A Mass Timber Whitepaper by

Mike Geric Construction +
Aryze Developments

Building for the Next Generation

A Letter of Introduction by Mike Geric Construction + Aryze Developments

Now more than ever we live in a society that is concerned about global issues. Collectively, we face a host of challenges that permeate all aspects of our lives and need to be addressed. The spectrum of issues is broad and diverse, spanning from the deteriorating environment to the increased awareness of a mental health crisis. Large scale responses to these issues have fostered a great deal of polarity and anguish. The fact is, there is no time to argue over a single, perfect answer to all the complexities of our world. Mike Geric Construction (MGC) and Aryze Developments Inc. (Aryze) have teamed up to create a whitepaper that advocates for a more humble but robust response to critical social issues as they pertain to our corner of the world—the development and construction industry.

The following whitepaper is meant to inspire tangible, direct action by calling for a nuanced approach to the future of construction through Mass Timber building. In this paper, we show how Mass Timber development serves both humanism and environmentalism. We synthesize an array of studies that show the benefits of building with wood—benefits that facilitate the well-being of entire communities as well as the longevity of our planet. We map out the Mass Timber opportunity to excite people about the possibility of high design that works in conjunction with sustainable building and human performance. Recognizing the wide range of issues that permeate the building industry, this paper is part of our commitment to creating positive change in the environmental and social aspects of the construction industry.

Both MGC and Aryze are passionate about building futures for our communities. We care about the impact of our work and are doing our best to make real changes, both big and small. We are glad that you care about your community and are doing your part too. We hope you enjoy learning about the benefits of Mass Timber and how we envision building for the next generation.

Thank you for reading.

Edward Geric, Owner
Mike Geric Construction

&

Ryan Goodman + Luke Mari, Partners
Aryze Developments

Overview

The Mass Timber Opportunity

Construction Innovation

Mass Timber has been at the forefront of construction innovation for the last 12+ years, pushing the public's understanding of building sustainability and technology. Along with being an accessible, local material, Mass Timber sequesters carbon, minimizes construction time, and outperforms steel and concrete in multiple areas including seismic, sound, insulation, waste—the list goes on. In fact, we have only scratched the surface of what Mass Timber offers to the world of construction, architecture, and urbanism.

It took extensive research, high-end equipment, and a team that is passionate about pushing the boundaries of building with wood—but we've arrived at a place where we can serve our community and environment. We know the history; we mastered the process; we grew to love the challenge. We see now that Mass Timber is as significant a building material as it is a creative and playful one. It is something both heavy and light.

Future Proofing Buildings

Concrete and steel have dominated tall building construction in North America for more than a century. Despite the versatility of these building materials, concrete and steel release high amounts of carbon dioxide (CO_2) during the production process and are difficult to reuse once the lifespan of a building ends. Wood, on the other hand, is an abundant and naturally renewable product and has the lowest embodied energy of any primary building material on the planet. As we become more aware of our impact on the environment, we must also become more aware of new methods of transportation, consumption, and housing. With climate change at the forefront of a generational shift, we can question the status quo, challenge existing norms, and push the boundaries of what was previously conceived as possible.

The magnitude and diversity of our forests here in British Columbia inspire the production of Mass Timber materials. Nobody takes care of our backyard the same way we do. Every log that goes into a Mass Timber building was thoughtfully selected and engineered with integrity. From the forest to the home, we are invested in Mass Timber production.

Building a Sustainable Life

Mass Timber architecture presents an opportunity for both environmental sustainability and improved personal health and wellness. There is a general understanding that wood buildings provide ecological benefits; however, there is also tremendous potential to explore how Mass Timber benefits our daily lives. Already, studies have found that the presence of wood elements in the built environment reconnects us with nature, which reduces stress reactivity and supports creative thinking.

By bringing natural elements into the interior environment through the application of wood to walls, ceilings, and floors, we can elevate the lived experience of indoor spaces. Since the average Canadian spends only 6% of their day outdoors, wood-built interiors offer significant mental and physical health benefits. Biophilic design fosters a point of intersection between the natural environment, aesthetics, and human-sensory experiences.

Mass Timber Primer

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What is Mass Timber?

Mass Timber is a solid or composite wood material used as the primary structure of a building. Mass Timber is engineered from existing wood-based products such as dimension lumber, boards, and panels. Once bound together, the engineered timber exhibits improved structural integrity while remaining a versatile material. The new composite units are then cut to project-specific dimensions at the factory.

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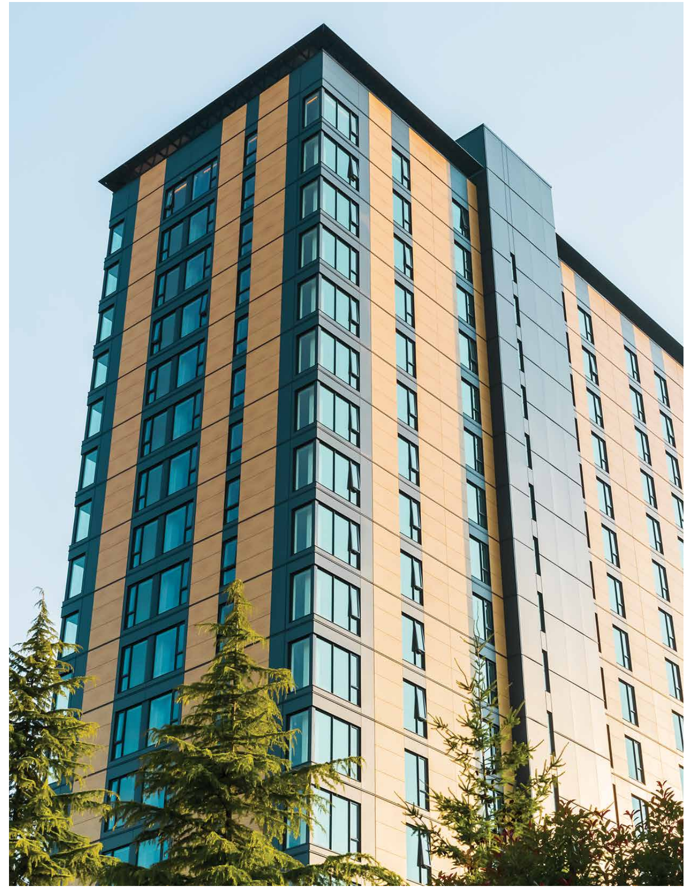
Large timbers are milled into long-spans and trusses that are then used to structure whole buildings. *Source: Kinsol Timber Systems*

A Brief History of Mass Timber

Tall wood construction is not a new phenomenon; wood buildings have stood all over the west coast of North America and east coast of Asia for well over 1000 years. In the last century, small dimension lumber has featured prominently alongside the growth of the city suburb, especially in North America. However, the changing climate and the desire for more wood-based design have pushed the construction industry toward Mass Timber innovation like that of engineered wood products. Although laminated wood products have been around for many centuries, engineered wood products (plywood, particle board, and a host of glue-laminated wood products) have a much more recent history in North America and, specifically, in British Columbia (BC).

