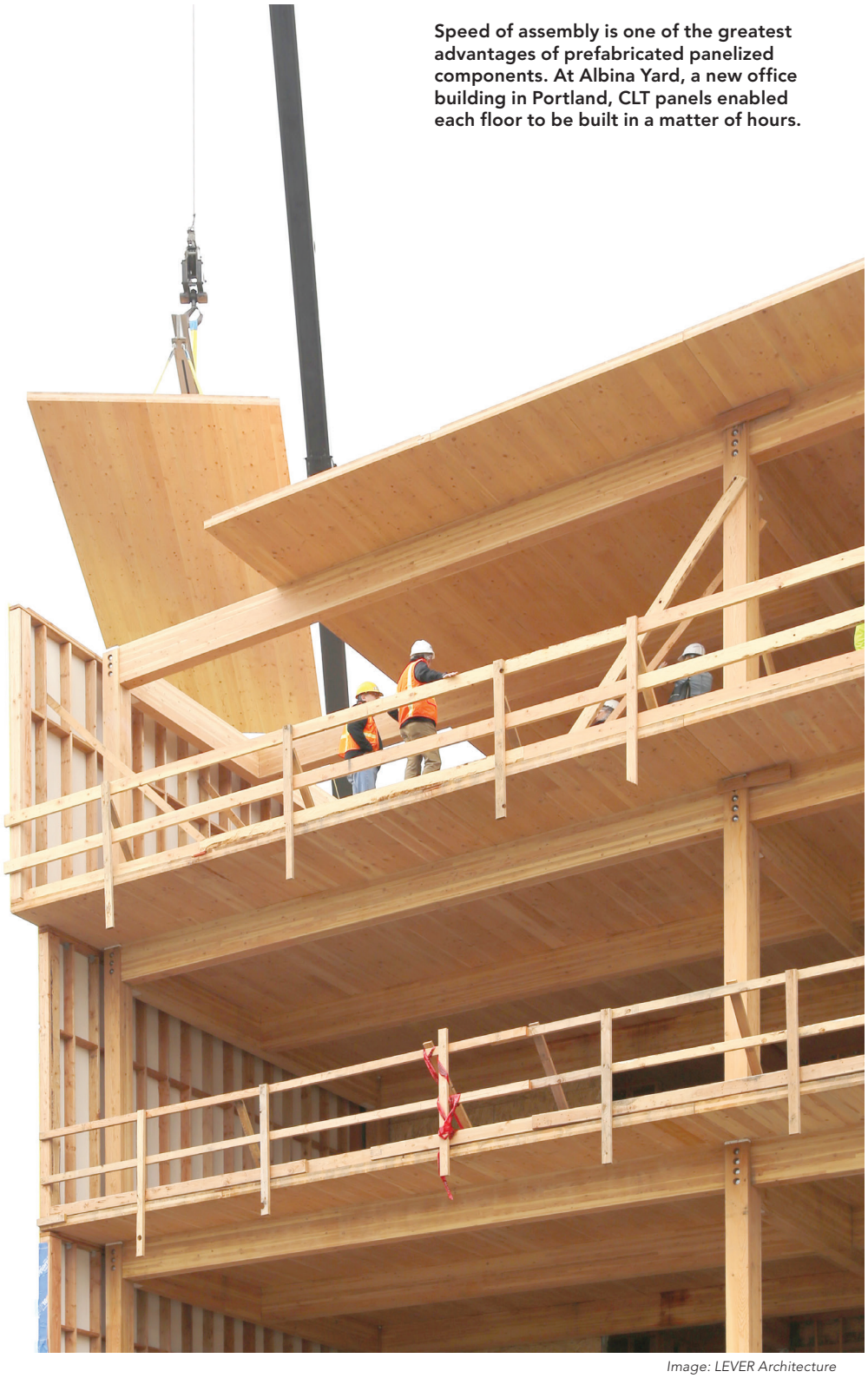
CONTINUING EDUCATION

The Business Case for Building with Wood

How wood construction can contribute to process efficiency, sustainability, and marketability

Sponsored by Think Wood | *By Juliet Grable*



Speed of assembly is one of the greatest advantages of prefabricated panelized components. At Albina Yard, a new office building in Portland, CLT panels enabled each floor to be built in a matter of hours.

Image: LEVER Architecture

For those involved in shaping tomorrow's built environment, this is an exciting time. Several converging trends are presenting both design challenges and new market opportunities. Cities are getting denser, spurring mixed-use projects that combine ground-level retail and several stories of residential units. Urban dwellers, millennials in particular, are seeking affordable dwellings that are close to work and include plenty of amenities. New office construction continues to be strong, but these offices are eschewing traditional configurations and instead tend to include common areas and open plans that encourage collaboration. At the same time, firms are under pressure to innovate, implement lean practices, and create repeatable designs. More stringent building and energy codes and a growing emphasis on resilience are catalyzing performance-based designs—buildings that not only ensure occupants can safely evacuate during a disaster but that also maintain some functionality during an event and to be safely used afterward.

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1.25 AIA LU/HSW

Learning Objectives

After reading this article, you should be able to:

1. Explain how wood construction can be used to reduce construction timeframes, ensure quality, and accommodate changes in the field.
2. Name some value propositions other than cost that are making wood an attractive construction choice for building owners.
3. Describe common prefabricated and modular components and assemblies that are used in wood construction today.
4. Describe how wood is being used to create environments that appeal to the new generation of employees and occupants.
5. Explain how recent code changes are enabling cost-effective, high-density designs.

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Alongside these trends, builders and owners are facing a tightening lending market, especially from the larger banks.[1] To remain competitive, many construction companies are incorporating off-site manufacturing into their processes to ensure faster, more efficient project delivery and make up for the shortage of construction workers.[2]

Increasingly, building owners and design professionals are turning to wood construction to satisfy all of these industry, market, and regulatory demands and challenges. Long valued as a building material for its performance and cost advantages, today's building owners are choosing wood to satisfy these and other value propositions, from environmental sustainability and resilience to creating distinctive buildings that appeal to the next generation of employees and apartment dwellers, all while meeting tight budgets and construction timelines.

Innovations in off-site manufacturing and prefabricated wood components and assemblies have expanded the options for wood construction. To fully serve their clients, design professionals must understand these trends and technologies and be able to communicate the benefits of the various wood construction systems to their clients.

Photo: © Albert Vecerka/Esto

Designed as an innovative and inspiring building that visibly demonstrates the UMass Amherst's commitment to environmental sustainability, the John W. Olver Design Building uses a CLT structural system that significantly reduces its carbon footprint.

COST BENEFITS

There's a reason why light-frame construction is the go-to method for most residential and many commercial projects. Wood is an abundant resource in North America, and tradespeople are familiar with the materials and methods of wood construction.

