MASS TIMBER 101:

A GUIDE TO THE HOTTEST SUSTAINABLE BUILDING MATERIAL

BY HEATHER HEIDENREICH

Wood has evolved as a construction material over 10,000 years – from the first Neolithic long house to modern timber framing – and has recently taken off in a new form: mass timber.

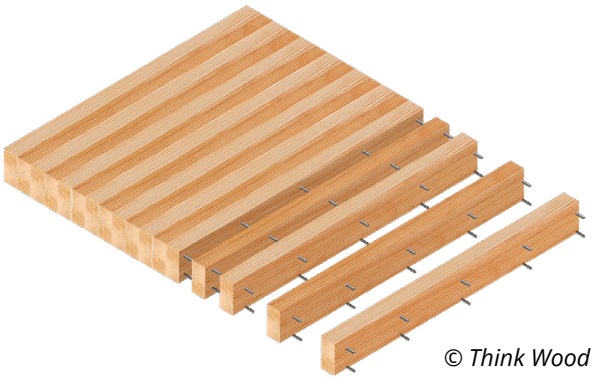
As research and testing of materials advance, the built industry is seeing a growing trend toward more buildings being constructed from mass timber. Indeed, an increasing number of owners and building officials are acknowledging the benefits mass timber provides not only for projects but also for communities. The attention given the material even extends outside AEC industry publications, including Vox magazine, which has touted it as the "hottest new thing in sustainable building."

This executive guide provides a broad overview of mass timber — what it is, its benefits, limitations, and code considerations — to help owners, designers, and contractors decide if it is the right material for their projects.

Defining mass timber

According to the Softwood Lumber Board-funded website, Think Wood, mass timber is "comprised of multiple solid wood panels nailed or glued together, which provide exceptional strength and stability." These large assemblies of lumber and timber are lighter than concrete or steel and meet the Type IV Heavy Timber Construction requirements of the International Building Code (IBC). The material can be used as load-bearing structures and interior finishes, offering endless opportunities for a warm and inviting aesthetic.

There are four typical types of mass timber elements:



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- **Nail-laminated timber (NLT)** is one of the oldest types of mass timber and can be found in century-old buildings or bridge deck construction. NLT is created with pieces of 2x to 4x dimensional lumber ranging in thickness from 4" to 12" that are sandwhiched together and then fastened with nails or screws. The commonly obtained materials and approach to construction means no manufacturing facility is required. Though you don't hear its name often, NLT is still in use today.

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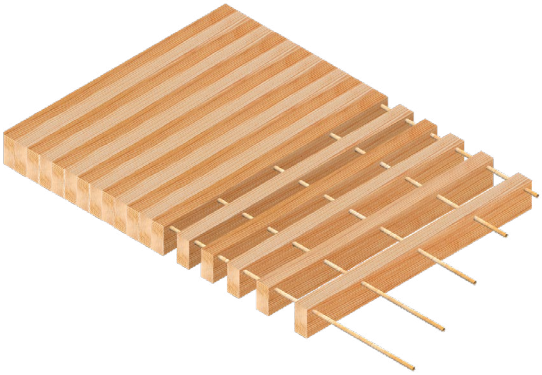
- **Glue-laminated timber (glulam)** may be used in floor and bridge decks, but it is more typically used as beams or columns. The formation is similar to NLT, but glue replaces the nails or screws. Ensuring the glue bond does require manufacturing facilities. Various layers are common for glulam members, which makes customizing straight members into a curve or taper shape relatively simple.



