

In Sync: Integrating Buildings Systems in Mass Timber Construction

Kerry Phillips
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Rachel Modica
Buro Happold



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



Course Description

This session explores the intricate coordination required to integrate HVAC, electrical, plumbing, and fire protection systems within mass timber construction. Drawing on lessons from three recent higher education projects with different mechanical systems, presenters will compare logistical, relative cost, and performance characteristics and advantages of each approach while demonstrating how early design collaboration and digital modeling can ensure the systems complement the expressive qualities of timber architecture. Participants will gain insight into strategies for routing and sequencing systems within cross-laminated timber and glulam assemblies, managing penetrations, and maintaining fire ratings while preserving the material's visual integrity. The session will also examine the importance of early subcontractor engagement, prefabrication planning, and trade sequencing to minimize field conflicts and rework.

Learning Objectives

1. Evaluate strategies for integrating mechanical, electrical, plumbing, and fire protection systems within mass timber buildings while maintaining structural integrity, fire-resistance ratings, and occupant safety.
2. Compare the performance characteristics, constructability considerations, and relative cost implications of different mechanical system approaches used in mass timber buildings to support informed design decisions that enhance building performance and occupant welfare.
3. Identify coordination methods, including digital modeling, prefabrication planning, and early interdisciplinary collaboration, that reduce field conflicts, improve construction quality, and minimize risks affecting building safety and long-term performance.
4. Apply best practices for routing building services, managing penetrations, and sequencing construction activities to preserve the durability, fire performance, and architectural integrity of exposed mass timber assemblies while supporting code compliance and occupant health, safety, and welfare.

In Sync:

Integrating Building Systems in Mass Timber Construction

Kerry Phillips
Rachel Modica

VALUES



Craft



Placemaking



Performance



Community



SOTO Mixed Use Office Building, S.A. TX



McKinney Municipal Complex, TX



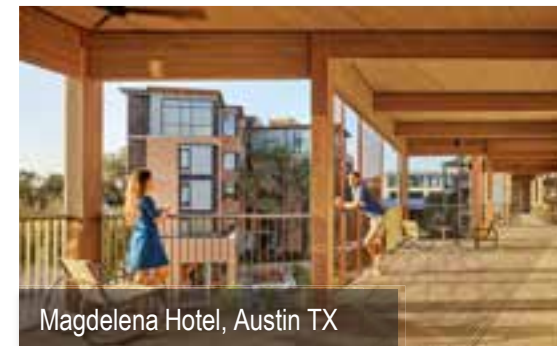
Museum Fine Arts Houston, Houston TX



Univ. of Pennsylvania, Data Science Engineering Building



Trinity University, Dicke Hall, San Antonio TX



Magdalena Hotel, Austin TX



Univ. of Denver Success Center, CO

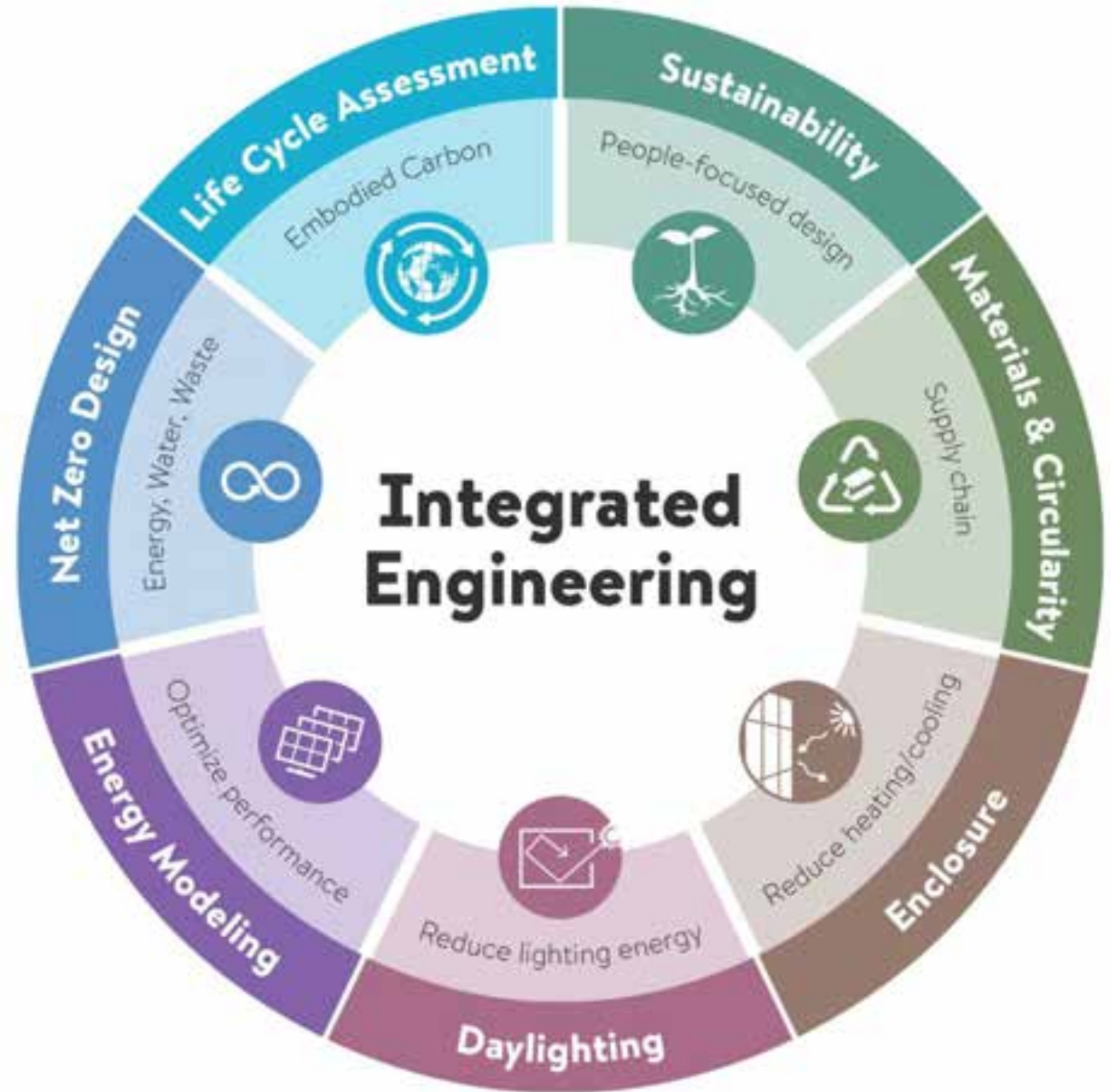


Gulf State Lodge, Gulf Shores AL

Buro Happold - Integrated Design

Better Decisions, Greater Project Value

- One coordinated team
- Performance-led design
- Earlier, smarter decisions
- Design aligned with mission and budget
- Resilient, implementable outcomes



University of Pennsylvania
Amy Gutmann Hall
Philadelphia, PA



Trinity University
Dicke Hall
San Antonio, TX



University of Denver
Burwell Center
Denver, CO



University of Pennsylvania
Amy Gutmann Hall

LOCATION: Philadelphia, PA

CLIMATE: Mixed/Humid

SIZE: 116,000 SF

STORIES: 6

CONSTRUCTION TYPE: III-A

COMPLETION DATE: 2024

Trinity University
Dicke Hall

LOCATION: San Antonio, TX

CLIMATE: Hot-Humid

SIZE: 34,400 SF

STORIES: 3

CONSTRUCTION TYPE: V-B

COMPLETION DATE: 2022

University of Denver
Burwell Center

LOCATION: Denver, CO

CLIMATE:

Cold/Semi-Arid/High Elevation

SIZE: 23,000 SF

STORIES: 3

CONSTRUCTION TYPE: III-B

COMPLETION DATE: 2020

University of Pennsylvania
Amy Gutmann Hall



Chilled Beams

Trinity University
Dicke Hall



Raised Access Floor

University of Denver
Burwell Center



VRF

University of Pennsylvania
Amy Gutmann Hall

Architect of Record & Design Architect:

Lake Flato

Associate Architect: **KSS Architects**

Landscape Architect: **Ground Control**

Civil: **Pennoni**

Structural Engineering: **Buro Happold**

MEP Engineering: **Buro Happold**

Lab Planner: **RFD**

General Contractor: **Gilbane**

Timber Vendor: **Nordic**

Trinity University
Dicke Hall

Architect : **Lake Flato Architects**

Landscape Architect: **Rialto Studio**

Civil Engineering: **Intelligent Engineering
Services**

Structural Engineering: **Datum Engineers**

MEP Engineering: **Introba**

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University of Pennsylvania

Amy Gutmann Hall

Philadelphia, PA

Completed 2024





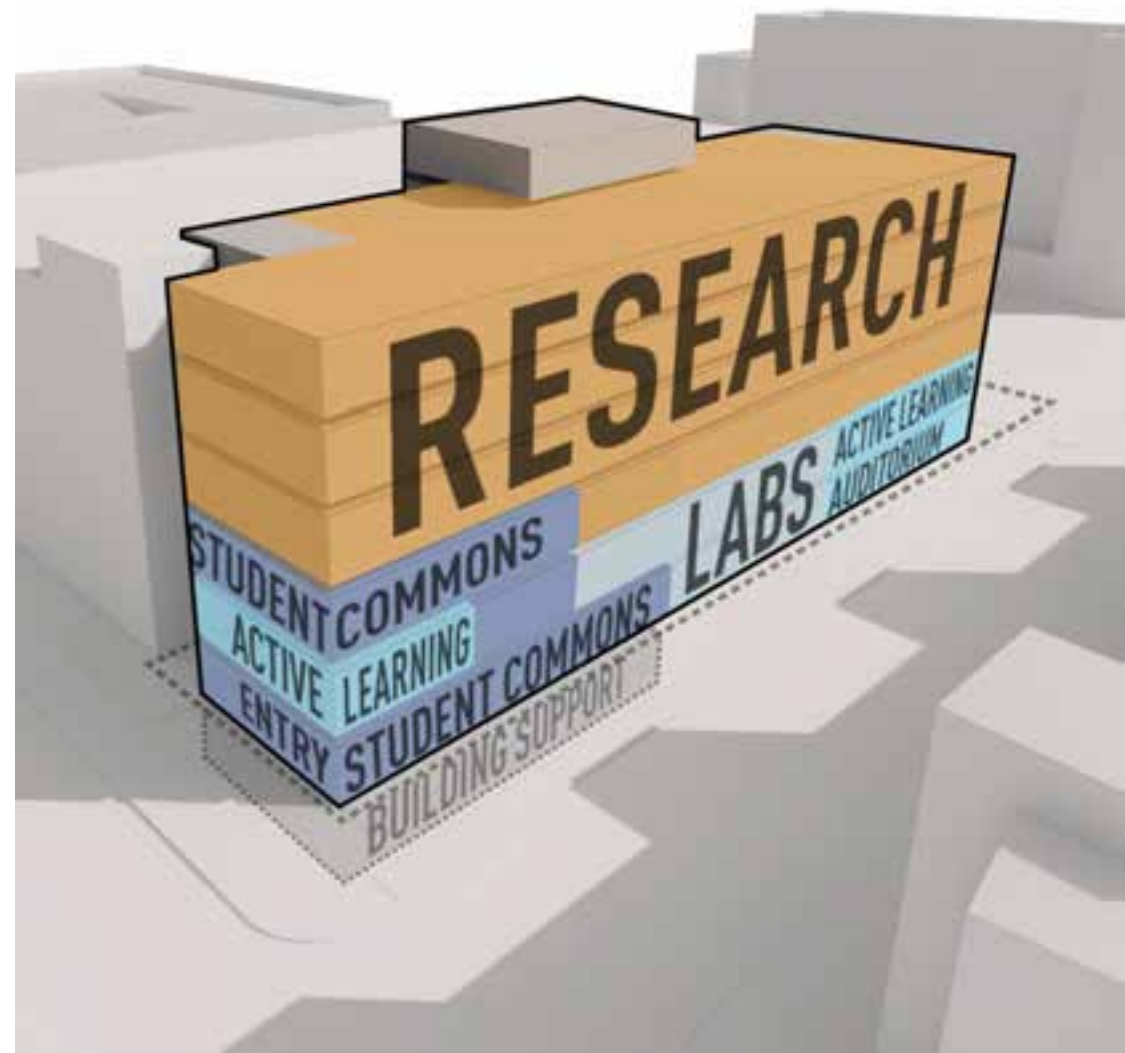
HOTEL

GARAGE

SITE

COLLEGE HOUSING

HOUSING





GOALS & ASPIRATIONS

Be the face of Penn Engineering :
PROCESS AS IDENTITY

A vibrant and welcoming experience :
HOME

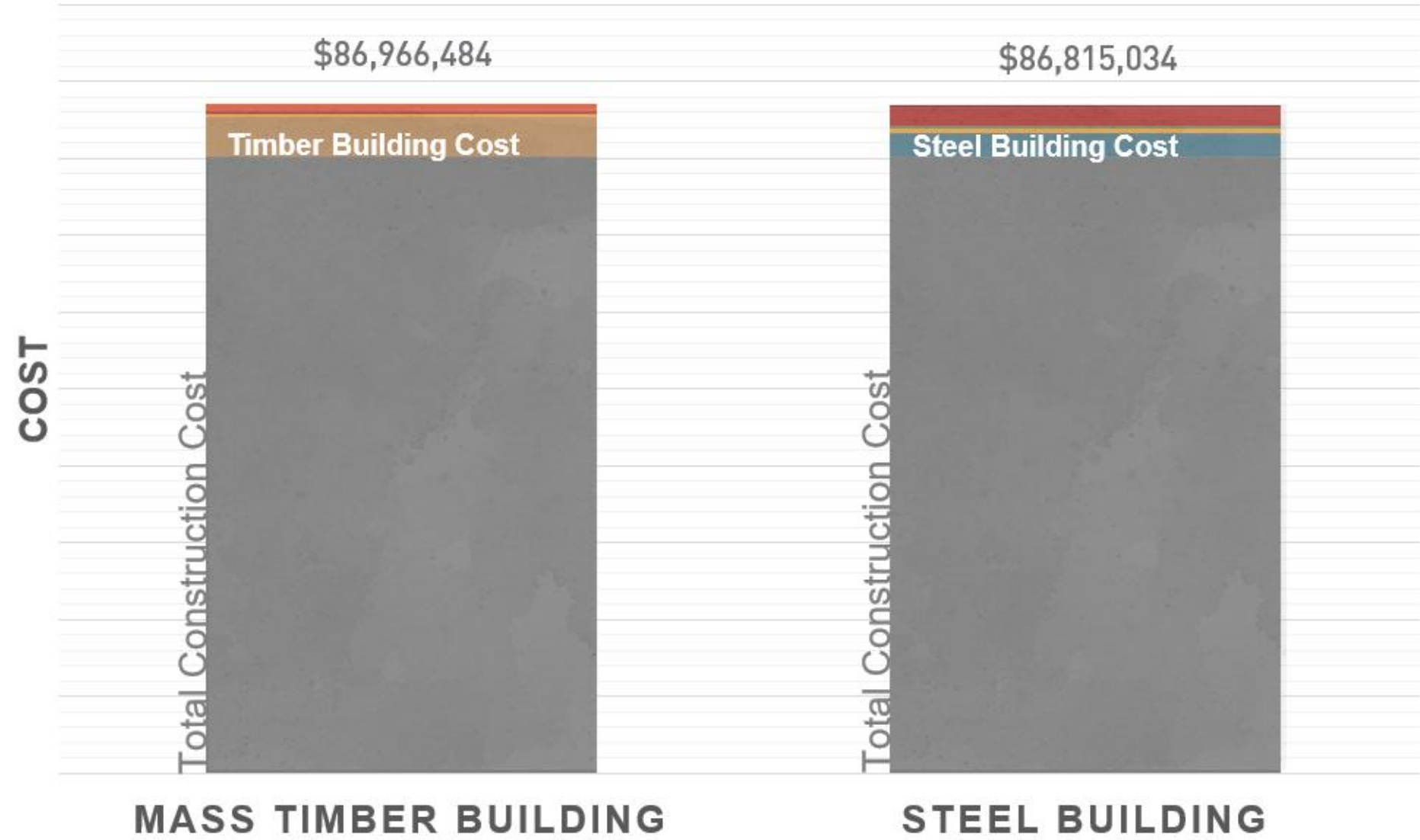
Impacts of a software not hardware focused engagement:
PEOPLE ARE OUR PRIMARY RESOURCE

