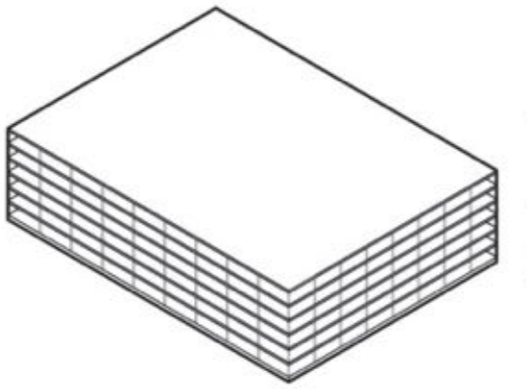
722.7.1 Minimum Required Protection
Where required by Sections 602.4.1 through 602.4.3, noncombustible protection shall be provided for mass timber building elements in accordance with Table 722.7.1(1). The rating, in minutes, contributed by the noncombustible protection of mass timber building elements, components or assemblies, shall be established in accordance with Section 703.6. The protection contributions indicated in Table 722.7.1(2) shall be deemed to comply with this requirement where installed and fastened in accordance with Section 722.7.2.

**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) | $1^1/_2$[b] | 1[b,c] | 1[b,c] | 0[c] | 1[b,c] | 0 | $1^1/_2$ | 1 | 1 | HT | 1[b,c] | 0 |

**Mass Timber Housing**
2021 IBC Type IV

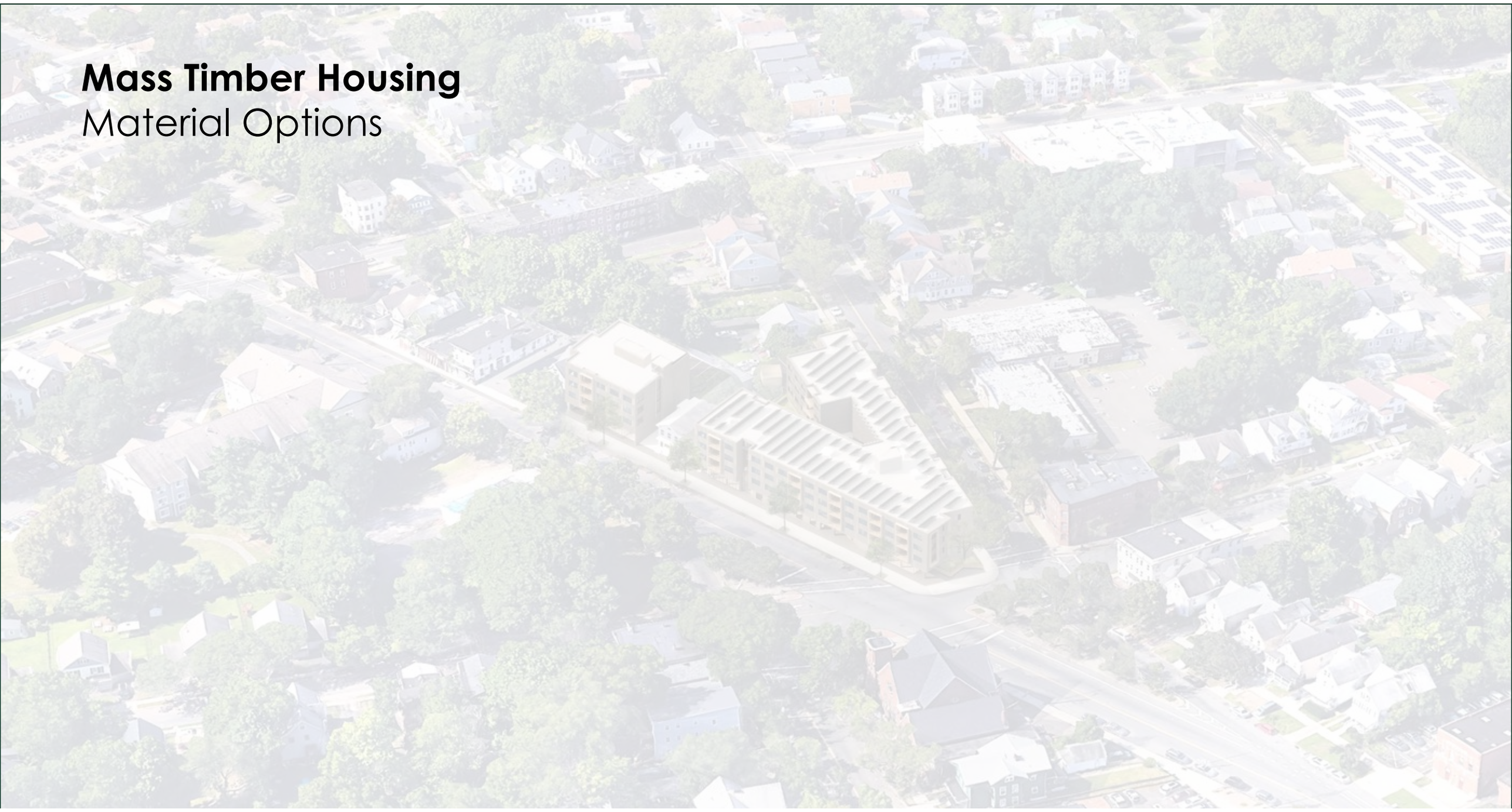


## TYPE IV-HT

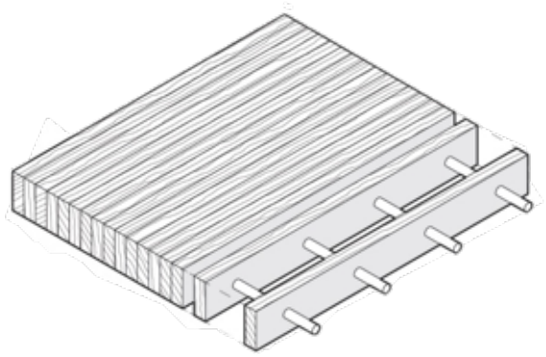
| | |
|---|---|
| Occupancy | R-2 |
| Max Stories | 6 |
| Building Height | 85' |
| Allowable Area | 61,500 sf |

Exposed heavy timber structure

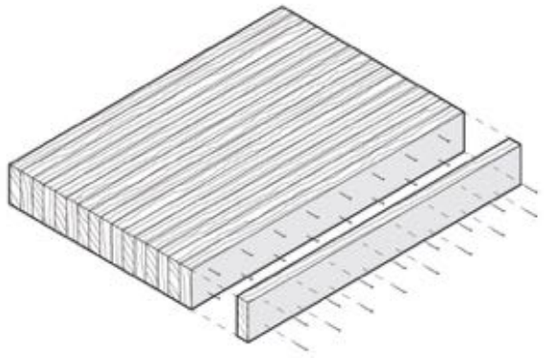
# **Mass Timber Housing**
# Material Options



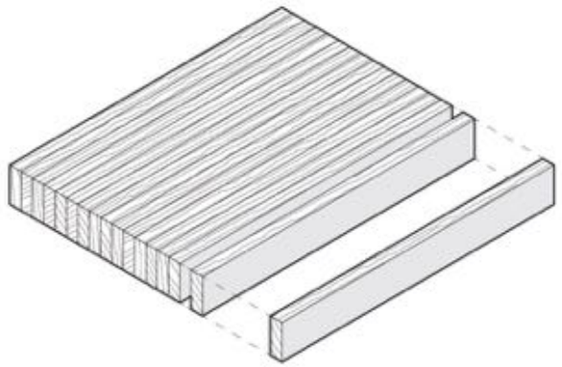
# **Mass Timber Housing**
Material Systems



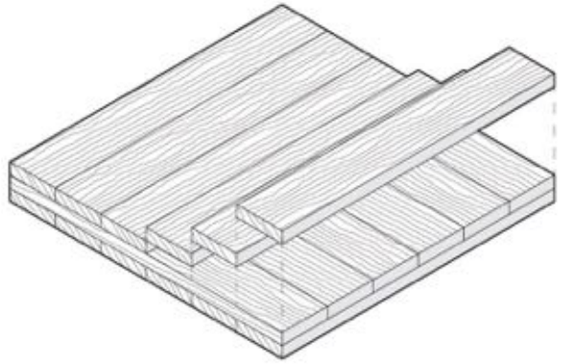
DLT
*dowel-laminated timber*



NLT
*nail-laminated timber*

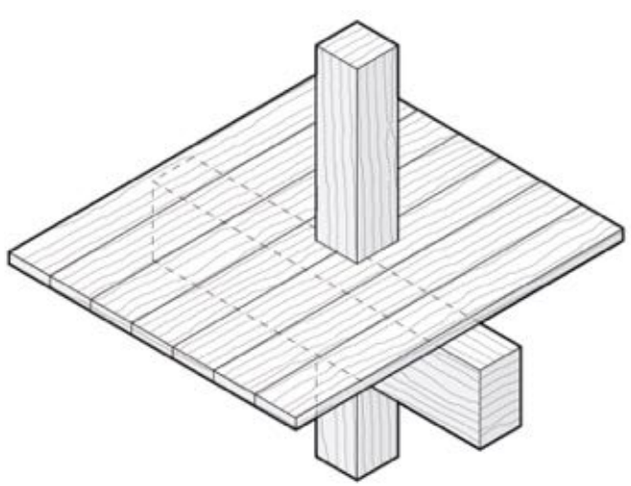


GLT
*glue-laminated timber*

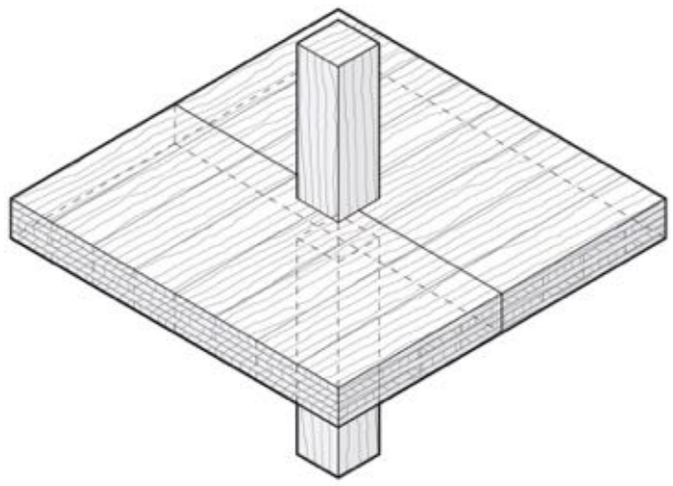


CLT
*cross-laminated timber*

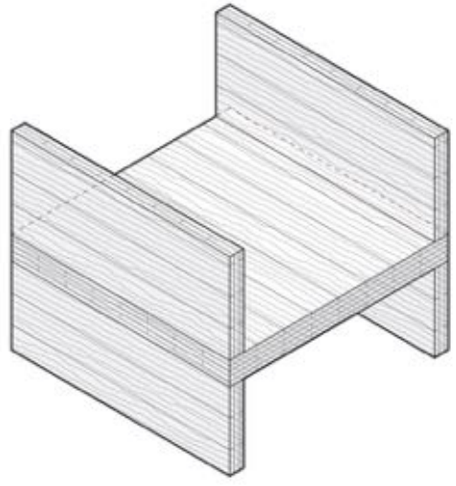
# **Mass Timber Housing**
Structural Morphologies



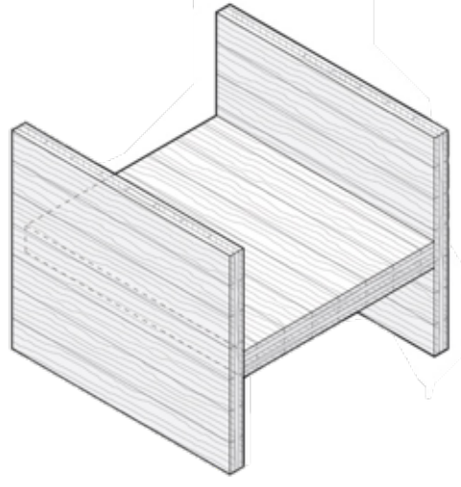
POST + BEAM
*glulam + structural floor panels*



