Mass Timber

Design Manual

vol. 2

WOODWORKS
WOOD PRODUCTS COUNCIL

THINK WOOD

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My engineering career began in typical fashion. Head down, building my technical expertise, staying in my lane. I designed steel and concrete buildings which I was, and still am, immensely proud of: museums, schools, hospitals. About ten years ago, I worked on my first mass timber project. It is only with the benefit of hindsight that I understand how drastically it changed the course of my career. It drew me into a world that was trying to challenge the status quo: to find meaningful ways to address climate change, to make better use of technology in both the design and fabrication processes, to create healthier spaces by using natural materials. Armed with the awareness of how urgently change is needed and how resistant our industry is to that change, the sidelines no longer seemed like the right place to be.

Steel and concrete will always have their place, but we have much to gain by increasing the use of mass timber in our built environment. It's green. It's beautiful. It's fast. And it's safe. While there are legitimate differences of opinion about the finer details of carbon accounting and life cycle analyses, any honest sustainability debate must acknowledge that we are better off using timber, a carbon-sequestering and renewable material, than materials which rely on permanent extraction and massive amounts of energy in production. We owe much to those in the forestry industry who are committed to maintaining the health and stock of our forestlands; without sustainable forestry practices, the case for mass timber would be just another gimmick.

Structural engineers are not necessarily the world's experts on beauty, but the evidence of our innate human attraction to natural materials is easy to observe. Next time you are in a public space with an exposed timber column, stand for a few moments and count how many people touch it. You rarely see people drawn in the same way to concrete or steel (or drywall, for that matter).

To those who are more concerned with balance sheets than beauty, the highly prefabricated nature of modern mass timber can translate into significant schedule savings. Small, efficient crews work quietly and quickly, with almost no waste on the job site. One can only imagine how the comparison to steel and concrete would pencil out if we paid the true cost of embodied carbon.

And finally, to return to the structural engineer's typical domain, large-scale and tall mass timber structures can be designed for safety, including fire safety. Our understanding of the char behavior of large-scale timber elements has a long history, and more recent research has given us better insight into how we can ensure burnout occurs in buildings with exposed combustible structure.

To all those who see the value and the potential of mass timber, I hope this compilation of resources aids you in your journey.

Tanya Luthi, PE
Vice President, Entuitive
Board of Directors, WoodWorks
January 2021

We live in fast-changing and uncertain times. The effects of climate change are becoming ever more evident with the increased frequency and intensity of catastrophic weather events like California's wildfires and storms that ravage our eastern shores. The digital revolution of the 21st century led by Silicon Valley changed how we communicate, shop and relate to each other. Yet, despite the technological advancements of the past quarter century, the global pandemic has proven one thing: that we still value what is most fundamental to our lives—our common humanity, the ability to gather face-to-face, and to share our lives with friends and family.

What do all these globally significant events have to do with mass timber you may ask? Well, everything. It is the single critical building material that can help solve the building industry's continuing contribution to carbon emissions and climate change. Trees are the lone renewable source of structural material, and our forests function as the lungs of our earth sequestering carbon and producing oxygen.

The same digital revolution behind our computers and smartphones makes possible our ability to build any type of building, however complex, big or tall, using one of the oldest building materials, wood. And to do so with incredible precision, with vast potential to transform construction to be quiet, fast, affordable and clean instead of noisy, slow, expensive and full of waste.

What we build with wood can enhance how we work and live and share physical spaces in our communities. With warmth of touch, richness of texture and fresh wood scent, these buildings are naturally biophilic, enhancing well-being and increasing the quality of our lives together.[1]

How do we as architects, engineers, contractors and developers take advantage of mass timber as we build our cities and towns? That's easy, provided there is willingness to challenge the status quo, to learn and research, and to aspire to a better future. And that's where resources like this Mass Timber Design Manual come in. It represents years of research and collaboration among the WoodWorks staff and its industry collaborators. It is the blueprint to understanding the basics of mass timber—from product research, engineering and design, system assemblies, code implications, construction, and life cycle evaluation.

Conceived as a living document to be continuously updated as the world of mass timber grows and matures, this manual can serve us well into the future. Is it the secret to becoming an expert and knowing how to design and build with these products? No, that secret is in each of us as we apply the knowledge within these pages to real projects that require aspiration, dedication and teamwork. Like everyone else, that was my experience when I set foot on this path nearly a decade ago. The reward for imagining, tackling the challenges, and pushing past obstacles has been exponential. Seeing light bulbs go on for the students of architecture and building construction technology working on the Olver Design Building, while seeing the same architecture give a sense of wonder to visitors as they experience the space is more than I could have imagined.

Like a tree nurtured by streams of water, with the spirit of collaboration and sharing of knowledge in resources like this manual, the world of mass timber will grow strong, with deep roots that will steady us during trials and produce fruits of our labor. This will benefit our environment by keeping our forests healthy and removing carbon from our atmosphere, benefit our economy by adding value to our rural regions and shape sustainable cities and towns where we can gather, celebrate and help each other, like a healthy forest.

Tom S. Chung FAIA, LEED BD+C
Principal, Leers Weinzapfel Associates
Board of Directors, WoodWorks
January 2021

How to use this manual:

This manual is helpful for experts and novices alike. Whether you're new to mass timber or an early adopter you'll benefit from its comprehensive summary of the most up to date resources on topics from mass timber products and applications to tall wood construction and sustainability.

The manual's content includes WoodWorks technical papers, Think Wood continuing education articles, case studies, expert Q&As, technical guides and other helpful tools. Click through to view each individual resource or download the master resource folder for all files in one handy location. For your convenience, this book will be updated regularly as mass timber product development and the market are quickly evolving.

Looking for support?

For support on a project, contact help@woodworks.org or join WIN www.woodworksinnovationnetwork.org. Visit www.thinkwood.com for more information.

Introduction

More and more, design and construction professionals are turning to mass timber to build everything from multifamily projects and commercial offices to signature public buildings and tall wood towers. Mass timber inspires innovation.

Growing in popularity, this new category of wood products can transform how America builds. Mass timber products consist of multiple solid wood panels, columns, and beams that are glued or fastened together, providing exceptional strength and stability. Conveying warmth and sophistication, these products can be used both as load-bearing structures and as interior finish materials.

Nimble and lightweight, prefabricated mass timber building systems can be assembled by fewer workers, even on tight, difficult-to-reach construction sites. Often modular, these building systems can be easily assembled like a kit of parts. Precisely manufactured assemblies, such as prefabricated mass timber panels, also provide thermal benefits and can help make building envelopes more energy-efficient and airtight. This makes mass timber buildings well-suited to energy-efficient construction and the rigorous standards of Passive House and net-zero-ready design.

Mass timber is a strong, low-carbon alternative to concrete and steel. When considered over the product's lifetime—from the harvest of raw materials through manufacturing, transportation, construction, and disposal or recycling—mass timber also has less embodied energy, produces less air and water pollution, and has a smaller environmental footprint than other structural materials.

For all these reasons, mass timber construction is on the rise. WoodWorks reports that since 2013, more than 1,300 multifamily, commercial, and institutional projects using mass timber or heavy timber have been constructed or are in the process of design in the U.S.[2] Mass timber is quickly becoming a movement and, as a building system, it is a must-know for architects, engineering and construction professionals.

Mass Timber Products

Mass timber is a category of wood product that can revolutionize how America builds, propelled in part by the International Code Council (ICC) move to include taller mass timber buildings as part of the 2021 International Building Code (IBC). Made by fastening or bonding smaller wood components with nails, dowels or adhesives, mass timber products are making a new generation of high-performance buildings possible.

Safe, Proven Performance

Mass timber construction meets the same performance demands as other structural materials, as set out in the International Building Code (IBC). In the event of a fire, mass timber products char on the outside, forming a protective layer while retaining strength. Mass timber hybrid structures meet, and in some cases exceed, the seismic performance of comparable steel and concrete buildings. Mass timber buildings can achieve sufficient stiffness, strength, and ductility to resist strong winds and earthquakes.

Lightweight Low Embodied Carbon Material

Mass timber products have a lighter environmental footprint than energy-intensive materials, contributing to low- and zero-carbon construction. Wood products are 50% carbon by dry weight, meaning mass timber buildings can store carbon well into the future, reducing their global warming potential. Mass timber's light weight gives it an advantage over steel and concrete assemblies. Lighter loads reduce transportation-related emissions, and can decrease overall foundation costs.

Efficient, Cost-Saving Construction

Mass timber construction is faster than other structural assemblies, and speed correlates to savings and revenue, whether the project is an office, school, student residence, condominium, or hotel. Because they're prefabricated, mass timber elements can be assembled by fewer workers, and lend themselves to tight, difficult to reach project sites.

Thermal and Health Benefits

Mass timber products can contribute to improved occupant comfort. They have lower thermal conductivity compared to concrete, steel-frame, and masonry construction and are well-suited to energy-efficient design. Prefabricated factory-built mass timber solutions can improve thermal performance by delivering a precise fit that is tested and airtight. In addition, an increasing number of studies focused on wood's biophilic qualities have linked the use of exposed wood in buildings with improved occupant well-being.[3]

Project Name	University of Oregon, Hayward Field
Location	Eugene, OR
Owner/Developer	University of Oregon
Architect	SRG Partnership, Inc.
Structural Engineer	MKA
Contractor	Hoffman Construction Company
Imagery	Kevin Scott

"We found that timber goes up a lot faster than steel or concrete. Being able to tell our clients that they can reduce their costs by reducing their construction time has become a really compelling story.

JOHN MITCHELL
ASSOCIATE PARTNER
HPA

Product Overview

Mass timber panels are large-format panelized wood products made from solid sawn or structural composite lumber (SCL) laminations. They include cross-laminated timber (CLT), nail-laminated timber (NLT), dowel-laminated timber (DLT), and glue-laminated timber (GLT). CLT is most commonly made from solid sawn laminations; however, it can also be made from SCL products such as laminated veneer lumber (LVL).[4]

The diversity of mass timber products gives design teams flexibility and versatility, and products are often combined to form customized structural assemblies. As large solid wood panels, mass timber products can be used for load-bearing wall, floor, and roof construction. They can also be designed to curve and cantilever, achieving expressive long-spanning designs, or be topped with concrete to form timber concrete composite (TCC) panels, a hybrid system used to reduce cross sections, increase spans, and lessen noise transfer and vibrations. Additionally, mass timber can be used as a complement to other building systems in conjunction with light-frame wood construction or in other types of hybrid structures.

Learn More

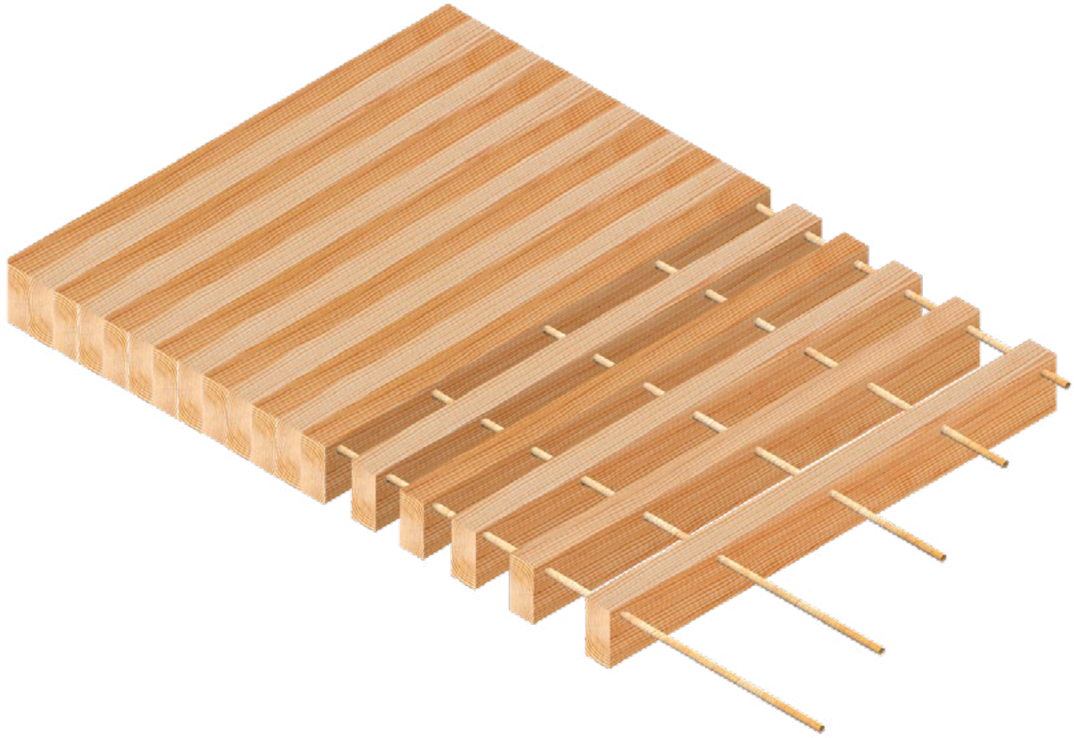
Project Name	Conference Center, Montana Dept of Fish + Wildlife
Location	Missoula, MT
Owner/Developer	Montana Fish, Wildlife & Parks
Architect	MMW Architects
Structural Engineer	Morrison-Maierle
Contractor	Quality Construction
Imagery	SmartLam/Paul Neff

Cross-Laminated Timber

Cross-laminated timber (CLT) is a wood panel system that has gained popularity in the U.S. after being widely adopted in Europe. It consists of layered lumber boards (usually three, five, or seven) stacked and glued crosswise at 90-degree angles, delivering excellent structural rigidity in both directions. Alternating grains improve CLT panels' dimensional stability. Finger joints and structural adhesive connect the boards. Board thickness varies between 5/8 inch and 2 inches, with board width most commonly ranging from 2.5 to 5.5 inches. The panels can be manufactured in custom dimensions, though transportation restrictions dictate their overall size.

Common applications include floors, walls, and roofs. Other applications include cantilevered floors and balconies, load-bearing elevator shafts, and stairs. The panels' ability to resist high racking and compressive forces makes them especially cost-effective for multistory and long-span diaphragm applications. In structural systems, such as walls, floors, and roofs, CLT panels serve as load-bearing elements and are well suited to taller timber construction. As with other mass timber products, CLT can be left exposed in building interiors—up to 8 or 9 stories in Type IV-C buildings under the 2021 IBC (depending on occupancy), offering additional aesthetic attributes..

Dowel-Laminated Timber



Dowel-laminated timber (DLT) is a mass timber product commonly used in Europe and gaining popularity in North America. Panels are made from softwood lumber boards (2×4, 2×6, 2×8, etc.) stacked on end and friction-fit together with dowels, typically made from hardwood lumber.

Similar to NLT, DLT panels can be used for walls, floors and roofs, stairs and elevator shafts, or bent and assembled to create curved structures. DLT's all-timber design, with no metal connectors, means it can be easily processed and cut using computerized numerical control (CNC) machinery. Alternating patterns of lumber can be used to create various aesthetic appearances. DLT panels can also accommodate mechanical services and sound absorbing insulation, tucked away as part of its cut and design.

DLT panels can be topped with concrete to form TCC panels.

Nail-Laminated Timber

A century-old building construction material, nail-laminated timber (NLT) is made from dimension lumber stacked on edge and fastened together with nails or sometimes screws to form a solid structural element. The boards are nominal 2x, 3x, and 4x thickness. Width is typically 4 to 12 inches. NLT gets its strength and durability from the nails/screws fastening the individual pieces of lumber.

Applications for NLT include foors, decks, roofs, and walls, as well as elevator and stair shafts. Adding plywood or oriented strand board sheathing on one face of the panel provides load-bearing capacity, allowing NLT to be used as a shear wall or structural diaphragm. NLT offers a consistent appearance for decorative or exposed-to-view applications and can include curves and cantilevers.

Historically, industrial buildings often used NLT construction to span between solid timber posts and beams and form sturdy solid floors. Many of these buildings are sought after for their historic appeal and continue to serve today as refurbished office and residential spaces. NLT's revival is due in large part to domestic availability. The mass timber product does not require a dedicated manufacturing, and can be fabricated with readily available dimensional lumber.