Stewards of the environment and human wellness:
EMBODIED CARBON & BIOPHILIA



COST COMPARISON Timber vs Steel – Total Construction Cost Impact

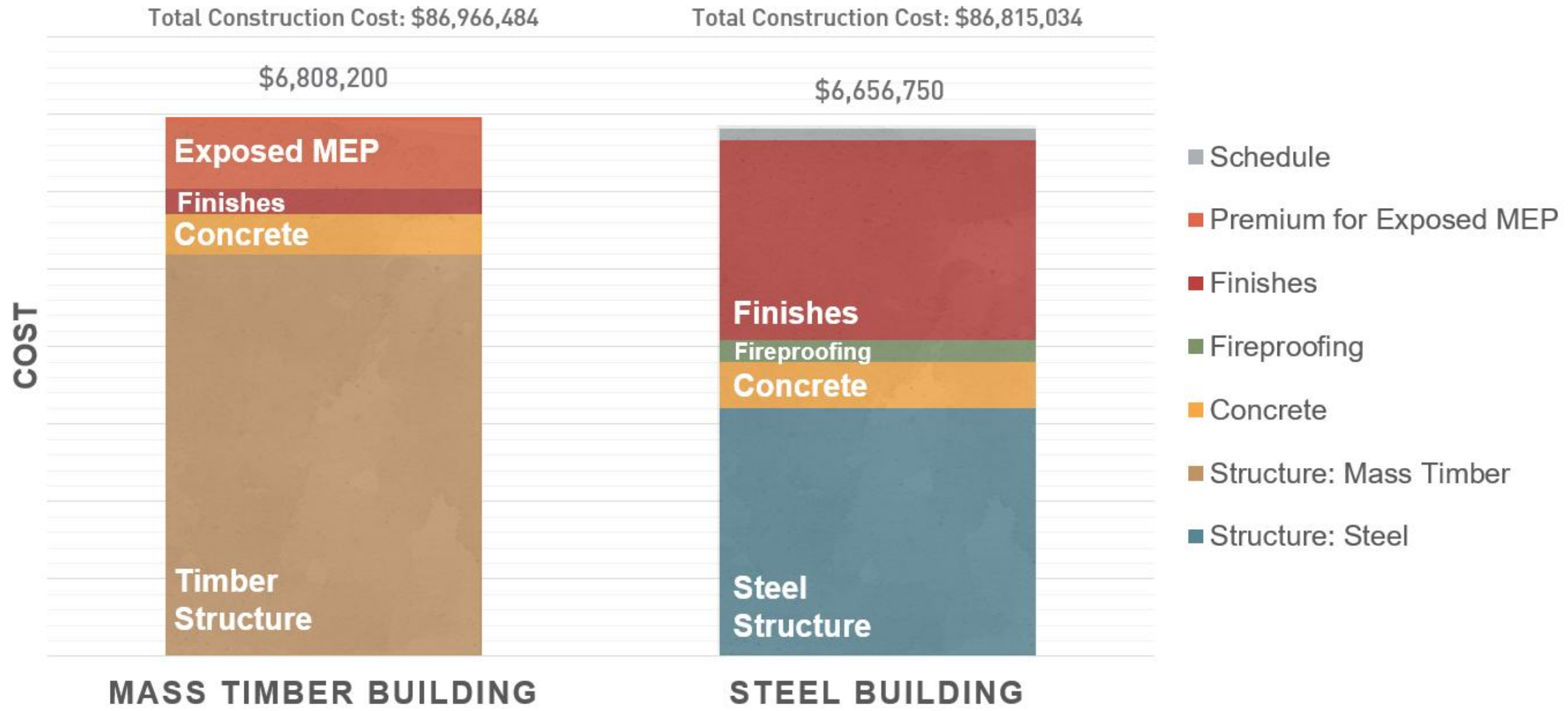
**At Concept*



Cost delta less than **.2%** of total construction cost

COST COMPARISON Timber vs Steel

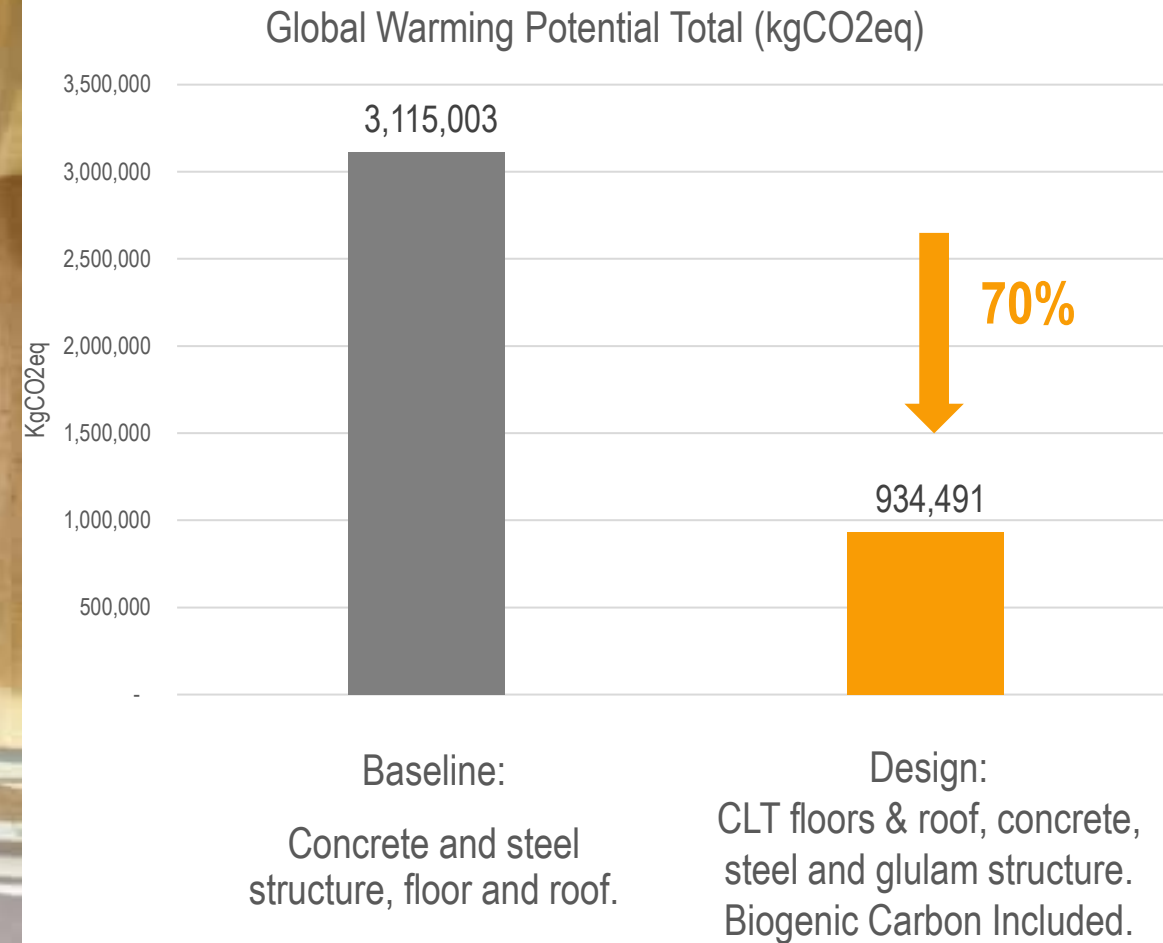
**At Concept*





EMBODIED CARBON REDUCTION

STRUCTURAL ANALYSIS (CONCRETE/STEEL)



CODE APPROACH – IBC 2018

- Construction Type: III-A
 - Primary structure: 1hr fire
 - Shafts and support frame: 2hr fire
- Occupancy Group: A & B
- Maximum Height to Roof: 85ft
- Maximum stories:
 - Group A-3: 4
 - Group B: 6
 - Horizontal fire separation at Level 5

CONSTRAINTS

- Tight Site
- Limited floor to floor heights
- Performance/Operations Familiarity



MEP System Selection at SD

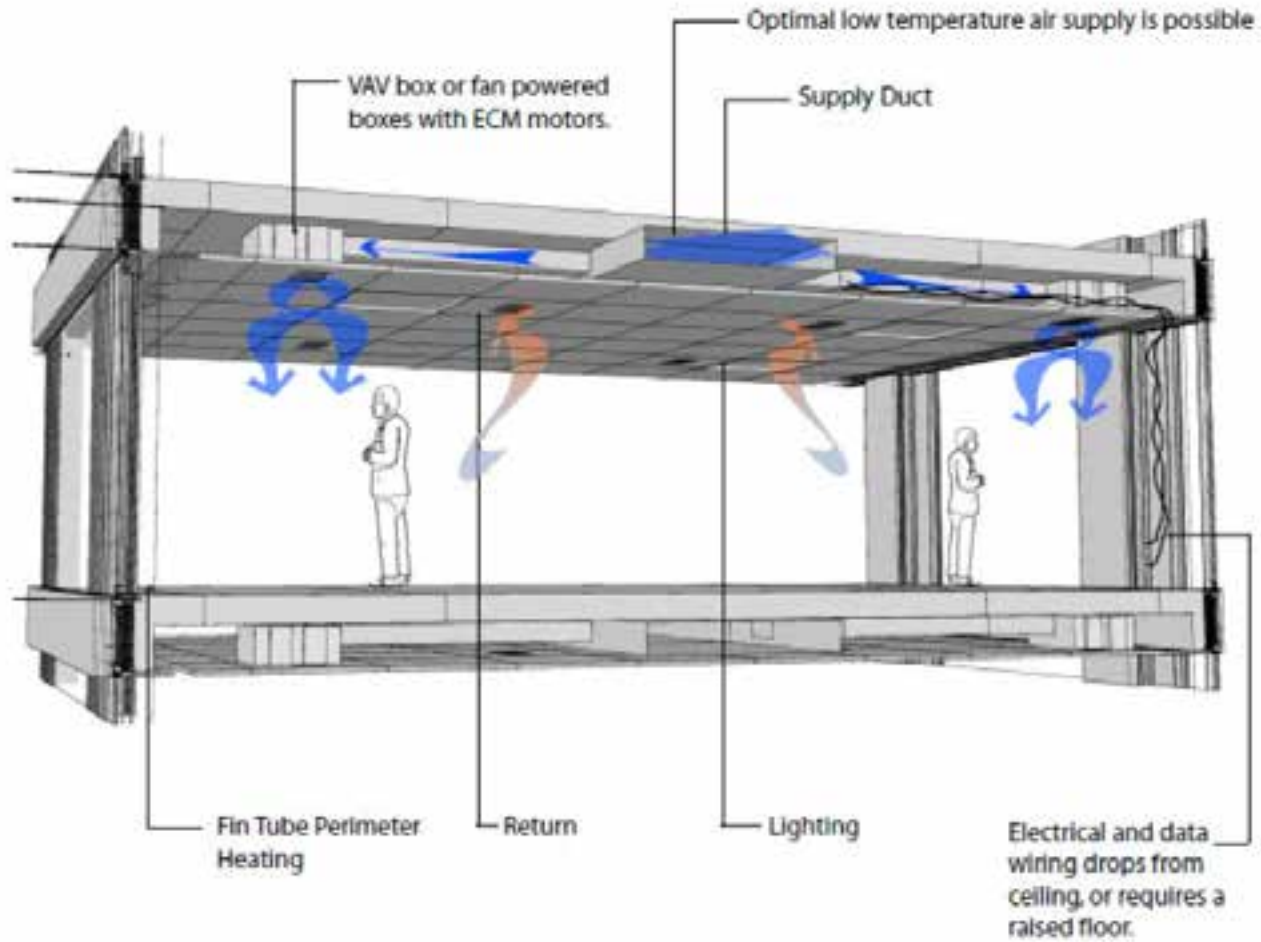
Considerations

- Maximize Timber Visibility
- Campus Chilled Water & Utility Steam
- Space Constraints
- Budget

Options:

- Underfloor Air Distribution
- Chilled Beams
- Variable Air Volume

BASELINE: Overhead VAV



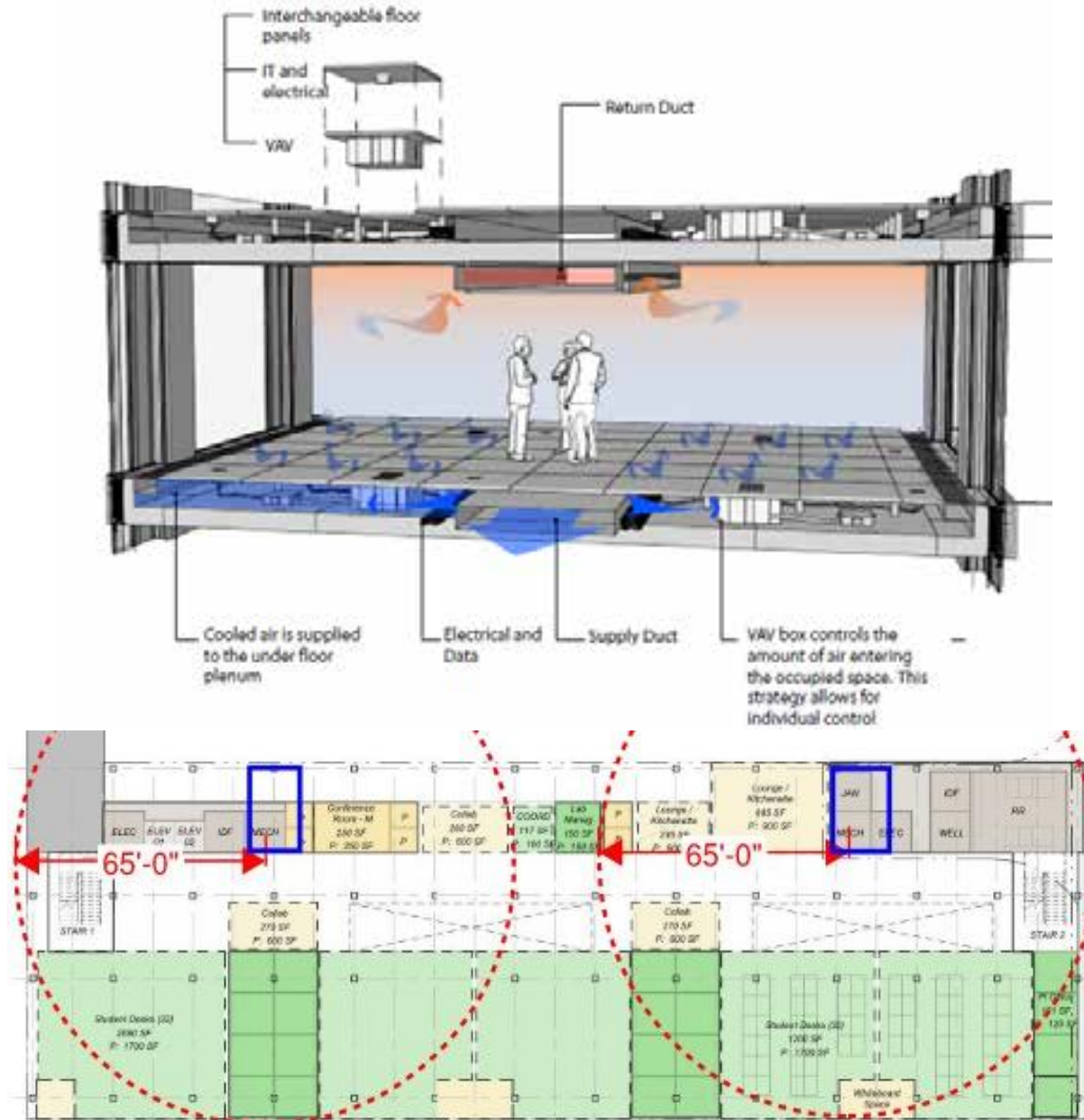
ADVANTAGES:

- High cooling and heating capacities
- Can cater variable load conditions
- Low capital cost

DISADVANTAGES:

- Deep ceiling requirements
- Less efficient
- Air quality isn't as good

Option A: Underfloor



Advantages

- Better ventilation effectiveness
- Air and electrical distribution occupy same space
- Lower operating costs than overhead ventilation
- Reduced ducting costs
- Flexible system, air terminal and power/it devices can easily be moved
- Quiet
- Open ceilings
- Potential for local control through adjustable floor diffusers

Disadvantages

- Plenum should be cleaned every 1-2 years
- Requires high ceilings
- Lower cooling/heating capacity
- Perimeter may need supplemental heating
- Shafts must be in the center of the building

