

Mass Timber Hybrid Systems: Combining Structural Materials to Maximize Efficiency

901 East 6th Street Office Building

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Course Description

Modern timber buildings typically include a combination of wood and other materials, with light wood framing, steel and concrete utilized where structurally efficient. However, successfully realizing a hybrid of mass timber and other materials requires an acute understanding of their differences, from fabrication tolerances to installation techniques, and connection details. In this presentation, two hybrid projects will be presented to illustrate these key design and construction considerations. The Condos at Lost Rabbit in Mississippi utilized what is seemingly the best of both worlds—mass timber floor systems that provide inherent beauty, fire resistance and thin floor structures, paired with light wood-frame bearing walls that can be used to run MEP services while meeting code requirements for acoustics and fire resistance when clad with materials such as gypsum. 901 E 6th in Austin is a unique 5-story project—and the first in Austin to include cross-laminated timber (CLT). By leveraging the respective capabilities of structural steel framing and CLT floor panels, this 129,444-sf office building was able to achieve highly-efficient floor plates, 14-ft floor-to-ceiling heights, and large windows. Hear firsthand from the design and development teams of these projects, as they discuss their reasons for using mass timber and lessons learned from the hybrid approach.

Learning Objectives

1. Explore lessons learned, preconstruction coordination requirements, and types of projects that may be suitable for a mass timber and wood-frame hybrid approach.
2. Discuss construction types and fire-rating considerations associated with the use of a number of different structural framing materials in hybrid buildings.
3. Highlight the recent use of mass timber in a hybrid steel/timber office building in Austin.
4. Review detailing techniques for CLT structures that result in cost-effective solutions that meet code requirements for fire and life safety, structural performance, and acoustics.

901 East 6th Street Office Building

901 E 6th Street is a unique 5-story office project—and the first commercial structure in Austin to utilize cross-laminated timber (CLT), a prefabricated mass timber product.



Project context

The building is in Austin, TX on the edge of downtown just east of a highway. It is part of the Saltillo TOD, a city-initiated transit-oriented development striving for infill development while maintaining a place for artisans in the area.



Overview

The use of mass timber floor plates and steel allowed the project to achieve long spans from core to perimeter, eliminating columns within the open office floor space.

This presentation will discuss the use of cross laminated timber, and the lessons learned along the way—from building official interaction, to design and detailing strategies for a steel/CLT hybrid structure, and construction administration.



Building design leadership

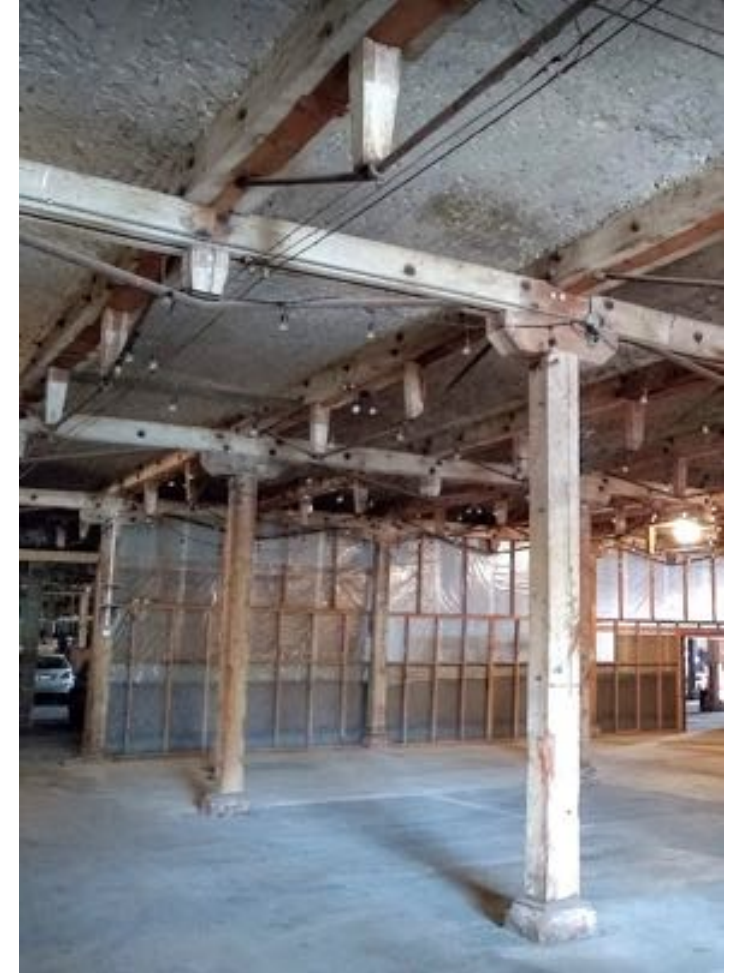
1. Architect- **TB/DS** – THOUGHTBARN / DELINEATE STUDIO LLC, led by partners Bart Whatley AIA, Robert E Gay, and Lucy Begg AIA.
2. The Owner's Design Team was comprised of Will Marsh & Bryce Miller of Endeavor, Richard Kooris, and Dennis McDaniel.
3. Structural Engineering- LEAP! Structures
4. MEP Engineering- Bay & Associates
5. Landscape Architecture- DWG Landscape Architecture
6. Civil- LOC Civil
7. Fire Engineering- Arup
8. Contractor- DCA Construction
9. CLT Panel Manufacturer- Structurlam



Inspiration & design

The design focused on using the materiality seen in turn of century warehouse buildings in a modern way. The building is designed to be an artistic statement to appeal to creative & high-tech tenants.