FLAT PLATE
*point supported two-way span*

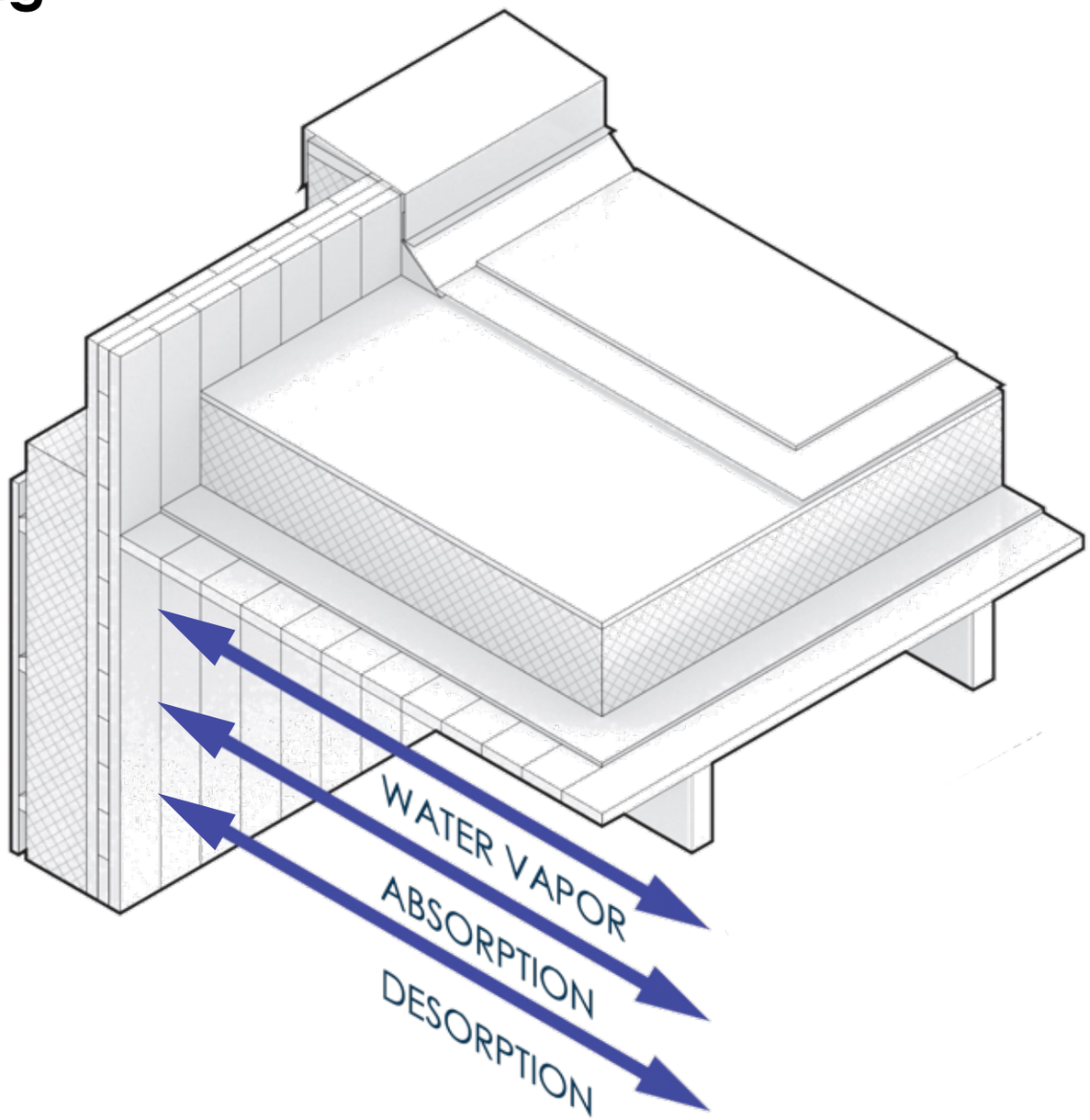


PLATFORM FRAME
*clt panels*

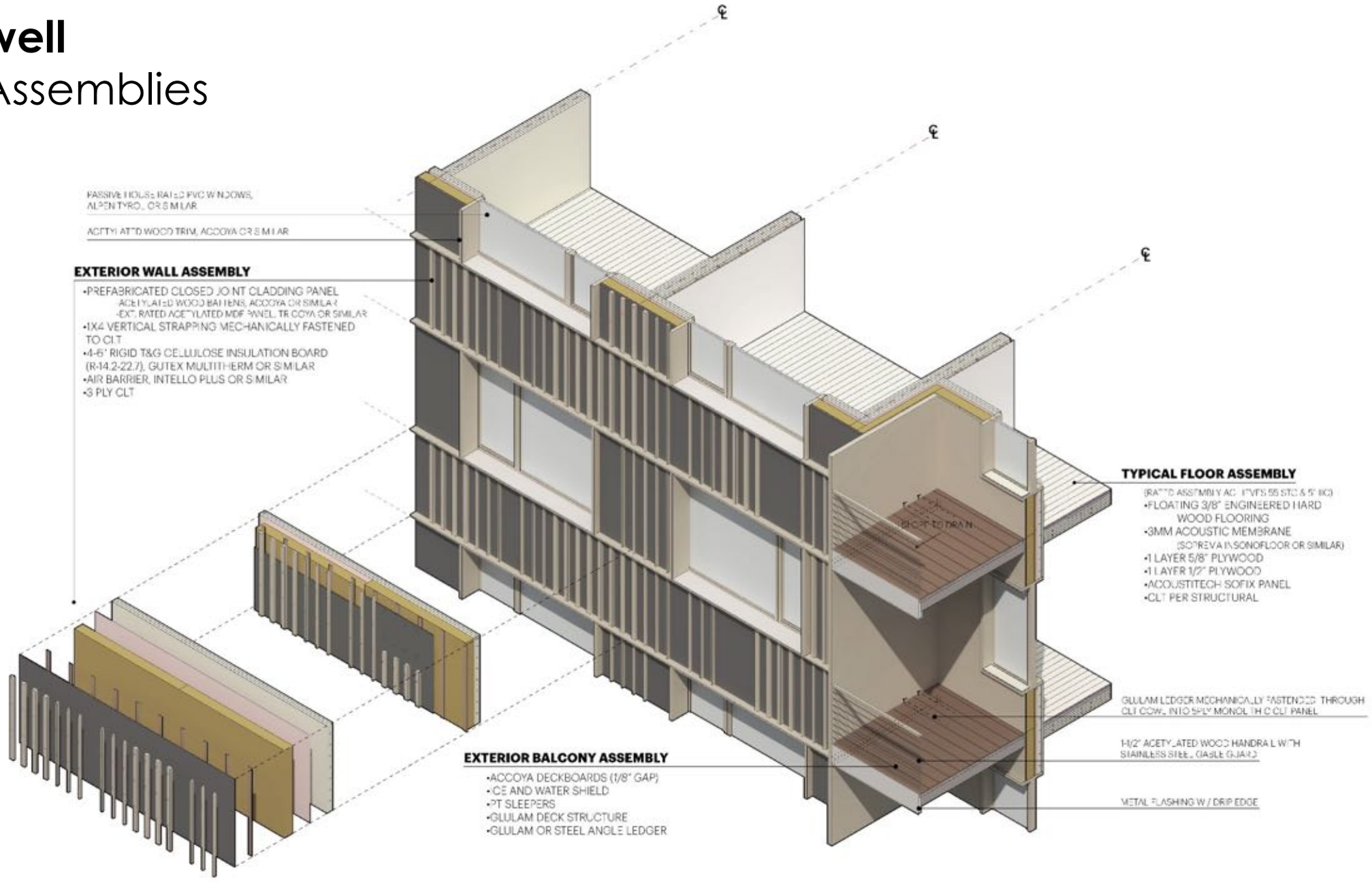


BALLOON FRAME
*clt panels*

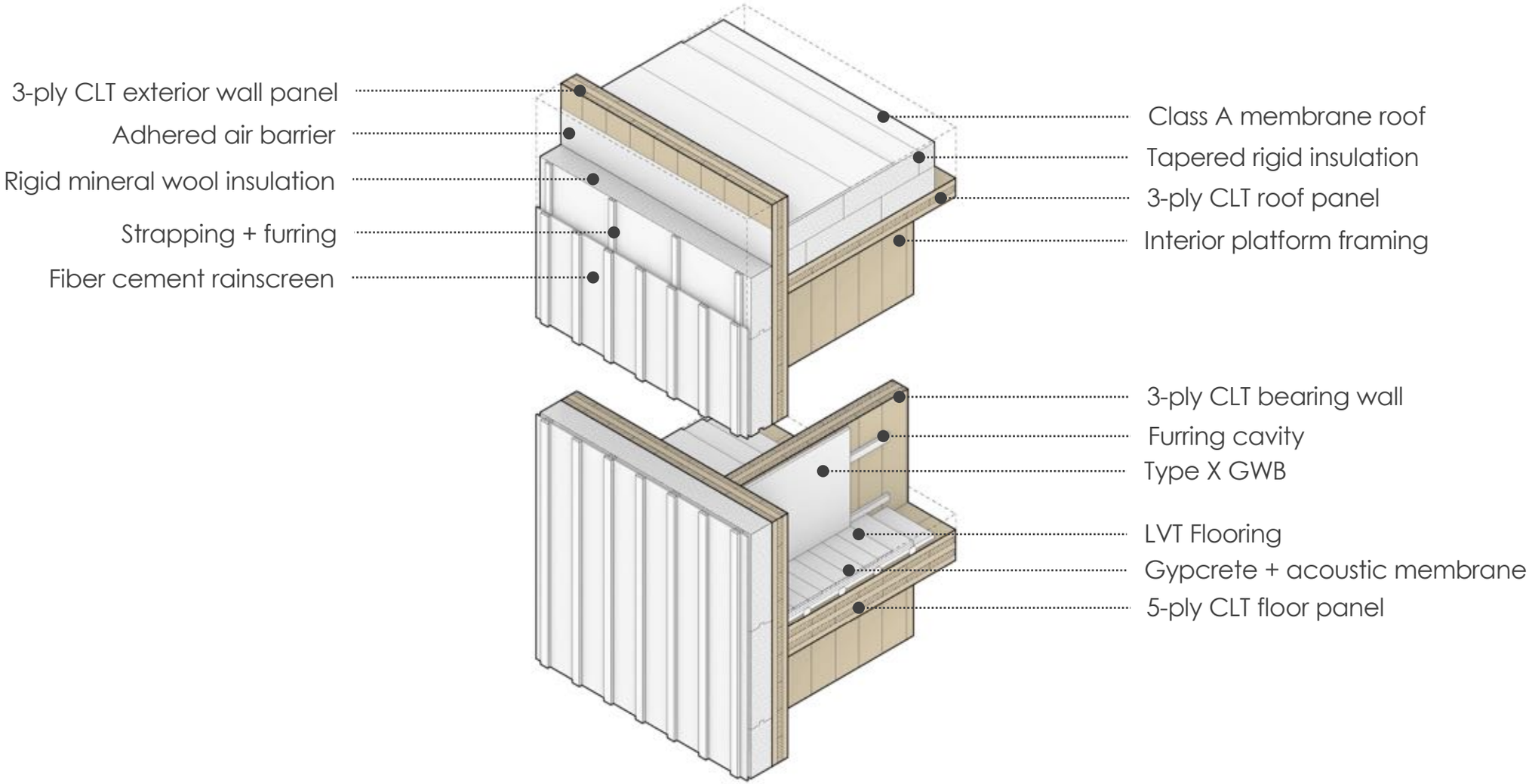
# **Mass Timber Housing**
Building Assemblies



# **340+ Dixwell**
## Building Assemblies

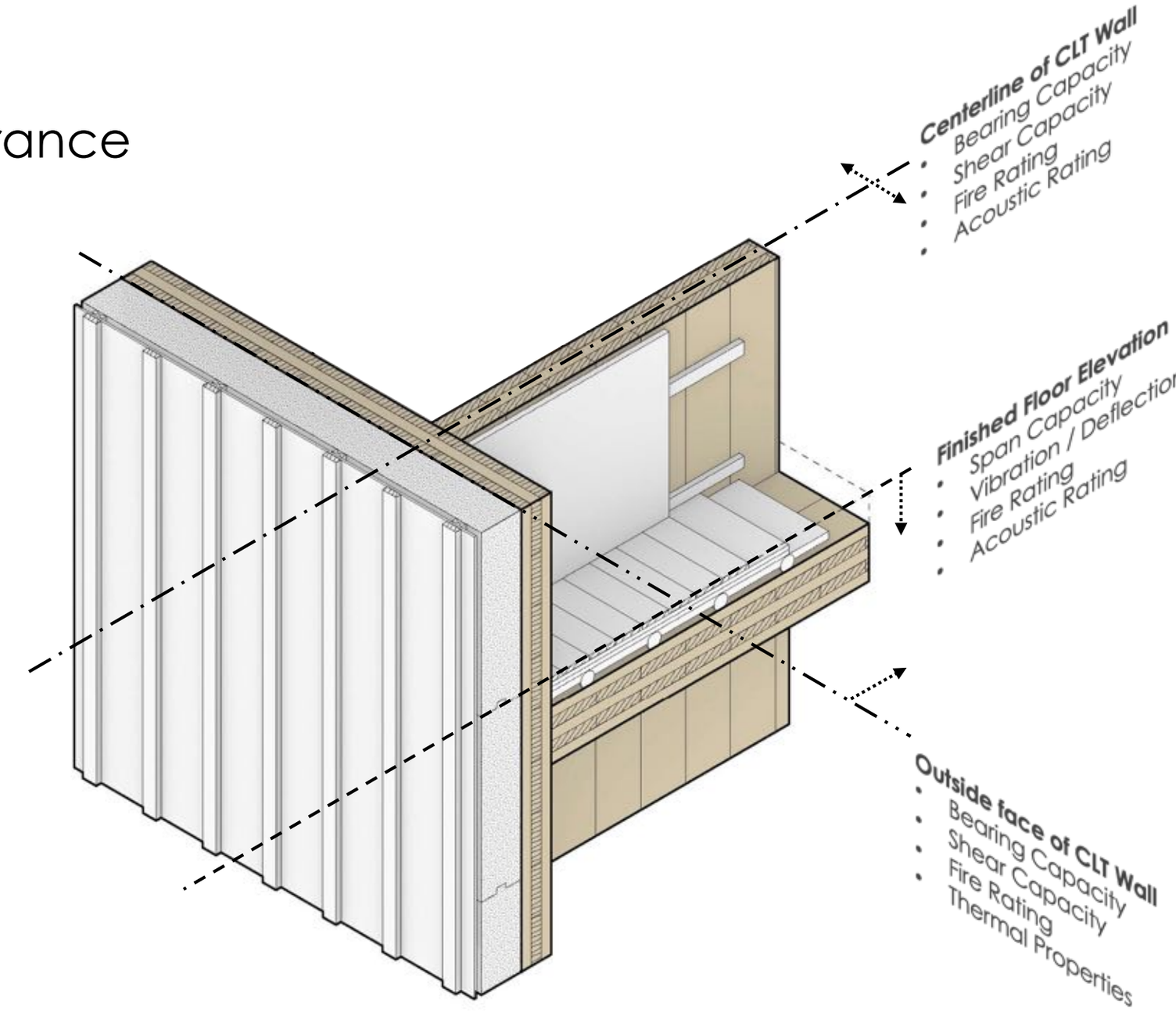


# **340+ Dixwell**
## Building Assemblies



# 340+ Dixwell

## Mass Timber Tolerance



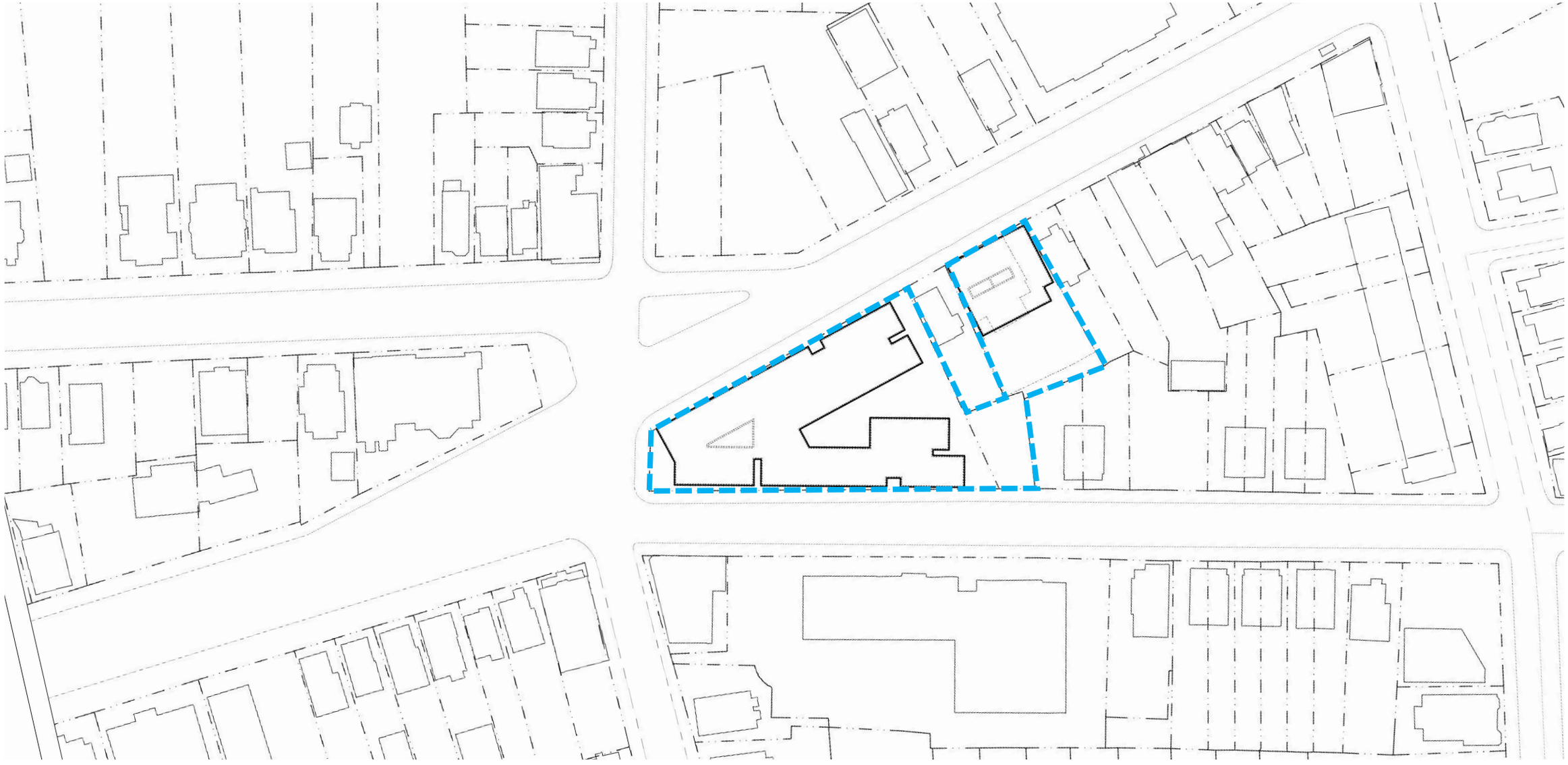
# **Mass Timber Housing**
## Structural Strategies

