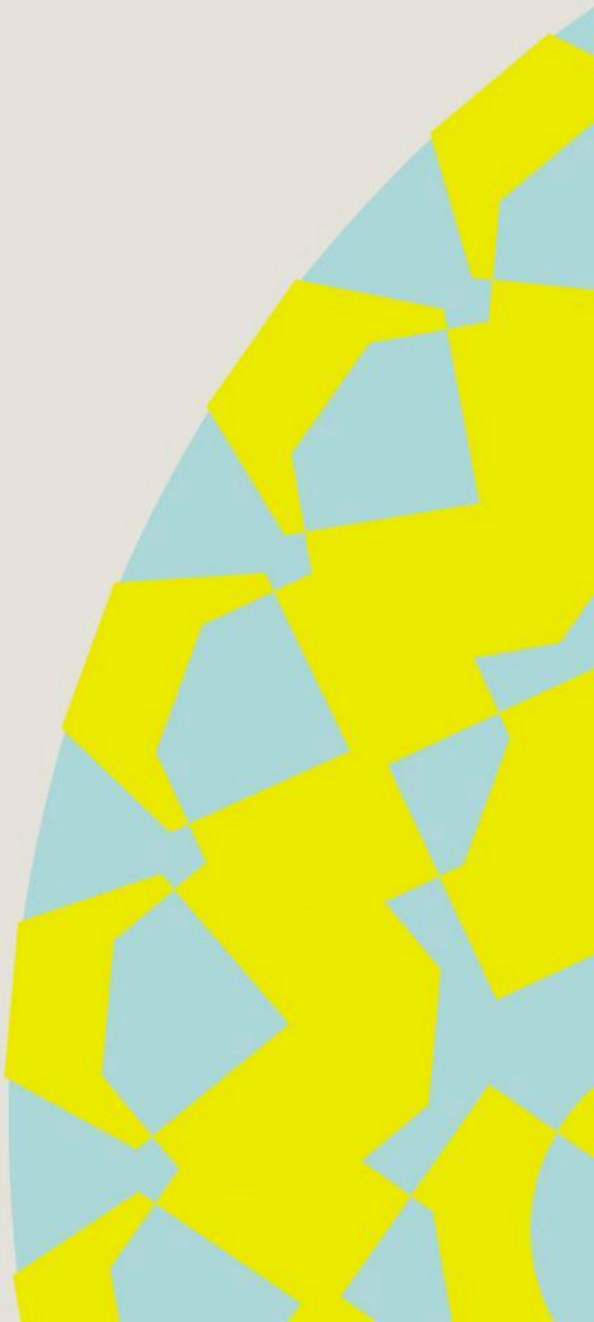
Hybrid Steel and Timber Structures in Modern Architecture

Course Number EX015

Friday, June 6, 10:30am - 11:00am

0.5 HSW/RIBA/LU



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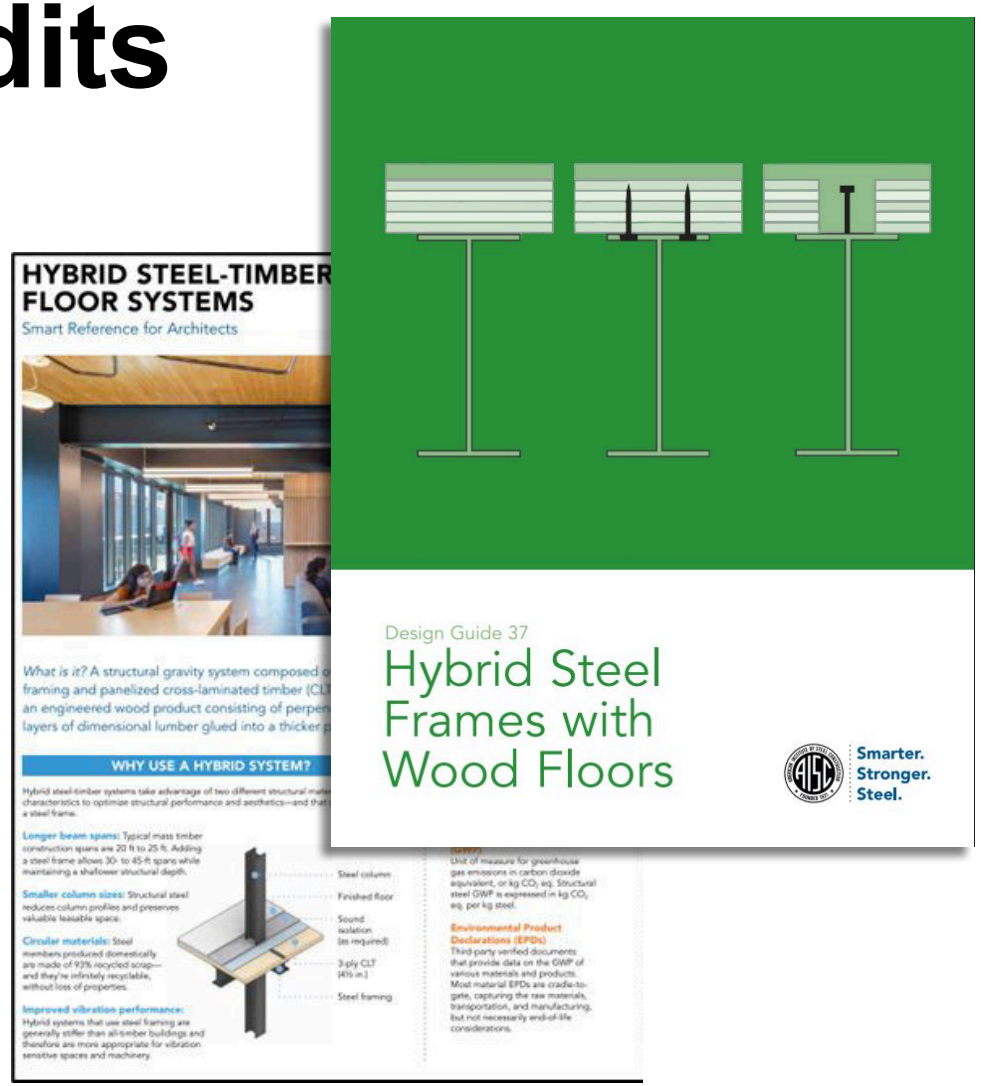

Course / Learning Objectives

- Define key components and benefits of hybrid steel and timber systems.
- Identify fire safety, and acoustic considerations unique to these systems.
- Identify strategies for integrating mechanical services into hybrid structures.
- Analyze case studies to apply hybrid solutions in real-world projects.

PHOTO BY EMMA PETER

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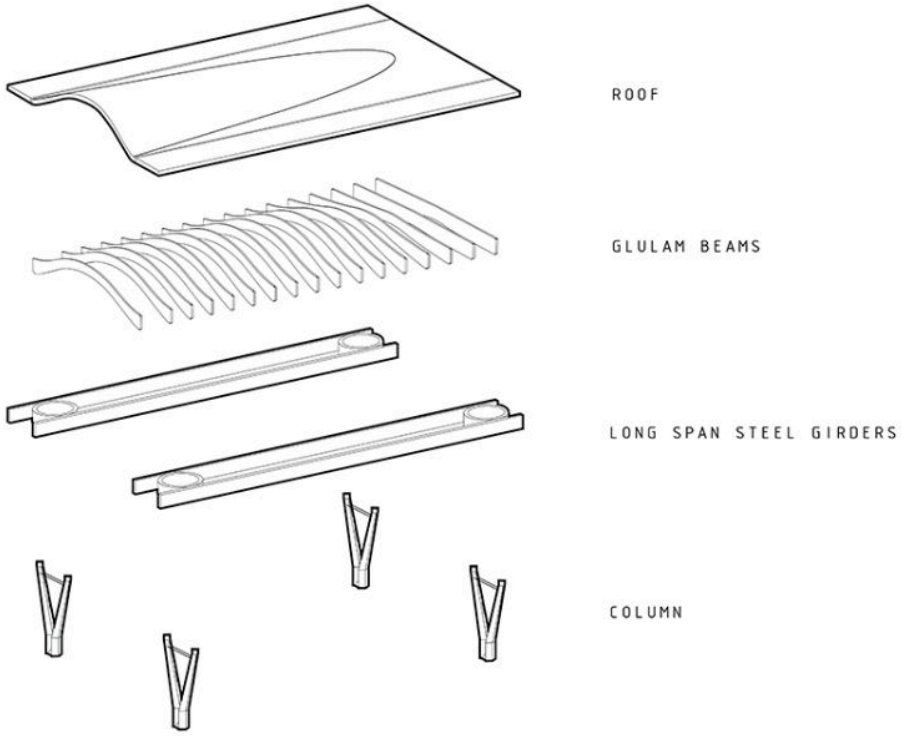
Portland Airport Grows With Expansive Mass Timber Roof Canopy

