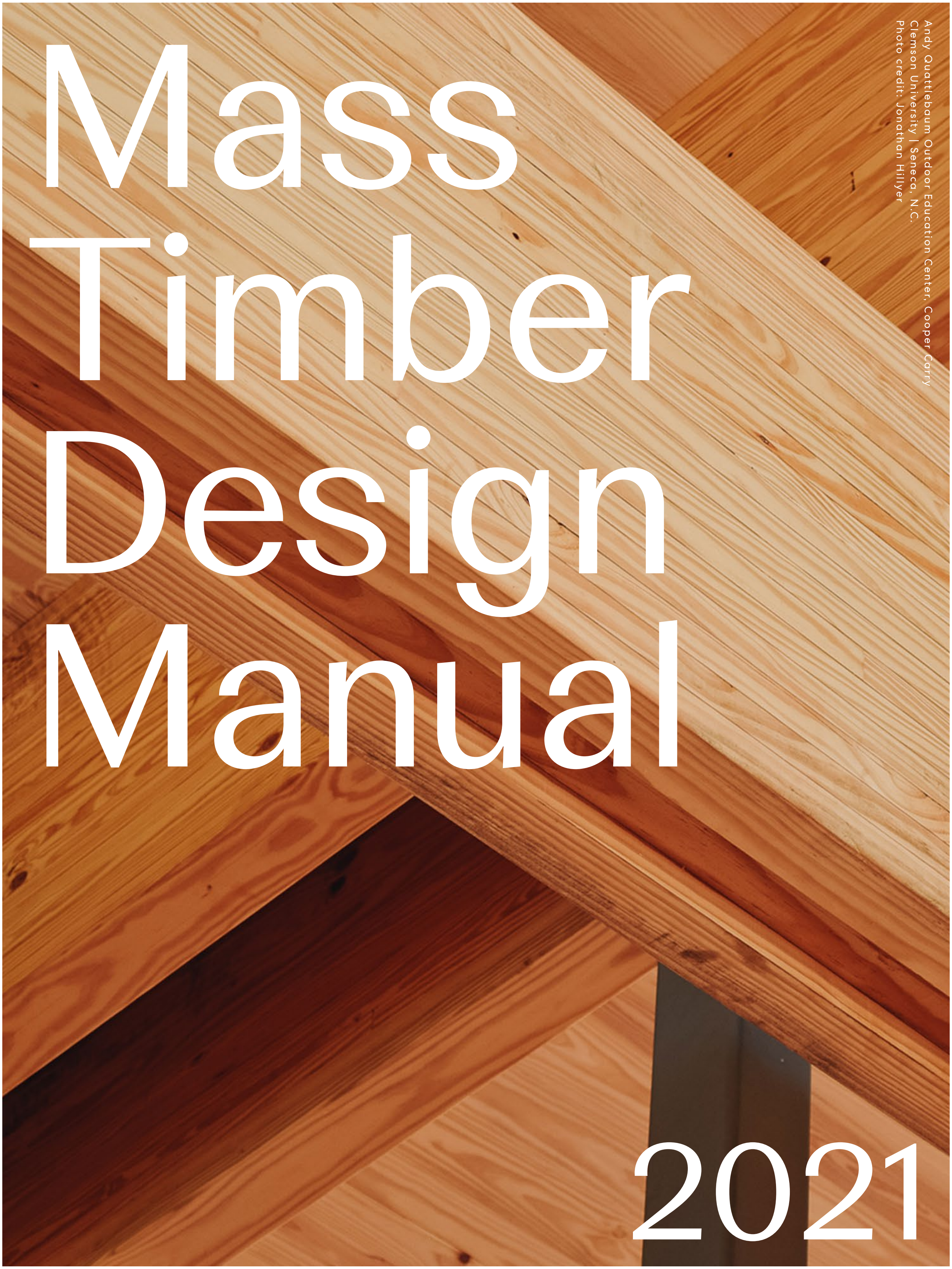

Mass Timber Design Manual

2021

Andy Quattlebaum Outdoor Education Center, Cooper Carry
Clemson University | Seneca, N.C.
Photo credit: Jonathan Hillyer

Published by:

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SLB SOFTWOOD LUMBER BOARD

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 safely, including in the event of fire. 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

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

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.

It is a new category of wood product that can transform how America builds. Mass timber products consist of multiple solid wood panels nailed or glued together, which provide exceptional strength and stability. Conveying warmth and sophistication, it can be used as a load-bearing structure and interior finish material.

Nimble and lightweight, prefabricated mass timber building systems can be assembled by fewer workers in tight, more difficult-to-reach construction sites. Often modular, these mass timber building systems can be easily put together 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.

It's a strong, low-carbon alternative to concrete and steel. When considered over their lifetime—from the harvest of raw materials through manufacturing, transportation, construction, disposal or recycling—mass timber products have less embodied energy, reduce air and water pollution and have a smaller environmental footprint.

For all these reasons, mass timber construction is on the rise. Since 2013, more than 1000 multifamily, commercial, or institutional projects using mass timber or heavy timber have either been constructed or are in the process of design in the U.S., according to WoodWorks.[2] Mass timber is quickly becoming a movement--as a building system it is a must-know for architects, engineering and construction professionals.

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 annually as mass timber product development and the market are quickly evolving.

LOOKING FOR SUPPORT?

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

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.

LIGHT-WEIGHT 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 can sequester carbon well into the future, reducing the global warming potential of a building. Mass timber's lower weight gives it an advantage over steel and concrete assemblies. Light and strong prefabricated assemblies, using mass timber products, can help curb emissions due to reduction of transport and can decrease a building's 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. Well suited to prefabrication, mass timber can be factory-built to take advantage of modular and panelized construction. They can be assembled by fewer workers in 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:	The Discovery Center
LOCATION:	Philadelphia, PA
OWNER/DEVELOPER:	East Park Leadership and Conservation Center
ARCHITECT:	DIGSAU
STRUCTURAL ENGINEER:	CVM
CONTRACTOR:	INTECH Construction, Inc.
PHOTOS:	Halkin Mason Photography LLC

“Wood, as a building material, is the most versatile and expressive of its origins. You can see, smell, and feel the tree in a piece of wood.”

JOE CELENTANO
PRINCIPAL
VMDO ARCHITECTS

Products Overview

A diversity of mass timber products gives design teams flexibility and versatility, and 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 be designed to curve, cantilever, and achieve expressive long-spanning designs. Mass timber panels made from these products can 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. As a complement to other building systems, mass timber can be used in conjunction with light-frame wood construction or in hybrid structures.

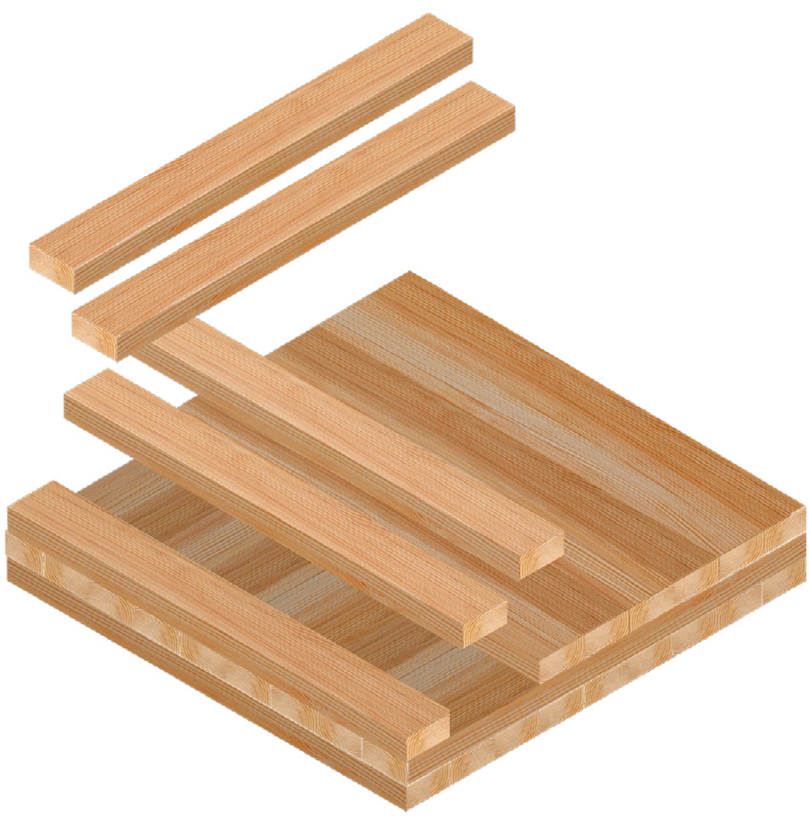
Learn More

PROJECT NAME:	Timber Lofts
LOCATION:	Milwaukee, WI
OWNER/DEVELOPER:	Pieper Properties
ARCHITECT:	Engberg Anderson Architects
STRUCTURAL ENGINEER:	Pierce Engineers
CONTRACTOR:	Catalyst Construction
PHOTOS:	ADX Creative

