SCOTT BARTON-SMITH, AIA, LEED AP BD+C | MAY 22, 2024

Getting Acquainted with Mass Timber

FOR BUILDING OCCUPANTS

Mass timber is emerging as a remarkable, renewable building material that can substantially reduce the carbon footprint of our buildings. Exposed timber surfaces create warm and inviting spaces, fostering a sense of well-being and connection to nature.

Comprised of minimally processed wood, mass timber, like all materials, undergoes changes over time. This is particularly true in its initial year of installment as it adapts to environmental conditions and building occupation. As a user of a mass timber building, you may notice occasional popping noises, fine cracks, or in rare circumstances, small wood flakes detaching. While these occurrences may initially raise concerns, they are normal as wood acclimates to its role as a building structure.

This white paper aims to provide insight into mass timber for anyone considering building with or about to occupy a mass timber structure. Understanding the multifaceted characteristics of mass timber construction enhances the appreciation and enjoyment of occupants living and working within these extraordinary spaces.

ABOUT THE AUTHOR

Scott Barton-Smith, AIA, LEED AP BD+C, is an Associate Principal at Bora Architecture & Interiors with over 30 years of experience on complex projects in education and research. He is a strong advocate for mass timber design and construction, having contributed expertise on over thirty precedent-setting mass timber projects throughout the nation and speaking internationally about the material's use and sustainability.

ABOVE Holgate Library mass timber (Photo courtesy of Timberlab)

WHY MASS TIMBER?

We believe mass timber creates superior spaces for people. Among its many virtues are its beauty, its connection to nature, and its sustainability. As a regional, renewable material, mass timber can significantly reduce a building's carbon footprint compared to concrete and steel alternatives.

But, like all structural materials, mass timber has its quirks. Concrete cracks. Steel rusts. Steel also loses strength at high temperatures. But, having worked with steel and concrete for over a century in the building industry, we have to come to understand and accept these nuances, finding ways to mitigate their worst impacts so we can optimize their benefits.

Mass timber, on the other hand, is newer to the construction scene, and many are not as familiar with it.

Mass timber is a minimally processed, natural material that changes over time—especially in the first year or so after its installation. This makes it all the more important to become acquainted with the nature of mass timber so occupants can appreciate it more.

EXACTLY WHAT IS MASS TIMBER?

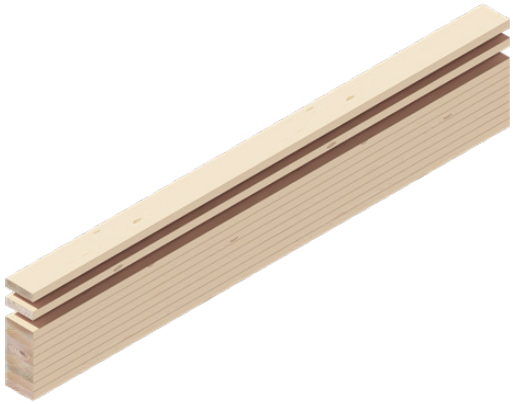
"Mass timber" refers to a family of very large engineered wood products. Essentially, large pieces of wood are created by laminating many smaller pieces together, typically with glue. Most mass timber products are built up using either dimension lumber or veneers as their building blocks, and are generally made using common structural softwoods such as spruce, pine, fir, Douglas fir, or southern yellow pine.

The different ways in which the smaller pieces of wood are arranged results in a variety of mass timber products used in buildings, each with their own unique qualities and aesthetics. For example, you may be familiar with:

- **Glued-Laminated Timber (Glulam)**
- **Cross-Laminated Timber (CLT),** which includes veneer-based panel products like Mass Plywood Panel (MPP) and Laminated Veneer Timber (LVT)
- **Dowel-Laminated Timber (DLT)**
- **Nail-Laminated Timber (NLT)**

According to the American Plywood Association, glulams were first standardized in the U.S. in 1963, and have been widely used throughout North America for over half a century. The North American standard for CLT was first published in 2011, over a decade after commercial approval in the European Union. Since then, its use has been steadily increasing across the continent, with the American wood industry group WoodWorks citing nearly 1,000 mass timber buildings that have been constructed up to December of 2023. Mass timber performance is now well understood. Like all certified building materials, mass timber products are manufactured to rigorous standard specifications, have been tested to perform predictably, are directly referenced in the building code, and come with a third-party manufacturing quality certification.

Mass timber is well integrated into today's building codes. In fact, it is allowed in three of the five code-designated "construction types" (Types III, IV, and V). There are also many specific provisions for the use of mass timber in construction as high as 18 stories.



Glued-Laminated Timber (Glulam)

Cross-Laminated Timber (CLT)

Dowel-Laminated Timber (DLT)

HOW DOES MASS TIMBER CHANGE OVER TIME?