12.05.24 | By Adrian Madlener



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LIBRARIES

New mass timber Teddy Roosevelt library aims to be one with nature

By John Caulfield, Senior Editor April 24, 2024 ▪ 3 min read

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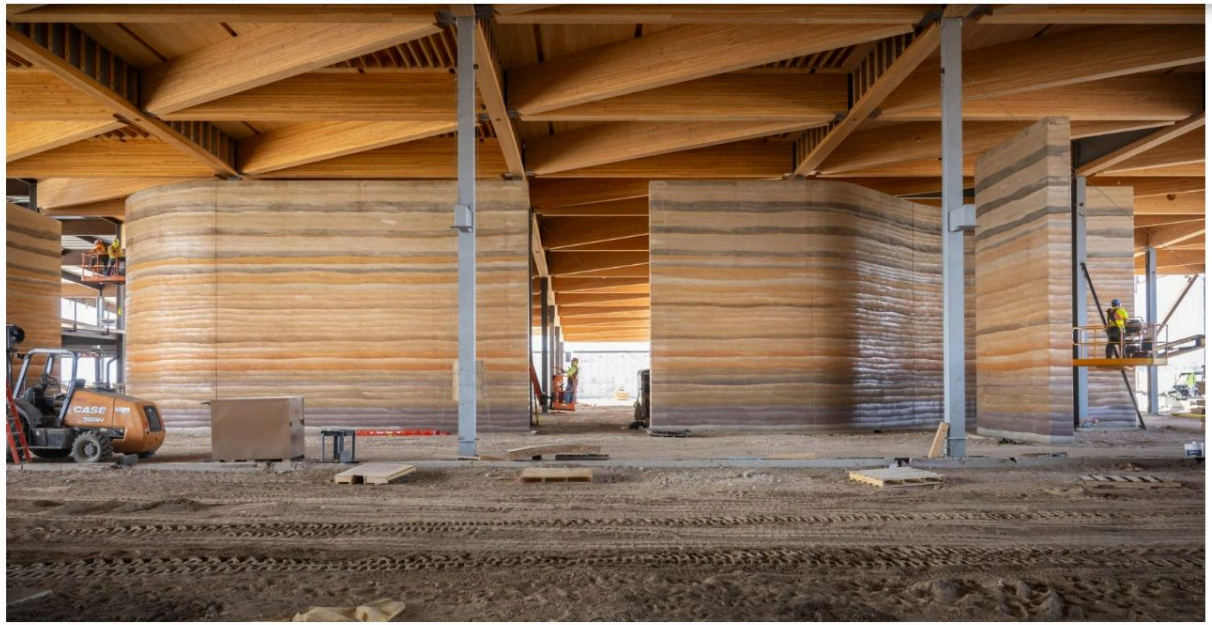
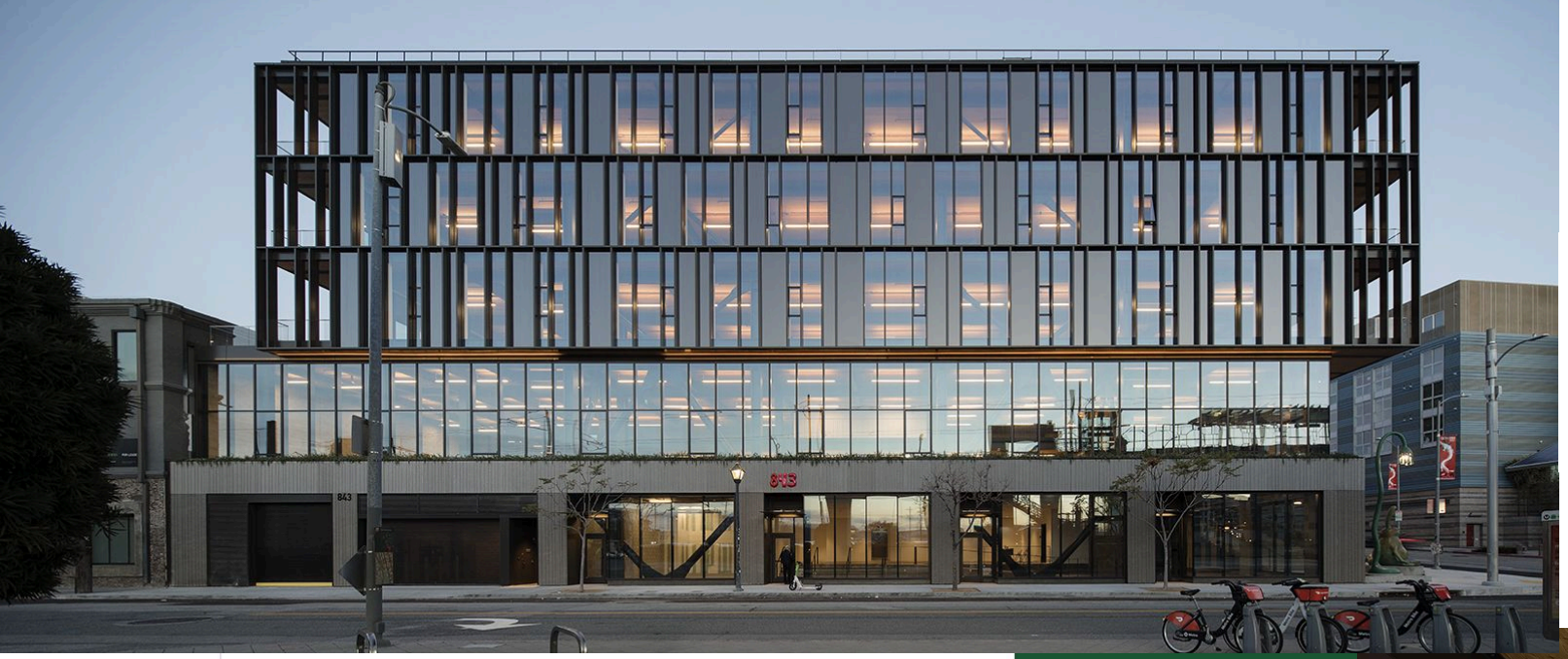


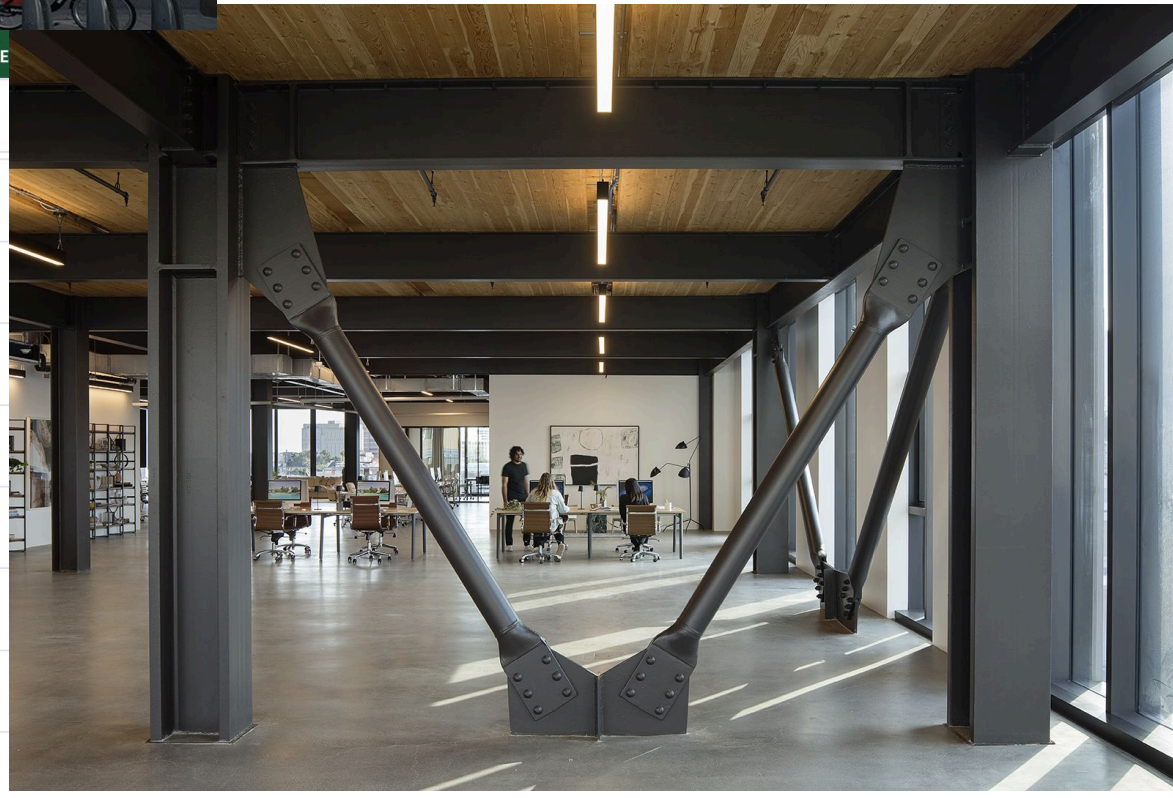
Theodore Roosevelt Presidential Library by Snøhetta rises out of North Dakota landscape



Could Los Angeles become the next big city to embrace mass timber construction?

COMMERCIAL

Verdant LA mixed-use building exposes mass timber for a natural touch



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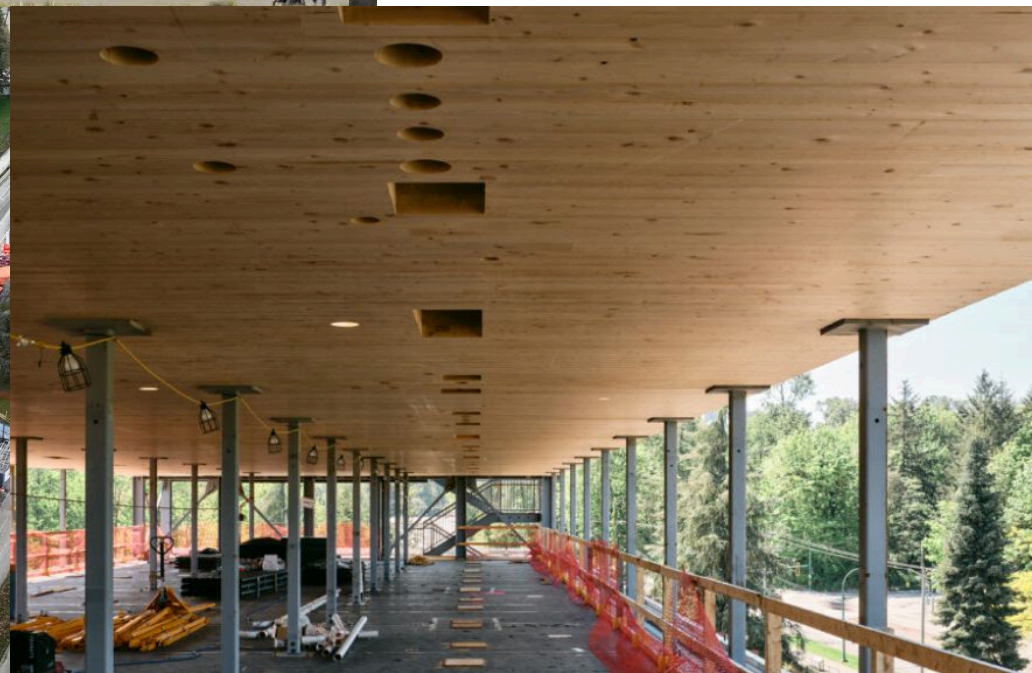
BCIT Tall Timber Student Housing

Location: Burnaby, B.C.

