# Structural Grids, Fire Resistance and MEP: Holistic Coordination in Mass Timber Design

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

# Course Description

Designing a mass timber building that is efficient—both in its use of timber fiber and application of code provisions—requires a high level of preconstruction coordination across all facets of design. Delivered by experienced structural and mechanical engineers, this presentation will address some of the critical decisions that should be made as early as possible in mass timber projects. These decisions can have a big impact on cost and either increase or limit opportunities later in design (the ripple down effect). Topics will include the unique role of the supply chain in the efficiency of a mass timber project, construction types, fire ratings, column grids and beam/panel spans, and MEP integration.

# Learning Objectives

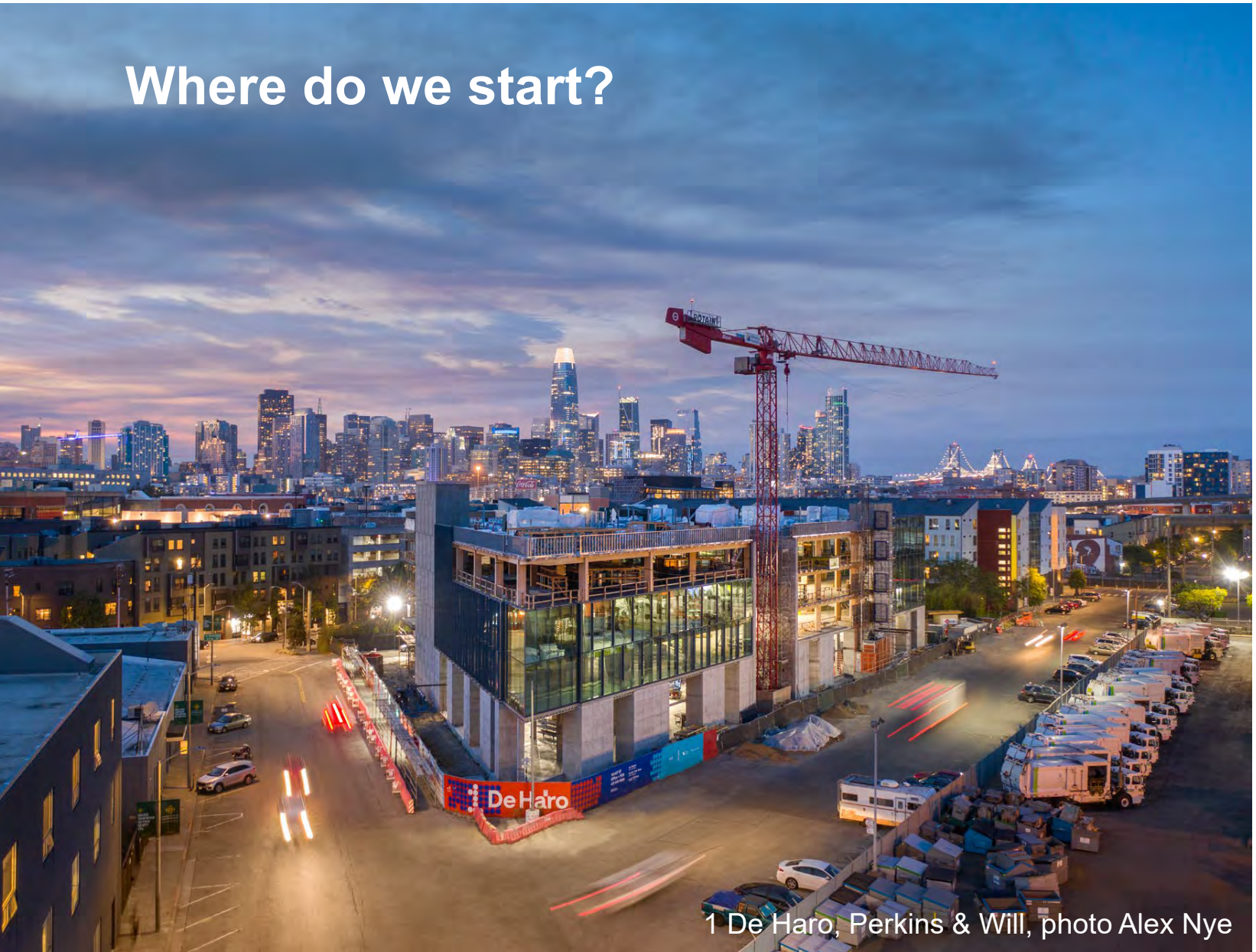
1. Identify construction types within the International Building Code where a mass timber structure is permitted.

2. Discuss the impacts of construction type on required fire-resistance ratings of structural elements, noting the impacts that these ratings have on member spans and grids.

3. Review code-compliance requirements and solutions for the fire-resistance design of through penetrations at MEP elements.

4. Highlight effective methods of integrating MEP services in a mass timber building and discuss their relative impacts on cost, aesthetics, occupant comfort and future tenant renovations.

# Key Early Design Decisions




1 De Haro, Perkins & Will, photo Alex Nye

# Key Early Design Decisions

**What is the Single Most Important Early Design Decision on a Mass Timber Project? Is it:**

**Construction Type**
**Fire-Resistance Ratings**
**Member Sizes**
**Grids & Spans**
**Exposed Timber (where & how much)**
**Sustainability**

**MEP Layout**
**Acoustics**
**Concealed Spaces**
**Connections**
**Penetrations**

**The Answer is…They All Need to Be Weighed (Plus Others)**

# Key Early Design Decisions

**One *potential* design route:**

1. **Building size & occupancy informs construction type & grid**

2. **Construction type informs fire resistance ratings**

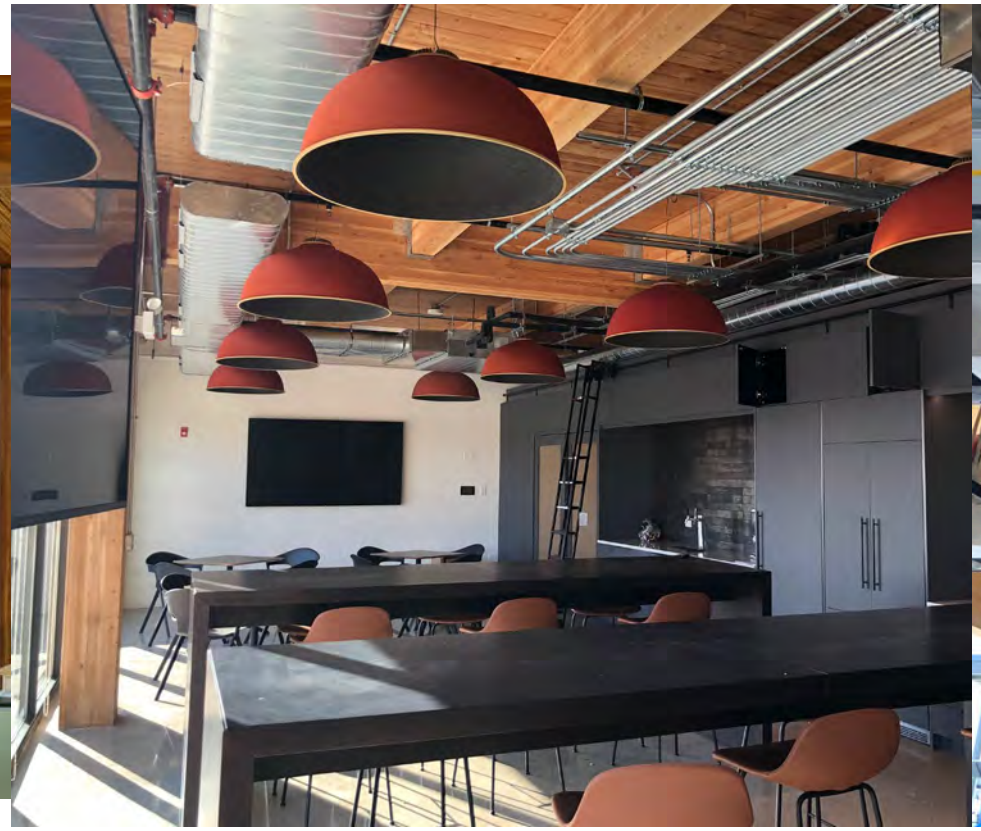
3. **Grid & fire resistance ratings inform timber member sizes & MEP layout**

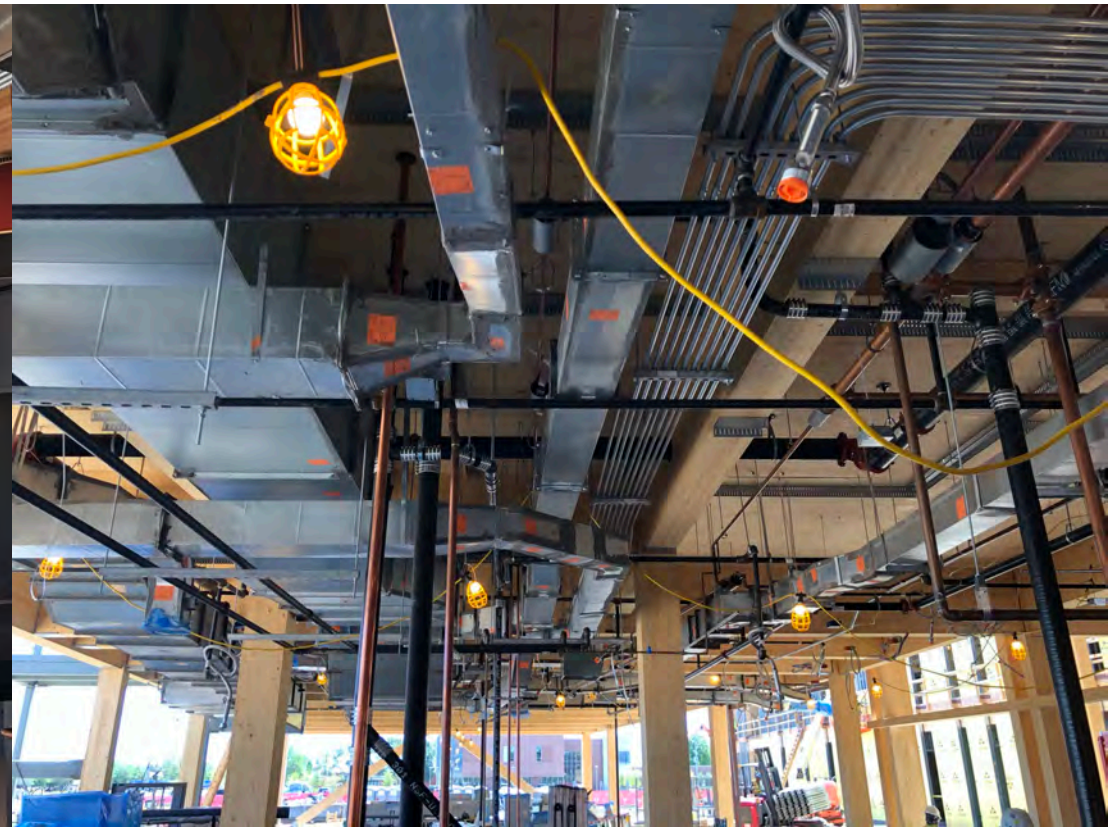
**But that's not all…**

# MEP Layout & Integration

Set Realistic Owner Expectations About Aesthetics

- MEP fully exposed with MT structure, or limited exposure?

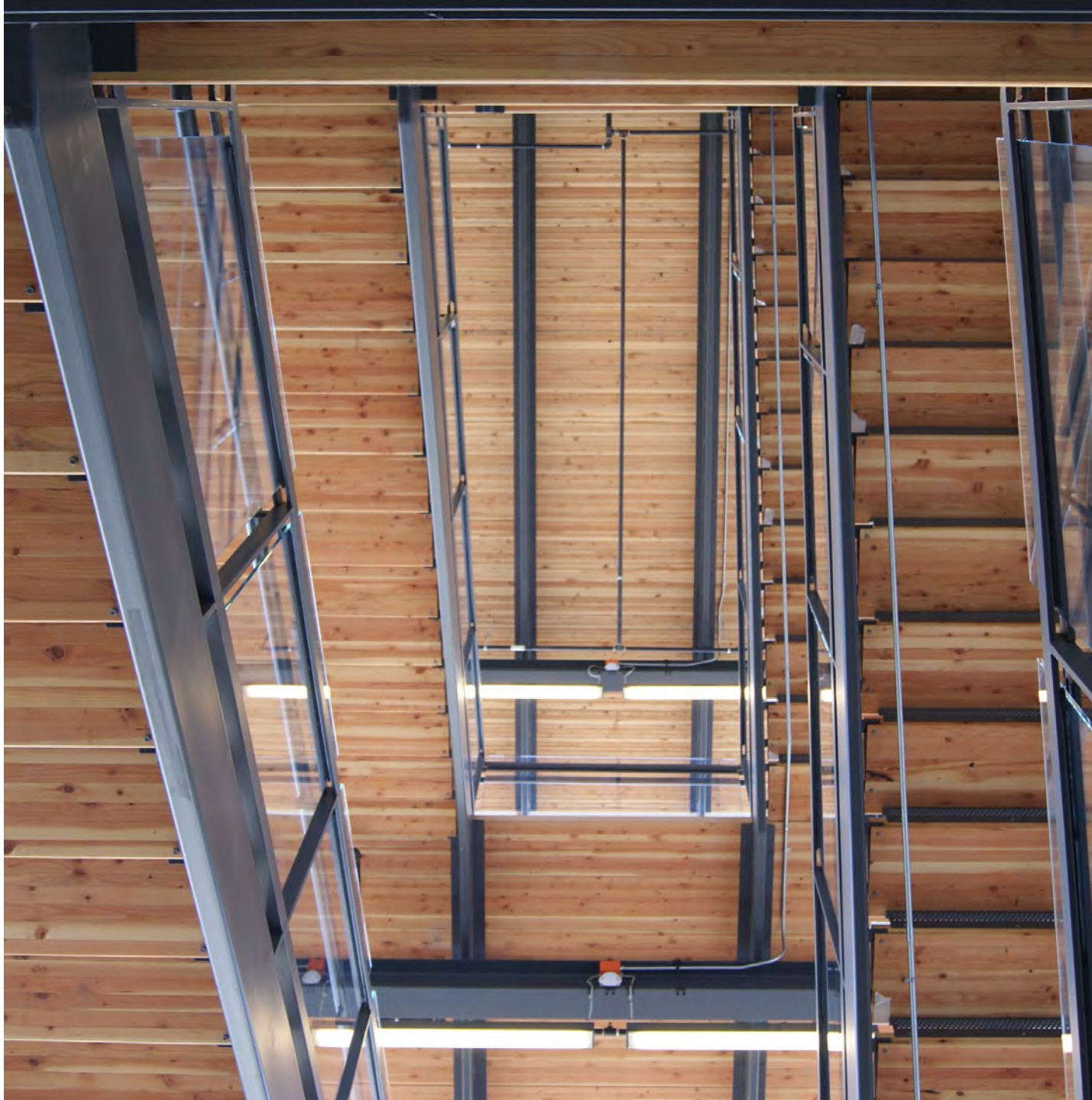




# Impacts on Architecture

**PLANNING EARLY WITH THE TEAM**

- Program for the Building
- Aesthetics / Exposed Ceilings
- Structural Scheme
- Performance Goals



