Is Wood the "New" Sustainable Solution for Buildings?

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Image Courtesy of Western Wood Structures

Builders began building with concrete – replacing wood - in the middle of the 19th century, initially for industrial buildings but later in the century – in Europe more so than the US – for residential properties as well. There were multiple reasons for this. First, concrete is more durable than wood and lasts two to three times longer. Second, there is much less risk of fire damage with concrete. And the fact that it retains heat in the winter and increases cooling in the summer makes for more energy efficient buildings – most particularly homes.

Steel was also introduced as a building material in the 19th century for industrial buildings. Steel frames are designed to be stronger and last longer than wood – and steel buildings often last decades longer than wooden structures. Steel structures are also more secure – as well as being completely termite proof. And way less susceptible to fires. [1]

But suddenly in the first quarter of the 21st century we are seeing builders returning to wood – which has been used to build structures since prehistory.

[1] There have been huge concerns about the dangers of wood with respect to fires, perhaps really accelerating after the Great Chicago Fire of 1871 which killed about 300 people, destroyed more than 3 square miles of the city including over 17,000 structures, and left more than 100,000 residents homeless.

So, what has caused this change?

Why is Wood now Back in Vogue?

The building industry currently accounts for about 39% of global energy-related CO_2 emissions. Almost a third of this results from manufacturing building materials such as steel, cement, and glass. Something like half a ton of CO_2 is emitted to manufacture a ton of concrete; approximately 2 tons of CO_2 are emitted in manufacturing a ton of steel[2]. To date, emission reduction efforts have not focused heavily on decarbonizing the construction sector. But that has begun to change as the industry looks to wood as a way of reducing emissions.

A new way of using wood has put the material back in play as a major building material. This is known as "mass timber" (short for massive timber and sometimes referred to as structural timber). Creating mass timber involves combining pieces of soft wood — such as pine, spruce, or fir - together to form larger pieces.

Mass timber is in fact a generic term that covers wood products of different sizes - and functions. Examples include glue-laminated (glulam) beams, laminated veneer lumber (LVL), nail-laminated timber (NLT), and dowel-laminated timber (DLT). The most common form of mass timber is known as cross-laminated timber – or CLT. CLT was first developed in the 1990's in Austria and then spread across Europe in the 2000's. It began to be used in the North America in the 2010's – although more so in Canada because of issues with US building codes. In 2015, CLT was incorporated into the International Building Code (IBC), which jurisdictions across the US adopt at their default. It's use in the US is currently almost exclusively for commercial buildings, which is not the case in Europe where it is also being used to build houses. (In the US, mass timber is perceived to not be able to compete with stick-frame construction used for home construction, which is cheap and ubiquitous – yet).

To create CLT, lumber boards are trimmed and kiln-dried and then glued on top of each other in layers, with the grain of each layer facing against the grain of the adjacent layer. Stacking boards together this way can create large slabs, up to a foot thick. The typical size of these slabs is around 10 x 40 feet, but much larger sizes are feasible. (The size used in particular constructions may be transportation constrained.)

Slabs of wood this large can potentially match or even exceed the performance of concrete and steel. CLT can be used to make floors, walls, ceilings – and even entire buildings. They can withstand severe fires as effectively as reinforced concrete structures of a comparable size. Wood actually has special characteristics that allow it to retain its stability during and after a fire. It forms

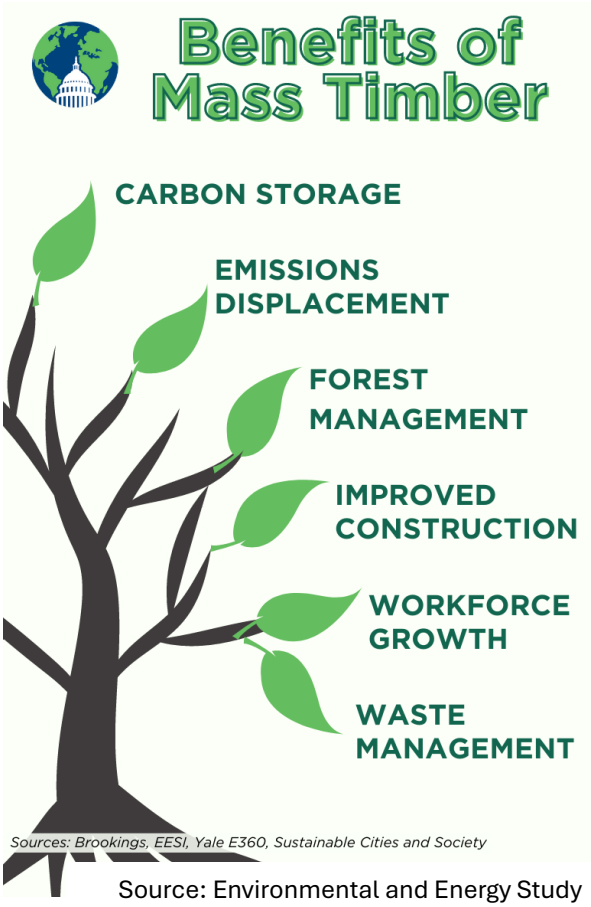
[2] There is now a movement to create and use "green steel". Green steel refers to steel produced using environmentally friendly and sustainable methods. This usually involves using renewable energy sources, reducing carbon dioxide emissions, and minimizing and recycling waste during the production process. This makes it greener, but it is not as green as wood. And it is estimated to cost 25% more than typical steel.