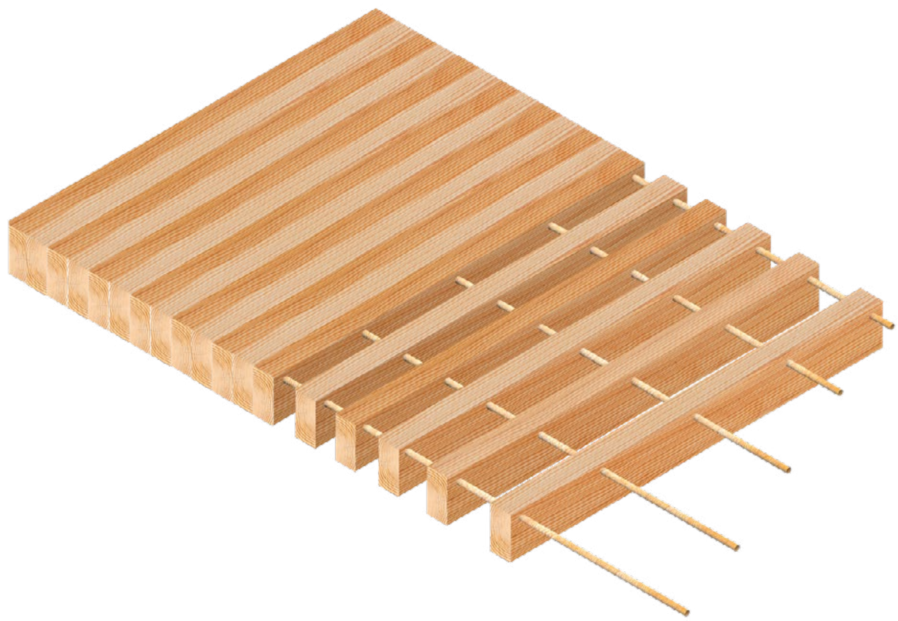
Cross-Laminated Timber

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 to 2 inches, with board width most commonly ranging from 2.5 to 5.5 inches. The panels can be manufactured at custom dimensions, though transportation restrictions dictate their overall size.

Common applications include floors, walls, and roofing. 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 stories in the 2021 IBC, offering additional aesthetic attributes.



Dowel-Laminated Timber



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

Similar to nail-laminated timber, DLT panels can be used for walls, floors and roofs, stairs and elevator shafts as well as 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.

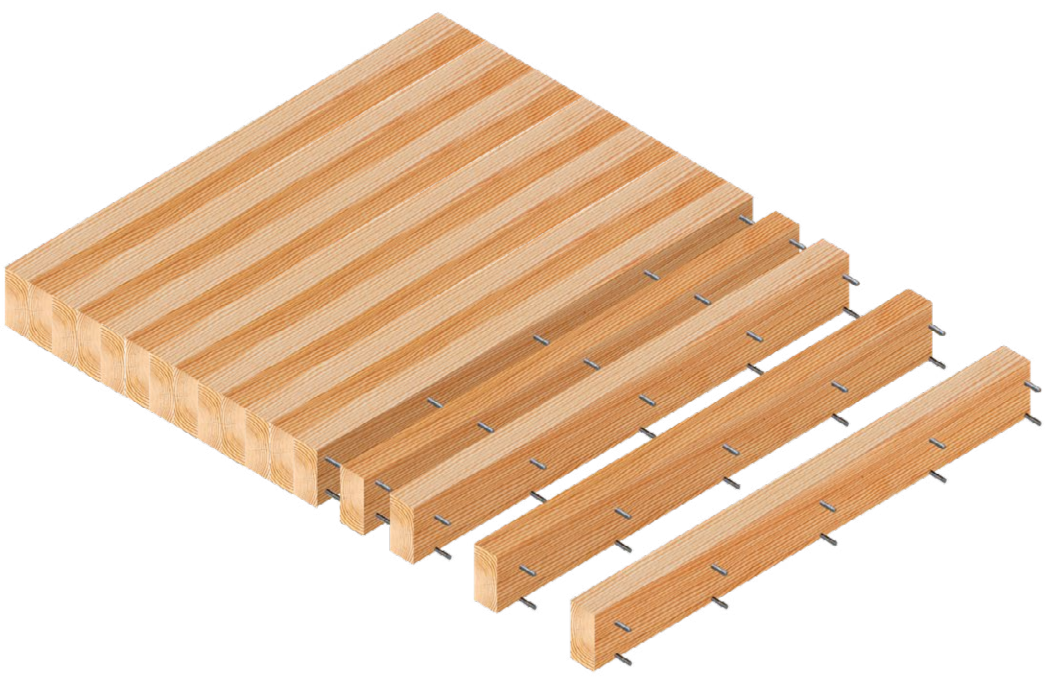
DLT panels can be topped with concrete to form timber concrete composite (TCC) panels, a hybrid system used to reduce cross sections, increase spans and lessen noise transfer and vibrations.

Nail-Laminated Timber

A century-old building construction material, nail-laminated timber (NLT) is made of dimensional lumber stacked together on its 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 4-12 inches. NLT gets its strength and durability from the nails/screws that fasten individual pieces of dimensional lumber into a single structural element.

Applications for NLT include flooring, decking, roofing, 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 to 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 facility—compared with other building materials like cross-laminated timber (CLT)—and it 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 as 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, straight or curved beams and affixed side-by-side to form panels. It is particularly well suited to long-spanning structures, 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. With careful specification and design that considers the flatwise structural properties, deep glulam sections can be placed flatwise as decking, similar to NLT.

PROJECT NAME:	Brentwood Public Library
LOCATION:	Brentwood, CA
OWNER/DEVELOPER:	City of Brentwood
ARCHITECT:	Fog Studio
STRUCTURAL ENGINEER:	Holmes Structures
CONTRACTOR:	Lathrop Construction Associates Inc.
PHOTOS:	Blake Marvin Photography

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

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 International Building Code (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-combatting benefits.

Such is the case for Boston-based Placetailor and Generate, teaming up to design a CLT Passive Demonstration Project in the city's Lower Roxbury neighbourhood. The project will showcase the innovative potential of CLT as a low carbon building material.

Over 400 miles north in Toronto, Canada, the Next Property Group and BNKC Architecture + Urban Design are demonstrating how century-old NLT construction can be reimagined as a thoroughly modern, high-tech commercial office building.

77 Wade

MASS TIMBER GOES HIGH-TECH

PROJECT DETAILS

ARCHITECT:	BNKC Architecture + Urban Design
SIZE:	Approx. 150,000 ft^2 (14,000 m^2)
OWNER/DEVELOPER:	Next Property Group
LOCATION:	Toronto, ON
STRUCTURAL ENGINEER:	Blackwell Structural Engineers
MECHANICAL / ELECTRICAL / PLUMBING ENGINEER:	Integral Group
PROJECT MANAGER:	Alliance 7 Construction Inc
MASS TIMBER FABRICATOR:	Structure Fusion
LIFE SAFETY:	Vortex Fire
DATE COMPLETED:	Under Construction

A thoroughly modern take on the 100-year-old, tried-and-tested construction technology of nail-laminated timber (NLT), 77 Wade is set to surround a new generation of knowledge workers with the warmth and beauty of wood. This contemporary approach to timber warehouses of the past consists of concrete-filled steel beams, glulam columns and prefabricated wood decking overhead. High-impact renderings of this state-of-the-art office envision a mass timber building that is sleek and futuristic.