# Key Early Design Decisions

## Construction Type – Primarily based on building size & occupancy

| | Construction Type (All Sprinklered Values) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | IV-A | IV-B | IV-C | IV-HT | III-A | III-B | V-A | V-B |
| Occupancies | Allowable Building Height above Grade Plane, Feet (IBC Table 504.3) | | | | | | | |
| A, B, R | 270 | 180 | 85 | 85 | 85 | 85 | 70 | 60 |
| | Allowable Number of Stories above Grade Plane (IBC Table 505.4) | | | | | | | |
| A-2, A-3, A-4 | 18 | 12 | 6 | 4 | 4 | 3 | 3 | 2 |
| B | 18 | 12 | 9 | 6 | 6 | 4 | 4 | 3 |
| R-2 | 18 | 12 | 8 | 5 | 5 | 5 | 4 | 3 |
| | Allowable Area Factor (At) for SM, Feet$^2$ (IBC Table 506.2) | | | | | | | |
| A-2, A-3, A-4 | 135,000 | 90,000 | 56,250 | 45,000 | 42,000 | 28,500 | 34,500 | 18,000 |
| B | 324,000 | 216,000 | 135,000 | 108,000 | 85,500 | 57,000 | 54,000 | 27,000 |
| R-2 | 184,500 | 123,000 | 76,875 | 61,500 | 72,000 | 48,000 | 36,000 | 21,000 |

# Key Early Design Decisions

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**For low- to mid-rise mass timber buildings, there may be multiple options for construction type. There are pros and cons of each, don't assume that one type is always best.**

# Key Early Design Decisions

## Fire-Resistance Ratings

- Driven primarily by construction type
- Rating achieved through timber alone or non-com protection required?

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[a,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) | 1½[b] | 1[b,c] | 1[b,c] | 0[c] | 1[b,c] | 0 | 1½ | 1 | 1 | HT | 1[b,c] | 0 |

# Key Early Design Decisions

## Fire-Resistance Ratings (FRR)

- Thinner panels (i.e. 3-ply) generally difficult to achieve a 1+ hour FRR
- 5-ply CLT / 2x6 NLT & DLT panels can usually achieve a 1- or 2-hour FRR
- Construction Type | FRR | Member Size | Grid (or re-arrange that process but follow how one impacts the others)

| Panel | Example Floor Span Ranges |
|---|---|
| 3-ply CLT (4-1/8" thick) | Up to 12 ft |
| 5-ply CLT (6-7/8" thick) | 14 to 17 ft |
| 7-ply CLT (9-5/8") | 17 to 21 ft |
| 2x4 NLT | Up to 12 ft |
| 2x6 NLT | 10 to 17 ft |
| 2x8 NLT | 14 to 21 ft |
| 5" MPP | 10 to 15 ft |

