Industrial Revolution

Every home that is built is a representation of compromises made between different and often competing goals: comfort, convenience, durability, energy consumption, maintenance, construction costs, appearance, strength, community acceptance, and resale value. Consumers and developers tend to make tradeoffs among these goals with incomplete information which increases risks and slows the process of innovation in the housing industry. The slowing of innovation, in turn, negatively affects productivity, quality, performance, and value. This department features a few promising improvements to the U.S. housing stock, illustrating how advancements in housing technologies can play a vital role in transforming the industry in important ways.

Mass Timber: A Sustainable Building Solution

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Abstract

Architects, designers, and developers are exploring designs using new products like cross-laminated and glued-laminated timber. These new mass timber products provide a significantly lower carbon footprint and store carbon in the building for its lifetime. The advent of new building code provisions allowing for the use of mass timber products to construct larger structures that go up faster than those made with alternative materials like concrete and steel can help address the affordable housing crisis more quickly and in a sustainable manner.

Introduction

A public and private partnership set out to test a possible solution to affordable housing shortages in Seattle and turned to mass timber, a category of wood products that includes cross-laminated timber (CLT), glued-laminated (glulam) timber, and other structural composite lumber products. To form these products, wood boards are combined to create large, premanufactured, multilayered, solid wood panels to be used in constructing walls, beams, roofs, and floors.

In April 2022, on a former surface parking lot in the city's Capitol Hill neighborhood, construction commenced on what is now known as the Heartwood. The eight-story, 67,000-square-foot structure built with CLT ceilings and glulam columns provides 126 housing units for residents with an income level between 60 and 100 percent of the city's median income. At the time, Heartwood was the first mass timber construction (also known as Type IV-C construction) workforce housing building up to nine stories, or 85 feet, permitted in the United States.

However, another mass timber affordable housing project is underway on the other side of the country. Earlier this year, developers broke ground in New Haven, Connecticut, on the nation's second affordable housing project that incorporates mass timber instead of only steel and concrete. The 340+ Dixwell, designed for 70 units, is being built in a neighborhood that once served as a stop along the Underground Railroad and will use mass timber from the ground up, including CLT for walls and in elevator and stair core walls.

Using mass timber panels can speed up construction time by at least 15 to 20 percent compared with concrete and steel construction (Pacheco, 2018), and it avoids using those same carbon-intensive materials by substituting in wood products that store carbon for the life of the building. The Brock Commons Tallwood House on the campus of the University of British Columbia in Vancouver, one of the tallest mass timber hybrid buildings in the world, stores 1,753 metric tons of carbon dioxide (CO2)-equivalent carbon and avoided an additional 679 metric tons of CO2 emissions by using structural wood for a total CO2 benefit of 2,432 metric tons. One building using mass timber is equivalent to taking 511 cars off the road for a year (FPAC, 2017).

Both the Heartwood and 340+ Dixwell are recipients of Wood Innovations Grants (Spiritos and Fernholz, 2021; University of Washington, 2019), a U.S. Department of Agriculture program designed to expand wood construction and new markets for wood products.

Background

Traditional construction elements used in taller structures, such as steel and concrete, are labor-intensive, nonrenewable, and carbon-emitting. On the other hand, mass timber construction uses wood products that are renewable and carbon-capturing.

Two of the most used types of mass timber products are CLT and glulam. CLT panels are made of layered timber stacked crosswise at 90-degree angles. The boards are then glued in place using a structural adhesive. The alternating directions of the boards serve to strengthen the CLT panels, allowing them to be used for load-bearing floors, walls, and roofs (exhibit 1).

Glulam is similar to CLT, except instead of being glued crosswise, glulam is composed of boards with parallel grains. Glulam is structurally sound and stronger than steel and can be used to form beams, columns, trusses, and more. Glulam is also known for its aesthetic attributes and often used as an exposed structural element for ceilings and walls.