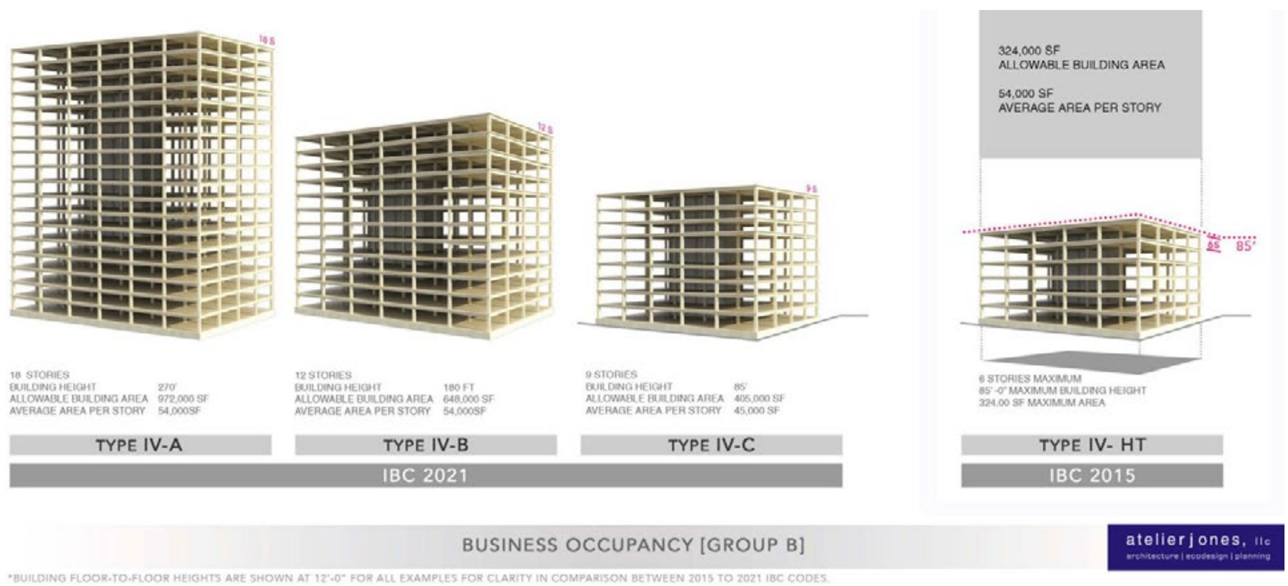
Glued-Laminated Timber (Glulam)

Glulam is composed of individual wood laminations (dimension lumber), selected and positioned based on their performance characteristics, and then bonded together with durable, moisture-resistant adhesives. The grain of all laminations runs parallel with the length of the members, which can be customized to create elements that are straight, curved, arched, and tapered.

As one of the oldest and widely used mass timber products, glulam's application is broad and includes virtually all building types. Beyond buildings, it can serve as the primary material for major load-bearing structures such as bridges, canopies, and pavilions. It can be used as columns or beams (straight or curved), or affixed side-by-side to form panels. It is particularly well suited to long-spanning structures and custom curvilinear shapes, and combines well with hybrid assemblies and building systems. While typically used as beams and columns, designers can use glulam in the plank orientation for floor or roof decking similar to NLT.

Project Name	The Soto
Location	San Antonio, TX
Owner/Developer	Hixon Properties
Architect	BOKA Powell
Structural Engineer	StructureCraft
Contractor	Byrne Construction
Imagery	Erika Brown Edwards

Construction Types for Mass Timber and 2021 Codes



Across the country, designers are increasingly turning to mass timber products to construct everything from multifamily housing and mixed-use commercial office buildings to schools, healthcare, and civic facilities. The 2015 IBC was first to incorporate CLT as a structural building product when it was recognized for use in Type IV (heavy timber, HT) construction. In response to the increasing use of CLT and other mass timber building components in Types III, IV, and V construction, the 2018 IBC added more detail to clarify the requirements of heavy timber construction. Most recently, the height of mass timber buildings are also on the rise supported by changes to the 2021 IBC.

The 2021 IBC includes three new construction types:

1. Type IV-A – Maximum 18 stories, with noncombustible protection on all mass timber elements.

2. Type IV-B – Maximum 12 stories, limited area of exposed mass timber walls and ceilings allowed.

3. Type IV-C3 – Maximum 9 stories, all mass timber permitted to be exposed (with a few exceptions e.g. shafts) and designed for 2-hour fire resistance.

These new types are based on the existing Heavy Timber construction type (renamed Type IV-HT) but with specified hourly fire resistance ratings for building elements and added levels of noncombustible protection. The code includes provisions for up to 18 stories of Type IV-A construction for Business and Residential Occupancies.

Along with their exceptional structural performance, design teams are leveraging mass timber products for their versatility, value, and climate change-combatting benefits.`

Ask an Expert

Making Early Design Decisions for a Successful Mass Timber Project

Early decision-making and good planning are critical to the success of mass timber projects. In this Q&A, WoodWorks' mass timber experts provide information you'll need before getting started.

What are the construction types within the IBC that allow a mass timber structure?

A building's assigned construction type is the main indicator of where and when all wood systems can be used. IBC Section 602 defines five main options (Type I through V). While Type IV construction is often associated with mass timber, Types III and V permit the use of wood framing throughout much of the structure and both are used extensively for modern mass timber buildings.

Type III (IBC 602.3) – Timber elements can be used in floors, roofs, and interior walls. Fire-retardant-treated wood (FRTW) framing is permitted in exterior walls required to have a fire-resistance rating of 2 hours or less.

Type V (IBC 602.5) – Timber elements can be used throughout the structure, including floors, roofs and both interior and exterior walls.

Type IV (IBC 602.4) – Commonly referred to as 'Heavy Timber' construction, this option has been in the building code for over a hundred years in one form or another, but its use has increased along with renewed interest in exposed wood buildings. In the 2021 IBC, Type IV construction has been renamed Type IV-HT, and three new subtypes have been added—IV-A, IV-B and IV-C, which allow up to 18 stories of mass timber construction.

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	HT	A	B	C	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b]	1[b]	0	1[b]	0	HT	3	2	2	1[b]	0
Bearing walls Exterior[e,f] Interior	3 3[a]	2 2[a]	1 1	0 0	2 1	2 0	2 1/HT	3	2	2	1 1	0 0
Nonbearing walls and partitions Exterior	See Table 602											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	See Section 2304.11.2	0*	0*	0*	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	2	2	2	1	0
Roof construction and associated secondary members (see Section 202)	1-1/2[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1-1/2	1	1	1[b,c]	0

**Nonbearing interior wall partitions in Types IV-A, IV-B and IV-C must be of mass timber construction or of noncombustible materials per IBC 602.4*

Source: IBC Table 601 / See IBC for footnotes

Comparison of Construction Types III, IV and V

Construction Type	III-A	III-B	IV-HT	IV-A	IV-B	IV-C	V-A	V-B
Exterior wall materials	FRTW	FRTW	FRTW or CLT	Mass timber or non-combustible	Mass timber or non-combustible	Mass timber or non-combustible	Any wood including mass timber	Any wood including mass timber
Exterior bearing wall FRR	2-hour	2-hour	2-hour	3-hour	2-hour	2-hour	1-hour	0-hour
Interior framing materials	Any wood including mass timber	Any wood including mass timber	Heavy timber including mass timber	Mass timber	Mass timber	Mass timber	Any wood including mass timber	Any wood including mass timber

Sources: IBC Section 602, Table 601 and Section 2304.11

What are the impacts of construction type on required fire-resistance ratings of structural elements?

For most building elements other than heavy timber, passive fire-resistive requirements are in the form of a required fire-resistance rating (FRR). The construction type of a building determines many of the minimum required FRRs for different building components, as shown in IBC Table 601 of the 2021 IBC.

Several features of Table 601 are relevant to mass timber. Footnote c in the code (see IBC for detailed footnotes) allows for timber components meeting the requirements of heavy timber to be used in the construction of all roofs having a fire-resistance rating of 1 hour or less in lieu of the required FRR. This means that a mass timber roof meeting the minimum size requirement of heavy timber can be used in construction Types I-B, II-A, and II-B, which otherwise prohibit the use of combustible framing.

Interior nonbearing walls and partitions generally do not have an FRR requirement, except for Type IV construction. In IBC 2015, note that the Table 601 reference to Section 602.4.6 should instead be to 602.4.8, which requires partitions in Type IV construction to be of solid wood construction or have a 1-hour fire-resistance rating.

In addition to requirements related to construction type, there are other requirements for FRRs in the IBC. For multi-unit residential buildings, walls and floors between dwelling or sleeping units are required to have an FRR of 1/2 hour in Type II-B, III-B and V-B construction when sprinklered throughout with an NFPA 13 system, and 1 hour for all other construction types (IBC 420, 708 and 711). Multiple separated occupancies (IBC 508.4), incidental uses (IBC 509), and special provisions (IBC 510) also require FRRs of select components and assemblies.

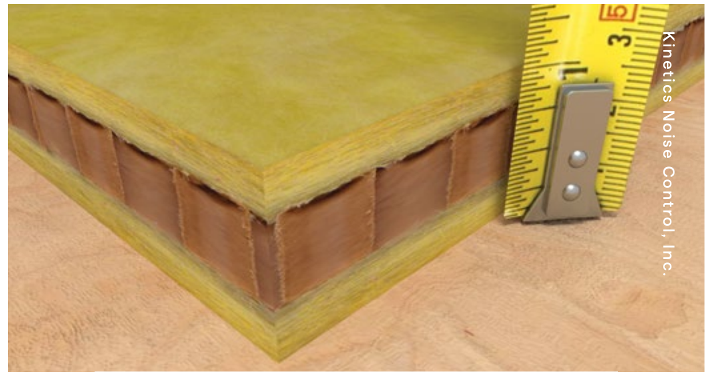
What are the code-compliance requirements for acoustics and what solutions can meet these requirements with tested mass timber assemblies?

Section 1206 of the 2021 IBC lists requirements for the acoustical performance of walls, partitions, and floor/ceiling assemblies in multi-family buildings. These assemblies, which separate one dwelling unit from another or from public areas, must have a sound transmission class (STC) rating of 50 and, in the case of floor/ceiling assemblies, an impact insulation class (IIC) rating of 50. (These ratings can be reduced to 45 when field-tested.) Note that these code requirements only apply to multifamily construction. Although guidelines related to acoustical performance in occupancies such as offices, schools, and hospitals do exist, they are not requirements under the IBC.

Bare mass timber floor/ceiling or wall assemblies are seldom used, in large part due to inadequate acoustical performance. For example, a 5-ply CLT floor with a thickness of 6.875 inches has an STC rating of 41 and an IIC rating of 25. As such, components are typically added to mass timber assemblies to improve their acoustics.

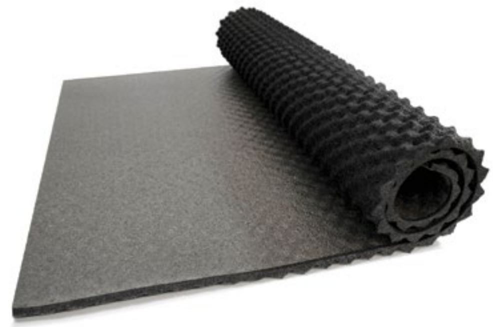
In-floor/ceiling applications, owners and design teams often want to expose the ceiling side of mass timber panels for aesthetic reasons, which means that any acoustical components must be installed on top of the assembly.

AcoustiTECH



Kinetics Noise Control, Inc.

Maxxon Corporation



Pliteq, Inc.

There are three main ways to improve an assembly's acoustical performance:

1. Add mass
2. Add decouplers
3. Add noise barriers

Adding mass is a common way to improve acoustical performance in mass timber. Due to the lack of mass inherent in the mass timber panel, a poured concrete or gypsum-based topping layer can be added, usually in the range of 1-3 inches thick.

Adding decouplers is another popular approach. Decouplers are products that decouple—or break direct connections—between finishes on one side of an assembly and the other. This reduces the amount of noise that can directly travel through finish to structure to finish. In mass timber floor/ceiling systems, the most common decoupling products are underlayments and mats placed between the mass timber panel and concrete or gypsum-based topping.

Although it is common to add noise barriers within light wood-frame assemblies (e.g., batt insulation in a floor cavity), this method is much less common in mass timber floor/ceiling assemblies. That said, several acoustically-tested mass timber floor assemblies include wood sleepers on top of the panels and noise barriers such as sand or batt insulation between the sleepers.

What are some effective methods of integrating mechanical, electrical and plumbing (MEP) services in a mass timber building?

Some options for incorporating MEP on mass timber walls include:

- Furring out a wall on the lower half of the mass timber wall to accommodate electrical outlets and plumbing pipes.
- Adding light-frame partition walls on one or both sides of the mass timber wall panel to accommodate MEP items, completely covering the mass timber wall panels. (Note that this can also have acoustical advantages.)

Figure 1
Photo: Charles Judd

- Running the conduit, pipes, etc. on the face of the mass timber wall panels, leaving them exposed and using them as architectural elements.

- Routing and boring the panels to take the electrical conduit, plumbing pipes, and mechanical chases. This can be done on site with traditional carpentry tools or in the factory using CNC technology. Structural effects related to panel cross-section reduction should be taken into account. (See Figure 1.)

Some options for accommodating MEP on mass timber floor panels include:

- Running the conduit, pipes, etc. on the face (ceiling side) of the mass timber floor panels, leaving them exposed and using them as architectural elements. (See Figure 2.)

- Creating a drop ceiling to conceal both the MEP and mass timber panels.

- Gapping the mass timber panels, running the MEP items between the panels, and adding wood ceiling inlay panels between the mass timber panels to conceal the MEP. (See Figure 3.)

- Utilizing a raised access floor system on top of the mass timber panels to conceal MEP items. (See Figure 4.)

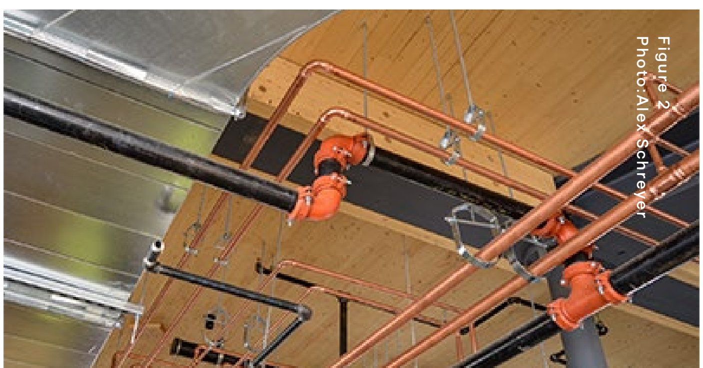


Figure 2
Photo: Alex Schreyer

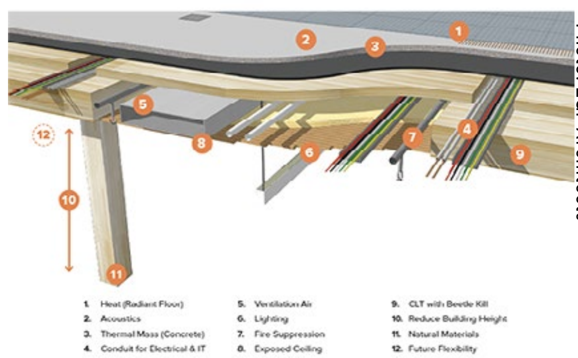


Figure 3
Photo: ZGF Architects

Figure 5
Photo: Alex Schreyer

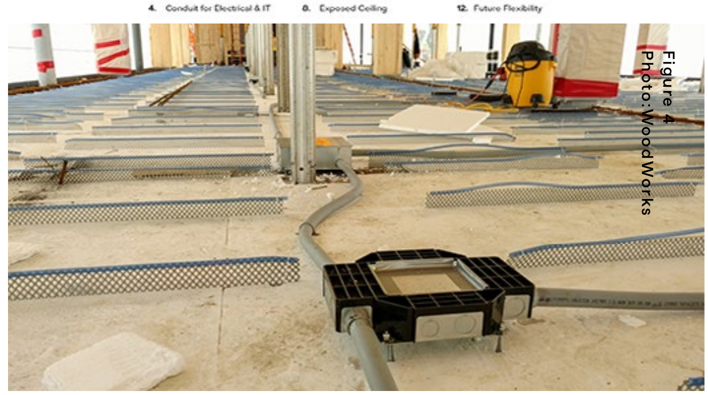


Figure 4
Photo: WoodWorks

- Embedding items such as electrical conduit and radiant heat tubing in a concrete topping layer cast on top of the mass timber panels. (See Figure 5.)

- For NLT and DLT options, varying the lamination depth (i.e., using 2×4 and 2×6 alternating laminations) and tucking smaller MEP items such as conduit and sprinkler lines in the gaps created.