A comparative analysis of one- to four-story office buildings constructed between 2009 and 2015 conducted by WoodWorks shows that wood offices cost 20 to 30 percent less per square foot than their non-wood counterparts.[4]

But beyond lower construction and lower overall costs, wood construction—and especially the use of prefabricated wood components and assemblies—allows project owners to meet tough construction timelines, ensure quality control, and differentiate their projects from others, whether offices, schools, or multifamily apartment buildings. In some cases, wood offices can capture higher rental rates than similar non-wood buildings. For example, the developer for Clay Creative, a timber office building in Portland, reports that tenants were willing to pay $7 more per square foot than a similar non-wood structure located across the river downtown.

Faster Project Delivery

Because they are manufactured off-site, prefabricated components are less vulnerable to weather delays and other complications associated with site-built construction. Off-site fabrication does require logistical planning to ensure the components arrive on time and in sequence; however, once the packages arrive, construction proceeds quickly. In fact, speed of construction is one of the key benefits of both light wood-frame construction and mass timber. Mass timber structures can be built more quickly than comparable steel, concrete, or even light wood-framed structures, which translates into reduced construction costs.[5] The methods often require smaller crews, and, depending on the size of the project and its proximity to other buildings, smaller cranes can be used to lift panels higher. In an example that highlights the speed and efficiency of mass timber construction, CLT panels were used to construct shear wall cores for the four-story John W. Olver Design Building at UMass Amherst. Four 60-foot-tall CLT panels comprising one of these cores were lifted and dropped into place with a crane and anchored to the foundation in a single weekend.[6] These wood components also add to the building's distinctive aesthetic, where exposed wood is promoted as a demonstration of the school's commitment to sustainability.

Faster construction schedules mean the building can be commissioned more quickly, enabling building owners to begin earning rental revenue sooner. Projects with shortened construction schedules and smaller crews may prove attractive to lenders—a real advantage during an era of tight lending and rising labor costs.[7]

Indirect Savings

Wood is light but strong. Glulam is stronger than steel at comparable weights, and it is stronger and stiffer than dimensional lumber, making it a cost-competitive choice for long structural spans and tall columns.[8] The lighter weight of wood can lead to reduced foundation sizes and other structural elements. For example, Carroll Smith Elementary School in Osceola, Arkansas, was originally designed in concrete block using steel construction elements.

Its design would have required expensive piers to address soft soil conditions, and the steel elements would have concentrated the load in small areas. Consequently, the project team opted for wood floors, walls, and roof deck, which reduced the need for piers and reduced the overall cost of the structural system—choices that saved approximately $10 per square foot compared to a steel structure with light metal-gauge framing.

Sustainability

Wood construction is often touted as a sustainable choice, and for good reason—wood is a naturally renewable material which, when sustainably harvested, has a lower environmental impact than many other building materials.

We can look at the environmental footprint of a building material from several angles, including the energy and water required to extract, manufacture and transport it, its longevity, and what happens to it at the end

of its life. This process, known as life-cycle assessment (LCA), can be used to compare different materials.

The production of concrete and steel are energy-intensive processes that release large amounts of greenhouse gases. Wood, on the other hand, requires far less energy to harvest and process. In addition, forests take in carbon dioxide from the atmosphere and store it as biomass. Wood is 50 percent carbon by dry weight. This means that wood products store, or sequester, carbon for the life of the building. Wood byproducts can also be used as fuel.

As an example, the original design of the John W. Olver Design Building included a steel structure. Changing the design from steel to a timber composite system significantly lowered the building's carbon footprint; in fact, the 70,000 cubic feet of timber utilized in the building will store 2,000 tons of carbon dioxide over its life.[9] From a structural perspective, this choice also allowed the team to reduce the number of beams by about half and eliminate beams perpendicular to MEP routing in many areas.

When thoughtfully managed, timber is a renewable resource that can create jobs for local economies, especially when mills manufacture "value-added" products such as engineered beams and mass timber components. In addition, because panels are manufactured specifically for each project, job-site waste is practically eliminated. Manufacturers can also repurpose leftover scraps for other elements or use as fuel. In some cases, mass timber products may utilize lumber that may have otherwise been wasted, such as wood from beetle-killed trees.[10]

Energy Efficiency

It's no coincidence that many of the recent wood-frame and mass timber buildings are reaching for ambitious energy-performance goals and green building certifications. Wood has low thermal conductivity compared to steel and concrete. Precisely manufactured assemblies such as prefabricated light-frame walls and wood components such as CLT panels can help building envelopes achieve superior air tightness.10 In addition, the dimensional stability of these components ensures that air tightness does not degrade over time.

Wood has inherent insulating qualities, and wood-stud walls are easy to insulate. In addition, wood construction is flexible enough to accommodate assemblies necessary to achieve the requirements of more stringent energy codes. These assemblies may include deeper wall cavities, the use of continuous exterior insulation, or a hybrid of both.

Wood buildings can not only meet or exceed energy code requirements but also meet the rigorous standards of green building programs such as LEED, the Living Building Challenge, Passive House, and the Architecture 2030 Challenge.

TYPES OF WOOD CONSTRUCTION

Today, wood construction may refer to one of several methods. These include light wood-frame, heavy timber, mass timber, and hybrid systems.

Light wood-frame construction, ubiquitous in residential construction and preferred in many commercial projects for its cost-effectiveness and speed of assembly, utilizes a repetitive combination of dimension lumber, I-joists, trusses, structural composite lumber, and oriented strand board or plywood decking and sheathing for floors, walls, and roof decks.

Heavy timber construction consists of solid or laminated timbers used as columns (posts) and beams which support floors.

Mass timber is a type of wood construction in which smaller wood members are used to form larger structural panels that are usually manufactured off-site. A common technique is to pair glulam beams and columns with roof and floor decks constructed with mass timber components—either CLT, NLT, or tongue-and-groove decking over glulam sub-purlins. Though such buildings can be designed with column-free spans that enable flexible open-office interiors, exposed wood columns can also be strategically used to enhance interiors while reducing costs.

Hybrid systems—those that combine light wood-frame and mass timber systems, for example, or which combine mass timber with concrete and/or steel—use different materials for different parts of the structure. An advantage of using light wood framing in conjunction with mass timber components is that light-frame partition walls or ceilings can be used to house MEP equipment.[3] Hybrid systems such as timber-concrete composite floors can bring the best of both materials together. For example, they can be used to achieve even greater column spacing, or to reduce vibrations in large floor spans.

Expanded Markets and Market Distinction

Wood construction is enjoying a renaissance. Developers and building owners are choosing wood construction for commercial office buildings, hotels, schools, and institutes of higher education, and some are promoting the performance and sustainability of wood as a way to distinguish their buildings.