Prior to the introduction of engineered wood, most of the construction in BC relied on solid structural timbers milled from large diameter trees like old-growth, coastal Douglas-fir and western red cedar stands. As log supplies from these old-growth stands diminished, much of the logging shifted to the interior of the province where trees are smaller and species composition more varied: the interior is home to trees like lodgepole pine, white sprue, trembling aspen, and subalpine fir. These smaller species do not lend themselves to large-dimension, construction-grade lumber. Yet, the need for long-span, high-strength structural timber for joists and beams has not diminished.

Rather than relying on our dwindling coastal forests, Mass Timber products can fill this need. Engineered wood products—being composed of many, smaller elements—offer an alternative, more responsible approach to construction. With state-of-the-art methods, small timber creates an exceptional product and makes a significant impact. To this end, engineered wood is a versatile material that pairs well alongside traditional steel and concrete construction while the advancement of solely Mass Timber buildings continues to catch on. The flexibility and quality of the product, along with the environmental benefits of Mass Timber, represent a critical building block for the future of the construction industry.



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When it was completed in 2017, Brock Commons Tallwood House in Vancouver was the tallest Mass Timber building in the world. *Source: naturallywood.com and Michael Elkan Photography*

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Standing at 8 storeys, the Carbon12 residential building in Portland was the tallest Mass Timber building in the US when it was completed in 2018. *Source: Andrew Pogue for Kaiser + Path*

Global Adoption

The accessible supply of high-quality building material from BC's forests means that wood-frame construction dominates residential building and single-family home construction throughout the province. Brick, concrete and, more recently, steel displaced wood as the most cost effective material in residential home construction in Europe and many parts of Asia; regions where timber is less accessible and more expensive than in BC. But still, even in these areas, wood finds extensive use on finished interior surfaces—more so than in BC in many cases—showing the high regard that these cultures have for this material as well as its aesthetic qualities.

We are in the middle of a Mass Timber revolution. All over the globe, innovative tall timber systems are in action, creating developments, designs, and tests for buildings that exceed heights that were previously imagined. Part of this evolution is being led by builders here in BC. The 18-storey Brock Commons Tallwood House at the University of British Columbia (UBC) was, until recently, the tallest wood building in the world. In addition, the 8-storey Wood Innovation and Design Centre in Prince George is a site that features Mass Timber innovation and, at the same time, studies it.