The lightness, transparency, and levity of 77 Wade's design, according to BNKC Architecture + Urban Design partner Jonathan King, is achieved using a hybrid concrete-steel and timber structural system that plays to the strengths of each building material.

"In this particular project, we're incorporating a composite timber deck system that brings together the qualities of wood with the qualities of concrete and steel and combines them to get the best attributes out of each material," says King. By doing so, this hybrid approach achieves spans equal to a traditional concrete and steel design and affords all the amenities expected of a modern office building, while retaining the warmth and charm of exposed wood.

The building's open concept plan will provide 20,000 ft2 per floor and accommodate upwards of 175 workstations, nearly double that of a traditional office layout. Its efficient design will accommodate over 1,000 office workers, while ample glazing, exposed mass timber, and 12-foot ceilings provide a pleasing occupant experience. Building amenities will include electric vehicle charging, bike storage, showers and changing facilities. The first floor will accommodate nearly 2,500 ft2 of retail space.

Image credit: Next Property Group

Image credit: Next Property Group

It will be the tallest mass timber office building in Canada targeting LEED Gold certification. The Toronto-based developer has embraced the benefits of mass timber as central to its promotion, including the fact that timber can be locally sourced and offers a smaller carbon footprint than other structural materials. The developer confirms mass timber's warmth and aesthetic is a draw for tenants and their employees, a big reason they left nearly 80% of mass timber exposed. The project is expected to be completed in 2021.

Learn More

Catalyst

MASS TIMBER SERVES AS AN AGENT OF CHANGE

Photo credit: Ben Benschneider

PROJECT DETAILS

LOCATION:	Spokane, WA
SIZE:	164,000 ft^2
CLIENT / OWNER:	Avista Development, Mckinstry, South Landing Investors LLC
ARCHITECT:	Katerra (Architect Of Record) + Michael Green Architecture (Design Architect)
STRUCTURAL ENGINEER:	KPFF
CONTRACTOR:	Katerra Construction
CLT SUPPLIERS:	Katerra, Structurlam
GLULAM SUPPLIER:	Western Archrib
COMPLETED:	2020

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 30x30 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 CO2e/m2," 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

Model-C

CROSS-LAMINATED TIMBER TAKES CENTER STAGE

Image credit: Generate/Placetailor

PROJECT DETAILS

ARCHITECT:	Placetailor, Generate
SIZE:	19,000 ft^2
DEVELOPER / GENERAL CONTRACTOR:	Placetailor
LOCATION:	Lower Roxbury, Boston, MA
STRUCTURAL ENGINEER:	Buro Happold Engineering
MECHANICAL / ELECTRICAL / PLUMBING ENGINEER:	Ripcord Engineering
MASS TIMBER FABRICATOR:	Nordic (supplier), Bensonwood (fabricator/installer)
CODE CONSULTANTS:	Code Red
DIGITAL IMAGERY:	Forbes Massie Studio
DATE COMPLETED:	Construction Begins Spring 2021

The Model-C demonstration project is a mass timber, mid-rise, multifamily, and certified Passive House building that shows how CLT systems can be leveraged to meet complex design and sustainability goals.

A collaboration between MIT start-up Generate and Boston-based design-build firm Placetailor, the five-story mixed-use project is the city's first full CLT building. It will include fourteen residential units and a ground floor co-working space open to its Lower Roxbury neighborhood.

The project demonstrates the "Model-C" building system – a kit-of-parts assembly constructed from prefabricated CLT building panels. This pairs mass timber products with high performance assemblies, including insulation and air-sealing that qualify buildings for high-performance, zero carbon, and Passive House certification.The project will operate at net-zero carbon, which is achieved by calculating both the building's embodied energy and its operational energy, and offsetting any annual excess energy use through carbon offset purchases.

While Model-C was originally developed as an optimal system for mid-rise multifamily buildings, its kit-of-parts assembly is intended to easily adapt to diverse site parameters and taller building applications. "We were looking at manufacturers, species, grades of product, ensuring the spans that you're looking at as a system can accommodate the program, but also give you a high performing building," said John Klein of Generate.

Generate and Placetailor have carefully documented the development of the Model-C demonstration project, and they

are committed to releasing project calculations and performance data to the public. "If we want to get to a zero-carbon world in the next decade, we have to show people how to do it in detail," said Colin Booth, Placetailor's Director of Strategy. "We want to share as much of this project as possible and as transparently as possible. We have cost information to share, performance and system specs, large batch energy modeling, all of this information to help people understand how we're doing what we're doing."

Learn More

Timber Design Applications

Unlike existing structural assemblies, mass timber calls for a holistic and innovative approach to its design applications. Successful design teams have learned new ways to manage optimizing costs, acoustic design, vibration and noise control, and fire performance. Timber span capabilities, construction type, fire-resistance ratings and connections 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.[4] Combining mass timber and concrete or steel in hybrid construction can provide a cost-effective and sustainable solution[5] for many occupancy types as well as improving building performance and design. Overbuilds are a technique to add additional stories on top of an existing building, maximizing development area per square foot.[6]

Just-in-time prefabricated mass timber construction, while requiring more upfront planning, can deliver schedule and time savings and reduced labor costs.[7] 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 open flexible design and exposed wood is well-suited to the needs of today's modern workplace.

In this section several Case Studies demonstrate mass timber's 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.

PROJECT NAME:	Latitude Dining Commons, UC Davis
LOCATION:	Davis, California
OWNER/DEVELOPER:	UC Davis Design and Construction Management
ARCHITECT:	HED
STRUCTURAL ENGINEER:	Rutherford Chekene
CONTRACTOR:	Otto Construction
PHOTOS:	Flank Development

Candlewood Suites at Redstone Arsenal

CONSTRUCTION ADVANTAGES SELL HOTEL DEVELOPER ON CLT

Photo credit: Lendlease

PROJECT DETAILS

ARCHITECT:	Benham (formerly Leidos)
SIZE:	62,688 ft^2
DEVELOPER / GENERAL CONTRACTOR:	Lendlease
LOCATION:	Redstone Arsenal, AL
STRUCTURAL ENGINEER:	Schaefer Structural Engineers
MASS TIMBER FABRICATOR:	Nordic Structures
DATE COMPLETED:	2015

The first hotel built in the U.S. using CLT is part of the Privatization of Army Lodging (PAL) program, a 50-year public-private partnership between the U.S. Army and developer Lendlease. The 92-room facility is designed to provide quality private-sector hotel lodging for soldiers and guests on U.S. Army installations and joint bases.

The four-story, rectangular slab-on-grade hotel used CLT for all exterior walls, parapet walls, interior walls, elevated floor slabs, and roof deck. The structure also used glulam columns and beams. While thicker CLT can span up to 25 feet without beams or columns, the 3-1/8-inch-thick roof panels of the Candlewood Suites spanned 16-1/2 feet. In a CLT structure, floors can rest directly on columns without intermediate beams at panel edges because of the bi-directional capacity afforded by CLT's crosslamination.

The design team also had to consider the differential movement between CLT and other materials. The project featured a full-height, four-story concrete brick veneer with a continuous drainage plane behind the cladding. To overcome the prescriptive limits for the height of the brick veneer, they used an engineered concrete brick product that is self-supporting up to 85 feet. This means they didn't have to support the brick at each floor, which would have complicated the building envelope design.

Sound control is also critically important in hotels. The CLT floor assembly achieved a Field Impact Insulation Class (FIIC) rating of 74, which was also substantially higher than the Impact Insulation Class rating of 50 required by code. The high FSTC rating demonstrates that this CLT assembly has better sound absorption qualities than originally determined by theoretical analysis.