The building explores new sustainable approaches utilizing mass timber within the office building typology.



Inspiration & design

The raw wood/steel interior, reminiscent of early 20th century warehouses, is complimented by an exterior cladding of tapered mild steel that will patina over time.



Materiality

Much like the formation of a tree, Cross Laminated Timber derives its strength from layer upon layer of smaller wood fibers to become a larger scale structural element. The wood ceiling above you is the bottom surface of seven inch thick CLT.



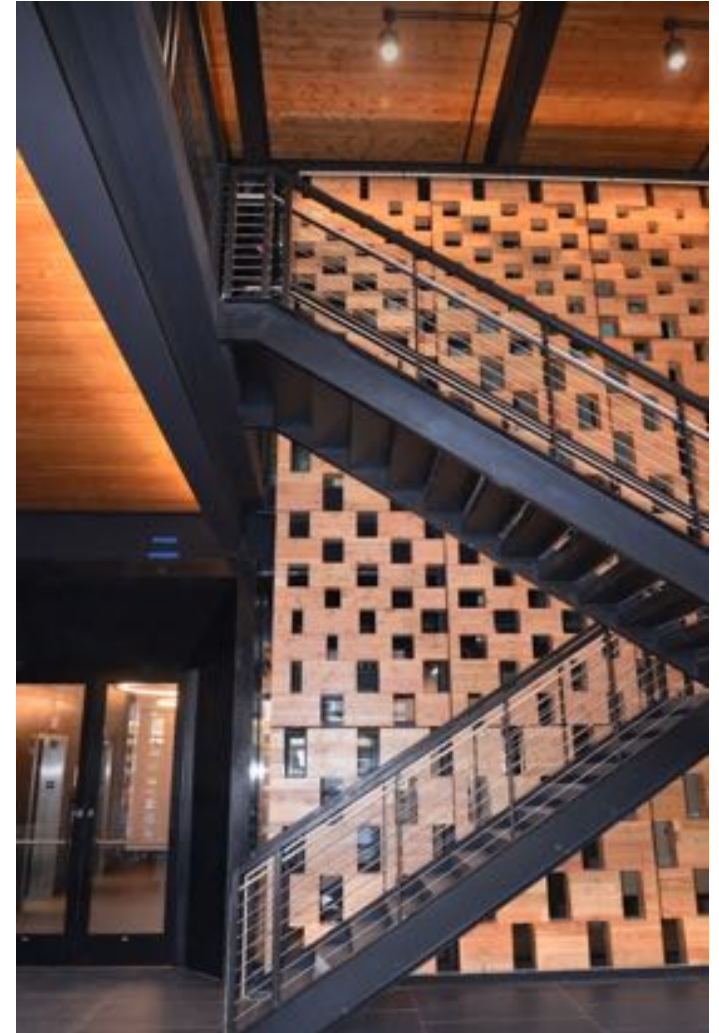
Sustainability

CLT was integral to fulfilling project goals for innovation, sustainability & aesthetics. Sustainability of CLT, being composed of a renewable material that sequesters carbon, was a draw. LEED gold rating achieved.



Creativity

This feature wall was created by stacking individual sections of CLT decking. The undulating screen design allows viewers to examine the exposed laminations of the CLT system that are normally hidden from view as a building material, while appreciating the play of light on the timber.