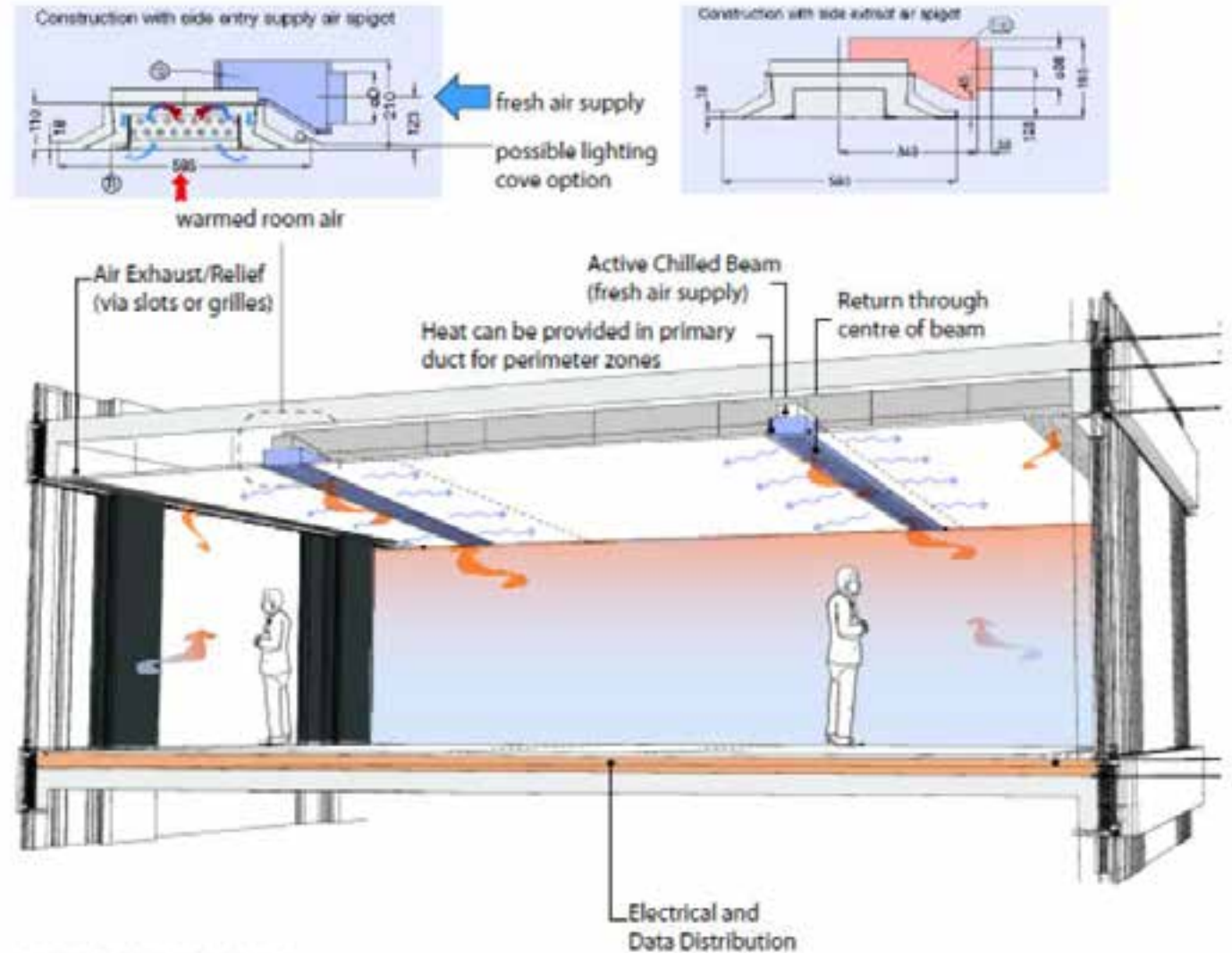
OPTION B: Active Chilled Beams

ADVANTAGES:

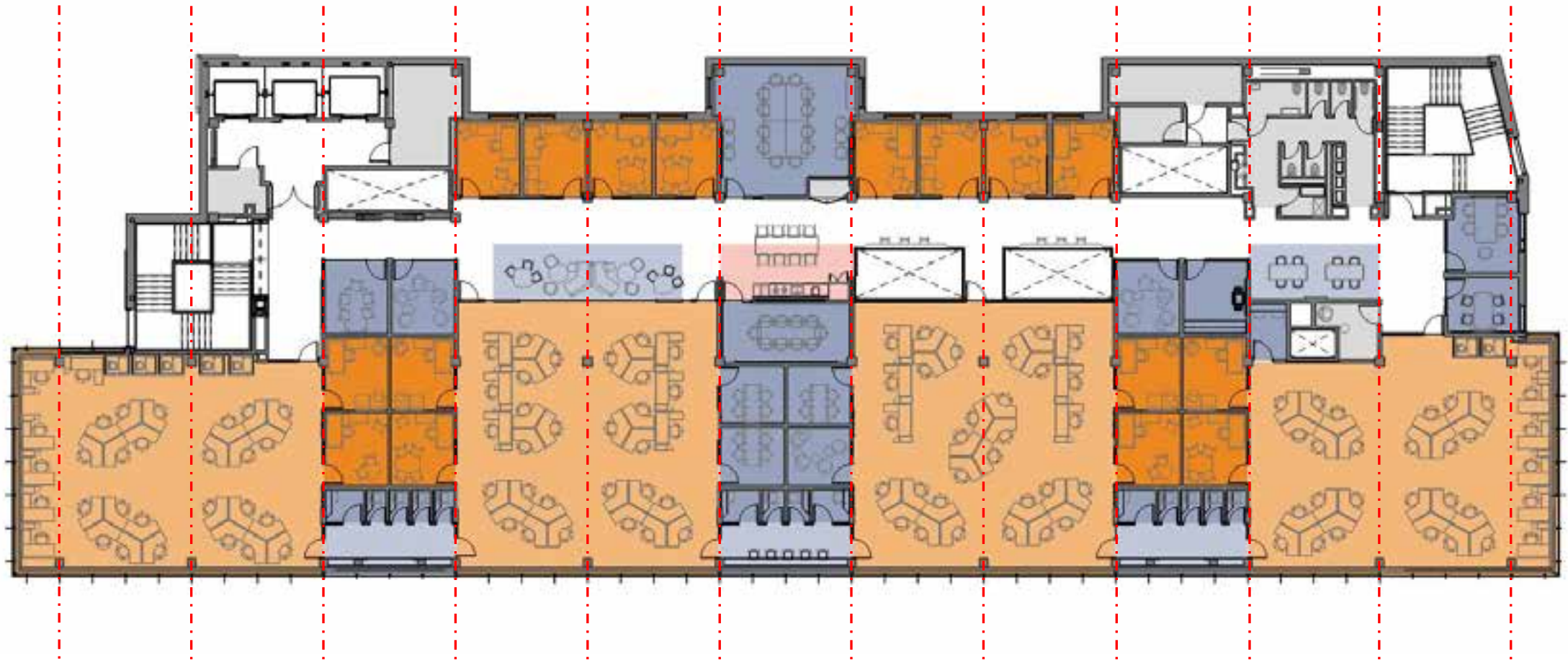
- High sensible cooling capacity
- Lower cooling energy consumption
- Quiet
- **Reduce overhead plenum height/reduced ductwork**
- Improved thermal comfort
- **No on-floor AHUs**

DISADVANTAGES:

- More dehumidification at DOAS
- No operable windows
- Condensation risk



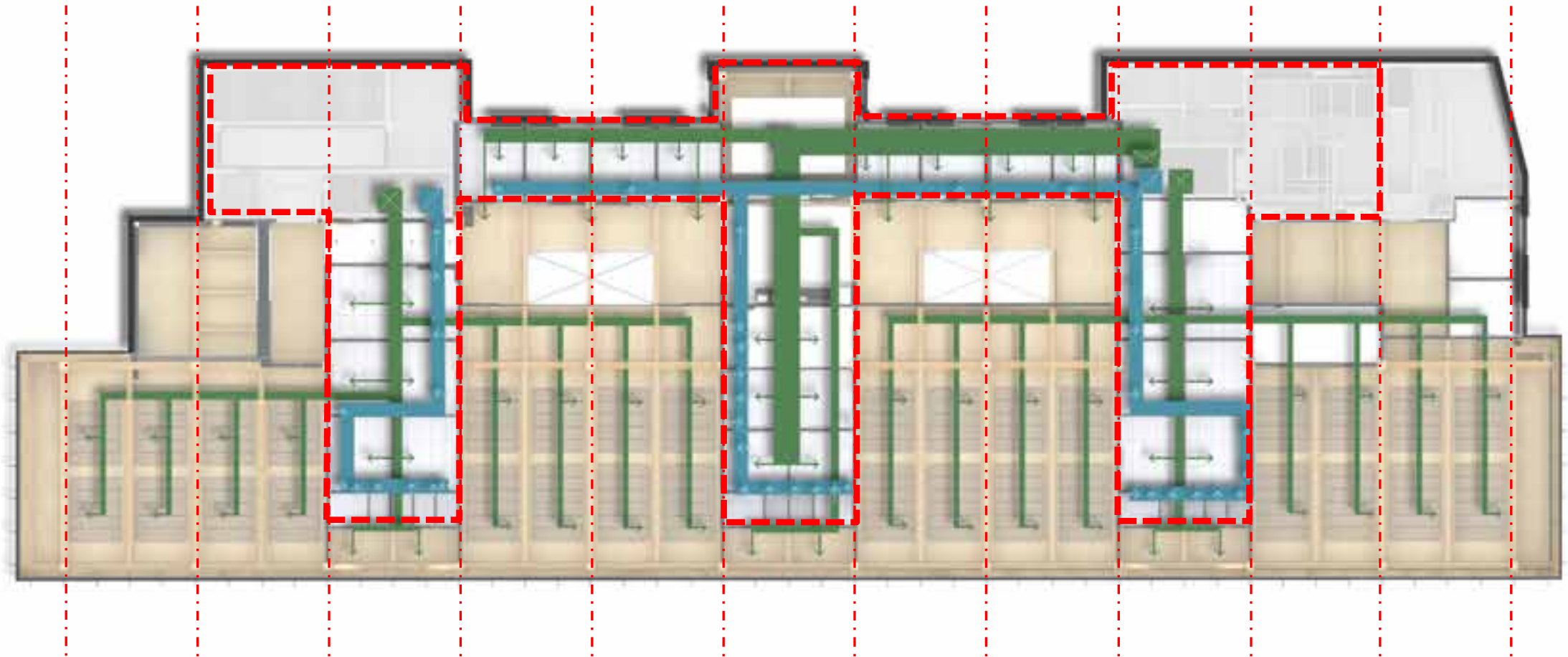
STRUCTURAL DESIGN – TYPICAL FLOOR PLAN



STRUCTURAL DESIGN – TYPICAL FLOOR PLAN

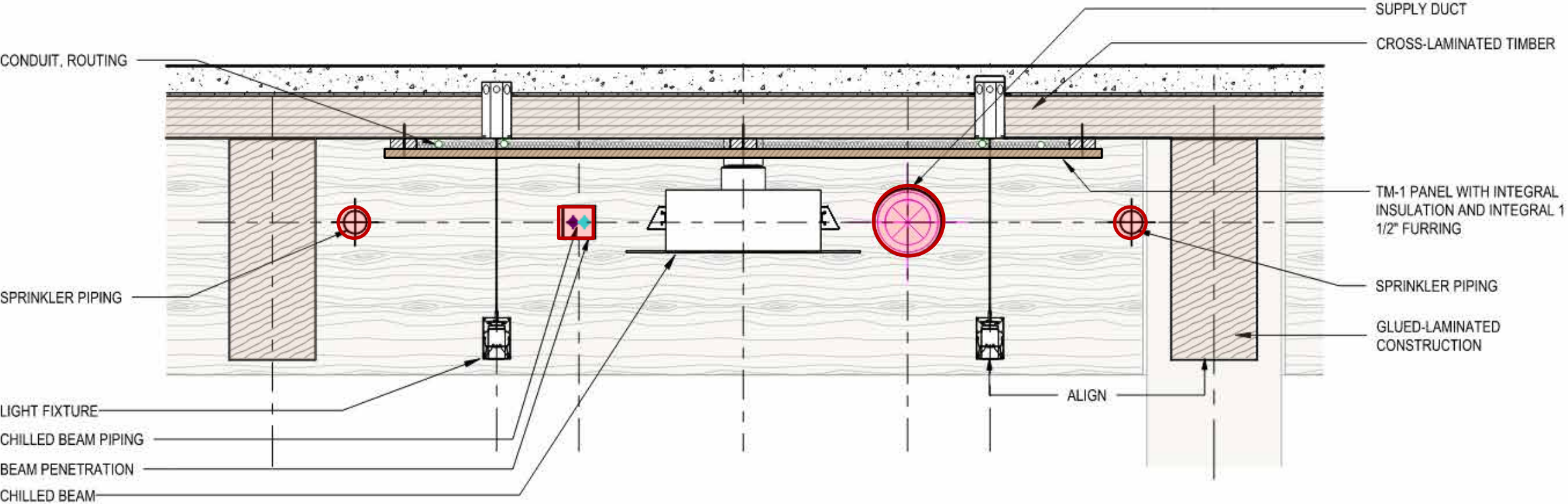
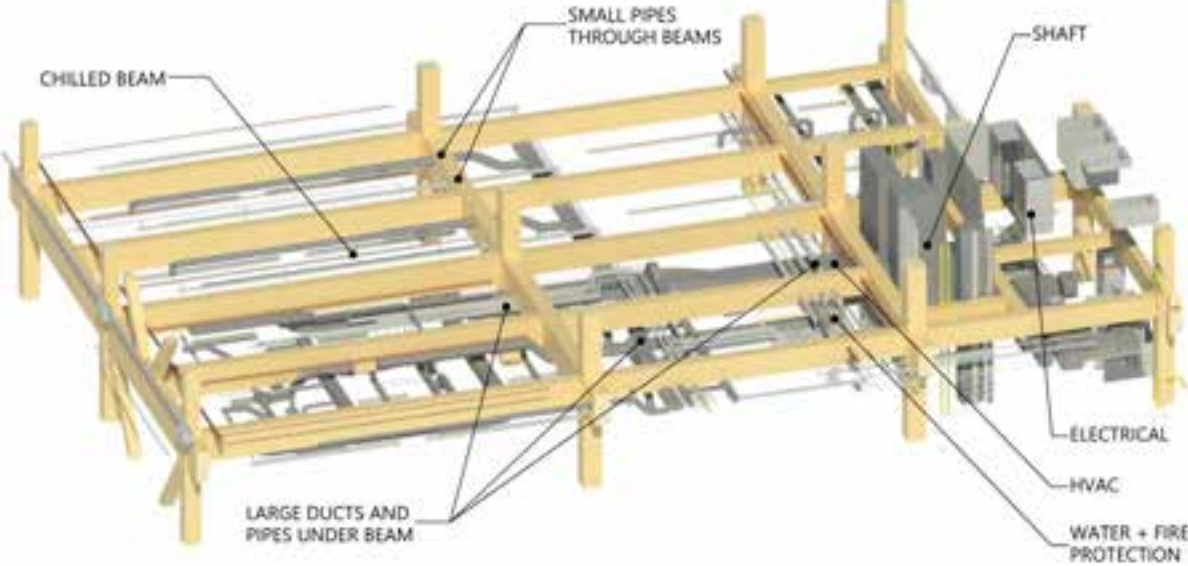


STRUCTURAL DESIGN – TYPICAL REFLECTED CEILING PLAN





STRUCTURAL + MEP DESIGN



STRUCTURAL + MEP DESIGN



NFPA 13 vs. FM 2-0 – Beam Pocket Requirements

- Both documents govern sprinkler placement in obstructed (beam pocket) construction, but they differ on how deep below the deck a head may sit
- Core difference: NFPA 13 permits deflectors up to 22 in. below the deck; FM 2-0 generally wants the head within 12 in. of the deck in every channel bay
- NFPA 13 is code (Philadelphia / IBC 2018); FM 2-0 is an insurer guideline, so a documented deviation is the path to reconcile them

NFPA 13 (2016) – Code Requirement

Definition: beams or members that impede heat flow or water distribution; panel construction limited to 300 sq ft bays.

Vertical placement (8.6.4.1.2): deflectors 1 in. to 6 in. below the beams and up to 22 in. below the deck, or in each bay 1 in. to 12 in. below the ceiling.

Obstructions: governed by the 8.6.5 tables and figures; minimum 4 in. from a wall (beam pocket face).