When it comes to energy efficiency and airtight construction, CLT panels for the hotel were manufactured to a tolerance of less than 1/16 inch, which is far tighter than anything that can be achieved in the field using conventional construction and materials.

According to the project team, CLT's advantages added up. Even with the additional requirements of blast protection, the Candlewood Suites at Redstone Arsenal demonstrate that CLT is an effective option for non-military hotels and other mid-rise projects.

Learn More

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, glued-laminated timber (glulam), cross-laminated timber (CLT), and nail-laminated timber (NLT).

Learn More

"When you use steel and concrete, it requires more material to be both structurally sound and have a clean finish. With mass timber, we can put up the structure and wood itself is the finish."

EDWIN LIANG
PROJECT MANAGER
MCN BUILD

Clay Creative

PROJECT DETAILS

LOCATION:	Portland, OR
ARCHITECT:	Mackenzie
STRUCTURAL ENGINEER:	Kramer Gehlen & Associates
CONTRACTOR:	Turner Construction Company
PHOTOS:	Christian Columbres

Clay Creative, a mixed-use project in the heart of Portland's Central Eastside Industrial District, is the result of a design approach in tune with both the neighborhood's historical context and its ongoing evolution into a creative area. Integral to the building's design and appeal is its heavy timber structural system. Five-stories of Type IIIA post-and-beam construction sit over a one-story, Type IA deck. The structure consists of dimension wood floor framing with plywood sheathing over vertical nail-laminated timber (NLT) decking; the decking spans between glulam beams and girders supported by glulam columns. Designers used an exterior steel moment frame to keep the core area open. Inside, they used a typical structural grid of 25x30 feet, with mid-bay beams in the long spans and girders in the short spans. Concealed steel bearing and knife plate connections attach to the exposed glulam beams with countersunk bolts for added fire protection. Sustainable design was a goal, so wood for the 90,000-sf building was locally sourced. The estimated construction cost came in at $300 per square foot.

Hudson Office Building

PROJECT DETAILS

LOCATION:	Vancouver, WA
ARCHITECT:	Mackenzie
CLIENT:	Killian Pacific
DATE COMPLETED:	2016
PHOTOS:	Christian Columbres

Across the river from Clay Creative in Vancouver, Washington the 45,000 square-foot Hudson Office Building is designed to evoke a contemporary industrial feel, with a three-story, Type VB structure that features a structural brick exterior, expansive glass entrances and exposed wood columns, beams and ceilings.

Columns and beams are designed on a grid of 25 x 25 feet. The floor and roof system includes NLT decking, offering a modern interpretation of traditional wood construction. In addition to aesthetics, the texture in the exposed wood ceilings reduces noise reflection and helps with acoustics—an important consideration for Class A buildings.

Diamond Foods Innovation Center

PROJECT DETAILS

LOCATION:	Salem, OR
ARCHITECT:	ZGF Architects
STRUCTURAL ENGINEER:	KPFF Consulting Engineers
CONTRACTOR:	Lcg Pence
PHOTOS:	Pete Eckert

Salem Oregon-based Diamond Foods Innovation Center was built to house a team of specialists who drive new product offerings, from R&D through manufacturing and delivery. With the need for expensive interior components such as state-of-the-art kitchens and labs, the two-story structure itself had to be relatively low cost. Multiple value engineering exercises led to a Type VA wood-frame system with dimension lumber walls, I-joists and glulam floors, and a light-frame truss and glulam roof.

The design team used a solar shading analysis tool to position vertical fins and a moderate roof cantilever to offset heat gain. Because the project is adjacent to a restored wetland and creek, the team was careful to choose environmentally safe materials, such as wood from sustainably managed forests that resists weather, mold, rot, and insects thanks to a chemical-free steam and pressure treatment. The two-story Type V project, including site improvements, was completed in 2015 for a cost of $2.1 million.

One North
Karuna East And West Buildings

PROJECT DETAILS

LOCATION:	Portland, OR
ARCHITECT:	Holst Architecture
STRUCTURAL ENGINEER:	Froelich Engineers
CONTRACTOR:	R&H Construction Co.
PHOTOS:	Andrew Pogue

Fifty miles north of the Diamond Foods Innovation Center is the Portland-based Karuna at One North. This 85,540-square-foot project includes a five-story Type IIIB building and separate four-story Type VA building, both with offices above ground-level retail. Both feature heavy timber post-and-beam construction over a concrete podium. Fire retardant-treated wood (FRTW) shear walls were used as part of the lateral-resisting system, and sprinklers were added on the exterior to allow the structure to exceed the 40-foot combustible exterior finish limit. Costs were estimated at between $175 and $225 per square foot, and the developer said rental rates surpass those of offices in downtown Portland.

“We could build with other materials, but we have comfort in knowing that we’re sequestering carbon and mass timber is a natural material.”

BEN WALTER
PRESIDENT
CWS ARCHITECTS

Mass Timber Cost and Design Optimization Checklist

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

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.

Learn More

PROJECT NAME:	Carbon12
LOCATION:	Portland, OR
OWNER/DEVELOPER:	Kaiser Group
ARCHITECT:	PATH Architecture
STRUCTURAL ENGINEER:	Munzing
FABRICATOR:	Structurlam
PHOTOS:	Andrew Pogue

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 International Building Code (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. 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.

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 fire-resistance ratings in the IBC. For multi-unit residential buildings, walls and floors between dwelling or sleeping units are required to have a fire-resistance rating 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

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 International Building Code (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 a sound transmission class (STC) rating of 50 and, in the case of floor/ceiling assemblies, an impact insulation class (IIC) rating of 50.

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
2x4 NLT wall	3-1/2" bare NLT 4-1/4" with 3/4" plywood	24 bare NLT 29 with 3/4" plywood	N/A
2x6 NLT wall	5-1/2" bare NLT 6-1/4" with 3/4" plywood	22 bare NLT 31 with 3/4" plywood	N/A
2x6 NLT floor + 1/2" plywood	6" with 1/2" plywood	34	33

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

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" has an STC rating of 41 and an IIC rating of 25.4 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 1-3" thick, is a common way to improve acoustical performance.

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

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 cross-laminated timber (CLT) manufactured from either solid sawn or structural composite lumber laminations, nail-laminated timber (NLT), and dowel-laminated timber (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:	Catalyst
LOCATION:	Spokane, Washington
OWNER/DEVELOPER:	McKinstry
ARCHITECT:	MGA | Michael Green Architecture
STRUCTURAL ENGINEER:	KPFF
CONTRACTOR:	Katerra
PHOTOS:	Andrew Giammarco

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 index highlighting the spectrum of available structural and architectural mass timber connections. It groups structural connections into three categories or 'Connection Classes' that share some common attributes regarding cost, constructability, and fire rating.

The 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

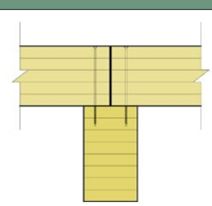
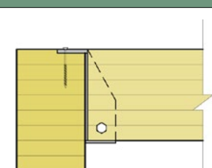
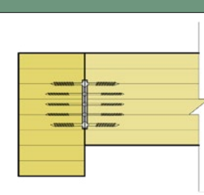
Connection Class	Class 1	Class 2	Class 3
Class Description	Requires only mass timber elements and fasteners	Utilizes steel fabricated elements, with components such as angles and plates, and includes fasteners	Prefabricated proprietary connectors
Connection Example			
	Beam Bears on Girder*	Beam Bears 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*

CONNECTION CLASSES IN RELATION TO FIRE RATING

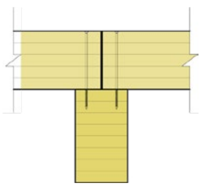
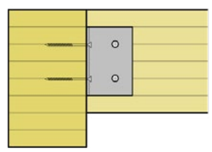
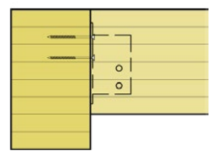
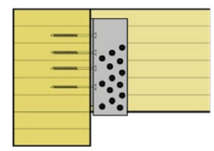
Connection Class	Class 1	Class 2	Class 3	Class 3
Fire Resistance	May be inherently fire resistant according to NDS calculations	Requires additional protection to meet fire-rating requirements	Tested fire-resistance rating (as specified by manufacturer)	Requires additional protection to meet fire-rating 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: International Building Code (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 (EWS) T300 Glulam Connection Details Construction Guide (APA T300); and American Institute of Steel Construction (AISC) Manual of Steel Construction.