As several of these options include some type of concealed space (e.g., a drop ceiling or raised access floor), it is worth noting that up to and including the 2018 IBC, Type IV buildings were not permitted to have concealed spaces in interior elements (except as permitted for partitions). Although several Type IV buildings received alternate methods approval for concealed spaces under these versions of the code, the lack of prescriptive opportunity steered some designers toward the use of Type III or V construction for their mass timber projects. The 2021 IBC allows concealed spaces under certain conditions in all four of the Type IV construction subtypes (IV-A, IV-B, IV-C and IV-HT) as described in IBC Section 602.4. For more information, see the WoodWorks technical paper, Concealed Spaces in Mass Timber and Heavy Timber Structures.

Insurance for Mass Timber Construction

Assessing Risk and Providing Answers

Mass timber has been embraced in the U.S. at a pace rarely seen for new building systems. This has been made possible by an unprecedented amount of research and product testing, standard development and building code changes, growth in manufacturing capacity, and education and support for individuals involved in mass timber projects. However, with relatively few built projects compared to traditional building systems—and almost none that have undergone an extreme event resulting in a loss claim—insurance has been a challenge.

This paper is intended for developers and building owners seeking coverage for mass timber buildings, for project teams looking to make their designs and installation processes more insurable, and for insurance industry professionals looking to alleviate their concerns about safety and performance. It examines two types of insurance: builder's risk (or course of construction) and fixed property (after the building is complete and occupied).

For developers and design/construction teams, it provides an overview of the insurance industry, including factors that affect premiums, how risks are analyzed, and important considerations for mass timber projects. For insurance brokers, underwriters and others in the industry, it provides an introduction to mass timber, including its growing use, code recognition and common project typologies. It also covers available information on fire performance and post-fire remediation, moisture impacts on building longevity, and items to watch for when assessing projects.

As with any unfamiliar material or building type, insurance challenges are anticipated. However, there is a great deal of information available to help evaluate the relative risks of mass timber construction, and successfully insured projects that can serve as examples for others in the design and construction industry.

Learn More

District Office

Open Plan Office Gets a Boost with Mass Timber

An exposed mass timber grid with efficient one-way CLT floor spans makes this Portland, OR-based speculative office complex uniquely versatile. Five feet from the core wall, a colonnade of glulam columns marches down the center of the building, spaced 10 feet on center, lending to its highly flexible and adaptable floor plate. Generous colonnade-to-window spans help to create the building's spacious, open plan. The wide grid layout recalls historic warehouses that once occupied the district, providing a connection to the area's architectural history.

The six-story building includes five stories of new offices with ground-floor retail and restaurant space as well as underground parking. Glulam beams and columns support 3-ply CLT panels in this light-filled, expansively glazed structure. Double-height spaces offer volume and circulation to the interior and allow tenants to create more intimate office layouts than are possible in a typical single-floor plan.

Location	Portland, OR
Size	106,000 ft^2
Owner	Beam Development & Urban Development + Partners
Architect	Hacker
Structural Engineer	KPFF
Mass Timber Suppliers	DR Johnson Wood Innovations; Freres Lumber Co., Inc. (feature staircase)
Contractor	Andersen Construction
Completed	2021
Imagery	Hacker

In every bay, CLT panels were installed with two-foot gaps, creating a mechanical chase that allows services like sprinkler lines to be easily installed without penetrating beams. The gaps also reduced the total volume of required CLT, in turn helping to lower material costs.

This project also boasts a feature CLT staircase, which was built using stringer shapes that were combined to form the stair itself. Stair veneers run vertically to expose the warmth and beauty of the wood's end grain.

Overall, the facility's design provides flexibility and adaptability while taking advantage of city views and connections to the active urban environment.

Learn More

Railyard Flats

Mass Timber Modernizes Historic Railyard Aesthetic

Railyard Flats is a three-story, 83,000-square-foot mixed-use project in Sioux Falls, SD. It includes 41 loft-style apartments with two floors of retail and office space and is the first building in the state to be constructed with DLT. Developer Pendar Properties credits the use of exposed timber as an important factor in the project's success. When Railyard Flats opened in summer 2021, it garnered peak lease rates and 100% residential occupancy.

The design team chose a hybrid mass timber and light-frame structural system for its warmth, sustainability, and ease of construction. The project's aesthetic is a nod to historic local railroads that once occupied the site, while its design offers all the comfort, amenities, and advanced technologies of a modern-built structure.

Location	Sioux Falls, SD
Size	83,000 ft^2
Owner	Pendar Properties
Architect	CO-OP Architecture
Structural Engineer	StructureCraft (Timber)
Mass Timber Suppliers	StructureCraft
Contractor	Journey Construction
Completed	2021
Imagery	Creative Coop

Visual-grade glulam beams and columns and mass timber decking serve as the primary structure, while light-frame wood and brick cladding form the walls. Prefabricated 5.5-inch DLT panels were ideal for Railyard Flats' long horizontal spans, and the thinner material proved cost effective.

DLT also helped designers improve the visual appeal of the exposed ceiling through the addition of a fine line kerf profile to the exposed board edges. Special attention was given to acoustic performance and the attenuation of unit-to-unit noise transfer. The mass timber decking was topped with a thick sound mat and concrete for an added sound barrier.

Learn More

Timber Design Applications

Unlike other types of structural assemblies, mass timber calls for a holistic and innovative approach to its design. Successful design teams have learned how to optimize costs while managing fire, acoustic and other performance objectives. Timber span capabilities, construction type, fire-resistance ratings, and connections are among the things that will drive a mass timber building's optimal layout and structural grid.

Mass timber is engineered for high strength ratings like concrete and steel but is significantly lighter in weight.[5] Combining mass timber and concrete or steel in hybrid construction can provide a cost-effective and sustainable solution[6] for many occupancy types as well as improve building performance and design.[7] In order to maximize development area per square foot, overbuilds can be used to add new stories to an existing building.[8]

Although it requires additional upfront planning, just-in-time prefabricated mass timber construction can deliver schedule and time savings and reduced labor costs.[9] This can be particularly useful for repeatable building types such as hotels, multifamily residential, and student dorms. Mass timber can be applied to virtually all building types and is particularly sought after for office design—its ability to create open, flexible spaces using exposed structural wood is well-suited to the needs of today's modern workplace.

In this section, case studies demonstrate the range of mass timber applications. Technical mass timber resources span essential topics such as code compliance for fire design, acoustics and noise control, designing for floor vibration, choosing structural connections, and best practices related to grid configurations, durability, moisture, and enclosures. Business case studies delve into the financial performance of U.S. developments constructed with mass timber. Created for the developer/investor audience, case studies discuss qualitative influences and provide qualitative data to examine investment success, challenges and lessons learned.

Project Name	G.K. Butterfield Transportation Center
Location	Greenville, NC
Owner/Developer	City of Greenville North Carolina
Architect	Jacobs Engineering Group
Structural Engineer	Jacobs Engineering Group
Contractor	TCC Enterprises
Imagery	Aaron Hines, City of Greenville, NC

Mass Timber Office Design

Breaking Convention with Wood Offices

While historically concrete and steel have been the default structure for office design, mass timber is rising in popularity and is equally capable of accommodating the needs of a modern workplace. Exposed mass timber construction lends itself well to open office layouts while offering aesthetic warmth and biophilic benefits.

The following projects highlight common considerations for office design, such as layout flexibility and market classification, in the context of mass timber hybrid solutions. Key project considerations for this building type include code opportunities related to fire and life safety, structural design and layout, acoustics, vibration, and cost. The projects make use of a wide range of mass timber products including solid wood, glulam, CLT and NLT.

Learn More

Adidas North American Headquarters

Prefabricated Mass Timber Cuts Construction Time

Location	Portland, OR
Size	213,000 ft^2
Client/Owner	Adidas North America Inc.
Architect	LEVER Architecture
Interiors	Studio O+A
Structural Engineer	KPFF
Mass Timber Supplier	DR Johnson Wood Innovations
Contractor	Turner Construction Company
Completed	2021
Imagery	Jeremy Bittermann, Garrett Rowland, LEVER Architecture

When Adidas announced plans to expand their North American Headquarters in Portland, OR, speed and budget were paramount. In response, the design and construction team chose a hybrid structural system of precast concrete and mass timber for the Gold Building and a mass timber post-and-beam solution for the Performance Zone Building, using prefabrication in both cases to reduce construction time.

Along with adding substantial office and meeting space, the expansion has transformed the existing plaza into a more cohesive campus landscape. The new additions strengthen the internal connections between existing buildings and alter the landscape linkages to the adjoining residential neighborhood. Both buildings cantilever over an on-site soccer field, showcasing views of both formal and pick-up matches. On the ground level, the buildings open directly onto the field, integrating diverse public spaces from café seating to outdoor training areas.

The 182,000 square-foot, five-story Gold Building includes a food hall, coffee bar, maker and creative labs, a meeting zone, and four levels of open workspace. The design team originally considered a conventional concrete structure but decided against it after determining it would require a 27-month construction schedule.

Instead, they selected a design that uses 10×30-foot mass timber cassettes, formed using glulam beams and CLT panels. The cassettes were prefabricated at a facility in nearby Riddle, Oregon, transported to the site, and lifted into place, helping to cut construction time by three months.

The 31,000 square-foot Performance Zone Building is a campus destination for athletic training and community events. Because the building design includes an overbuild atop an existing underground parking structure, the design team chose a lightweight structural timber system, eliminating the need for a seismic retrofit of the garage below. The result is an intricate post-and-beam design constructed from glulam beams and columns and CLT panels, resembling a unique, Jenga-style configuration.

Learn More

Mass Timber Cost and Design Optimization Checklists

Proper planning is key to realizing savings on a mass timber project. These design optimization checklists, developed by WoodWorks, provide a breakdown of critical items to consider when completing a mass timber building—from pre-design and schematic through to design development.

They are intended for building designers (architects and engineers), but many of the topics should also be discussed with the fabricators and builders. The cost optimization checklists will help guide coordination between designers and builders (general contractors, construction managers, estimators, fabricators, installers, etc.) as they are estimating and making cost-related decisions on a mass timber project.

Learn More

"We wanted to offer something unique, leveraging the value, the ambiance and the aesthetic of exposed wood. It's also sustainable and extremely efficient from an engineering perspective.

GERALD EPP JR.
BUSINESS DEVELOPMENT ENGINEER
STRUCTURECRAFT

Project Name	Washington, DC Southwest Public Library
Location	Washington, DC
Owner/Developer	DC Public Library, Washington DC
Architect	Perkins&Will
Structural Engineer	StructureCraft
Contractor	Turner Construction
Imagery	James Steinkamp Photography

Efficient Structural Grid Designs for Mass Timber Buildings

Achieving the highest level of cost efficiency possible with mass timber requires an understanding of both material properties and manufacturer capabilities. When it comes to laying out a structural grid, the square peg/round hole analogy is pertinent. Trying to force a mass timber solution on a grid laid out for steel or concrete can result in member size inefficiencies and the inability to leverage manufacturer capabilities.

Knowing how to best lay out the structural grid—without sacrificing space functionality—allows the designer to optimize member sizes, but cost efficiency for a mass timber building goes beyond column spacing. The structural engineer's role in optimizing a mass timber structural layout involves taking a system vs. product approach.

This paper describes that approach, along with other considerations, such as design parameters and challenges, connections, grid spacings, and lessons learned from built structures in the U.S. that can help engineers optimize their mass timber projects.

Ask an Expert

Creating Efficient Structural Grids for a Mass Timber Building

When it comes to mass timber construction—particularly for commercial and multifamily projects—planning an efficient structural grid is key. WoodWorks' mass timber experts answer frequently asked questions and more in this Q+A focused on designing the best structural grid for the project.

During what phase of design should project teams consider a mass timber building's structural grid?

It is critically important to design a mass timber building as a mass timber building from the start. This requires a thorough understanding of how to best layout the structural grid, without sacrificing space functionality.

What factors influence mass timber grid system design?

Simplistically, there are two main grid options for mass timber buildings: square and rectangular. In deciding which to use, there are a number of factors to consider.

To determine efficient grid spacing, it is important to understand possible span ranges for mass timber floor panels. Due to their relatively light weight, allowable spans for these panels are often governed by vibration and deflection rather than bending or shear capacity. In addition to panel vibration design, the vibration performance of the framing system as a whole (including beams) should be taken into account.

What are some practical examples of square mass timber grids?

Based on completed buildings in the U.S., square grids tend to range from 20×20 to 30×30 feet. Although a mass timber panel may be able to span the 20-foot distance between support beams in a 20×20-foot grid, an alternate method would be to include one intermediate beam within each bay to reduce the span of the mass timber floor panel. For example, a 20×20-foot grid could have one intermediate beam in order to allow 3-ply CLT floor panels spanning 10 feet to be used. This scenario was used for the Albina Yard office building in Portland, OR.

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" thick)	17 to 21 ft
2×4 NLT	Up to 12 ft
2×6 NLT	10 to 17 ft
2×8 NLT	14 to 21 ft
5" MPP	10 to 15 ft

Albina Yard is built on a 20×20-foot grid with one intermediate beam in each bay and 3-ply CLT panels spanning 10 feet between glulam beams

Larger square grids such as 28×28 or 30×30 feet with one intermediate beam can also be used. This typically results in the use of 5-ply CLT or 2×6 NLT/DLT/GLT floor panels spanning 14 or 15 feet. This scenario was used for Clay Creative, also in Portland. In general, thinner floor and roof panels may result in lower material costs. However, lower horizontal panel costs may be offset by higher beam (and perhaps column) costs, and additional intermediate beams need to be coordinated with MEP systems. Considering this, a cost analysis comparing thicker floors with fewer beams to. thinner floors with more beams may be necessary.

First Tech Federal Credit Union includes a 12×32-ft grid with 5-1/2-in. CLT panels spanning 12 ft between glulam beams.

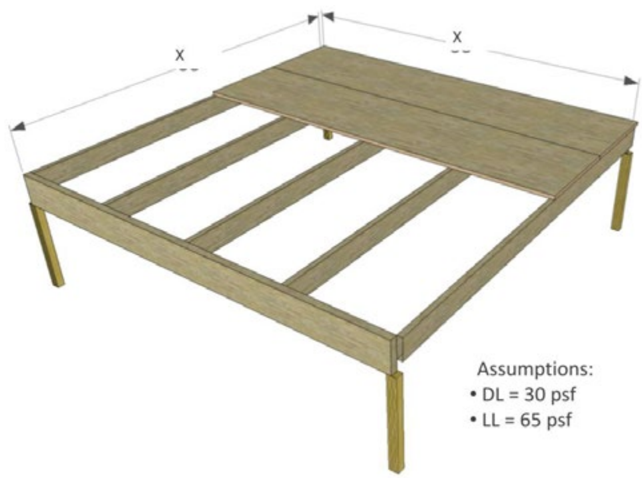
Going much beyond a 30 or 32-foot span with glulam girders starts to require fairly large (deep) beams. It can be done, but economics and headroom issues may outweigh the benefits of longer spans. The image below illustrates several square grid options and associated member sizes.

What are some practical examples of rectangular mass timber grids?

Rectangular grids are usually in the 12×20-foot to 20×32-foot range. The main difference with a rectangular grid is that intermediate beams tend not to be used, often simplifying the approach to accommodating MEP. The narrower grid dimension is typically based on the span capability of the floor panel. The larger grid dimension is based primarily on programmatic layout, while also taking into account economical spans for glulam. Projects that have used this scenario include the First Tech Federal Credit Union in Hillsboro, OR, which used a 12×32-foot grid with 5-1/2-inch CLT panels spanning 12 feet, and the 111 East Grand Office in Des Moines, IA, which used a 20×25-foot grid with 2×8-foot DLT panels spanning 20 feet.

How do manufacturer capabilities impact grid dimensions?

An important step in mass timber building design is to consult with manufacturers to determine the most efficient panel layouts for their capabilities. Most North American CLT manufacturers certified to the ANSI/APA PRG-320 Standard for Performance-Rated Cross-Laminated Timber are capable of producing panels between 8 and 12 feet wide and between 40 and 60 feet long. Minimizing the amount of waste from each panel is key to maximizing efficiency. For example, a grid with 20-foot increments could be very efficient, using 40-foot-long panels or 60-foot-long panels if the manufacturer is capable of producing those sizes. On the other hand, a 24-foot grid may not be as efficient since it would either require 48-foot-long panels (for double spans) or cutting 16 feet from 40-foot-long panels. Both options increase waste and reduce efficiency. When considering especially long panels, trucking logistics should also be taken into account.