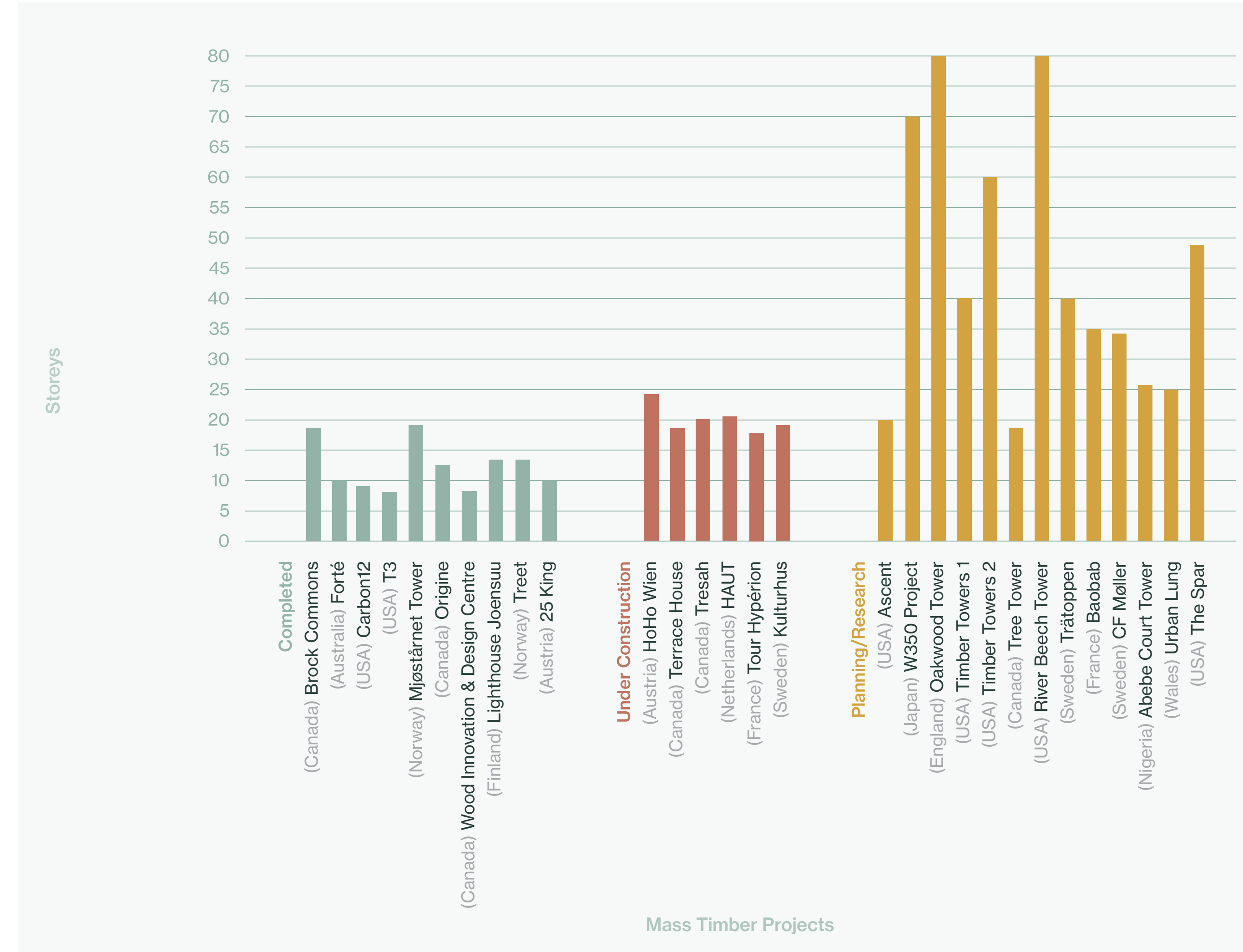

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Table 1
A partial list of the tall-wood buildings that are completed, under construction, or in the planning phase. Mjøstårnet Tower, a mixed-use building in Brumunddal, Norway, is currently the tallest completed wood structure in the world. However, several projects currently under construction will soon dwarf this building.

Many tall Mass Timber projects are being planned or under construction in major cities around the world. The Brock Commons Tallwood House has undoubtedly drawn attention in North America. In Europe, similar praise will certainly come after the completion of HoHo Tower in Vienna (Austria). In South America, the Public Library Constitución has become a site of civic engagement and collective memorial following the 8.8-degree earthquake and Tsunami that hit Chile in 2010. In the plans for Tokyo (Japan), the W350 building is by far the most ambitious timber project; this building, standing at 70 storeys, will be the tallest hybrid timber skyscraper in the world. Sooner than later, Lagos (Nigeria)—the most populated metropolis in Africa—will feature the tallest wood residential building on the continent, the Abebe Court Tower. Already built, The Forté residential building in Melbourne (Australia) functions as a model for modern, wood-built apartments.

Mass Timber construction has been so significant on the global stage that the most popular timber material, cross-laminated timber (CLT), was incorporated into the International Building Code (IBC) in 2015. Around the world, the design and construction industry feels the impact of a Mass Timber alternative. Mass Timber has grown into an international occurrence, raising the universal standards of sustainable construction.

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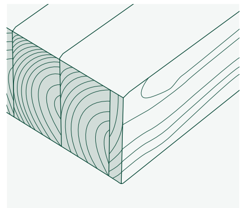

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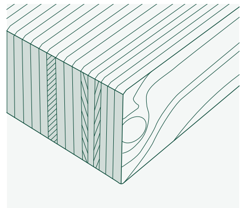

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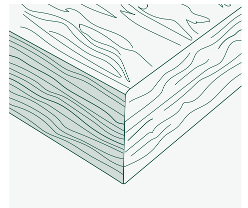

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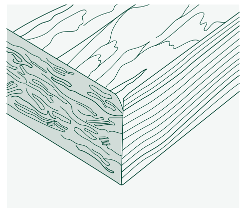

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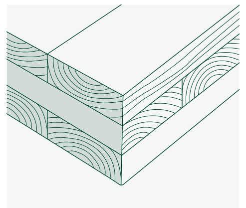

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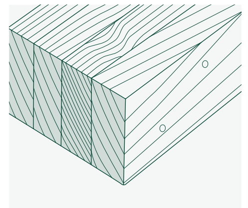

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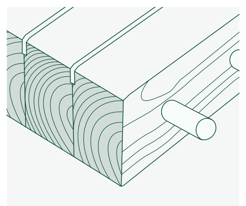

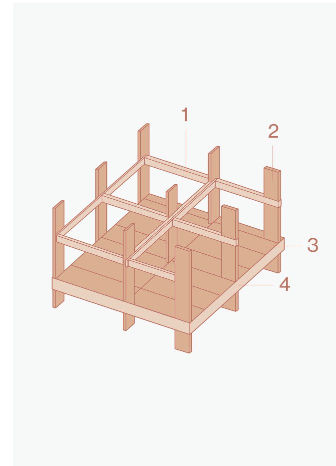

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Figure 1
1. Glulam Beams
2. CLT Walls
3. CLT Floor
4. Glulam Deep Beams

Mass Timber Technology

1. **Glue-Laminated Timber (glulam; GLT)** is made by bonding individual pieces of dimensional lumber together with durable, moisture-resistant structural adhesives to form columns, beams, and headers.

2. **Laminated Veneer Lumber (LVL)** is fabricated by laminating layers of wood veneers together using a waterproof structural adhesive. The product is then hot pressed using both heat and pressure to cure the billet which can then be ripped into project-specific boards.

3. **Laminated Strand Lumber (LSL)** is made by bonding parallel strands of wood to create a composite piece of lumber. Using a steam injection press, the product is then compacted into mats.

4. **Parallel Strand Lumber (PSL)** is made by bonding thin parallel wood strands together with an adhesive. These are used for beams, headers, columns, and posts.

5. **Cross-Laminated Timber (CLT)** is fabricated by laminating dimensional lumber in perpendicular layers, resulting in strong panels with a two-way span capability. These are ideal for floors, walls, and roofs.

6. **Nail Laminated Timber (nail-lam; NLT)** is created from dimensional lumber stacked on edge and fastened together with nails. Plywood sheathing is often added to one top side to provide a structural diaphragm for floor, wall, and roof structures.

7. **Dowel Laminated Timber (DLT)** is similar to NLT; however, instead of nails or screws, DLT uses wood dowels to join laminations.