# FRR Impact on Structure

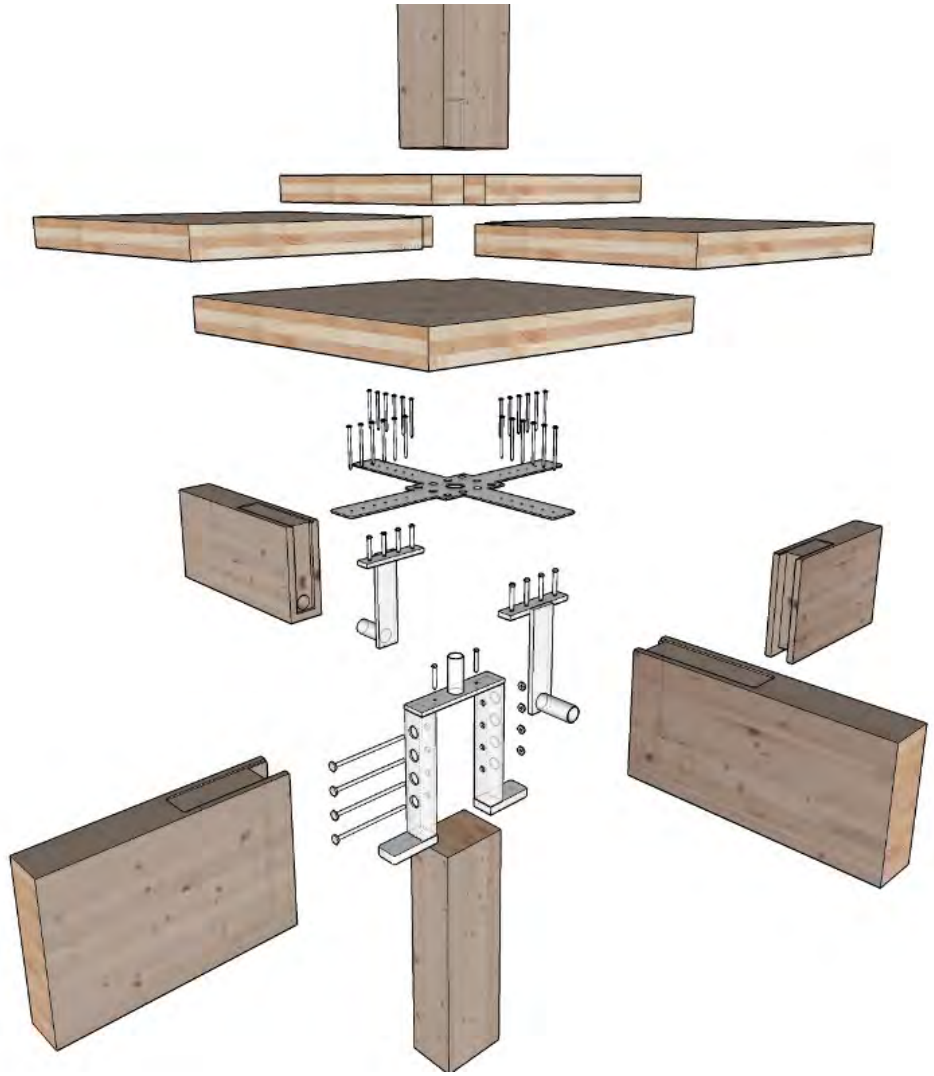
Effective Char Depth

1 Hour = 1.8 in

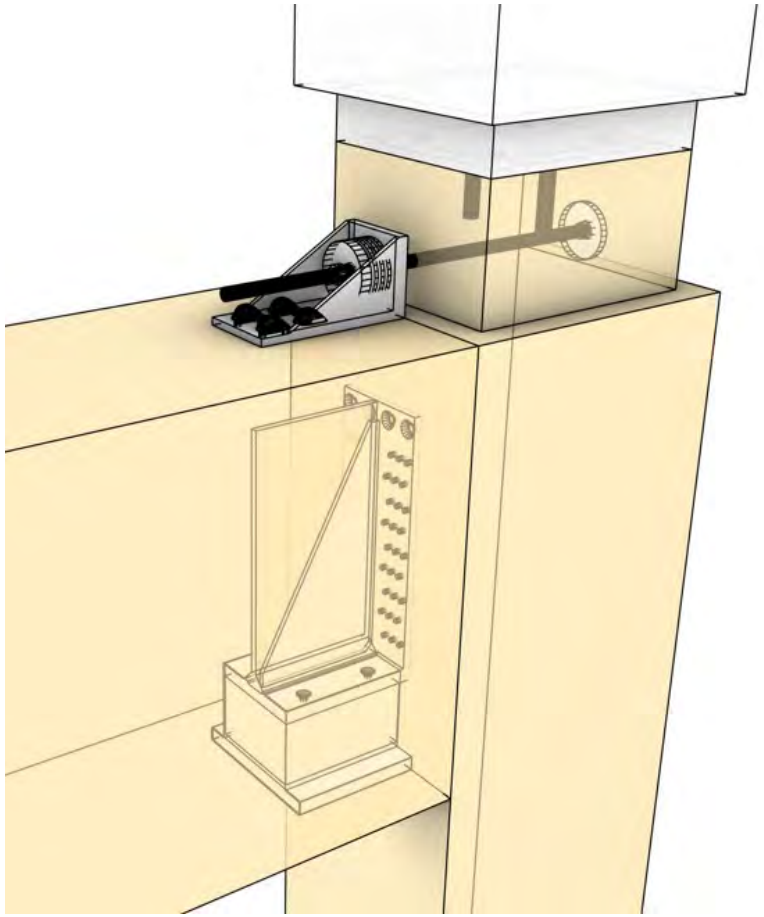
Effective Char Depth

2 Hour = 3.2 in

# FRR Impact on Structure



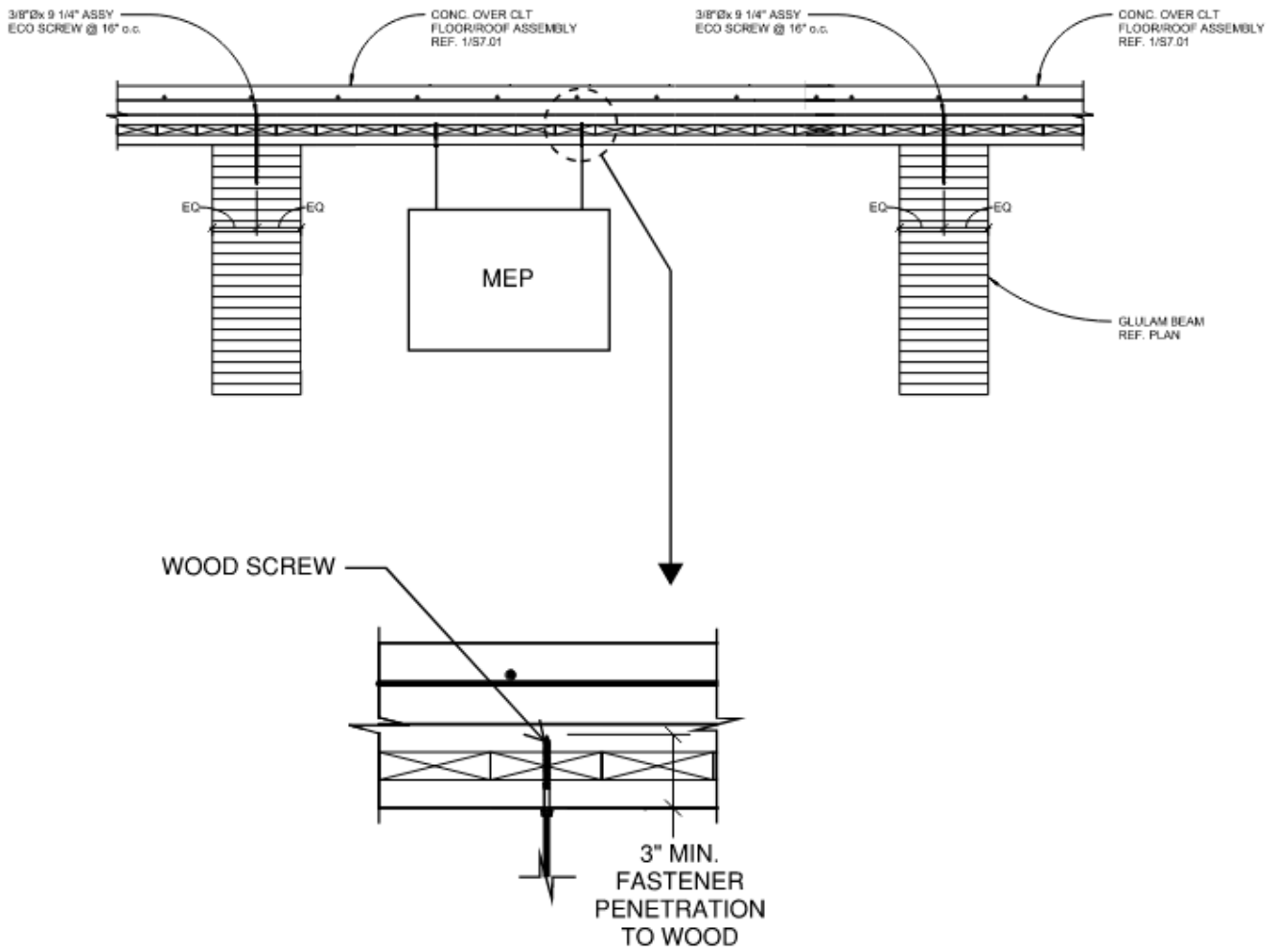
# FRR Impact on Structure



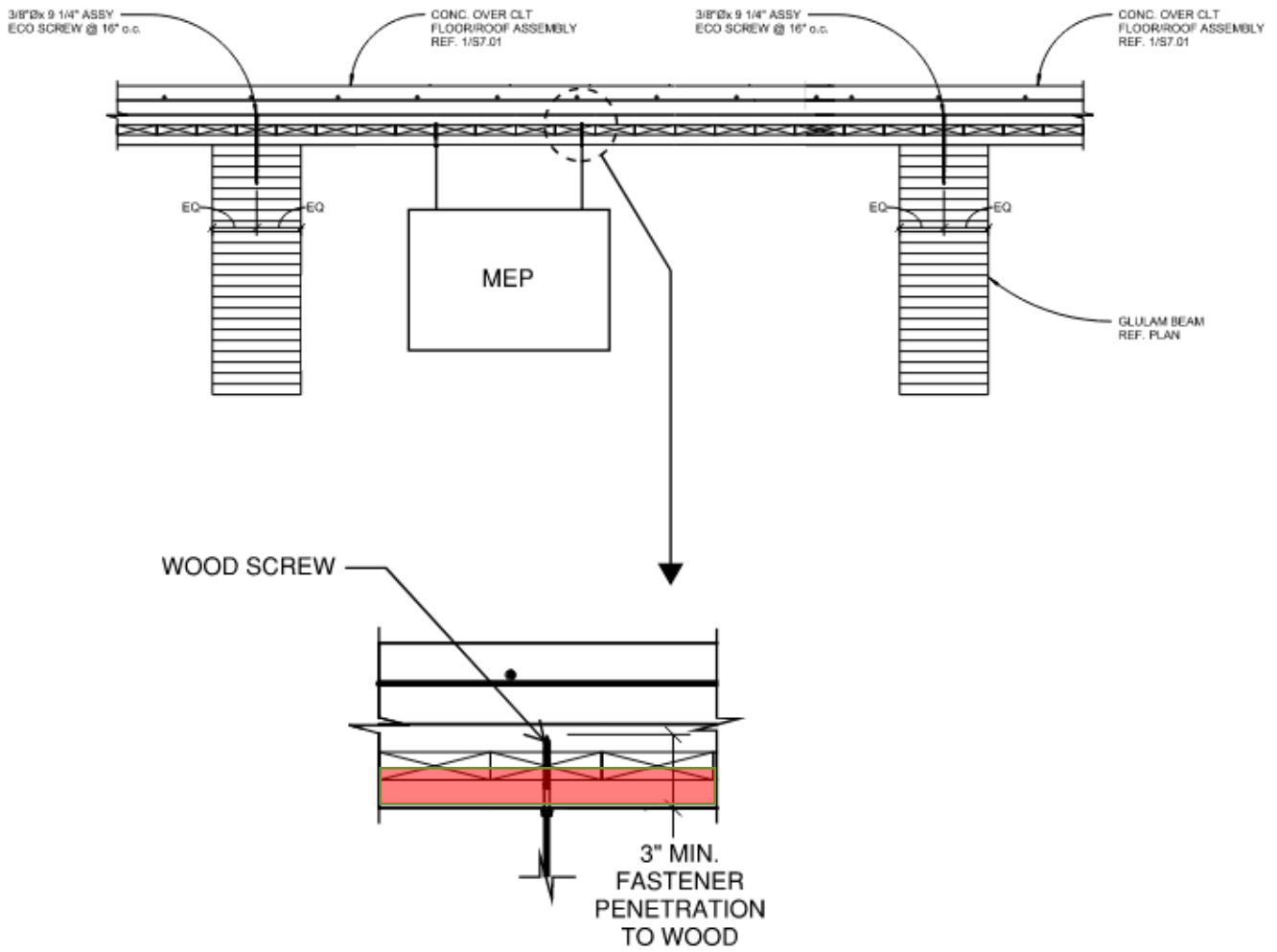
# FRR Impact on Structure

*Images Courtesy of: MTC Solutions*
*(Ricon and Megant Fire Testing)*

# FRR Impact on MEP

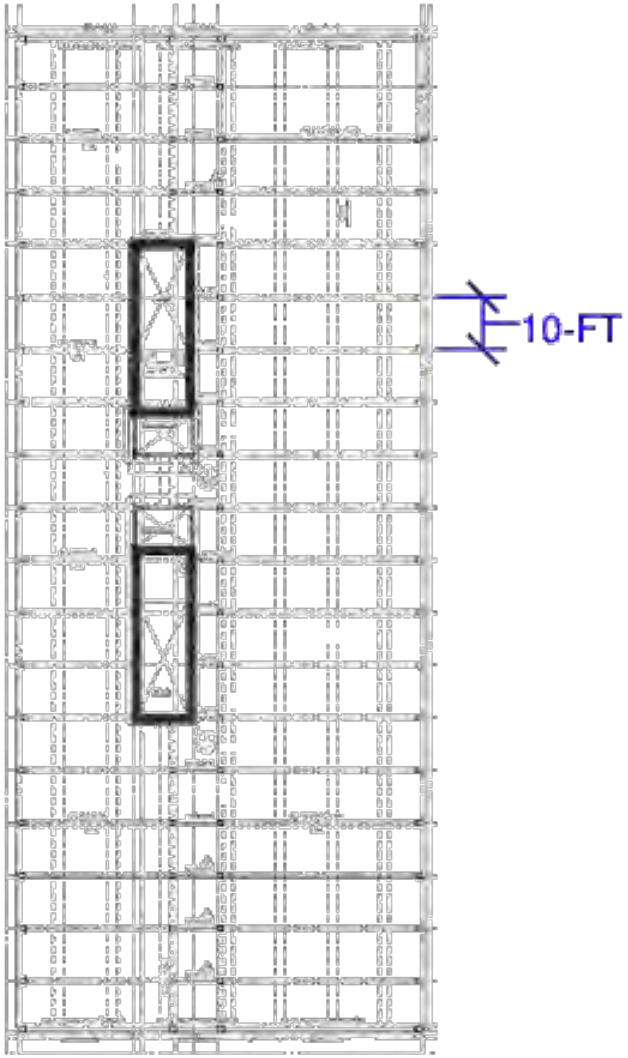


# FRR Impact on MEP




ONE WAY
ROAD CLOSED

# Structural Efficiency

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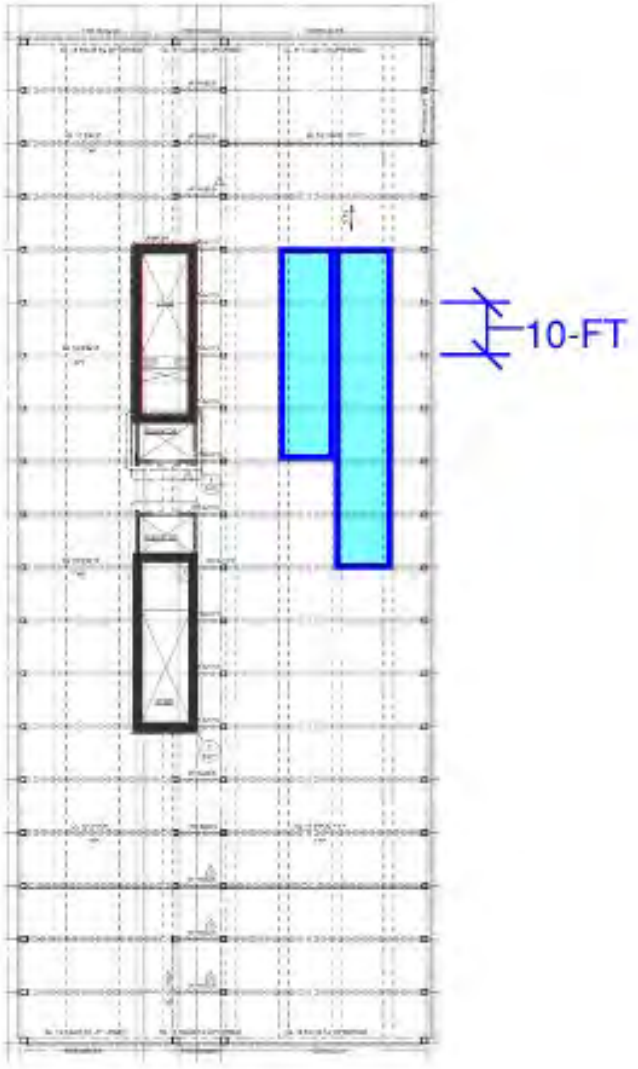


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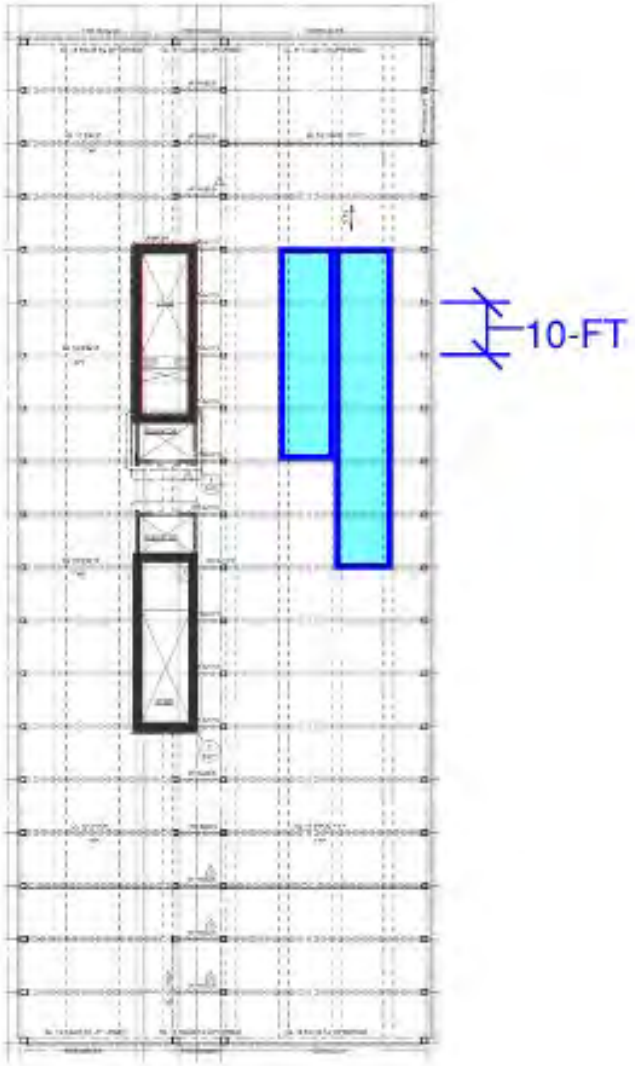


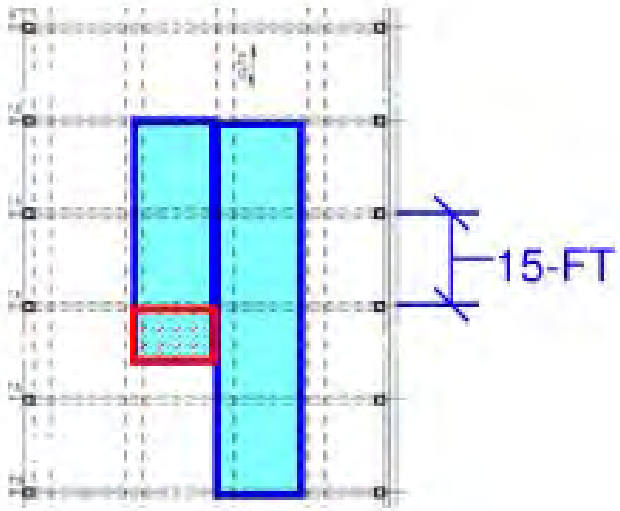

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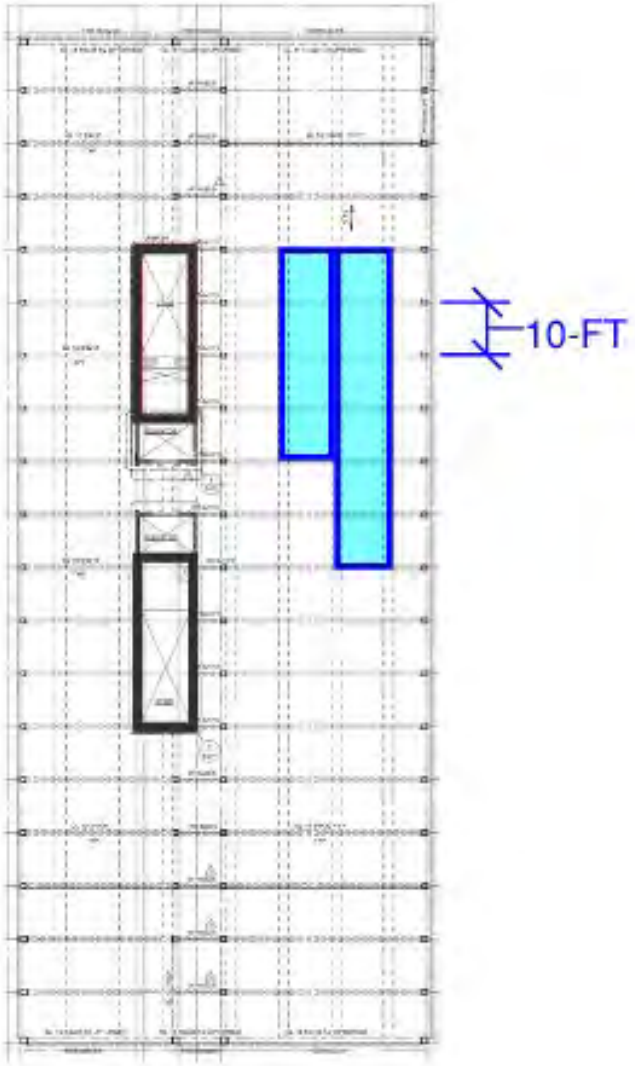
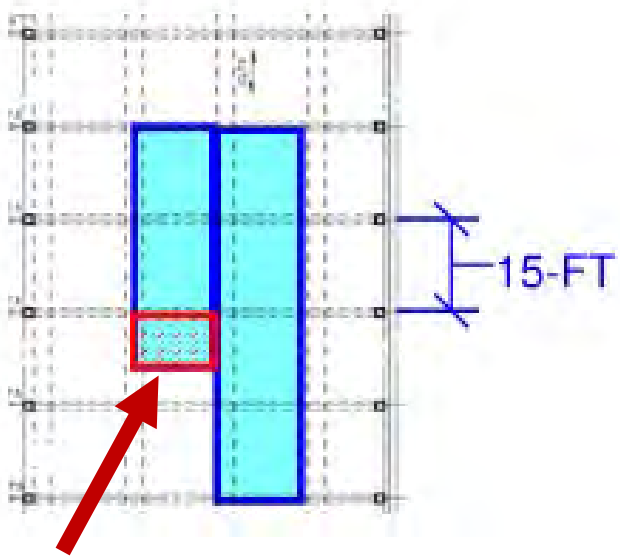
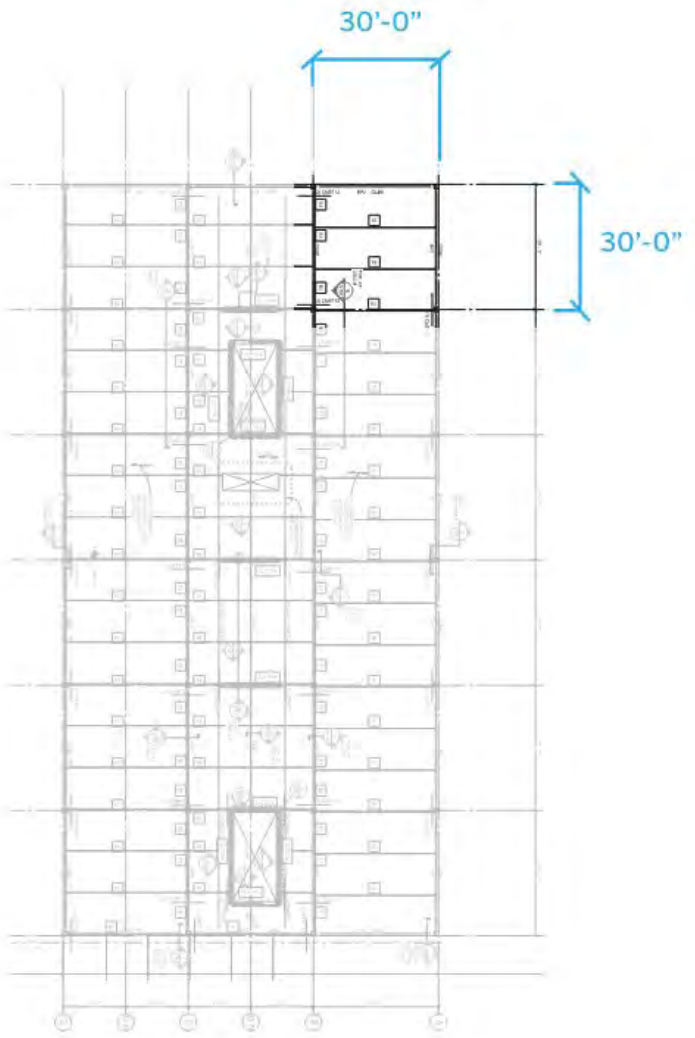