Approximate Member Sizes – Office Floor Framing			
X	Mass Timber Panel	Glulam Purlin	Glulam Girder
20'	2×8 NLT/DLT/GLT or 7-PLY CLT	None	6-3/4"x21"
	2×4 NLT/DLT/GLT or 3-PLY CLT	5-1/8"x18" @ 10' oc	6-3/4"x21"
25'	2×6 NLT/DLT/GLT or 5-PLY CLT	5-1/8"x24" @ 12.5' oc	6-3/4"x30" or 8-3/4"x27"
30'	2×6 NLT/DLT/GLT or 5-PLY CLT	6-3/4"x27" @ 15' oc	8-3/4"x36" or 10-3/4"x33"

Note: All member sizing needs to be confirmed by a licensed engineer for conditions of your project. All glulam members assumed to be 24F-V4

Del Mar Civic Center

Expressive Mass Timber Complements Coastal Architecture

Location	Del Mar, CA
Size	68,000 ft^2
Owner/Developer	City of Del Mar
Architect	The Miller Hull Partnership, LLP
Structural Engineer	Hope Amundson, Inc. | Coffman Engineers
Contractor	R.A. Burch & EC Constructors
Completed	2018
Imagery	Chipper Hatter

The Del Mar Civic Center was designed to reflect its community: a laid-back beach town known for intimately-scaled Coastal Craftsman wood architecture. The expressive use of wood, variety of outdoor public spaces, and sweeping views of the ocean make this project, in the words of the architect, "quintessential Del Mar architecture." The facility functions as a series of interconnected structures, courtyards and terraces, and open spaces that follow the contours of the seaside site.

The facility's structure includes a warm wood interior that welcomes residents to the city's main gathering spaces, including both Town Hall and City Hall offices. Inspired by the needle pattern of the Torrey pine, the iconic cupola-shaped roof over the Town Hall is spanned by a king post truss that includes glulam top chords and steel-tension members. Glulam beams and open-web wood trusses frame the City Hall roof while glulam columns provide support for the facility's curtain wall glazing. The Civic Center's intricate design creates a bold geometric form when viewed from below.

The roof's low extended eaves provide shaded outdoor space without impacting outward-looking views. In addition to aesthetics, the timber-framed design facilitates natural ventilation, reducing energy costs and creating a pleasant, healthy space for visitors and city staff. To manage sound, designers chose a wood acoustical panel grille system. Where glulam beams and wood trusses extend to the exterior, wood eave tails were attached for added durability. The expressive wood structure visible throughout the main public areas complements the Coastal Craftsman style of the nearby Del Mar Library, the historic Powerhouse Park Community Center, and St. Peter's Parish.

Mass Timber Fire Design

Fire design is an important consideration for any mass timber project, along with an understanding of fire-resistant testing as it relates to specific mass timber assemblies and penetrations. Because mass timber products char at a predictable rate like heavy timber, they have inherent fire resistance that allows them to be left exposed and still achieve a fire-resistance rating.

Fire Design of Mass Timber Members

This technical paper delves into how to meet fire-resistance requirements in the 2018 IBC as it relates to mass timber, including calculation and testing-based methods. It includes fire-resistance rating requirements and helpful charts based on building type and element. Along with fire-resistance ratings of exposed mass timber elements, the document breaks down the specific circumstances wherein the code allows for the use of mass timber in commercial and multi-family construction.

A building's assigned construction type is the main indicator of where and when all wood systems can be used.

- Type III (IBC 602.3) – Timber elements can be used in floors, roofs, and interior walls. FRTW framing is permitted in exterior walls required to have a fire-resistance rating of 2 hours or less.
- Type V (IBC 602.5) – Timber elements can be used throughout the structure, including floors, roofs, and both interior and exterior walls.
- Type IV (IBC 602.4) – Commonly referred to as 'Heavy Timber' construction, this option has been in the building code for over a hundred years in one form or another, but its use has increased along with renewed interest in exposed wood buildings.

For most building elements other than heavy timber, passive fire-resistive requirements are in the form of a required fire-resistance rating (FRR). The IBC defines FRR as the period of time a building element, component, or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703. The construction type of a building determines many of the minimum required fire-resistance ratings for different building components.

In addition to requirements related to construction type, there are other requirements for FRRs in the IBC. For multi-unit residential buildings, walls and floors between dwelling or sleeping units are required to have an FRR of 1/2 hour in Type II-B, III-B and V-B construction when sprinklered throughout with an NFPA 13 system, and 1 hour for all other construction types (IBC 420, 708 and 711).

Mass timber elements can be designed so a sufficient cross-section of wood remains to sustain the design loads for the required duration of fire exposure. This sets mass timber apart as a unique building material—one that is able to achieve structural performance and passive fire-resistance objectives for larger and taller wood buildings than ever before, while offering enhanced aesthetic value and environmental responsibility.

Learn More

Inventory of Fire Resistance-Tested Mass Timber Assemblies & Penetrations

This comprehensive list of mass timber assemblies and penetration fire stopping systems includes helpful information and data related to fire resistance tests of mass timber floor and roof assemblies; CLT wall assemblies; penetrations and fire stops in CLT assemblies; and tests of connections.

Learn More

Aspen Art Museum

One-of-a-Kind Interwoven Wood Space Frame

Location	Aspen, CO
Size	30,000 ft^2
Owner	Aspen Art Museum
Architect	Shigeru Ban Architects
Structural Engineer	KL&A Engineers and Builders
Specialty Timber Engineer	Creation Holz (Switzerland)
Contractor	Turner Construction in association with Summit Construction
Specialty Timber Fabricator	Spearhead
Completed	2014
Imagery	Greg Kingsley

Pritzker Prize-winning architect Shigeru Ban's one-of-a-kind wooden space frame design for Colorado's Aspen Art Museum is as practical as it is beautiful, demonstrating how mass timber can offer both cutting-edge capabilities and aesthetic benefits.[10]

Centrally located in the alpine resort town on a prominent downtown corner site, the four-story building's intricate timber ceiling crowns much of the upper floor and reaches out to form a canopy over a rooftop sculpture garden. A basket-weave composite wood screen wall envelopes the building, while a unique, interlocking two-way wood space frame forms the structural roof system, which is designed to carry heavy Colorado snow loads. The resulting mesh-like design filters soft light into the interior spaces below, maximizing naturally diffused daylight while minimizing the damaging impacts of direct sunlight.[11]

The floating plane of the 3-D space frame roof is supported on only a few clustered columns, cantilevering from interior to exterior, where it supports the screen wall. The space frame is laid out on a 4-foot grid, with top and bottom laminated spruce veneer chords offset 2 feet in each plan direction.

The diagonal webs that connect the top and bottom chords are comprised of curved laminated birch plywood members that snake up and down, their dimensions shifting subtly in response to structural demands. The connections between web and chord members are made almost entirely with long, fully-threaded wood screws installed from above to bind tight half-lapped joints while remaining invisible to the building occupants.

The project's use of wood offers natural insulative benefits, while the overall building design relies on a "Thermos" principle to boost energy performance—similar to a vacuum flask, interior rooms are kept at a constant temperature by protective exterior spaces. These 'wrapper' spaces support air circulation and serve as a visual connection to the outdoors.

Acoustics and Mass Timber

Room-to-Room Noise Control

The use of mass timber buildings presents unique acoustic challenges. With careful design and detailing, mass timber buildings can meet the acoustic performance expectations of most building types. This resource delves into important acoustic considerations for mass timber construction and design, with an emphasis on controlling room-to-room noise.

When it comes to the fundamentals of acoustics and code, Section 1206 of the 2018 IBC lists requirements for acoustical performance of walls, partitions and floor/ceiling assemblies in multi-family buildings. These assemblies, which separate one dwelling unit from another or from public areas, must have an STC rating of 50 and, in the case of floor/ceiling assemblies, an IIC rating of 50.

Exposed mass timber calls for some unique acoustic considerations. Bare mass timber floor/ceiling or wall assemblies are seldom used, in large part due to inadequate acoustical performance. For example, a 5-ply CLT floor with a thickness of 6.875 inches has an STC rating of 41 and an IIC rating of 25. As such, components are typically added to mass timber assemblies to improve their acoustics.

For example, if leaving mass timber exposed in floor/ceiling application, acoustical components should be installed on top of the assembly. Adding mass to timber using a poured concrete or gypsum-based topping layer, usually in the range of 1 to 3 inch thick, is a common way to improve acoustical performance.

Examples of Acoustically-Tested Mass Timber Panels

Mass Timber Panel	Thickness	STC Rating	IIC Rating
3-ply CLT wall	3.07"	33	N/A
5-ply CLT wall	6.875"	38	N/A
5-ply CLT floor	5.1875"	39	22
5-ply CLT floor	6.875"	41	25
7-ply CLT floor	9.65"	44	3O
2×4 NLT wall	3-1/2" bare NLT 4-1/4" with 3/4" plywood	24 bare NLT 29 with 3/4" plywood	N/A
2×6 NLT wall	5-1/2" bare NLT 6-1/4" with 3/4" plywood	22 bare NLT 31 with 3/4" plywood	N/A
2×6 NLT floor + 1/2" plywood	6" with 1/2" plywood	34	33

Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks

Decouplers can be used to mitigate acoustic challenges. These products decouple, or break direct connections between finishes on one side of an assembly and the other. This reduces the amount of noise that can directly travel through finish to structure to finish. Common examples in light wood-frame construction include resilient channels and air spaces. In mass timber floor/ceiling systems, the most common decoupling products are underlayments and mats placed between the mass timber panel and concrete or gypsum-based topping.

Designing a building for noise control has a significant impact on the overall occupant satisfaction. Laboratory and field tests have already shown that mass timber assemblies can provide satisfactory sound insulation and this is contributing to the use of mass timber for more projects.

Learn More

Acoustically-Tested Mass Timber Assemblies

This inventory of acoustically-tested mass timber assemblies includes CLT floor assemblies with and without concrete/gypsum topping with wood sleepers, NLT, GLT, MPP & T&G decking floor assemblies, and other mass timber floor and wall assemblies.

Learn More

CLT Diaphragm Design for Wind and Seismic Resistance

With the recent release of the American Wood Council's 2021 Special Design Provisions for Wind and Seismic (2021 SDPWS), U.S. designers now have a standardized path to utilize CLT floor and roof panels as a structural diaphragm. This WoodWorks technical paper provides a brief summary of the new CLT diaphragm provisions set out in the 2021 SDPWS along with recommendations for their implementation.

This resource explores the details necessary to gain a better understanding of shear capacity and CLT diaphragm provisions. It includes diagrams demonstrating typical components and panel-to-panel connections, and information related to design loads and force increase factors.

This paper is a companion to the upcoming *CLT Diaphragm Design Guide*, which includes the design of collector and chord details, full examples, and pre-calculated tables of connection capacities.

Learn More

Mass Timber Floor Vibration Design

In many floor applications, the size of the mass timber panels and supporting framing, which significantly influences construction cost, is largely determined by limiting the floor vibrations perceived by occupants or sensitive equipment to acceptable levels. While vibration design is a primary driver of the framing system cost of floors, little information has been available to U.S. designers on how to design mass timber floors for vibration.

This design guide bridges the information and experience gap by synthesizing current design procedures and recommendations for mass timber floors, presenting the results in a format that is both approachable and useful to the engineering design community. It covers the entire range of currently available mass timber panels, including CLT manufactured from either solid sawn or SCL laminations, NLT and DLT, and the support of such panels on a framework of timber beams.

As with any lightweight, long-span floor system, vibration performance may control a mass timber floor's design up to and including panel selection (grade and thickness) and/or supporting member sizes and arrangement. To help designers assess the vibration performance of these types of floors, this document provides recommended analysis approaches and performance target ranges. It focuses on the design of mass timber floor systems to limit human-induced vibration. The primary performance goal is to help designers achieve a "low probability of adverse comment" regarding floor vibrations in a manner consistent with the vibration design guides for steel and concrete systems.

Learn More

Project Name	Ford Calumet Environmental Center
Location	Chicago, IL
Owner/Developer	Chicago Park District
Architect	Valerio Dewalt Train
Structural Engineer	Matrix Engineering / SDI Engineering
Contractor	Chicago Commercial Construction
Imagery	Tom Harris

"The more we discovered about mass timber—from the aesthetics to the environmental qualities—the more we realized this was the direction we wanted to go.

ANNE HABER
PARTNER
PENDAR PROPERTIES

Barracuda Condominiums

Mass Timber Condo Makes the Most of a Tight Lot

The Barracuda Condominiums, a 7-story hybrid mass timber and steel-frame building located in Madison, WI's Basset Street neighborhood, just two blocks from the Wisconsin State Capitol, [12]is helping to meet the region's growing demand for owner-occupied housing.

The building's form resembles the streamlined, torpedo shape of a ray-finned barracuda that comes to a point at its southwest corner, making the most of its narrow, triangular lot. The condo complex features 19 two-bedroom/two-bathroom units that range from 1,400 to 1,730 square feet and offer custom-designed showcase kitchens and sleeping porches. The top floor units also include large, private landscaped balconies.

Location	Madison, WI
Size	45,000 ft^2
Developer	Henry Hamilton Partners, LLC
Architect	Populance, LLC
Structural Engineer	Fink Horejsh, LLC
Contractor	1848 Construction, Inc.
Completed	2020
Imagery	Scott Breneman

Barracuda's framing system consists of structural steel beams and columns with glulam floor decks, supporting five levels of residences built over two levels of concrete parking. The condos' warm timber ceilings frame 10-foot high windows that provide three-quarters of the building units with a view of Lake Mononaand the majority of the remaining units with a view of the Wisconsin Capitol and cityscape.

Project Name	Chemeketa Community College Agriculture Building
Location	Salem, OR
Owner/Developer	Chemeketa Community College
Architect	FFA Architecture and Interiors, Inc.
Structural Engineer	KPFF
Contractor	Swinerton Builders
Imagery	Christian Columbres

Building Enclosure Design Guide for Wood Frame Multi-Unit Residential Buildings

Thoughtfully designed building enclosures consider all environmental and structural loads imposed on the structure over its expected service life. Building enclosures should be designed with a project's regional climate and weather conditions in mind, as well as building use. Mass timber enclosures should be dry and ideally near-room temperature conditions to perform at their best. In most cases, this means incorporating most or all of the required thermal insulation on the exterior of the mass timber element.

This guide, authored by RDH Building Science, explores these topics along with enclosure control layers, design applications, enclosure detailing, and best practices for mass timber buildings.

Learn More

Mass Timber Connections

Connection Classes

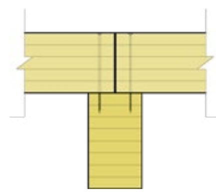
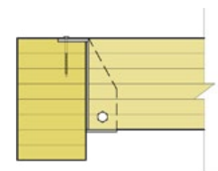
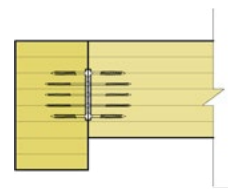
Connection Class	Class 1	Class 2	Class 3
Class Description	Requires only mass timber elements and fasteners	Utilizes steel fabricated elements, with components such as angles and plates, and includes fasteners	Prefabricated proprietary connectors
Connection Example			
	Beam Bears on Girder*	Beam Bears on Steel Bearing Seat with Knife Plate*	Beam Connected to Girder with Proprietary Concealed Connector*

**Table 8 in the WoodWorks Index of Mass Timber Connections*

With the rise in mass timber construction throughout the U.S. there is increasing interest from design teams to better understand cost drivers related to this building type. Connections in a mass timber structure can significantly affect the overall project cost. However, because mass timber connection design must consider not only structural design but also aesthetics, fire rating requirements, constructability, accommodations for shrinkage and swelling, and moisture protection, finding the optimal solution takes research and planning.

To aid designers in this effort, WoodWorks created an online CAD/Revit tool supported by an index highlighting the spectrum of available structural and architectural mass timber connections. Structural connections are grouped into three categories or 'Connection Classes' that share some common attributes regarding cost, constructability, and fire rating.

An accompanying paper defines these "classes" (or groupings). Class 1 connections require only mass timber elements and structural fasteners. Class 2 connections are custom steel fabricated elements, made up of components such as plates and angles, and include structural fasteners. Class 3 connections are prefabricated proprietary connectors available from suppliers such as Simpson Strong-Tie, Rothoblaas, MiTek, and others. Class 3 connections are often backed by supporting tests for strength and fire rating.