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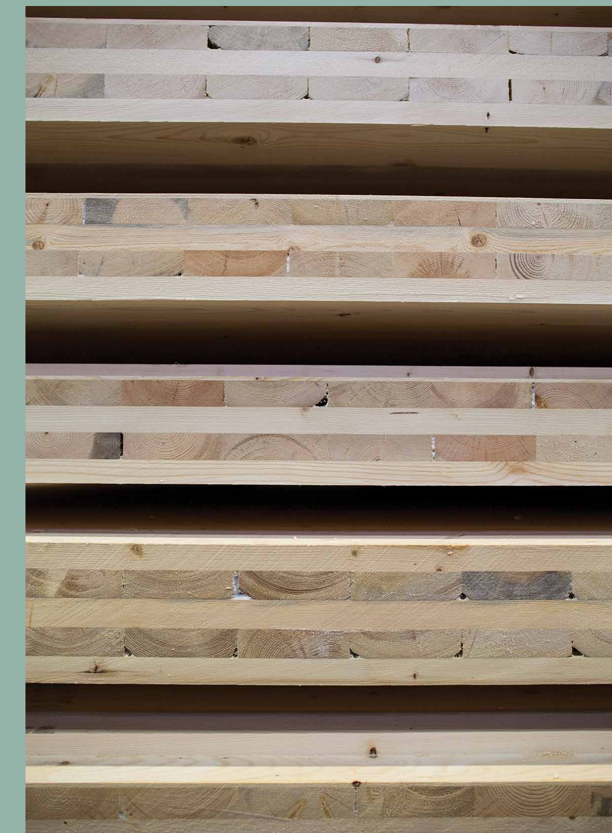
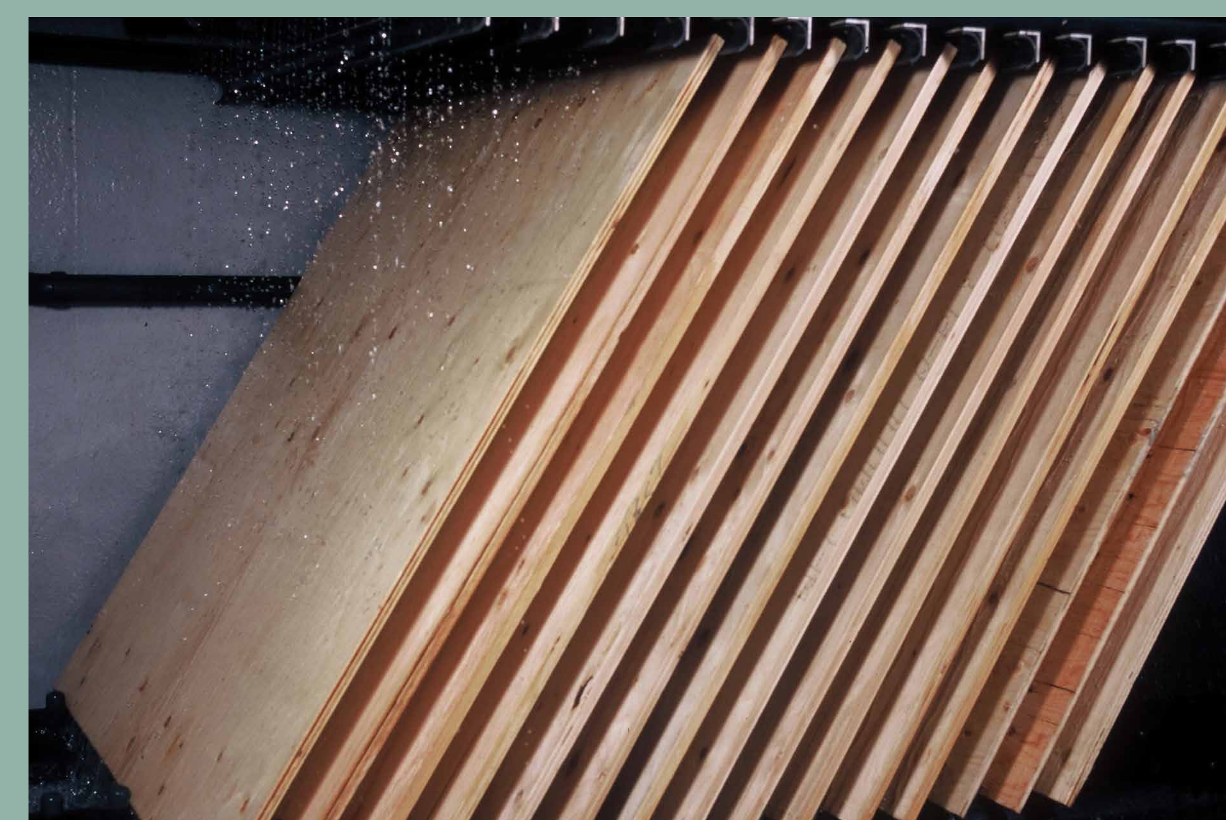
The top image is CLT. You can see the perpendicular layers of laminated dimensional lumber. The bottom image is LVL. The boards were engineered by laminating layers of wood together with adhesive and then hot pressing to ensure structural integrity.
Source: naturallywood.com





Construction Technology in the Climate Change Era

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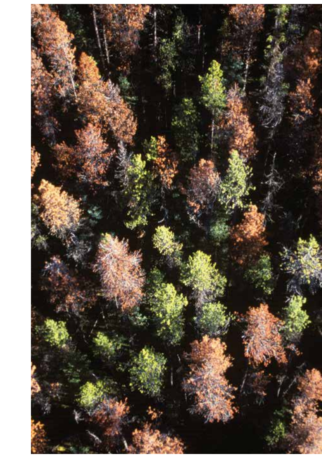
A Green Solution

Wood is the most abundant and naturally renewable building material on the planet. Wood has the lowest embodied energy of any primary building material; with its capacity for sequestering carbon and the minimal extraction and processing energy required, designing with wood—where suitable—makes a significant contribution to the sustainability of a design.



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The pine beetle first targets larger matured trees before moving to smaller trees or variant species. *Source: naturallywood.com*

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Pine beetle attacks cause the reddened pine shown in this image. The mountain pine beetle is an insect native to central BC and the Rocky Mountains. A pattern of relatively warm winters in BC led to a massive beetle outbreak that resulted in the loss of millions of hectares of pine forest between 1995 and 2015 (reported by the provincial government). Mountain pine beetles primarily attack matured, large-diameter stands; however, as more trees become infested and the beetle population increases, the insects spread to younger, smaller trees. When beetle infestations are most extreme, the beetle attacks spread to non-traditional species like Douglas-fir and white spruce. Once infested, the tree will start to redden and die within two years, no matter the size. *Source: naturallywood.com*

The Beetle Problem: A Path Forward

Large tracts of interior forests are threatened by spruce beetle and, more recently, mountain pine beetle. Increased beetle attacks are the result of long-term climate change—especially the absence of low winter temperatures—and the abundance of over-aged stands of lodgepole pine, a tree that is especially susceptible to beetle attacks. The situation in Prince George, for example, is so severe that virtually the entire supply of timber for the region is now drawn from beetle-killed stands. The 2012 Timber Supply Analysis of the Prince George Timber Supply Area (TSA) estimated that between 77% to 83% of the mature pine stands in the TSA would be dead by 2024 because of attacks by the mountain pine beetle. Because of damage brought by the pine beetle, there is much lower resistance to harvesting timber in the interior of the province and to coastal harvesting in second-growth stands. This is where the vast majority of BC's future wood supply will flow from.