Status: mandatory

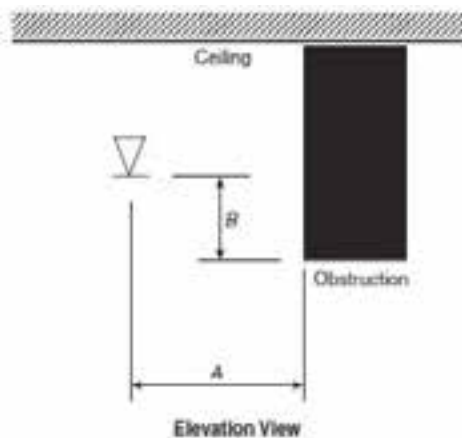


FIGURE 8.6.5.1.2(a) Positioning of Sprinkler to Avoid Obstruction to Discharge (SSU/SSP).

FM Global 2-0 (Oct 2021) – Insurer Guideline

Definition: assembly that blocks hot gas spread to the nearest four sprinklers – members deeper than 12 in. spaced closer than the allowable sprinkler spacing.

Vertical placement: a head in every channel bay, thermal element 1 in. to 12 in. below the underside of the ceiling; exceptions allow up to 22 in. only for specific member depths and spacings.

Obstructions: checkerboard figures plus grouped-object rules (objects within 3x the smaller width are treated as one).

Status: loss-prevention recommendation – deviations may be requested from FM.



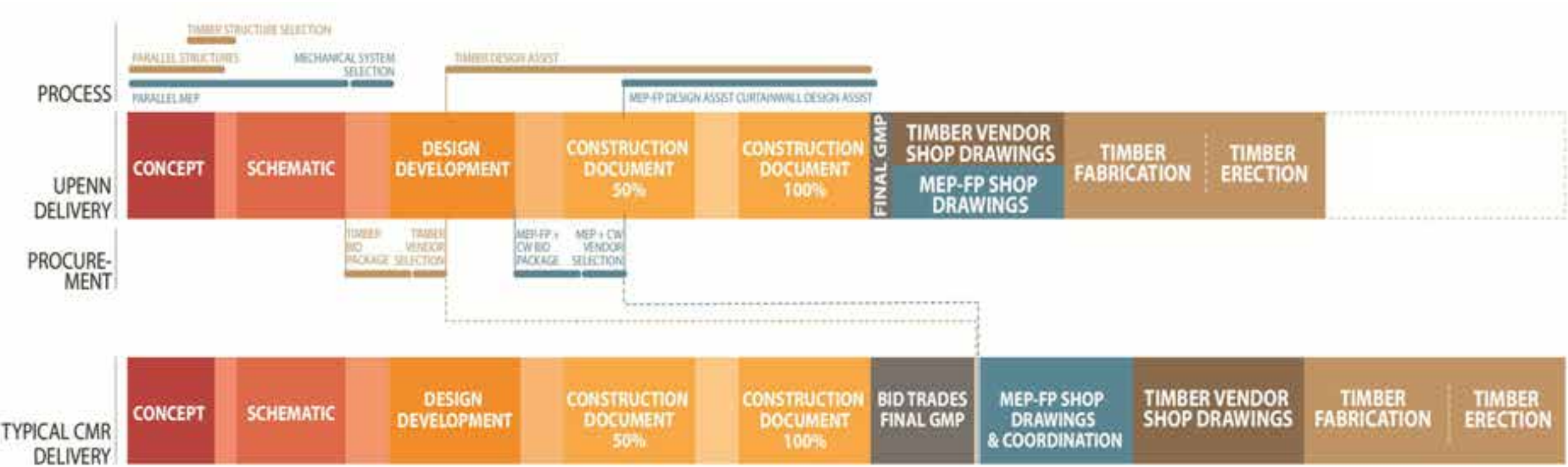
DESIGN SCHEDULE PLANNING

Concept:	Build Consensus Around Goals, Testing Options, Comparative Pricing, Addressing Perceived Risks CMR Selected at end of Concept
SD:	Informal Mass Timber Engagement
100% SD	Issue Timber Design Assist Package
50% DD	Select Mass Timber Design Assist Partner
100% DD	Issue MEP, FP & Curtainwall & Elevator Design Assist Package Packages
CD:	Full Trade Partner Engagement

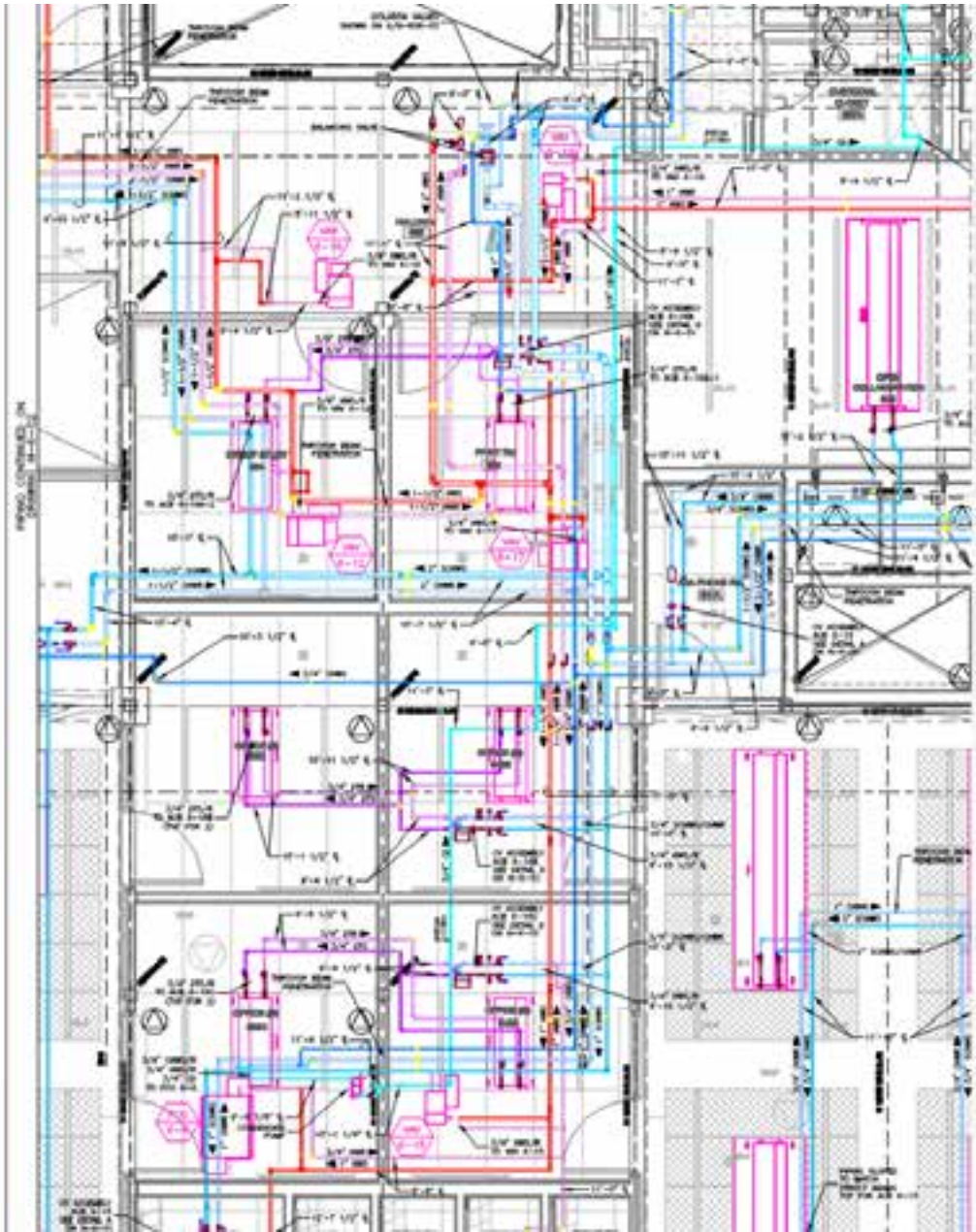
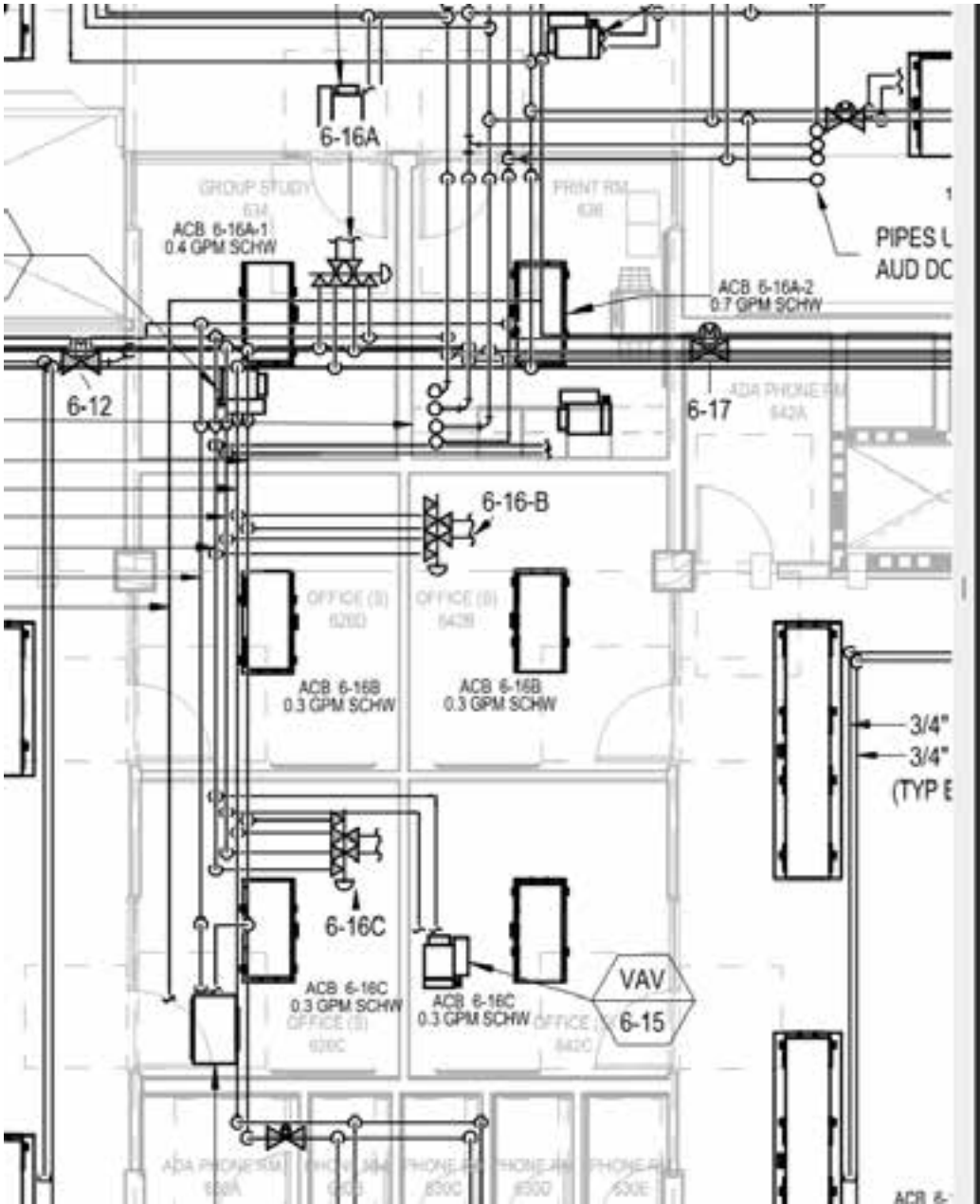


TRADE PARTNER ENGAGEMENT & PROCUREMENT

- Informal Mass Timber Engagement: Throughout SD
- Issue Timber Design Assist Bid Package: 100% SD
- Select Mass Timber Design Assist Partner: 50% DD
- Issue MEP, FP & Curtainwall Design Assist Package Bid Packages: 100% DD
- Select MEP, FP & Curtainwall Design Assist Partners: 25% CD



CONSTRUCTION DRAWINGS VS SHOP DRAWINGS











Trinity University

Dicke Hall

San Antonio, TX

Completed 2022









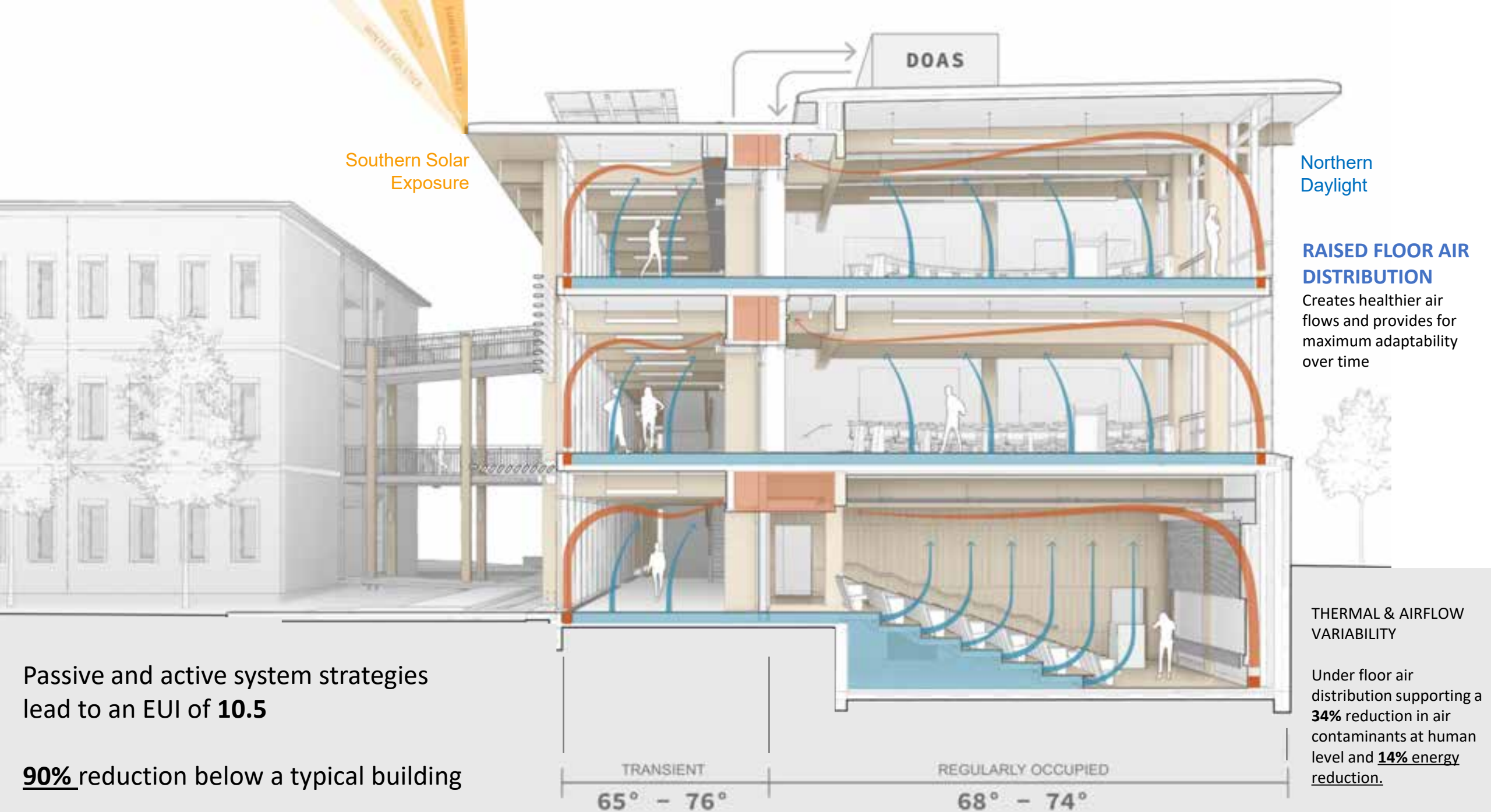
CODE + CONSTRAINTS

- Construction Type: V-B
 - Primary structure: Unrated
 - Shafts and support frame: 1 hr
- Occupancy Group: B & A-3
- Maximum Height to Roof: 60ft
- Maximum stories:
 - Group B: 3
 - Group A-3: 2 (A-3 limited to first floor)
 - 1 hr separation between A and B

CONSTRAINTS

- Historic Context
- Limited floor to floor heights





Under Floor Air Distribution - Principles and Design Basis

What it is

- Under-floor air distribution supplies conditioned air through a pressurized raised-floor plenum, giving flexible, quiet, individually controlled comfort.
- Air rises in a displacement "piston effect," carrying heat and contaminants up and out through a ceiling return plenum.
- Temperature stratifications allows only the occupied zone be cooled, reducing the cooling load within the space resulting in an energy efficient system