Wood can help building owners meet market demand in several ways. One of the most obvious is through market distinction. In today's competitive market, retailers often need to rebrand to capture loyal customers, and companies must offer work environments and amenities that appeal to the new generation of workers. Wood can be part of designs that help secure higher rents and attract quality employees and tenants.

Open layouts: Open layouts, which facilitate collaboration and daylighting, are becoming more popular, especially in commercial offices. Mass timber construction facilitates open layouts because wood members—glulam beams, NLT, and CLT panels, for example—can accommodate larger spans that reduce or eliminate the need for support columns.

Aesthetics and biophilia: When ceilings are treated with wood or when wood structural panels are left exposed, they contribute to an interior aesthetic that is increasingly recognized as beneficial to health. The burgeoning field of biophilic design is revealing quantifiable health and wellness benefits of materials perceived as "natural" or organic, especially when paired with good daylighting and strategies that ensure healthy indoor air. In addition, studies have revealed that tenants and homeowners show a preference for exposed wood, particularly in residential settings.[11, 12]

Regional identity: Wood, especially when left exposed, can be used to convey a building owner's preference for natural materials and connect occupants to the local environment. For example, western red cedar and southern yellow pine are strongly linked with their regions. Projects that showcase regionally sourced wood products celebrate the region's identity and can even instill feelings of pride and belonging.

Connectivity: Strong, reliable internet connectivity is a must in today's buildings. While all building materials, even glass, block Wi-Fi signals to some extent, wood is on the lowest end of the spectrum. Concrete, brick, and metal are among the top signal blockers.[13]

THE ADVANTAGES OF OFF-SITE CONSTRUCTION

Prefabricating components and assemblies off-site offers many advantages, including efficiency at every stage of the process, less disruption of building activities, and faster speed of construction.

The most common categories of off-site prefabrication include modular systems, panelized systems, subassemblies or components, and hybrid systems.

Modular assemblies are complete buildings or rooms that are fabricated off-site and delivered fully assembled, complete with fixtures and exterior and interior finishes.

Panelized systems are complete assemblies such as walls. They may be open (non-insulated) or closed (insulated). Enhanced panels come complete with windows, doors, electrical and plumbing, and finishes.

Subassemblies and components include floor and roof trusses and panelized components such as cross-laminated timber (CLT) panels.

Hybrid systems include a combination of two or more discrete system types.

Photo: Courtesy of Sierra Institute for Community and Environment

At the new Plumas County Biomass Boiler Building in Quincy, California, the interior surfaces of the CLT panels were left exposed to showcase the material.

The Factory Advantage

Off-site production holds a number of advantages. Manufacturing can be more easily controlled, ensuring superior quality, and it is not subject to the foibles of weather and delays caused by the other trades. The factory setting is usually safer for workers as well, as assembly takes place on the ground in a familiar, monitored environment free from weather-related hazards.

An additional benefit is the accuracy and precision enabled through the use of computer numerical control (CNC) machining. The increasing use of 3-D modeling software such as building information modeling, or BIM, can be combined with off-site manufacturing to achieve very high efficiencies. BIM allows teams to thoroughly review components before they are fabricated and can also be used to coordinate logistics, such as the delivery of components.

Computer automation and the controlled factory environment enables much greater material efficiency as well; in addition, unused or leftover materials can be stockpiled for later use or used as fuel. Off-site production can reduce waste by 20 to 40 percent.

Because of wood's light weight, wood-frame and mass timber construction is ideally suited for prefabrication. Panels are manufactured specifically for each job, complete with precut openings for doors and windows and service channels for MEP equipment. They can be shipped to the job site precisely when they are needed, precluding the need to store materials on an already-crowded job site. Weather protection is important for prefabricated parts and assemblies; consequently, manufacturing, transportation, and construction site logistics must be very good.

In a dramatic example of how prefabricated mass timber panels can reduce construction time, the primary superstructure for the Plumas County Biomass Boiler Building in Quincy, California, was erected in just over a week. The project, which was led by the Sierra Institute for Community and the Environment, utilized CLT panels for the structure and required only a small crew to lift, set, and screw them into place.

The building, which was completed in December of 2017, houses an innovative biomass boiler system that utilizes woody byproducts generated from forest restoration and management activities. The interior

MASS TIMBER COMPONENTS

Panelized products that are manufactured off-site include mass timber elements such as cross-laminated timber (CLT) panels, nail-laminated timber (NLT) panels, dowel-laminated timber (DLT) panels, and glue-laminated timber (GLT) panels, and columns and beams (glulam).

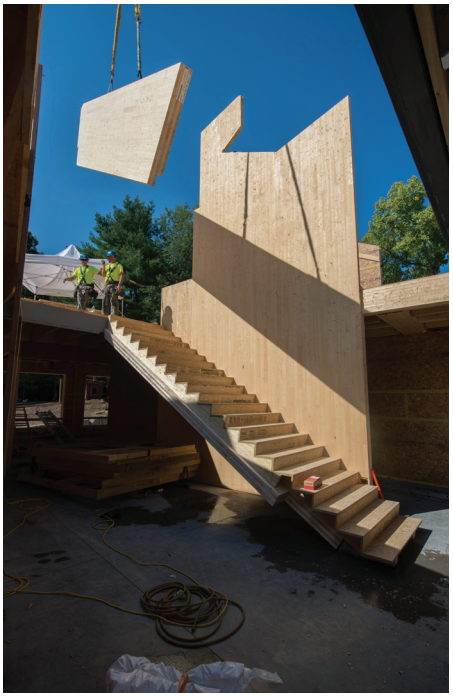
Cross-laminated timber: CLT panels are manufactured by stacking layers of wood in alternating perpendicular layers and gluing them together. CLT panels may be used in both vertical and horizontal assemblies.

Nail-laminated timber: NLT is manufactured with dimension lumber that is stacked on edge and fastened together with nails; plywood sheathing is often attached to one face to provide a structural diaphragm. The Binational Softwood Lumber Council has developed the *NLT U.S. Design and Construction Guide* to help ensure the safe, predictable, and economical use of NLT.

Dowel-laminated timber: This mass timber element is similar to NLT, but it uses wood dowels instead of nails as fasteners. It is ideal for floor, wall, and roof structures. Because it is an all-wood mass timber product, it can be processed using CNC machinery, and any number of custom profiles can be milled into the exposed face.