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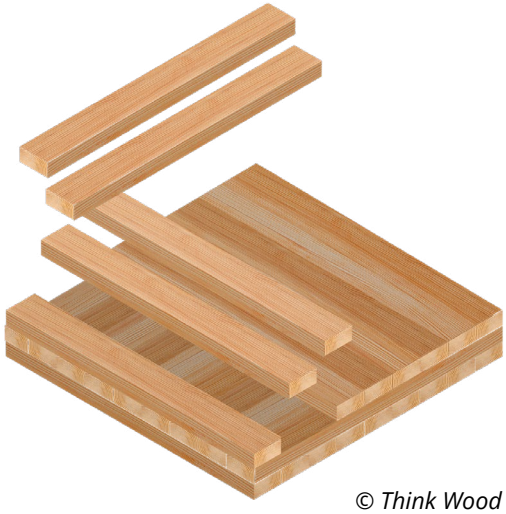
- **Dowel-laminated timber (DLT)** is more commonly found in Europe than in the U.S. It mimics NLT construction but instead of mechanical fasteners it uses friction-fit through-dowels to hold the layered lumber boards together.



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- **Cross-laminated timber (CLT)** is the current industry buzz. It has been widely adopted throughout Europe and is making advancements in the U.S. To create, lumber board layers are stacked and glued at 90-degree angles and laid in odd lamination counts (three, five, seven, etc.). Alternating grains provide some two-way slab properties, though the odd lamination count does define a strong direction, or span direction.

Each type of mass timber construction offers unique benefits to owners and contractors, and careful consideration of new and improved codes can help teams decide which type is best for their project.

New changes to the code

As CLT began its rise in popularity across the U.S. due to its unique aesthetic, sustainable qualities, and potential cost savings, the International Code Council (ICC) created an ad hoc committee in 2015 to reevaluate the use of wood in tall buildings.

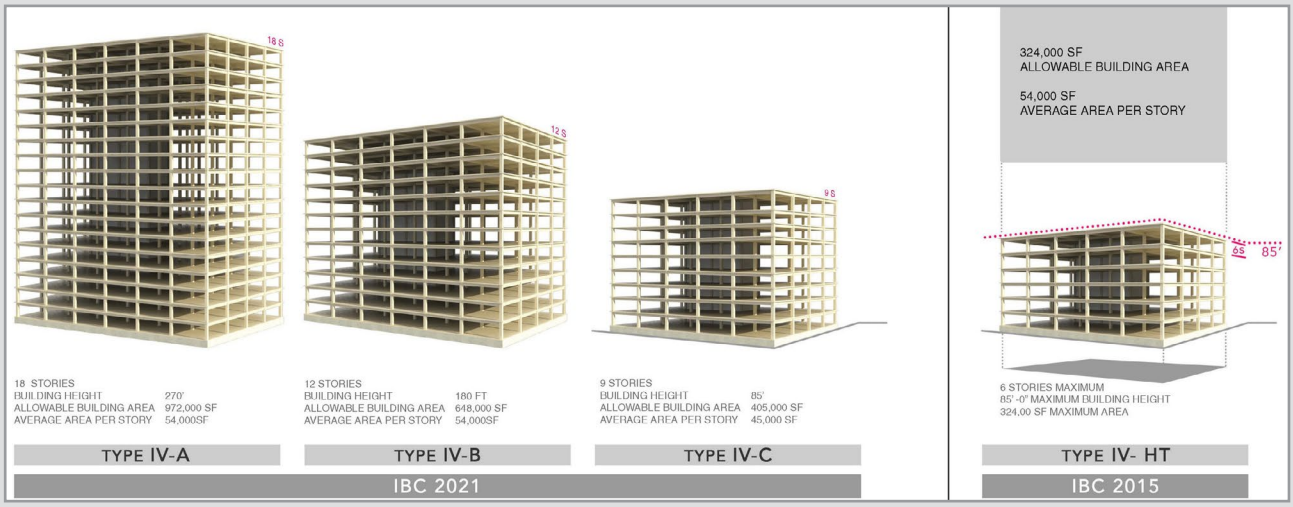
Up until that point, only historical data had been available for reference, leaving it up to city councils to decide on their own if their local codes should allow mass timber, and if so, at what parameters.