a protective carbon layer when exposed to intense heat so that the flames can only damage the outer layer of the wood. More on this below.

Advantages of Building with Wood

There are a number of advantages of wood construction.

- **Wood actually has a positive climate impact -** Wooden buildings serve as an extension of the carbon storage capacity of forest trees, storing over a ton of CO_2 for every cubic meter used. And trees removed for use in buildings create space for new trees to be planted, which then remove CO_2 from the air. (Unlike steel and concrete, forests are able to continuously regenerate, ensuring that there is always an ample supply of wood). Buildings made of wood reduce CO_2 emissions from other building materials like steel and concrete. And, wooden buildings – particularly houses - can be easily dismantled when they have reached the end of their useful service lives. Most of the components can then be recycled – producing no waste. Moreover, substituting mass timber for concrete and steel avoids the substantial carbon embedded in those materials. Cement and concrete manufacture is estimated to be responsible for around 8% of global GHG emissions, more than any country other than the US and China



Source: Environmental and Energy Study Institute

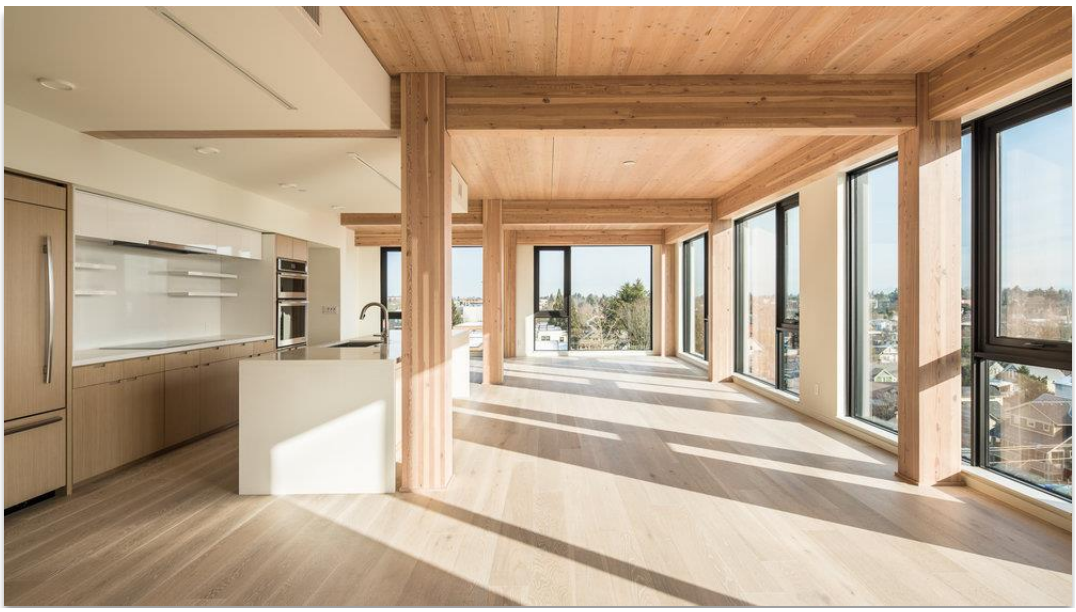
- **Building with wood uses less energy and generates fewer emissions –** According to the College of Environmental Science and Forestry at the State University of New York, a steel-framed home uses 17% more energy, has 26% more global warming potential, and emits14% more air emissions than a wood-framed home. A concrete-framed home uses 16% more energy, has 31% more global warming potential, and emits 23% more air emissions than a wood-framed home.