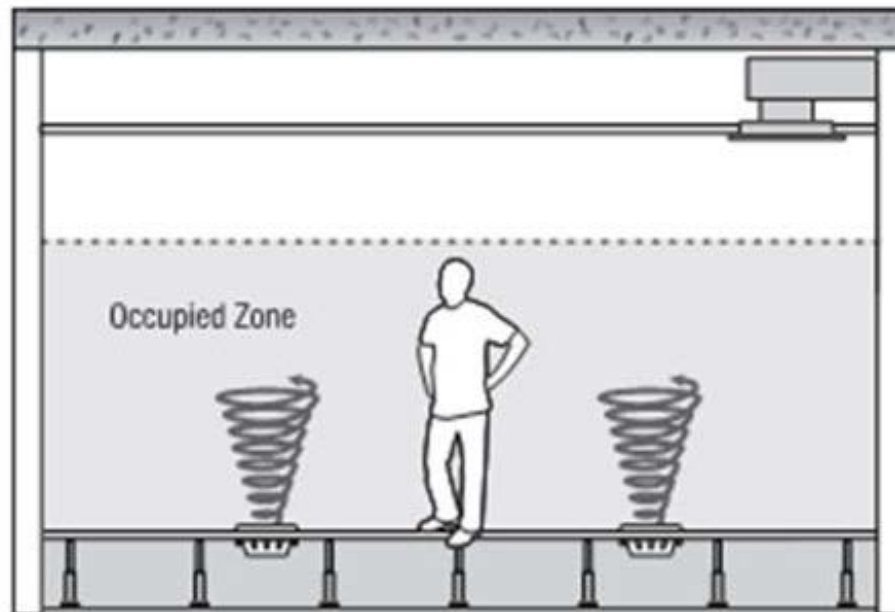


Figure 3: Underfloor air distribution

Under Floor Air Distribution - Principles and Design Basis

Things to Consider

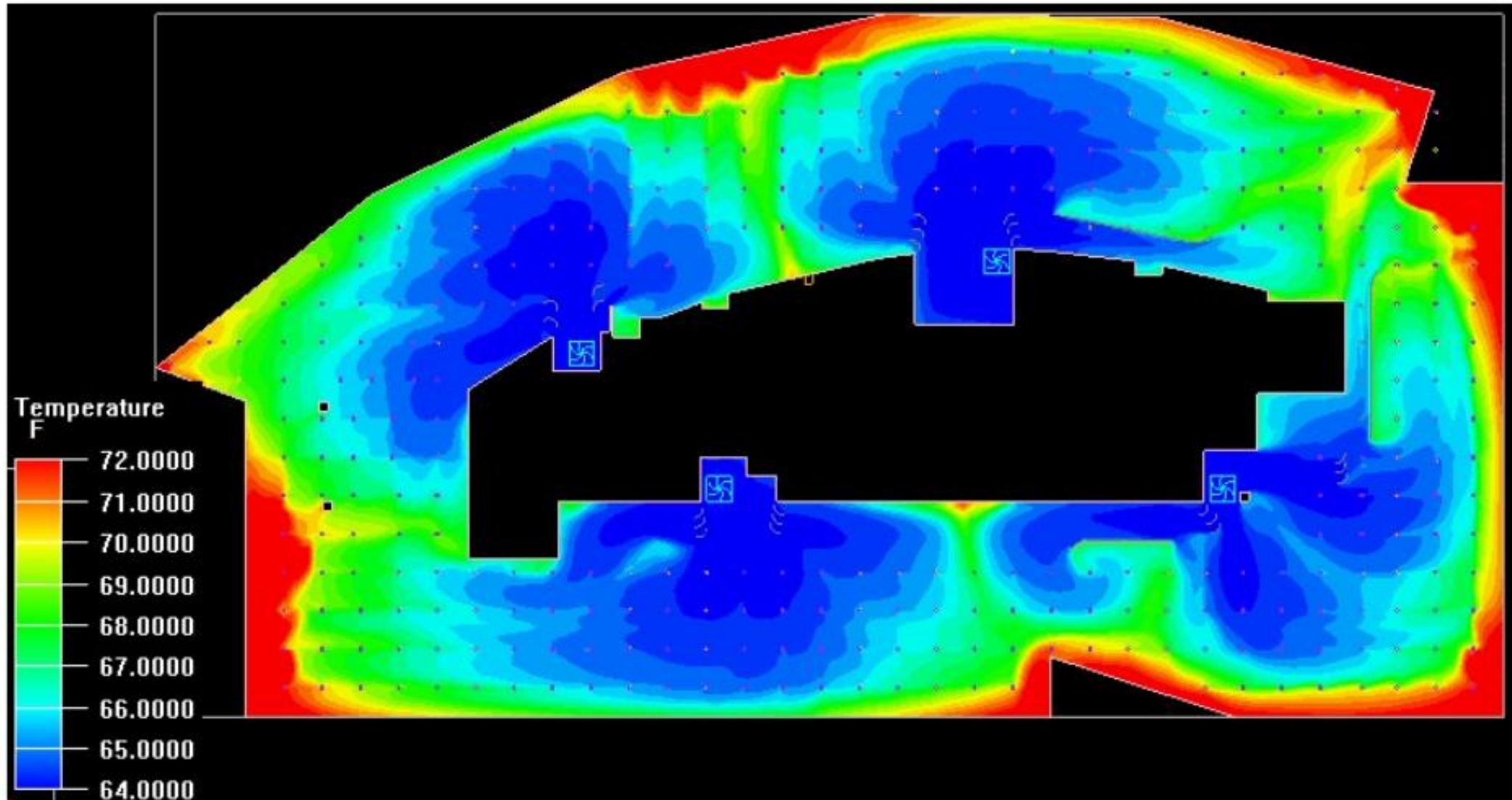
- Space Planning - Temperature degrades within floor plenum, requires multiple dedicated rooms for air towers on the floors
- Detail of air plenum and testing of air tightness
- Underfloor air has specific requirements for diffuser placements, air velocities and return plenum heights

Applicability

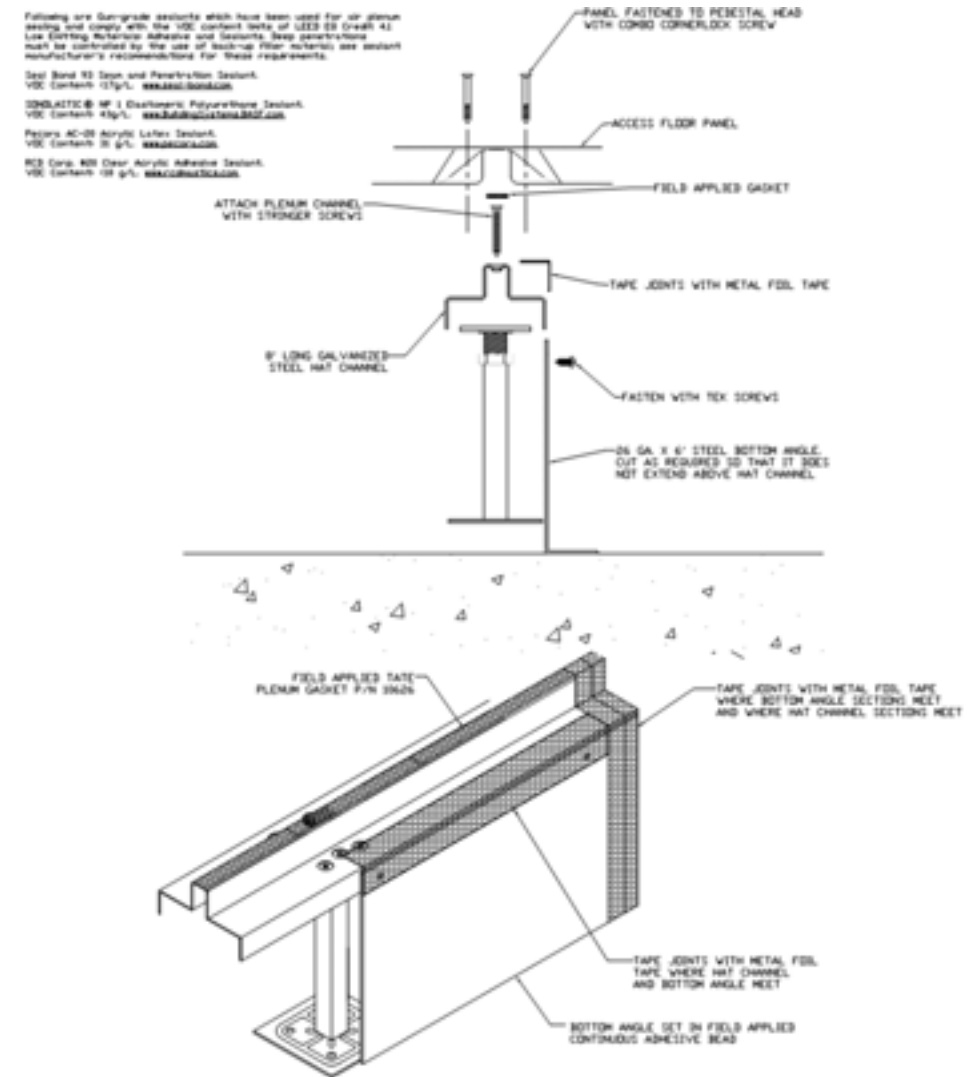
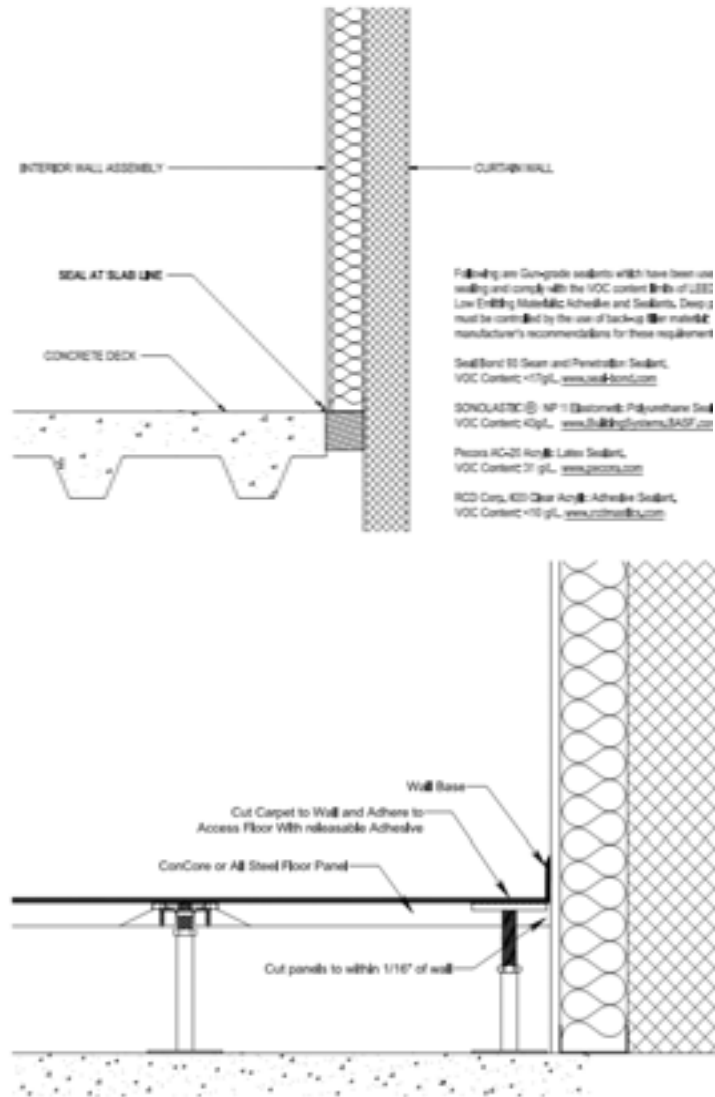
Best fit: Open-plan floors, meeting rooms, high-churn and high-ceiling spaces.
Avoid in: secure facilities, wash-down areas and food service.

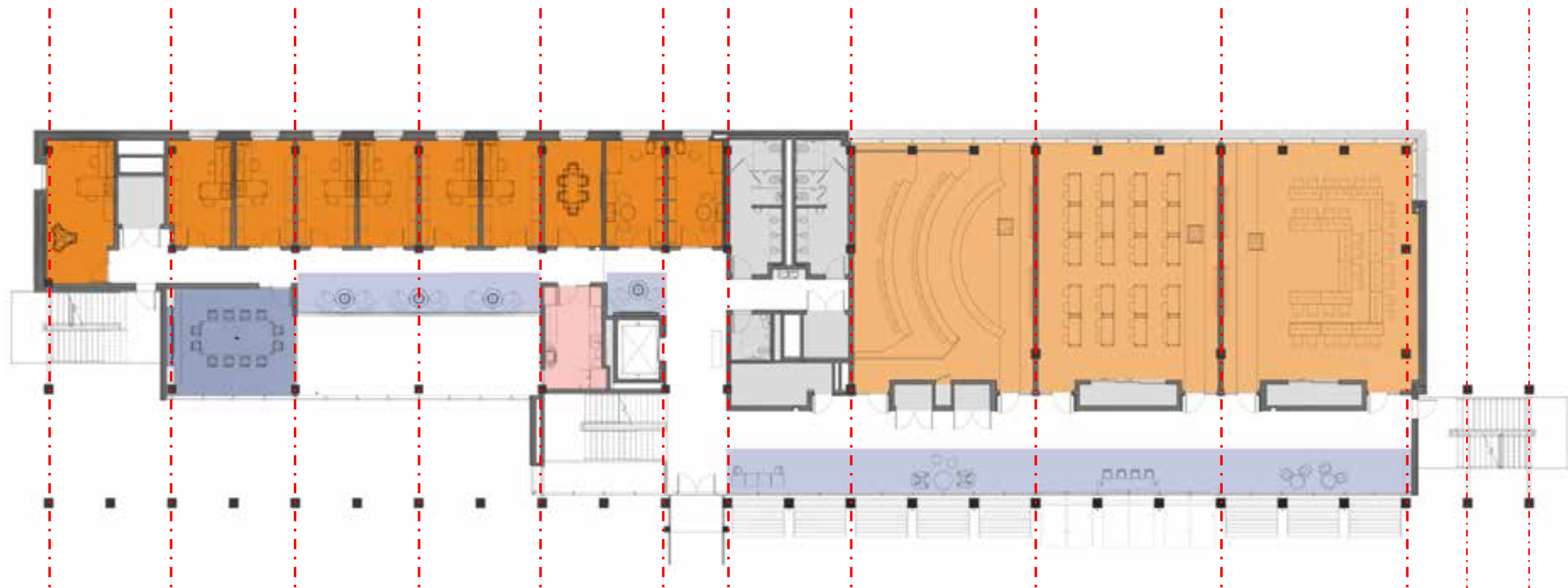


Airflow Within Supply Plenum – Temperature Decay



Supply Air Plenum Sealing

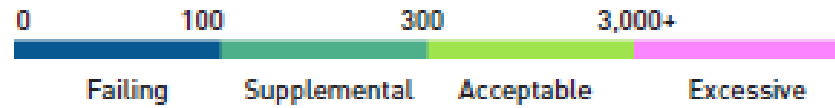




Add dimensions

DICKE HALL – DAYLIGHT HARVESTING

Useful Daylight Illuminance (UDI)