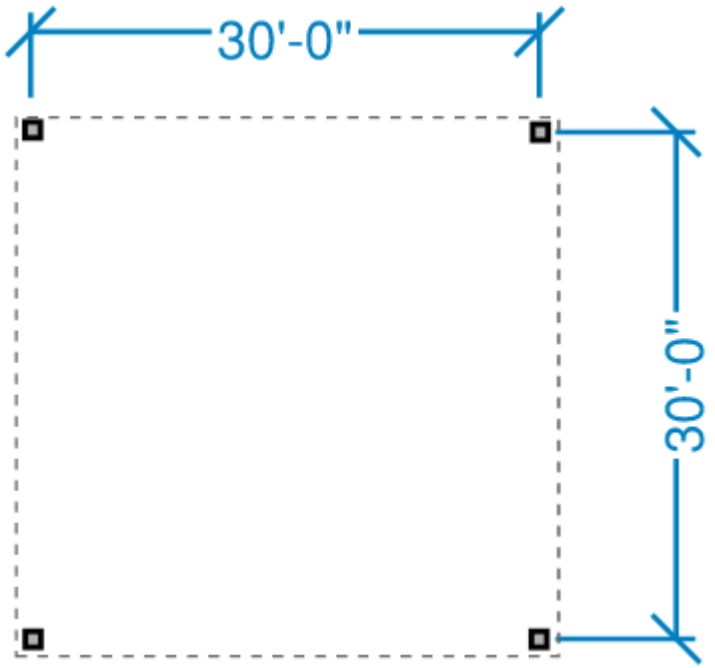




Inefficient use
of panel length

# Building Grid & MEP Integration

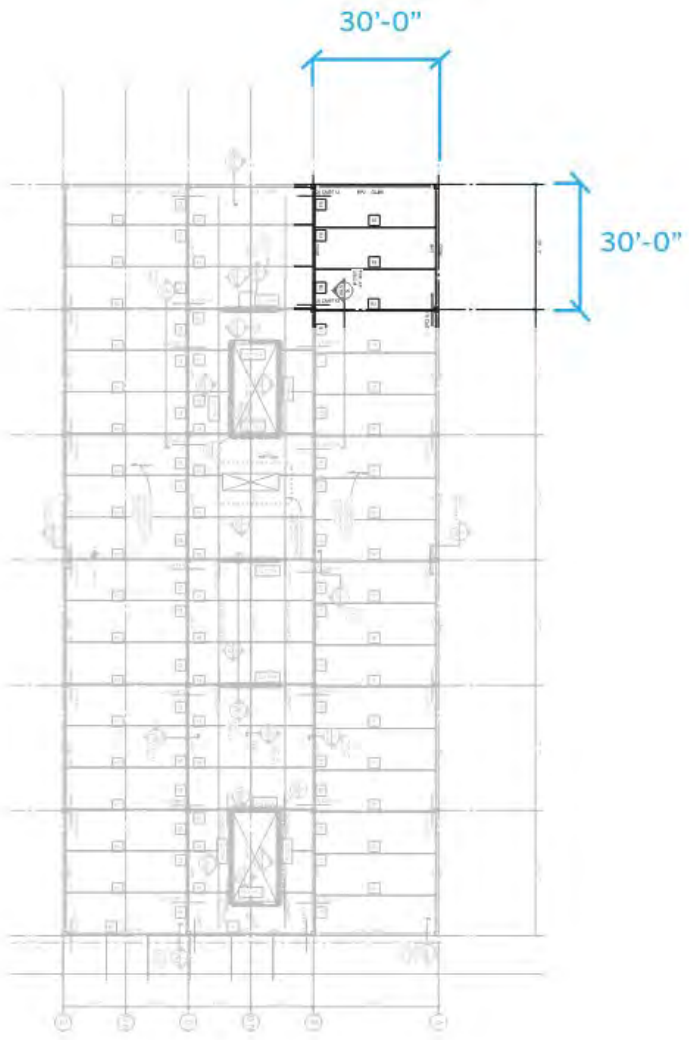
# Optimize Building Grids

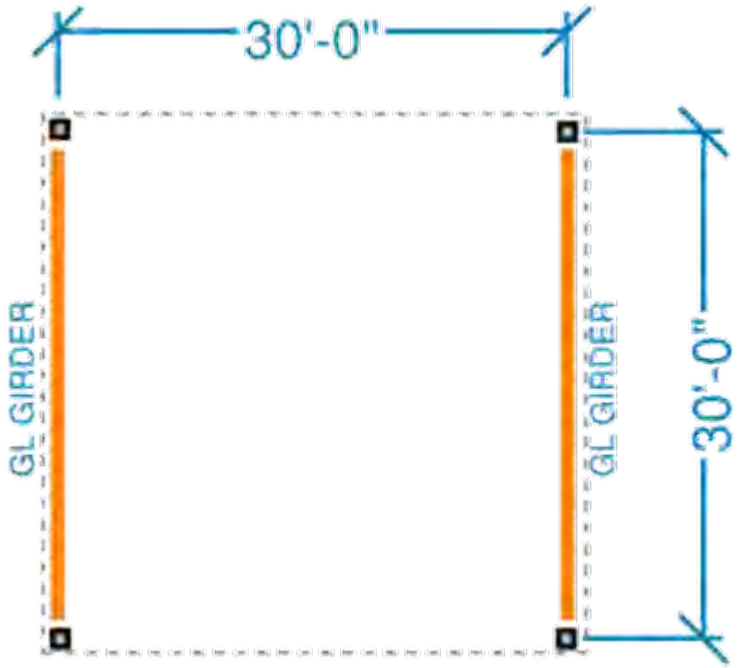



Partial Plan

# Optimize Building Grids




Partial Plan

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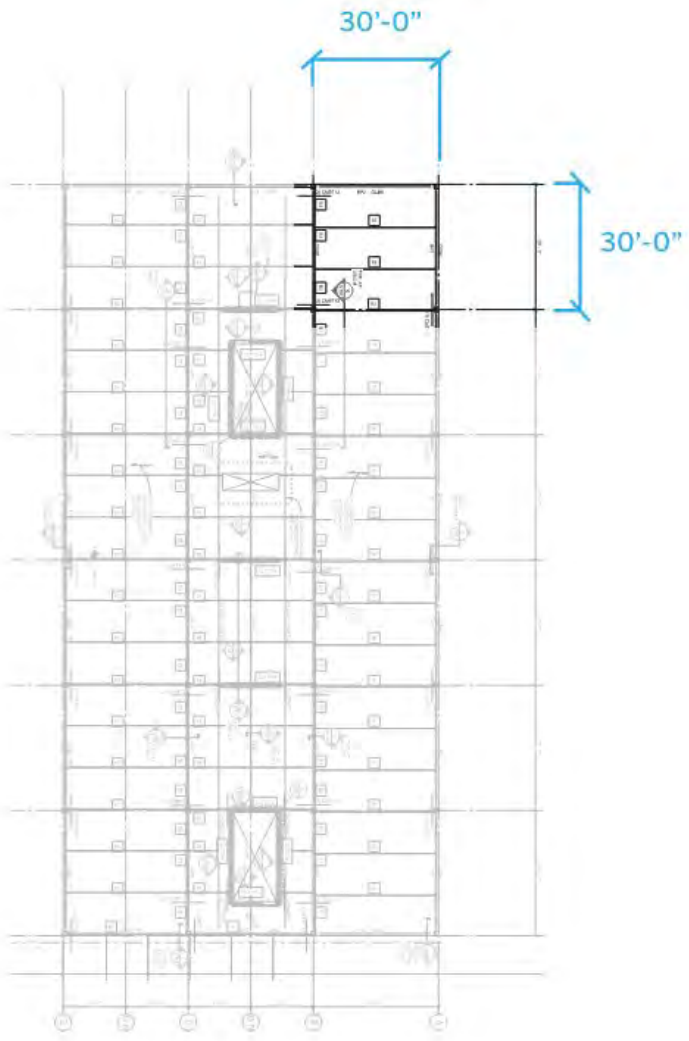


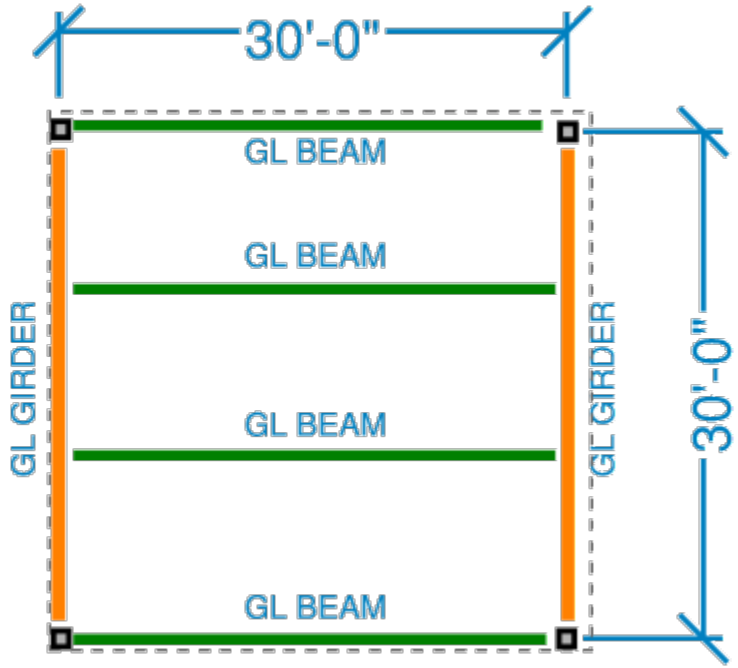


Partial Plan

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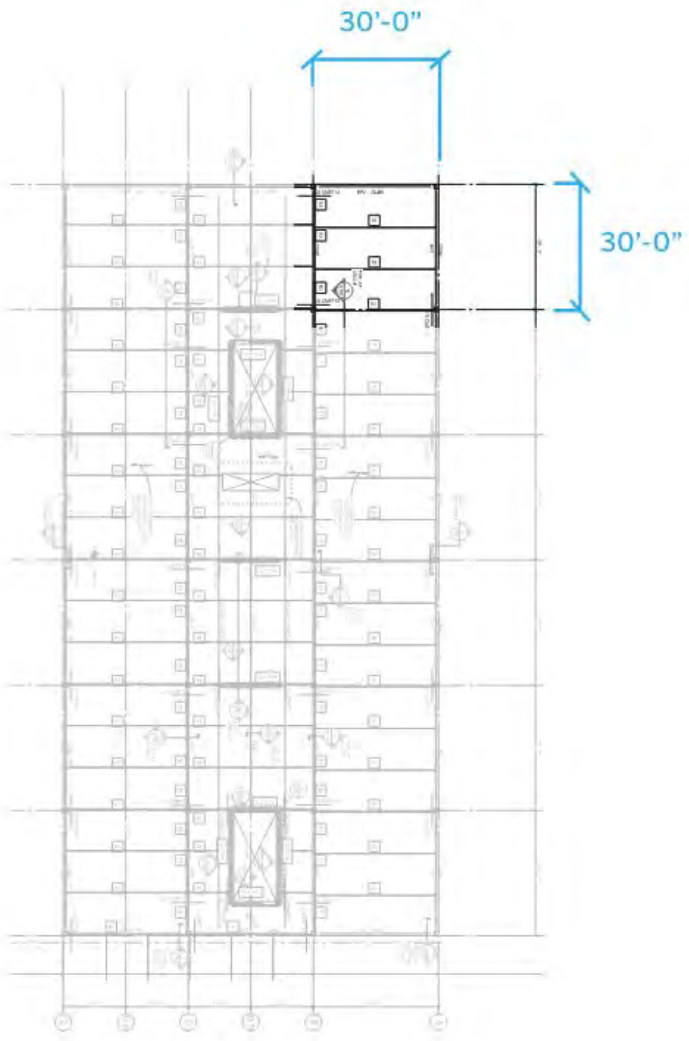
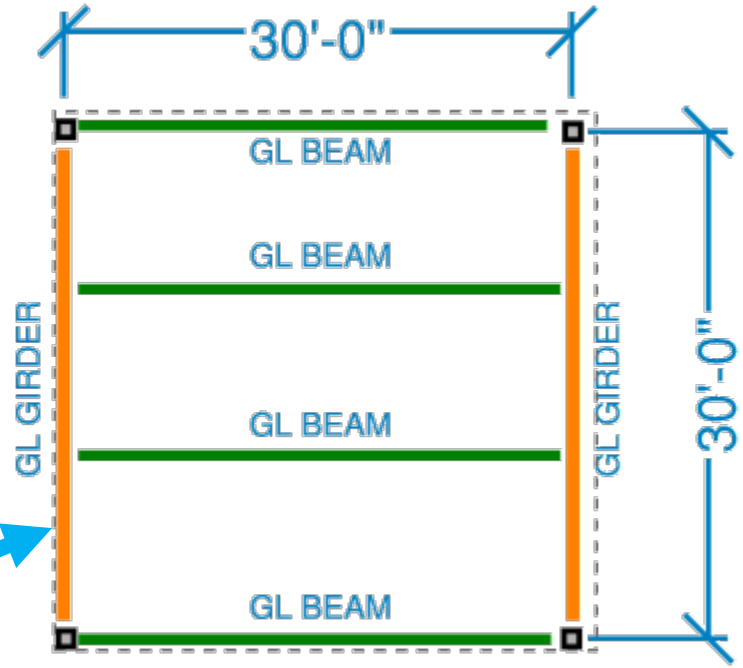