Exhibit 1

Stack of Cross-Laminated Timber Panels Showing the Cross Section of Three Layers to Each Panel

Panels are most often three, five, seven, or nine layers. Photo credit: naturally:wood (n.d.)

Why Mass Timber?

Now that the International Code Council-developed model building codes include mass timber construction types up to 18 stories (van de Lindt, Koliou, and Bahmani, 2023), architects, engineers, and designers are exploring designs using new products like CLT and glulam that can create an aesthetically warm living space by giving residents a closer connection to nature.

Mass timber buildings are constructed with large, premanufactured, multilayered, solid wood panels, resulting in solid timber floors and walls typically ranging from 5 to 12 inches in thickness (exhibit 2). Typical mass timber products include CLT, nail-laminated timber, glulam, and structural composite lumber—all renewable and sustainable engineered wood products.

Using prefabricated wood panels makes for efficient construction and renovation and enables end-of-life disassembly and material repurposing. Again, using the Brock Commons mass timber building in Vancouver as an example, the prefabricated mass timber construction generated 65 percent less waste than tall concrete and steel construction (Acton Ostry Architects Inc., 2017).

Exhibit 2

Apex Clean Energy Headquarters in Charlottesville, VA, Boasts a Potential Carbon Benefit of 3,000 Metric Tons

A mass timber panel is lifted into place during construction. Apex Plaza, n.d. Photo credit: American Wood Council (2022).

Using prefabricated mass timber panels also speeds up construction time by at least 15 to 20 percent compared with conventional construction (Pacheco, 2018).

Although mass timber products may still cost the same or more than traditional materials, the cost savings related to speed of construction can ultimately lower the overall project cost by shortening the project's duration up to 25 percent compared with traditional concrete and steel construction (DLR Group et al., 2018).

Mass Timber Health and Welfare Benefits

Key federal initiatives addressing affordable housing—such as tax credits to build or rehabilitate affordable housing, American Rescue Plan funds for investments in housing, and the U.S. Department of Housing and Urban Development's (HUD) Community Development Block Grant program—primarily address barriers in supply only. What is not addressed are approaches that go beyond supply barriers and structural quality to consider the health, mental health, and well-being that a building's materials can offer.

A growing body of science focuses on the health benefits of living in spaces that connect us to the natural world. Known as biophilic design, using mass timber makes a connection with nature even in the most urban of settings. Emerging research suggests that natural building products like wood can have significant mental and physical health benefits for inhabitants.

Researchers at John Hopkins Medicine (2019) and many other institutions have concluded for decades that environmental stresses take a serious toll on heart health. Left untreated, those kinds of conditions can lead to medical emergencies such as heart attacks or high blood pressure, which can exacerbate the existing issues of those already living in affordable housing. A comprehensive study from the University of British Columbia indicates that the biophilic benefits of being near wood products lower blood pressure and heart rate while also increasing parasympathetic nervous system activation to achieve greater learning outcomes (Fell, 2010).

Mass Timber as Solution for Carbon Reductions

Wood is a climate-friendly building material. Wood products can reduce greenhouse gas emissions by storing carbon and displacing emissions from conventional carbon-intensive building materials like concrete and steel. Using mass timber can reduce construction phase emissions relative to these materials by 69 percent, especially when sourced from sustainably managed forests (Himes and Busby, 2020). These climate benefits are particularly strong for structural wood products used in the built environment, which results in long-lasting carbon storage during the life of the building and during the end-of-life phase of those materials decades in the future. Wood products like glulam and CLT offer fire resistance and structural strength in addition to natural carbon sequestration and, thus, present a promising alternative to building materials with high greenhouse gas footprints, like concrete and steel for large-scale commercial affordable housing and rapidly constructed modular homes.