Companies that develop high-value, end-use products—products like Mass Timber—can use the fibre supply from second-growth as well as interior forests rather than wood from the areas protected by environmental lobbyists. Because engineers fabricate Mass Timber products using fibre supplies from beetle-killed timber and fast-growing interior forests, Mass Timber materials bypass the potential grievances associated with old-growth logging and increasing atmospheric CO_2 levels.

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A mixed boreal forest stand in northern BC. *Source: naturallywood.com*

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Douglas-fir logged from Sayward Forest on Vancouver Island, BC. *Source: naturallywood.com*

Social License

Unlike in the US, private companies own only a fraction of forest land in Canada. This is true for BC in particular where the provincial government owns approximately 94% of the 22 million hectares of forest land. While this makes forest management in BC complex, it also means that the province manages forest policy to meet public needs and goals. Government responsiveness to the public, especially with regards to resource extraction, is an example of *social license*.

Now more than ever, extracting resources from public land requires a social license. This is especially true in our coastal rainforests, where old-growth trees facilitate one of the most ecologically spectacular regions in North America. The controversies around logging places like Meares Island, the Carmanah Valley, the Stein River Valley, and the Great Bear Rainforest have made front-page headlines around the world. In each of these examples, the public protected some of the most biodiverse forests in the region and redirected industry toward more sustainable and less prominent second-growth forests.

Very few second-growth forests approach the magnificence of their coastal counterpoints. Harvesting timber from second-growth stands is a much less controversial process because it is less ecologically disturbing, it allows for more sustainable regulation, and it fosters a practice of extracting trees at their peak growth rates, thus maximizing carbon capture. Two-hundred years is old for substantial portions of the interior plateau forests, unlike coastal old-growth that can contain trees 600 to 800 years of age and older.

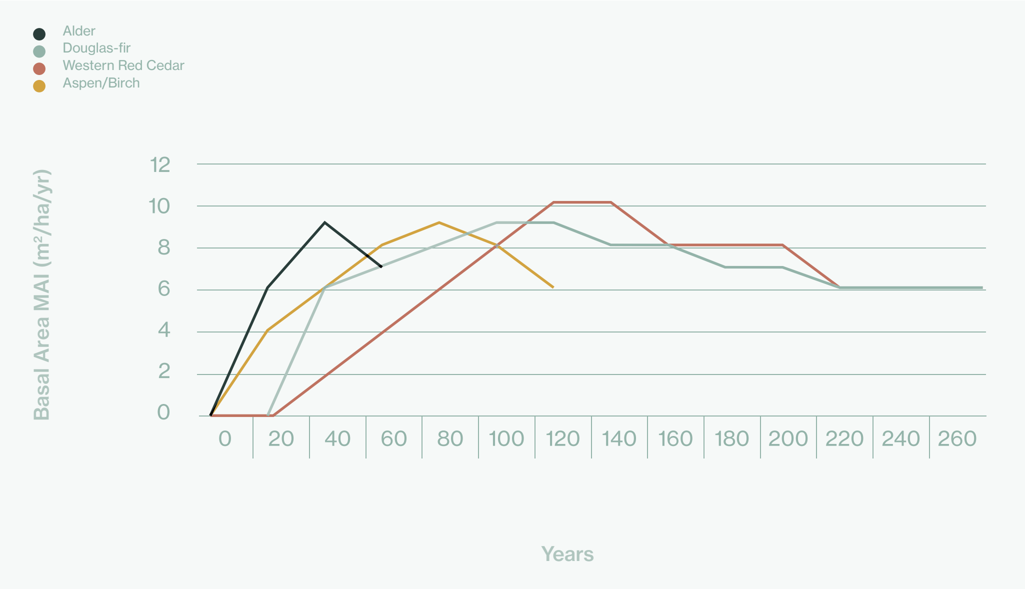

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Table 2 (Basal Area MAI)

Certain species hit their peak growth earlier than others; Table 2 shows the change in mean annual increment (MAI) of various tree species over their respective lifetimes. The MAI of a forest reflects the average growth of a tree's basal area as measured on a per hectare of forest per year basis.

Trees & Carbon Dioxide: A True Connection

Ecologists and foresters agree that large-diameter trees act as a significant CO_2 sink, tieing up carbon dioxide for centuries, if not millennia, and countering the effects of increased atmospheric levels of CO_2. Trees absorb sunlight and CO_2 and excrete oxygen, something that we benefit from greatly. This process, commonly called photosynthesis—literally meaning "to make from light"—removes CO_2 from the atmosphere and stores it in the wood. Trees offer us an organic material that is both versatile and beneficial.

Over its lifespan, a tree will go through a period of exponential growth, much like humans do. For most trees, this rapid growth occurs in their "teenage" years and coincides with the period of optimal CO_2 absorption. Yet, these periods vary significantly with each species. Long-lived species like Douglas-fir and western red cedar do not hit their peak growth years until they are older than 60 years, while species like trembling aspen, paper birch, and lodgepole pine hit their growth spurts early, somewhere between 30 and 60 years of age. By the time any of the latter species reaches 100 years of age, they have reached "old age" and are starting to decline. By comparison, a 100-year-old Douglas-fir is just hitting its fastest period of growth and carbon accumulation.

The most common way that foresters describe how trees grow is by showing the growth of the basal area, the cross-section at the base of each tree. Foresters calculate this basal area—summed on a per-hectare or per-acre basis, and volume of wood over time (m²/ha/yr or ft²/ha/yr)—to get the mean annual increment (MAI) of a particular area of forest. Simply put, MAI tells us the average growth of basal area per hectare of forest per year. Different tree species display a similar pattern of MAI growth to those highlighted in Table 2 above, with slight variations based on the longevity of each species. Initially, as trees grow, MAI increases rapidly in an exponential curve. As the tree canopies start to overlap, and the trees start to compete with each other, MAI starts to fall off. MAI reaches its maximum just as space between trees becomes limited, competition leads to overcrowding, and trees start to die off. As more trees die out, MAI falls until it reaches a point where the mean annual increment and the current annual increment (CAI) meet. The age at which MAI and CAI meet is defined as the *culmination age* of the stand. If we want to maximize the amount of CO_2 that a given hectare of forest sequesters, we would harvest each stand as they reached this point.