Design Strategies for Affordable Mass Timber Multi-Family Housing

September 20, 2023

# 340+ Dixwell

## Site Context



# 340+ Dixwell

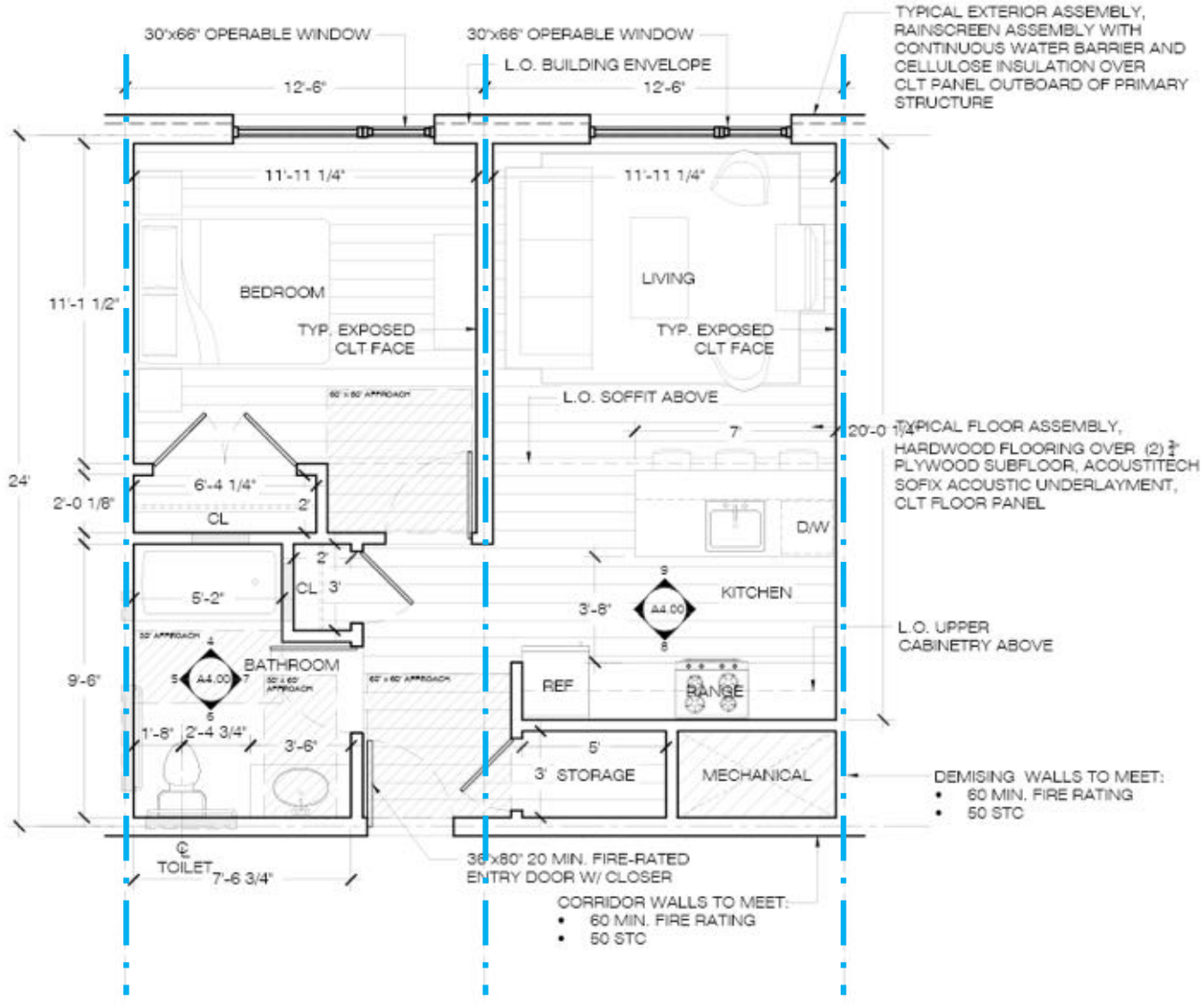
## Level 1

# 340+ Dixwell

Level 2

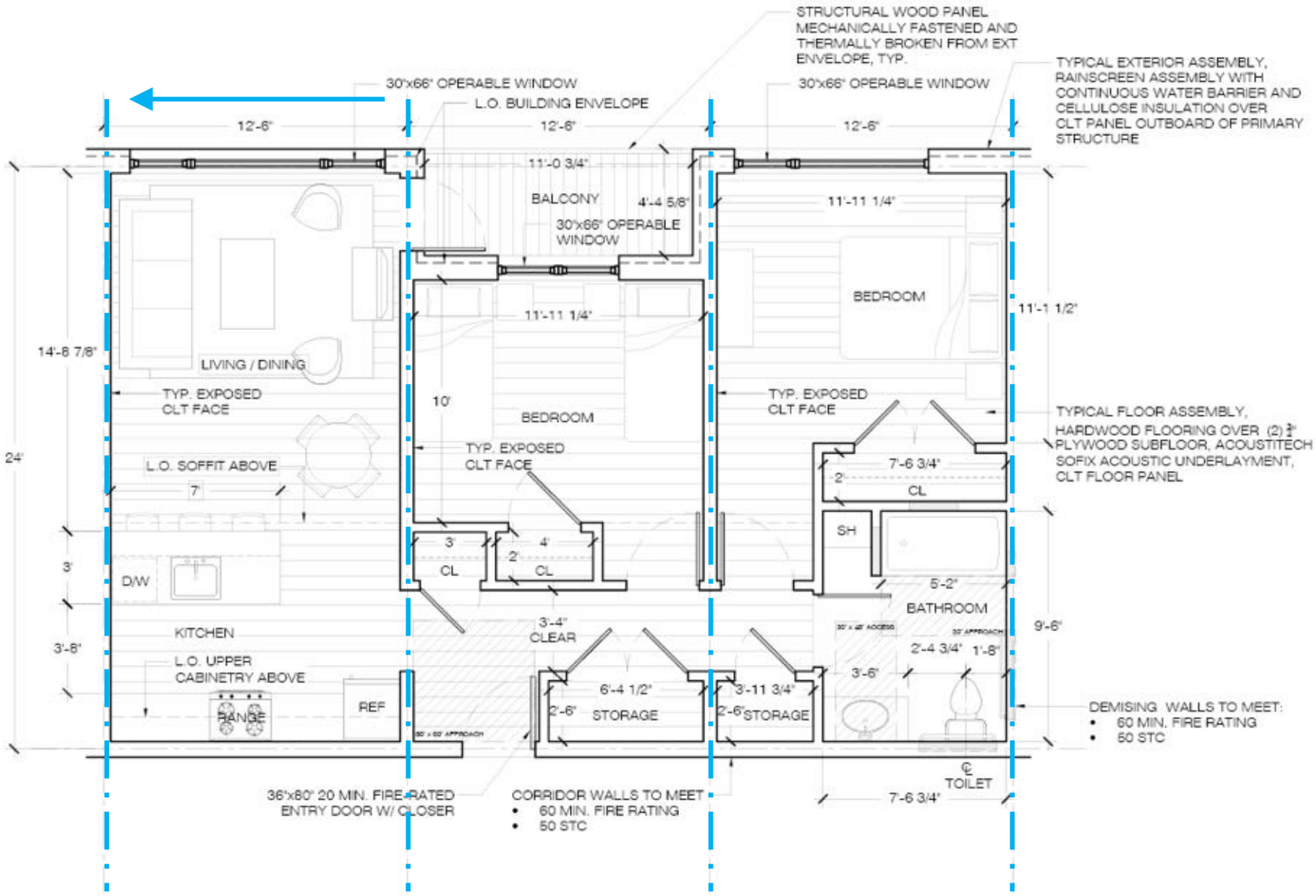
# 340+ Dixwell

## 1 BR Layout



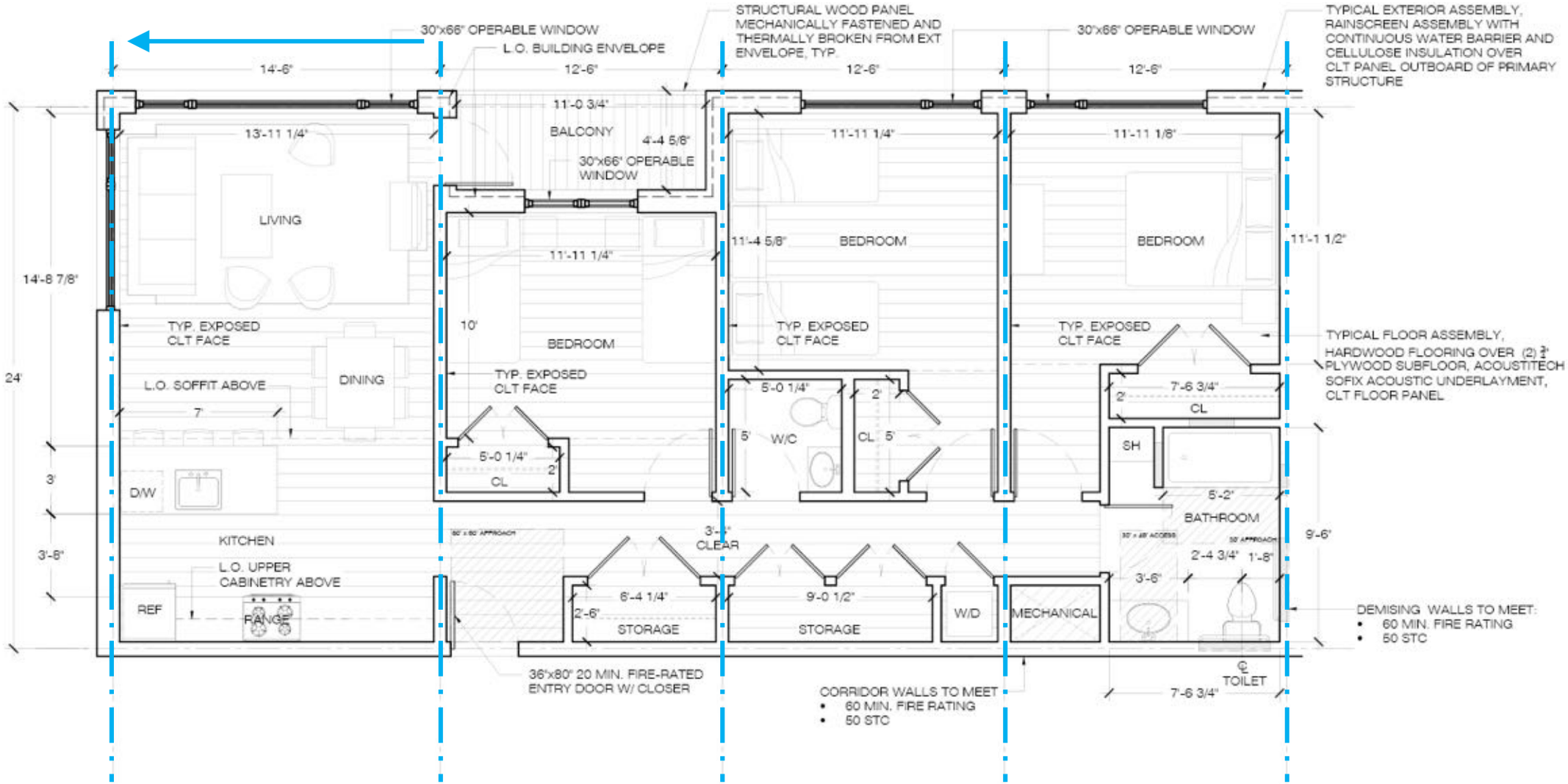
# 340+ Dixwell

## 2 BR Layout



# 340+ Dixwell

## 3 BR Layout



# CLT Shear Wall Design per IBC 2021

Note: the following is not adopted by the code under which this project was permitted

## AWC SDPWS2021 (2015 IBC)

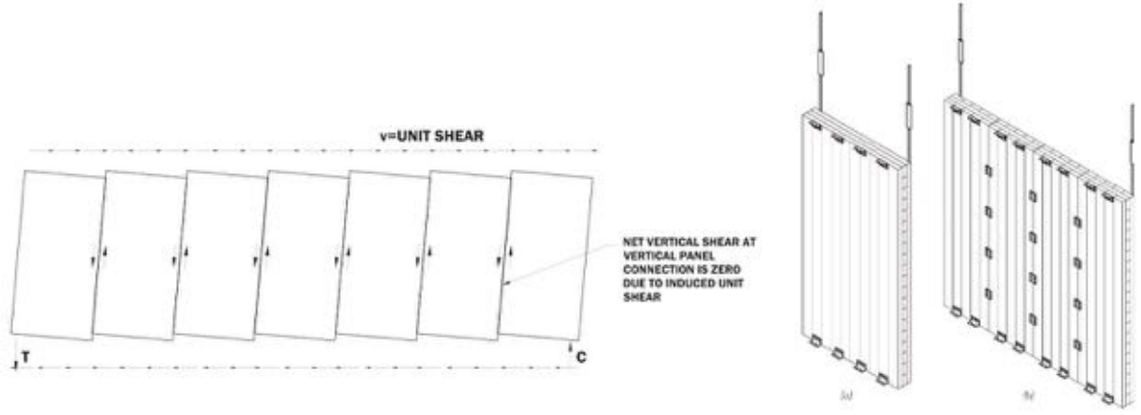
Section 4.6.3.2
Nominal Unit Shear Capacities: Nominal unit shear capacities for CLT shear wall systems used to resist wind or seismic forces shall be in accordance with the requirements in Appendix B, where design and construction is in accordance with Appendix B.