Value creation

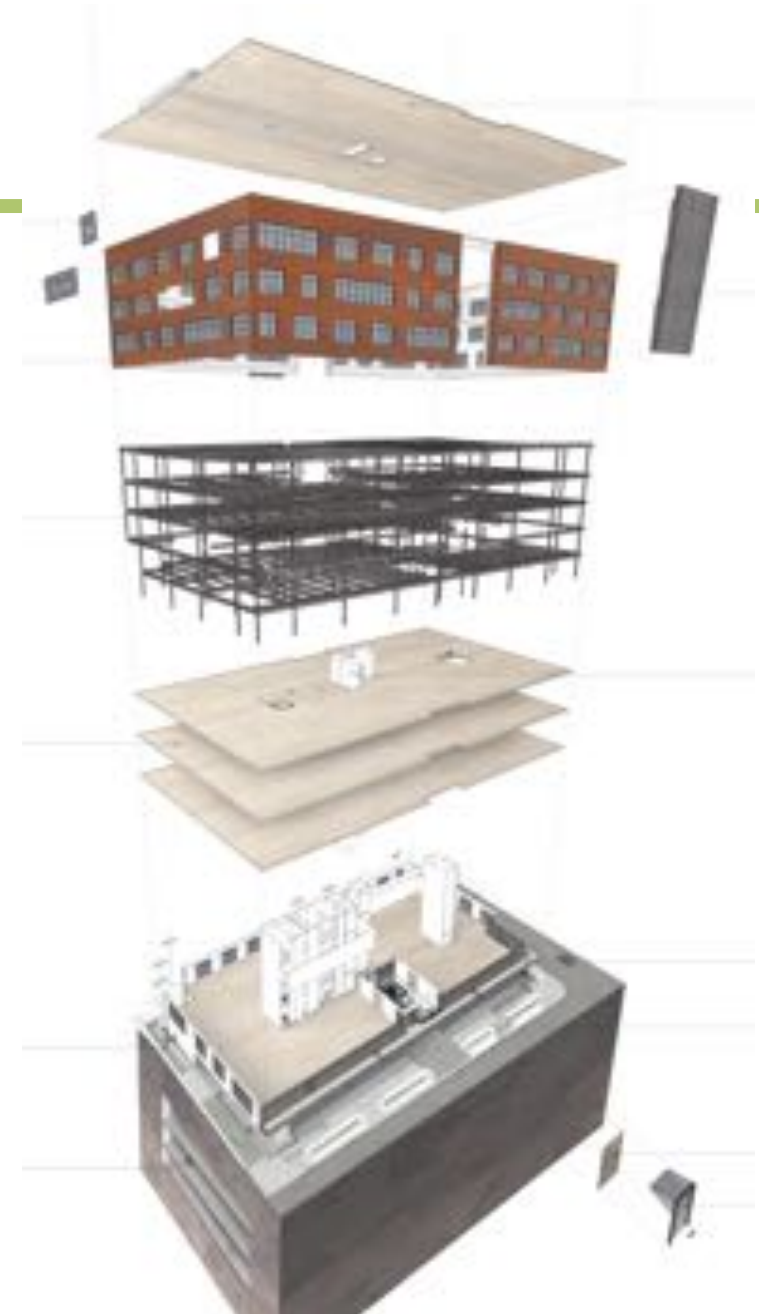
Leasing broker feedback has been that CLT helped generate interest, assisted in faster leasing, and helped support higher lease rates.



Hybrid structure

Evaluation of structural systems.

1. Relied on CLT manufacturer for design coordination.
2. The contractor and structural engineer assisted with bay size studies for all mass timber and for hybrid structural systems.
3. Shafts have a different rating than the frame, so steel braces were used for lateral support.
4. Speed of construction was considered but the main consideration became bay sizes.



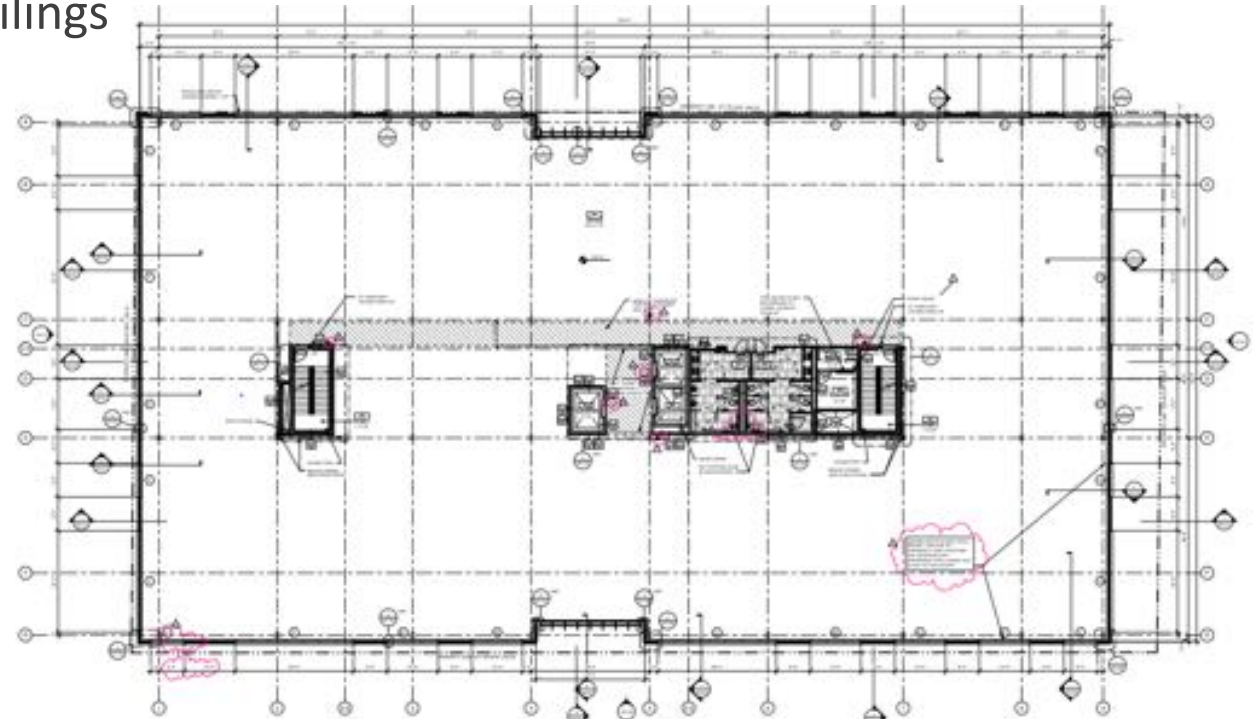
Hybrid structure

Why a hybrid structure?