Architect: Perkins&Will

Completion: 2025



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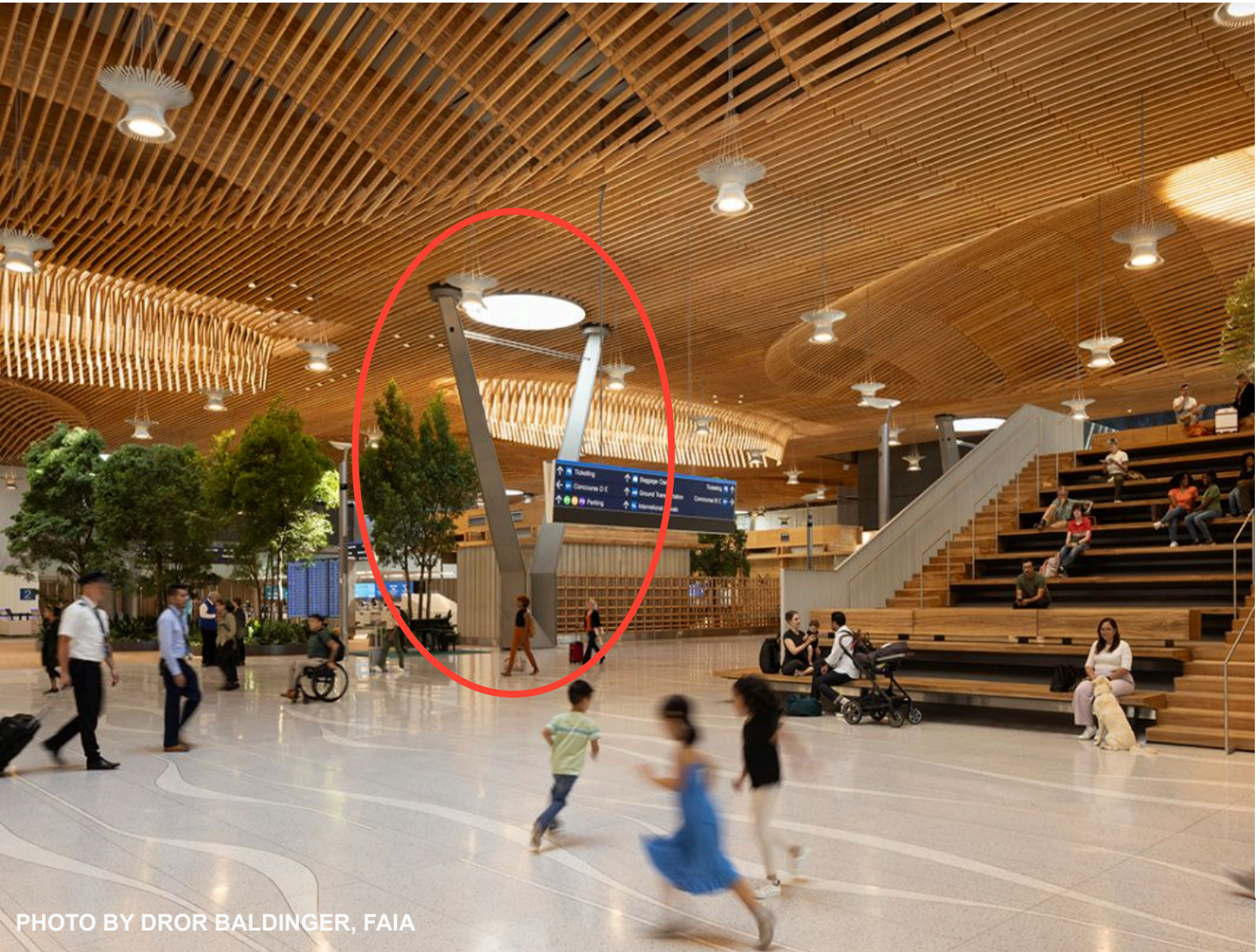
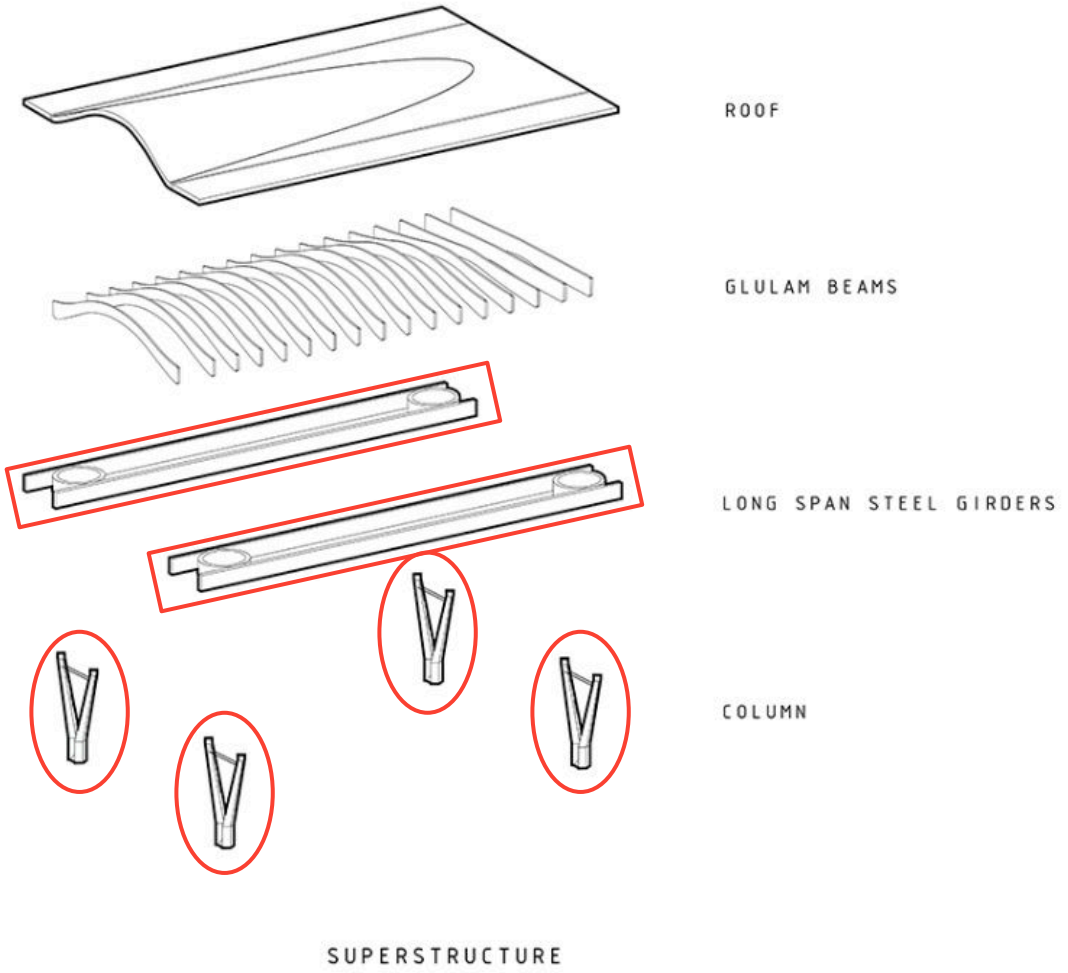


PHOTO BY DROR BALDINGER, FAIA



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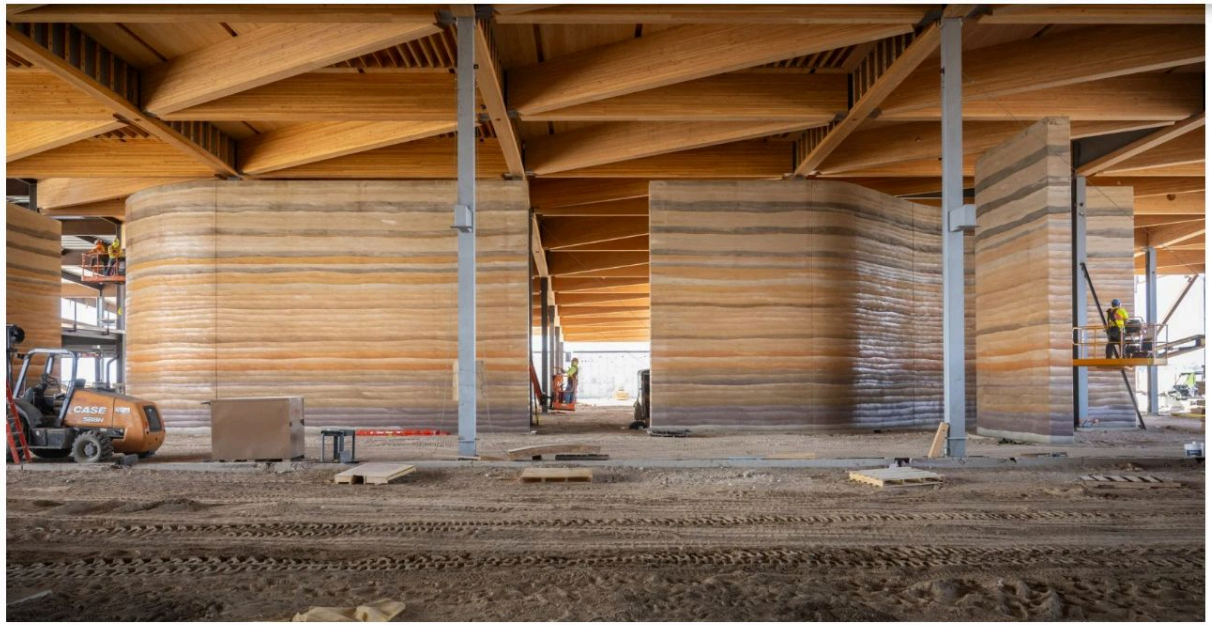

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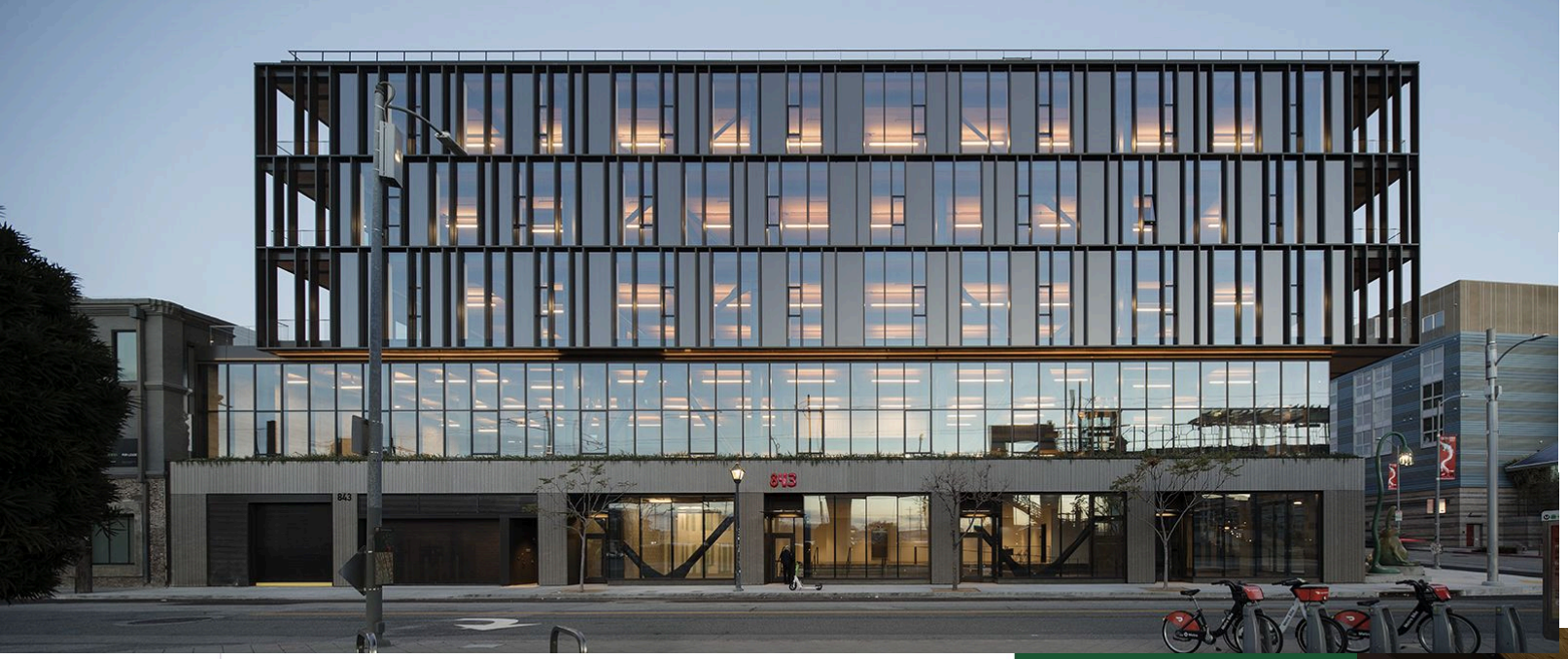