Appendix B Section B.3 Shear Wall Requirements
CLT panels forming either a single-panel or multi-panel shear wall shall have aspect ratio, h/bs, **not greater than 4 nor less than 2.** All CLT panels forming a multi-panel shear wall shall have the same panel height, h, and individual panel length, bs.

Appendix B Section B.3.7 CLT Shear Walls with Shear Resistance Provided by High Aspect Ration Panels Only
a. All CLT wall panels used as part of the designated lateral force-resisting system shall have aspect ratio, **h/bs, equal to 4,** and
b. All CLT wall panels that are not part of the designated lateral force-resisting system shall have aspect ratio, h/bs, not less than 4

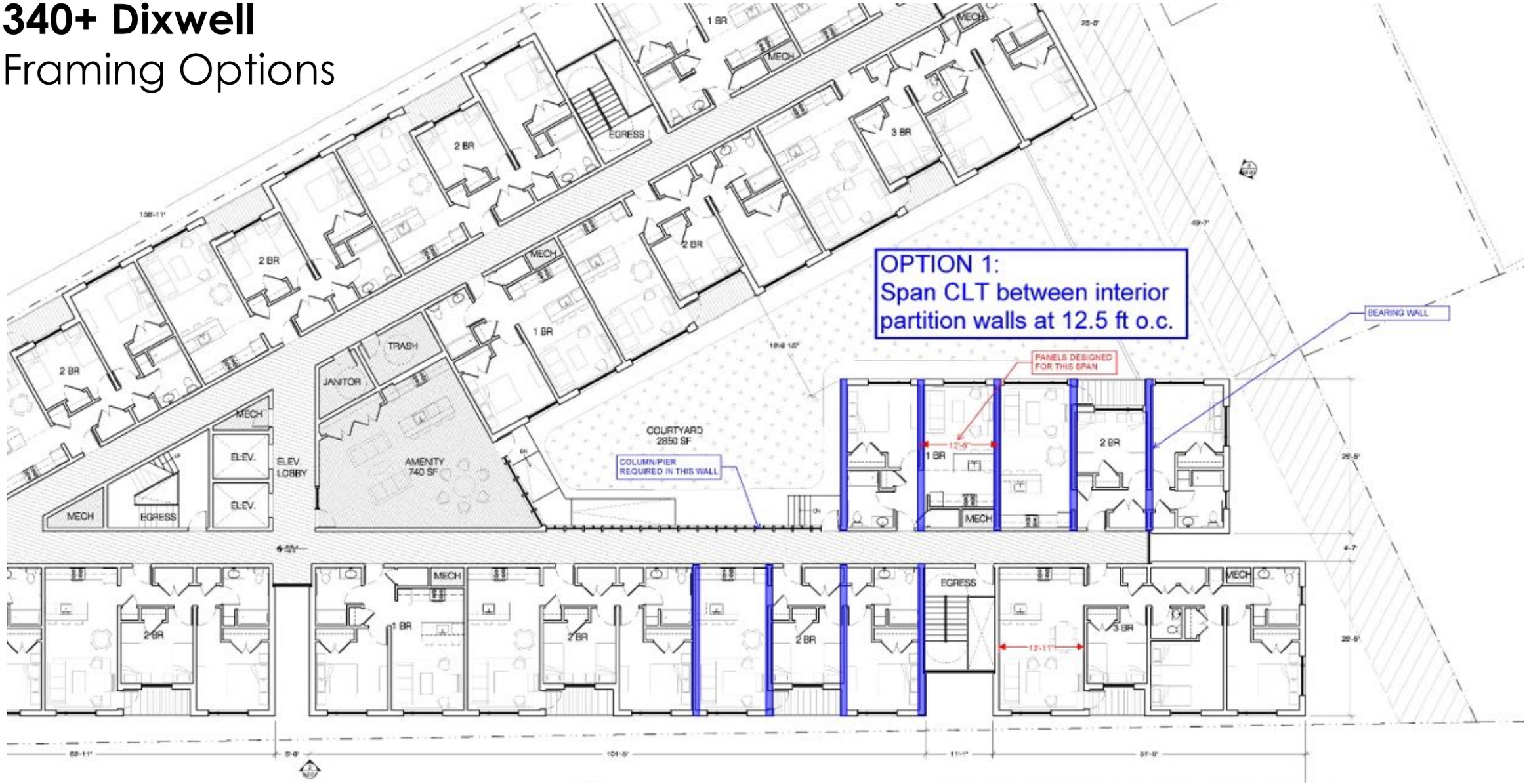
## ASCE 7-22

| Seismic Force-Resisting System | Response Modification Coefficient, $R^a$ | Overstrength Factor, $\Omega_0{}^b$ | Deflection Amplification Factor, $C_d{}^c$ |
|---|---|---|---|
| **A. BEARING WALL SYSTEMS** | | | |
| 20. Cross-laminated timber shear walls | 3 | 3 | 3 |
| 21. Cross-laminated timber shear walls with shear resistance provided by high-aspect-ratio panels only | 4 | 3 | 4 |

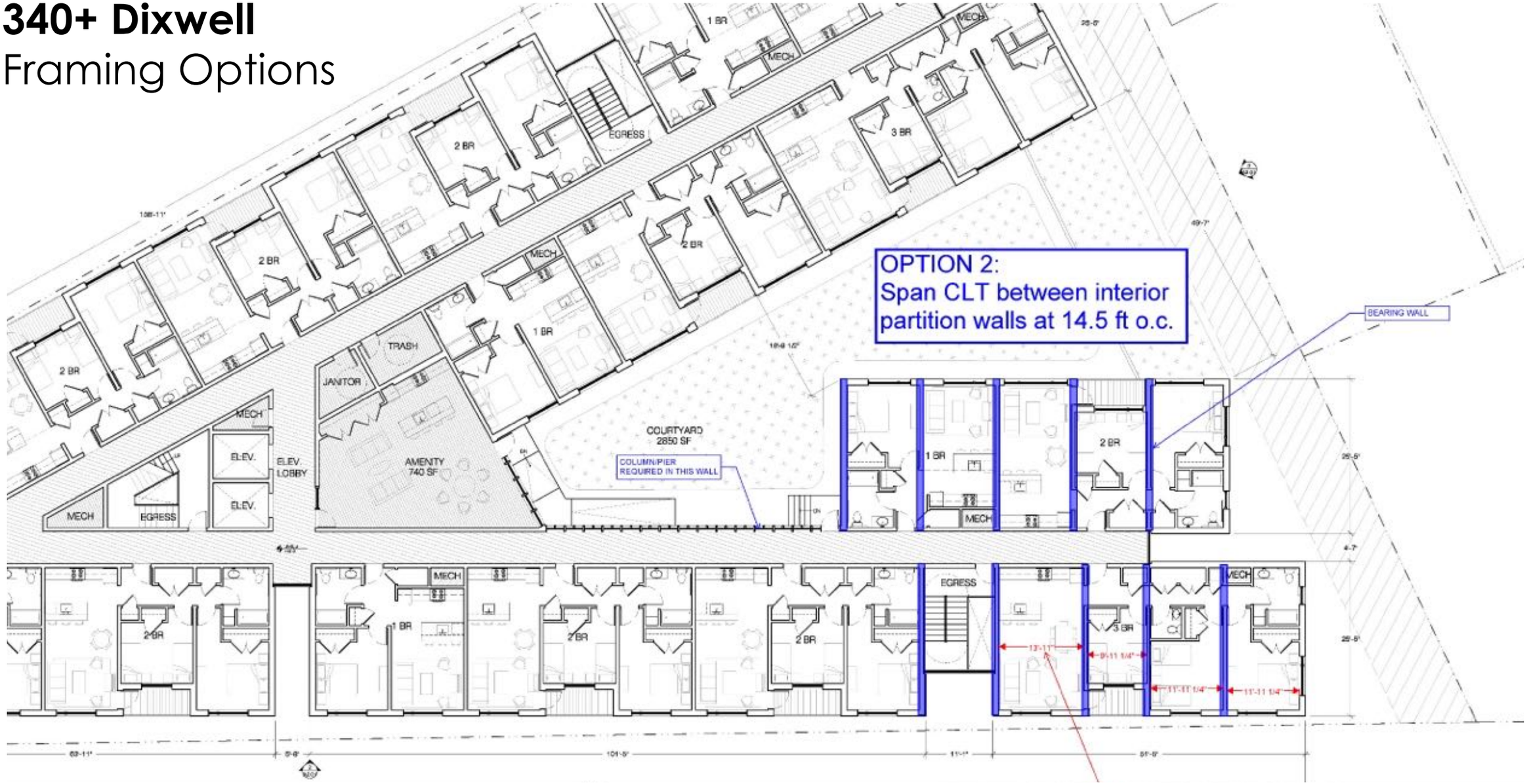



Images: Amini, M. Omar, et al. "Seismic Design of CLT Shear Walls Using ASCE 7-22 and SDPWS 2021." *STRUCTURE Magazine*, May 2023