Steel allowed longer spans for an open floor plan with minimal columns.

Steel can achieve shallower sections for same span.

- Lower floor-to-floor heights/higher ceilings
- More space for MEP systems



Hybrid structure

Why Introduce Steel into Timber System?

- Steel can be structurally complementary to timber and is often used in areas of highly concentrated forces – connections, braces, columns, trusses
- Steel sometimes needed for demand – long spans, transfer beams, ductility (seismic)
- Steel can be aesthetically complementary to timber in connections, braces, trusses

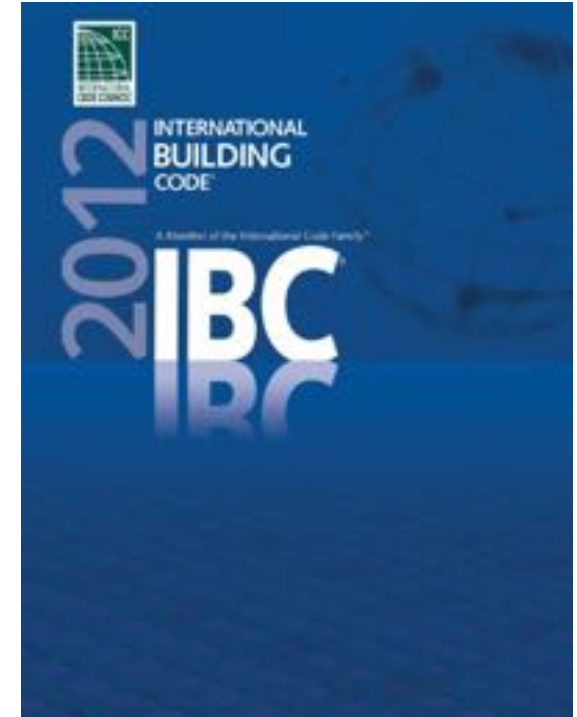


Codes and permit approval

Austin was under the 2012 IBC at time of permitting and the 2012 code had no prescriptive provisions for mass timber.

Hybrid construction precluded Type IV heavy timber construction.

We used calculated fire resistance to the 2015 National Design Specifications for Wood Construction, as allowed by IBC Section 722 for up to 1 hour ratings.



Design particulars: Codes and permit approval

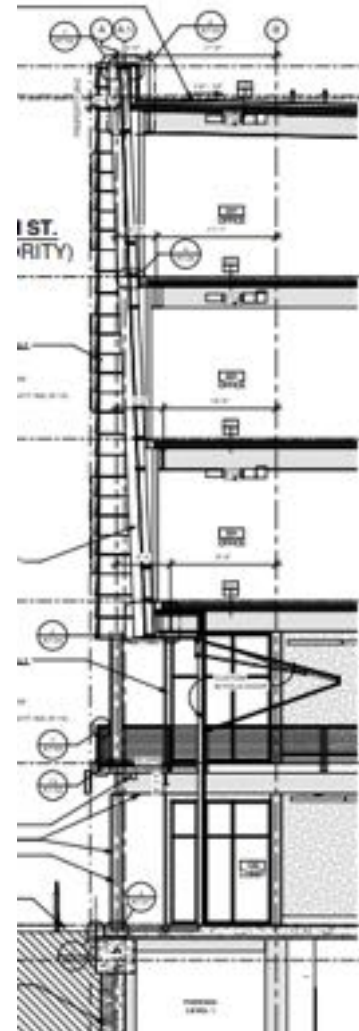
78' tall 5 story Group B building with steel required Type III-A, fully sprinklered construction.

Type III-A. Non-combustible exterior & interior elements any material. 1 hour primary structural frame, 1 hour floors.

Solution. Fire-resistive material on steel, CLT thickness for 1 hour performance.

Structural steel was rated with an intumescent coating to allow the steel to present itself in a more pure form.

1 hr structure & 2 hr shafts dictated a separate structure for shafts. With challenges getting acceptance of CLT to perform to 1 hr, did not seek to use CLT for shaft walls.



Design & permitting assistance

US CLT Handbook

Design/Build Contractor & Crosslam Timber Solutions

Woodworks

American Wood Council

Arup Fire Engineering

Structurlam



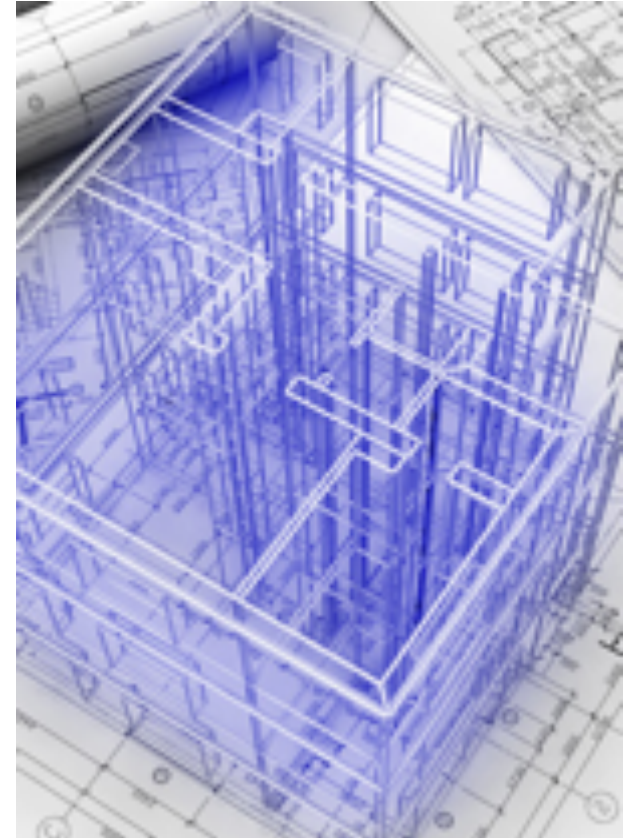
Design planning for a prefabricated element