Many people are critical of both old-growth logging and the increased atmospheric CO_2 levels from the forestry industry. Mass Timber construction using fibre from fast-growing interior wood supplies and beetle-killed timber should represent a win-win situation on both fronts.

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A mosaic of young and juvenile stands of lodgepole pine located in northern BC. The original stands were likely clear-cut in the 1950s or 1960s. Wildfires following logging were common at that time, and most of the older trees (probably between 60 and 70 years of age) regenerated naturally following a wildfire. The areas in the foreground of the picture were clear-cut approximately 20 years ago, while the light green square block in the middle of the picture is a much more recent disturbance, possibly as a result of pine beetle control or oil and gas exploration. *Source: naturallywood.com*

Table 2 compares the changes in basal area MAI over time for a selection of tree species in British Columbia. In general, deciduous (leaf bearing) species have very fast initial growth but do not live as long compared to many coniferous (cone and needle bearing) species. Coniferous species experience slower initial growth but can live for an extremely long time, often more than 1200 years for Douglas-fir and western Red cedar. Sixty years of age is old for a red alder. At 90 years, trembling aspen stands are deteriorating. Birch and black cottonwood can live to 160 years plus, but even they are beyond their best years at that point.

Second-Growth Forest Management

An optimal stand of Douglas-fir trees occupies the area in which it grows totally, leaving little room for other plants to grow. This is called a fully stocked stand and will probably contain between 1000 and 1200 stems per hectare. With overlapping needles that create a canopy over nearly every square inch of the ground, these stands catch almost every photon of light from the sun that falls on them. Indeed, if you add up the surface area of the needles from all the trees in a fully stocked stand, you would find that they are equivalent to 2 or even 3 times the area of the ground below them. This is why when you walk into the stands of second-growth forests on Vancouver Island, they are dense and dark and have very little growth in the understorey. There are isolated patches of light here and there—possibly where a tree was blown over by a windstorm or removed by insects or disease—that manage to find the forest floor. Still, very few species survive in the low light available to them under thick canopy. In this situation, trees capture more CO_2 per hectare than at any other time in their long lifespans. As a forest ages, the trees start to compete severely with each other, and many of the smaller trees in the stand get overtopped and die out. The stands then begin to open up and more sunlight reaches the forest floor. At this point, the rate at which a tree captures CO_2 diminishes exponentially; in other words, the sink is full.

The same process occurs in stands of lodgepole pine, trembling aspen, and paper birch, but it happens much faster than for either Douglas-fir or western red cedar. The grand period of growth for these species usually happens between 30 and 60 years of age. After that, individual tree growth slows and stands gradually open as smaller trees die out. If we want to maximize the amount of CO_2 captured in these second-growth stands, we should harvest shortly before the end of this juvenile period of growth, before these trees start to heavily compete with each other. This strategy would maximize the positive ecological effects of Mass Timber production, as the trees required have already captured and stored the largest amount of atmospheric CO_2 per year possible.

Enhanced Living—Your Mass Timber Home

4

Beautiful & Healthy Interiors

The use of wood as a structural or finishing material has positive effects on the health and well-being of occupants. The positive effects include mental health benefits, improved indoor air quality and acoustics, and a positive sensory response to wood that has always been intuitive but is increasingly being proven by research and experience. The use of exposed wood in interiors has been proven to offer restorative properties. The presence of wood elements in the built environment reconnects us with nature, and has been found to reduce stress and support creative thinking.

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Several studies conducted in BC over the past decade have shown that the presence of natural-wood interiors can lower heart rate, blood pressure, and overall stress levels. At the same time, studies show that a biophilic design fosters a creative headspace and increases cognitive performance. *Source: Carbon12, Andrew Pogue for Kaiser + Path*

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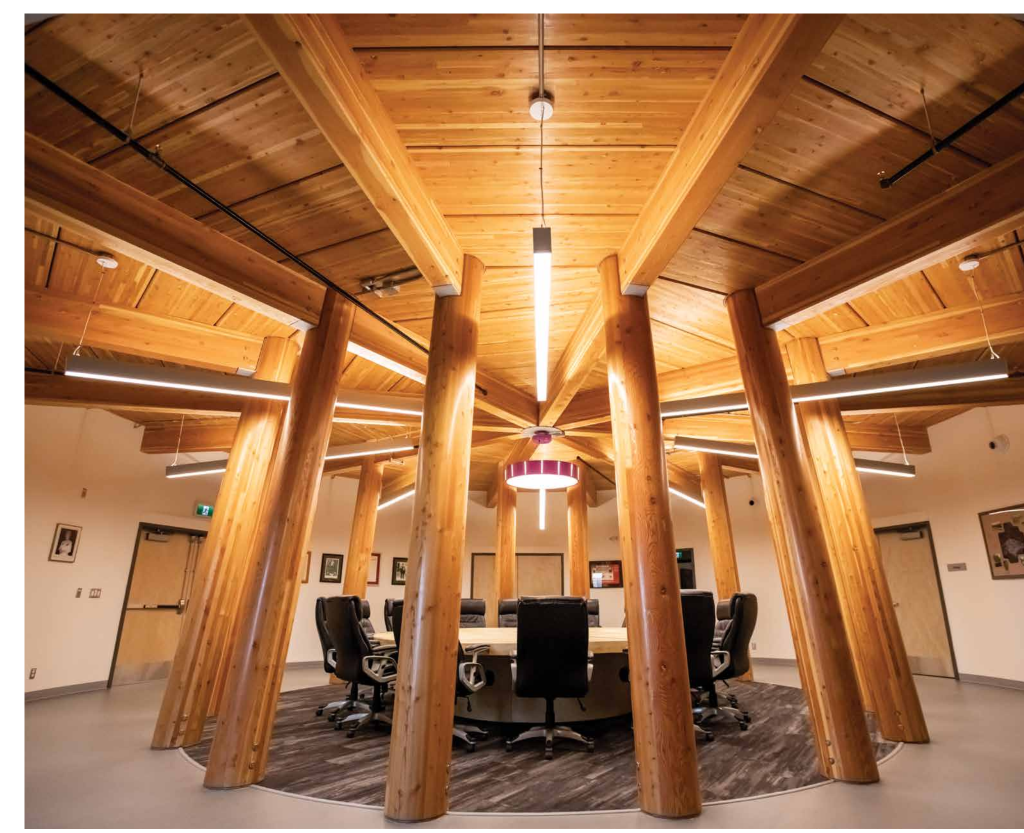
The Salt River First Nation Business and Conference Centre features exposed wood throughout the whole building to connect the occupants to nature and provide warmth within the building. *Source: Western Archrib*



How Quiet Will My New Home Be?