It is normal for all wood products, including mass timber, to change over time—reflecting their response to environmental factors, their qualities as a once-living material, and the unique aesthetics of a tree. This is part of the wonder and beauty of mass timber we celebrate. The sections below highlight key features of mass timber one should know as they live with it everyday.

It Responds to Moisture

Mass timber's raw material is wood, which is the fibrous flesh of trees. At a microscopic level, wood looks like a bundle of tubes; this is how wood effectively conveys water and nutrients from its roots to its branches. This parallel tube cell pattern translates to our eyes as the wood's grain. When working together, these tubes are very strong and comprise the structure that holds enormous trees erect and resistant to wind and snow. When living, a tree naturally contains a lot of water within its cell structure. In fact, water can often make up over half of the weight of freshly cut green wood.

Like all plant cells, wood cells readily absorb and release water, expanding when moist and shrinking when dry. This phenomenon occurs both from exposure to liquid water, as well as from everyday exposure to varying humidity levels. When lumber is cut from raw logs to be used in mass timber, it has to be dried in a kiln to reduce its moisture content, a process which causes the cells to dry and shrink slightly. The wood is then laminated together in a factory, fabricated, and sent to the construction site for assembly, where it is exposed to natural humidity in the air and often rained on. Absorbing some of this moisture, the wood in the mass timber expands again slightly, but remains resilient—the lamination glues are waterproof, and, unless exposed to liquid water for many months, wet wood does not decay.

After construction, a building's newly functioning mechanical system conditions the interior air to a comfortable humidity. The newly installed wood in the building reacts by drying and shrinking again, eventually reaching a moisture equilibrium. Although most shrinking occurs within the first month or so, it may take a year or more for the moisture in the wood to reach equilibrium with the mechanically conditioned space.

Being remarkably large pieces of wood, mass timber naturally dries faster on the outside during this process than it does deep within. This differential rate of drying creates a tension in its adjacent wood cells, which can cause something known as a "check," in which the wood cells separate parallel to the grain. This is usually seen as a split or gap in the surface of a piece of wood. Most of the cells are not broken in the checking process; they are simply separated. Since the strength of wood comes from its long tubular cells, most checking does not affect the strength of the wood. Checking is a well-understood phenomenon universal to virtually all wood buildings made with large timbers.

Deep checks that extend through most of a member can be a structural problem. However, because mass timber is made of many layers of wood laminated together, checks tend to be superficial and limited to the depth of a lamination.

RIGHT, ABOVE These dowels represent the microscopic structure of wood cells.

RIGHT, BELOW A check is a separation between cells where the strength of the cells is undiminished.

What Was That Noise?

"Checking" resulting from the tension building among wood's densely packed cells may produce a popping sound as they suddenly snap apart. This is merely the sound of the tension being released. It can be a loud pop, which can be especially noticeable in a quiet space, but rest assured that this is normal as the wood acclimates.

Because the wood takes some time to acclimate to its interior environment, it is normal to hear pops like this on occasion during the first year or so of service life.

Construction Damage

During construction, large pieces of mass timber are moved from trucks by crane into position on the building. Despite the contractor's best efforts, occasionally timber is scraped or dented on other construction. Corners tend to be most vulnerable to this sort of incidental damage. Thankfully, the corners of large rectangular members contribute little to the strength of the member. In fact, traditionally, when construction technology did not allow the same care that contractors take now, corners were often sharp, splintery, and susceptible to damage. Timber corners were preemptively removed, or "chamfered," to minimize these disadvantages without reducing the structural capacity of the wood.

Today, mass timber edges are typically no longer chamfered since the process tends to be more expensive due to increased fabrication time. Instead, architectural-grade mass timber is sanded for a smooth finish, a process which inherently produces slightly rounded corners.

If damage to mass timber occurs during construction, the contractor will discuss it with the engineer and architect. If the damage is judged to be minor, loose pieces will be removed and the remainder may be sanded to improve the appearance and remove splinters. In very conspicuous locations, the design/construction team may elect to remove wood from the damaged area and glue a patch of wood, specially cut to replace the damage.

ABOVE Minor construction damage on the corner of a glulam beam

ABOVE Example of traditional timber framing. Note that corners of the beams and column have been cut off, or "chamfered."

Knots

With wood being a natural material, its grain is never perfectly consistent—but the variation is what makes it beautiful. "Knots" are tree branches that become embedded in the tree's trunk as it grows. When the trunk is made into lumber, these branches are cut and typically appear as darker circles or ovals along the surface of the wood.