Working with Structurlam, CLT panels were precut and custom designed for this project.

Manufacturer provided design assistance, and our structural engineer of record was responsible for both the CLT and steel frame design.

Steel can be structurally complementary to timber and is often used in areas of highly concentrated forces – connections, braces, columns.

BIM/Prefabrication: Steel industry already familiar with 3D modeling/BIM/advanced shop fabrication. Easy to marry up CLT prefabrication benefits with steel.



Design planning for CLT

Manufacturer offered a variety of factory finish options.

- 5 ply CLT floor panels used. SPF with DF exposed layer.
- Selected planed & sanded panels without a sealer.
- Panels sealed in the field.

Panels were delivered for construction sequence.

With a tight urban site & the need to sequence wood panels with steel erection, we used an off-site staging yard for CLT panels.



Design planning for CLT

CLT manufacturer interaction throughout design and construction phases.

GC hired manufacturer-recommended timber sub-contractor to install CLT.

Non-timber subcontractor interaction with the CLT panels showed that some field work could have been done in the factory for better quality control. Plumbers don't necessarily make clean cuts!

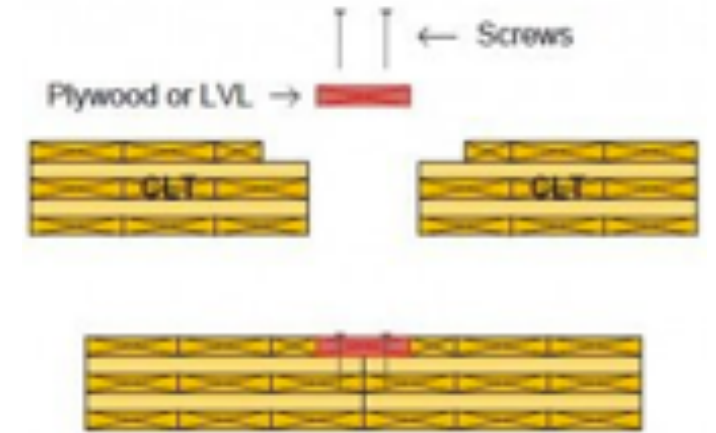


Connections

Wood to steel beams: Beams were pre-punched so that CLT could be anchored to the steel with a screw.

Wood to wood: A surface spline was used to connect wood panels. The wood panels were pre-cut to accept the spline.

Wood panels to columns: Sheet metal to close CLT cut outs at continuous columns and prevent topping slab pour from leaking through.

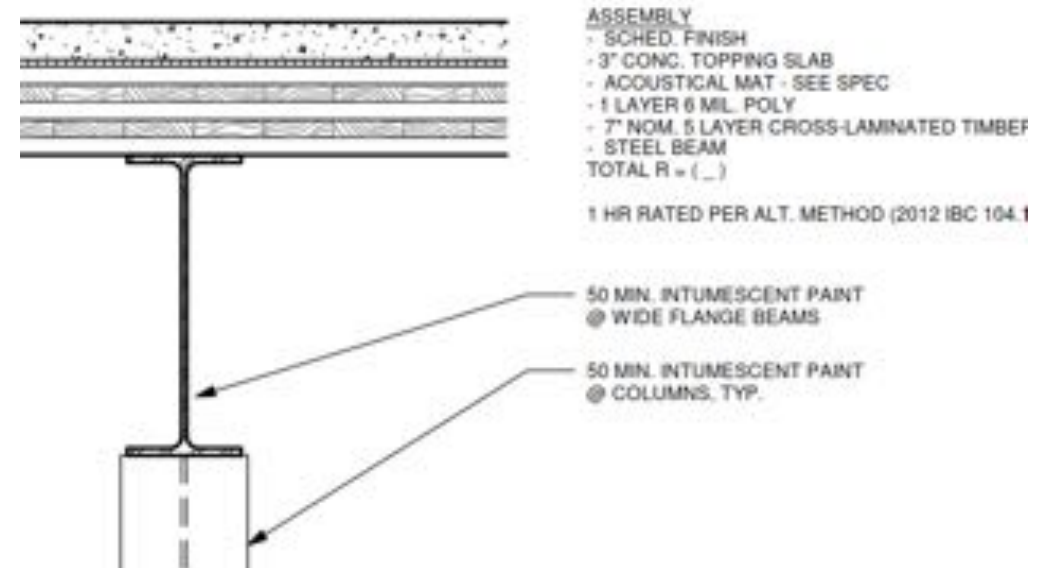


Acoustics

A tenant will not likely ask about acoustics of floor assemblies unless the building is a unique structure.