- **With wood you can construct buildings faster and with lower labor costs - and less waste -** Building with wood takes place less at construction sites and more on the factory floor. Walls, ceilings and even entire rooms made of wood can be precisely pre-assembled in production plants. Because these prefabricated pieces can be assembled a few at a time – and with relatively little labor - they can be shipped to the construction site on a just-in-time basis, avoiding extensive on-site inventory and minimizing on-site disruption – not to mention noise. (A study by the American Wood Council – albeit not an unbiased organization - reported that mass timber buildings are roughly 25% faster to construct than concrete buildings and require 90% less construction traffic). And, unlike reinforced concrete, there is no need for curing times. Even tall towers can be constructed within weeks, with low labor costs.

- **Wood can support many times its own weight -** Wood has a high load-bearing capacity with low dead weight. As a result, components made of wood are lighter than their concrete, steel, or brick counterparts; CLT buildings weigh around 80% less than comparably sized concrete buildings. Therefore, wooden buildings require smaller foundations, which saves space and money. And because the wood is light, it makes it easier to add more stories. Since mass timber is lighter it can also be built on urban and other lands not suitable for heavy concrete construction.

- **Wood is a good insulator** - Mass timber has about one-third the thermal insulating ability of a comparable thickness of fiberglass batt insulation, but about 10 times that of concrete and masonry, and 400 times that of solid steel.

- **Wood feels good to the touch –** Unlike steel or concrete, wood smells good, feels good and creates a pleasant atmosphere. It is a warm building material that does not draw heat from the human body. Wood can absorb and release moisture and therefore helps maintain a naturally regulated indoor climate. Wood is often left exposed in mass timber buildings — it doesn't need to be wrapped to meet code — and many people appear to really like to see large expanses of exposed wood and appreciate the way it captures light.



Interior of an all-wood condo unit in Portland Oregon. Courtesy VOX

Many also find the acoustics to be a positive. There have been studies that suggest that wooden structures have a calming effect and can even result in a drop in blood pressure; one report claimed that timber interiors improved patients' recovery time in a hospital.

- **Mass timber performs well in fires -** Wood can burn, yet modern wooden buildings are at least as safe as those made of other materials. In fact, mass timber is actually quite difficult to ignite. Like all other buildings, wooden structures must comply with official safety regulations. In the event of a fire, wood, unlike other building materials, burns slowly and in a highly predictable and more controllable manner. When there is a fire, the outer layer of mass timber will tend to char, but that effectively shields the interior, allowing it to retain structural integrity as well as load-bearing capacity for at least several hours, even in an intense fire. Reports on fire testing of CLT from the US Forest Service and the International Code Council indicate that CLT meets the code for fire safety. In contrast, steel behaves very differently in a fire; once it reaches a certain temperature it becomes highly unpredictable, which can result in the building being totally destroyed. (That being said, wood burning releases various pollutants that can harm the environment and human health. For instance, when wood is burned, the carbon stored in the tree is released as CO2. Moreover, wood smoke contains fine particulate matter (PM2.5), carbon monoxide, volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs) which can degrade air quality and pose a health risk).

- **Mass timber actually performs well in earthquakes -** The performance of mass timber in earthquakes has been extensively tested and has proven to be quite good. While concrete simply cracks in earthquakes, which means concrete buildings might need to be demolished and replaced, wood buildings can be repaired after earthquakes.

Where are Wooden Buildings Being Built?

As noted earlier, building with mass timber began in Europe in the 1990s. France has now mandated that all new buildings be built from 50% timber or other natural materials. Mass timber is being used for construction in many countries. It is being used in the US as well, but as noted earlier it is not as widespread in the US as in Europe.

While building with wood is definitely spreading, it has not all been smooth sailing. For example, several CLT panels in a 1,000-pound ceiling cracked and collapsed during construction of an Oregon State University Forestry School building in March 2018. Inspectors found dozens of faulty cross-laminated timber panels and the manufacturer admitted to fabrication defects of the panels. Shortly thereafter plans for a wooden tower in Portland, Oregon fell through, largely as a result of this event. But construction with mass timber is still expanding.

Initially the creation of CLT was perceived to result in timber sturdy enough to build as high as 12 stories, or 85 feet high as classified in the ICC's International Building Code of 2018. But now, even taller buildings are being built – or proposed.