Interior Girder




Partial Plan

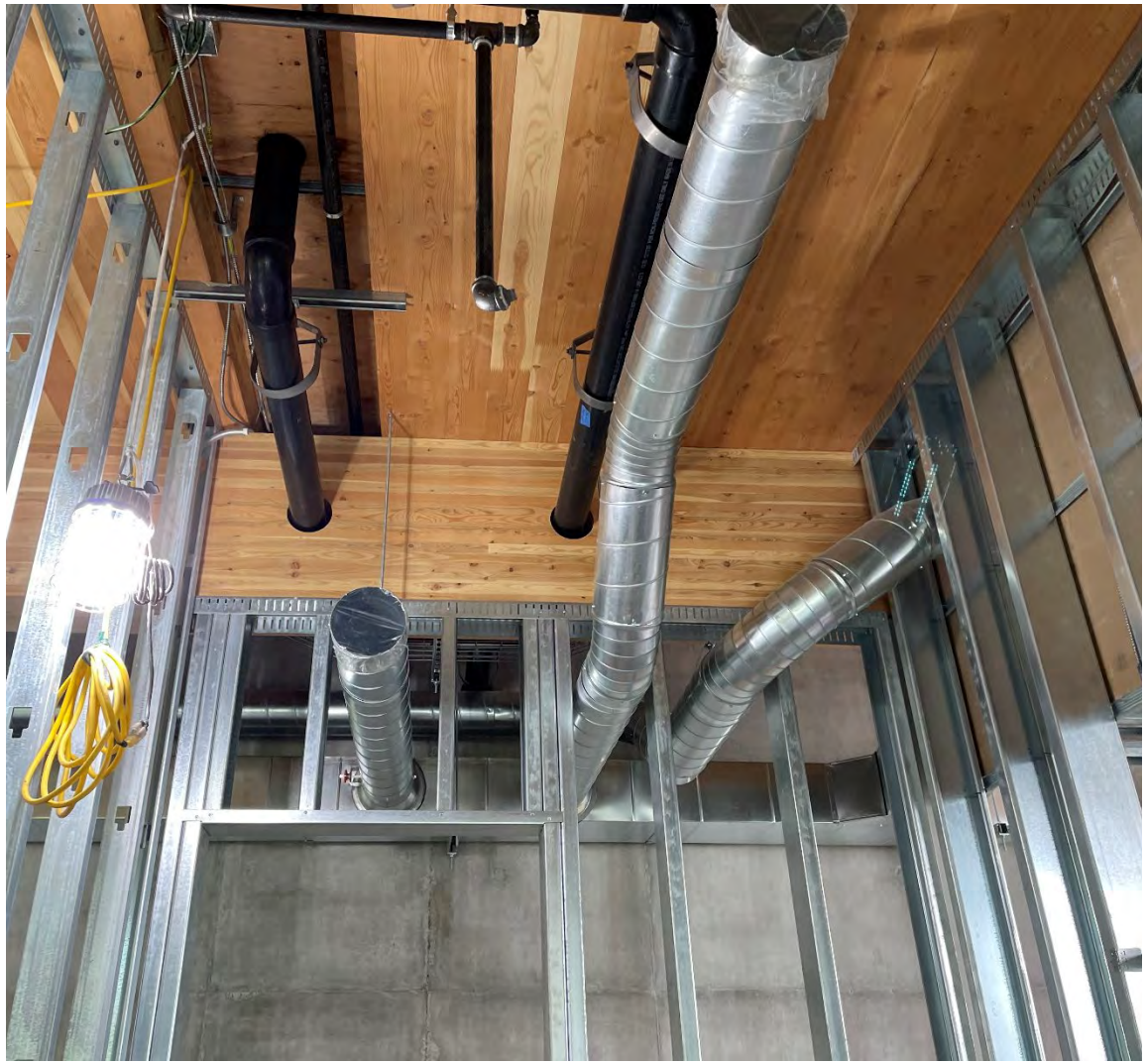
# Priority Coordination

**OVER/UNDER/THROUGH**

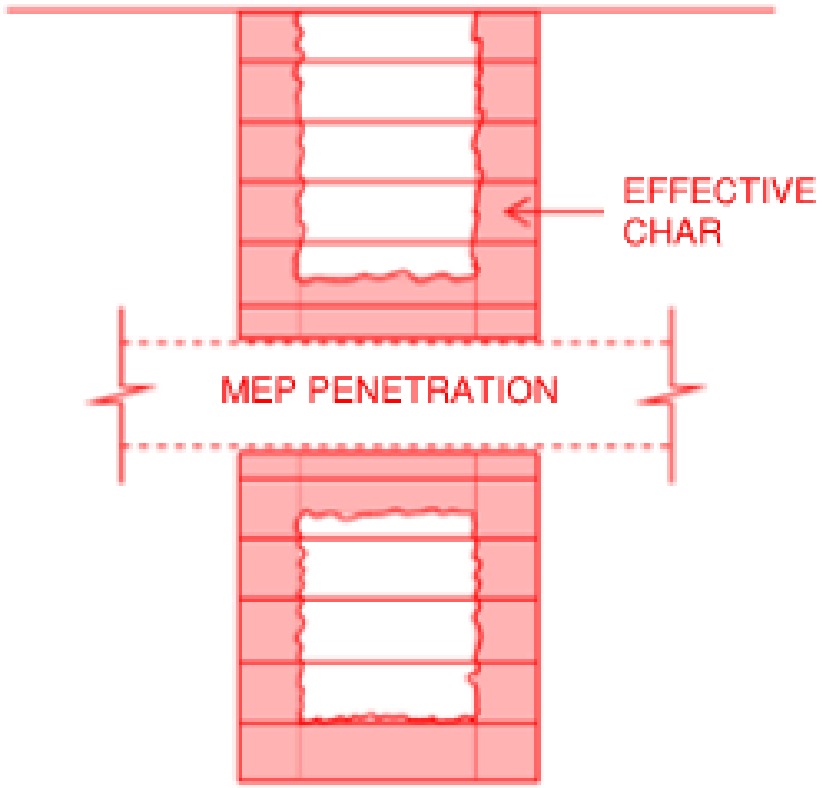
Plan for structural crossings among all trades

# Over-Under-Through

# Over-Under-Through



# Over-Under-Through



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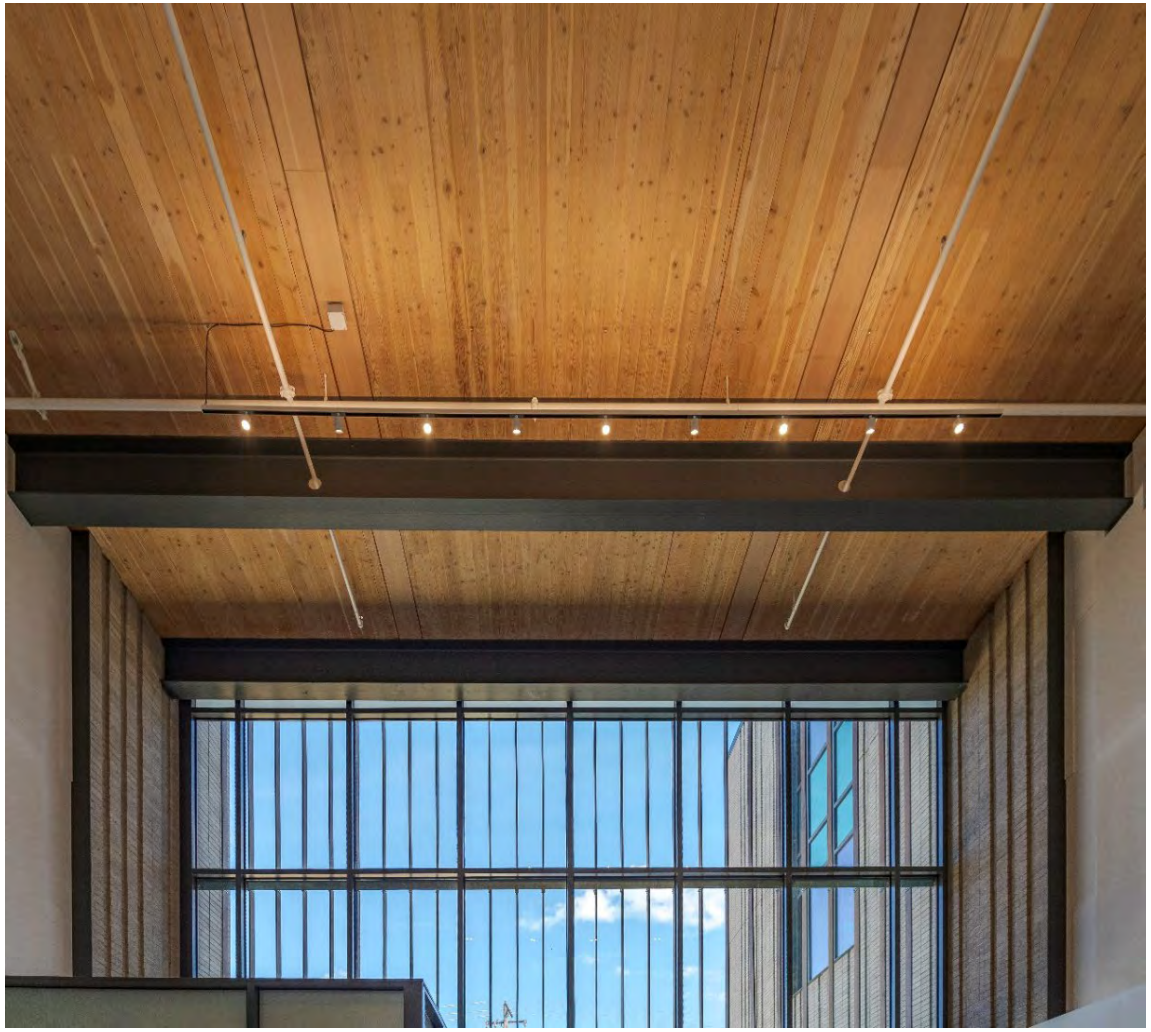
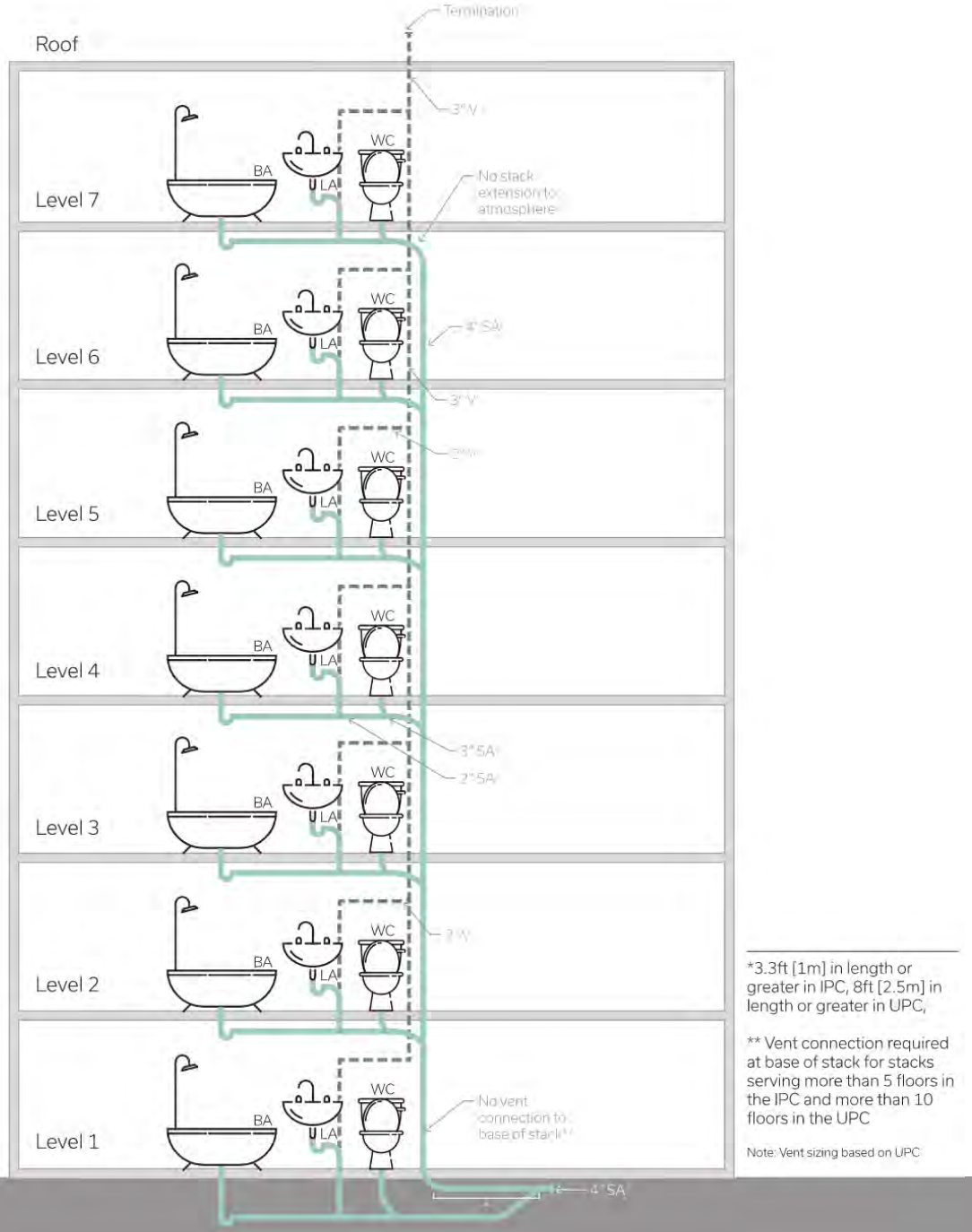