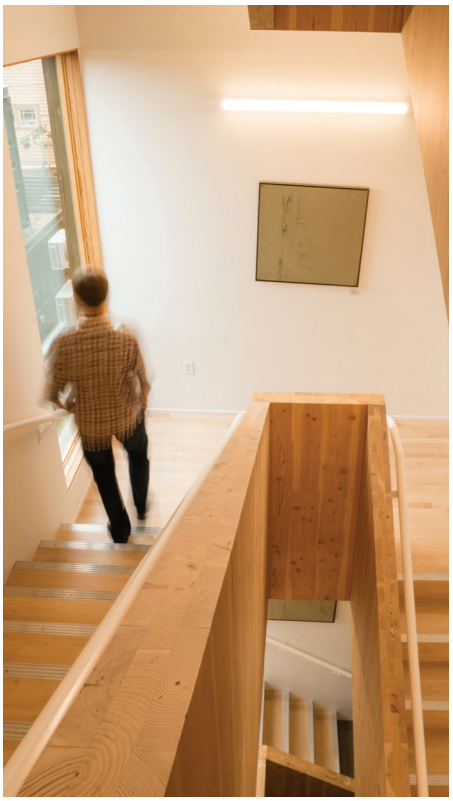
Glue-laminated timber: Also called glulam or GLT, glue-laminated timber is a structural engineered wood product that is manufactured by arranging dimension wood laminations according to their stress-rated performance. Glulam beams and columns are often used in residential and commercial buildings, and GLT panels can be used in floor and wall assemblies.

Photo: Courtesy Gray Organschi Architecture



A new addition to Common Ground High School in New Haven, Conn., was framed using heavy timber and mass timber components in just four weeks.

Photo: Courtesy of Oregon Department of Forestry



At Albina Yard, a speculative mass timber office building constructed in Portland, exposed wood, high ceilings, and shared spaces are designed to inspire creative collaboration.

THE POSSIBILITIES OF PODIUM DESIGN

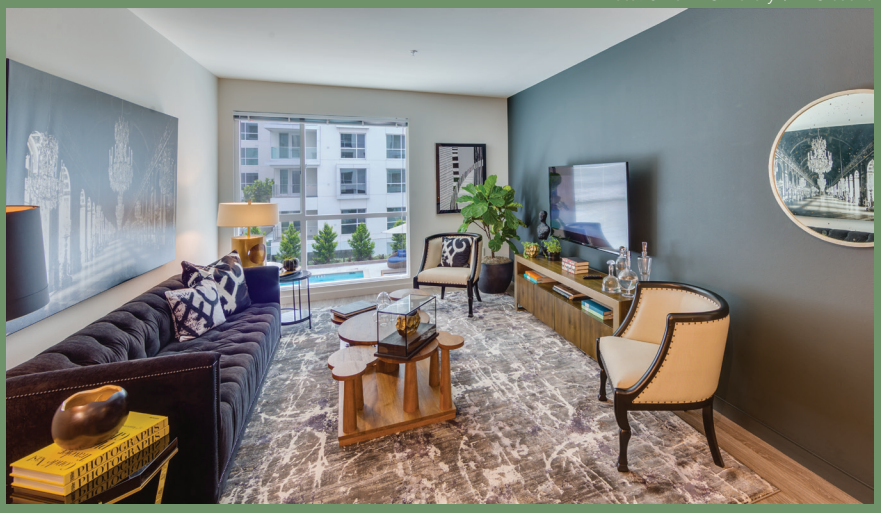
Podium construction allows designers to expand the possibilities of certain construction types. Podium construction refers to a light wood-frame structure built over a one- or multi-story "podium" of another construction type. The International Building Code (IBC) Section 510.2 considers these constructions as separate structures built on top of each other; consequently, area limitations, continuity of fire walls, and allowable number of stories are considered separately. Buildings must still comply with the maximum allowed building height for that construction type.

The podium is typically concrete construction, with the upper slab acting as a three-hour fire-resistance-rated fire-separation and structural-transfer slab for the framing above it. This enables higher-density projects with additional stories while allowing project owners to take advantages of the lower cost and speedier construction of wood framing. Some common configurations enabled by podium construction include four or five stories of residential use over retail, commercial, office, and/or parking. Mezzanines can be used in conjunction with podium construction to achieve even greater densities.

Previous versions of the IBC only allowed podiums to be one story above the grade plane. The 2015 IBC allows multiple story podiums, opening the door for buildings with double podiums and five stories of wood framing.

WREN, a multifamily project completed in the South Park district of Los Angeles, took advantage of podium code allowances to meet the owner's density requirement of 195 units per acre through cost-effective wood-frame construction. The project includes two seven-story structures with a "five-over-two" configuration—five levels of Type III construction built atop double podiums—the first project in the city to utilize this design.

Photo: © Kevin C. Korczyk/K2 Creative



The 362 apartments at WREN, a new residential community designed by Togawa Smith Martin for downtown Los Angeles, range from 487 to 1,750 square feet and are available in studio, one-, two-, and three-bedroom floor plans.

surfaces of the CLT panels were left exposed to showcase the material. The project also set a precedent in California by using CLT as the seismic-force-resisting lateral system (the first building in California to use CLT for both gravity and lateral systems) and is a pertinent example of resilient design that can help ensure important infrastructure remains functional following a disaster.

In many of these innovative buildings, wood is being used for pragmatic reasons such as speed of assembly but also to achieve ambitious sustainability goals and convey messages about an institution's or organization's mission. A $7.5-million, 14,000-square-foot addition to the Common Ground High School exemplifies this approach. Located in New Haven, Connecticut, the environmental charter school offers students an innovative curriculum of urban agriculture combined with sustainable land-management practices.

The new school building was framed in just four weeks by a crew of five using prefabricated materials. Alan Organschi, designer and principal at New Haven, Connecticut-based Gray Organschi Architecture, designed the project, which is constructed with heavy

timber and mass timber components. Black spruce CLT panels act as the tension surface and final ceiling finish. Vertical CLT panels form bearing and shear walls, while glulam rafters and heavy timber trusses span the large ground-floor multipurpose space.

The project was used as an opportunity to connect students with the resources used to construct their new addition, which is targeting LEED Gold certification. Students learned which forests produced the wood and where the CLT panels were fabricated. They also appreciate the "fresh" indoor air quality, which can in part be attributed to the wood materials used throughout.[14]

Albina Yard, a four-story, 16,000-square-foot speculative office building with ground-floor retail located in North Portland, Oregon, demonstrates how the use of prefabricated components can streamline construction as well as the benefits of the precisely engineered panels that enable a predictable and easy-to-construct system. The building utilizes mass timber construction along with a glulam timber frame. CLT panels were made with regionally sourced Douglas fir and manufactured in Oregon; Albina Yard was the first project in the country to use domestically produced CLT.

The design team at LEVER Architecture always planned to use wood as the primary structural material. It priced two approaches: standard tongue-and-groove wood decking and CLT; however, its primary goal was to utilize domestic CLT in a market-rate office building, thus paving the way for broader market adoption in Portland and beyond. Consequently, the team worked with engineers and fabricators to optimize CLT costs by simplifying details and leveraging CLT's two-way spanning capacity to use fewer glulam beams. Prefabrication also allowed components to be assembled on-site five times faster than a conventional wood decking system.