Currently, the tallest building using this material is an 18-story building in Norway that has offices, apartments, and a hotel.

Mjøstårnet building in Brumunddal Norway. Source: UBM Magazine

The tallest all wooden commercial building in Canada, is T3 Bayside in Toronto, opened in 2021.

T3 Bayside Building Toronto. Rendering from T3 Bayside

This was the second T3 building built by StructureCraft for the Hines corporation. The first, T3 Minneapolis, was the largest mass timber building in the US when it opened. The 180,000 sq. ft. timber superstructure was installed in only 9.5 weeks. Hines has since opened additional T3 buildings in Atlanta and Nashville, also built by StructureCraft.

A much taller - by a wide margin - wooden building has been proposed for Chicago. The River Beech is intended to be 80 stories – if it is actually built.

Rendering of the River Beech Building Chicago. Source: Curbed.com

And an even taller building – of 11,150 feet or over 100 stories - is being discussed to be built in Tokyo – by 2041. The building, being termed a “plyscraper” is called W350 (which is intended to commemorate the 350th anniversary of building materials giant Sumitomo Forestry – and celebrate the intended 350-meter height of the building).

Rendering of W320 Building in Tokyo. Source UBM Magazine

There are a number of other, mostly one-off, CLT projects in the US. These include the Catalyst innovation hub in Spokane, the Carbon 12 condominiums in Portland, Oregon, and the Franklin Elementary School in West Virginia. Because they are one-offs, they require extra work in testing, designing, and securing permits. And there's a shortage of both suitable materials and builders and contractors familiar with this approach.

But interest in the US is beginning to grow. On the supply front, Vaagen Brothers, a well-known Washington sawmill, has already spun off a second company focused on CLT and other mills are expected to follow suit. A company called Katerra opened the largest CLT manufacturing facility in North America in Spokane, Washington.

Dozens of projects are being laid out by architects across the US — including a 23-story project in Milwaukee. Walmart and Microsoft are working on mass timber for new campuses. Microsoft has claimed that its Silicon Valley project will be the "largest mass wood structure built to-date in the US" when completed in late 2024. Most states in the country are expected to eventually follow the international building codes that enable if not encourage mass timber construction.

So mass timber construction is starting to happen in the US as well.

Are There Negative Sides of Using Wood as a Building Material?

The biggest issue about using timber for additional construction revolves around concerns that forests – including North American forests - are not sufficiently protected to be able to deal with the

significant increase in demand for wood that will result. For example, the Natural Resources Defense Council issued a report on the amount of GHGs being released by clearcutting in Canada's boreal forest.

There are two very different certification standards for harvested wood: the Sustainable Forestry Initiative (SFI), sponsored by the industry, and the Forest Stewardship Council (FSC), an independent body created by environmentalists. As you would expect, the FSC standards regarding clearcutting, pesticide use, etc. are much stricter. Though the SFI has recently made changes to its rule, environmentalists remain critical.

Some environmentalists also worry that the sequestration benefits of wood as a building material are overestimated. For example, the International Institute for Sustainable Development issued a report in 2019 aimed at pointing out weaknesses in lifecycle analyses (LCAs) related to building materials - wood in particular. They found that "existing LCAs produce widely variable results, even for similar buildings." They also noted that there is regional variability in building performance and that LCAs tends often exaggerate the importance of "embodied carbon" in the wood by underplaying emissions in other parts of the life cycle. For example, the report suggested that the most uncertain parts of most LCAs have to do with carbon sequestered in wood and carbon released at the end of life — two issues of particular importance with respect to mass timber.

Back in 2018 multiple environmental groups, perhaps most notably the Sierra Club, sent a letter to California state officials urging caution about mass timber. They didn't suggest that mass timber not be used for construction, but argued that under current forestry practices the climate benefits have been exaggerated and mass timber really needs to come from "climate-smart forestry" - often