Learn More

Mass Timber Construction Management

As the demand for mass timber projects increases, so too does the need to expand the industry's capacity to build them. WoodWorks initiatives, alongside this overview of best practices, increases construction industry proficiency in the estimation, procurement, and management of mass timber projects. The technical guide covers project management and installation training. It also includes an introduction to the upcoming WoodWorks Mass Timber Construction Manual.

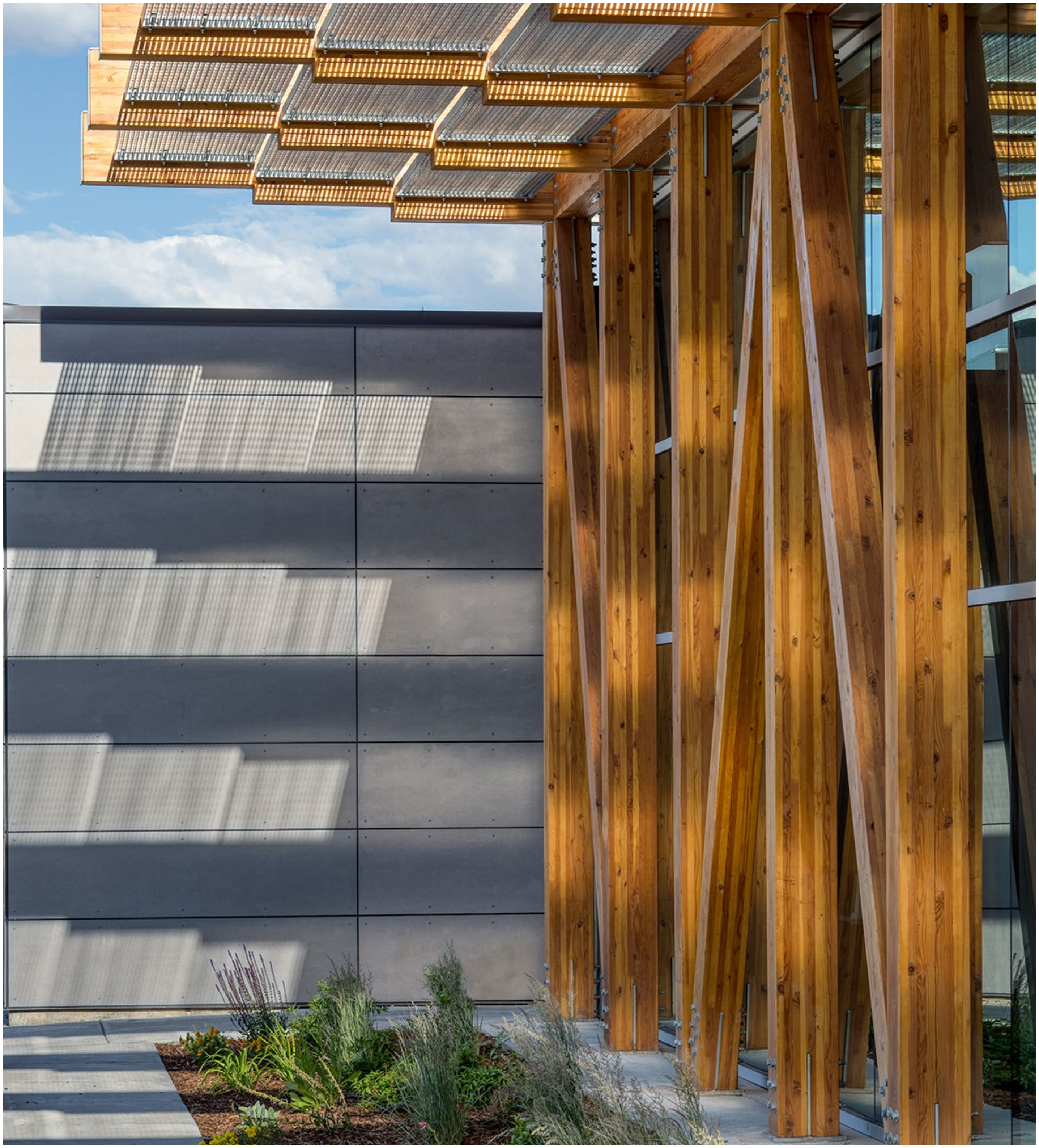
Learn More

Building Enclosure Design Best Practices

Thoughtfully designed building enclosures consider all environmental and structural loads imposed on it 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 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



PROJECT NAME:	WBWCD Water Efficiency Research Center
LOCATION:	Layton, Utah
OWNER/DEVELOPER:	Weber Basin Water Conservancy District
ARCHITECT:	GSBS Architects
STRUCTURAL ENGINEER:	ARW Engineers
CONTRACTOR:	Sirq Construction
PHOTOS:	Paul Richer

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 Building Science guide 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

Solutions for Building Taller

The rising demands placed on the built environment are significant in the face of rapid population growth.[8] 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, the height of wood buildings is on the rise thanks to advancing technologies and a growing body of research demonstrating their safety and strength. The 2021 International Building Code Includes 14 code changes that allow mass timber structures of up to 18 stories. This mounting interest in mass timber is further energized by its smaller environmental footprint and its ability to store carbon.

As a safe, eco-friendly alternative to steel and concrete, some jurisdictions are taking steps to encourage taller wood and mass timber construction. Several states, including Oregon, Washington, and California, adopted taller wood construction ahead of the 2021 code change.

In this section, two Case Studies demonstrate how tall wood construction can meet both residential and mixed-use commercial needs. Resources include summaries and links to four technical papers focused on taller wood mass timber buildings -- emerging code changes, shaft wall requirements, fire resistance ratings and considerations related to concealed spaces. Learn More highlights two useful publications. The first is Tall with Timber: A Seattle Mass Timber Tower Case Study. This report provides a cost comparison between a mass timber and cast-in-place post-tension concrete framing system for a hypothetical 12-story, mixed-use building in Seattle, Washington. The second, 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 International Building Code.

PROJECT NAME:	INTRO
LOCATION:	Cleveland, OH
OWNER/DEVELOPER:	Harbor Bay Real Estate
ARCHITECT:	HPA I Hartshorne Plunkard Architecture
STRUCTURAL ENGINEER:	Fast+Epp
CONTRACTOR:	Panzica Construction Company
RENDERINGS:	Harbor Bay