Connection Classes in Relation to Fire Rating

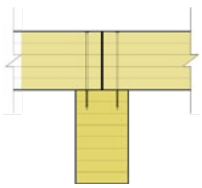
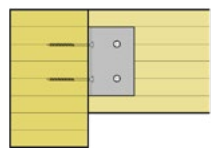
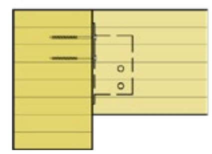
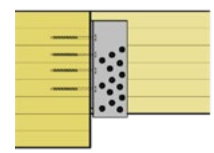
Connection Class	Class 1	Class 2	Class 3	Class 3
Fire Resistance	May be inherently fire resistant according to NDS calculations	Requires additional protection to meet fire-rating requirements	Tested fire-resistance rating (as specified by manufacturer)	Requires additional protection to meet fire-rating requirements
Connection Example				
	Beam Bears on Girder*	Beam Connected to Girder with Steel Angles*	Beam Connected to Girder with Proprietary Concealed Face-Mounted Knife Plate Connector*	Beam Connected to Girder with Proprietary Hanger*

**Table 8 in the WoodWorks Index of Mass Timber Connections*

Like any other, mass timber connections should be based on well-established principles of structural mechanics. Minimum requirements and guidelines are standardized in a variety of sources, including but not limited to: the IBC; American Society of Civil Engineers (ASCE/SEI 7) Minimum Design Loads and Associated Criteria for Buildings and Other Structures; American Wood Council National Design Specification® for Wood Construction; APA – The Engineered Wood Association APA T300 Glulam Connection Details Construction Guide (APA T300); and American Institute of Steel Construction (AISC) Manual of Steel Construction.

Learn More

Project Name	Hidden Creek Community Center
Location	Hillsboro, OR
Size	51,000 ft^2
Owner/Developer	City of Hillsboro
Architect	Opsis Architecture
Structural Engineer	KPFF
Contractor and Timber Installer	Swinerton Builders
Imagery	Christian Columbres

Durability and Moisture Management

For durability and moisture management, mass timber components should remain warm and dry throughout the building's construction and occupancy. This is achieved by effectively managing moisture exposure during construction, by ensuring the building enclosure is designed with the necessary layers to control the loads on the enclosure, and by providing the mass timber elements an opportunity to dry out if wetted unexpectedly. This RDH Mass Timber Building Science Primer covers best practices for moisture control starting in the design phase through to construction and operation. It describes strategies to mitigate any risks when exposing the mass timber enclosure and other elements, including floors, to moisture during construction and occupancy.

Learn More

Timber Construction

As an organization that provides free project support related to the design, engineering and construction of wood buildings in the U.S., WoodWorks has experienced the growth of mass timber up close. The program began seeing a significant increase in mass timber projects in 2015, driven largely by design team interest in wood's light carbon footprint, sustainability, and aesthetics. Developers soon began seeing quantitative value in mass timber's installation speed and the market distinction offered by the beauty of exposed wood structures. However, as interest grew, they realized that because there had yet to be a critical mass of mass timber projects undertaken in the U.S., it was difficult to find general contractors and installers with significant mass timber experience—because there wasn't yet a critical mass of projects to gain experience on—which was ultimately preventing more of these buildings from being realized. To help contractors and installers gain the experience needed to successfully bid and complete projects, WoodWorks launched its Mass Timber Construction Management Program.

Project Name	1 De Haro
Location	San Francisco, CA
Owner/Developer	SKS Partners
Architect	Perkins&Will
Structural Engineer	DCI Engineers
Contractor	Hathaway Dinwiddie Construction Company
Imagery	Kyle Jeffers

Mass Timber Construction Management

The WoodWorks Mass Timber Construction Management Program helps GCs and installers gain the experience they need to successfully bid and complete projects. It includes two distinct elements—project management curriculum and installer training—which are both supported by the foundational U.S. Mass Timber Construction Manual.

Mass timber is unique in that it draws installation techniques from other construction types, which means that professionals with concrete, precast, tilt-up, and structural steel experience can readily adapt to these materials. Understanding how mass timber differs from other building systems, however, is key to cost effectiveness. The manual gives contractors and installers a framework for the planning, procurement, and management of mass timber projects and provides a bridge from their experience with other systems. While intended primarily for these individuals, it is a useful reference for all members of a mass timber project team.

Learn More

> **Mass timber allows us to highlight design precision and high-quality construction. Exposing wood allows us to celebrate the structure rather than spend money to cover it up.**

MATT COVALL
SENIOR ASSOCIATE
PERKINS&WILL

Mass Timber Business Case Studies

Get an insider's look into the business case and financial models behind successful mass timber projects. From detailed timelines and product strategy to investment highlights and quantitative overviews, developers share how their projects penciled out as well as valuable lessons learned and key performance metrics. Projects featured in this collection include The Canyons, a for-rent institutional housing project in Portland, OR; Clay Creative, an institutional office project also in Portland, OR; Timber Lofts, a residential redevelopment and addition in Milwaukee, WI; and The ICE Blocks, an institutional office in Sacramento, CA. Business case studies are prepared by WoodWorks in partnership with investment and development experts to address the performance of U.S. properties constructed with mass timber structural systems. Future editions will include additional case studies covering a range of project subtypes, mass timber products, and geographic locations.

Learn More

Project Name	1 De Haro
Location	San Francisco, CA
Owner/Developer	SKS Partners
Architect	Perkins&Will
Structural Engineer	DCI Engineers
Contractor	Hathaway Dinwiddie Construction Company
Imagery	David Wakely

Solutions for Building Taller

The rising demands placed on the built environment are significant in the face of rapid population growth.[13] Design teams are being asked to deliver sustainable and affordable solutions that accommodate more density, provide much-needed housing, combat climate change, and boost health and well-being.

Mass timber products are facilitating new opportunities to build taller wood buildings, a design typology that can play an important role in meeting this diverse list of needs. Internationally and here at home, there are a growing number of mass timber buildings over eight stories tall thanks to advancing technologies and a growing body of research demonstrating their safety and strength. The 2021 IBC includes 17 code changes that allow mass timber structures up to 18 stories—and in some jurisdictions, timber buildings go even taller through the use of an alternate means process.

At the time of publication, jurisdictions that have adopted the tall mass timber provisions in the 2021 IBC, either whole or with local amendments, include California, Maine, Oregon, Utah, Washington. and Virginia, as well as the cities of Denver, Colorado and Austin, Texas. The list is expected to grow quickly, however, as several other jurisdictions are considering adoption. Others are also in the process of adopting the 2021 IBC as a whole.

In this section, several case studies demonstrate how tall wood construction can meet residential, office, and mixed-use commercial needs. Resources include an Ask the Expert Q+A answering questions related to the fundamentals of tall timber construction as well as summaries and links to four technical papers focused on taller mass timber buildings. These papers address emerging code changes, shaft wall requirements, fire-resistance ratings, and considerations related to concealed spaces.

Mass Timber Buildings and the IBC (jointly developed by ICC and AWC), provides an invaluable overview of requirements for mass timber construction as found in the 2021 IBC.

Tall Wood Buildings in 2021 IBC

Required Fire-Resistance Ratings by Construction Type (IBC Table 601)

Building Element	I-A	I-B	IV-A	IV-B	IV-C	IV-HT
Primary Structural Frame	3*	2*	3	2	2	HT
Ext. Bearing Walls	3*	2*	3	2	2	2
Int. Bearing Walls	3*	2*	3	2	2	1/HT
Floor Construction	2	2*	2	2	2	HT
Roof Construction	1½*	1*	1½	1	1	HT

**These values can be reduced based on certain conditions in IBC 403.2.1, which do not apply to Type IV buildings.*
Source: Tall Wood Buildings in the IBC: Up to 18 Stories of Mass Timber, WoodWorks

In 2019 the ICC approved a set of proposals to allow tall wood buildings as part of the 2021 IBC opening up new opportunities for mass timber. Based on these proposals, the 2021 IBC includes three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber or noncombustible materials. These new types are based on the previous Heavy Timber construction type (renamed Type IV-HT) but with additional fire-resistance ratings (FRR) and levels of required noncombustible protection. This technical paper provides an overview of these changes accommodating up to 18 stories of Type IV-A construction for Business and Residential Occupancies.

To meet specific fire performance standards set out by the IBC these new construction types in some cases require noncombustible protection. All mass timber in Type IV-A construction requires noncombustible protection. Most of the mass timber in Type IV-B requires noncombustible protection with limited exposed mass timber elements. This noncombustible protection increases the fire-resistance rating of the mass timber element.
Along with a summary of code changes, the paper outlines the results of fire tests, managed by the AWC and the U.S. Forest Products Laboratory at the US Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Fire Research Laboratory, that were instrumental to the adoption of these new construction types into the code.

Learn More

Mass Timber Buildings and the IBC® Code Guide

Jointly developed by ICC and AWC, this handbook provides an overview of requirements for mass timber construction as found in the 2021 IBC. The document reviews the 2015 IBC's recognition of CLT, the reorganization of heavy timber provisions in the 2018 IBC, followed by the historic changes in the 2021 IBC and International Fire Code® (IFC®) for tall mass timber construction.

More than 100 full-color Imagery, illustrations, and tables enhance comprehension and help users visualize code requirements. Content accurately reflects mass timber provisions in the 2015, 2018, and 2021 IBC, and 2021 IFC. Results are provided for five fire tests in a fully furnished structure constructed to simulate Types IV-A, IV-B, and IV-C. Includes detailed examples of code application and methods of determining code compliance, application of energy, sound transmission, structural loads, and other code provisions to mass timber construction. For users preparing for ICC certification exams, the book includes 50 practice questions.

Learn More

Project Name	The Canyons
Location	Portland, OR
Owner/Developer	Kaiser Group Inc
Architect	Path Architecture
Structural Engineer	Catena Consulting Engineers
Contractor	R&H Construction
Imagery	Jeremy Bitterman

INTRO

Tall Timber Adds Distinction to Coveted Cleveland Locale

When Chicago-based Harbor Bay Real Estate Advisors acquired a coveted corner lot adjacent to Cleveland, OH's well-known West Side Market, they embraced the opportunity to honor the cultural prestige of their historic surroundings. The resulting development, dubbed INTRO, will be the city's first—and one of America's tallest—mass timber buildings.

Partnering with design firm Hartshorne Plunkard Architecture (HPA), Harbor Bay's 115-foot tall, nine-story mass timber complex will provide 300 apartments—many with unobstructed lake and skyline views. The design team considered traditional concrete and steel construction, but then looked to mass timber as an opportunity to achieve project goals including aesthetics, speed of construction, and environmental performance. According to Harbor Bay, INTRO's construction time has been about 25 percent faster than typical concrete or steel construction, which was achieved by streamlining the project's workflow and carefully managing just-in-time delivery and trade coordination.

Location	Cleveland, OH
Size	512,000 ft^2
Owner	Harbor Bay Real Estate Advisors
Architect	Hartshorne Plunkard Architecture (HPA)
Structural Engineer	Fast+Epp
Mass Timber Supplier	Binderholz
Timber Procurement and Installation	Seagate Mass Timber Inc.
Contractor	Panzica Construction
Completed	2022
Imagery	ImageFiction

Nearly half of the building's interior surfaces feature exposed structural wood, including precisely cut glulam beams and columns, as well as CLT floors and ceilings in the units' bedrooms and living rooms. This approach was guided by an Alternatively Engineered Design report specifying how the tall wood building could safely include an exposed timber interior.

The resulting mass timber structural system consists of 3,000 cubic meters of blond hem-fir and spruce trees harvested in the Austrian Alps. Eight of the nine stories, set atop a one-story concrete podium, will use mass timber. The project also features an acre of public green space, 40,000 square feet of new ground-floor retail, and a top-floor event venue with 55-foot-long roof trusses. The project is set to be completed in spring 2022.

Learn More

Ask an Expert

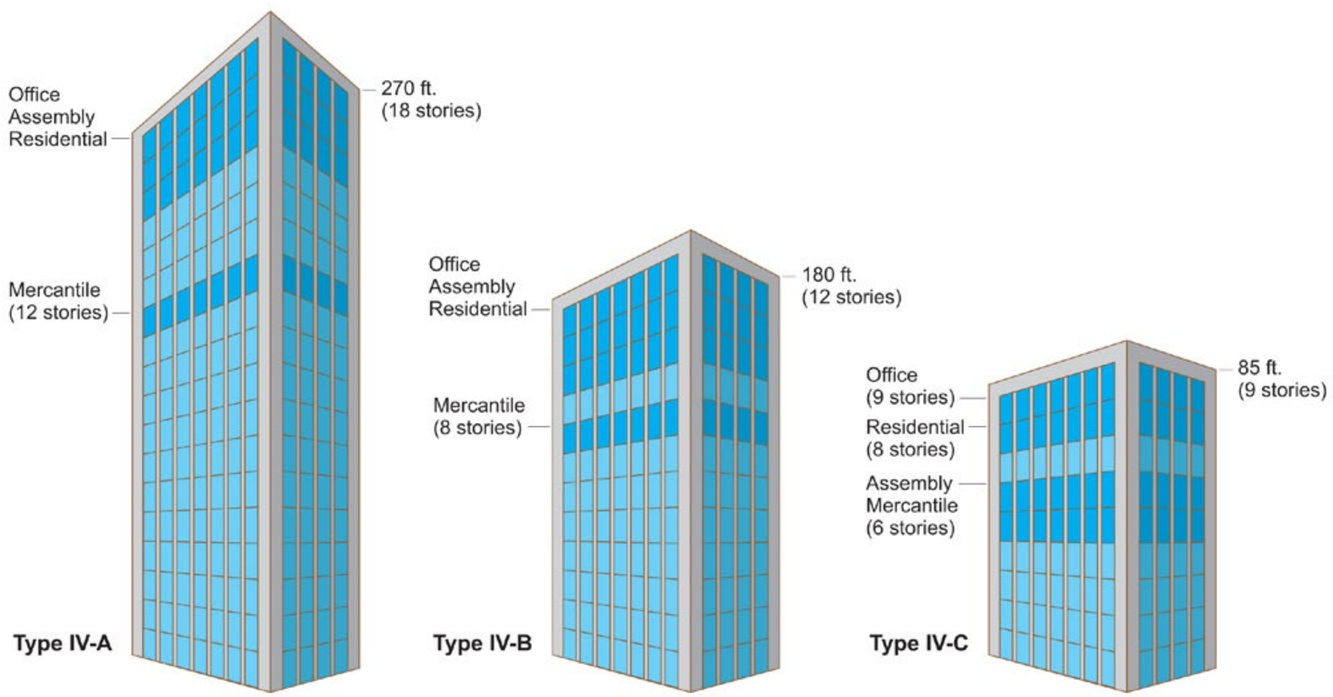
Over the past decade, there has been growing interest in tall buildings constructed from mass timber as a means to achieve greater urban density through more sustainable construction. In this Q&A, WoodWorks' mass timber experts answer some of the most frequently asked and fundamental questions about tall mass timber design and construction.

What is the current status of tall mass timber buildings in the building code?

In the U.S., the 2021 IBC includes three new construction types—Type IV-A, IV-B, and IV-C. These construction types are based on the previous Heavy Timber construction type (Type IV, changed to IV-HT in the 2021 IBC) but with additional requirements regarding fire-resistance ratings and the use of non-combustible protection. To read more about the ongoing status of the 2021 IBC and jurisdictions that have adopted the tall wood code provisions visit WoodWorks' website.

What are the height limits for the new construction types?

The 2021 IBC's three new construction types—Type IV-A, IV-B and IV-C—allow the use of mass timber or noncombustible materials in buildings up to 18, 12 and nine stories (respectively).



How much timber can be exposed in Types IV-A, IV-B, IV-C and IV-HT construction?

The following chart provides a breakdown of exposure limits by building type.

Required Noncombustible Protection on Mass Timber Elements by Construction Type

	IV-A	IV-B	IV-C	IV-HT
Timber Exposure Allowances	No exposed timber permitted	Ceilings and integral beams up to an area equaling 20% of fire area or dwelling unit area or Walls and integral columns up to an area equaling 40% of fire area or dwelling unit area or A combination of each, with the sum of ratios (actual exposed divided by allowable exposed) not to exceed 1.0	Full interior timber exposure permitted*	Full interior timber exposure permitted*
Interior Surface of Building Elements	Always required. 2/3 of FRR, 80 minutes minimum	Required with exceptions. 2/3 of FRR, 80 minutes minimum	Not required*	Not required*
Exterior Side of Exterior Walls	40 minutes	40 minutes	40 minutes	15/32" FRT sheathing or 1/2" gypsum board or noncombustible material
Top of Floor (above Mass Timber)	1" minimum	1" minimum	Not required*	Not required*
Shafts	2/3 of FRR, 80 minutes minimum, inside and outside	2/3 of FRR, 80 minutes minimum, inside and outside	40 minutes minimum, inside and outside	Not required*

**Not required by construction type. Other code requirements may apply.*
5/8" Type X gypsum = 40 minutes.

What are the fire-resistance rating requirements for tall mass timber?