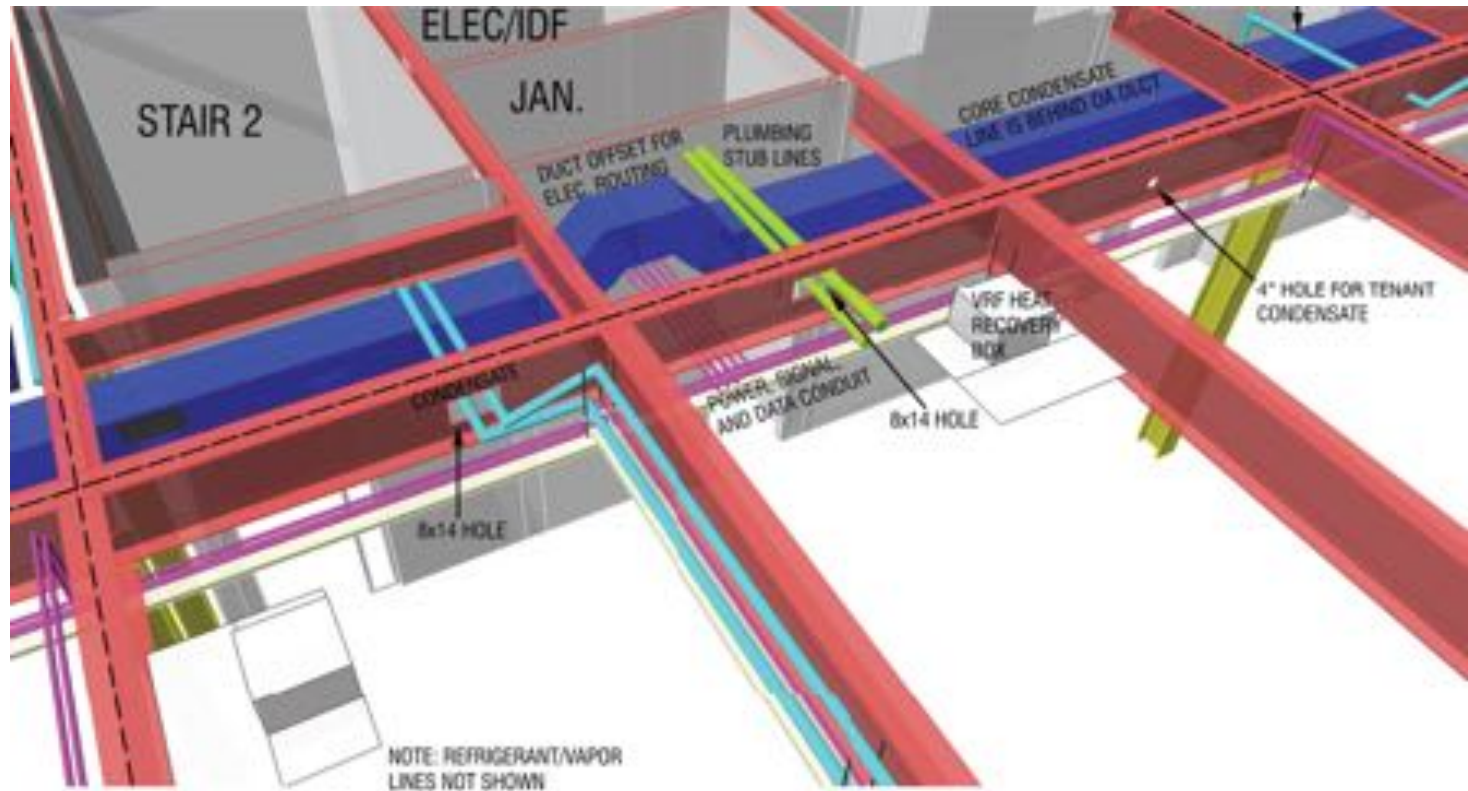
Lack of testing data for the designed floor assembly.

Acoustic engineer modeled the assembly to estimate STC & IIC ratings. Estimated rating for 3" concrete on 1/4" acoustic mat, 7" CLT- 55 STC, 45 IIC versus 52/29 with just 5" concrete slab.