Origine

MASS TIMBER CAN DELIVER EFFICIENT, COST EFFECTIVE, AND SAFE TALLER CONSTRUCTION

Photo credit: Stéphane Groleau

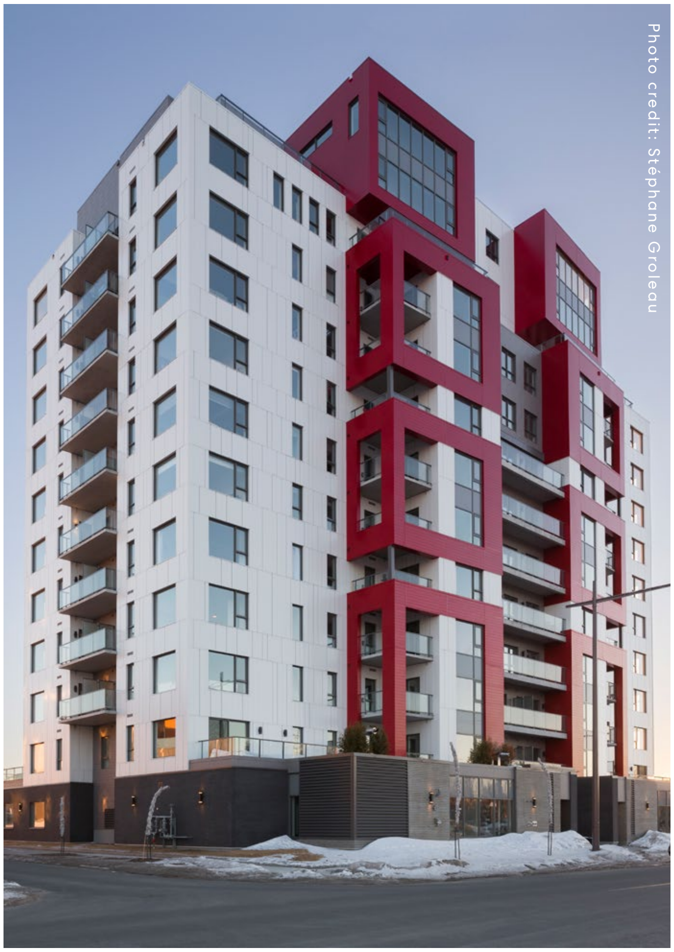
PROJECT DETAILS

ARCHITECT:	Yvan Blouin Architect
CONTRACTOR:	EBC
CODE:	Technorm, GHL Consultants
DATE COMPLETED:	October 2017
DEVELOPER:	NEB group
ENGINEER:	Groupe conseil SID inc
LOCATION:	Quebec City
MASS TIMBER SOURCE:	Nordic Structures
SIZE:	9,600 ft^2

As a 13-story, 92-unit condominium tall wood building constructed prior to the building heights allowed in the 2021 codes, Origine showed how mass timber can deliver efficient, cost effective, and safe residential construction. As the tallest timber building in eastern North America at the time of its construction it was instrumental in advancing industry knowledge of this building type, from new architectural, engineering, and construction methods to product, code, and fire protection expertise.

To construct the tall wood building, the designers had to first demonstrate the project would meet Quebec Construction

Code requirements. When the project began in 2014, the Code stipulated that buildings of more than four stories had to be of non-combustible material. An alternative solution—known as equivalent measures—was required to show that the Code's performance goals and functional statements were being respected. After two years of research and development, the project team successfully demonstrated that Origine would be equally safe built out of wood as it it would be if it were built from non-combustible construction.



Wood is used from the first floor all the way up to the thirteenth. Load-bearing walls, shear walls, floors, and the roof are all made from CLT, with glulam timber posts and beams rounding out the structural system. CLT was encapsulated for added fire protection, and left exposed in some common areas. The project benefited from the rapid ease and assembly of mass timber construction, taking four months to erect the building. The use of mass timber not only meant that the building could go up as a kit of parts with fewer workers, but could also proceed during cold winter months between December and April.

Units range from studio apartments to three-bedroom units, each with its own layout and furnishings. In addition to the carbon-locking benefits of a wood-frame and mass timber construction, the building features a number of environmentally-friendly features. The roof is covered with a white waterproofing membrane to better reflect the sun and reduce the heat island effect. The building has a gas central heating system that provides domestic hot water and feeds the network of pipes for the radiant floors. In addition to providing comfort, the gas-heated floors will result in savings of up to 30% over regular electric heating.

"We believe mass timber is much more than a structural building material; it is an opportunity to guide building design and construction towards a future of sustainable building on an entirely new scale."

CRAIG CURTIS
FORMER CHIEF ARCHITECT
KATERRA

PROJECT NAME:	T3 Minneapolis
LOCATION:	Minneapolis, MN
OWNER/DEVELOPER:	Hines
ARCHITECT:	MGA	Michael Green Architecture + DLR Group
STRUCTURAL ENGINEER:	StructureCraft
CONTRACTOR:	Kraus Anderson Construction
PHOTOS:	Corey Gaffer, courtesy Perkins&Will

2150 Keith Drive

A MODERN MASS TIMBER OFFICE BUILDING

PROJECT DETAILS

ARCHITECT:	DIALOG
SIZE:	162,491 ft^2 (15,096m^2)
DATE COMPLETED:	Anticipated completion 2022
LOCATION:	Vancouver, BC
CLIENT:	BentallGreenOak
IMAGE CREDIT:	DIALOG

This 10-story commercial office, to be located in Vancouver's False Creek Flats--a burgeoning sustainable green enterprise zone--takes advantage of the growing interest in workplaces that feature exposed mass timber and flexible open floor plans. Given an enthusiastic thumbs up by the city's Development Permit Board, the 10-story mass timber structure will accommodate more than 500 staff members for a range of potential tenants.

Mass timber was selected as the structural system for the building because of its sustainability, aesthetic, and functional qualities. A distinctive honeycomb design sets this mass timber office building apart, while offering the practical benefit of reducing thermal breaks through the building envelope. To be assembled as a prefabricated kit of parts and built on a concrete podium, this project will use a number of engineered wood products to achieve its design goals, including CLT and glulam.

The building's design uses a perimeter braced structural system that creates a striking expression of the building from the exterior and eliminates the need for conventional cast-in-place concrete cores. Instead, an innovative mass timber structure is proposed for all floors above level 2: a series of timber shear walls in the interior and a series of structural braces on the exterior resist the wind and seismic load that the building must withstand.

The distinctive structural seismic and lateral design of diagonal glulam buckling-restrained braces creates a cellular expression on the façade that wraps around the building and is continuous at all elevations. This signature design is a direct reflection of the structural system. The balconies are connected by a diagonal strut visually aligned with the timber braced frames, creating a self-supported balcony structure that does not rely on cantilevers from the primary building structure. This allows the balcony elements to be pinned back to the primary structure.

The exterior cellular structure works at multiple scales. At the neighborhood scale, it creates a strong identity with an exoskeleton that references nature. At the street scale, the two-story cells reduce the mass of the building and create a finer grain texture. At the human scale, the cellular alcoves provide refuge, and protection from the elements. Anticipated completion date is 2022.

Tall Wood Buildings in 2021 IBC

In 2019 the ICC approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (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.

REQUIRED NONCOMBUSTIBLE PROTECTION ON MASS TIMBER ELEMENTS BY CONSTRUCTION TYPE

	IV-A	IV-B	IV-C	IV-HT
Interior Surface of Building Elements	Always required. 2/3 of FFR, 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
Source: Tall Wood Buildings in the IBC: Up to 18 Stories of Mass Timber, WoodWorks

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

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

Shaft Wall Requirements in Tall 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.

FRR REQUIREMENTS FOR TALL MASS TIMBER STRUCTURES (HOURS)

Building Element	IV-A	IV-B	IV-C
Primary Frame	3	2	2
Exterior Bearing Walls	3	2	2
Interior Bearing Walls	3	2	2
Roof Construction	1.5	1	1
Primary Frame at Roof	2	1	1
Floor Construction	2	2	2

Source: Demonstrating Fire-Resistance Ratings for Mass Timber Elements in Tall Wood Structures, WoodWorks

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

PROJECT NAME:	Carbon12
LOCATION:	Portland, OR
OWNER/DEVELOPER:	Kaiser Group
ARCHITECT:	PATH Architecture
STRUCTURAL ENGINEER:	Munzing
FABRICATOR:	Structurlam
PHOTOS:	Andrew Pogue

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

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 - low-, mid-rise and tall timber; and mechanical plenums in mass timber buildings.

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 International Building Code® (IBC®). The document reviews the 2015 IBC's recognition of cross-laminated timber (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 photos, 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.

PROJECT NAME:	Seattle Mass Timber Tower Rendering
LOCATION:	Seattle, WA
CONTRIBUTORS:	DLR Group, Martha Schwartz Partners, Fast+Epp, Swinerton, WoodWorks, Heartland
RENDERINGS:	DLR Group

Tall With Timber

A MASS TIMBER TOWER CASE STUDY

This 100-page report provides an insightful comparison between a mass timber (design case) and cast-in-place post-tension concrete (baseline) as structural framing systems for a 12-story, hypothetical mixed-use building in Seattle. The case study tower is 214 feet tall with the roof of the highest occupied floor at 180 feet height. The mixed-use program includes street level retail, five floors of commercial offices, and a hotel.