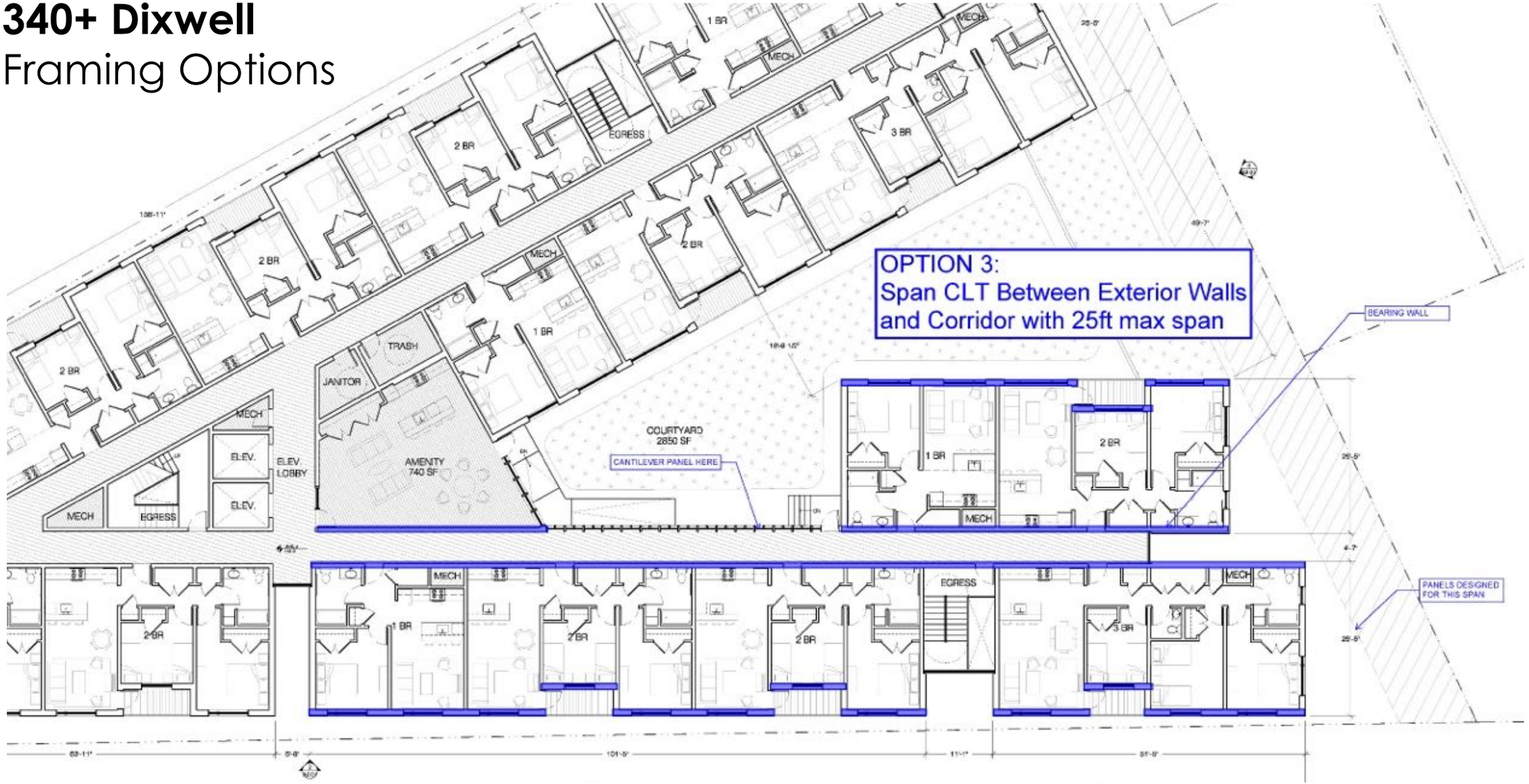
# **340+ Dixwell**
Framing Options



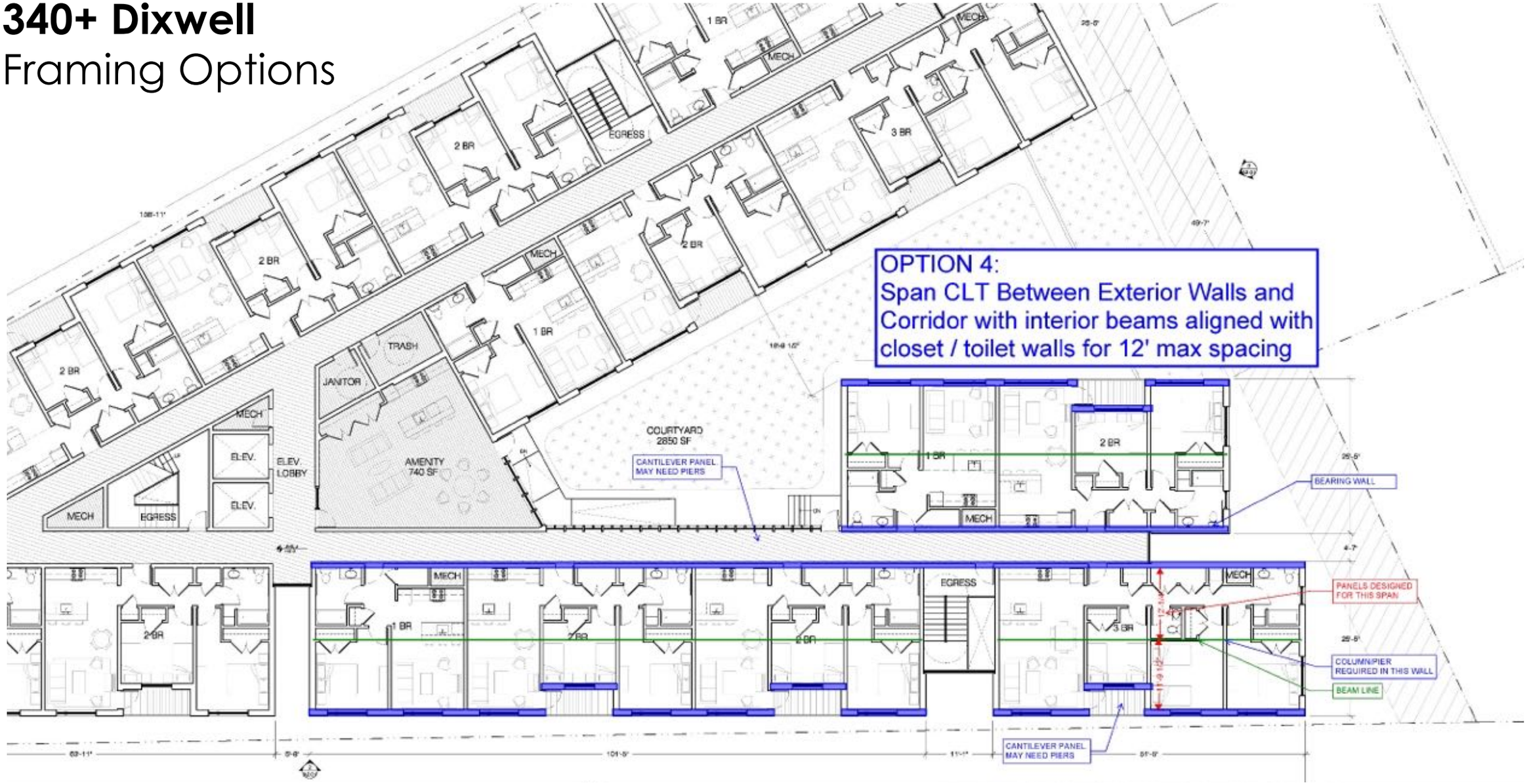
# **340+ Dixwell**
Framing Options



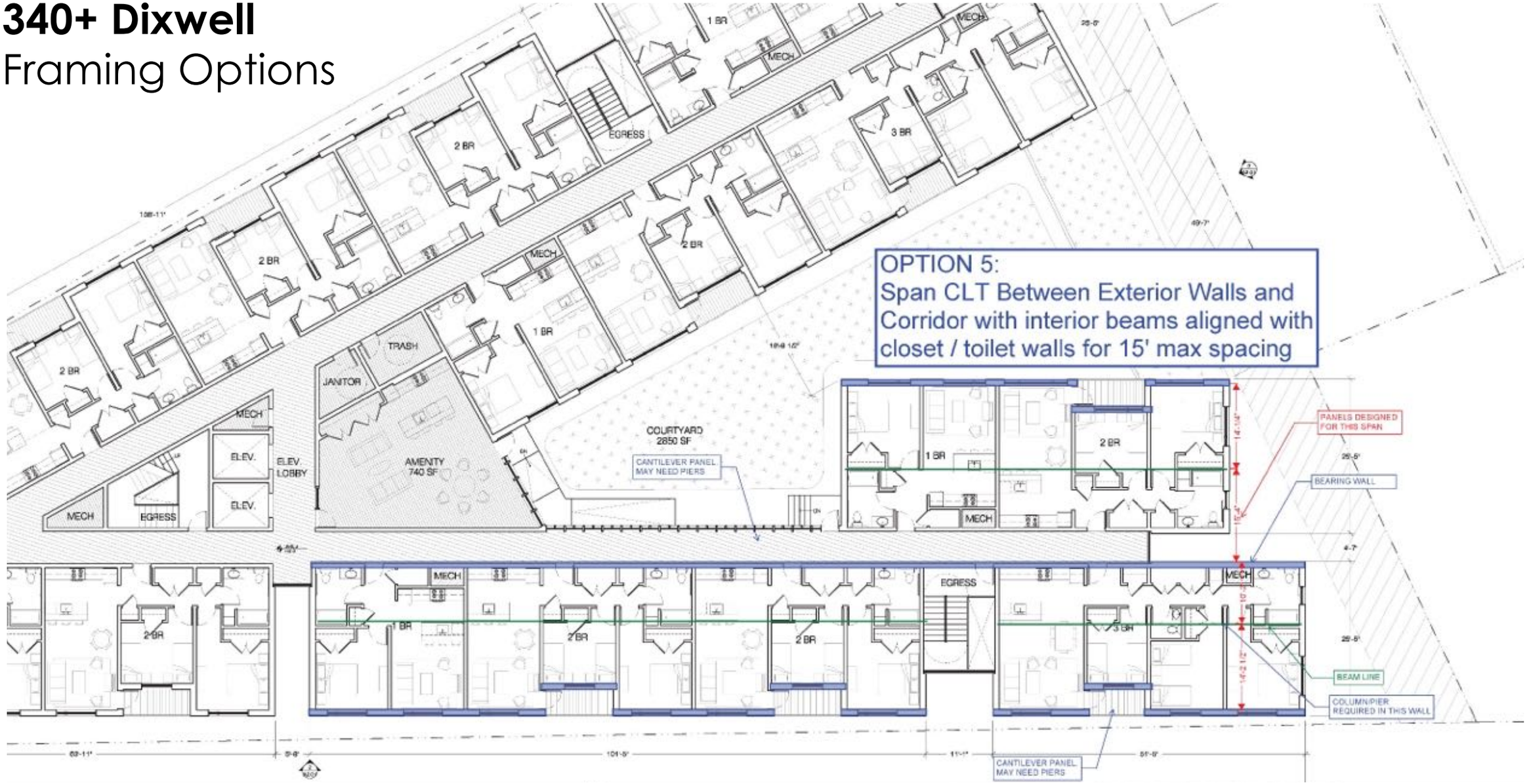
# **340+ Dixwell**
Framing Options



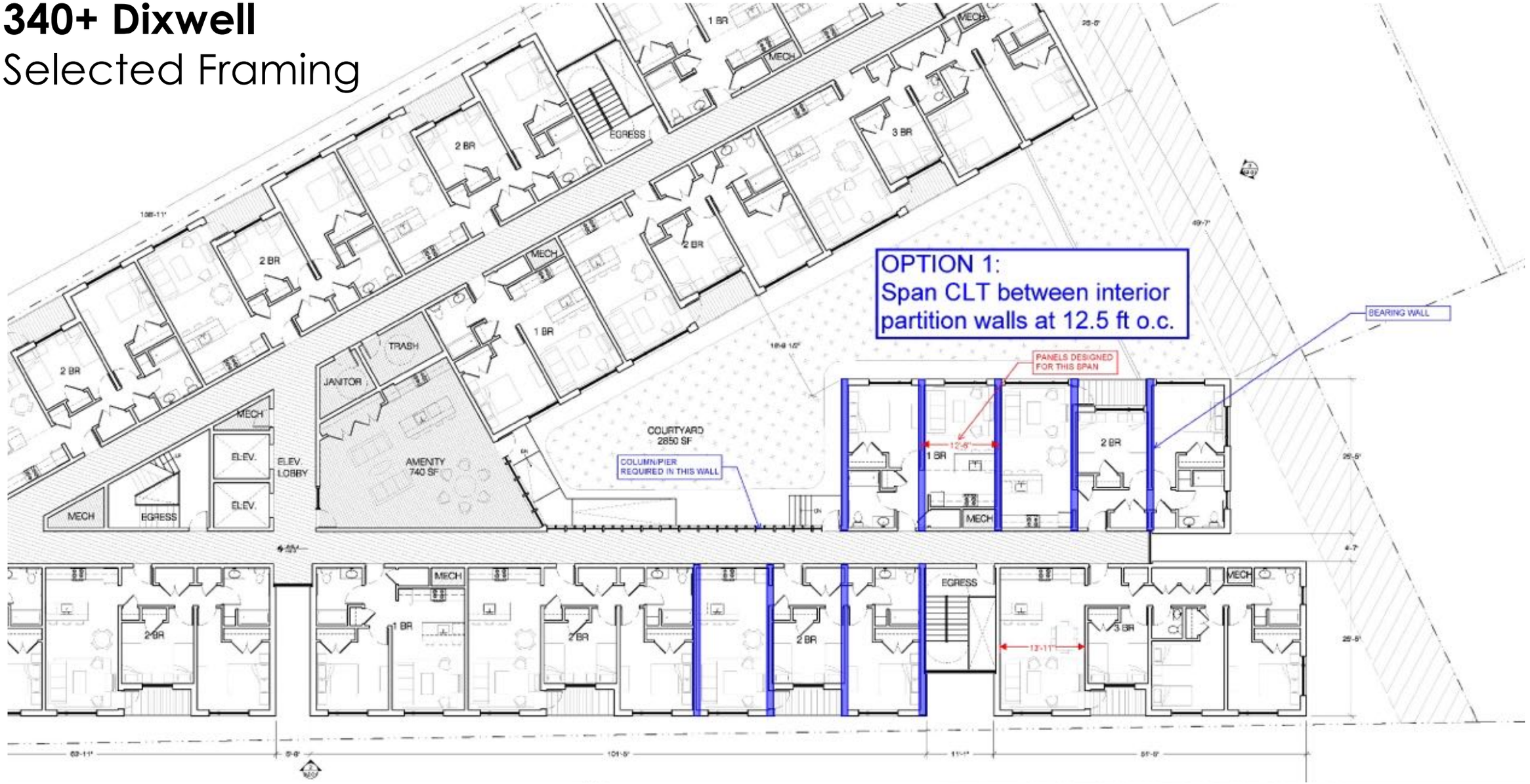
# **340+ Dixwell**
Framing Options



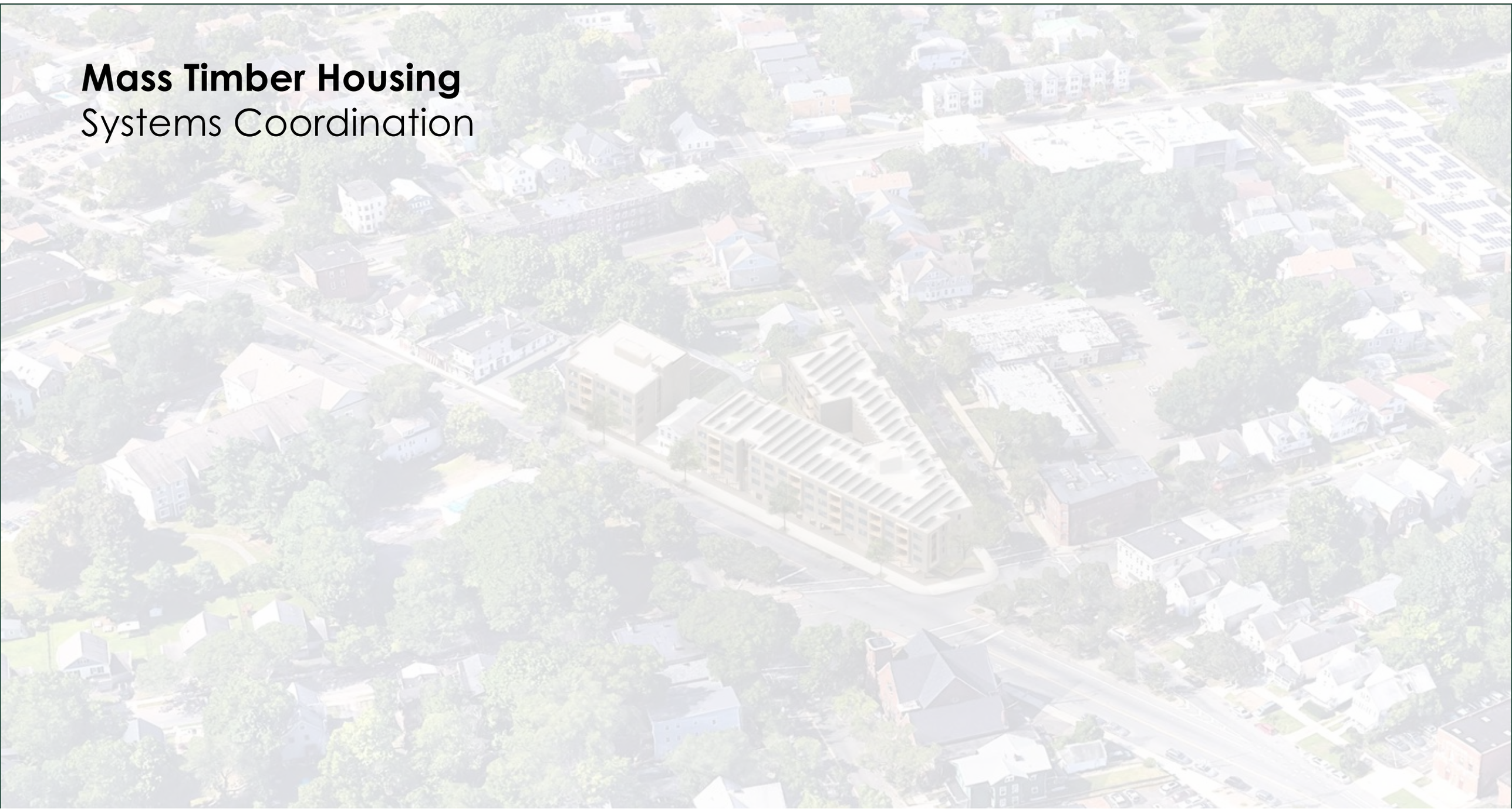
# **340+ Dixwell**
Framing Options



# **340+ Dixwell**
Selected Framing



# **Mass Timber Housing**
## Systems Coordination



Design Strategies for Affordable Mass Timber Multi-Family Housing