FRR Requirements for Tall Mass Timber Structures (hours)

Building Element	I-A	I-B	IV-C
Primary Frame	3	2	2
Ext. Bearing Walls	3	2	2
Int. Bearing Walls	3	2	2
Roof Construction	1.5	1	1
Primary Frame at Roof	2	1	1
Floor Construction	2	2	2

Source: 2021 IBC Table 601

What are some examples of tall mass timber projects recently completed in the U.S.?

Some notable U.S.-based tall mass timber projects that go beyond the prescriptive limits of previous versions of the IBC include:

- Carbon12 – Portland, OR – Eight stories of mass timber
- INTRO – Cleveland, OH – Eight stories of mass timber over a concrete podium
- Ascent – Milwaukee, WI – Nineteen stories of mass timber over six stories of concrete
- 80 M Street – Washington, DC – Two new mass timber floors and a habitable penthouse over an existing seven-story structure
- Apex Plaza – Charlottesville, VA – Six stories of mass timber over two stories of concrete
- 11 E Lenox – Boston, MA – Seven stories of mass timber

Learn More

Shaft Wall Requirements in Tall Mass Timber Buildings

This paper builds on Tall Wood Buildings in 2021 IBC and provides an in-depth look at the requirements for shaft walls, including when and where wood can be used.

A shaft is defined in Section 202 of the 2021 IBC as “an enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and roof.” This applies to stairs, elevators, and mechanical/electrical/plumbing (MEP) chases in multi-story buildings.

Tall wood structures using construction types IV-A, IV-B, or IV-C must be constructed from mass timber or noncombustible materials (or a combination thereof). This means that mass timber may be used for shaft walls in tall wood construction Types IV-A, IV-B, and IV-C, with one exception: Type IV-A buildings that exceed 12 stories or 180 feet. When used as shaft walls in Type IV-B or IV-C buildings (or IV-A buildings that do not exceed 12 stories or 180 feet) mass timber must be covered on both faces with noncombustible materials.

Shaft enclosures are required to have an FRR of not less than 2 hours when connecting four or more stories. An FRR of not less than 1 hour is required for shaft enclosures connecting less than four stories. Shaft enclosures are also required to have an FRR not less than the floor assembly penetrated.

Mass timber shaft walls are required to have noncombustible protection: 80 minutes for Types IV-A and IV-B (or 120 minutes for load-bearing shaft walls in Type IV-A), and 40 minutes for Type IV-C. The remaining time required to meet the full 2-hour FRR (or 3-hour FRR for load-bearing shaft walls in Type IV-A) must be demonstrated through the inherent fire resistance of the mass timber element, or by other means approved by the building official.

In addition to the FRR and contribution of noncombustible protection, designers must consider factors such as acoustics and structural loads when choosing shaft wall assemblies for tall wood buildings.

Learn More

Ascent

Mass Timber Reaches New Heights in Milwaukee

With construction set to be completed in summer 2022, Ascent (located in Milwaukee, WI's East Town neighborhood) is currently the tallest timber tower in the world. The 493,000-square-foot, mixed-use building includes 259 apartments, a wellness and fitness center, and a top-floor amenity level. Extensive BIM modeling and numerical coding of every mass timber component helped to speed up construction. According to the project's general contractor, a conventional concrete and steel structure of this kind would typically take 8 days per floor to complete—but with mass timber, the project team completed a new floor every 5 to 6 days.[14] Due to the expansive use of wood, Ascent represents a carbon benefit equal to removing 2,350 cars from the road for one year.[15]

The project's fitness amenities boast a unique indoor/outdoor pool with retractable glass walls that bring the outdoors inside during warm weather while also offering year-round use for residents. The entire top floor features a 360-degree view, including two rooftop terraces with panoramic sights of Milwaukee and Lake Michigan. Nineteen residential stories are constructed from mass timber above a six-story concrete magazine housing the building's parking garage. A system of glulam beams and columns support 5-ply CLT floors while two concrete cores provide lateral stability.

Location	Milwaukee, WI
Size	493,000 ft^2
Architect	Korb + Associates Architects
Developer	New Land Enterprises & Wiechmann Enterprises
Structural Engeer/Mass Timber Design Program	Thornton Tomasetti
Contractors	C.D. Smith Construction (lead builder) and Catalyst Construction
Completed	2022
Imagery	New Land Enterprises

To reach 25 stories in height and expose 50% of the mass timber, the City of Milwaukee required the project team to demonstrate that Ascent could meet the rigorous fire safety standards of a Type I building. Subsequent fire testing proved that the timber structural members not only met, but exceeded fire rating requirements, clearing the pathway to approvals.

Learn More

Demonstrating Fire-Resistance Ratings for Mass Timber Elements in Tall Wood

Changes to the 2021 IBC have created opportunities for wood buildings that are larger and taller than allowed in past versions of the code. Occupant safety, and the need to ensure fire performance in particular, was a fundamental consideration as the changes were developed and approved. The primary way to demonstrate that a building will meet the required level of passive fire protection, regardless of structural materials, is through hourly FRRs of its elements and assemblies.

FRRs for the new mass timber construction types are similar to those required for Type I construction, which is primarily steel and concrete. In addition to meeting FRR requirements, all mass timber elements used in Types IV-A, IV-B, and IV-C construction must meet minimum size criteria prescribed in IBC Section 2304.11.

Definitions of the new construction types, found in IBC Sections 602.4.1, 602.4.2, and 602.4.3, dictate that only mass timber or noncombustible materials can be used for the structural systems. This includes guidelines for whether the wood may be exposed on the building's interior, or must be covered with noncombustible protection. The exception: no exposed timber is allowed at shaft walls, within concealed spaces, or on the exterior side of exterior walls.

General allowances for exposed timber include:

- Type IV-A: No exposed timber permitted
- Type IV-B: Limited exposed timber permitted, as follows:
    - Ceilings (including integral exposed beams) up to 20% of floor area in dwelling unit or fire area,or
    - Walls (including integral exposed columns) up to 40% of floor area in dwelling unit or fire area, or
    - A combination of each using sum of ratios (actual exposed/ allowable exposed wood) not to exceed 1.0
- Type IV-C: All exposed timber permitted

The paper includes a review of contribution of noncombustible protection to FRR, contribution of mass timber to FRR, noncombustible protection on top of mass timber floors and example assemblies.

Learn More

Project Name	Lakeview Office Building
Location	Kirkland, WA
Owner/Developer	Mount Baker Holdings, LLC
Architect	LMN Architects
Structural Engineer	Coughlin Porter Lundeen
Contractor	Sierra Construction
Imagery	Benjamin Benschneider

Apex Plaza

Clean Energy Meets Tall Timber Ambitions

Inspired by the natural strength, resilience, and beauty of trees themselves, Apex Clean Energy's Charlottesville, VA headquarters is built with a mass timber structure and other natural materials that harvest energy from the sun, resulting in a built expression of the firm's corporate values. The eight-story tall wood building will serve as the central hub for the locally-owned clean energy company and is the first large-scale mass timber project in Virginia.

By prioritizing clean power generation, on-site battery storage, and state-of-the-art efficiency initiatives, Apex Plaza makes the transition from energy consumption to energy optimization. A total of 875 roof-and canopy-mounted solar panels are expected to produce 364,000 kWh/year of electricity, equivalent to the annual energy use of 50 homes and supplying 60% of the energy demand of Apex's offices.[16]

Location	Charlottesville, VA
Size	187,000 ft^2
Owner	Apex Clean Energy
Architect	William McDonough + Partners, Design Architects
Structural Engeer	Simpson Gumpertz & Heger
Mass Timber Fire Engineering Consultant	ARUP
Contractor	Hourigan
Completed	2021
Imagery	William McDonough + Partners

The six-story CLT panel and glulam post-and-beam structure is built over a concrete podium. The nearly all-wood structure uses 1.6 million board feet of black spruce, which North American forests can grow in a mere seven minutes,. and creates a carbon benefit equal to the amount of energy needed to power 300 homes for a year.[17]

Apex Plaza prioritizes occupant well-being, from excellent views and natural sunlight to automated lighting controls and operable shades. The building's green roof creates a habitat to promote biodiversity and stormwater retention, and Cradle to Cradle Certified® products were incorporated wherever possible. The timber structure was designed to be deconstructed and disassembled by specifying only mechanical fasteners. When the building's service life ends, Apex's mass timber elements can be reused as part of a circular economy.

Learn More

I’m not sure the development team appreciated what they were going to get with mass timber until it came to life. It’s such a different, unique experience that really differentiates the property from anywhere else.

SOPHIA RAZZAQUE
ASSOCIATE
LAKE|FLATO

Concealed Spaces in Mass Timber and Heavy Timber Structures

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 IBC to address the potential of fire spread in non-visible areas of a building.

The choice of construction type can have a significant impact on concealed space requirements for mass timber building elements. Because mass timber products such as 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, glulam, NLT, structural composite lumber (SCL), and tongue-and-groove (T&G) decking—can be used and exposed in the following construction types, whether or not a fire-resistance rating is required.

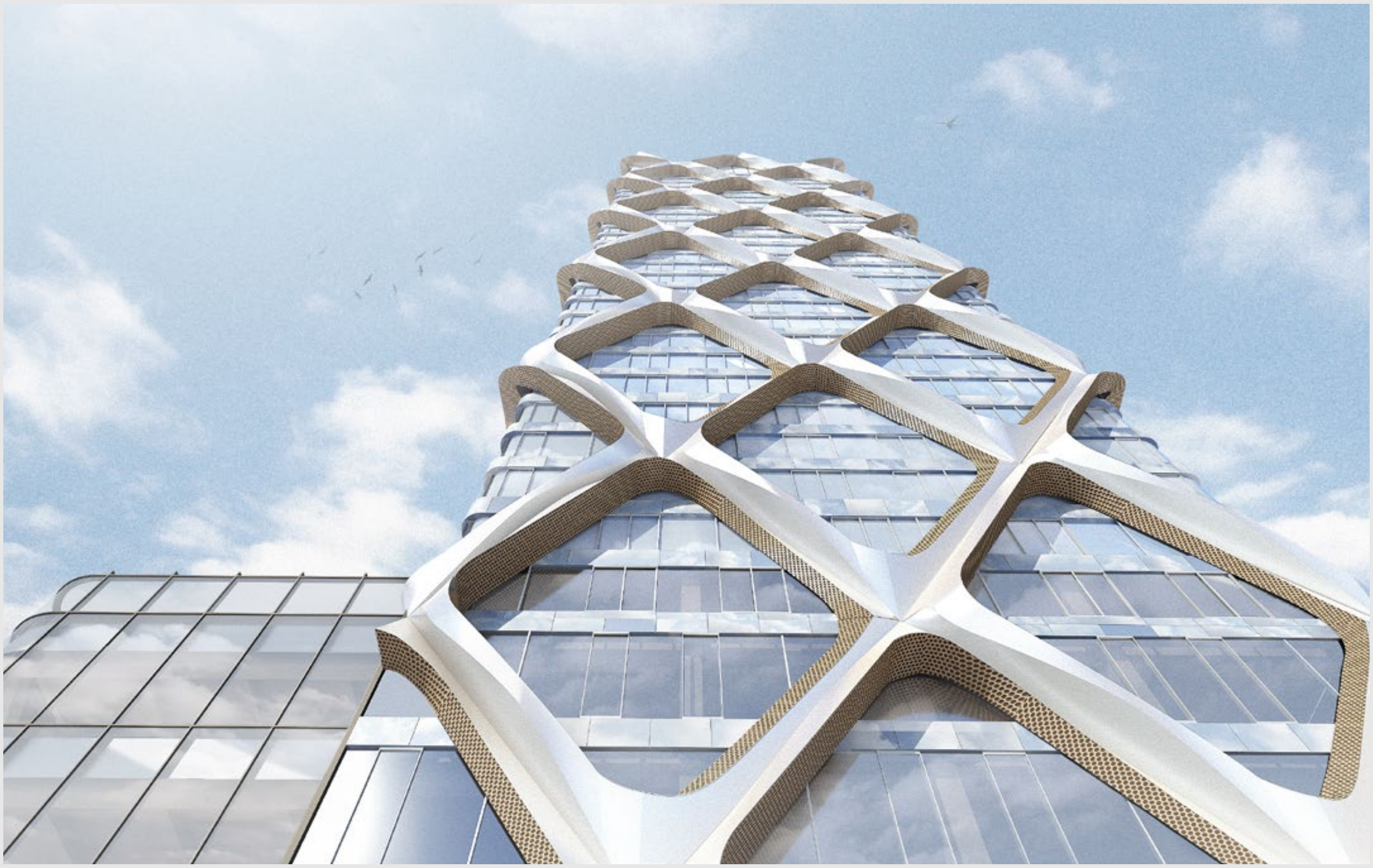
- Type III – Floors, roofs, and interior walls may be any material permitted by code, including mass timber; exterior walls are required to be noncombustible or fire retardant-treated wood.
- Type V – Floors, roofs, interior walls, and exterior walls (i.e., the entire structure) may be constructed of 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.

In addition, this paper delves into allowances and requirements for concealed spaces in low-rise, mid-rise and tall wood buildings, and mechanical plenums in mass timber buildings.

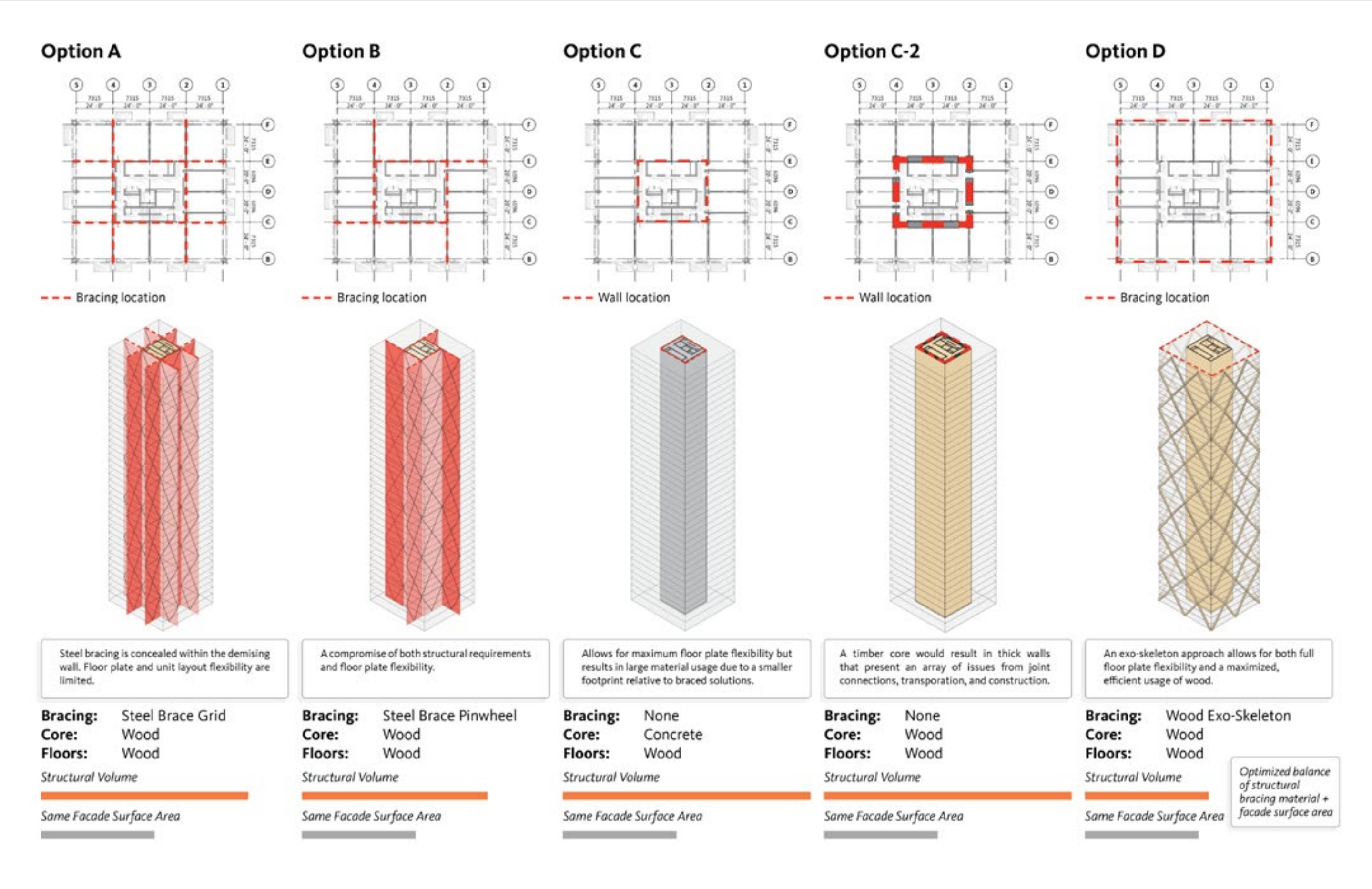
Learn More

PMX-35

A Prototype of the World's Tallest Net-Zero Timber Building



Proto-Model X, (PMX-35) is a prototype exploring how prefabricated, offsite manufacturing can produce replicable timber building components to reach greater heights than ever before. Designed by Gensler and Michael Green Architecture (MGA) in partnership with Alphabet-backed Sidewalk Labs, the project approach is borrowed from product manufacturing where it's common to design and test prototypes before launching into full-scale production. As a digital proof-of-concept, the prototype stands in for a real building, providing insight into its hypothetical performance.