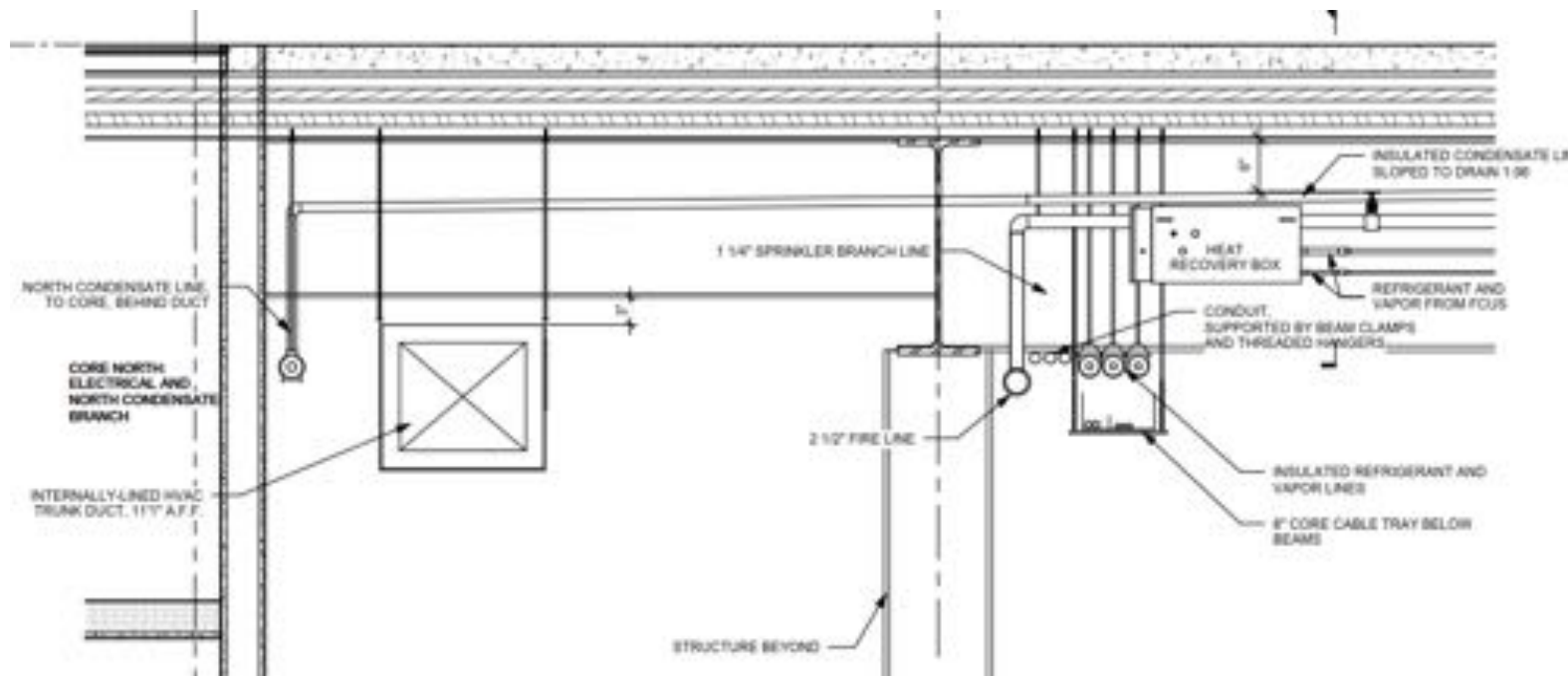
Details

Planning utility routing: Design interactions between Architect, MEP Engineer & material suppliers.



Details

Planning utility routing.



Details

Planning utility routing.



Lessons learned

BIM/Prefabrication: Steel industry already familiar with 3D modeling/BIM/advanced shop fabrication. Easy to marry up CLT prefabrication benefits with steel.

Nailer: Nailer can provide convenience for attaching timber decking elements and conduit pass-thru.

Fire Rating: If intent is to leave steel exposed, target an un-protected (zero-hour) construction type.



Lessons learned

Flexibility for tenants: It is hard to anticipate what tenants will do.

Make allowances for tenant utility routing & provide guidelines.



Lessons learned

Capitalize on wood as a natural material for occupant comfort.

The girder and joist directions were aligned such that the most wood could be seen when entering a floor from the elevator or stairs.



Lessons learned

Tolerances: Timber tolerances can be very exact. Coordination with other systems require adjustability. Recommend certain connections be shop fitted by timber supplier prior to delivery.

Bent steel plate edging overlapping the bottom of CLT panels was used where panel edges aligned with the steel frame.



Lessons learned

Moisture Effects: Wood shrink/swell with moisture change - steel does not. Provide expansion joints and detail for field adjustability. Develop a moisture management plan.

Thermal Effects: Steel expands/contracts with temperature change – wood does not. Provide expansion joints and detail for field adjustability.



Lessons learned

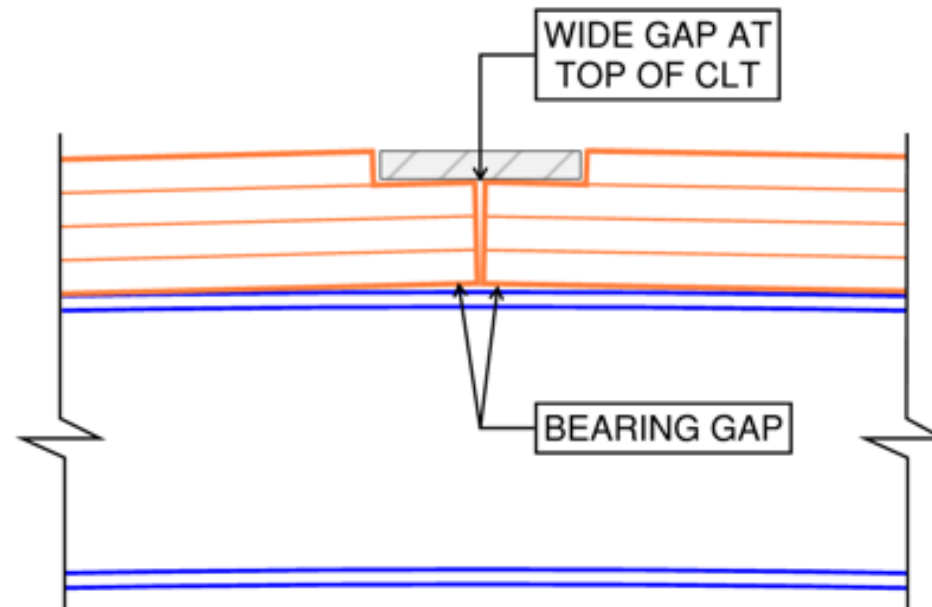
Installation & weather protection.