The study includes an analysis of system design, structural cost, and constructibility, while highlighting the overall challenges and opportunities of tall wood construction. Fire performance, environmental footprint, and life safety are investigated along with health and wellness, procurement and labor, and risk management and insurance.

A valuable resource of interest to design teams looking to delve deeper into the cost-benefits of tall mass timber building solutions. The report includes a rich appendix of practical modeling, construction scheduling, and illustrated design examples.

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, three 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.

PROJECT NAME:	Cedar Speedster
LOCATION:	Seattle, WA
OWNER/DEVELOPER:	Revelution LLC
ARCHITECT:	Weber Thompson
STRUCTURAL ENGINEER:	DCI Engineers
CONTRACTOR:	Turner Construction Company
PHOTOS:	Image courtesy Weber Thompson

Platte 15

DENVER'S FIRST CLT WORKSPACE BRINGS CONTEMPORARY SUSTAINABILITY TO HISTORIC DOWNTOWN

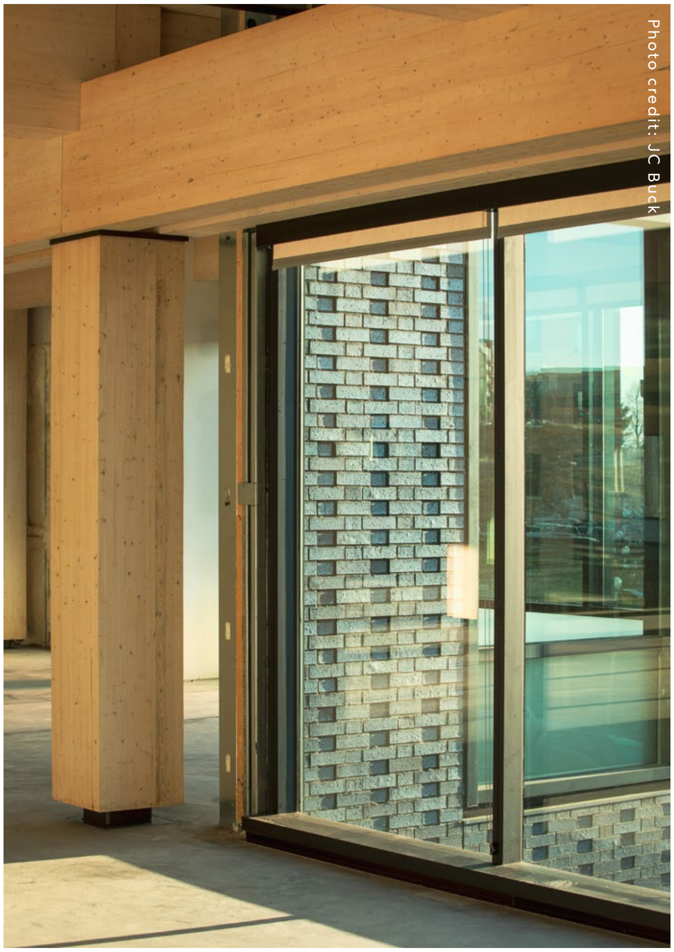
Photo credit: JC Buck

PROJECT DETAILS

ARCHITECT:	OZ Architecture
SIZE:	Five stories; 150,418 ft^2
CONSTRUCTION TYPE:	Type III-B
OWNER:	Crescent Real Estate LLC
LOCATION:	Denver, CO
STRUCTURAL ENGINEER:	KL&A Engineers & Builders
GENERAL CONTRACTOR:	Adolfson & Peterson Construction
TIMBER SUPPLY AND INSTALLATION:	Nordic Structures/FGP Construction

This five-story workspace–located in one of Denver's most popular neighborhoods–incorporates a mass-timber frame, built using glue-laminated timber (glulam) beams and columns, as well as cross-laminated timber (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."



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 30x30 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.

Learn More

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

EXPOSED MASS TIMBER STRUCTURE AS A TEACHING TOOL

PROJECT DETAILS

LOCATION:	Amherst, MA
SIZE:	87,500 ft^2
TOTAL COST:	$52 Million
CONSTRUCTION COST:	$36 Million
CONSTRUCTION TYPE:	IV
COMPLETED:	January 2017
CLIENT:	University Of Massachusetts Building Authority
ARCHITECT:	Leers Weinzapfel Associates
STRUCTURAL ENGINEER:	Equilibrium Consulting • Simpson Gumpertz & Heger (EOR)
CONSTRUCTION MANAGER:	Suffolk
TIMBER SUPPLY:	Nordic Structures
TIMBER INSTALLATION	North & South Construction • Bensonwood

Photo: Albert Vererka / Esto

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.

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

Bullitt Center

TIMBER FRAME TEACHES ENVIRONMENTAL AND STRUCTURAL LESSONS

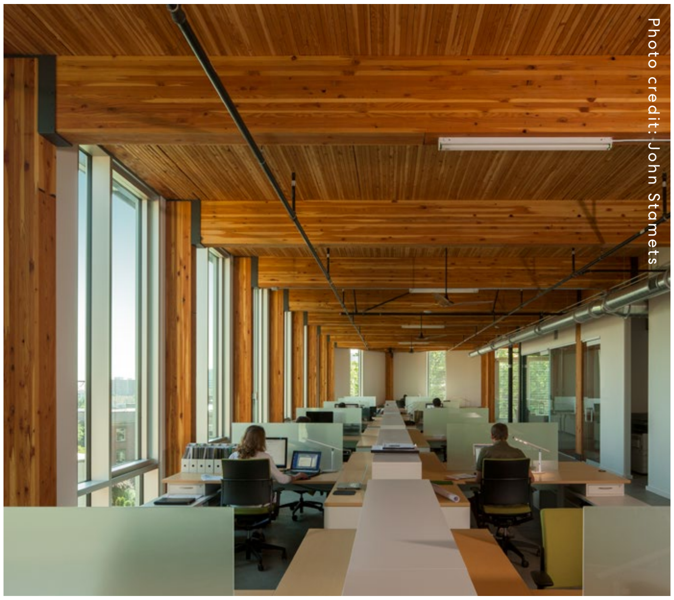
Photo credit: John Stamets

PROJECT DETAILS

LOCATION:	Seattle, WA
SIZE:	52,000 ft^2
TOTAL PROJECT COST:	$32.5 million
ARCHITECT:	Miller Hull Partnership
DATE COMPLETED:	2013
OWNER:	Bullitt Foundation
DEVELOPER:	Point32
ARCHITECT:	Miller Hull Partnership
CONTRACTOR:	Schuchart Construction
STRUCTURAL ENGINEER:	DCI Engineers
MEP ENGINEERING:	PAE
LANDSCAPE ARCHITECTURE:	Berger Partnership
MECHANICAL ENGINEERING:	PSF Mechanical

From its inception, the Bullitt Center in Seattle set out to achieve ambitious sustainability targets. The six-story, 52,000-square-foot mass timber office is designed to meet stringent requirements of the Living Building Challenge (LBC)—using photovoltaic cells to generate enough electricity to sustain the needs of its tenants, recycling its own water and waste, and reducing energy use by more than 80 percent compared to an average office building.

At the heart of this state-of-the-art structure lies a heavy timber frame—a traditional building system that is increasingly being used in new and innovative ways. The podium structure (four floors of wood over two stories of reinforced concrete) is built with a Type IV heavy timber frame—Douglas-fir glulam beams and columns, finished to an industrial appearance grade. A solid dimension lumber wood deck forms the floors and roof; the Douglas-fir members were set on edge and then nailed to one another to form a solid panel. CDX plywood is used for roof and floor diaphragms and for some wall panels.