For example, IMEG's Chicago structural team was involved in the permitting process and building type approval for the first heavy timber (HT) project built in the City of Chicago in over 50 years, a new, 45,000-sf multi-use building in the historic Fulton Market District. (Read the case study.) From the outset, the city did not view glulam construction as equal to heavy timber construction (wood framing

Glulam was used for the beams, columns, and decking at 1040 W. Fulton in Chicago.

TYPE IV – Heavy Timber Construction per 2021 International Building Code

- **Section 602.4.1, Type IV-A.** All mass timber elements are completely protected (encapsulated in drywall) to provide the required fire resistance rating. Maximum proposed potential – 18 story Residential / 18 story Business
- **Section 602.4.2, Type IV-B.** Allows exposed wood surfaces not to exceed 40% of the wall area. Exposed areas must be separated by a minimum of 15 feet. Concealed spaces, shafts and certain other spaces are still required to be fully protected by non-combustible materials. Maximum proposed potential – 12 story Residential / 12 story Business
- **Section 602.4.3, Type IV-C.** Exposed wood surfaces permitted to be similar to HT construction. Concealed spaces, shafts, etc., still required to be fully protected. Maximum proposed potential – 8 story Residential / 9 story Business
- **Section 602.4.4, Type IV-HT.** This is the same as the current Type IV construction with no fundamental changes. Maximum potential – 5 story Residential / 6 story Business



members with minimum dimensions and other restrictions to attain fire resistance) as outlined in the Chicago Building Code, even though the IBC viewed them as the same. The IMEG team used exhibits and testimonials from Wood Council members to show how glulam is indeed the same as heavy timber and received approval from the city to build the project. The City of Chicago ultimately changed their building code provisions as a result.

Other cities are sure to follow, as mass timber was adopted into the 2021 IBC. The code defines the material as "structural elements of Type IV construction primarily of solid, built-up, panelized, or engineered wood products that meet minimum cross-section dimensions of Type IV construction." A common concern with mass timber construction is fire protection. Tall structures built with combustible materials would seemingly burn faster, but the thickness of mass timber elements means they char well and are slow to burn. The ICC's ad hoc code committee recognized that mass timber in combination with concrete provides equal or superior fire protection without the use of gypsum. The committee subsequently divided the Type IV construction type into four sub-categories delegating how much can be used in buildings of varying heights.

The code now allows much taller heights for Type IV-A, B, and C, with a sprinkler requirement for buildings taller than 85 feet. This substantial change now allows for 270 feet, nearly 18 stories, for Type IV-A construction. Additionally, the allowable building areas increased with the code changes, which equates to almost three times the area for a sprinkled building. These changes give owners much more flexibility than ever before.

Markets suitable for mass timber

Mass timber elements can be used in many ways. Currently, the most common market sectors for mass timber construction are:

- Single and Multi-Family Residential Buildings
- Office Buildings
- Hotels
- Commercial/Retail
- Schools

In stick-frame residential projects, CLT panels commonly replace plywood over wood I-joists, sawn lumber, or trusses. The panels can reduce floor-to-floor height and remain exposed for an architecturally pleasing finish. Commercial projects may utilize CLT panels along with glulam beam and column framing to achieve a more open floor plan over a more traditional stick frame option. (Read the IMEG case study on the Washington County Events Center, pictured.) While CLT panels do provide diaphragm and shear wall action, demand loads may require the lateral core elements to become concrete or steel systems.

Other considerations for high rise construction are becoming more commonplace as code limits are revised. Within each market sector, code research becomes a vital portion of the design process. Will Type IV, Heavy Timber Construction be able to remain exposed or will gypsum or other protective measures be required? How tall can the building be built and how large of a footprint can it have? The answers to these questions will impact design decisions for the rest of the building.