The wood of a knot expands and contracts with varying moisture conditions, just like the rest of the wood. But knots tend to have a different density than the surrounding wood, and therefore expand and contract at a different rate. A knot may thus become loose as the wood dries, especially if the knot happens at an edge or corner of a piece of mass timber. The primary wood grain bends around the knot. So little imperfections like knots you see in mass timber, or even small voids where knots have fallen out, do not degrade the wood's structural capacity.

All wood used in mass timber is specially selected, or "graded," for strength and appearance. The grading process takes small imperfections like knots into account. A piece of wood with any knots that are too big, too close together, or too close to a splicing "finger" joint are removed in the initial grading process and deemed ineligible for mass timber.

In rare circumstances, if a check occurs on the corner or edge of a piece of wood, the tension released may also free a knot or a small flake of wood. Although rare, this is normal and does not compromise the strength of the wood.

ABOVE Looking closely at the finished surface of CLT, one can see many small imperfections like checks and knots that are deemed acceptable within standard limits. Also note the "finger joints" just above and on the right.

Gaps Between Pieces of Timber

There are limits to the precision of construction. Because of the difficulty of moving heavy building components, human error, and the natural expansion and contraction of building materials, the construction industry has evolved to allow for small dimensional variations.

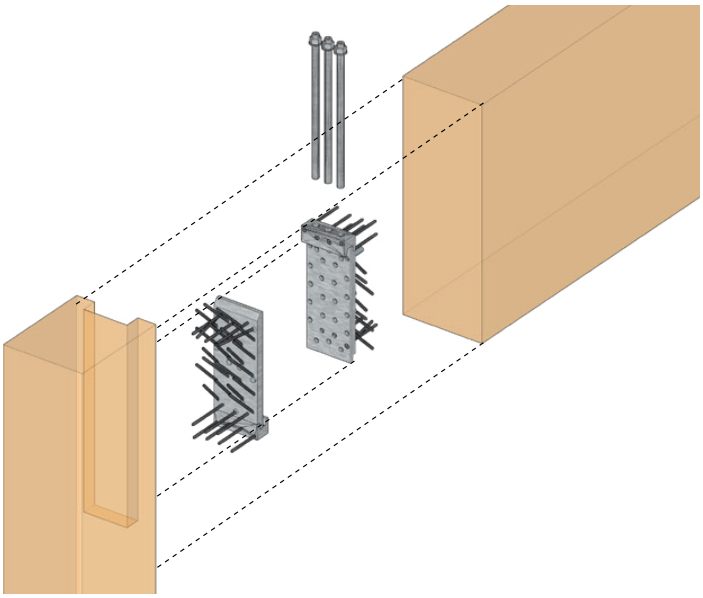
ABOVE Small gaps are anticipated between structural members, like between these beams and column.

When we design buildings, we expect that there will be variations between what we draw and what is actually built. We call this "construction tolerance." For example, where a beam connects to a column, we know that the column may be slightly out of plumb, or the beam might be installed at a slight angle. Therefore, the structural engineer designs the connection to tolerate these slight variations, and to perform well despite them.

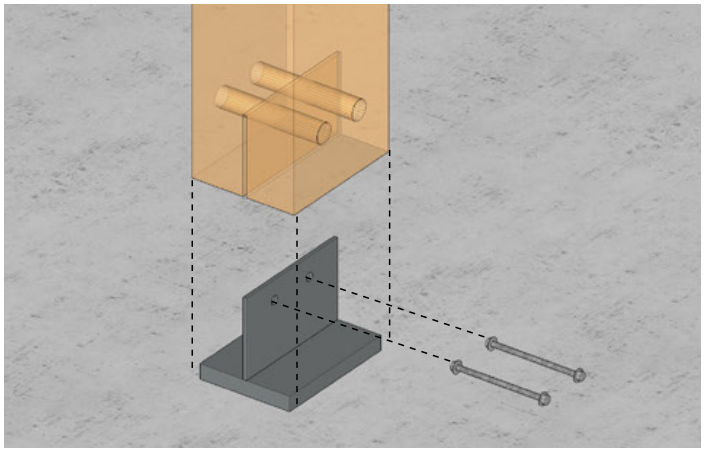
Mass timber is relatively dimensionally stable because the wood grain of one lamination tends to resist the expansion or contraction of the piece to which it is laminated. Mass timber is also cut in a factory under controlled conditions by computer-guided machines known as Computer Numerical Control (CNC) machines. That means they are cut very precisely to fit in a specific location within your building. Because of this dimensional stability and CNC cutting, mass timber is very accurate compared to other structural systems. For example, a 40-foot-long glulam beam may be within +/- 1/8" of what the drawings show per the ANSI A190 standard. That is a very light tolerance, but can easily result in a 1/8" gap between a beam and a column. Additionally, mass timber buildings always include other structural materials like concrete walls and foundations or steel brace frames. These other materials generally have larger tolerances which can result in gaps between these materials and the mass timber, or may force larger gaps in the mass timber to accommodate the tolerance of the other materials.