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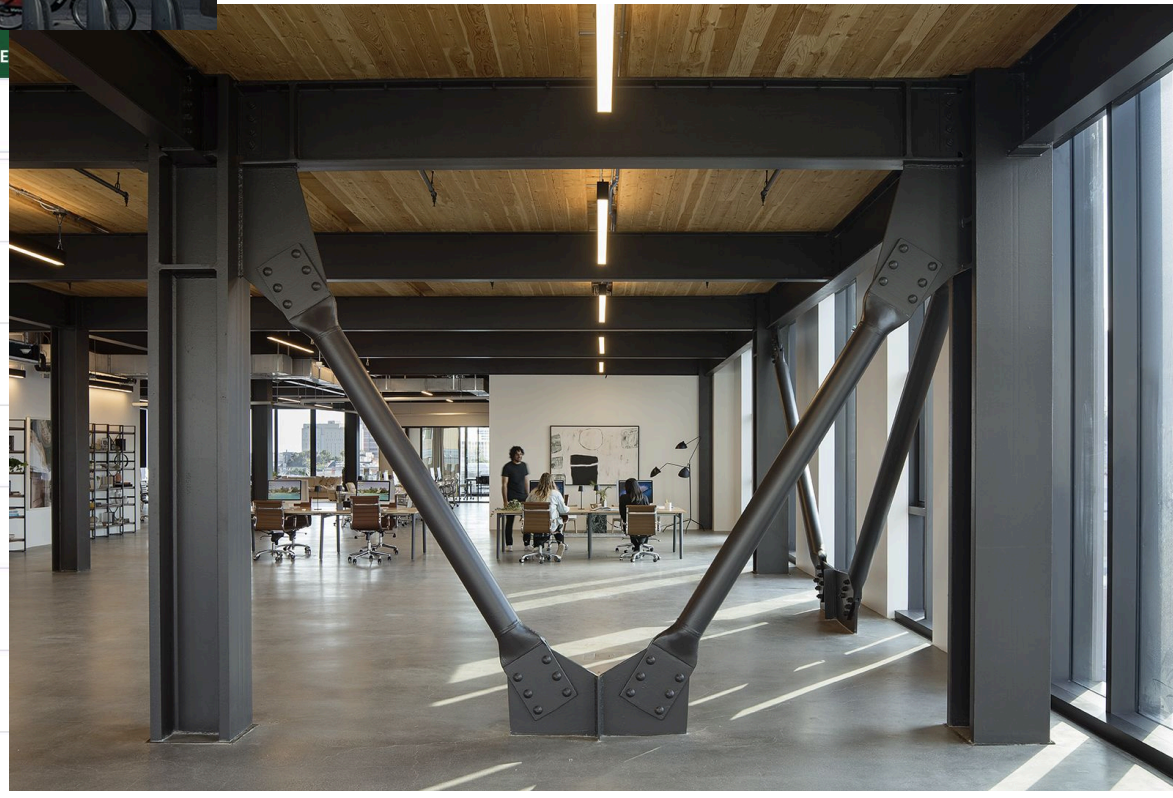

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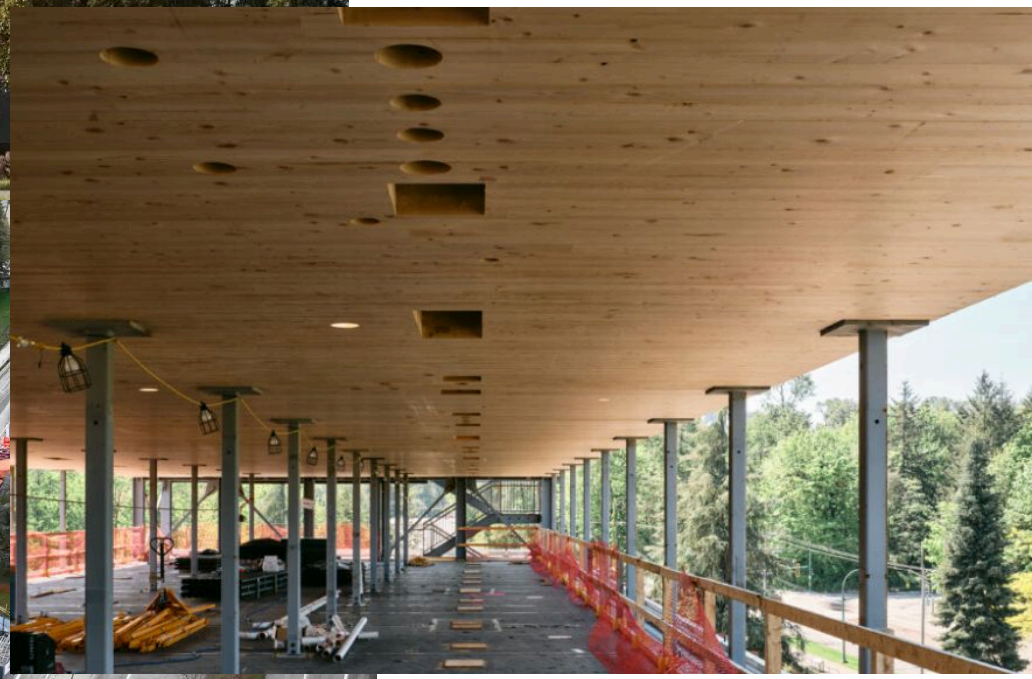
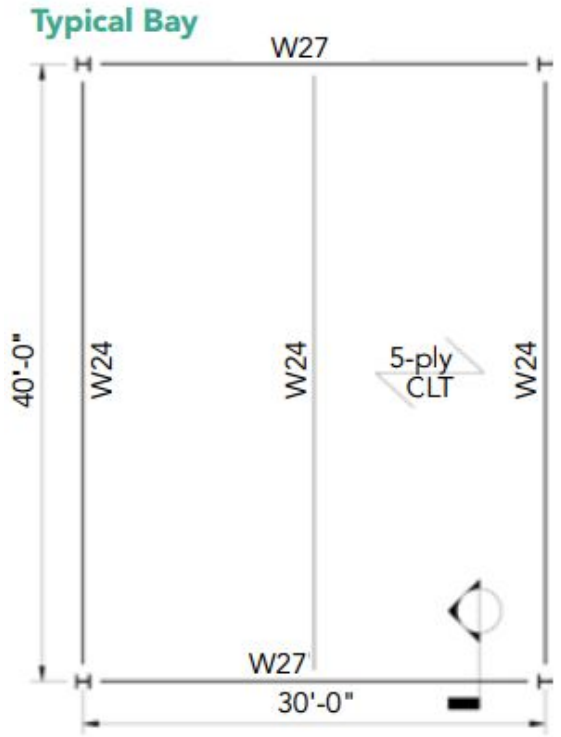
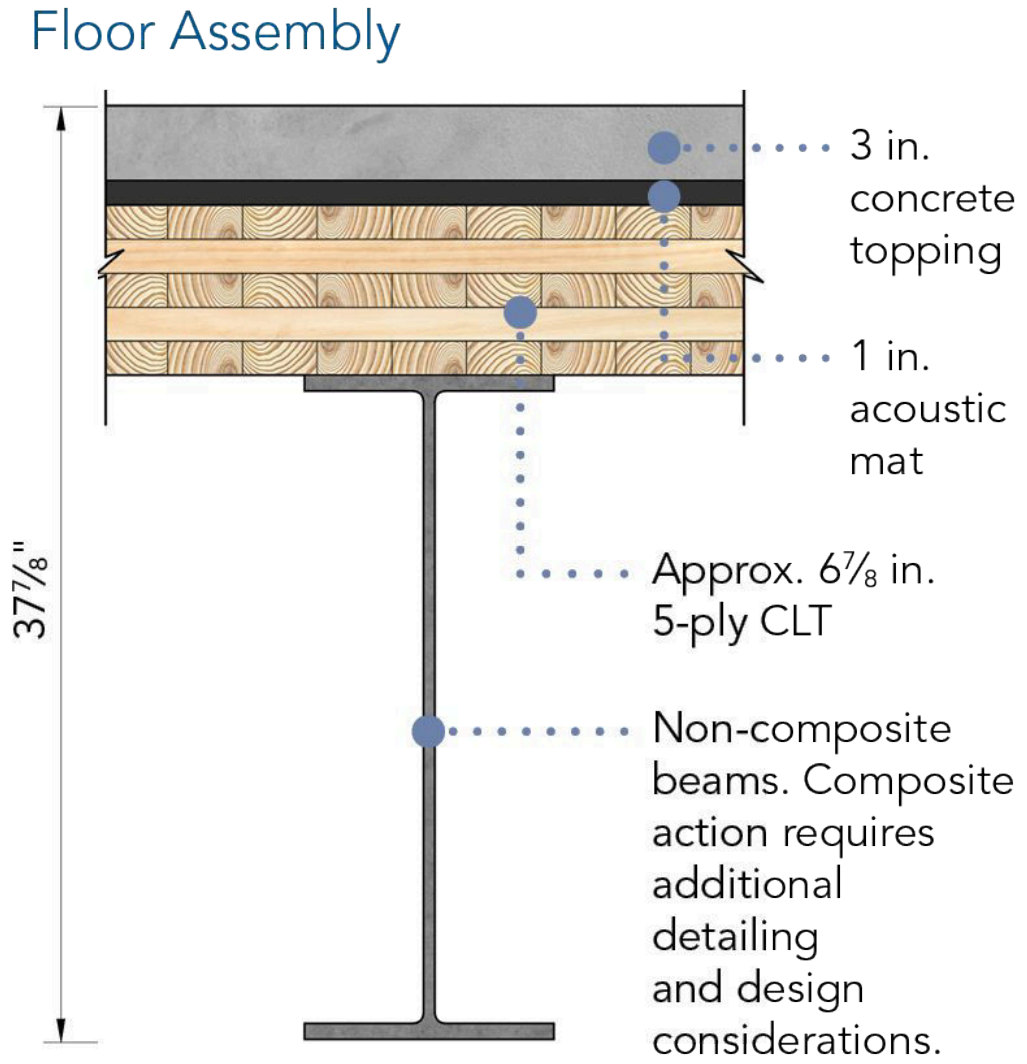


PHOTO: FAST + EPPS

What is it?

A structural gravity system composed of steel framing and panelized cross-laminated timber (CLT).





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Why use a hybrid system?

Aesthetics: showcase exposed structure

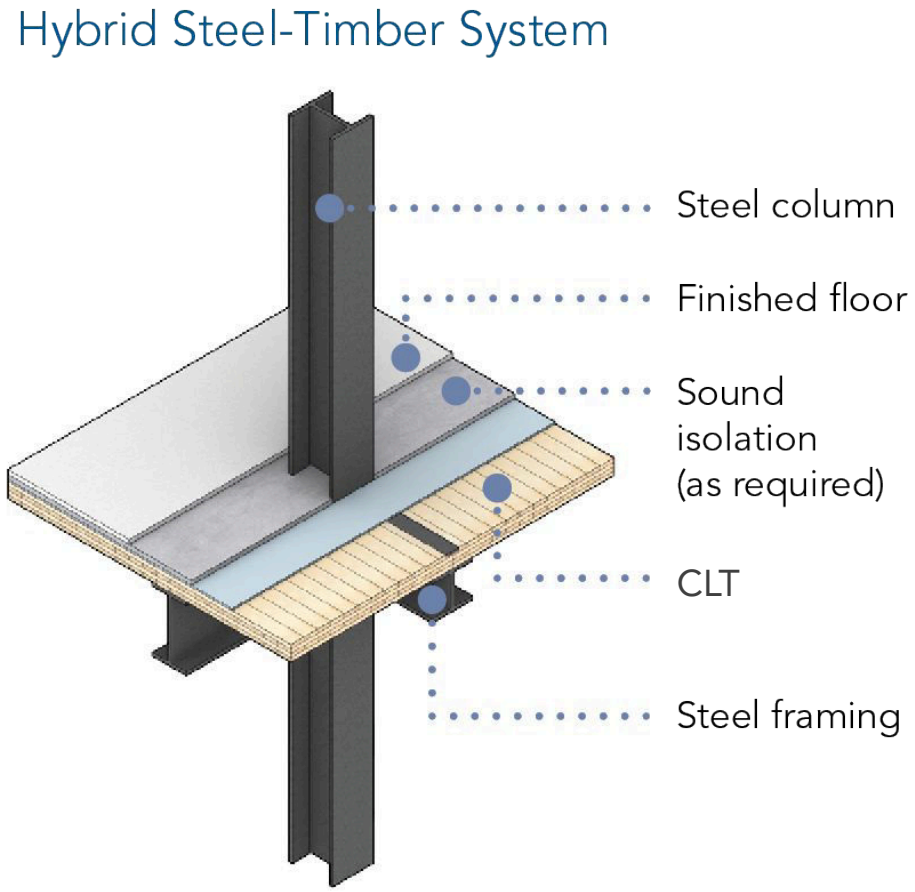
Long beam spans: 30- to 45-ft spans with shallower structural depth

Small column sizes: reduces column profiles and preserves valuable leasable space

Adaptable system: lightweight system that minimizes foundation loads and is easily modified.