DAYLIGHT HARVESTING

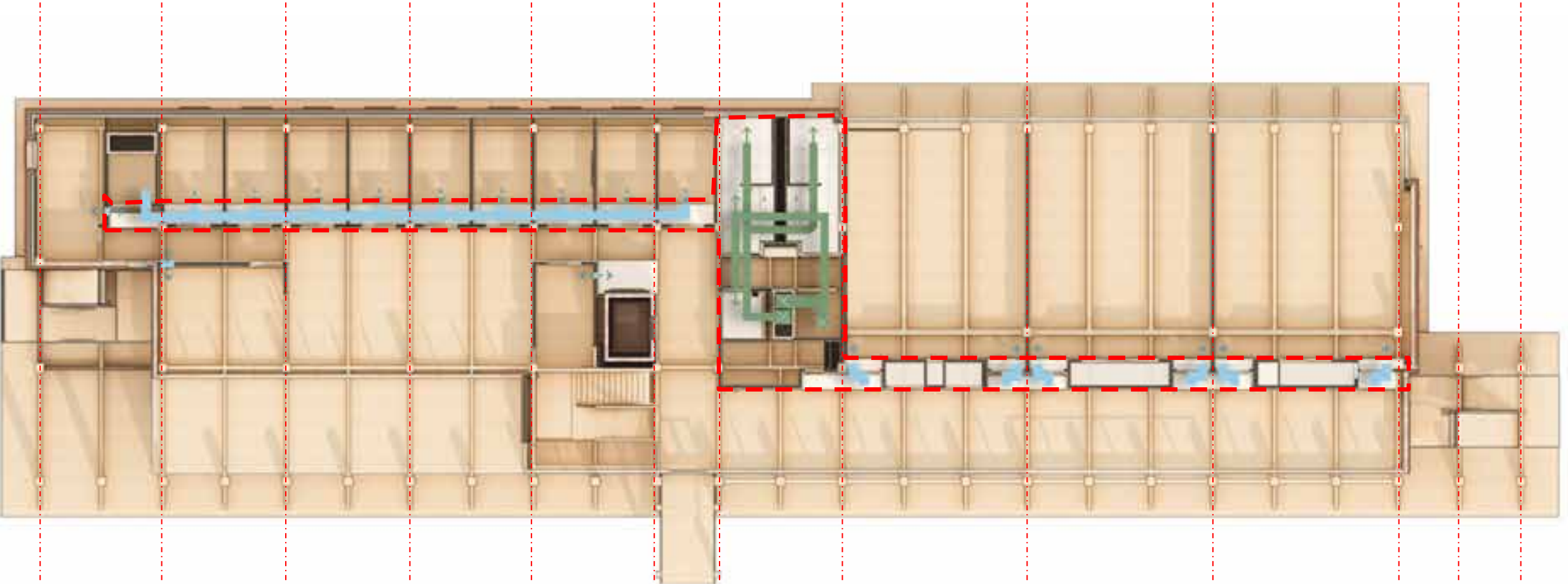
98% of regularly occupied spaces have access to daylight and views

COMFORT ZONING

Transient spaces are located on south side of building to protect zones of tighter temperature control from solar heat gain while leveraging south views into campus



STRUCTURAL DESIGN – TYPICAL REFLECTED CEILING PLAN







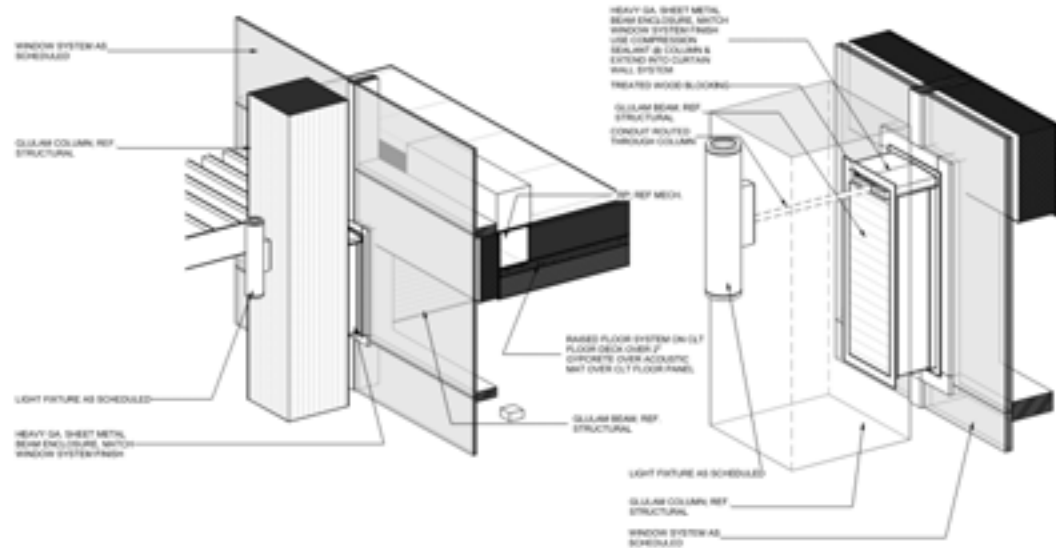
DESIGN & PROCUREMENT SCHEDULE

Concept:	Build Consensus Around Goals Testing Options Addressing Perceived Risks
SD:	Develop mass timber design Integrating system thinking
50% DD:	GC selected and engaged
100% DD	Timber Bid Package
50% CD:	Timber Vendor fully engaged
100% CD:	MEP Partners brought on board through CMR/GMP process









7 AXON - COLUMN / BEAM / CURTAIN WALL DETAIL
SCALE:

6 AXON - BEAM METAL ENCLOSURE
SCALE:

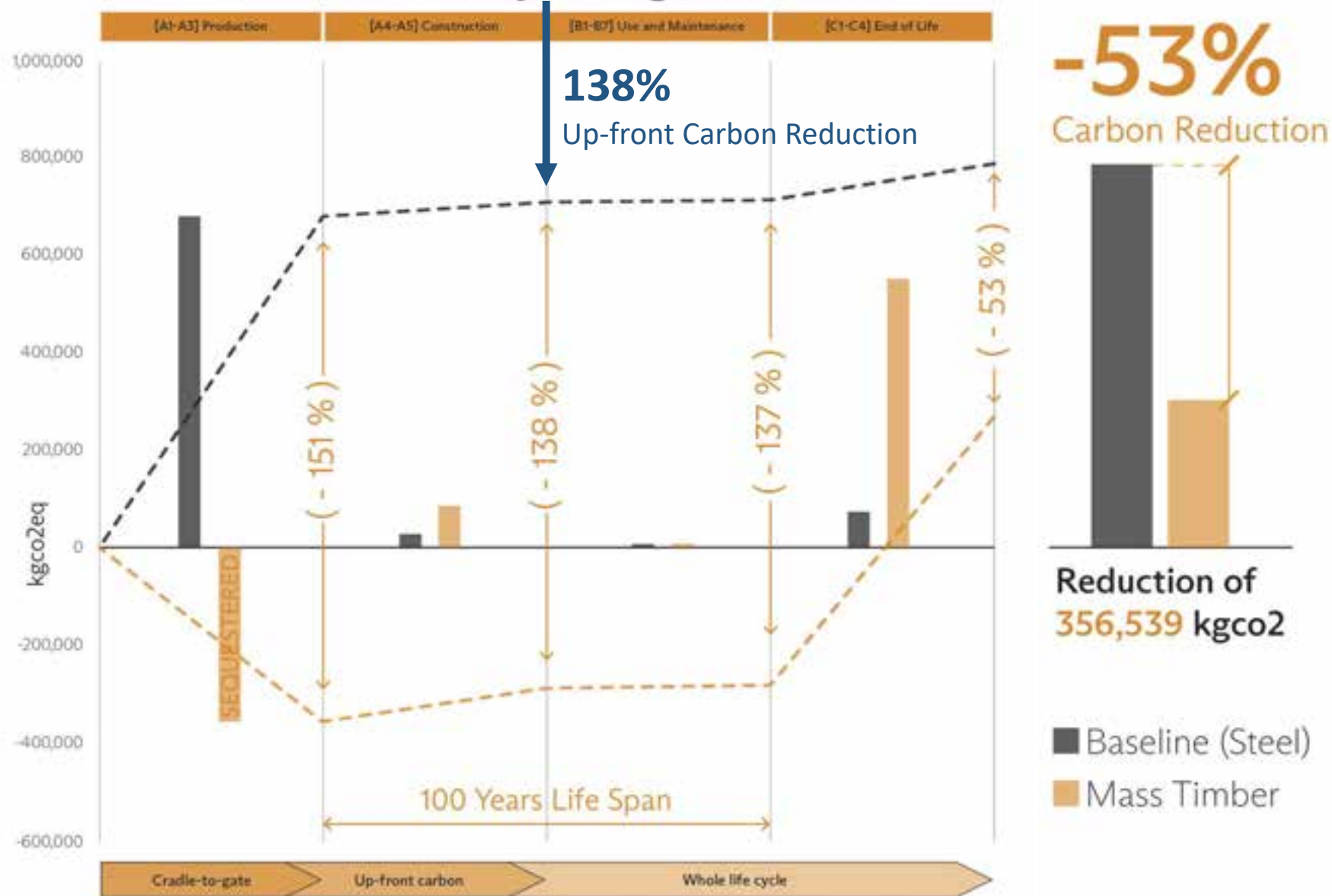




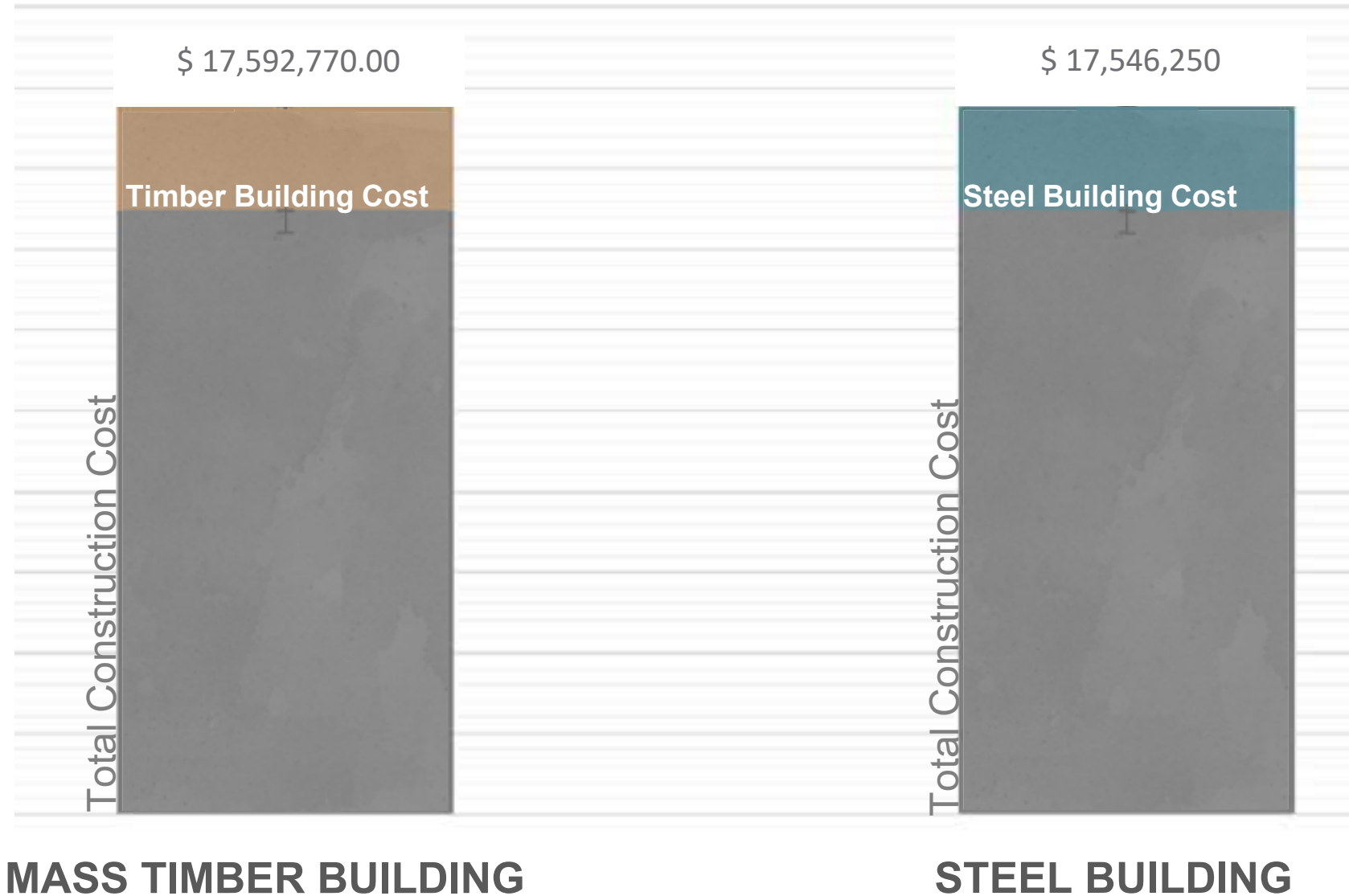




Dicke Hall - Life Cycle Stages of Carbon



COST COMPARISON Timber vs Steel – Total Construction Cost Impact



Cost delta less than **.3%** of total construction cost

University of Denver

Burwell Center

Denver, CO

Completed 2020





CODE 2016 IBC

- Construction Type: III-B
 - Primary structure: 0hr fire
 - Shafts: 1hr fire
- Occupancy Group: B & A-3
- Maximum Height to Roof: 75ft
- Maximum stories: 3

CONSTRAINTS

- Cost
- Performance/Operations Familiarity



DESIGN & PROCUREMENT SCHEDULE

Concept:	CMR engaged in Concept
SD	Tested Options
SD 100%	Documented 3 Options: Steel, Concrete, Timber
DD 25%:	Approved to move forward with timber structure
DD 50%:	Revised Estimate Package
DD 100%:	Timber Bid Package
CD 50%:	Timber Fully Engaged Informal MEP Engagement
CD 100%/GMP:	MEP Partners brought on board through CMR/GMP process

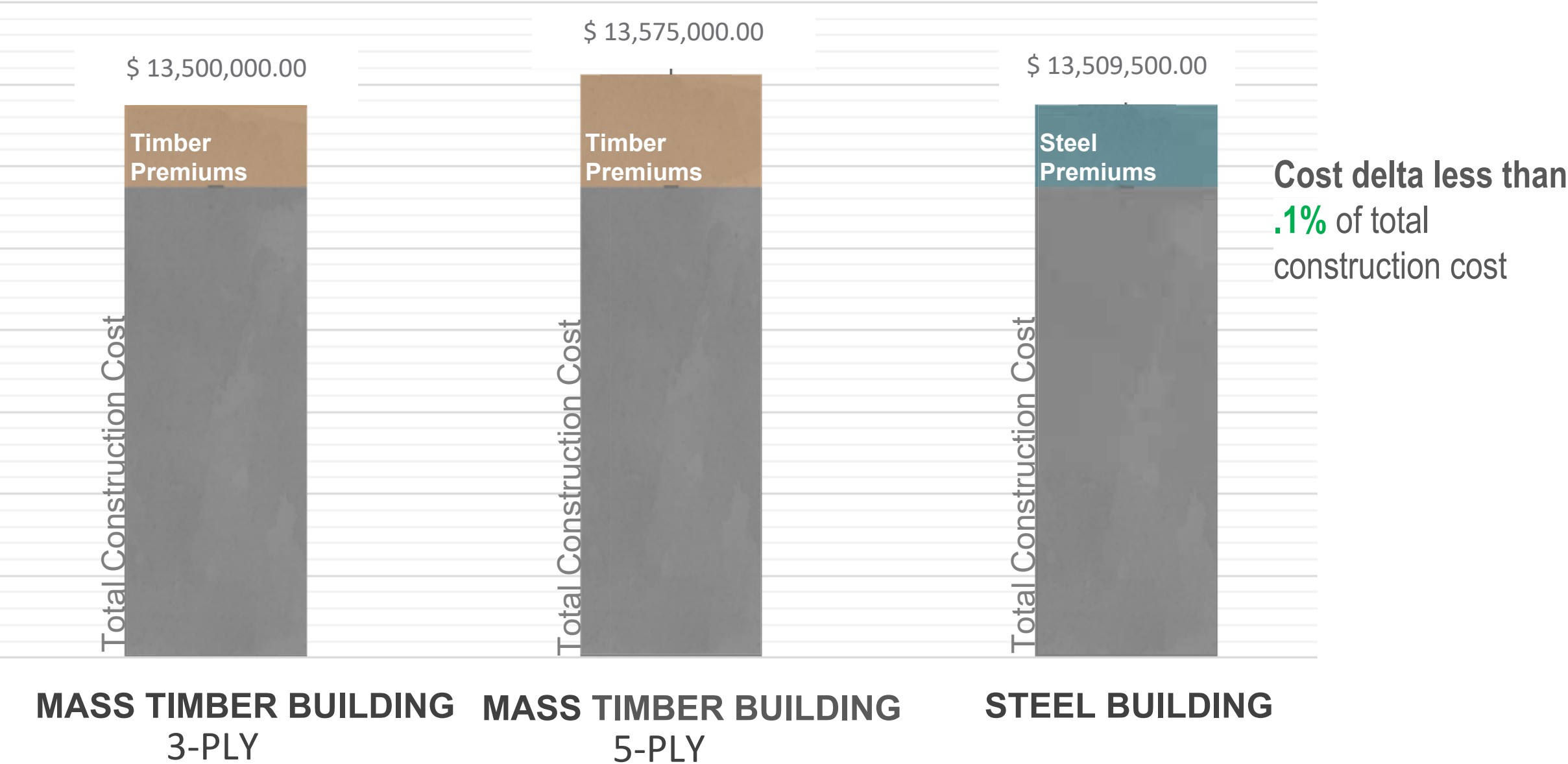


PROCUREMENT: BEST PRACTICES

- ❑ Early Go/No-Go Decision on Mass Timber
- ❑ CM/GC design-assist
- ❑ Early supplier selection vs. competitive bid
- ❑ Optimize structural grid with supplier input
- ❑ Maximize time for design coordination
 - Shop drawing release
 - MEP coordination
 - Fabrication lead time
 - Constructability reviews
- ❑ Transfer of Revit model to contractor