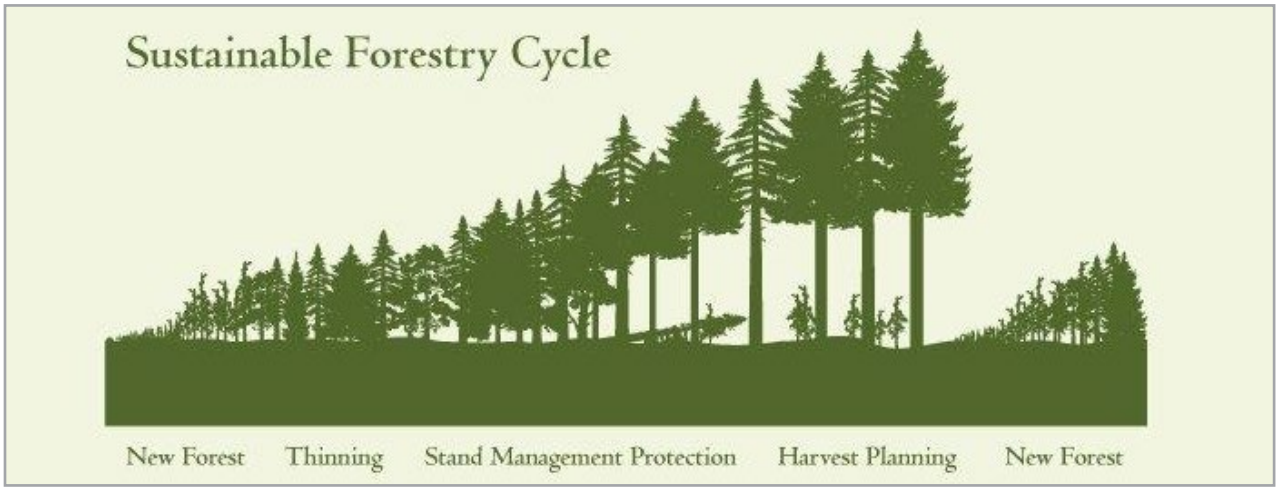
Washington County Events Center

Benefits and limitations of using mass timber

In addition to being a safe choice for fire protection, mass timber is attractive to many architects and owners because it is a renewable resource with a low environmental impact, and it can create a warm and inviting aesthetic when left exposed. This also means fewer finishes are required in a building – a cost-saving benefit to owners.

The biggest benefit of mass timber construction comes from its environmental advantages, which include:

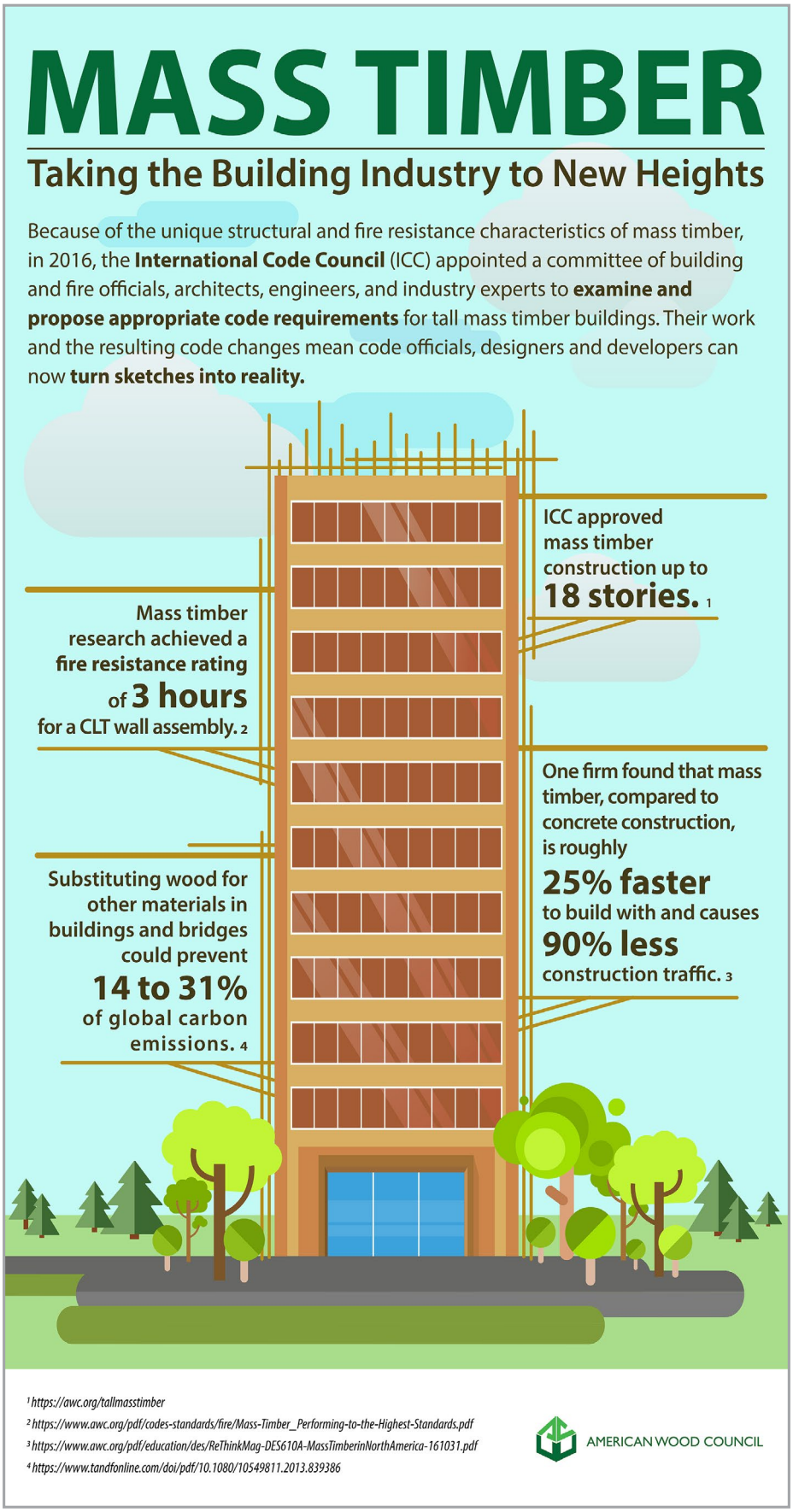
- **Less embodied carbon.** Compared to concrete and steel, mass timber has one-fourth the embodied carbon — the CO2 emitted during the manufacture, transport, and construction of building materials, as well as in a building's end-of-life phase. This is because mass timber is a lighter material that costs less to transport and is less energy intensive. In addition, using mass timber as a flooring material instead of concrete (where most of a building's carbon resides) can make a huge impact on lowering the building's overall carbon footprint.
- **Sequestration of carbon.** Wood and other biobased materials also have the ability to sequester carbon, or in other words, capture and store carbon dioxide. This sequestered carbon, in addition to the lower initial embodied carbon, can create a net negative for the carbon consumption of a mass timber or wood-framed structure. Taking advantage of the full life cycle of mass timber can reduce the amount of CO2 in the atmosphere with a goal of reducing global climate change.
- **Sustainable resource.** If the life cycle of timber growth and harvest is managed intentionally, it's possible to reduce the environmental impact of building with mass timber even further. For example, the average rate of harvest for all of Washington state's commercial forestland is 1.1 percent, which means that for every acre harvested, there are nearly 99 acres of new forest growing, according to Forests & Fish Law. As shown in the accompanying illustration, the process of producing new timber requires careful and intentional forest management.



Courtesy, Washington Forest Protection Association

Though this sustainable forestry cycle shows a promising outlook for mass timber construction, it's important to realize the other environmental factors involved in the entire manufacturing and building process. Yes, mass timber is a renewable resource, but the production process does emit carbon dioxide, as it takes energy to cut down forests, manufacture the raw materials into lumber ready for building, and transport these materials to the site. However, when compared to other building materials, mass timber still results in lower overall carbon emissions.