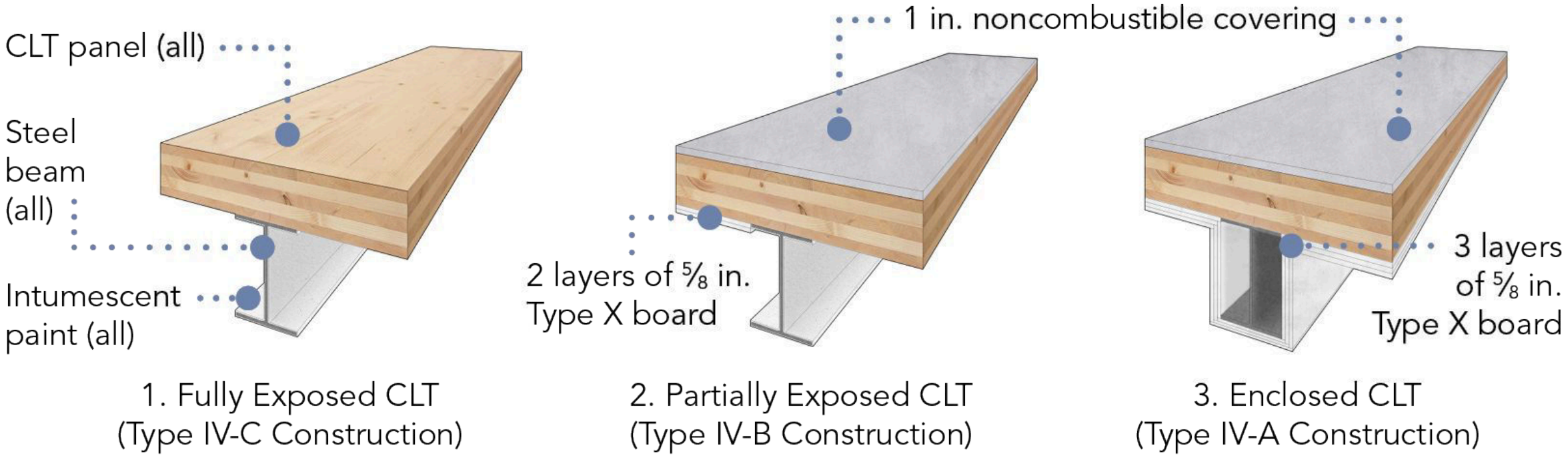
Speed of construction: off-site fabrication and easy/fast installation on-site.

Improved vibration performance: hybrid systems are generally stiffer than all-timber buildings



Fire Protection

Type IV Buildings – Timber Exposure Limits per ASCE-22



1. Fully Exposed CLT (Type IV-C Construction)

2. Partially Exposed CLT (Type IV-B Construction)

3. Enclosed CLT (Type IV-A Construction)

2024 *IBC* includes new code provisions allowing Type IV-B timber ceiling exposure up to 100%.

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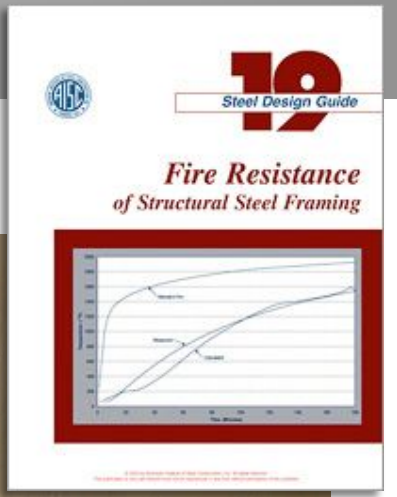
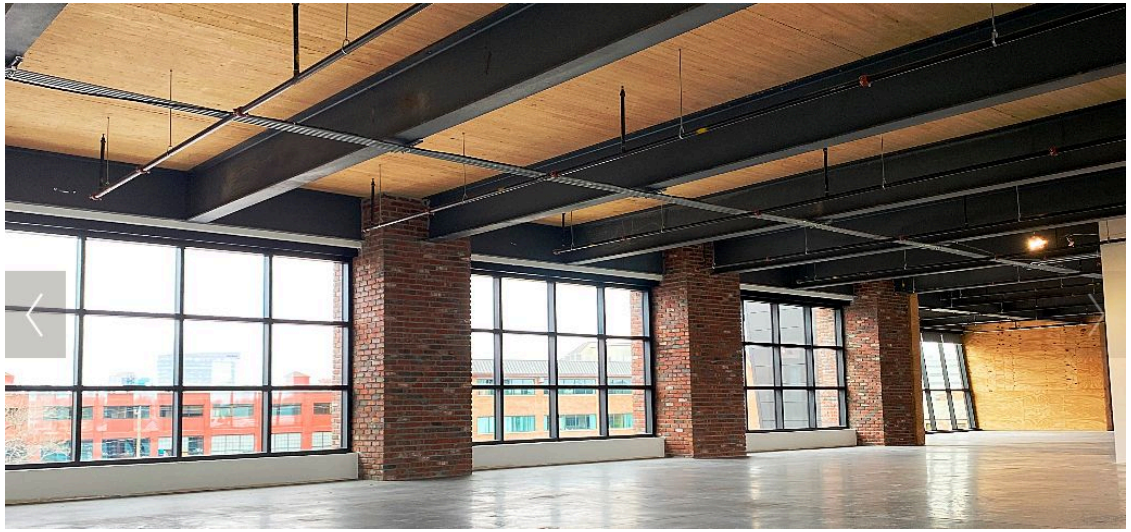
Fire Protection





Stamford Media Village (photo courtesy of DeStefano & Chamberlain, Inc.)

Intumescent paint (photo courtesy of Megan Stringer)

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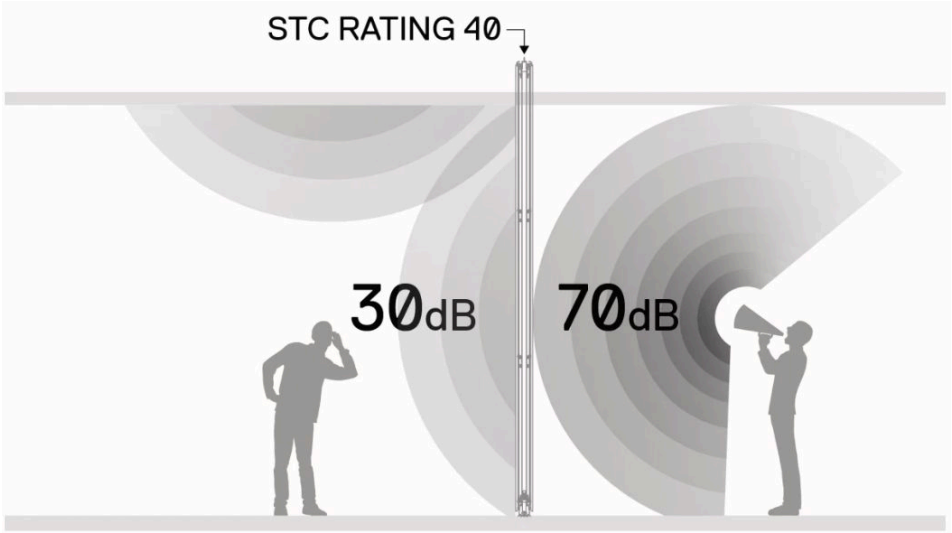
Acoustics