The design and structure of Mass Timber buildings differ greatly from traditional light wood-frame buildings. Mass Timber buildings are engineered to be much quieter.

When speaking about acoustic performance in residential buildings, major factors affecting sound transmission are the mass of a partition, the air space within a wall or floor assembly, and the use of absorptive material within wall and floor cavities. With Mass Timber buildings, the relatively large size and strength of both the floors and structural walls result in less sound transmission between walls and less vibration between floors.

→ Located in Victoria, BC, the homes in Tresah highlight exposed Mass Timber in their interiors, showcasing the beautiful wood structure of the building.

← **Figure 2**
Sound can be transmitted through a solid structure by hitting one side of a barrier and causing the interior side of the same barrier to vibrate, re-radiating the original sound wave on the inside of the structure. This is known as sound transmission. Various building materials can be tested and rated for their sound transmission class (STC). The second source of building noise is sounds that originate by direct contact with a floor or wall that causes these partitions to vibrate. Like STC, impact sound for a particular material can be tested and an impact insulation class (IIC) can be given. The larger and stronger the assembly or partition, the better the acoustic performance.

Mass Timber excites architects and builders. Designing with Mass Timber is an opportunity to incorporate the aesthetic value that wood offers. Those living in the Pacific Northwest know there is something special about the presence of exposed wood: the familiar aesthetic and sensory experience of the forest. Now, the industry is shifting to bring that experience into the homes of people living across the continent.

How Warm (or Cool) Will My New Home Be?

Mass Timber panels such as cross-laminated timber (CLT) make it much easier to insulate tall buildings from heat loss in the winter months and to protect from overheating in the summer months. By comparison, exposed concrete lacks an additional layer of insulation and is virtually incapable of reducing heat transfer between the exterior and interior environment. Mass Timber construction often outperforms both steel and concrete in terms of its ability to resist heat transfer and heat loss. Mass Timber buildings are warm in winter, cool in summer, and contribute to lower, total energy bills.

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The condos in Carbon12 offer a perfect example of Mass Timber home design. While the thermal performance of Mass Timber materials insulate the interior from the natural elements outside, the presence of wood fills the space, bringing the natural world inside. *Source: Carbon12: Andrew Pogue for Kaiser + Path*

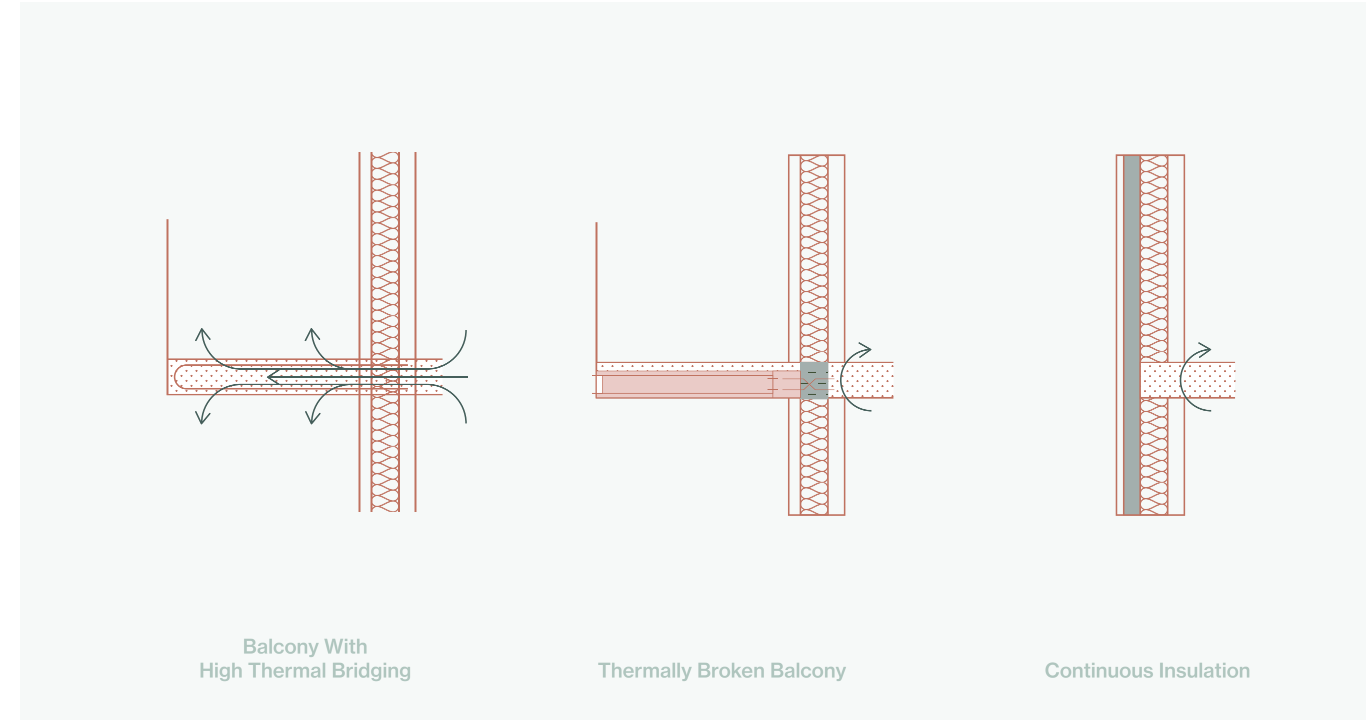

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Figure 3
Where Mass Timber construction does have a distinct advantage over other materials is in its thermal performance. Solid wood and Mass Timber panels have much lower thermal conductivity ratings (the so-called k-values or the rate at which heat transmits or passes through a material). These products also have much higher thermal resistance (so-called R-values or the ability of a material to resist heat transfer or loss). Thus, engineered wood products and wood, more generally, will significantly outperform other building materials such as concrete, steel, and glass in areas where heat loss is an issue due to thermal bridging.