There are some limitations to using mass timber -- fire ratings requiring the wood materials to be covered; closer grid spacing; the need for a concrete topping on the floor panels (and potentially still requiring steel or concrete for the lateral systems); and deforestation concerns. These limitations notwithstanding, however, mass timber continues to be a cost-effective and sustainable choice. As more owners, designers, and contractors understand mass timber's contributions toward sustainable goals, its use will continue to expand.



Courtesy, American Wood Council, Leesburg, VA

How far will your dollar stretch?

Projects rarely have an unlimited budget, so cost considerations weigh heavily on the decision-making process. This section will focus solely on CLT panels.

CLT material does come at a premium over steel or concrete. So why is it such a hot topic in today's industry if that's the case? Because material cost is only one aspect of the big picture costs. As owners, contractors, and design teams discuss building materials, there are other cost considerations to include. Overall cost savings for CLT will be realized through reductions in:

- **Material weight:** When it comes to installing foundations, a CLT building will weigh less than steel or concrete, which will equate to smaller foundations and fewer concrete materials.

- **Construction schedule:** Prefabrication is a key component to reducing the assembly time. Upfront, more time is spent planning so minimal field cutting is required. A "kit of parts" means easier assembly due to relatively large, prefabricated panels and little modification on site.

- **Labor costs:** At first, framing crews may be apprehensive about working with CLT. But a good framing crew has all the skills needed to work with this material and could possibly cut the crew size in half due to the ease of using prefabricated materials. CLT requires no special tools, and a regular crane typically can lift the panels into place.

- **Construction waste:** The amount of construction waste is very minimal because the panels are shop-fabricated and arrive at the site assembled, so there is little to no field cutting.

- **Fewer errors and tolerances:** Again, because the panels are prefabricated, the final product is much cleaner and more level than a stick-built project. MEP system penetrations can also be coordinated up front in the shop drawing and fabrication process, making the assembly process simpler.

Is mass timber right for your project?

Along with mass timber's sustainable benefits and changes to codes, the improvements to the structural capacity of cross-laminated timber, nail–laminated timber, and dowel-laminated timber as wall and floor material has helped to grow the market.

However, mass timber may not be a fit for every project type. When determining whether to use mass timber in your next project, ask the following questions:

1. Does mass timber match your building type (i.e., exposed framing)?
2. Is sustainability a high priority for your project?

3. What are the pros and cons (cost versus schedule)?
4. Is aesthetics a prominent feature?
5. Where is the building located and is the local building department open to allowing mass timber construction?
6. Is the entire team (owner, designers, contractors, and supplier) on board?
7. Have you considered how additional project-specific factors (e.g., MEP systems, waterproofing, and envelope detailing) might be affected using mass timber?

If you determine that mass timber is right for you and the codes in your location allow for such a project, you can engage a design team familiar with the intricacies of working with mass timber and enjoy the benefits of having an aesthetically pleasing and sustainably built structure.

Additional Resources

- Mass timber and taller wood construction: https://www.naturallywood.com/topics/mass-timber/
- Think Wood: https://www.thinkwood.com/mass-timber
- WoodWorks: https://www.woodworks.org/design-and-tools/building-systems/mass-timberclt-code-related/
- U.S. Forest Products Laboratory Testing Research: https://www.fpl.fs.fed.us/research/highlights/science_making_a_difference.php
- Cross-Laminated Timber Fire Testing: https://www.youtube.com/watch?v=HuVTCOmRGd0

ABOUT THE AUTHOR

Heather Heidenreich, SE, PE, is Director of Structural Engineering for IMEG's Technical Operations Team, which provides the firm's designers with the latest industry knowledge, standards, and tools. She has designed various building types utilizing wood, masonry, reinforced concrete, precast concrete, and structural steel for a variety of markets.

Contact her at Heather.L.Heidenreich@imegcorp.com.