COST COMPARISON Timber vs Steel – Total Construction Cost Impact

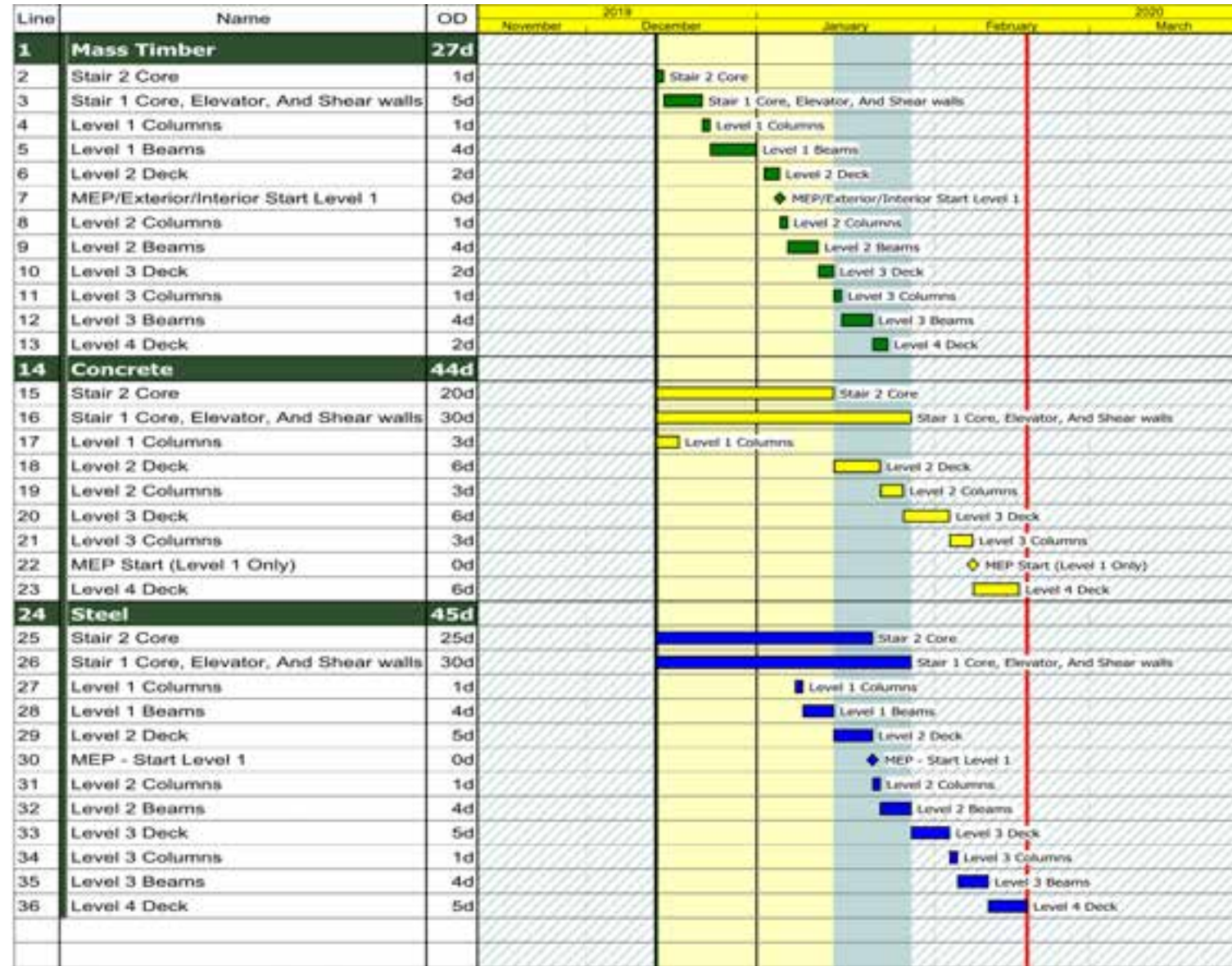


CONSTRUCTION EFFICIENCIES: FASTER SCHEDULE

40% Faster than Concrete!

- Concurrent CLT core wall erection
- Eliminate re-shores
- Accelerated start of MEP rough-in
- Reduced manpower & crew size
- Prefabrication / precision-fit
- Minimal weather protection
- No temp heat required

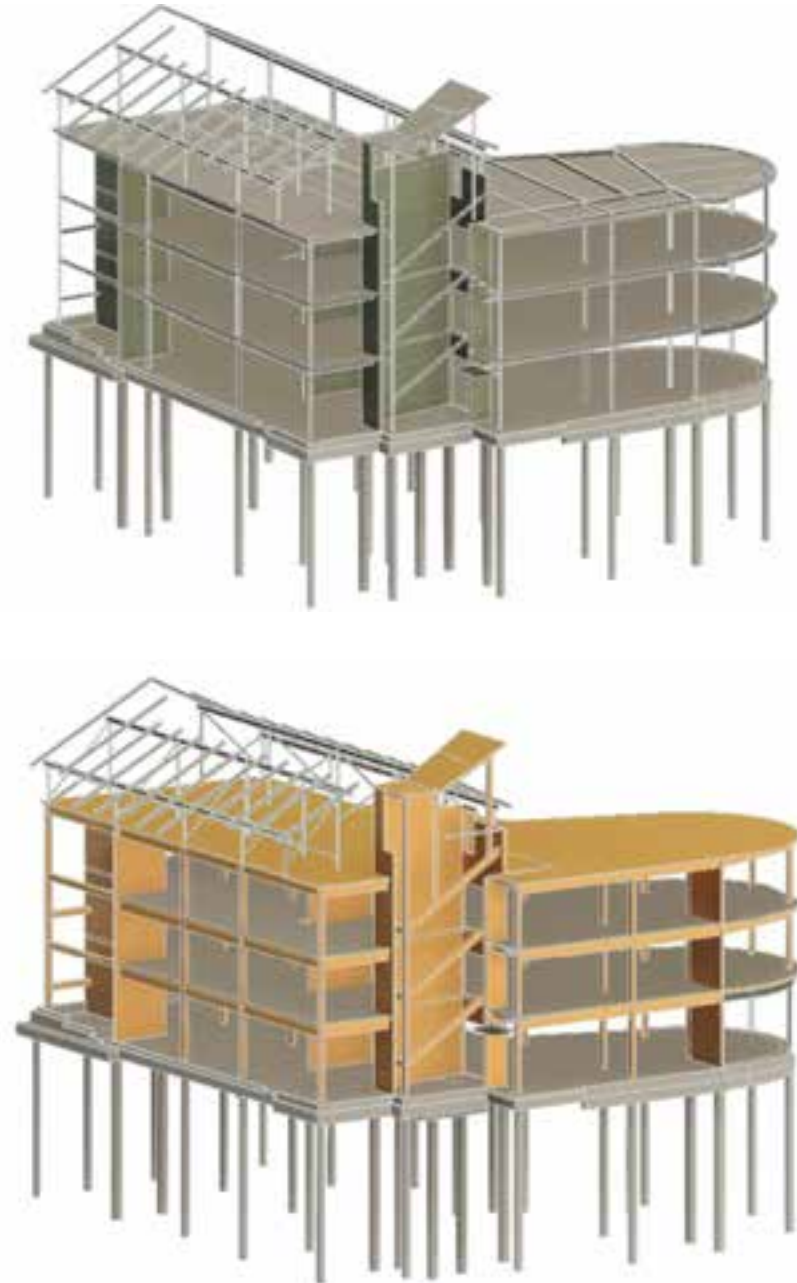
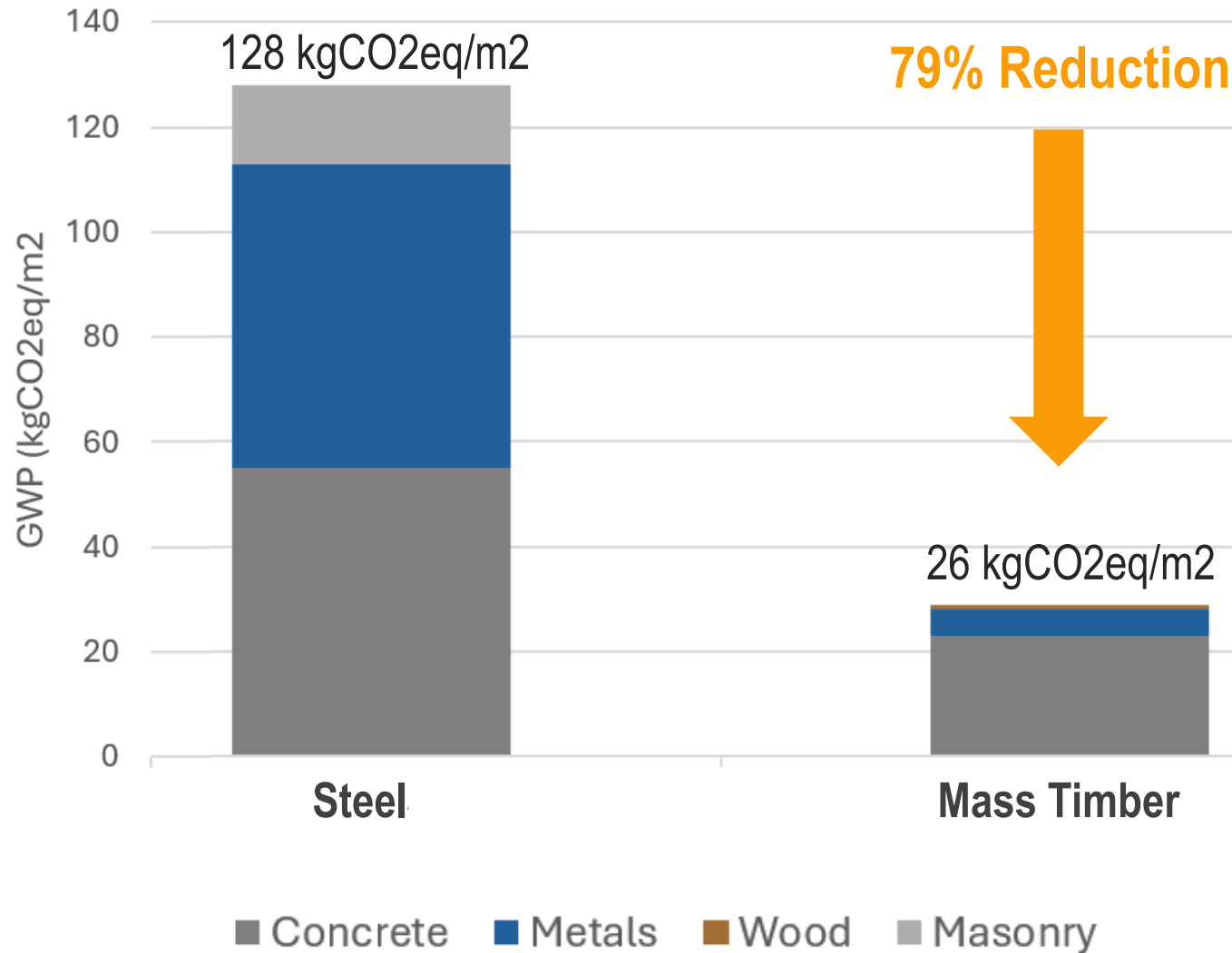
Erected in 6 weeks with 8 person crew





EMBODIED CARBON REDUCTION

Superstructure Structural GWP



We expected CLT to contribute in the stairs & public spaces





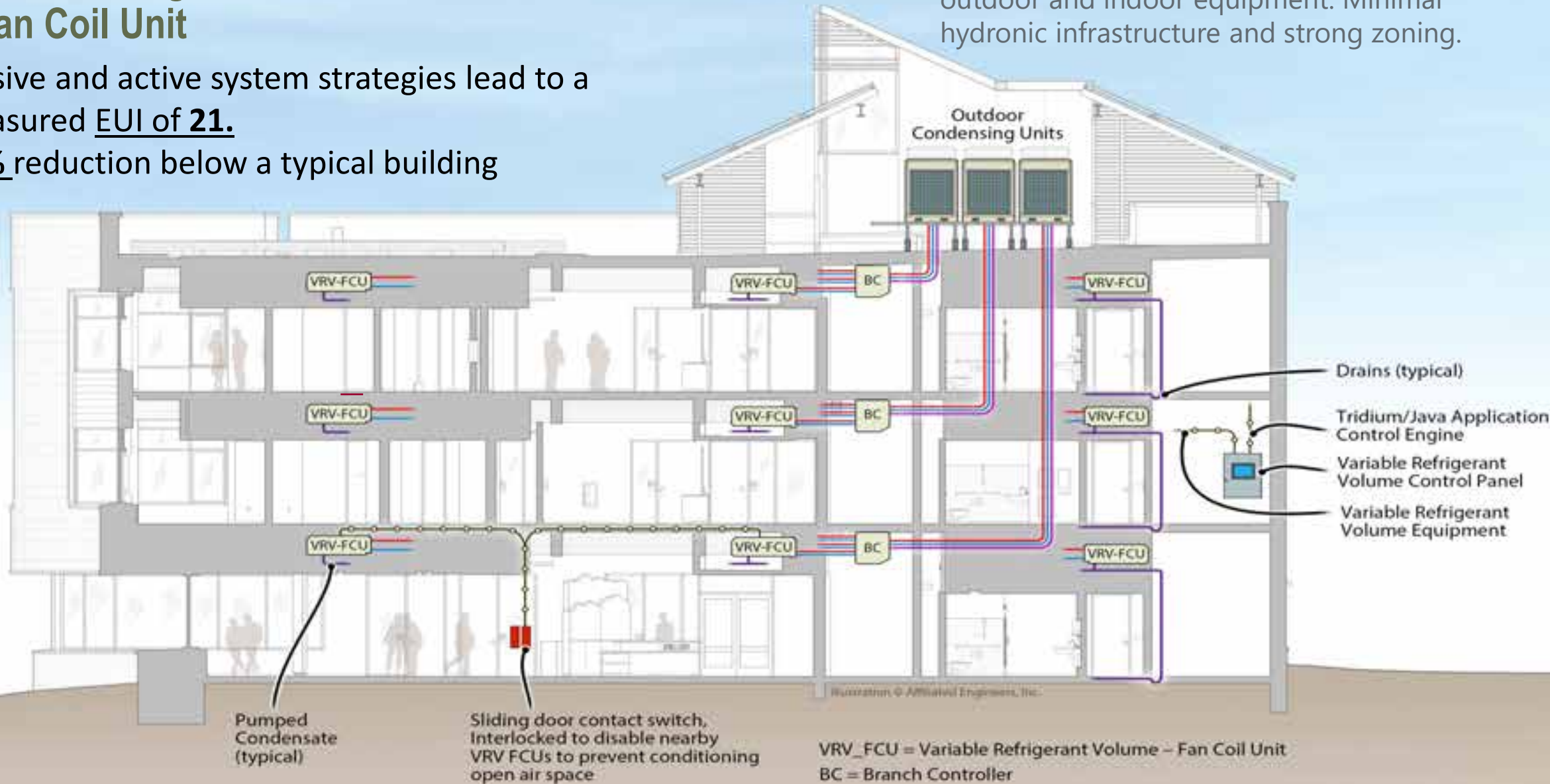
But discovered delight in exposing the “back side” as well.

Variable Refrigerant Volume – Fan Coil Unit

Passive and active system strategies lead to a measured EUI of 21.