September 20, 2023

# 340+ Dixwell
## Systems Layout

# **340+ Dixwell**
## Unit Interior

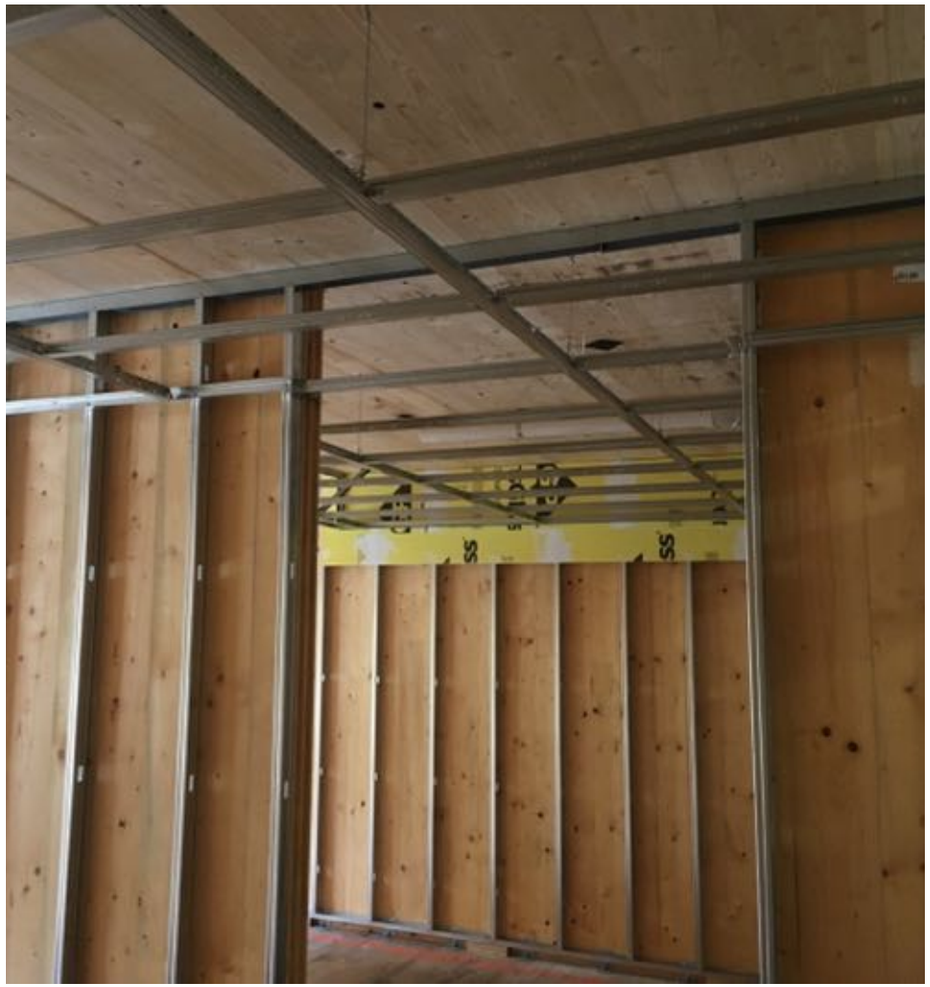
**340+ Dixwell**
Unit Interior

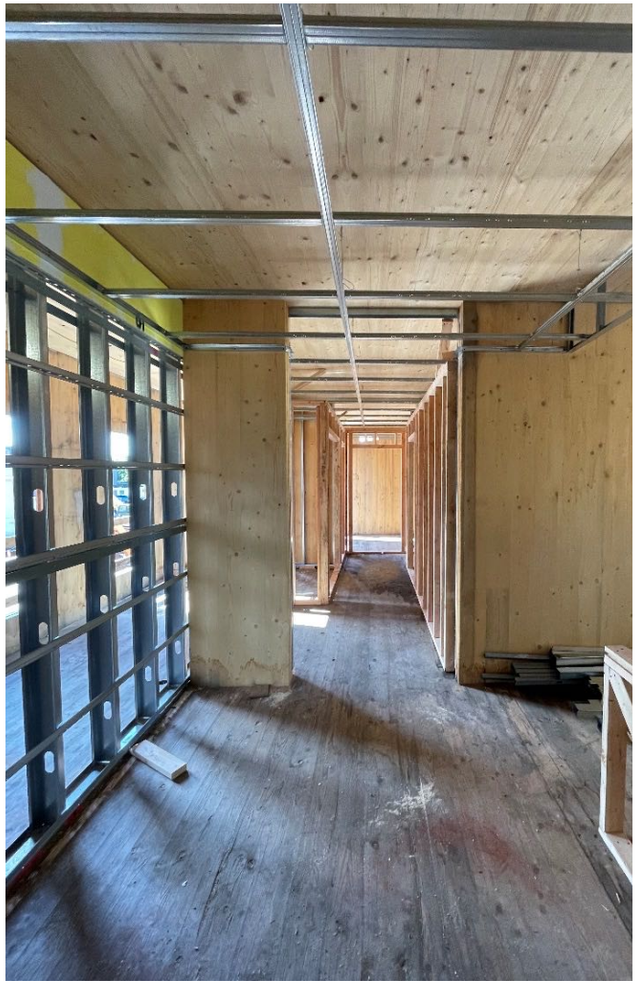
**340+ Dixwell**
Residential Corridor

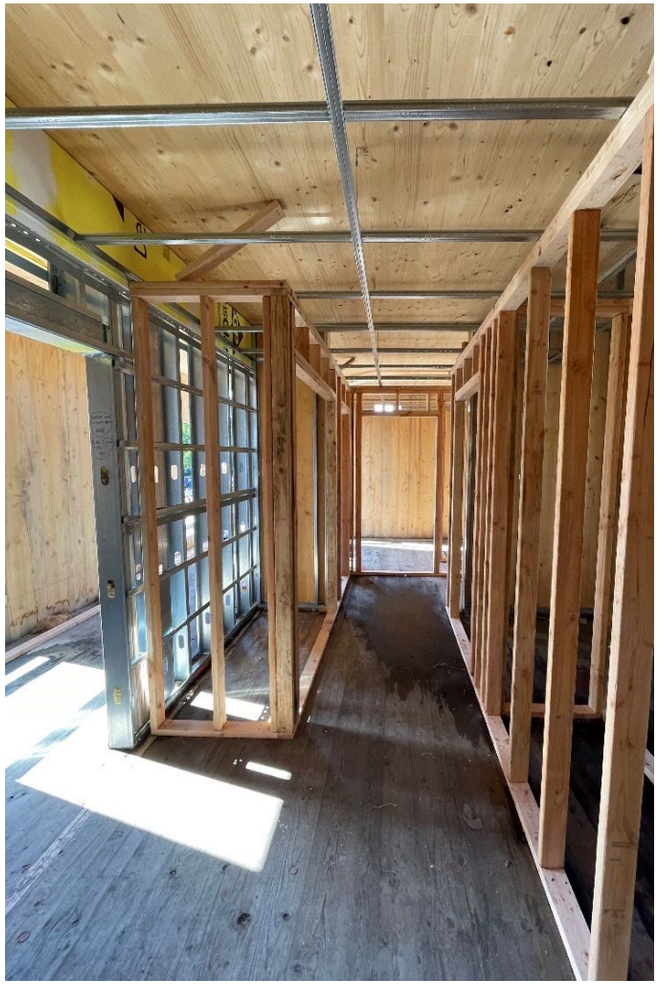
**340+ Dixwell**
MEP Distribution

# **340+ Dixwell**
MEP Distribution

**340+ Dixwell**
MEP Distribution







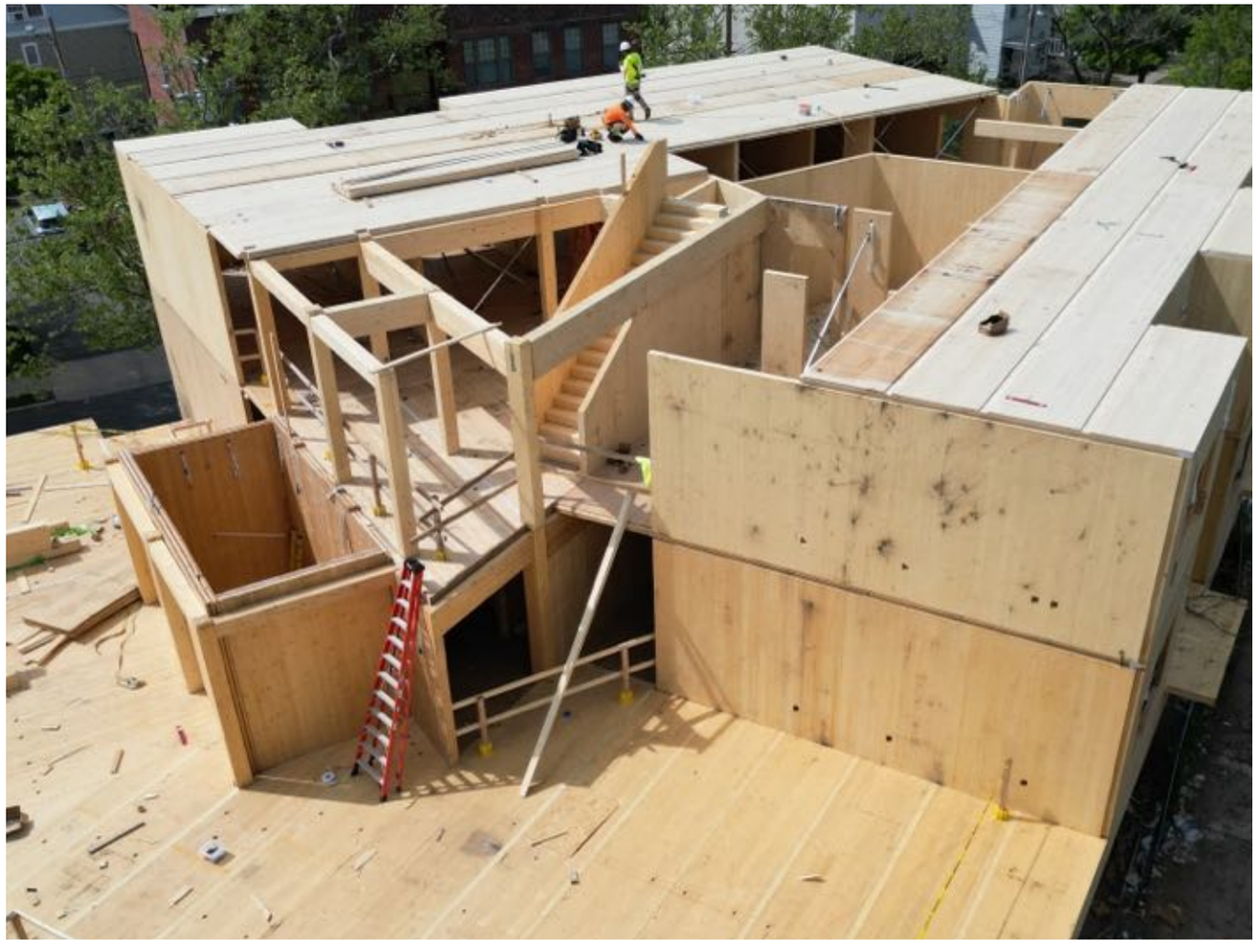
# **Mass Timber Housing**
## Structural Coordination