Lessons learned

Beam Camber: Can create fit-up and connection issues – particularly with wider panels. Can be a challenge with glulam beams as well.

Recommendations: Avoid steel camber if feasible. Recommend $\frac{3}{4}$ " maximum (steel industry minimum). Do not fully fasten spline until all DL is on beam.



Lessons learned

Roof drains.



Tieback anchors.



Conclusion

Efficiency was realized with cross-laminated timber panels in that besides structure, they were a finish material and provided fire rating.

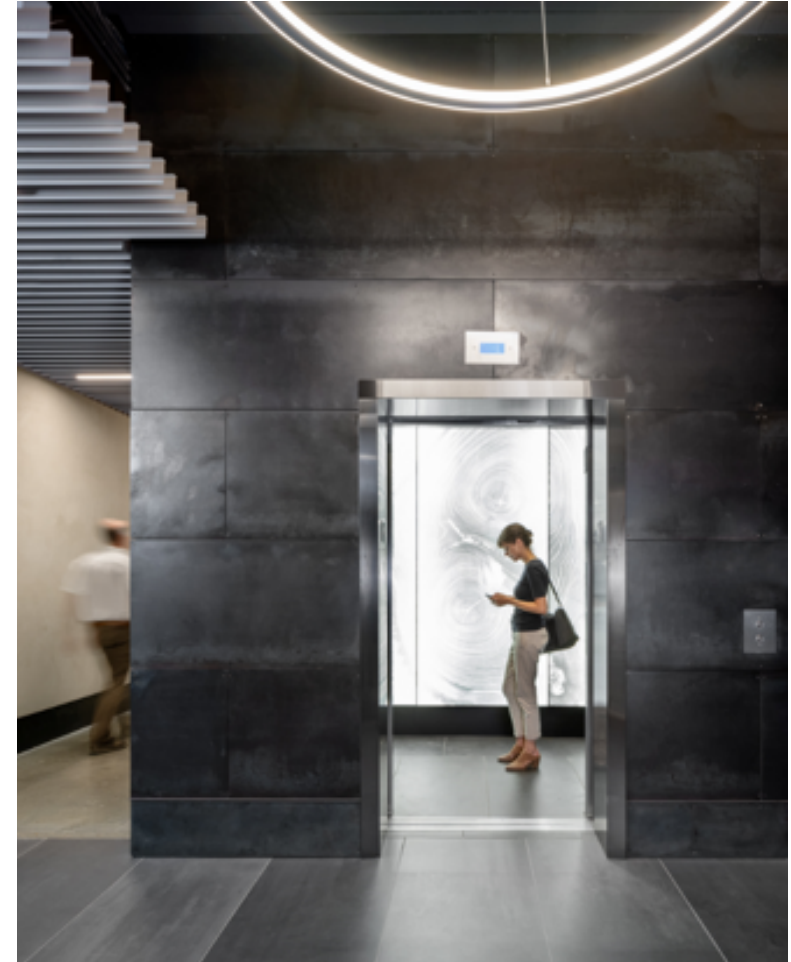
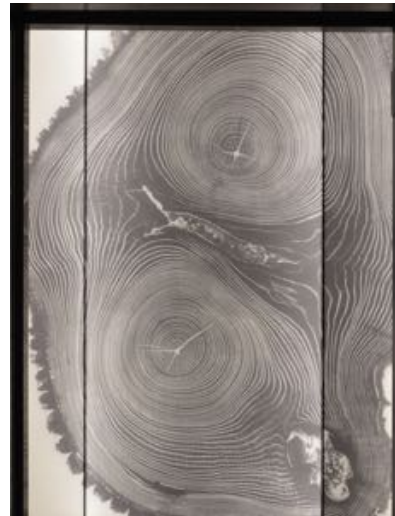
Next time would lean on more prefabrication process for greater quality and speed in construction.



Community & art

The works of art on the back wall of each elevator are three distinct relief prints created from wood cuts by Connecticut artist Bryan Nash Gill that artistically complement the foundational focus on wood in this building.

“I found that the inside of things was more beautiful and complex than what was visible from the outside... You’ll never know what you’re missing if you don’t find some way to get inside and look.”
© Bryan Nash Gill, Artist



> QUESTIONS?

This concludes The American Institute of
Architects Continuing Education Systems Course

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