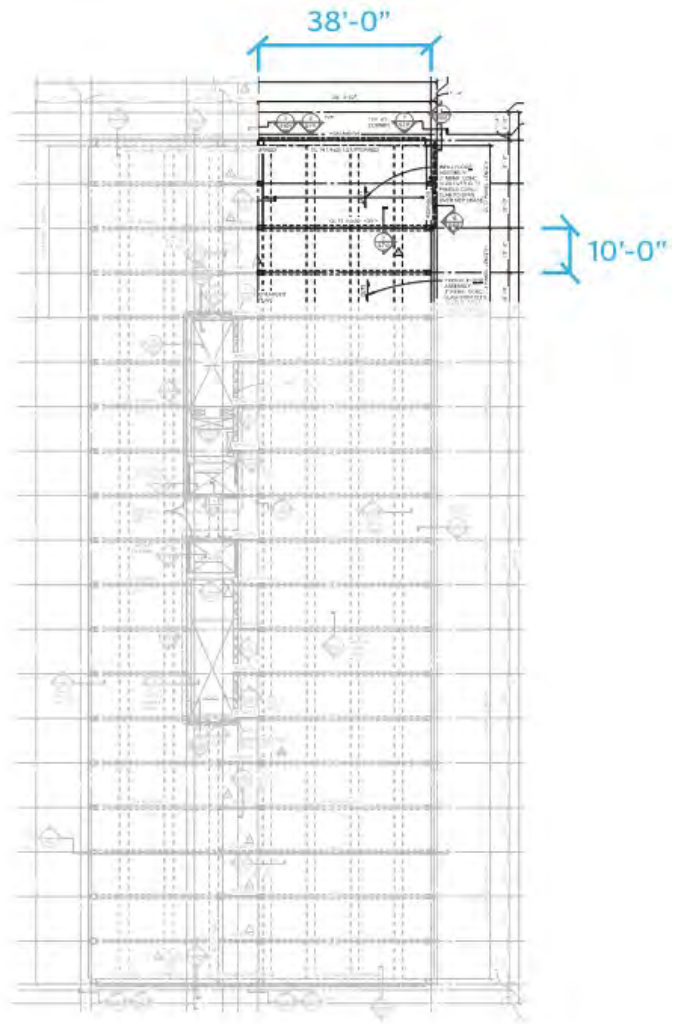


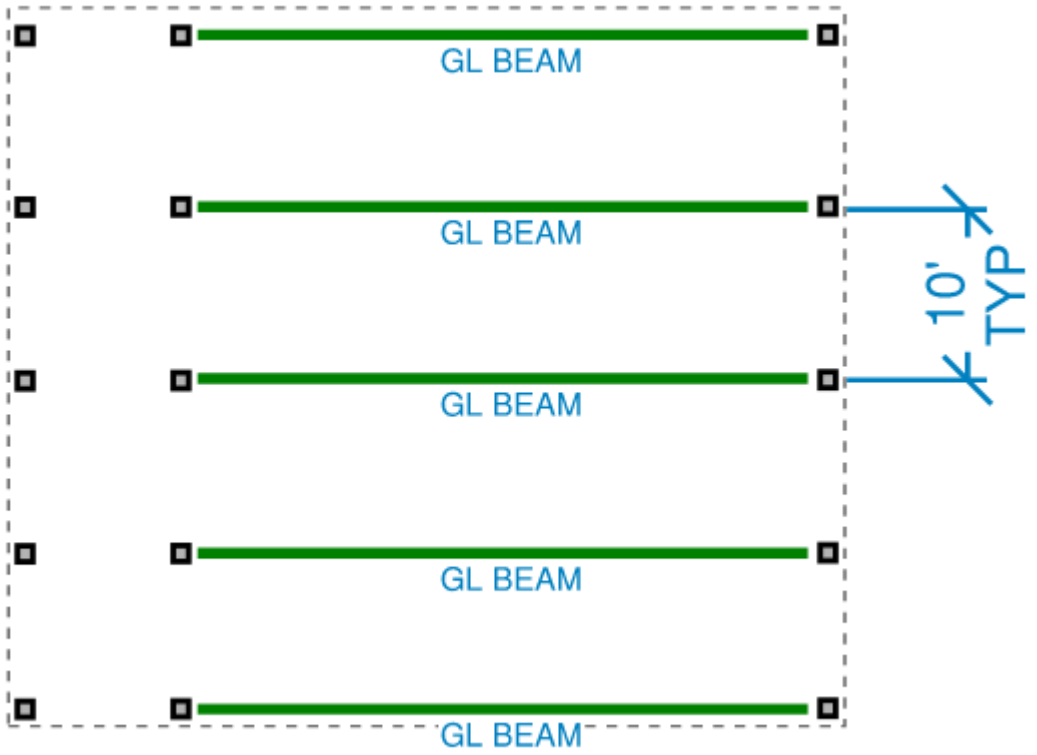

# Priority Coordination

**STACKING**

Maximize vertical and limit horizontal runs, plan ahead for “islands”