Engineered steel or aluminum fabrications are almost always used to connect two pieces of mass timber together. They are secured into the wood via bolts or screws. The metal is inserted into slots and recesses CNC-cut into the timber, which are slightly oversized to allow for construction tolerance. Often the end of the beam and/or column is also CNC-cut to have notches or ledges that create stronger connections—even when accounting for construction tolerance.

In your finished building you may see gaps a fraction of an inch wide between pieces of mass timber. Rest assured that these gaps are designed to allow for construction tolerance, and that there is steel embedded within the wood that is holding the timber beams and columns together. In buildings where fire resistance rating is required by code, if engineering shows that the tolerance gaps may be wider than code allows, fire-resistant sealant is inserted in the gap but may be invisible in the finished product.



ABOVE This exploded diagram illustrates one type of steel connector that is attached to a mass timber beam and column and is concealed from view in the finished construction because it fits within a CNC-cut recess in the column. These connectors are designed to perform even if the column, beam, or other adjacent construction are not quite perfect.



ABOVE This exploded diagram illustrates a steel post base fabrication inserted into a slot CNC-cut into the bottom of the column. Once the wood column is set on the steel post base, steel bolts are inserted through the wood and steel to hold it all together. Often, wood plugs completely conceal the bolts. The CNC-cut slot and bolt holes are slightly oversized to allow for construction tolerance.

Light's Impact

Wood is photosensitive. When exposed to light it will change in appearance. Naturally occurring compounds in wood—like lignin and tannins—darken when exposed to ultraviolet radiation in sunlight, creating a lovely effect. Different tree species used in mass timber react differently. Most conifer species become darker and warmer in color, while the Douglas fir, which tends to be striped with blonde, orange, and even pink wood when freshly cut, becomes a more uniform brown-orange.

Timber will be exposed to sunlight during construction. But don't worry—this color change is limited. Most of the impact occurs within the first month or so, after which the wood will not continue to darken. If a portion of the timber is covered during construction, when exposed later it may show a "tan line." If exposed to sunlight—even if inside next to a window—the "tan line" will equalize over time. This photosensitivity only occurs on the outermost cells of the wood and does not impact the strength or longevity of the timber. In fact, the impact is so thin, it can be sanded off.

ABOVE This piece of CLT was exposed to UV light through a modern window. The left side was exposed to light for 170 days, the center for 30 days, and the right was protected from light. The degree of tanning shows that most of the effect occurs within the first month of exposure. The wood color equalized when exposed uniformly for another two months.

Pitch

Pitch is a highly tacky and complex substance produced by certain tree species primarily for defense against biological attack. Many coniferous trees, like those typically used for making mass timber, have resinous wood, with specialized canals that produce pitch. If a tree is injured during its growth, pitch can accumulate at the injury site. Even if the wound heals, the substance may remain and create a "pitch pocket" in the wood. Pitch reacts to the moisture and temperature of the wood and will move more when conditions are warm and moist. When a tree is milled into lumber, and that lumber is used to make mass timber, pitch pockets may be hidden within the timber.

When the wood acclimates to interior conditions with ambient warmth and humidity, pitch may start to flow out of canals, or pitch pockets. Once the pitch reaches the wood's surface, it loses its remaining moisture and dries to a solid state. In our experience this happens in only a tiny fraction of the wood used in a mass timber project. This happens slowly, and in small amounts of approximately a teaspoon at most. We have never seen a case in which there is enough pitch to damage an adjacent surface.

You may notice some golden or reddish pitch on the surface of mass timber when you move in. Our recommendation is to let it dry completely. If you try to wipe it off while it is still tacky, it can smear and discolor the wood. When dry, it can be cleanly snapped off with your fingers.

ABOVE Pitch on a glulam

A Future With Mass Timber

In short, mass timber is a wonderful living material that just takes some getting used to for those who are unfamiliar with its qualities. It is unlike concrete or steel in that it changes over time as it settles into its new role as a building structure. But you can rest assured that the unique quirks you experience—from checks to knots to gaps—have no bearing on the structural soundness of your building, freeing you to enjoy the experience of living in a beautiful, healthy space carved out of nature itself.

Should you have further concerns or questions, your facilities management can arrange a post-occupancy visit from your building's architect and structural engineer. The team who intentionally designed your building out of carefully selected, graded mass timber would love to hear about your experience.

ABOVE Portland Community College Opportunity Center @ 42nd Avenue

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REFERENCES

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Product Standard for Structural Glued Laminated Timber

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