# **340+ Dixwell**
## Post+Beam and Panelized

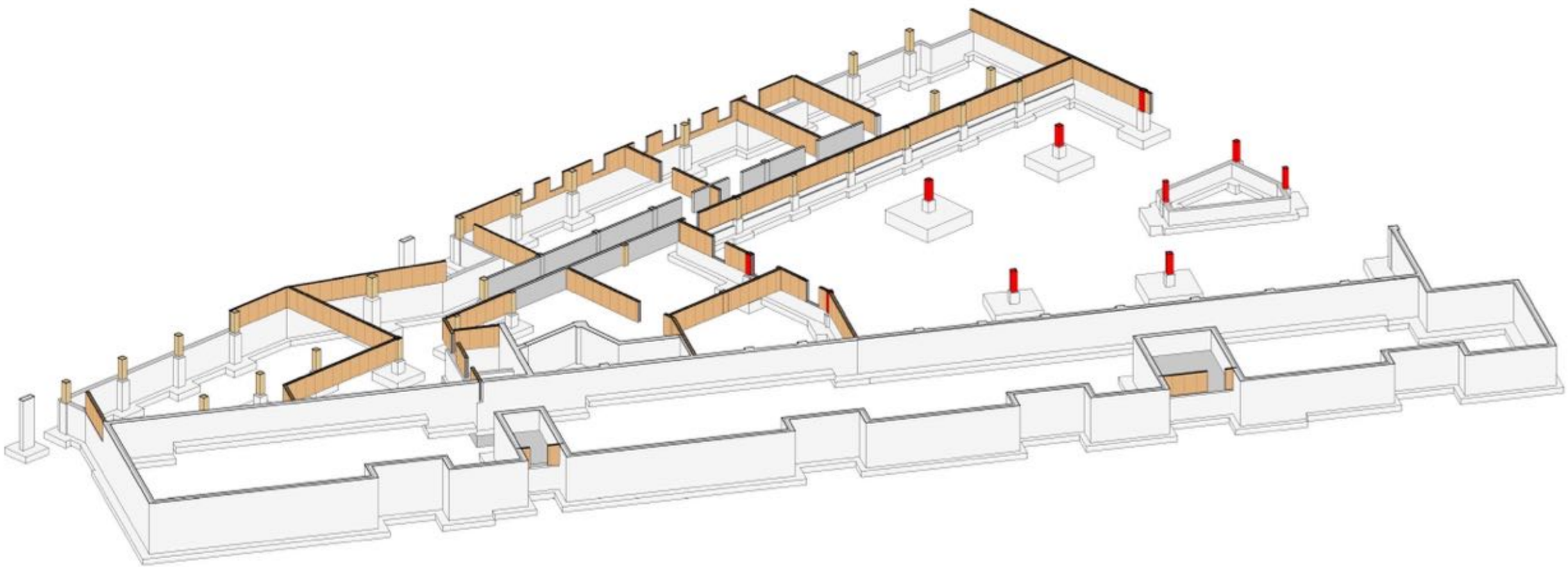
**340+ Dixwell**

Post+Beam and Panelized

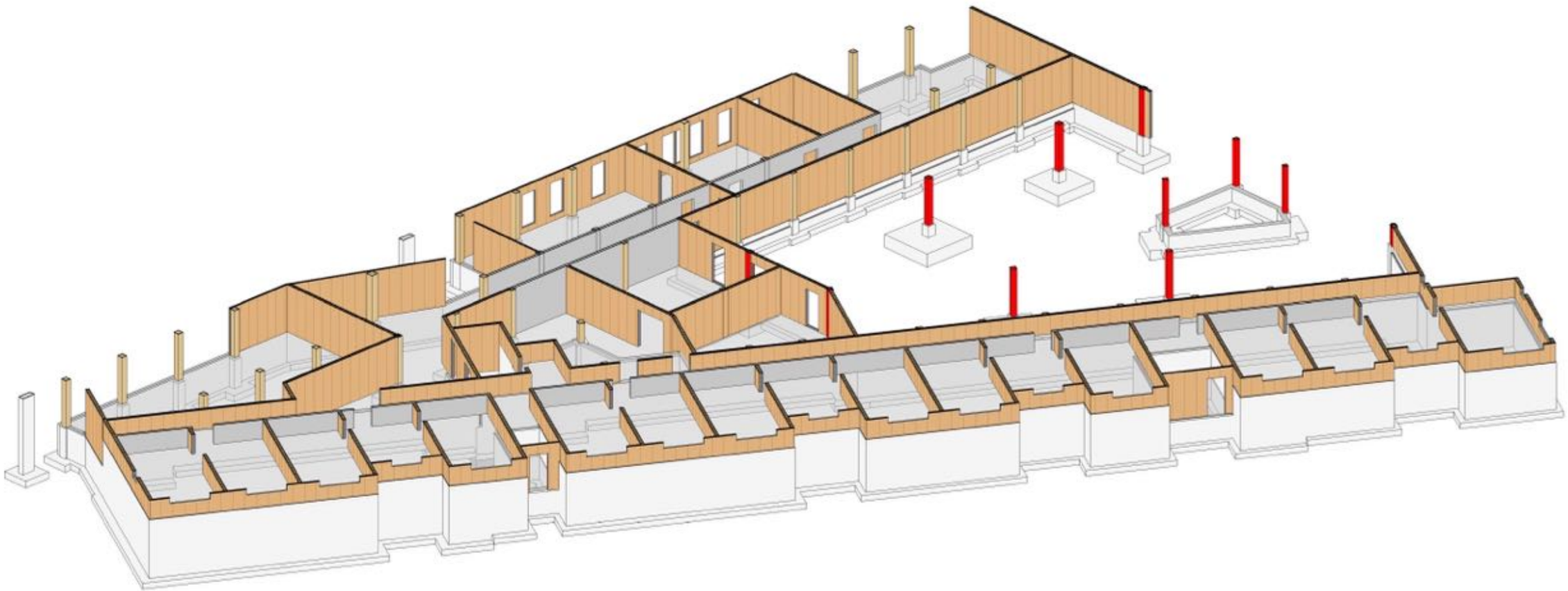
# **340+ Dixwell**
Mass Timber Shaft



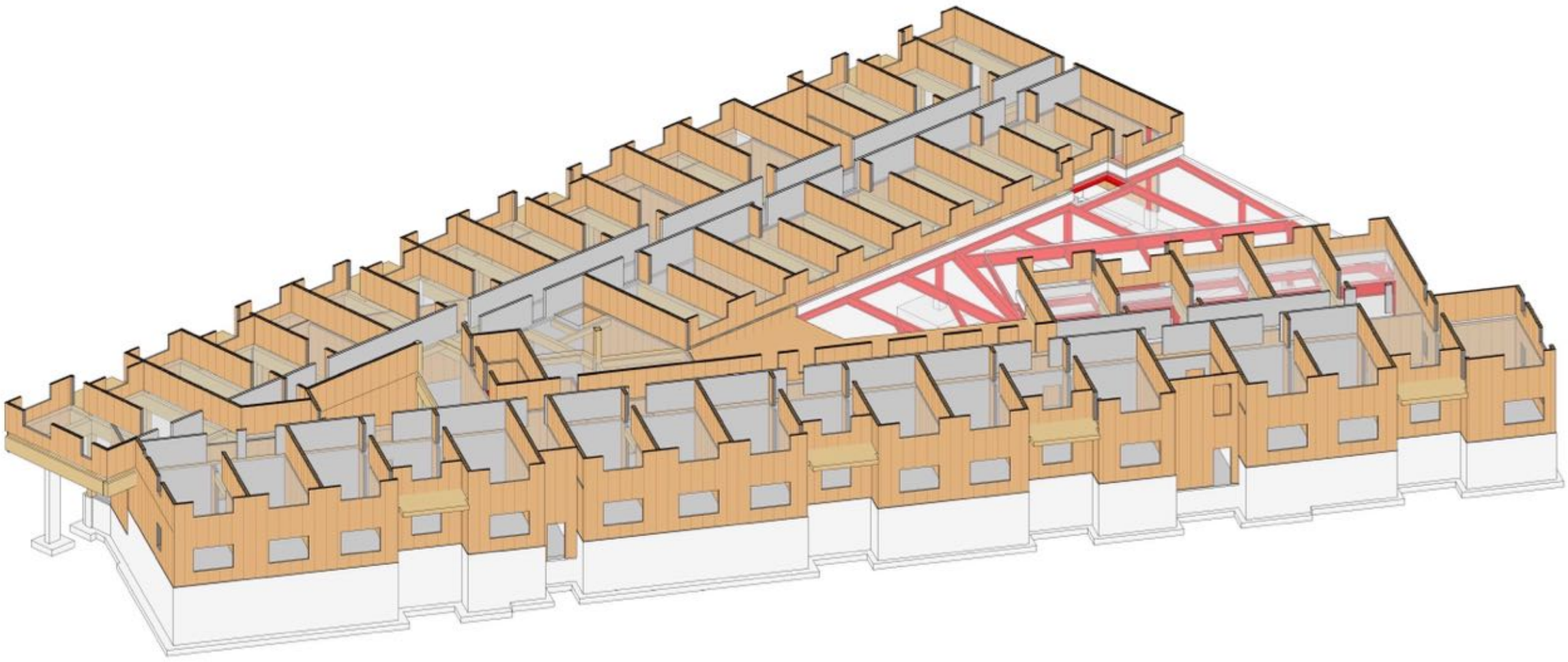
**340+ Dixwell**
Structural Model



**340+ Dixwell**
Structural Model



**340+ Dixwell**
Structural Model



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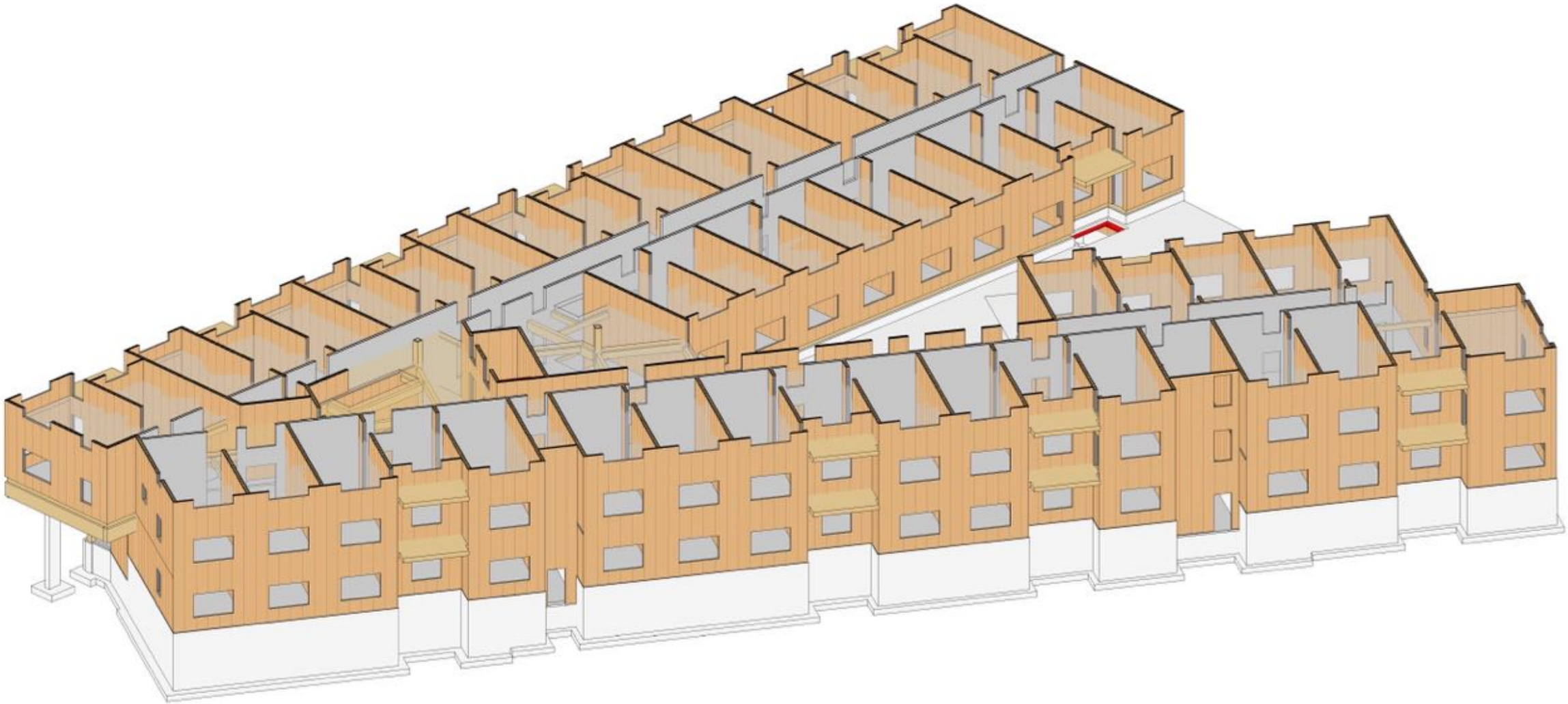
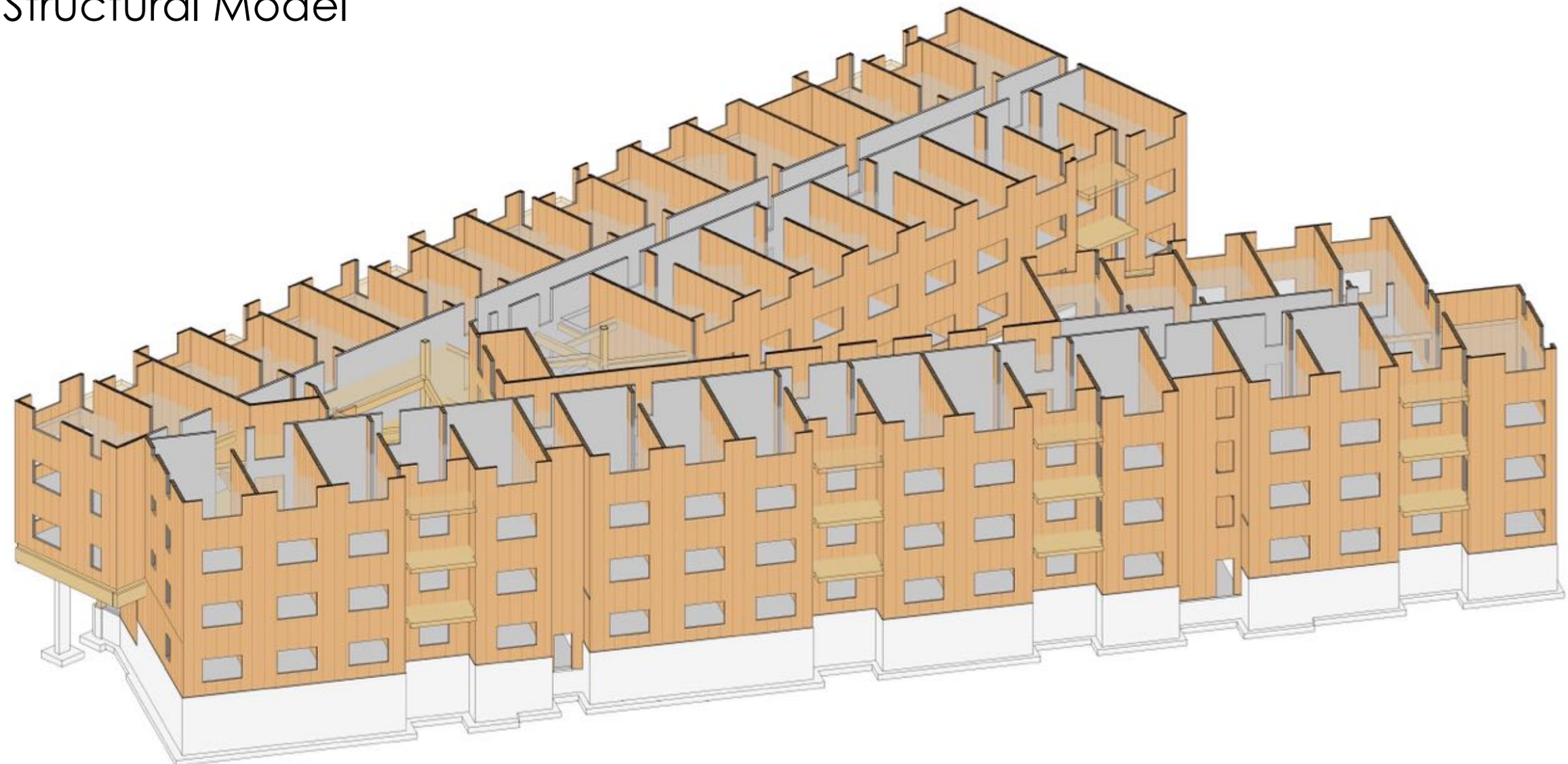
Structural Model