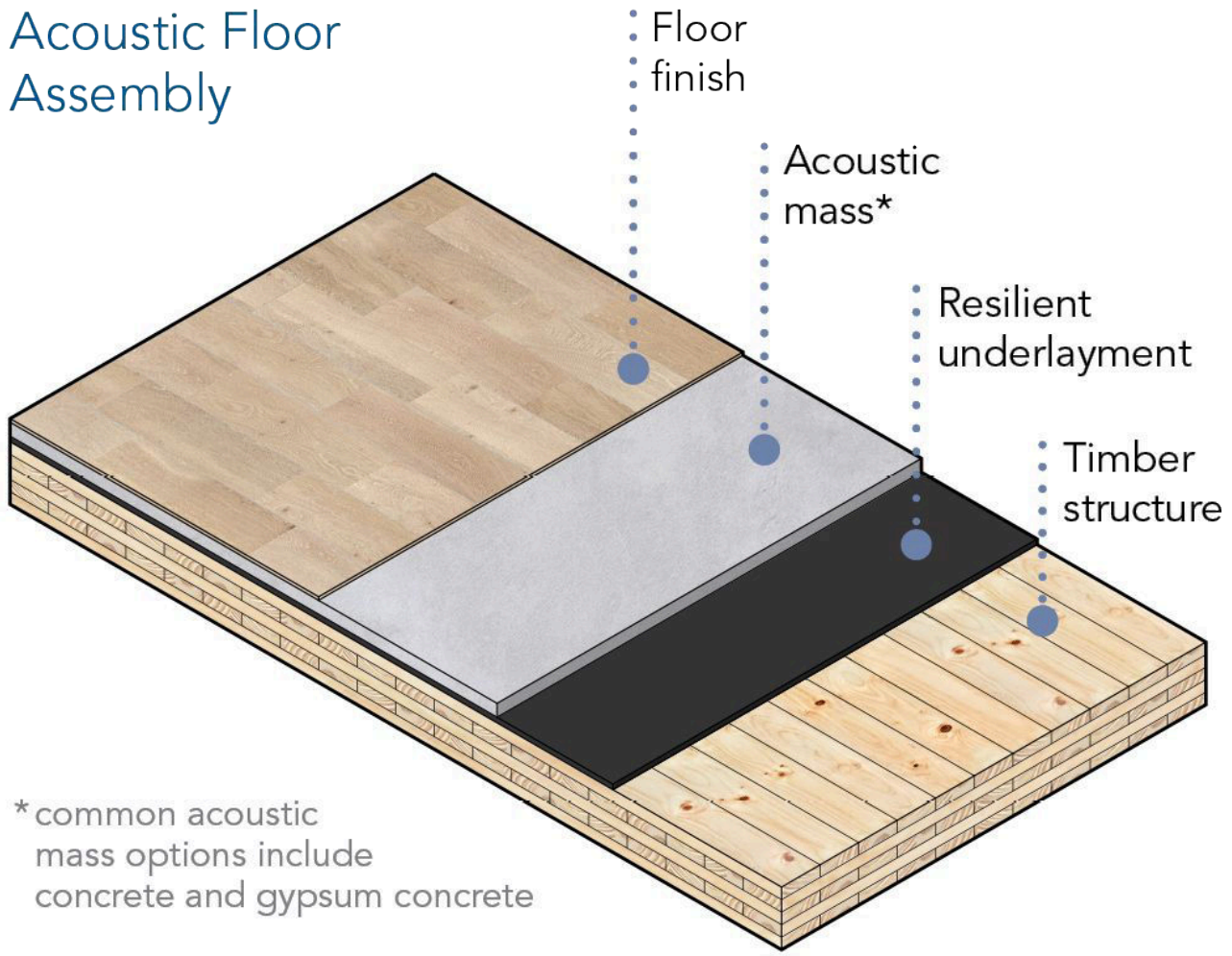


Normal Voice – 54 dB

Raised Voice – 61 dB

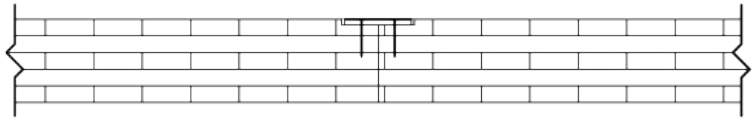
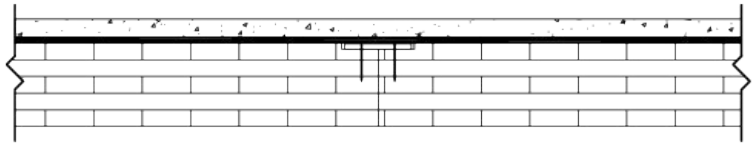
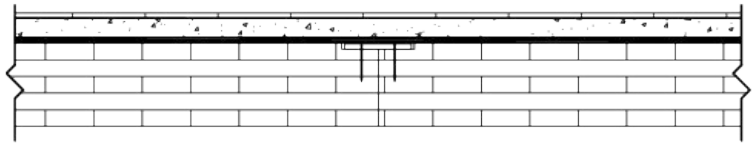
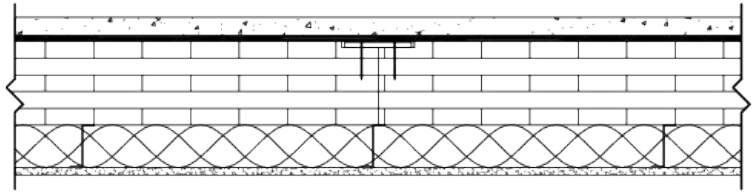
Loud Voice – 67 dB

Shouting – 75 dB



Acoustics

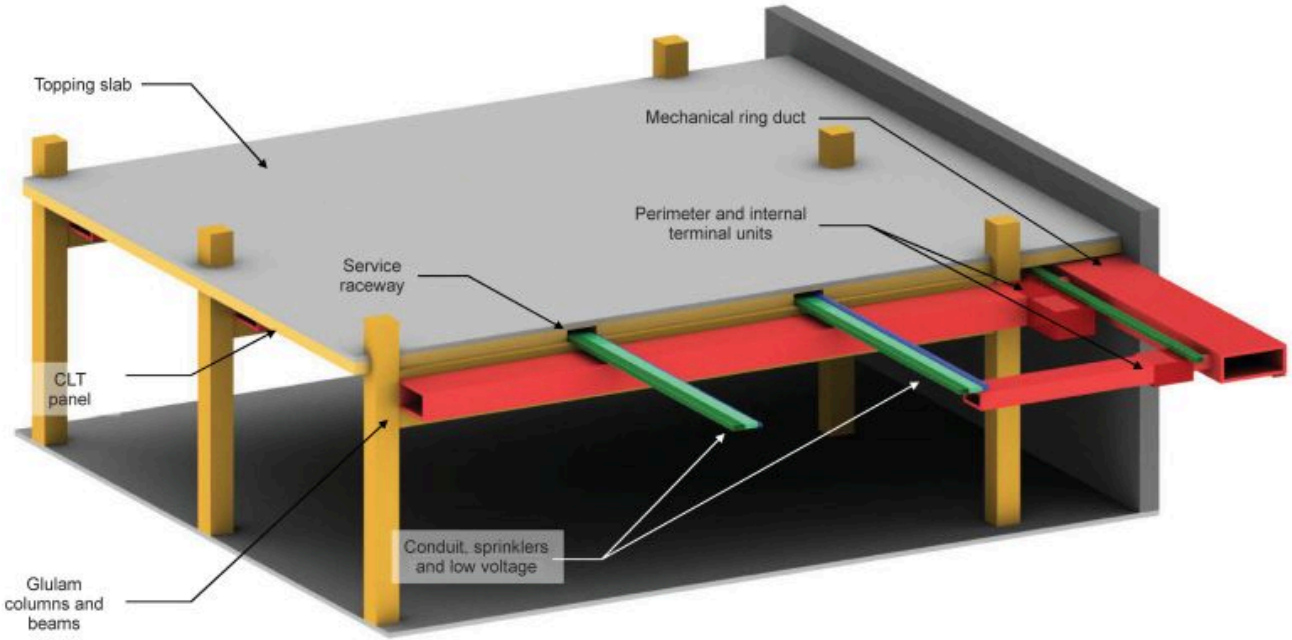
Example Floor Assemblies

		STC	IIC
	Bare CLT 5-ply	42	26
	1½ in. precast concrete, ½ in. rubber membrane	56	48
	10mm wood floor, 2mm closed cell foam, 1½ in. precast concrete, ½ in. rubber membrane	55	51
	1½ in. precast concrete, 9mm closed cell foam, CLT 5-ply, 16mm Type X gypsum board installed on Z channels	70	56

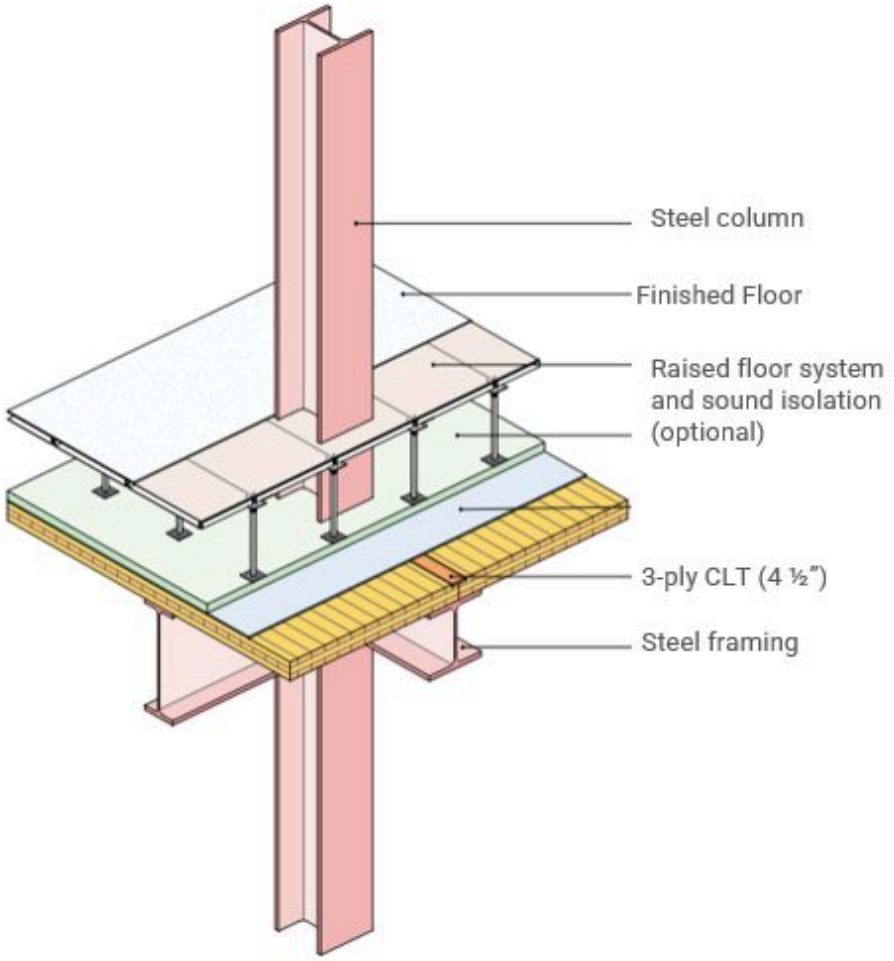
Refer to Sabourin (2015) for full floor assemblies table.

MEP

Unlike traditional full mass-timber construction, hybrid systems offer more flexibility with systems coordination.



Typical mass timber structure - services distribution



Typical raised floor assembly - hybrid steel timber structure

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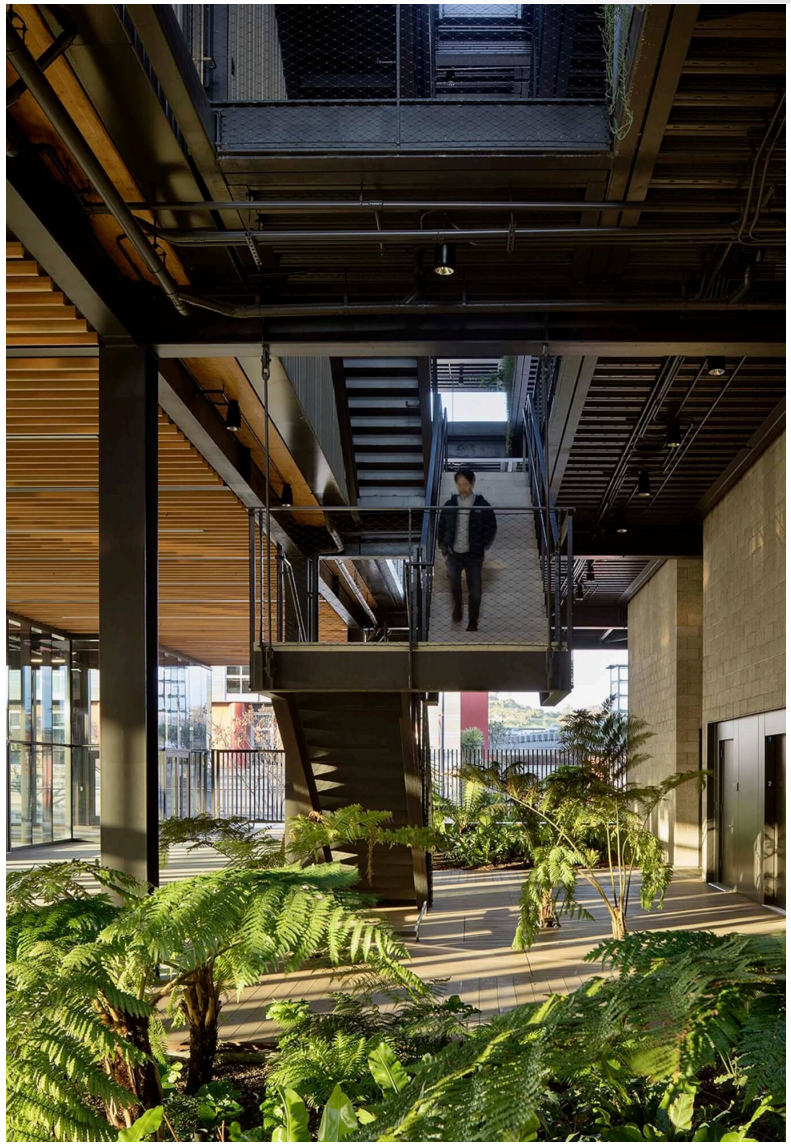
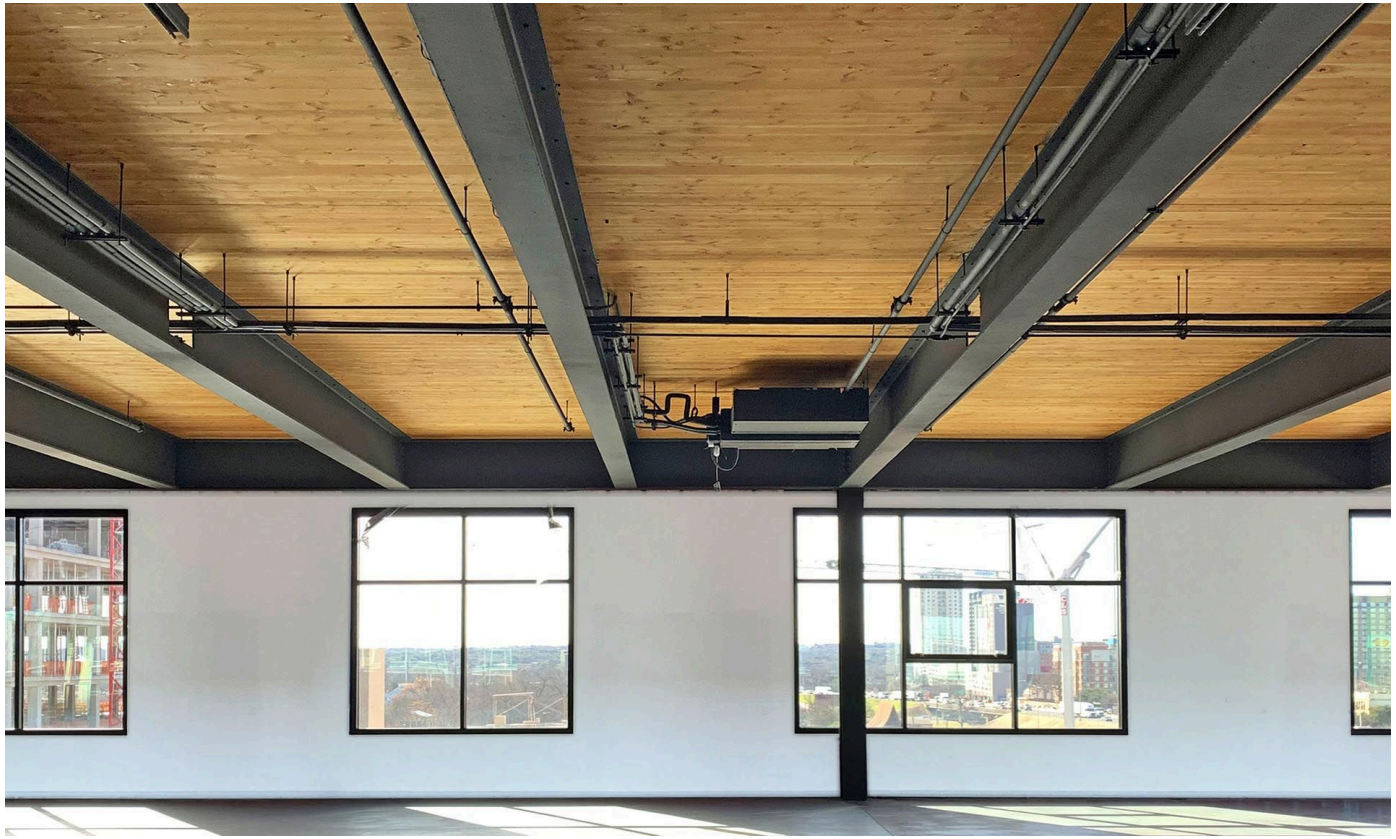
MEP