Life cycle assessment played an important role in achieving the project's sustainability goals. "More people are paying attention to life cycle assessment, and wood is coming out as the winner when it fits within the structural criteria for the project," Court said. "In fact, I think one of the things we learned with the Bullitt Center is that wood has the structural capability to do way more than we're letting it do right now. People need to look at wood with fresh eyes, especially because it has so many environmental virtues over concrete or steel."

Along with carbon storing benefits of the wood used in the project, it all comes from sustainably managed forests. All of the wood in the project, including the lumber that comprised the glulam beams and columns, is certified as Forest Stewardship Council (FSC) 100% (formerly known as FSC Pure). And to further reduce its carbon footprint, all wood products come from mills within about 600 miles of the job site.

The building is designed to a life expectancy of 250 years, making it significantly more sustainable than the average office building designed for a 40- or 50-year lifespan. The total potential carbon benefit of the facility is 1,703 metric tons of CO2, equivalent to 325 cars off the road for a year or the energy to operate a home for 145 years.

Learn More

“Wood is the only true sustainable building material: it literally regrows itself. Wood construction is so fast, and the tolerances are so accurate.”

SHAWN BRANNON
PROJECT MANAGER
ADOLFSON & PETERSON CONSTRUCTION

Edie Sonne Hall

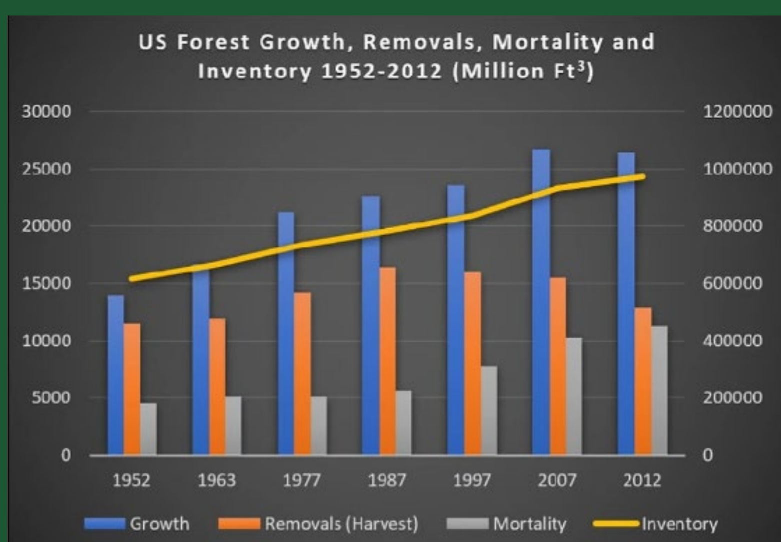
Q+A

How do you know if the mass timber products you're 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.

EDIE SONNE HALL
Founder and Principal
Three Trees Consulting

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.



USFS 2014 US Forest Resources Facts and Historical Trends.

Q+A

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.

Q+A

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

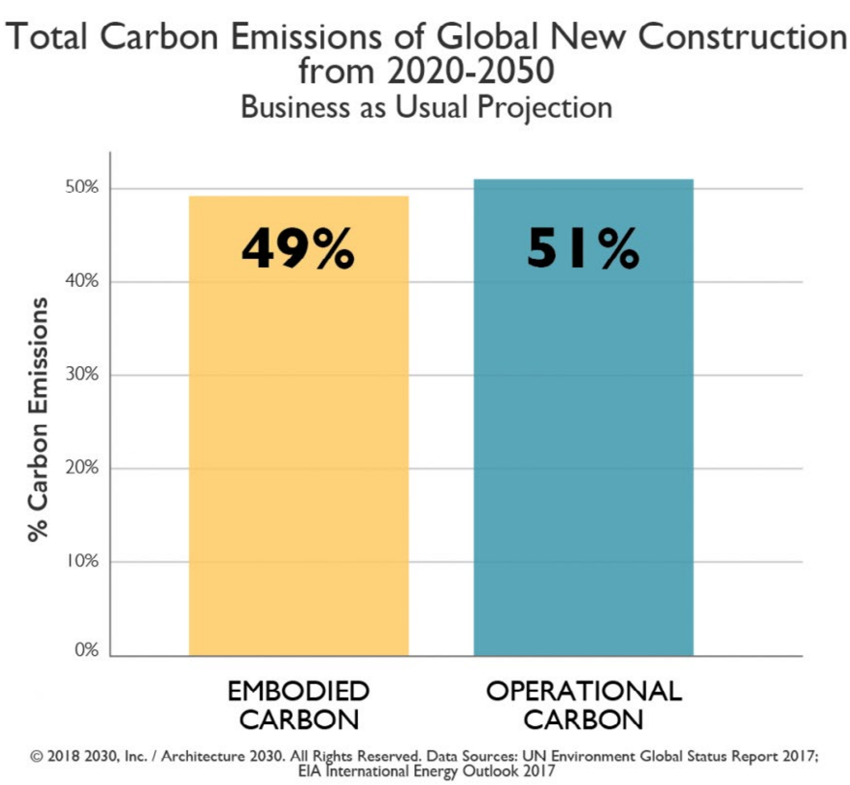
Wood products as building materials are one important climate solution because they take less energy/emissions to manufacture than other materials, and store carbon through the useful lifetime of the product.

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.

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 (CO2) 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.

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

PROJECT NAME:	Princeton University Laboratory for Embodied Computation
LOCATION:	Princeton, NJ
OWNER/DEVELOPER:	Princeton University
ARCHITECT:	The Living (Design Architect), NK Architects (AOR)
STRUCTURAL ENGINEER:	Buro Happold Consulting Engineers
CONTRACTOR:	Epic Construction
PHOTOS:	Michael Moran, Pablo Marvel

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

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

"There's an aesthetic aspect that is unmatched, but one of the best things about mass timber is its ability to sequester carbon."

ADAM ARNDT
PRESIDENT
CATALYST CONSTRUCTION

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

PROJECT NAME:	Freedom House
LOCATION:	Green Bay, WI
OWNER/DEVELOPER:	Freedom House Ministries Green Bay
ARCHITECT:	Berners Schober
STRUCTURAL ENGINEER:	RA Smith, Inc.
CONTRACTOR:	Immel Construction
PHOTOS:	Tricia Shay Photography

Timber City

A SUSTAINABLE RESEARCH INITIATIVE

Timber City is a research initiative of Gray Organschi Architecture, supported by the Hines Research Fund For Advanced Sustainability at Yale University. It's focused on how mass timber can help transform urban centers from being a source of carbon emissions to a carbon sink through the development of new buildings and structural typologies in wood. Research explores topics such as: factors influencing the regional supply of mass timber, mass timber's role in a low carbon economy along with an investigation of the complex spatial, architectural, legal, and logistical challenges of constructing timber buildings in dense urban centers.

Learn More

PROJECT NAME:	The Kendeda Building for Innovative Sustainable Design
LOCATION:	Atlanta, GA
OWNER/DEVELOPER:	Georgia Institute of Technology
ARCHITECT:	The Miller Hull Partnership in collaboration with Lord Aeck Sargent, a Katerra Company
STRUCTURAL ENGINEER:	Uzun + Case
CONTRACTOR:	Skanska USA
PHOTOS:	Jonathan Hillyer, Miller Hull, Lord Aeck Sargent

Conclusion

As design professionals look to the decade ahead there are many challenges on the horizon, from addressing pressing environmental and social issues to accommodating rapid population growth and shifting market demands. There is 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, there are actions design professionals are taking in their day-to-day practice 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, from newer innovations like CLT and DLT to tried-and-tested technologies such as NLT and glulam, are opening up even more possibilities. Mass timber products combined with concrete, steel and light-frame wood construction can deliver building solutions for virtually any occupancy type. They 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.

And when it comes to reducing a building's environmental footprint, lifecycle 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 that would otherwise be emitted back into the atmosphere.

With all of these advantages, understanding mass timber design and construction is quickly becoming essential knowledge for building professionals today. While not 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.

All of the resources referenced in this manual are available for free download in one easy access folder here:

www.WoodWorks.org/MTdesignmanual

Sources

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