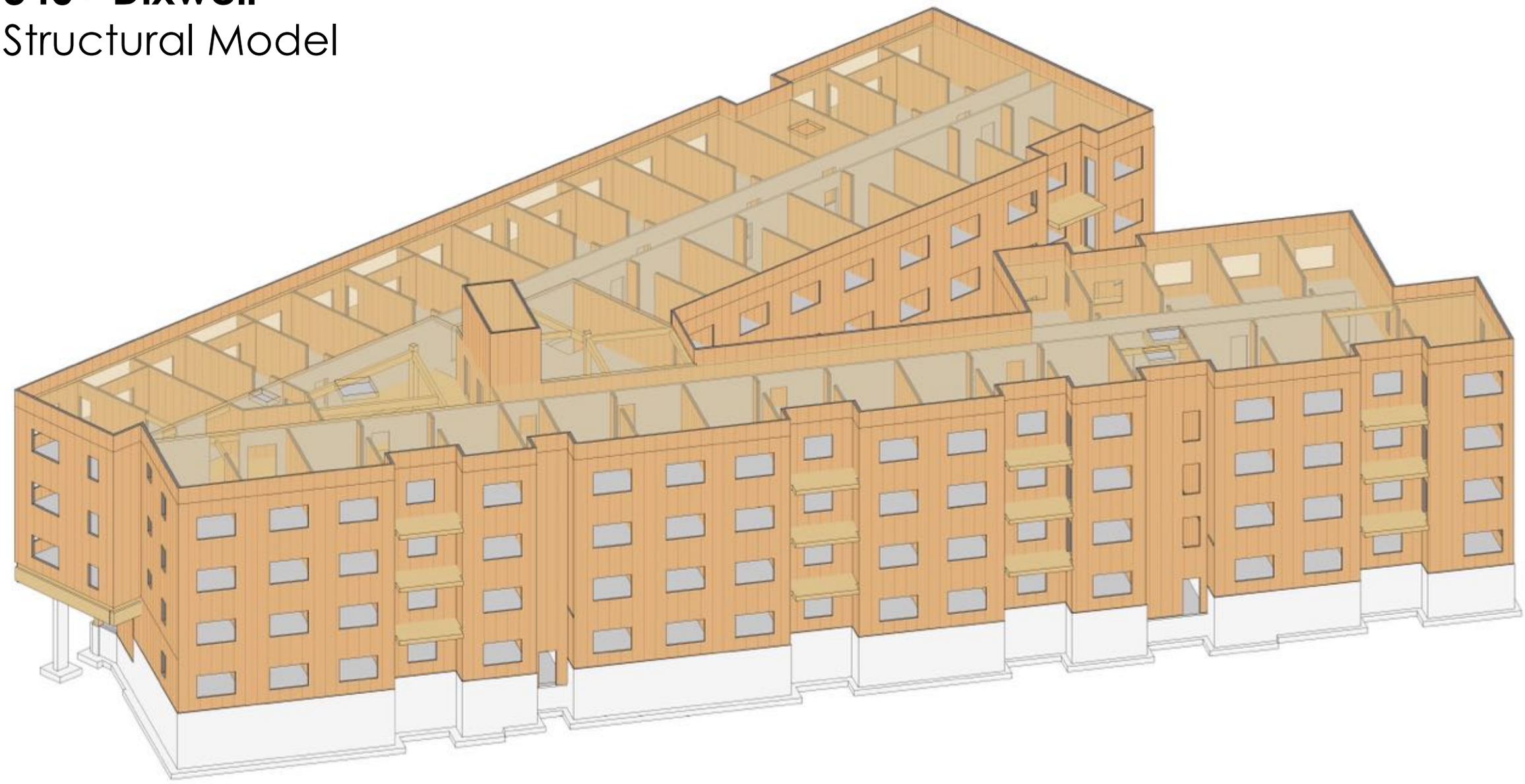


**340+ Dixwell**

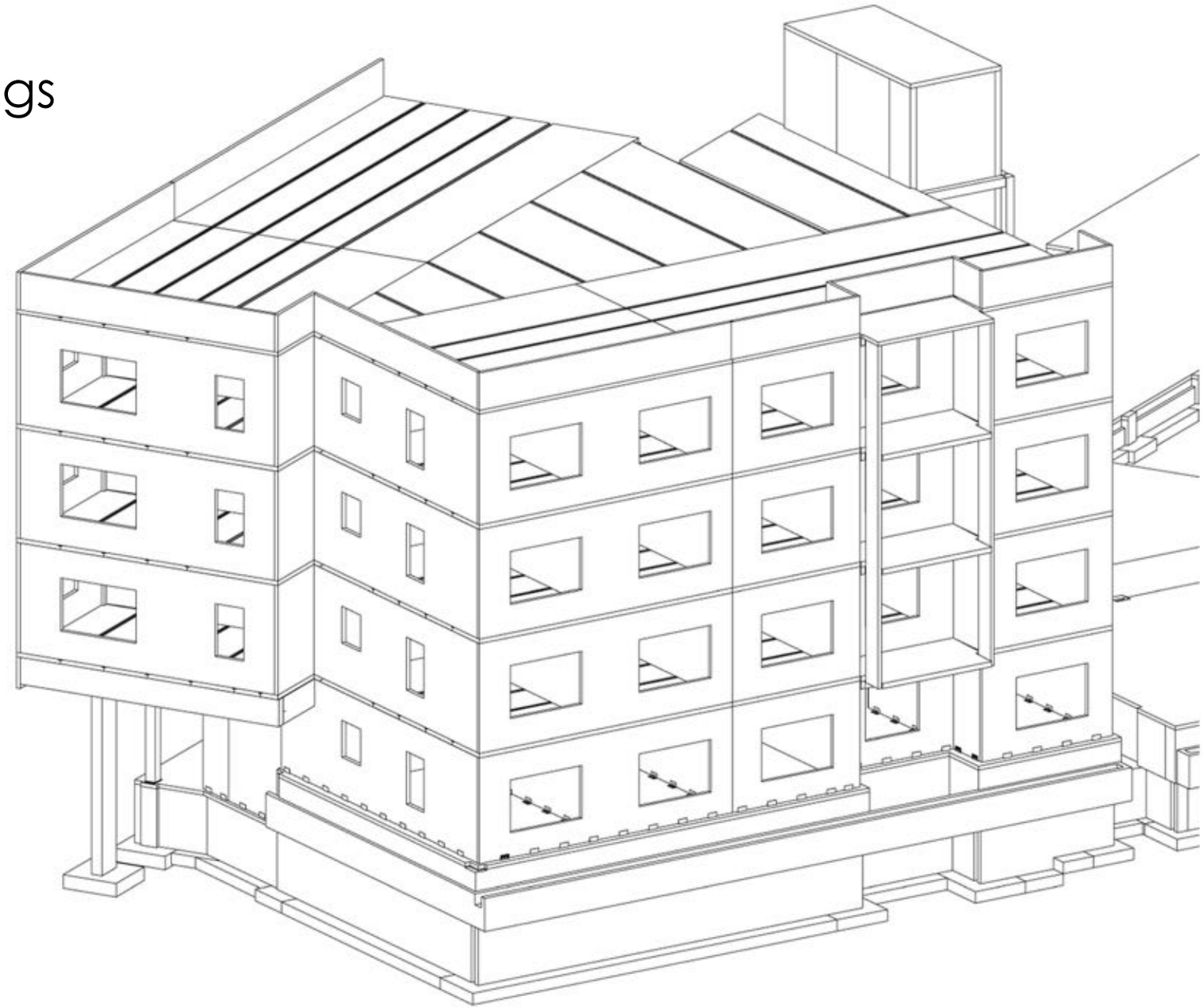
Structural Model



**340+ Dixwell**
Structural Model



**340+ Dixwell**
Shop Drawings

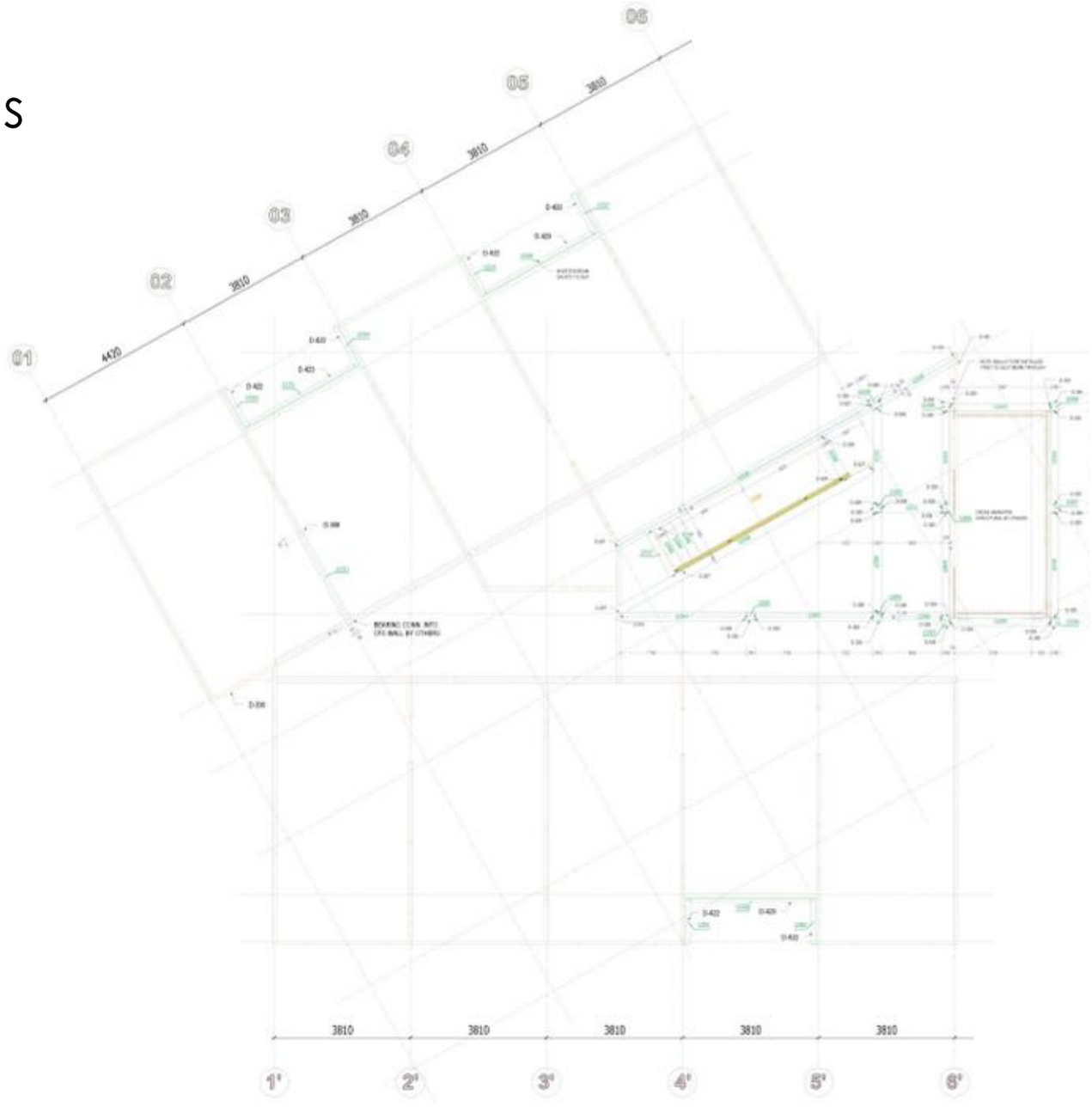


**340+ Dixwell**

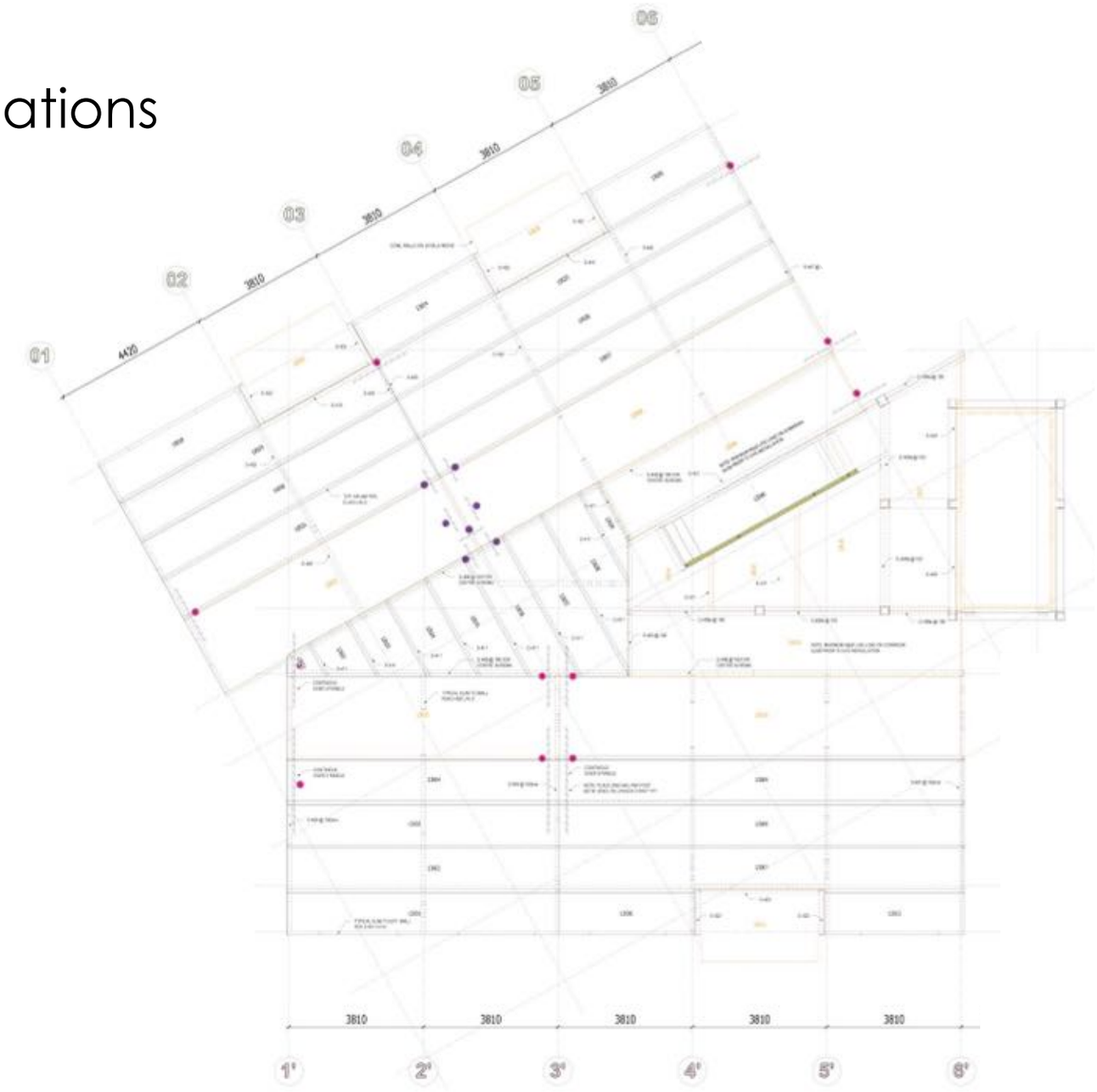
Wall + Column Locations

# **340+ Dixwell**
Base Connections

**340+ Dixwell**
Glulam Locations



# **340+ Dixwell**
Penetration Locations



# **Mass Timber Housing**
## Design Strategies

# **Design Strategies**
## Site + Sequence

- Identify constraints and opportunities afforded by project site and location.
- Early coordination with mass timber supplier(s), if possible.
- Design delivery sequence and storage scenarios and identify impacts for on-site laydown space and heavy equipment access
- Collaborate with GC/CM to schematize delivery and installation sequence for follow-on systems and trades.

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## **Design Strategies**
## Material Interface

- Identify interface between site work and prefabricated mass timber components and introduce tolerances for installation.

- Develop construction details with an understanding of mass timber installation sequence, identifying opportunities for simplification.

- Identify potential issues for exposed timber surfaces.

## **Design Strategies**
## Material Interface

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# **Design Strategies**
## Structural Geometry

- Organize building geometries around repetitive spans and consistent structural centerlines.
- Design floor and roof panels for multiple spans to maximize sizing and performance advantages.
- Test floor panel span orientation for structural and construction efficiency.
- Study panelized vs post+beam solutions.

## **Design Strategies**
## Exterior Envelope

- Coordinate panelized wall construction dimensions and logistics with mass timber supplier(s)
- Identify opportunities to minimize panel joints.
- Develop thermal insulation and weather barrier solution appropriate to local climate.
- Coordinate MEP routing at building envelope to minimize penetrations.

Design Strategies for Affordable Mass Timber Multi-Family Housing

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# ❯ QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course


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