Source: the Architect's Newspaper - Jeremy Bittermann

In hybrid steel-timber construction, it is often a design aspiration to leave the underside of the timber slabs exposed.



901 E Sixth Source: Thoughtbarn & Delineate Studios, Photo by Casey Dunn

MEP

Cellular beams, Photo courtesy - Waugh Thistleton Architects

Castellated or cellular beams can ease integration of building systems while further reducing the weight of the structure.

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Case Study - RISD

The first cross-laminated timber-steel hybrid residence hall in New England.

Source: NADAA Architects

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Case Study - RISD

The team ultimately chose the hybrid CLT system due to its inherent sustainability, beauty, and speed of construction.

6 weeks vs 2.5 weeks for installation time

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Case Study - RISD

The team agreed that the hybrid solution showed best results in terms of speed of construction, cost effectiveness and sustainability.

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Houston Endowment Headquarters

Photo credits Productora

"Together, steel and mass timber achieve a highly efficient and visually appealing new headquarters."

- Arch Daily

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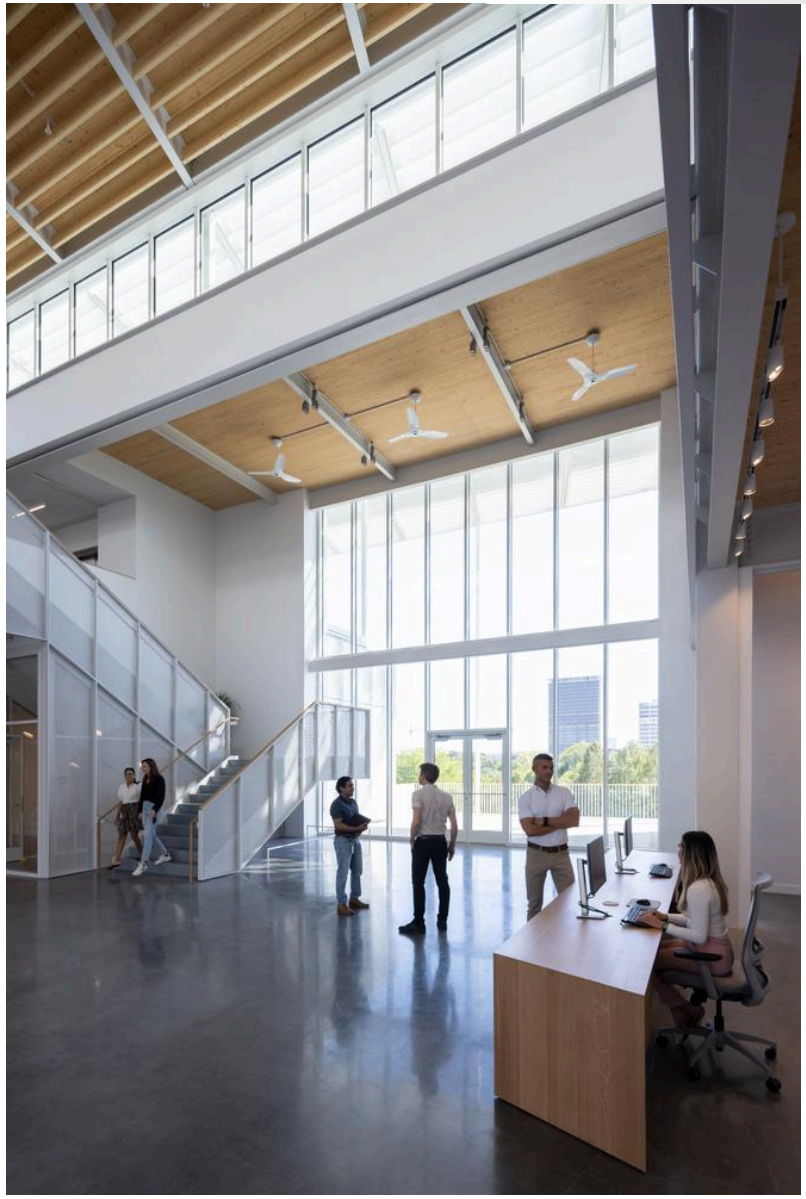
Houston Endowment Headquarters



- 40,000 sqft, 2-story office building
- Bay size - 30 ft x 30 ft
- 3 ply CLT panels spanning 10 ft

Fig. 2-11. Houston Endowment Headquarters side rendering (photo courtesy of Kevin Daly Architects with Productora, 2021).

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Houston Endowment Headquarters

The use of this system, allowed the spaces to be larger and create a collaborative environment that feels airy and bright.

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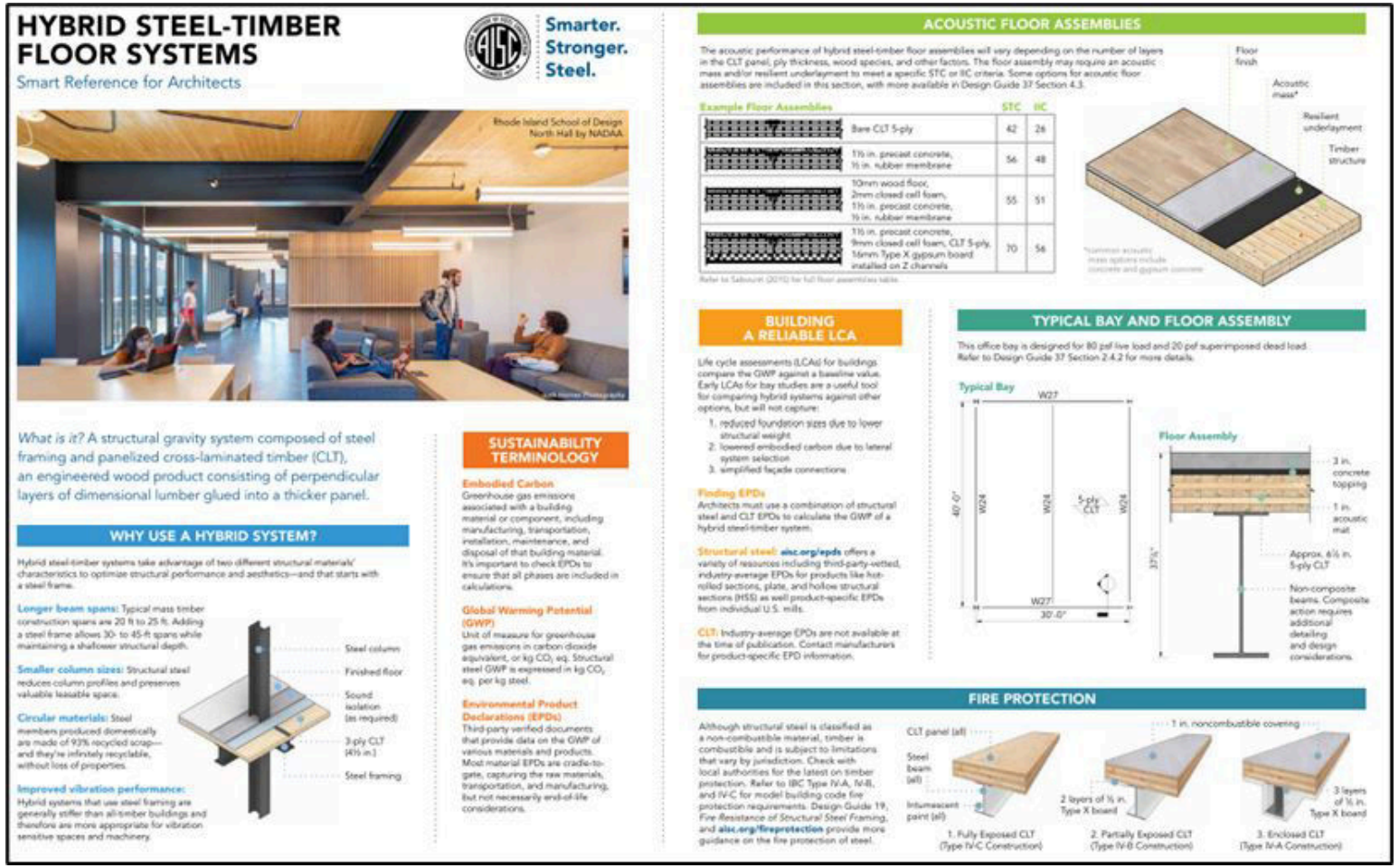
Design Guide 37 - Smart Reference



HYBRID STEEL-TIMBER FLOOR SYSTEMS

Smart Reference for Architects

Smarter. Stronger. Steel.