The 472,000-square-foot building prototype is designed to accommodate 35-stories of retail, offices, residential, and integrated building services, which are housed below ground to maximize efficiency. Standing at approximately 426 feet tall and 158 feet wide, PMX-35 uses a cross-brace frame and tuned mass timber—engineering tactics typical of tall building design. All components in PMX-35's 'kit-of-parts' are modular and interlocking, including infrastructure like plumbing. Standardization of the parts enables the manufacturing process to be faster and more predictable, and their interlocking nature enables easy on-site assembly.

PMX-35 was developed through collaboration with a world-class team of architects, engineers, and environmental designers, many of whom are emerging leaders in the field of mass timber buildings.

Learn More

Mass Timber and Sustainability

When it comes to ensuring a more sustainable built environment, material choices matter. Wood is a naturally renewable material for building, with a lighter environmental footprint than steel or concrete. Increasing the use of mass timber products can play an important role in achieving ambitious eco-friendly design goals and low or even zero carbon construction.

Timber stores carbon and, with the least embodied energy of all major building materials, it requires less energy from harvest to transport, manufacturing, installation, maintenance, and disposal or recycling. Harvesting and replanting increases forests' carbon sink potential as the rate of sequestration is greater during young, vigorous growth. Active forest management, or forest thinning, mitigates wildfires, cuts carbon emissions, replenishes area waterways, expands wildlife habitat, and creates jobs in rural areas.

Mass timber's sustainability as a building material rests on the sustainability of our forest practices. North America has more certified forests than anywhere else in the world, a seal of approval based on the latest best practices. Forest management in the U.S. operates under federal, state, and local regulations to protect water quality, wildlife habitat, soil, and other natural resources. Modern forestry standards ensure a continuous cycle of growing, harvesting, and replanting. In fact, strong markets for wood products encourage forest owners to keep their lands as forests and invest in practices to keep trees healthy.

In this section, several case studies demonstrate how mass timber can meet ambitious sustainability objectives in diverse regions of the country. The Ask an Expert Q&A answers common questions design teams may have about carbon accounting and the impact of mass timber on the health of our forests. Resources include summaries and links to helpful information and continuing education courses.

"When it comes to cutting carbon in the built environment, one of the biggest opportunities is making mass timber mainstream. We need to shift from asking 'Why mass timber?' to 'Why not mass timber?'

STEVEN PAYNTER
OFFICE BUILDING LEADER, PRINCIPAL
GENSLER

The Impact of Wood Use on North American Forests

As green building has evolved beyond its initial emphasis on energy efficiency, greater attention has been given to the choice of structural materials and the degree to which they influence a building's environmental footprint. Increasingly, wood from sustainably managed forests is viewed as a responsible choice. When evaluating mass timber as a building material, design teams are increasingly considering long-term forest sustainability as well as attributes such as low embodied energy and light carbon footprint.

In the U.S. and Canada, forest sustainability is measured against criteria and indicators that represent the full range of forest values, including biodiversity, ecosystem condition and productivity, soil and water, global ecological cycles, economic and social benefits, and social responsibility. Sustainability criteria and indicators form the basis of individual country regulations as well as third-party sustainable forest certification programs.

Using wood in buildings can provide an incentive to landowners to keep forested lands forested instead of converting them to uses such as urban development. Learn how specifying wood can contribute to forest sustainability.

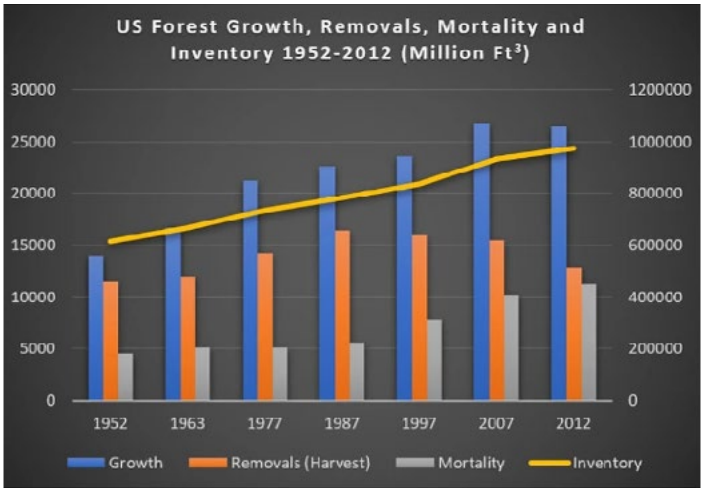
Learn More

Project Name	Girl Scouts Camp Lakota
Location	Frazier Park, CA
Owner/Developer	Girl Scouts of Greater Los Angeles
Architect	Perkins&Will
Structural Engineer	Risha Engineering
Contractor	illig Construction Company
Imagery	Here and Now Agency

Ask an Expert

Edie Sonne Hall

How do you know if the mass timber products youre specifying for a project are harvested from sustainable forests. Will an increased demand for wood products cause deforestation Forestry expert Edie Sonne Hall answers some of these questions and more. Sonne Hall has a Ph.D. in forestry from the University of Washington and specializes in forest carbon accounting and life cycle assessment. She brings over twenty years of experience developing sustainable forestry strategies and policies at the state, regional, national, and international level.



USFS 2014 US Forest Resources Facts and Historical Trends.

Does increased demand for wood products cause reduction in supply of forests?

I know it's counter-intuitive, but forest product demand can actually lead to more forests. The alternative economic hypothesis suggests that forest product demand provides revenue and policy incentives to support sustainable forest management. Industrial timber revenues can contribute to avoiding land-use change, even in the US. In general, data shows that global regions with the highest levels of industrial timber harvest and forest product output are also regions with the lowest rates of deforestation. And indeed, we can see from empirical data that higher demand leads to more supply (growth). With a higher demand for forest products, landowners have revenue and incentives to invest in forest planting and management, which can keep forests as forests and increase investment in forest productivity.

How can we be assured of forest sustainability? If we are harvesting trees, what are we doing to water, wildlife, and all those beautiful forests?

We can be assured that timber is harvested sustainably in ways that support water quality, biodiversity, and habitat through mechanisms like forest certification, responsible fiber sourcing standards, and best management practices.

Forest certification is a mechanism for forest monitoring and labeling timber, wood and pulp products, and non-timber forest products, where the quality of forest management is judged against a series of agreed standards (WWF, 2018) related to water quality, biodiversity, wildlife, and forests with exceptional conservation value. The highest level of sustainability assurance is third-party forest certification. The three major certification systems—Sustainable Forestry Initiative (SFI), Forest Stewardship Council (FSC), and American Tree Farm System (ATFS)—all have slightly different principles and procedures. There are about 96 million acres of certified forests in the US, which is about 19% of total US timberland—above the global average of 11%.

The next level of assurance can be achieved from responsible fiber sourcing. The three major responsible fiber sourcing standards are: PEFC Controlled Sources, FSC Controlled Wood, and SFI Fiber Sourcing. These requirements include measures to limit the risk of fiber coming from undesirable sources such as high conservation forests or illegally harvested forests, protect water quality, provide training to foresters, engage in research, and outreach to landowners.

An additional way to assess forest management impact on water in the US is by tracking compliance of Best Management Practices (BMPs). These are regionally appropriate guidelines for streamside buffers and road construction to reduce erosion and maintain water quality. BMPs are tracked in the US and are above 90% compliance in all states.

Does wood product demand cause deforestation?

This is, almost by definition, not true. Deforestation (land-use change) occurs when there is a higher demand for the land than wood products. Demand for wood products does not contribute to deforestation, and in fact, provides incentives to keep land as forests instead of converting it to other uses like agriculture or development. In fact, in the US and Canada, where there is a healthy forest products market, there is "extremely low risk of deforestation." Note, while the U.S. is the largest producer of industrial roundwood, not all of the wood products consumed in the U.S. are harvested domestically. Specifiers should still be aware of where their wood products come from and take appropriate precautions if sourcing from areas with higher risk of sourcing controversial wood.

Is using wood the best carbon mitigation pathway? Isn't it better to let trees grow?

Wood products as building materials are one important climate solution because they take less energy/emissions to manufacture than other materials, and store carbon through the useful lifetime of the product.

The 2016 UN Food and Agriculture Organization report, "Forestry for a Low Carbon Future," lists six key strategies for integrating forests and wood products into climate change strategies: 1) plant more trees, 2) increase carbon density/stocks in existing forests, 3) increase wood product carbon storage, 4) reduce deforestation and degradation, 5) use biomass for energy, replacing fossil fuel, and 6) use wood products in construction materials, avoiding fossil fuel emissions in manufacturing products with higher combined emissions.

That is not to say you should implement all these strategies in all forests. Wood products are one critical forest use that can be complementary with many other forest uses for climate and conservation benefits.

Project Name	The Lighthouse
Location	South San Francisco, CA
Owner/Developer	Alexandria Real Estate Equities, Inc.
Architect	Gensler
Structural Engineer	Arup
Contractor	XL Construction
Imagery	Jason O'Rear

Mass Timber Demand Research

How will demand for mass timber impact forests?

Using USDA Forest Service Forest Inventory and Analysis (FIA) data, incremental U.S. softwood timber harvests were projected to supply what would be needed for the highest-volume scenario of mass timber and light framing consumption in 2035. Growth in reserve forests and riparian zones (an area of trees located adjacent to water sources like rivers, lakes, and wetlands) were excluded and low confidence intervals were used for growth estimates, while high confidence intervals were used for harvest and consumption estimates in order to create the most conservative scenario. Results were considered for the U.S. in total and by three geographic regions (North, South, and West).

Will rising demand for mass timber products result in unsustainable levels of harvesting in coniferous forests in the United States? The answer is no. U.S. forest growth exceeds harvest levels by 18% after meeting incremental demand for both lumber and mass timber in 2035.

Overstocked forests are vulnerable to drought, disease, and insects, making them prone to high rates of tree mortality and wildfires that are very difficult to control. As part of their mass timber demand analysis, the study authors also assessed areas of opportunity to sustainably increase harvesting beyond current levels by looking at under-utilized growth by state, owner, and region. These sources can meet increased demand and make our forests more resilient without requiring any policy changes.

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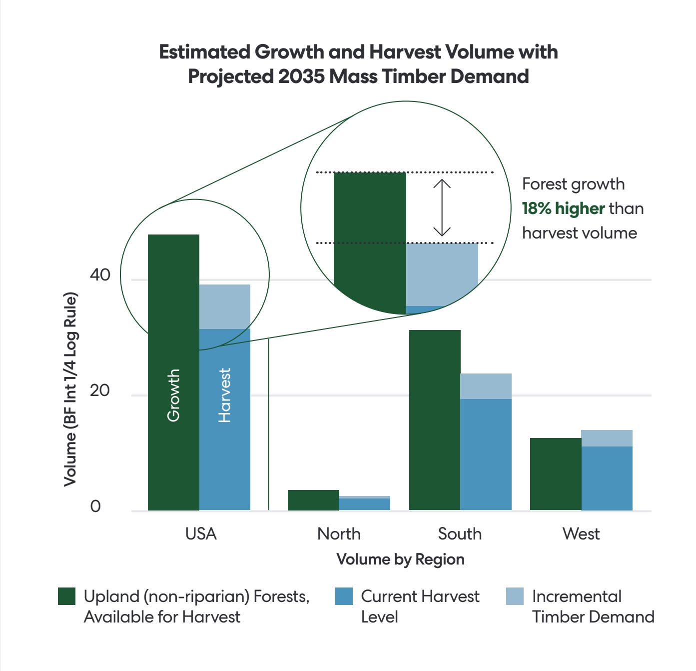


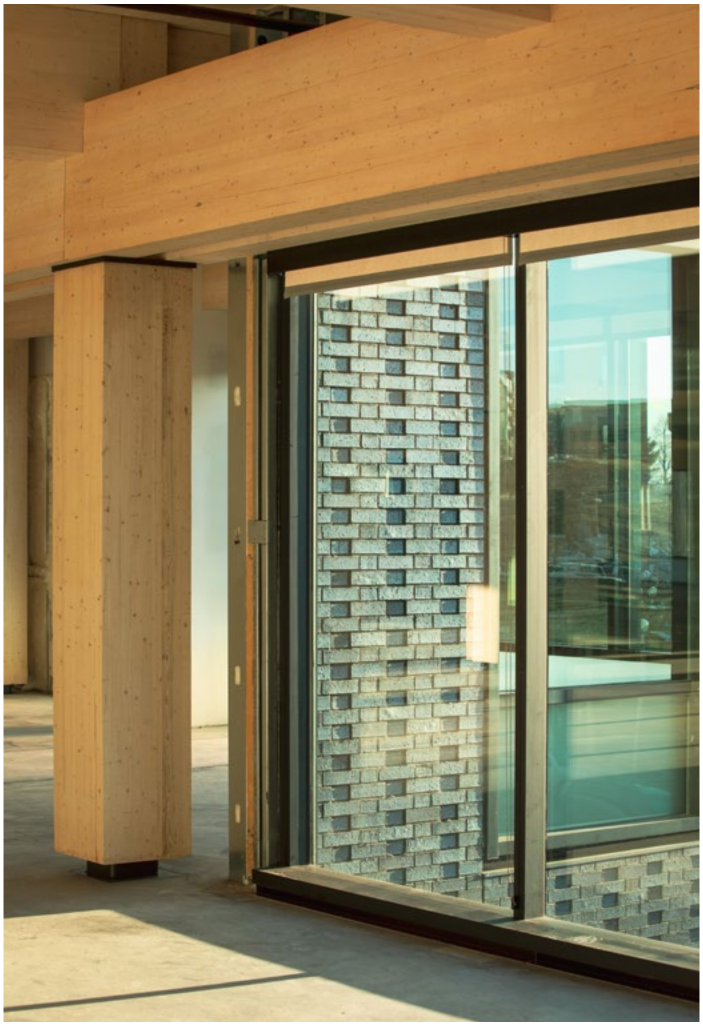
Platte 15

Denver's First CLT Workspace Brings Contemporary Sustainability to Historic Downtown

This five-story workspace–located in one of Denver's most popular neighborhoods–incorporates a mass-timber frame, built using glulam beams and columns, as well as CLT floor and roof panels.The majority of the five floors are dedicated to office space, with ground floor retail and two levels of concrete below. Soaring interior ceiling heights, outdoor patios, and a rooftop deck provide unobstructed views and plenty of appeal for potential tenants.

Sustainability was a driving factor for the design team's decision to use mass timber. "When tenants see the warmth of wood, it definitely resonates," said Conrad Suszynski, Co-CEO of Crescent Real Estate. "It also resonates with us. We're committed to sustainable building; it's intrinsic to who we are and what we aspire to be. We wanted to reduce the carbon footprint of Platte Fifteen, and mass timber helped us get there. We think it's industry's job to be pushing these trends, and we are committed to finding a way to make it all work."