The glulam wood columns and beams were milled in Portland using a Hundegger K2 CNC joinery machine. According to LEVER, the use of CAD/CAM software and CNC technology "allowed the team to rapidly design and prototype precise connections, milled to a $^{1}/_{8}$-inch tolerance."[15]

EXPANDING MARKETS AND TECHNOLOGIES FOR WOOD

Over the past decade—and thanks to a few early adopters—projects have shown how code-compliant wood structures can meet seismic, fire, and other code requirements while satisfying project goals and budgets. Now, these newer methods of wood construction are moving into the mainstream.

Schools, office buildings, mixed-use projects, and hotels are all examples of markets that are primed for expanding use of wood construction. These sectors have average building sizes well within the scope of current codes, and examples in each category are showing how wood construction—whether light-frame, heavy or mass timber, or a hybrid—can make for more cost-competitive construction, achieve performance and sustainability goals, and create appealing and distinctive buildings that attract higher rents.

Commercial Office Building: Karuna at One North

Karuna at One North in Portland consists of two new buildings totaling 85,540 square feet: a five-story Type IIIB building (consisting of four floors of Type IIIB construction over a Type I concrete podium) and a separate four-story Type VA building (consisting of three floors of Type VA construction over a Type I concrete podium). Both include offices above ground-level retail.

Glulam columns and beams create the primary structures. Fire-retardant-treated wood (FRTW) shear walls form part of the lateral-resisting system, and sprinklers added on the exterior allow the structure to exceed the 40-foot combustible exterior finish limit.

Influenced by the work of modernist Spanish architect Antoni Gaudí and designed by Holst Architecture, the building exteriors feature warm wood cladding accented by shaded window walls that curve out from the facade. Karuna at One North uses 50 percent less energy than a conventional code-built structure but was built at a comparable cost per square foot.[16] On its website, Holst states, "Using a mostly timber wood frame helped us achieve our rigorous sustainability goals and set a new standard for offices." According to developers, rental rates surpass those of offices in downtown Portland, even though the building is 1 mile north of downtown.

The project has garnered several awards, and the new buildings join another distinctive wood building that was completed a year earlier. Dubbed The Radiator for its gilled facade that was designed by Path Architecture and completed a year earlier, the Type IIA structure was the first five-story wood-frame building to be erected in the city in more than 100 years.

School: Franklin Elementary

School districts are increasingly embracing wood as a safe, cost-effective, and sustainable alternative to more conventional methods of construction. Franklin Elementary is the first design-build school project in the state of West Virginia, and the first school in the United States to be built using CLT.

Facing a short construction window and tight budget, Franklin's school district chose CLT for the structure over concrete masonry units and insulated concrete forms, which are commonly used for school construction in the state.

The CLT structure highlights the versatility of the material and how it can be used to accommodate design. In places where the design needed to avoid columns, the thickness of the CLT panels was increased to enable greater spans. Similarly, the roof panels ranged in thickness from about 5 to $9^{9}/_{16}$ inches.

Speed of construction was a huge plus on this project. After the foundation was completed in late March 2014, a small crew

AFFORDABLE HOUSING: ORCHARDS AT ORENCO

Location: Hillsboro, Oregon
Architect: Ankrom Moisan Architects
Engineer: Stonewood Structural Engineers

At a time when housing costs are skyrocketing, responsible developers are turning to wood to keep the cost of construction down while still offering attractive, energy-efficient rental housing. Orchards at Orenco is a prime example. This three-story, 57-unit "deep green" multifamily development, completed in Hillsboro, Oregon in 2015, is the largest Passive House project in the United States. Wood helped the project meet ambitious energy-efficiency goals while remaining cost-effective. The 58,000-square-foot project utilized a modified balloon framing on a concrete slab-on-grade foundation. Most walls consist of 2-by-10 framing with blown-in fiberglass cavity insulation and 1½ inches of rigid mineral wool on the exterior. Sheathing joints were taped, which helped create an airtight envelope and achieve an astounding measured airtightness of 0.13 ACH50, well under the Passive House requirement of 0.6 ACH50. A spun-bonded polyolefin sheet membrane serves as the water-resistive barrier.

Orchards at Orenco was built to be affordable to renters with incomes under $30,000. In addition, the extremely low energy demand will ensure renters enjoy low utility bills for the life of the building.

CONSTRUCTION TYPES, HEIGHTS, AND AREAS

The International Code Council (ICC) categorizes buildings into five construction types, and further breaks these into subtypes designated as either Protected (A) or Unprotected (B). Types with the A subtype designation have more rigorous fire-resistance rating requirements.

Building codes allow wood structures in a variety of construction types. Type III, often referred to as "ordinary" construction, is frequently associated with multifamily projects, but Type IIIA commercial office buildings that fall under this designation may be constructed with up to six stories of wood. For these buildings, the exterior walls must be noncombustible or fire-retardant-treated wood, but interior elements may be of any construction type.

Type IV, or heavy timber construction, utilizes solid or laminated wood members; however, concealed cavities are only allowed in partitions. New provisions for combustible concealed spaces will be introduced in the 2021 IBC.

Type V is most commonly wood frame and is permitted in many building occupancy classifications.

The code provides height and area limitations for each construction subtype. However, there are several ways to increase these allowances.

Equipping buildings with fire sprinklers enables both height and area increases. Buildings equipped with automatic sprinkler systems qualify for a height increase of 20 feet and one story, as per IBC 2015 Section 504. For example, the allowable building height for Construction Types IIIA and IV, with a B occupancy, is five stories and 65 feet. The sprinkler allowance increases the building height to six stories and 85 feet. In addition, as per IBC 2015 Section 506, designers may increase the tabulated floor area by 300 percent for single-story buildings and 200 percent for multistory buildings.

As per IBC 2015 Section 506.3, a building that has more than 25 percent of its perimeter adjoining an open space (or frontage) qualifies for an area increase, though smaller than the one afforded by sprinklers.

Finally, for Type III and Type V buildings, projects may add an additional floor by designing a mezzanine into the project. As per IBC Section 505, a mezzanine can be up to one-third of the floor area of the room or space where it is located and must be open to the room below. It is not considered a story, nor is it counted in the allowable floor area per IBC Chapter 5.

Here are some other special provisions outlined in Section 510:

The overall combined height of the two buildings is measured from grade plane and is limited by the more restrictive height limits of the two building types.

IBC Section 510.4 allows buildings with parking below (S-2 occupancy) and any Group R occupancy above. This provision allows a podium of Type I or Type IV construction with a 2-hour fire separation. If sprinklered, this can be reduced to a 1-hour fire separation. Again, the overall height restrictions set forth in Table 503 apply.

IBC Section 510.5 sets forth provisions for R-1 and R-2 Type IIIA buildings up to six stories and 75 feet. For these constructions, the first floor assembly above the basement must have a fire-resistance rating of not less than 3 hours, and the floor area is compartmentalized into areas of not more than 3,000 square feet each by 2-hour fire-resistance-rated fire walls. In this case, smaller-footprint buildings would require fewer firewalls, making it more cost-effective.