Pierobon et al. (2019) conducted a life-cycle assessment of an eight-story, above-grade, nonresidential structure with three stories of below-grade parking in the Pacific Northwest. Three construction material scenarios were evaluated—a traditional reinforced concrete building and two using CLT and glulam, with one using gypsum wallboard and one using exposed wood for fire resistance. The study considered harvesting and extraction, transportation, manufacturing, and construction transportation and installation. The study found an average reduction of 26.5 percent in global warming potential in the two CLT-glulam scenarios, excluding the benefit of stored carbon, and determined that using nonrenewable fossil energy was 8 percent less in the CLT-glulam scenarios. Furthermore, an additional 1,556 to 2,567 tons of carbon dioxide equivalent (CO_2e) biogenic carbon was stored in the structure of the CLT-glulam building scenarios with and

without gypsum wallboard protection, respectively. CO2e measures the carbon emissions with the same global warming potential as 1 metric ton of another greenhouse gas. Biogenic carbon emissions are defined by the U.S. Environmental Protection Agency (2014) as CO2 emissions related to the natural carbon cycle.

The wood sourced to make these products in the United States comes from sustainably managed forests that are constantly replanted on carefully planned rotations to provide a host of additional benefits beyond just carbon sequestration. These forests provide better water quality, wildlife management, and recreational benefits for our citizens.

Mass Timber and Managing Wildfire Risk

Mass timber can also form part of our country's effort to address the devastating wildfires that have increased in recent years. Mass timber products can be manufactured from smaller-diameter trees and other lower-value forest resources, creating new market incentives for forest thinning and incentives for harvesting forest resources that the industry has typically overlooked. Wildfire prevention strategies often remove small-diameter trees and underbrush and leave the larger, more fire-resistant trees in place (Manke, 2021). Initial research on CLT and glulam manufactured from low-value, small-diameter Ponderosa pine shows these products perform as well as those produced using bigger-diameter trees of traditional lumber species (Lee, 2022).

In the summer of 2023, residents across the Midwest and East Coast experienced challenges and health complications from intense exposure to wildfire smoke—a seasonal reality that residents of Western states have been forced to live with in recent years as climate change has sparked wildfires in greater number and intensity. Smoke from historic blazes in Canada moved south and east, shrouding cities in smoke and particulate and creating health risks for millions of Americans with respiratory issues. Evidence of the smoke's breadth and scope was evident during HUD's Innovative Housing Showcase, held this past June on the National Mall, which featured two modular mass timber structures temporarily built on site and shrouded in smoke from Canadian wildfires.

Studies show climate change has a significant effect on wildfires, such as heat and drought, creating perfect conditions for the kind of catastrophic wildfires that ignited across the West in recent years and in Canada this summer. Decades of forest management practices, including fire suppression and policies that have enabled dense undergrowth, have also maximized flammable materials that contribute to rapid spread and intensity of wildfire. Combined, these factors and conditions provide another critical selling point for mass timber and its potential to contribute to overall forest health and reduce the risk of wildfires in forests across the West.

The forest health argument is motivating states like Washington, Oregon, and California to advance policies and incentives to accelerate markets and new opportunities for the mass timber sector (Cover, 2018).

Mass Timber as a Solution

America's housing stock is failing to keep up with the need for affordable housing for its workforce. National Low Income Housing Coalition-collected data estimate a shortage of 7 million affordable

and available rental homes for extremely low renters (NLIHC, n.d.). In addition, new multifamily units are renting at prices well out of reach for middle- and low-income renters (Hoyt, 2020). Nearly two-thirds of renters across the country say they cannot afford to buy a home and that saving for a down payment is unrealistic in the current economic climate, considering home prices are rising at twice the rate of wage growth (Sisson, Andrews, and Bazeley, 2020).

Using mass timber modular, factory-built components for the structure and building envelope can speed up the assembly and construction schedule while also requiring smaller crews than conventional materials to complete the project (Hicks, 2021). Given the significant affordable housing shortfall, a sense of urgency should exist, and mass timber can help to speed up delivery. It also provides a host of other benefits to both residents and the environment, as enumerated previously, making it a compelling new option for consideration in affordable housing projects across the country.

Acknowledgments

The author thanks Heather Stegner for her significant contributions to this article.

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