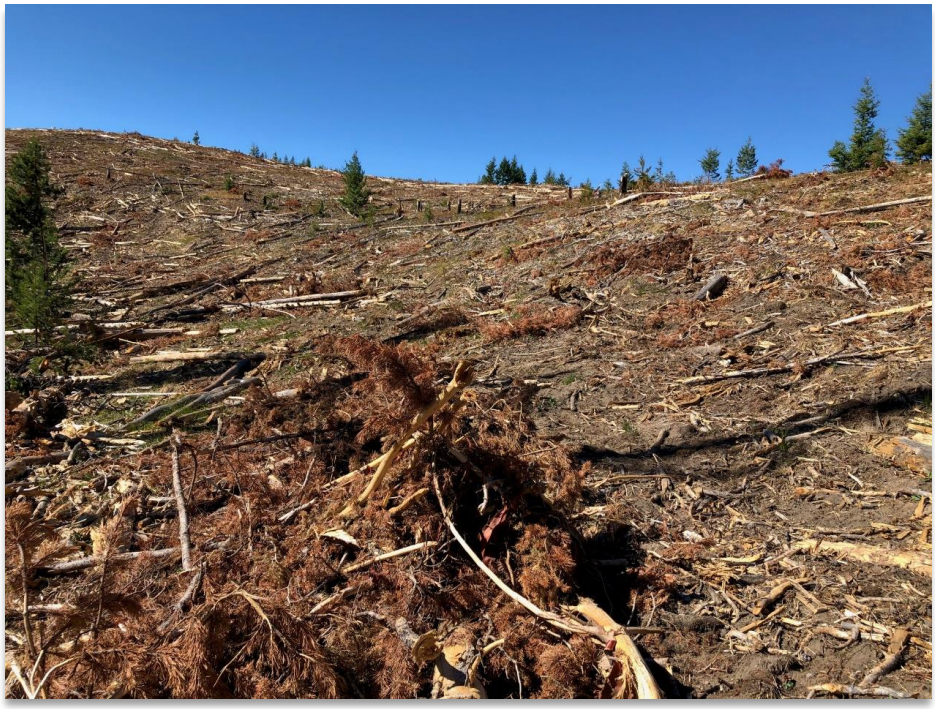


Image of a Clearcut Forest in Montana – Courtesy Daily Montanan

better known as sustainable forestry. It listed a number of climate-smart forestry guidelines, including: “Tree plantations should not be established at the expense of natural forests.” The Sierra Club has also made the point that nearly 2/3 of the carbon held by trees is lost to the atmosphere when forests are cut and milled, and replanting with young trees does not fully offset that loss.

The older the tree, the greater its potential to store carbon. So, replacing a tree removed for construction will not result in the same level of carbon sequestration for a number of years. And forests need ‘silent periods’ during which they are supposed to regenerate.

The problem with increased mass timber demand is that it’s encouraging some businesses to replace old growth forests with fast-growing “monocultures”, like pine or spruce. This is not good for biodiversity; a high diversity of trees has a more favorable impact on the ecosystem. Monoculture plantations have been cropping up all over the world – perhaps most notably in China and Brazil. They have been dubbed “green deserts” rather than forests by their critics.

At COP26 in Glasgow in 2021 more than 100 global leaders committed to halting deforestation by 2030, with 30 financial institutions promising to eliminate harmful practices from their portfolios by 2025. It still is not clear if the treaty means zero or net zero. Old growth forests sequester hundreds of years’ worth of carbon and its paramount that we protect them.

So, there are definite concerns about the use of mass timber.

A recent article in Business Week pointed out another potential issue. The article talks about a building at Singapore’s Nanyang Technological University, one of 30 buildings built from mass timber in Singapore in the last several years. The problem? Mold – in a country where it rains on average 180 days per year. Mold is likely to be an issue in other locations with frequent rain and/or high humidity. The wood in several of these locations is apparently starting to rot as well. The wood used in these buildings was largely Austrian spruce, which is apparently susceptible to mold and rot when not treated properly.

Some local experts reported that the problem could have been avoided by using a thicker protective coating, but the builder thought that would be too expensive – as would have an alternative wood less susceptible to mold such as larch. Bottom line: since this is now a known problem in areas like Singapore, future buildings can hopefully avoid the problem by using the appropriate woods and treating them to help avoid this problem.

Bottom Line

There clearly seem to be a range of benefits from using mass timber for construction – environmental benefits and more - even for very large buildings. The use of wood appears to be growing worldwide – including in the US.

But the industry needs to make sure that giant growth in leveraging mass timber does not result in a loss of mature forests and intensified clearcutting. The impact of such unsustainable forestry could totally undo the benefits of wood construction outlined in this article.

The good news is that this would appear to be a manageable problem. The use of mass timber must go hand-in-hand with an even expanded emphasis on sustainable forestry. That would enable the world to benefit from the use of mass timber while at the same time reducing the negative effects of not conducting climate-smart forestry.

The challenge is getting that message out – and getting governments and companies to act on it.