Photo: © Kevin C. Korczyk/K2 Creative

Five stories of wood construction built on a double podium enabled high densities at Wren, a new residential community designed by Togawa Smith Martin for downtown Los Angeles.

Source: WoodWorks

Multistory Business Occupancy: Allowable Building Sizes

	Common Construction Types: 3–4 Stories				Common Construction Types: 5+ Stories		
	Steel/Concrete	Wood Framing			Steel/Concrete	Wood Framing	
Construction Type	IIB	IIIB	VA	VB	IIA	IIIA	IV
Stories[a]	4	4	4	3	6	6	6
Height (feet)	75	75	70	60	85	85	85
Maximum Story Area[b] (square feet)	69k	57k	54k	27k	112.5k	85.5k	108k
Total Building Area[c] (square feet)	207k	171k	162k	81k	337.5k	256.5k	324k

[a]Assumes: NFPA 13 sprinklers throughout (IBC 504.2)
[b]Assumes: NFPA 13 sprinklers throughout (IBC 506.3), multistory building, no frontage increase
[c]Assumes: 3 or more stories (IBC 506.4), no frontage increase

This chart shows how including sprinklers can increase height and area allowances for Type III and V buildings to the same levels (or nearly so) as Type II buildings.[24]

from City Construction Company began setting CLT panels; the last was set in mid-June. During one day, a crew of four plus a crane operator installed 33 panels, or 10,000 square feet of building surface.

Construction was able to proceed safely in all weather conditions, which allowed the project to be completed on time—another benefit for challenging climates. Now that the state's School Board Authority has approved CLT construction, it can be used to construct other schools throughout the state.

Hospitality: Candlewood Suites Hotel at Redstone Arsenal

When building a new Candlewood Suites hotel at Redstone Arsenal in Alabama, developer Lendlease chose CLT for its speed and quality. The four-story, 62,688-square-foot hotel was built 37 percent more quickly and with 44 percent fewer person-hours than similar hotels. It was built with just an 11-person crew: three experienced carpenters and eight unemployed veterans who received on-the-job training. CLT was utilized for all exterior walls, parapet walls, interior walls, elevated floor slabs, and roof deck; glulam columns and beams were also part of the structure. The wood components are sealed with cladding on the exterior and drywall on the interior.

As with Franklin Elementary, the project team remarked on the ability to safely work with CLT under all weather conditions. Bill Tobin, vice president and master superintendent at Lendlease, cited several safety advantages of CLT. Very few crew members were required to work within the swing radius and fall of the crane, and safety measures such as handrails were attached to panels while they were still on the ground, ensuring they were immediately safe to workers once set into place.[17]

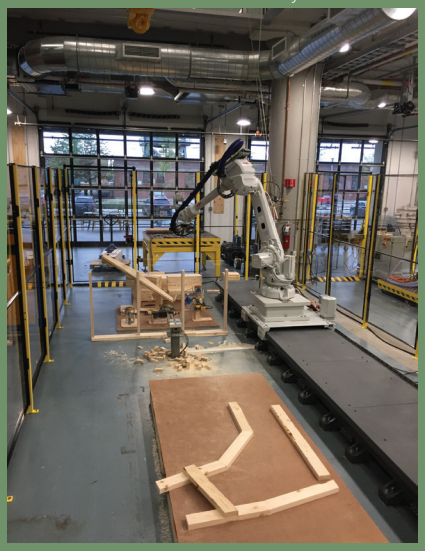
The CLT construction also helped achieve other performance goals, including energy efficiency and sound protection. The CLT panels were manufactured to a tolerance of less than $^{1}/_{16}$ inch, which guaranteed an airtight envelope. In addition, field testing of CLT floor and wall assemblies resulted in sound transmission class (STC) ratings significantly higher than those required by code.

BUILDING EXPERTISE

Early adopters of newer mass timber construction techniques often face steep learning curves. To navigate this new landscape, some leading firms have committed to building wood expertise both within their firms and throughout the profession. Two of these leading firms are Perkins+Will and Hickok Cole.

The Building Technology Lab at Perkins+Will explores design-to-fabrication automation with an emphasis on low embodied energy to no-carbon assemblies. Specific focus areas include the integration of robots into the design process, structural material selection and performance optimization, climate-sensitive facade design automation, innovation in mass timber technologies, and robotic fabrication.

Photo: Courtesy of Perkins+Will.



A robot at Perkins+Will's Building Technology Lab converts complex curved designs into NLT structures.

For one project, the Building Technology Lab used a robot to fabricate a NLT pavilion that served as Perkins+Will's expo hall booth at Greenbuild 2018 in Chicago. The design process developed for the project allows any complexly curved digital surface to be converted into a digital array of trimmed 2-by-4s and wooden nails. Picking up one 2-by-4 at a time, the robot cuts, mills, and nails the boards together to assemble panels of NLT. These panels are erected by hand with wooden dowel connections to form the pavilion structure.

Hickok Cole seeks to educate clients, general contractors, and the general public about the benefits of mass timber as an alternative to steel and concrete.

"Hickok Cole wants to challenge people's perception of what is possible with the material of wood in order to establish itself as a regional leader in mass timber design and construction," says Sean McTaggart, AIA, LEED Green Associate, for Hickok Cole.

The firm's iLab program provides microgrants for designers to research and apply emerging concepts and technologies. One end result of this program is Timber Towers in Philadelphia, which is the firm's vision of "building tall" with wood in order to combat climate change on a large scale. Hickok Cole is also working with the Softwood Lumber Board and the District of Columbia's Department of Energy and the Environment to build a mass timber ranger station on Kingman Island in Washington, D.C.

"No matter the size of the project, we recognize that the time has come for architects to find ways to reduce our carbon footprint, minimize waste, and truly rethink the construction process," McTaggart says.

Firms can also benefit from having material experts to draw from when considering different types of projects. In many cases, firms rely on structural engineers. In the case of wood, WoodWorks and the American Wood Council provide project consulting and code expertise. Staffed by regional architects and engineers, WoodWorks offers project support from design through construction at no cost.

MARKET DISTINCTION

Increasingly, the next generation of multifamily tenants, office workers, and students value uniqueness and authenticity in their homes, schools, and workspaces. Informed by mobile technology and driven by a sense of creative place-making, buyers and tenants are especially drawn to the pockets of the built environment that convey warmth and "naturalness" and a connection to the past—but with modern amenities and super-fast Wi-Fi speeds, of course.

Many building owners are turning to wood construction in order to distinguish themselves to their customers and clients—and in some cases, to rebrand. They're using building design to project values: environmental sustainability, health and wellness, and the celebration of local culture.