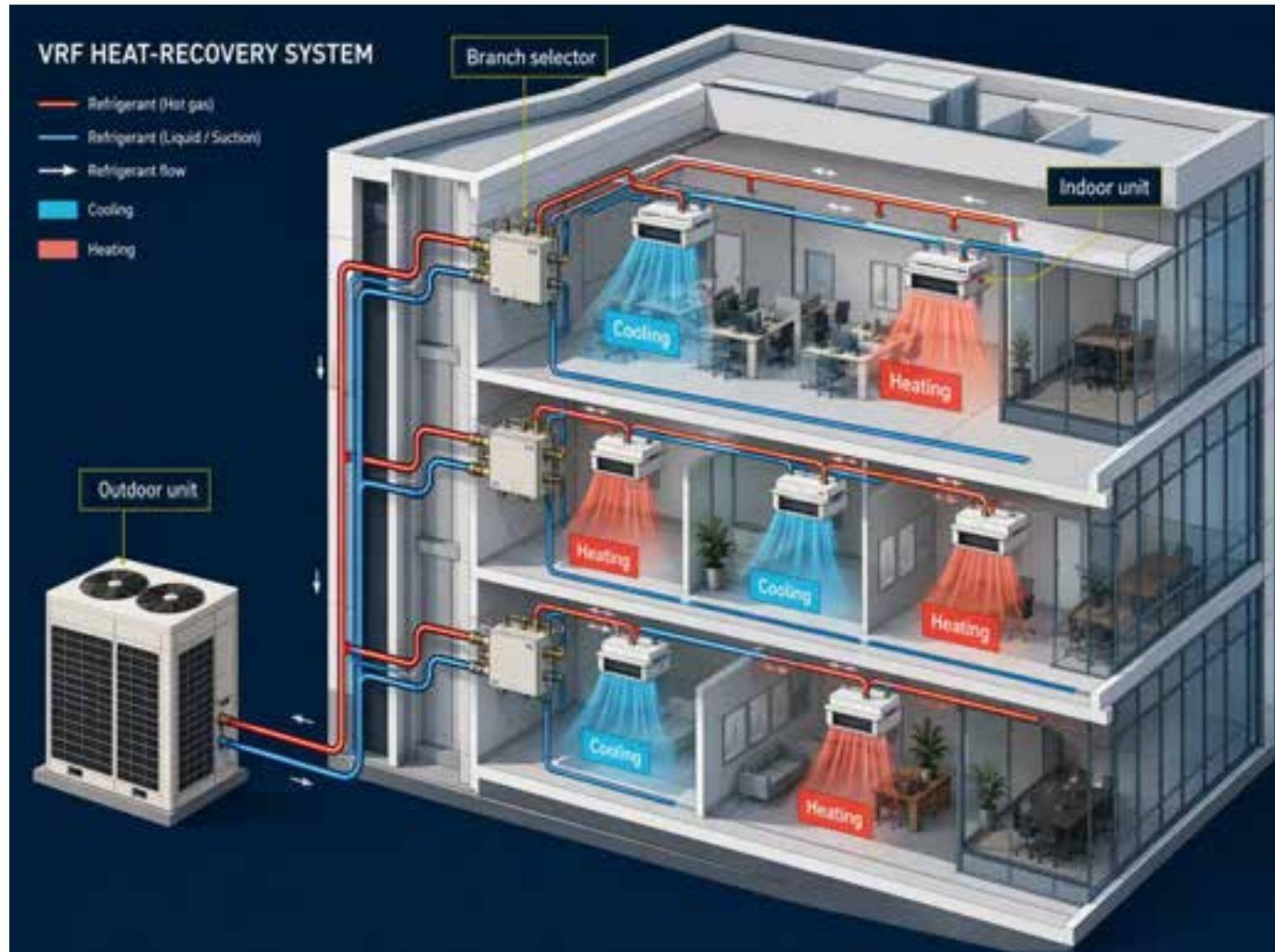
71% reduction below a typical building

Refrigerant moves heat directly between outdoor and indoor equipment. Minimal hydronic infrastructure and strong zoning.



VRF | Maximum zoning with minimal hydronics

Best aligned with tight space, tenant control and phased fit-out.



Why it resonates

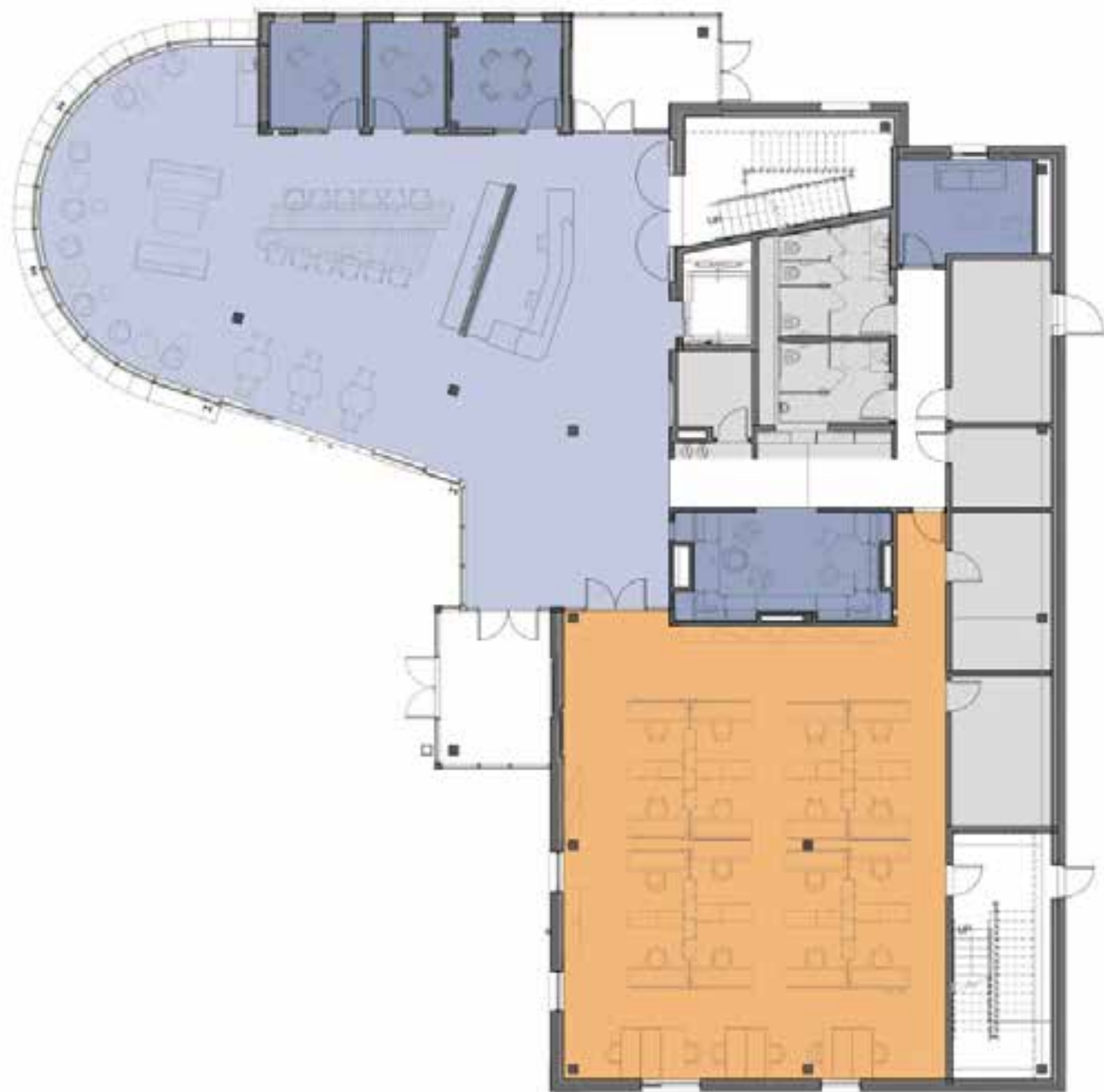
Small risers, flexible zones, reduced central plant and strong fit-out adaptability.

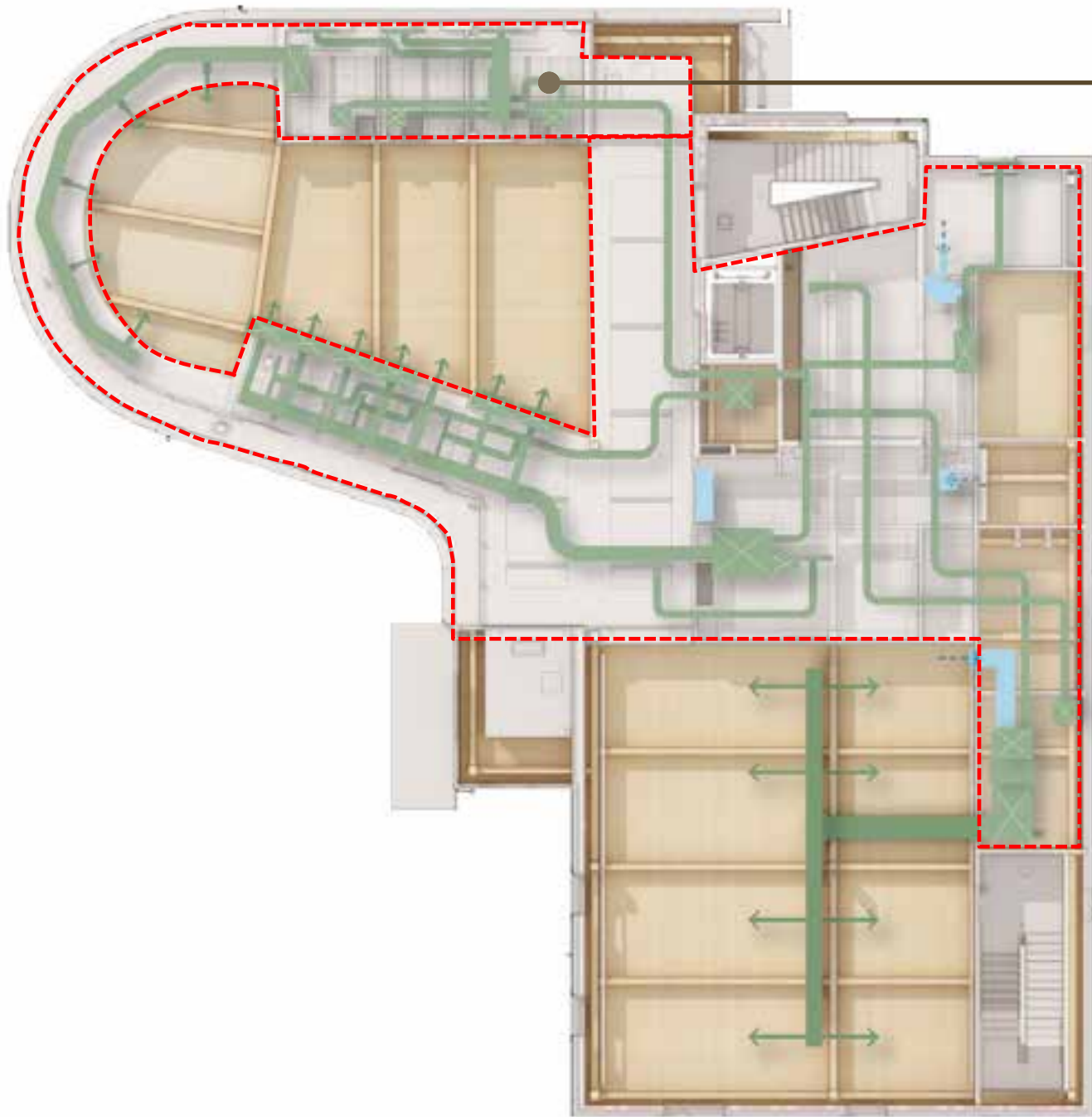
Design trade-offs

Distributed refrigerant, roof-unit density, proprietary controls and separate ventilation / latent control. VRF system life

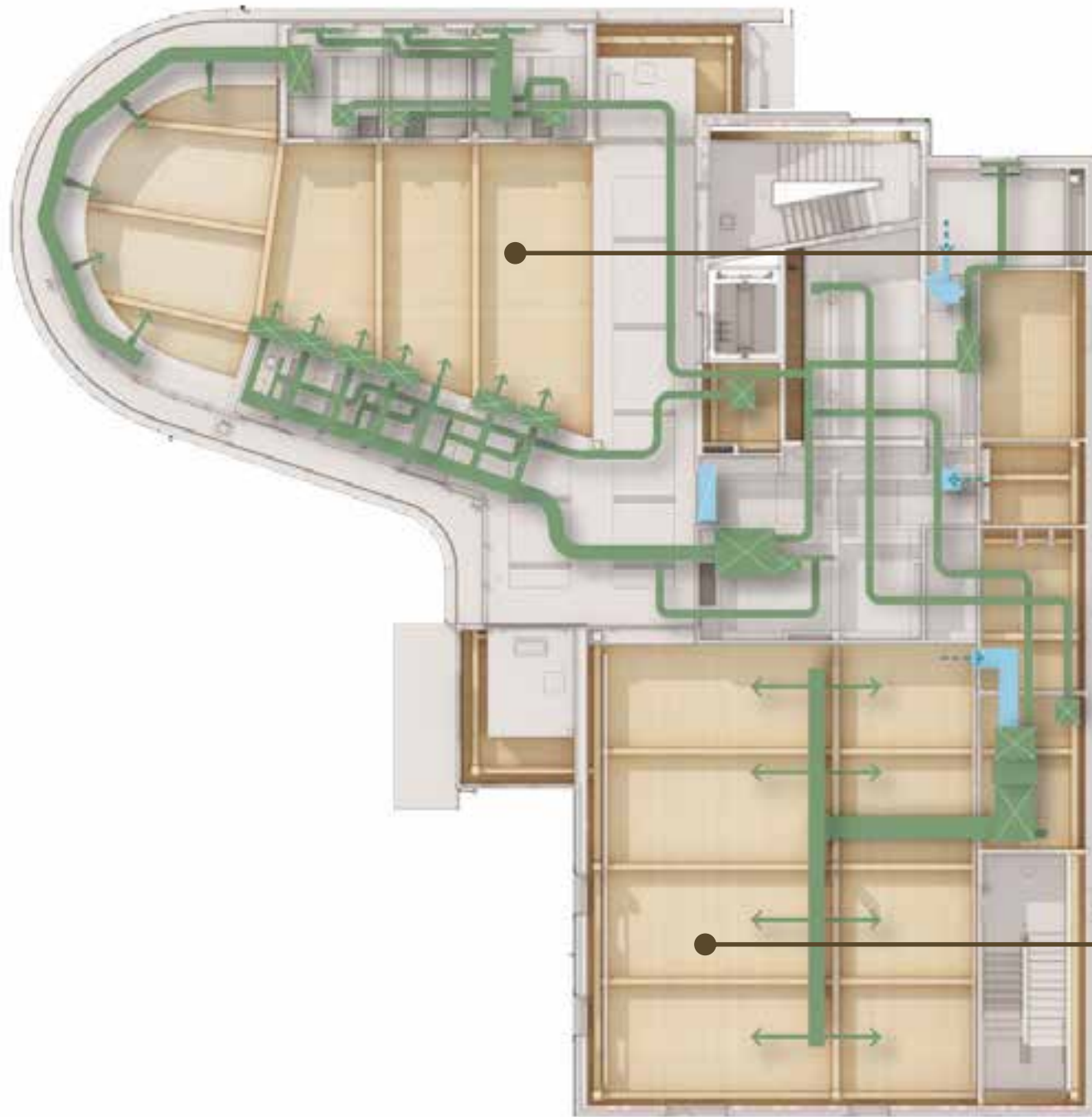
Things to Consider

Refrigerant safety, piping feasibility, DOAS integration, acoustics, controls and failure-domain planning.











MEP COORDINATION

Challenge: No exposed conduit!

- ❑ Well defined space programming
- ❑ Originally explored access flooring
- ❑ 3" topping slabs at floor & roof assembly
- ❑ 3D model ALL conduit
- ❑ Penetration overlay with CLT shop drawings
- ❑ Strategic placement of soffits & ceilings



MEP COORDINATION: Conduit at Roof Deck



DOUGLAS AND JAMIE MORDECAI EXECUTIVE LOUNGE



University of Pennsylvania
Amy Gutmann Hall

Architect of Record & Design Architect:

Lake Flato

Associate Architect: **KSS Architects**

Landscape Architect: **Ground Control**

Civil: **Pennoni**

Structural Engineering: **Buro Happold**

MEP Engineering: **Buro Happold**

Lab Planner: **RFD**

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Eng.**

Structural Engineering: **KL&A**

MEP Engineering: **Affiliated Engineers (AEI)**

General Contractor: **PCL Construction**

Timber Vendor: **Nordic**

- Identify aesthetic MEP routing goals early
- Determine extent of flexibility required
- Consolidate MEP in soffits/ceilings
- Prioritize MEP penetration coordination
- Maximize shop penetrations
- Minimize field penetrations



In Sync:

Integrating Building Systems in Mass Timber Construction

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Rachel Modica

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*This concludes The
American Institute of
Architects Continuing
Education Systems Course.*