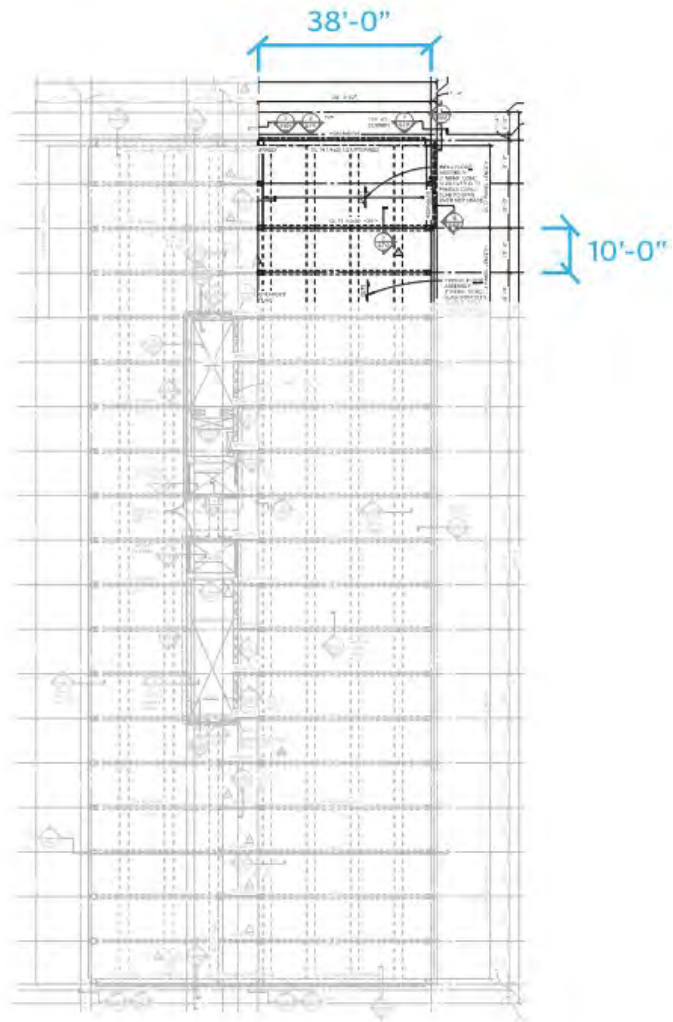
# Creating space

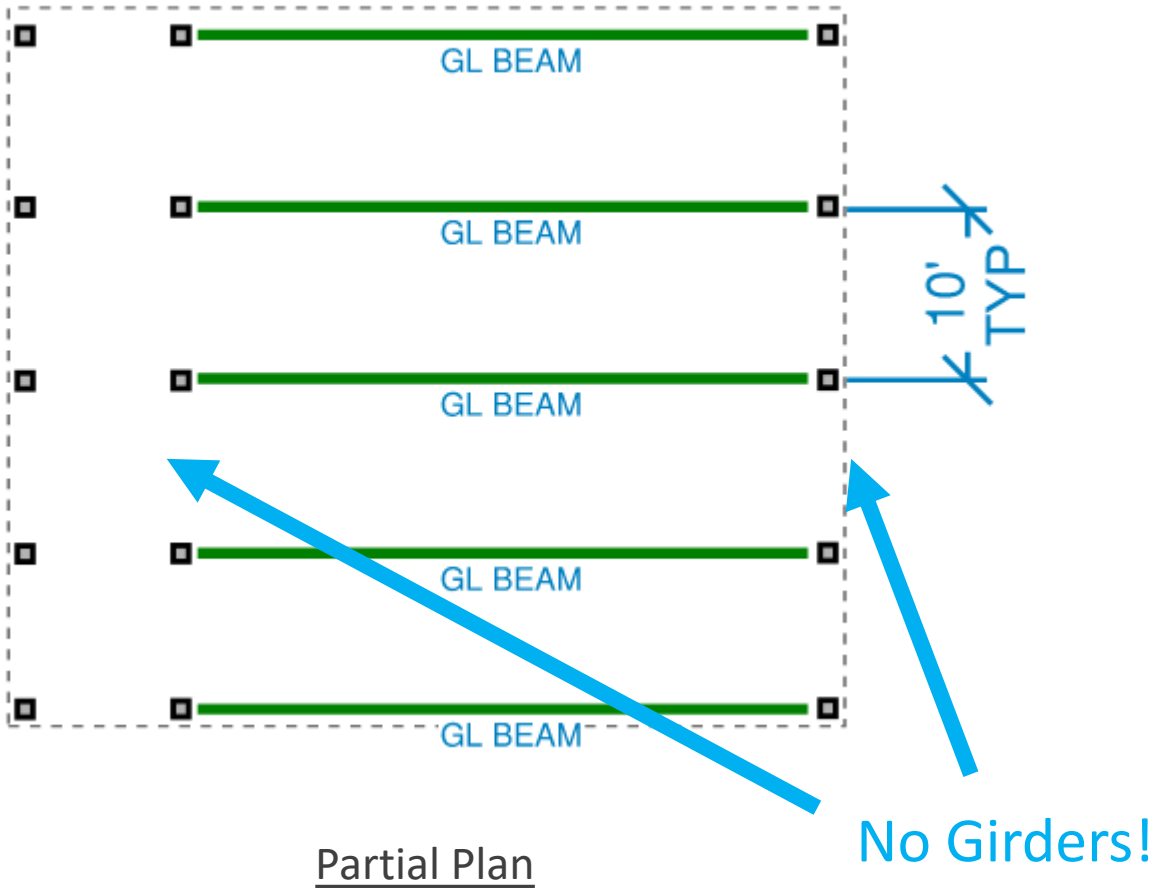



Partial Plan

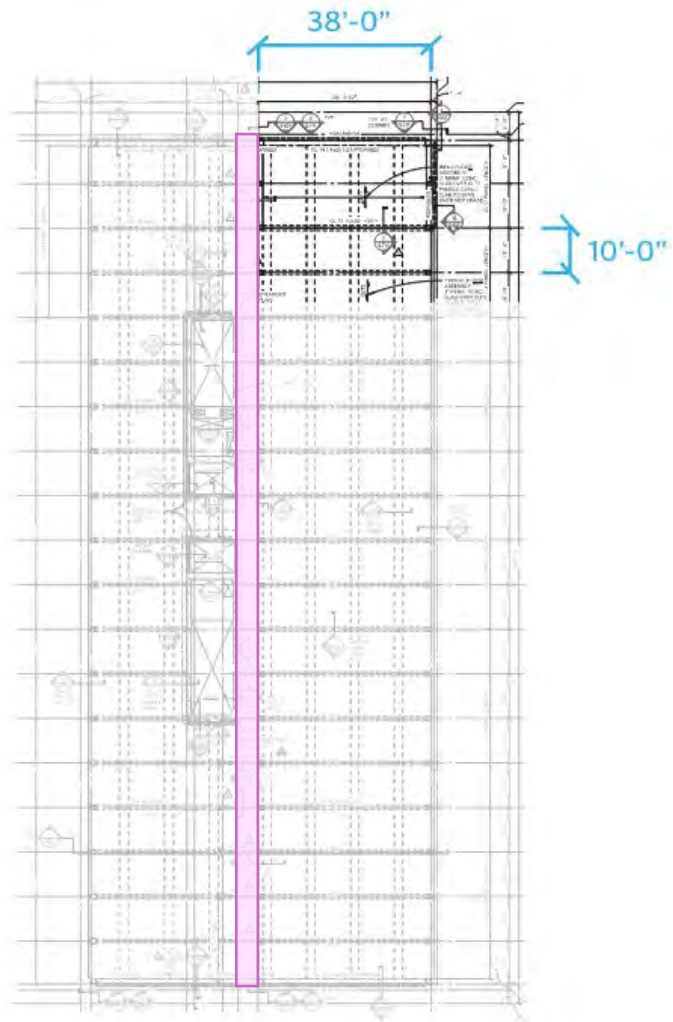
# Creating space

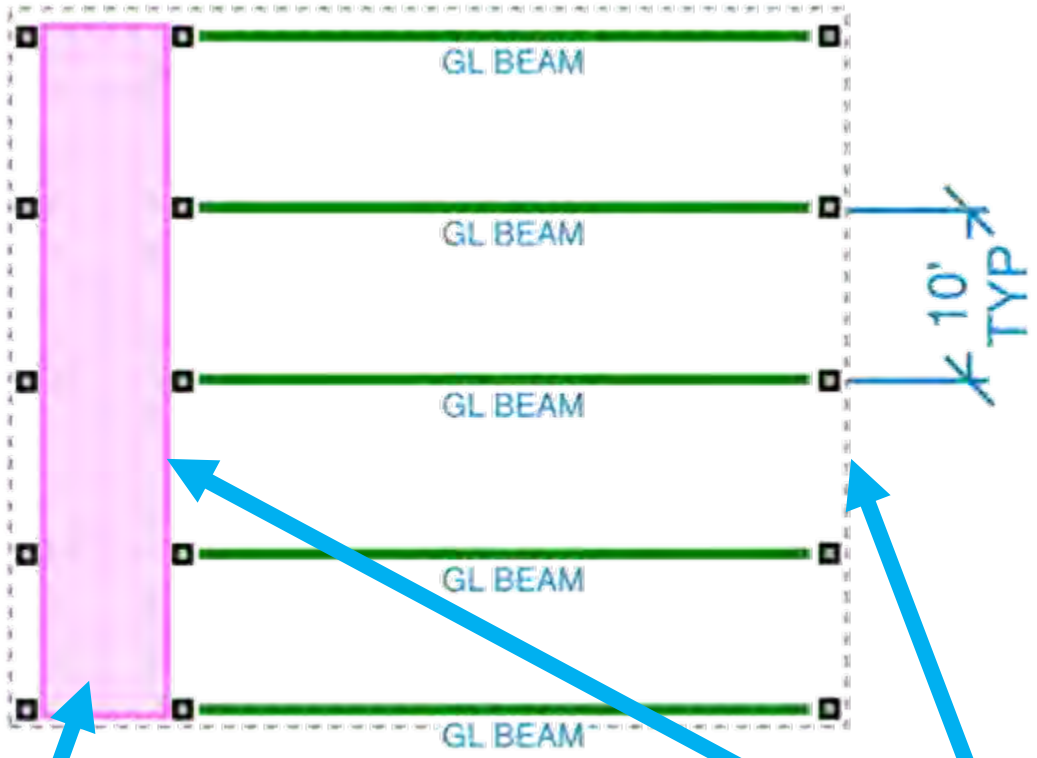



Partial Plan

# Creating space




No Beams!

Partial Plan

No Girders!


URE CO.

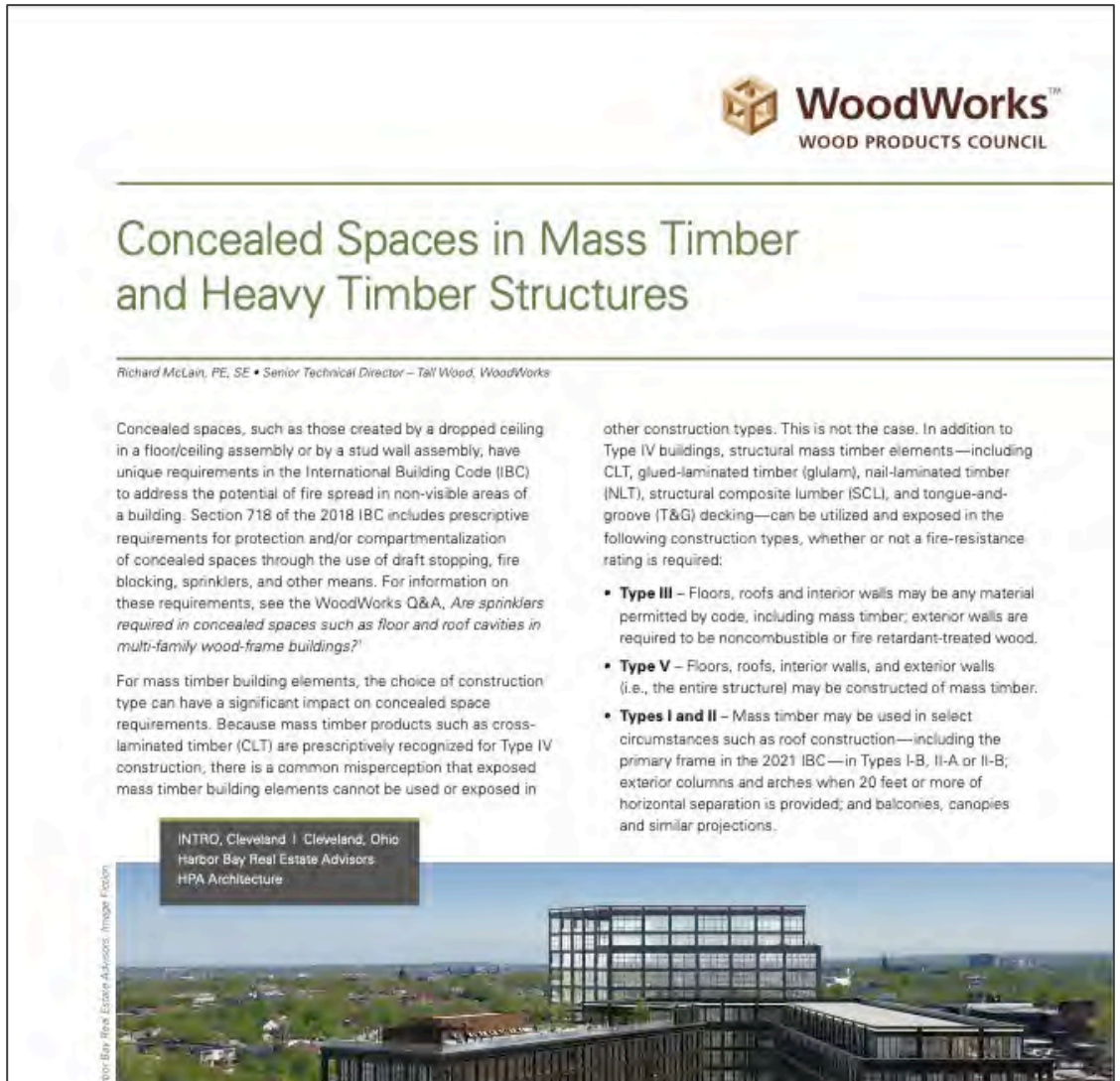
# Priority Coordination

**EXPOSED VS. CONCEALED**

Is there anywhere to hide?

# Construction Types

## Concealed spaces solutions paper



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### Concealed Spaces in Mass Timber and Heavy Timber Structures

*Richard McLain, PE, SE • Senior Technical Director – Tall Wood, WoodWorks*

Concealed spaces, such as those created by a dropped ceiling in a floor/ceiling assembly or by a stud wall assembly, have unique requirements in the International Building Code (IBC) to address the potential of fire spread in non-visible areas of a building. Section 718 of the 2018 IBC includes prescriptive requirements for protection and/or compartmentalization of concealed spaces through the use of draft stopping, fire blocking, sprinklers, and other means. For information on these requirements, see the WoodWorks Q&A, *Are sprinklers required in concealed spaces such as floor and roof cavities in multi-family wood-frame buildings?*[1]

For mass timber building elements, the choice of construction type can have a significant impact on concealed space requirements. Because mass timber products such as cross-laminated timber (CLT) are prescriptively recognized for Type IV construction, there is a common misperception that exposed mass timber building elements cannot be used or exposed in other construction types. This is not the case. In addition to Type IV buildings, structural mass timber elements—including CLT, glued-laminated timber (glulam), nail-laminated timber (NLT), structural composite lumber (SCL), and tongue-and-groove (T&G) decking—can be utilized and exposed in the following construction types, whether or not a fire-resistance rating is required:

- **Type III** – Floors, roofs and interior walls may be any material permitted by code, including mass timber; exterior walls are required to be noncombustible or fire retardant-treated wood.
- **Type V** – Floors, roofs, interior walls, and exterior walls (i.e., the entire structure) may be constructed of mass timber.
- **Types I and II** – Mass timber may be used in select circumstances such as roof construction—including the primary frame in the 2021 IBC—in Types I-B, II-A or II-B; exterior columns and arches when 20 feet or more of horizontal separation is provided; and balconies, canopies and similar projections.

INTRO, Cleveland | Cleveland, Ohio
Harbor Bay Real Estate Advisors
HPA Architecture

The John W. Olver Design Building at UMass Amherst includes exposed wood structure in some areas and dropped ceilings in others. Architect: Leers Weinzapfel Associates

https://www.woodworks.org/wp-content/uploads/wood_solution_paper-Concealed_Spaces_Timber_Structures.pdf

# 01

Early planning + integrating MEP systems

# HVAC Systems

**SELECTION CONSIDERATIONS**

## Overhead or floor/underfloor

# HVAC Systems

**SELECTION CONSIDERATIONS**

## Decoupling ventilation from thermal comfort systems

# HVAC Systems

**SELECTION CONSIDERATIONS**

## Central Systems Equipment or Distributed?


# 02

## Case Study

# PAE Living Building

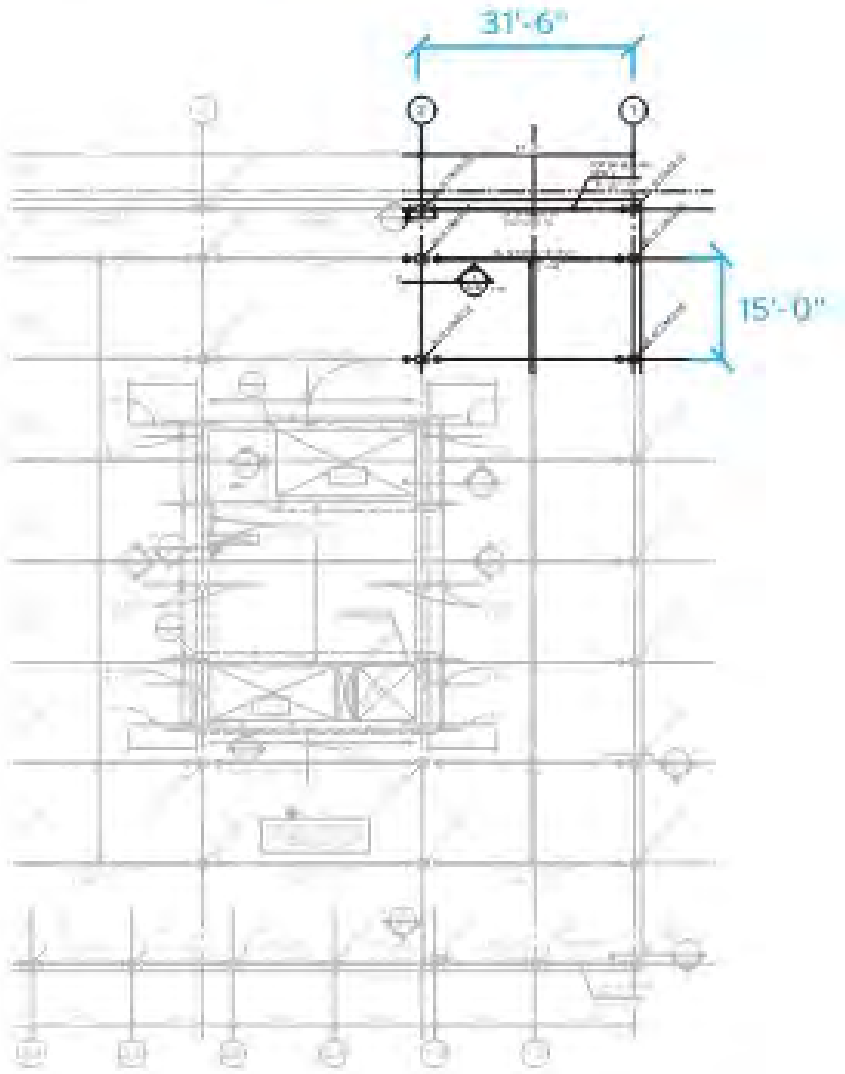
# PAE – Structural System

Construction Type: III-A

Building Grid: 31’-6”x15’-0”