Specific demographic groups are pushing some of these trends. Millennials, defined as the generation born between 1981 and 1997, have the reputation of being both tech savvy and environmentally conscious. They have embraced the sharing economy and are comfortable with services such Uber, Lyft, Airbnb as well as shared workspaces and open office plans. This huge cohort, with an estimated 83 million individuals, was greatly impacted by the Great Recession of 2007. Saddled with student debt and a depressed job market, many delayed traditional milestones such as marriage and home ownership. Today, Millennials are eager to enter

the housing market; however, the things they are looking for in a home tend to be slightly different than their parents.

Millennials value health and wellness. They're more likely to patronize locally owned restaurants that serve dishes with ingredients sourced from nearby farms and ranches. They spend significant portions of their income on "self-care"—whether fitness classes, organic food, or massages. They want to do work that is meaningful and seek employment with companies that have good track records when it comes to sustainability and workers' rights, and they expect perks like employee lounges and fitness centers.[18, 19]

Alongside this influence, there's growing support for biophilic design in the building professions. Biophilia is commonly defined as the affinity humans feel for the natural world. Proponents of biophilic design argue that fostering the connection between people and the natural world is vital to health and well-being. Starting with a now-famous study published in 1984, which showed that post-operative patients recovered more quickly if their rooms included views of green space compared to those whose rooms faced out onto a wall, numerous studies since have quantified the benefits of biophilic design on productivity, absenteeism, and perceived well-being.[20, 21]

Wood is a natural material that can directly connect building occupants with ecological systems. It is often incorporated into "green" buildings with other natural materials and "organic" colors and finishes that together create wholesome, nurturing interior environments. A collaborative study conducted by the University of British Columbia and FPInnovations has established a link between wood and human health. In this study, 119 university students were exposed to rooms which included visible wood surfaces and "control rooms" with white surfaces. Students in the wood rooms showed lowered sympathetic nervous system (SNS) activation, which is a proxy for stress.[22]

Making It Real in Retail

In the world of retail, companies face a constant struggle to distinguish themselves. They not only have to attract (and keep) loyal customers from other brick-and-mortar companies, they must convince customers to physically walk into their buildings rather than shop online. Consequently, there is a huge emphasis on customer experience, often abbreviated as CX, which can be defined as the long-term relationship between a customer and a brand.

Sometimes this means companies must rebrand to keep up with changing preferences and values. Chain restaurants present an interesting test case. Known in the past for their comforting sameness, today many are creating distinctive buildings attuned to their cultural and environmental surroundings, in part to capture the loyalty of Millennials, who value authenticity and localism. This is accomplished as much with building design as with the menu offerings. Some of these companies are moving away from garish colors and synthetic plastics and are instead integrating organic palettes and natural materials, including wood, into their buildings.

A revamped McDonald's in Chicago's River North neighborhood illustrates this trend and exemplifies urban sustainability. The 19,000-square-foot restaurant is a one-story building with a sophisticated glass and steel facade. But its most outstanding feature is its CLT roof deck.

Designed by Ross Barney Architects and built by Walter Daniels, the building is considered Type IIIB construction (construction other than heavy timber in which the structural interior framing elements are entirely or partly wood). It marked the first time CLT has been used in Chicago, and a rush of mass timber buildings have since broken ground.

Inside, the space is lit with ample daylight and warmed with exposed CLT panels and green plants. The deck is dropped above the ordering area, and the glass-lined space supports a cluster of birch trees. In addition, a row of apple trees growing on the roof is visible through the clerestory windows, connecting diners with the plants from which food comes.

"The major message that they want to convey by their new architecture is authentic and natural, and that's what their new prototype really stresses," Carol Ross Barney, principal at Ross Barney Architects, told *Chicago Magazine*.

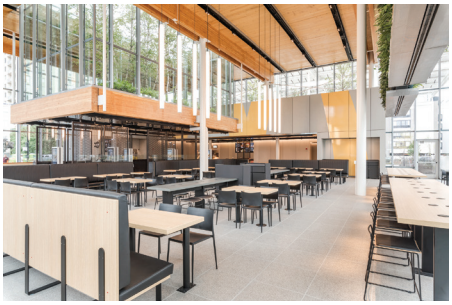
The roof supports a solar array; other sustainable features in the LEED-certified project include permeable paving and daylighting, which reduces energy demand from artificial lighting. The Chicago McDonald's reflects the company's larger sustainability goals, which include cutting greenhouse gas emissions from its restaurants, corporate offices, and supply chains by 36 percent by 2030.

Attracting Quality Tenants and Employees

T3, which stands for Timber, Transit, Technology, was completed in Minneapolis in 2016. Taking design cues from old brick and timber warehouses, T3 is the first commercial property in the United States to use wood for its structure and interior. The seven-story, 220,000-square-foot building, designed by Michael Green Architecture in collaboration with the DLR Group, was constructed with 8-by-20-foot NLT panels and glulam beams and columns. The six stories of timber framing are built on a 29,000-square-foot concrete podium. Laminated veneer lumber (LVL) was used in the stairs.

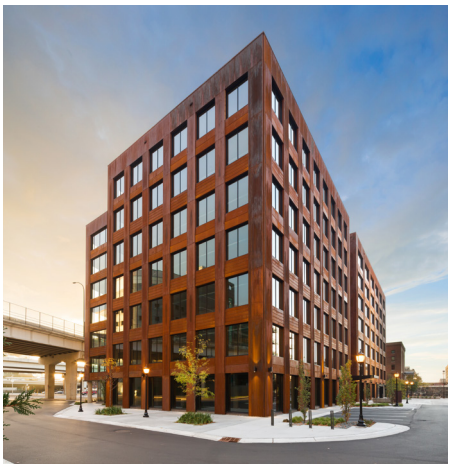
This building was created expressly to attract a certain kind of tenant. The T3 North Loop website states: "A company's brand optics—what it represents in the minds of employees and other stakeholders—is of paramount importance," and it touts T3 as a "tangible recruiting tool for employers." The building has plenty of features and amenities expressly designed to appeal to millennial workers: workspaces that promote collaboration and are also

Photo: Courtesy of Ross Barney Architects



A new flagship McDonald's restaurant in Chicago, built in part using CLT panels, effectively rebrands the fast-food chain and sends a strong message about the company's commitment to sustainability.

Architecture: Michael Green + DLR Group | Photo: Ema Peter



T3, a speculative "tall wood" building completed in Minneapolis, demonstrates the marketability of mass timber buildings and is already being replicated in several other major cities.

"high-tech, stylish, comfortable, cool, and fun." Amenities include an open but flexible office plan, coffee bar, fitness center, bike repair shop, and rooftop deck. The building is also within walking distance to many restaurants and public transit options—the second "T" in T3.