Location	Denver, CO
Size	150,418 ft^2
Owner	Crescent Real Estate LLC
Architect	OZ Architecture
Structural Engeer	KL&A Engineers & Builders
Timber Supply and Installation	Nordic Structures/FGP Construction
Contractor	Adolfson & Peterson Construction
Imagery	JC Buck



A design is more sustainable when the building itself can be quickly, easily, and efficiently constructed. Platte Fifteen's mass timber system delivered on every level, reducing construction time by 20 percent compared with a traditional steel structure. Mass timber's construction and structural efficiency meant less waste. The 30×30 grid maximized tenant value, moreover leaving wood exposed to the interior eliminated the need for additional finishes.

Platte Fifteen has a relatively conventional lateral system for a five-story structure. There were no wood shear walls in the design; lateral resistance is provided by the concrete core in combination with a glulam frame with steel rod bracing. The final design includes 3-ply CLT panels with glulam beams and exposed columns with minimalized connections. The roof—which is also 3-ply CLT—supports a terrace with large tree planters and Colorado snow loads. The CLT floor panels are topped with three inches of concrete, but the team used CLT as the diaphragm instead of concrete topping.

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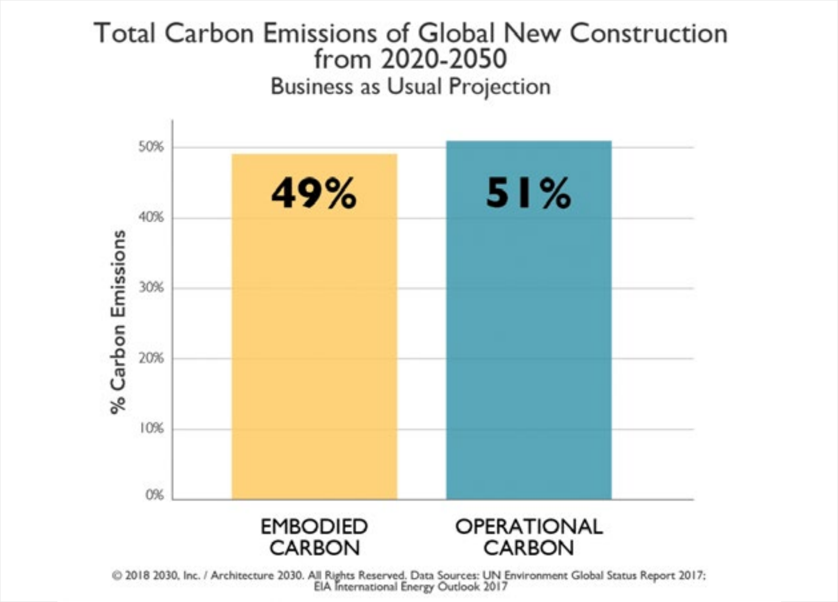
How to Calculate the Wood Carbon Footprint of a Building



Buildings consume nearly half the energy produced in the United States, use three-quarters of the electricity, and account for nearly half of all carbon dioxide (CO_2) emissions. The magnitude of their impacts is the driving force behind many initiatives to improve tomorrow's structures—from energy regulations and government procurement policies, to green building rating systems and programs such as the Architecture 2030 Challenge.

The building sector has a critical role to play in what happens over the next 30 years. Not only do buildings account for almost 40 percent of global GHG emissions, but the increasing urbanization of the population means that 2.48 trillion square feet of building is expected to be added to the global building stock by 2060. This number is essentially double the current building stock, making the choice of materials in buildings over the next decades that much more important.

Understanding a material's impact at every stage of its life is essential for designers looking to compare alternate designs or simply make informed choices about the products they use. Life-cycle assessment (LCA) is an internationally recognized method for measuring the environmental impacts of materials, assemblies, or whole buildings from extraction or harvest of raw materials through manufacturing, transportation, installation, use, maintenance, and disposal or recycling.

How to Calculate the Wood Carbon Footprint of a Building

One of the reasons wood tends to have lower embodied carbon is that it requires far less energy to manufacture than other materials—and very little fossil-fuel energy, since most of the energy used comes from converting residual bark and sawdust to electrical and thermal energy. For example, the production of steel, cement, and glass requires temperatures of up to 3,500 degrees Fahrenheit, which is achieved with large amounts of fossil-fuel energy.

Embodied carbon of different materials can be compared if they have the same functional equivalency, which means they provide the same service for the same length of time. The difference between these two values is referred to as the substitution benefit, meaning the avoided emissions achieved by using the lower embodied carbon material instead of the higher embodied carbon material. LCA studies consistently demonstrate wood's substitution benefits.

Wood is comprised of about 50 percent carbon by dry weight, and a wood building is providing physical storage of carbon that would otherwise be emitted back into the atmosphere. In a wood building, the carbon is kept out of the atmosphere for the lifetime of the structure—or longer if the wood is reclaimed and reused or manufactured into other products. In 2013, one study estimated the global stock of carbon stored in wood products in use was approximately 19,671 Gt (billion metric tons) CO_2e, increasing an average of 315.3 Gt CO_2e/yr.

Architects and engineers can use whole building LCA tools to help evaluate environmental impacts of building designs. These tools use life-cycle inventory data to readily assess material choices. For example, the Athena Impact Estimator for Buildings gives users access to life-cycle data without requiring advanced skills.

An EPD is a standardized, third-party-verified label that communicates the environmental performance of a product. Data for an EPD is based on an LCA report, third-party verified for conformance to a specific set of product category rules (PCR).

Growing forests absorb, store, and release carbon over extended periods of time. This cycle is a closed-loop cycle through natural processes of growth, decay, and disturbances. It is also a closed-loop cycle when forests are harvested for use in products or energy. The biogenic carbon cycle fundamentally differs from the open/one-way flow of fossil carbon to the atmosphere.

No one material is the best choice for every application. There are tradeoffs associated with each, and each has benefits that could outweigh the other material choices based on a project's design objectives. Nonetheless, with growing pressure to reduce the environmental impacts of buildings beyond operational performance, LCA is an important tool helping designers make wise low carbon material choices, such as mass timber.

Learn More

John W. Olver Design Building at the University of Massachusetts Amherst

Exposed Mass Timber Structure As a Teaching Tool

The John W. Olver Design Building at the University of Massachusetts Amherst could be described as a 'living-learning' facility for architecture; building and construction technology; and landscape architecture and regional planning. Designed to be as much a lesson in itself as a place to learn, the building demonstrates to students firsthand advanced sustainable design and building technologies.

The four-story, 87,500-square-foot John W. Olver Design Building at the University of Massachusetts Amherst features a glulam column-and-beam frame, glulam brace frame, CLT shear walls, timber-concrete composite floor system, and unconventional cantilevered forms.

Location	Denver, CO
Size	150,418 ft^2
Owner	Crescent Real Estate LLC
Architect	OZ Architecture
Structural Engineer	KL&A Engineers & Builders
Timber Supply and Installation	Nordic Structures/FGP Construction
Contractor	Adolfson & Peterson Construction
Imagery	Albert Vererka / Esto

As is often the case with innovative building designs, there were additional measures needed to get code approval. “Transparent and early engagement with building officials was very important,” said Chung. “We initiated discussions with the state building inspector during schematic design and provided updates at all critical stages. By the time the construction documents were done and we were ready to submit for official variances, the building inspector had all the information he needed to write a letter of support to the variance committee.”

Life cycle assessment (LCA) was used to quantify the environmental benefits of using a mass timber structure. Along with carbon storing benefits, the facility saves the equivalent of over 2,500 metric tons of carbon when compared to a traditional energy-intensive steel and concrete building.

The facility meets Massachusetts’ stretch energy code, which emphasizes energy performance, over prescriptive requirements. Results are promising: the facility is already surpassing its energy targets. It is predicted to have a total site energy use intensity (EUI) of 43 kBTU/SF/year, compared against an EUI of 62 kBTU/SF/year for the baseline design—a 50% improvement over the base code.

To learn more consult the Environmental Building Declaration—Design Building, University of Massachusetts, Amherst Technical Report and Summary.

Learn More

Project Name	University of Denver Burwell Center for Career Achievement
Location	Denver, CO
Owner/Developer	University of Denver
Architect	Lake|Flato & Shears Adkins Rockmore Architects
Structural Engineer	KL&A
Contractor	PCL Construction Services
Imagery	Frank Ooms

The Role of Wood Products in Green Building

Architects can incorporate sustainable features into their designs through their choice of building materials. Wood building products and components fit well within many sustainable building scenarios, while also adding other benefits such as natural warmth and beauty. It is renewable and sustainable, and wood products typically require less energy to produce than other building materials. Green building standards also recognize wood's contribution to improved energy performance over time. With two of the most well-known programs, LEED and Green Globes, it is possible to earn 8-10 percent of potential credits through substantial use of wood in construction.

Learn More

Catalyst

Mass Timber Serves as an Agent of Change

Location	Spokane, WA
Size	164,000 ft^2
Owner	Avista Development, Mckinstry, South Landing Investors LLC
Architect	Katerra (Architect Of Record) + Michael Green Architecture (Design Architect)
Structural Engeer	KPFF
Contractor	Katerra Construction
Completed	2020
Imagery	Ben Benschneider

Aptly named for its goal of inspiring new ways to build, Catalyst is the first CLT office building constructed in Washington state and the first to use panels produced at Katerra's new CLT production facility. It is also designed to meet Passive House principles and zero-carbon/zero-energy certification from the International Living Future Institute (ILFI). The five-story building also contains classroom and lab space for approximately 1,000 Eastern Washington University students studying engineering and applied sciences.

Catalyst was constructed using an all-wood structural system, including glulam columns and beams, CLT shear wall panels and glulam/CLT composite floor and roof ribbed panels. Most of the timber structure and the exterior CLT wall panels are left exposed to the interior. It is one of the first projects in North America to achieve a long span using true wood-to-wood composite action in these rib panels according to Katerra's Design Project Manager, Drew Kleman. Such composite action is typically achieved using concrete.

End-to-end design, manufacturing and assembly made for a faster, more efficient construction. For example, the design team collaborated closely with the CLT manufacturing team to optimize the fit between the desired 30×30 grid spacing and the CLT plant's capabilities.

Safety was another benefit of the CLT rib panel system since all 350 panels could be quickly lifted into place, reducing the time workers spent under a crane. Katerra ran four crews—shear walls, columns and beams, floor panels and hardware—and each had four to five people working at any one time. The entire structure took 11 weeks to erect.

Efficiency also translates to energy savings over the life of the building, according to Jim Nicolow, Director of Sustainability for Katerra. The use of large factory-built mass timber panels translates to improved airtightness of the envelope and better performance over time.

Along with efficient construction and interior beauty, mass timber makes the building a zero-carbon, climate-saving solution. "The global warming potential for Catalyst was about half what you might expect for a project like this; the median reported value in the Carbon Leadership Forum's Embodied Carbon Benchmark Study for commercial projects is 396 kg CO_2e/m^2," Nicolow said. "You not only have a low-embodied carbon building, but you have a carbon-sequestering material that essentially makes up for some of the emissions associated with the conventional materials that went into the building."

Learn More

Project Name	Hotel Magdalena
Location	Austin, TX
Owner/Developer	Unknown
Architect	Lake|Flato
Structural Engineer	StructureCraft and Architectural Engineers Collaborative
Contractor	Mycon General Contractors
Imagery	Casey Dunn

Designing Beneficial Spaces for Living, Working, and Well-being

Occupant health and well-being is more important than ever, especially given the fact that Americans, on average, are spending approximately 90 percent of their time indoors. As a result, building professionals are rethinking how we design, use, and occupy buildings. COVID-19 is also changing the ways in which buildings are designed. Design teams are incorporating touchless entries, improved ventilation systems, and design features that allow people to spread out with renewed interest.

But the increased focus on beneficial spaces is not just on occupant safety; designers are looking for simple ways to improve the way people feel inside a building, through design choices such as the use of exposed wood. When wood is left exposed as the structure or an interior finish material, it helps complement biophilic design goals as people associate the grain, texture, visual warmth, and color of wood with nature.

This resource explores architecture designed to improve the well-being of building occupants. It examines ways in which buildings can be designed to help reduce stress, promote healing, support learning, improve employee productivity, and enhance retail customer experience; and delves into the role of wellness-focused building standards and their overlap with existing green building standards.

Learn More

"Developers are starting to see that it's not always about density. We're going to have to start creating different spaces for people to live and work in. Timber goes a long way in doing what steel and concrete just can't deliver.

THOMAS CORRADO
SENIOR ASSOCIATE, SENIOR PROJECT DESIGNER
HICKOK COLE

Conclusion

As design professionals look to the decade ahead, they see many challenges—from addressing pressing environmental and social issues to accommodating rapid population growth and shifting market demands. There is also an increasing understanding that the built environment is inextricably linked to many of the complex issues of our day. While these problems are global in scale, and, in some cases, beyond the influence of the AEC industry alone, design professionals are taking action in their day-to-day practices that can begin to make an impact. Expanding the use of mass timber in all types of buildings, from industrial and commercial to civic and multifamily, can play an important role in tackling the 21st-century challenges facing the built environment.

Mass timber design applications are broad. A range of mass timber products are opening up even more possibilities—from newer innovations like CLT and DLT to tried-and-tested technologies such as NLT and glulam. Mass timber products combined with concrete, steel, and light-frame wood construction can deliver building solutions for virtually any occupancy type. They also lend well to modularized prefabrication and open flexible grid configurations.

Mass timber performs when it comes to safety, thermal efficiency, acoustics, durability, moisture management and biophilic design. Rigorous testing has proven mass timber is fire-safe and offers natural fire resistance.

Additionally, when it comes to reducing a building's environmental footprint, life cycle assessment and carbon accounting demonstrate mass timber's benefits. Not only is sustainably harvested wood a low-carbon alternative to extracting energy-intensive materials, but timber buildings store carbon, keeping it out of the atmosphere for the lifetime of the structure—and even longer if the wood is then reclaimed and reused.

With all of these advantages, understanding mass timber design and construction is quickly becoming essential knowledge for building professionals. While not entirely new, mass timber building systems are emerging technologies evolving in response to ongoing engineering advancements. As a 'living document,' this manual will be regularly updated with the most recent research, product information and other important findings to help AEC professionals stay up-to-date with the industry's latest resources.

Sources

1. 14 Patterns of Biophilic Design, Improving Health & Well-Being in the Built Environment, https://www.terrapinbrightgreen.com/reports/14-patterns/
2. Building Trends, Mass Timber, https://www.woodworks.org/publications-media/building-trends-mass-timber/
3. Designing Beneficial Spaces for Living, Working, and Well-being, https://www.thinkwood.com/education/designing-beneficial-spaces-for-living-working-and-well-being
4. https://drive.google.com/file/d/1z3F7KxFlskczo4nEYecxvZhHhJkKctv8/view?usp=sharing
5. Wood Handbook, Chapter 4, Mechanical Properties of Wood, https://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr113/ch04.pdf
6. Literature Review of Cost Information on Mid-Rise Mass-Timber Building Projects, https://sustain.ubc.ca/sites/default/files/Mass%20Timber%20Cost%20Review_2019.pdf
7. https://sustain.ubc.ca/sites/default/files/Mass%20Timber%20Cost%20Review_2019.pdf
8. Wood is Leveling Up to Combat America's Housing Crunch, Think Wood, https://www.thinkwood.com/blog/overbuilds-and-infills-level-up
9. Cross-Laminated Timber Will Save Time, Labor Costs On Local Commercial Construction Projects, https://www.bisnow.com/seattle/news/construction-development/cross-laminated-timber-will-save-time-labor-costs-on-local-commercial-construction-projects-99301
10. https://www.archpaper.com/2019/01/shigeru-ban-architects-mass-timber/
11. http://www.wooddesignandbuilding.com/wp-content/uploads/2016/11/WoodDB_S15-70_ebook.pdf
12. https://www.cityofmadison.com/dpced/planning/documents/222shs_loi.pdf
13. Urbanization, Our World in Data, https://ourworldindata.org/urbanizationv
14. https://vimeo.com/666167351
15. New Land Enterprises: https://www.dropbox.com/sh/fmvta3byw6zuop4/AAAjniNK-s3NtOt2ALCGxny5a?dl=0&preview=Ascent+-+Quick+Facts.pdf, calculated using WoodWorks' Carbon Calculator: https://www.woodworks.org/resources/woodworks-carbon-calculator
16. https://www.apexcleanenergy.com/company/sustainability/headquarters/
17. https://www.apexcleanenergy.com/company/sustainability/headquarters/
18. https://www.stateforesters.org/where-we-stand/forest-management/

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