Typical Floor Panel: CLT 5-ply

Topping Material: 3.5” normal weight concrete



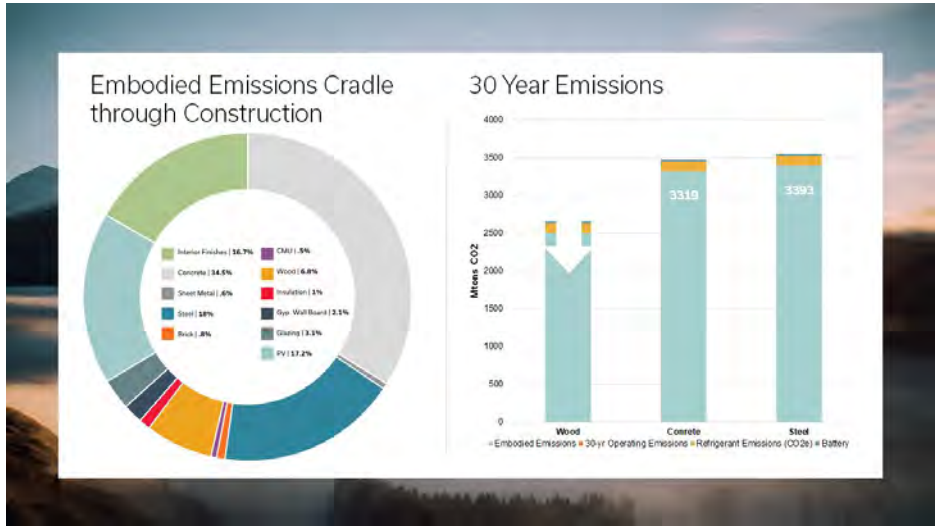
# PAE – Structural System

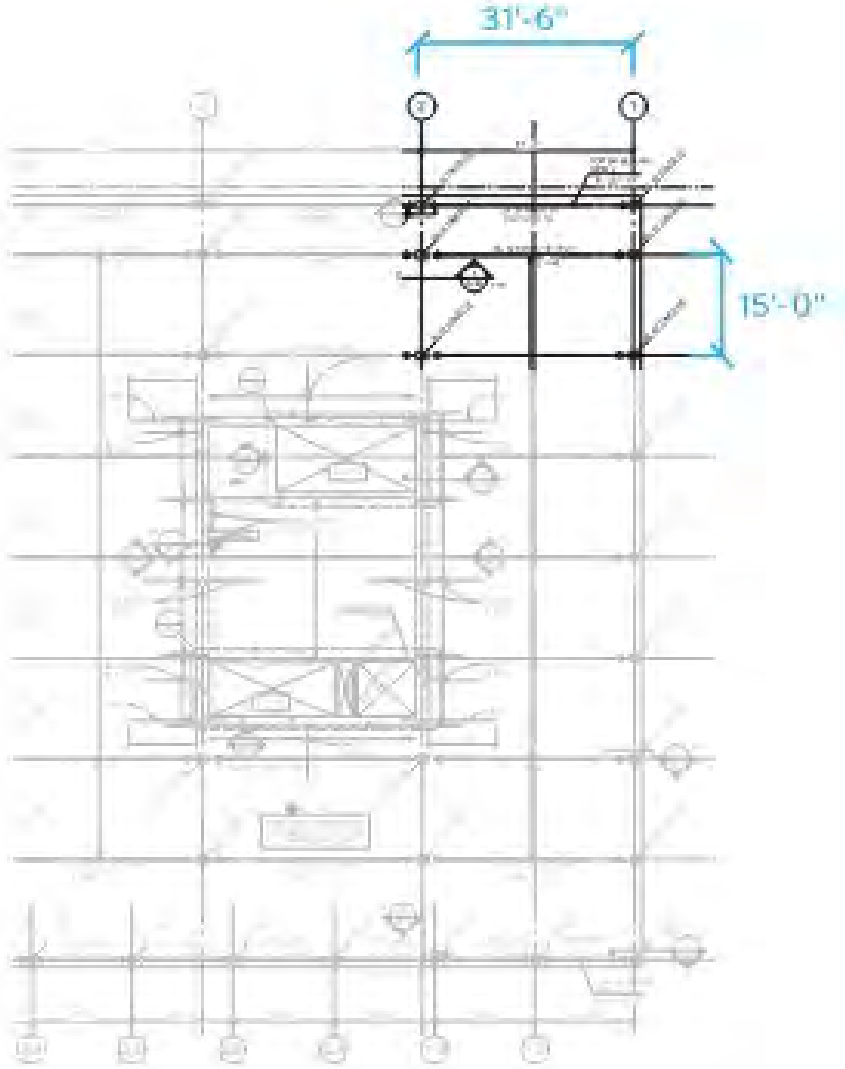
Construction Type: III-A

Building Grid: 31’-6”x15’-0”

Typical Floor Panel: CLT 5-ply

Topping Material: 3.5” normal weight concrete

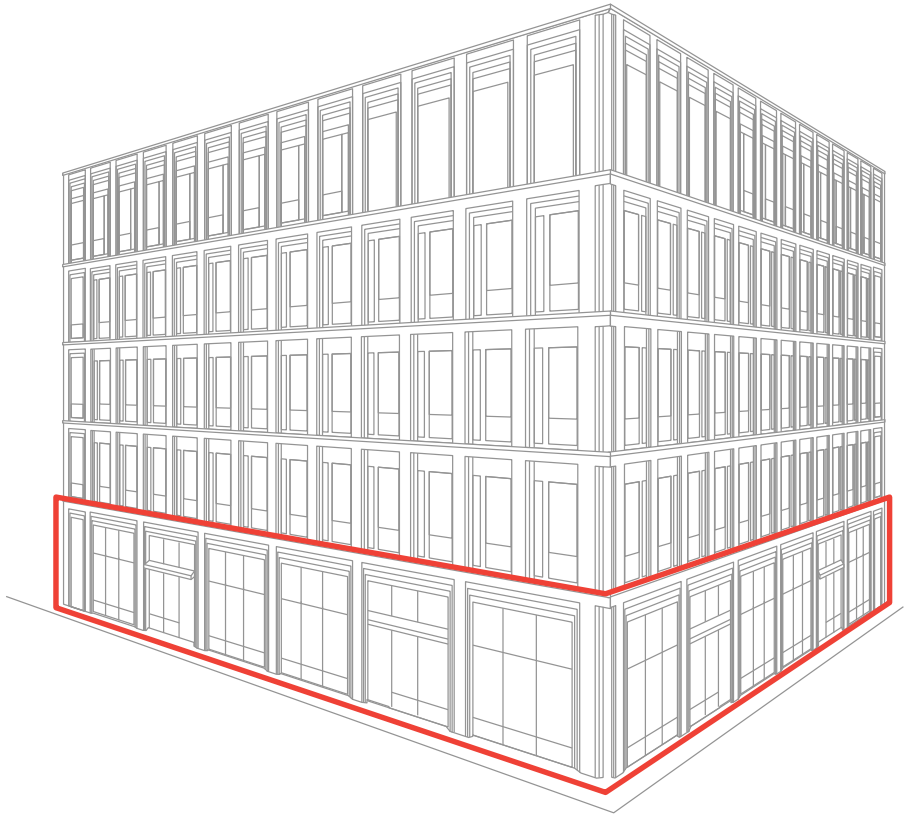


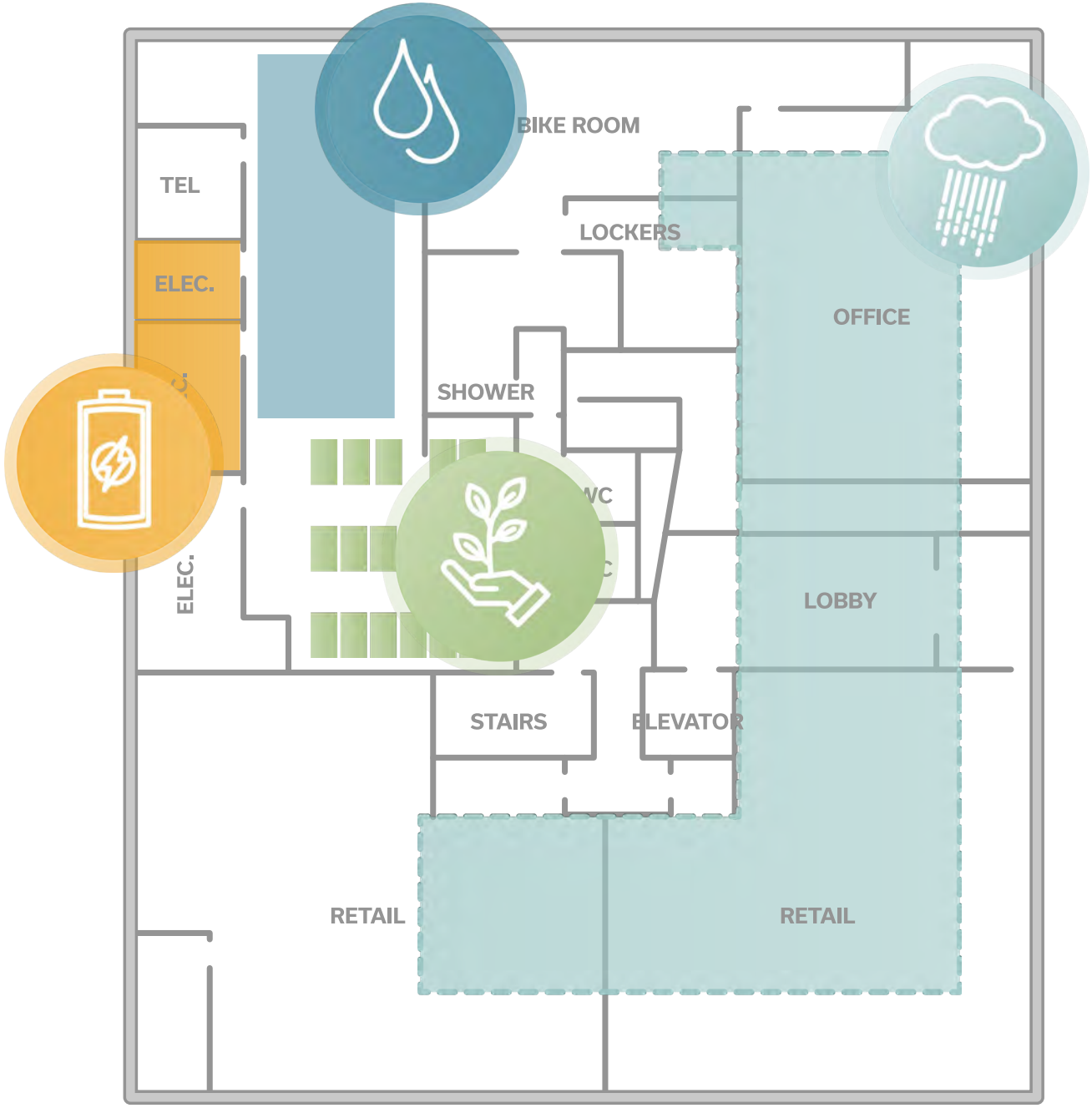




ONE WAY
ROAD CLOSED

# PAE Living Building

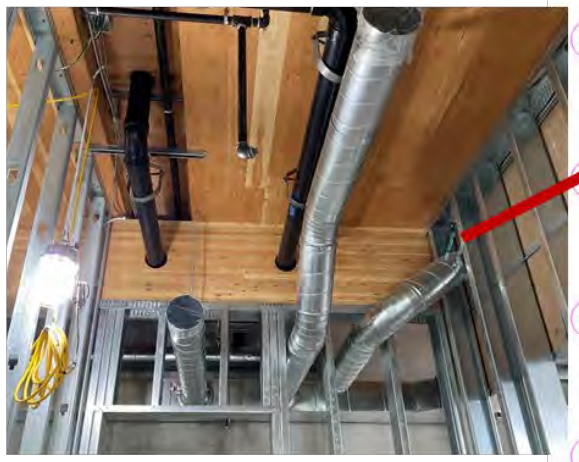
**PLANNING THE FIRST FLOOR AND CORE**

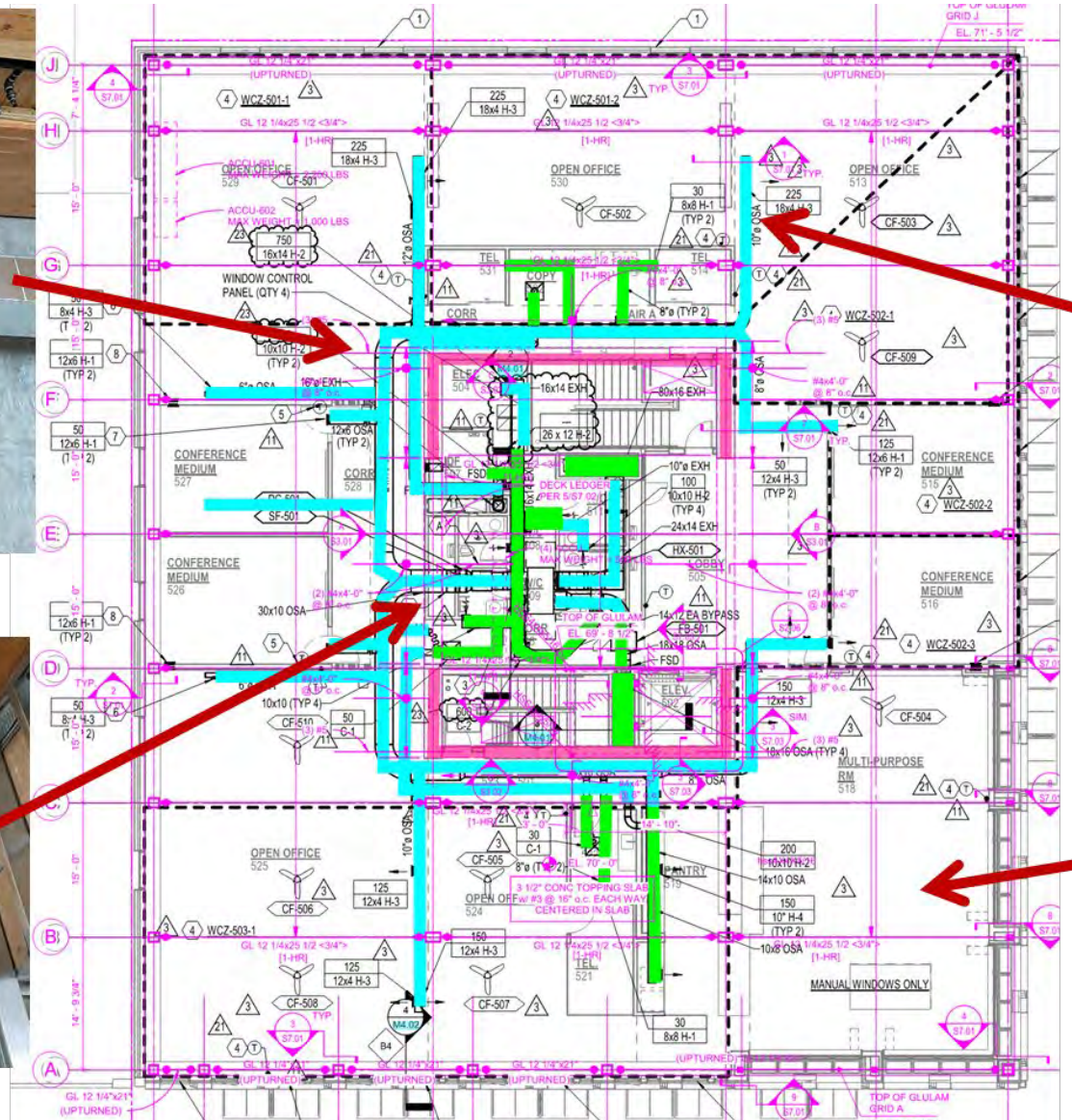




# PAE – MEP Coordination

PAE Living






# Keys to Mass Timber Holistic Coordination

# QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course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