"There was this demand for a new type of office," says Steve Cavanaugh of DLR Group. "More textural, more sustainable. It was aligning with the values of the younger tech companies. And when that market demand started to push in there married with the development of wood technology, it started to become more feasible."

The building owner did not secure any leases before going forward with construction. However, before completion, Amazon has leased two floors to become the anchor tenant; as of this writing, the building has been sold to an investment group and is 82 percent leased. Additional T3 buildings are in the works for Atlanta and Chicago, with more to come, proving the replicable nature of this design.

The timber structure was completed in two-and-a-half months at an average of nine days per floor—a rate which exceeds conventional steel-framed or concrete construction and allowed the owner to lease the space sooner. In addition, the 2.2 million board feet used in the structure will sequester about 700 tons of carbon for the life of the building.

But although the project has garnered much attention and praise for its Timber construction, the other two Ts in T3—Transit and Technology—are also key to its success.

The project is located one block from a major transit hub and has direct access to the Minneapolis Skyway, a system of elevated walkways which connects buildings, and a hike-and-bike trail. T3 is also the first office building in Minneapolis to receive preliminary Wired Certification, a standard which identifies buildings with best-in-class internet connectivity. The standard considers several factors, including the quality and diversity of IT connectivity, the extent of physical internet infrastructure, and the IT readiness of a building. According to WiredScore, T3 received certification "due in part to the density and diversity of lines to the site, multiple points of entry for carriers, and multiple riser pathways to support IT security and future growth of building tenancy."[23]

What does the wood construction have to do with Wi-Fi connectivity? Quite a lot, it turns out. Different construction materials interfere with wireless signals to varying degrees. Concrete and masonry are the worst when it comes to blocking wireless signals, whereas tests conducted by the U.S. National Institute of Standards show the impact of plywood and drywall on Wi-Fi signals to be near zero.

ROCKY MOUNTAIN INNOVATION CENTER

Location: Basalt, Colorado
Architect: ZGF Architects
Structural Engineer: KPFF Consulting Engineers

The Rocky Mountain Institute calls its new 15,600-sqare-foot office building in Basalt, Colorado, "a physical manifestation of the organization's work and values." It demonstrates resource and energy efficiency along with innovative high-performance construction techniques.

Here, the overarching goals included creating a building that is not only exceptionally energy efficient but also one that would inspire other developers and owners to build similarly sized office buildings with significantly reduced energy demand.

Photo: © Tim Griffith

The CLT and glulam structure at the Rocky Mountain Institute helps capture carbon and reduce energy demand while creating a healthy, inspiring interior space for occupants.

The super-insulated building envelope utilizes a hybrid construction with both light wood framing and mass timber elements. The roof and exterior walls are made with structural insulated panels (SIPs), while the floors are constructed with CLT panels manufactured from trees killed by the mountain pine beetle. The 4-foot-wide CLT panels are centered on a row of glulam columns spaced every 20 feet. A secondary layer of CLT panels spans the opposite direction, forming the substrate for a concrete topping layer. A chase below the CLT panels houses mechanical and plumbing equipment and is easily accessible for maintenance.

These systems were energy efficient and easy for trades to work with, allowing the structure and envelope to be constructed quickly which, in this cold climate, was necessary because of the short construction window. The project was completed early and under budget.

Inside, the light-filled, comfortable environment connects occupants to nature. The exposed CLT and glulam structure celebrates the natural resources of the region while the balanced neutral palette maximizes light reflection and minimizes eye strain, and the exposed wood elements did not require finishes.

According to the Rocky Mountain Institute, the new net-zero energy building is the most energy-efficient building located in climate zone 7 in North America; it uses 74 percent less energy than similar office buildings in that same zone and cost only 10 percent more to build.

The project has garnered praise and earned several green building certifications, including LEED Platinum, Living Building Challenge Petal Certified, and Passive House.

CONCLUSION

Project owners and developers are increasingly turning to wood for its flexibility, sustainability, and cost advantages. The aesthetic and design possibilities of wood are also enabling these owners to enjoy a competitive advantage when it comes to attracting tenants and employees. Consequently, we are seeing examples of wood construction in all sectors, from mid-rise offices and hotels to schools and hospitals. As architecture firms continue to build expertise and capacity, expect to see more of these exemplary wood projects break ground in the near future.

Continues at ce.architecturalrecord.com

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CONTINUING EDUCATION

To receive AIA credit, you are required to read the entire article and pass the test. Go to **ce.architecturalrecord.com** for complete text and to take the test. The quiz questions below include information from this online reading.

1. **Mass timber structures can be built 25 percent more quickly than comparable steel, concrete, or even light wood-framed structures, which translates into reduced construction costs.**
   - **A.** True
   - **B.** False

2. **What property of wood enables wood products to sequester, or store carbon in a building?**
   - **A.** Wood is 50 percent carbon by dry weight.
   - **B.** Wet wood is 50 percent carbon.
   - **C.** Wood is noncombustible.
   - **D.** Wood is strong.

3. **Which building material is the best at allowing Wi-Fi signals through?**
   - **A.** Concrete
   - **B.** Glass
   - **C.** Metal
   - **D.** Wood

4. **Because glulam is stronger than steel at comparable weights and stronger and stiffer than dimensional lumber, it is a cost-competitive choice for:**
   - **A.** long structural spans.
   - **B.** tall columns.
   - **C.** Both A and B
   - **D.** None of the above

5. **What term describes complete buildings or rooms that are fabricated off-site and delivered fully assembled, complete with fixtures and exterior and interior finishes?**
   - **A.** Panelized components
   - **B.** Modular systems
   - **C.** Hybrid systems
   - **D.** Both B and C

6. **Podium construction consists of one or two stories of concrete construction, where the upper slab acts as a 3-hour fire-resistance-rated fire-separation and structural-transfer slab for the framing above it.**
   - **A.** True
   - **B.** False

7. **What demographic group is more likely to seek employment with companies that have good track records when it comes to sustainability and workers' rights and expects perks like employee lounges and fitness centers?**
   - **A.** Millennials
   - **B.** Baby boomers
   - **C.** Generation X
   - **D.** All of the above

8. **In one study, university students exposed to rooms with visible wood surfaces showed lowered sympathetic nervous system (SNS) activation, which is a signal for:**
   - **A.** hunger.
   - **B.** stress.
   - **C.** boredom.
   - **D.** pleasure.

9. **What is a big trend among brick and mortar retailers?**
   - **A.** A shift away from customer service
   - **B.** Encouraging all customers to shop online
   - **C.** An emphasis on customer experience
   - **D.** Refurbishing old buildings

10. **Per IBC Section 504, buildings equipped with an automatic sprinkler system qualify for:**
    - **A.** a height increase of 40 feet and two stories.
    - **B.** a height increase of 20 feet and one story.
    - **C.** a footprint that's twice as large.
    - **D.** omitting firewalls.