Rhode Island School of Design North Hall by NADAA

What is it? A structural gravity system composed of steel framing and panelized cross-laminated timber (CLT), an engineered wood product consisting of perpendicular layers of dimensional lumber glued into a thicker panel.

WHY USE A HYBRID SYSTEM?

Hybrid steel-timber systems take advantage of two different structural materials' characteristics to optimize structural performance and aesthetics—and that starts with a steel frame.

Longer beam spans: Typical mass timber construction spans are 20 ft to 25 ft. Adding a steel frame allows 30- to 45-ft spans while maintaining a shallower structural depth.

Smaller column sizes: Structural steel reduces column profiles and preserves valuable leasable space.

Circular materials: Steel members produced domestically are made of 93% recycled scrap—and they're infinitely recyclable, without loss of properties.

Improved vibration performance: Hybrid systems that use steel framing are generally stiffer than all-timber buildings and therefore are more appropriate for vibration sensitive spaces and machinery.

Steel column
Finished floor
Sound isolation (as required)
3-ply CLT (4½ in.)
Steel framing

SUSTAINABILITY TERMINOLOGY

Embodied Carbon
Greenhouse gas emissions associated with a building material or component, including manufacturing, transportation, installation, maintenance, and disposal of that building material. It's important to check EPDs to ensure that all phases are included in calculations.

Global Warming Potential (GWP)
Unit of measure for greenhouse gas emissions in carbon dioxide equivalent, or kg CO_2 eq. Structural steel GWP is expressed in kg CO_2 eq. per kg steel.

Environmental Product Declarations (EPDs)
Third-party verified documents that provide data on the GWP of various materials and products. Most material EPDs are cradle-to-gate, capturing the raw materials, transportation, and manufacturing, but not necessarily end-of-life considerations.

ACOUSTIC FLOOR ASSEMBLIES

The acoustic performance of hybrid steel-timber floor assemblies will vary depending on the number of layers in the CLT panel, ply thickness, wood species, and other factors. The floor assembly may require an acoustic mass and/or resilient underlayment to meet a specific STC or IIC criteria. Some options for acoustic floor assemblies are included in this section, with more available in Design Guide 37 Section 4.3.

Example Floor Assemblies	STC	IIC
Bare CLT 5-ply	42	26
1½ in. precast concrete, ½ in. rubber membrane	56	48
10mm wood floor, 2mm closed cell foam, 1½ in. precast concrete, ½ in. rubber membrane	55	51
1½ in. precast concrete, 9mm closed cell foam, CLT 5-ply, 16mm Type X gypsum board installed on Z channels	70	56

Refer to Sabourin (2015) for full floor assemblies table.

Floor finish
Acoustic mass*
Resilient underlayment
Timber structure
*Common acoustic mass options include concrete and gypsum concrete.

BUILDING A RELIABLE LCA

Life cycle assessments (LCAs) for buildings compare the GWP against a baseline value. Early LCAs for bay studies are a useful tool for comparing hybrid systems against other options, but will not capture:

1. reduced foundation sizes due to lower structural weight
2. lowered embodied carbon due to lateral system selection
3. simplified façade connections

Finding EPDs
Architects must use a combination of structural steel and CLT EPDs to calculate the GWP of a hybrid steel-timber system.

Structural steel: aisc.org/epds offers a variety of resources including third-party-vetted, industry-average EPDs for products like hot-rolled sections, plate, and hollow structural sections (HSS) as well product-specific EPDs from individual U.S. mills.

CLT: Industry-average EPDs are not available at the time of publication. Contact manufacturers for product-specific EPD information.

TYPICAL BAY AND FLOOR ASSEMBLY

This office bay is designed for 80 psf live load and 20 psf superimposed dead load. Refer to Design Guide 37 Section 2.4.2 for more details.

Typical Bay
W27
40'-0"
W24
W24
5-ply CLT
W24
W27
30'-0"
37½"

Floor Assembly
3 in. concrete topping
1 in. acoustic mat
Approx. 6½ in. 5-ply CLT
Non-composite beams. Composite action requires additional detailing and design considerations.

FIRE PROTECTION

Although structural steel is classified as a non-combustible material, timber is combustible and is subject to limitations that vary by jurisdiction. Check with local authorities for the latest on timber protection. Refer to IBC Type IV-A, IV-B, and IV-C for model building code fire protection requirements. Design Guide 19, *Fire Resistance of Structural Steel Framing*, and aisc.org/fireprotection provide more guidance on the fire protection of steel.

CLT panel (all)
Steel beam (all)
Intumescent paint (all)
1. Fully Exposed CLT (Type IV-C Construction)
2 layers of ½ in. Type X board
2. Partially Exposed CLT (Type IV-B Construction)
1 in. noncombustible covering
3 layers of ½ in. Type X board
3. Enclosed CLT (Type IV-A Construction)

HYBRID STEEL-TIMBER FLOOR SYSTEMS

Smart Reference for Architects

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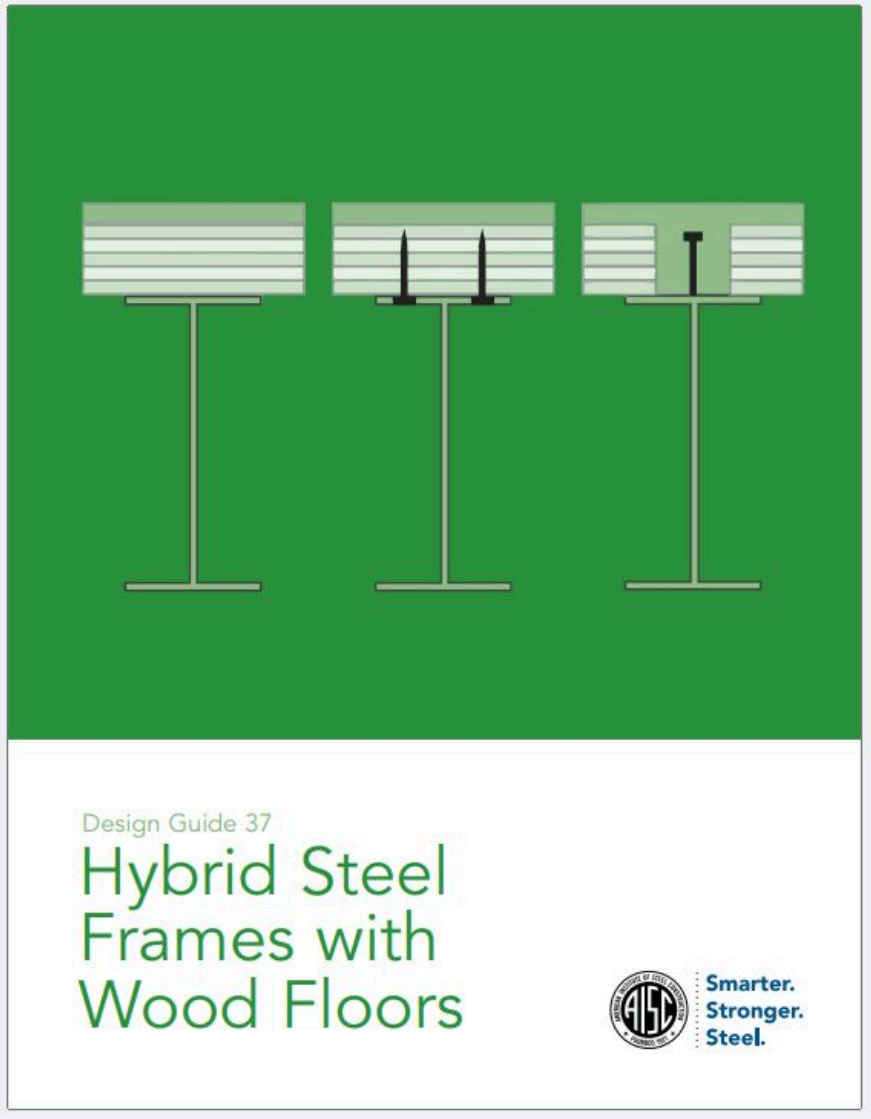
Additional Resources



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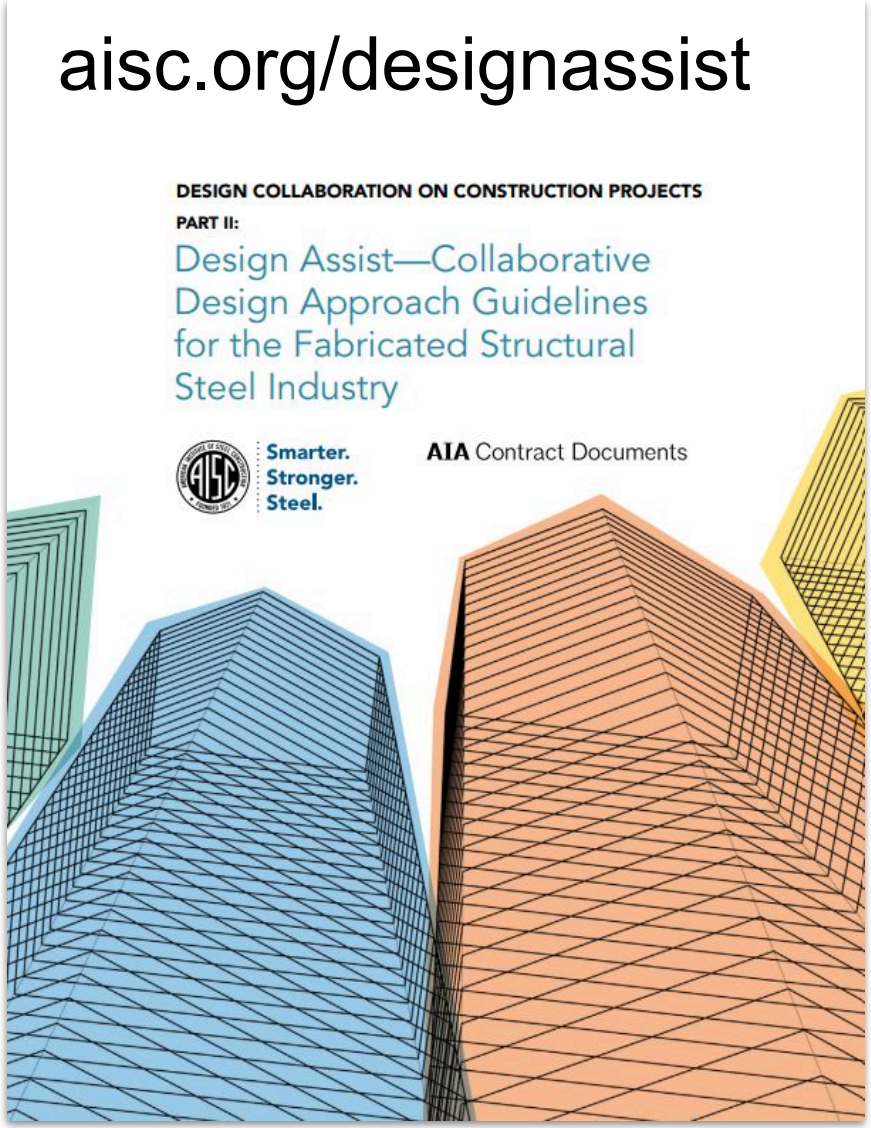


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QUESTIONS