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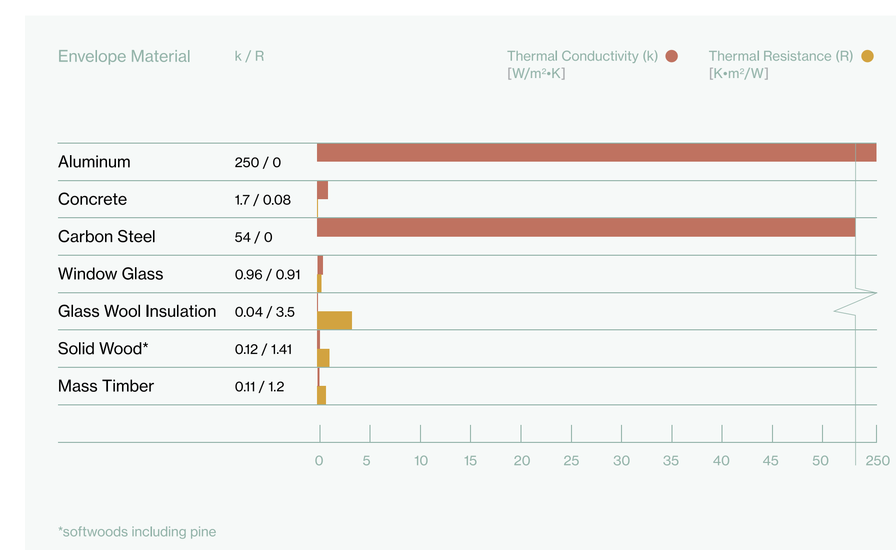
Table 3
Summary of the thermal conductivity (k-values, measured in Watts/square meter Kelvin [W/m²•K]) and thermal resistance (R-values, measured in degrees Kelvin/square meters per Watt [K•m²/W]) for various building materials commonly used for the exterior building envelopes. When considering an ideal k-value, the lower the value the better; less conductivity means less heat loss. The opposite is true for R-values: a higher thermal resistance value means better insolation.



Mass Timber Building Design & Safety

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The Safety of Mass Timber Buildings

The current BC Building Code restricts traditional wood construction (ie, 2×4, 2×6, and 2×12 dimension lumber) to a maximum build height of 6 storeys. Yet, there is an exception to the rule: Mass Timber. The tallest wood building in BC, the 18-storey Brock Commons Tallwood House at UBC, uses Mass Timber to achieve its height. The UBC Chief Building Official and the BC Building and Safety Standards branch developed a building-specific document, the UBC Tall Wood Building Regulation, to accommodate this Mass Timber project. While the code for light frame construction remains the same today, BC has adopted the 12-storey tall wood provisions found in the 2020 National Building Code in advance of its publication. One might say that 2020 is the year of Mass Timber. From here, permission for Mass Timber building will only be easier to obtain.

← Engineering studies show that Mass Timber materials like the LSL columns and beams photographed here are stronger than 35 MPa concrete in shear capacity, the property that allows buildings to resist lateral forces associated with ground movements in seismic events. *Source: naturallywood.com*

The main questions that must be addressed by any tall wood building, especially one that is constructed completely of wood without a concrete elevator shaft or steel support girders, are as follows:

1. Do engineered wood products have the inherent strength required to go taller than 6 storeys?
2. Do engineered wood products have inherent fire resistance, flame spread, and smoke repellent properties that will allow occupants enough time to safely evacuate a tall wood building and, at the same time, retain enough structural strength during a fire to allow firefighters to safely enter the building?
3. Do engineered wood products compromise sound transmission within the building that could sacrifice the comfort level and general happiness of the residents of that building?
4. Will the exterior of the building (the building envelope) hold up well to wind and seismic loads; will shrinkage or creep of the Mass Timber wood elements be an issue; how will water be repelled; how will the material on the exterior dry out if it is wetted; how will air and vapor flow be controlled; and how well will the building insulate from heat or cold?

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Table 4

A comparative summary of the cost/square foot associated for 12-storey and 20-storey projects in traditional concrete frame, Mass Timber exposed beam, and Mass Timber encapsulated beam structures.

Source: Michael Green Architecture. The Case for Tall Wood Buildings 2018

The Cost Effectiveness & Efficiency of Mass Timber Construction

In 2018, Michael Green Architecture began an intensive study that compared the cost-effectiveness of Mass Timber construction to traditional concrete and steel construction. Green compared the construction costs of 12- and 20-storey Mass Timber projects that use exposed and encapsulated timber elements to traditional concrete and steel construction for 5 geographical areas in BC (Vancouver, Northern BC, the Southern Interior of BC, the Fraser Valley, and Vancouver Island). The geographic variation allowed the authors to correct for additional costs due to weather, labour availability, and the transportation cost of materials. In 9 of 10 comparisons, exposed-beam Mass Timber construction cost less than the concrete-steel alternative.

There are currently only 3 companies producing Mass Timber products in BC—compared to the dozens of respective companies in Germany, France, and Scandinavian countries. As Mass Timber projects become more common, the number of companies offering these products is bound to increase. Increased competition should result in the price of Mass Timber construction material decreasing. By comparison, the price of steel and concrete is only expected to increase in the future as carbon pricing makes its way into the Canadian marketplace. Over time, the price advantage of Mass Timber as a building material compared with steel and concrete should only increase.

An Evolving BC Building Code

In Canada, BC is paving a path for the future of Mass Timber construction. In 2012, all building codes across the nation established the height limit for wood buildings at 6 storeys. In March 2019, the province of British Columbia announced an increase to heights of 12 storeys, a significant shift in only 8 years' time. This was a brilliant move; BC is adjusting the building code to accommodate taller wood buildings because they are a safe, economical, and environmentally friendly alternative to concrete apartments and office buildings. Despite this announcement, BC Building Code continues to restrict traditional wood construction (ie, 2×4, 2×6, and 2×12 dimension lumber) to a maximum build height of 6 storeys.

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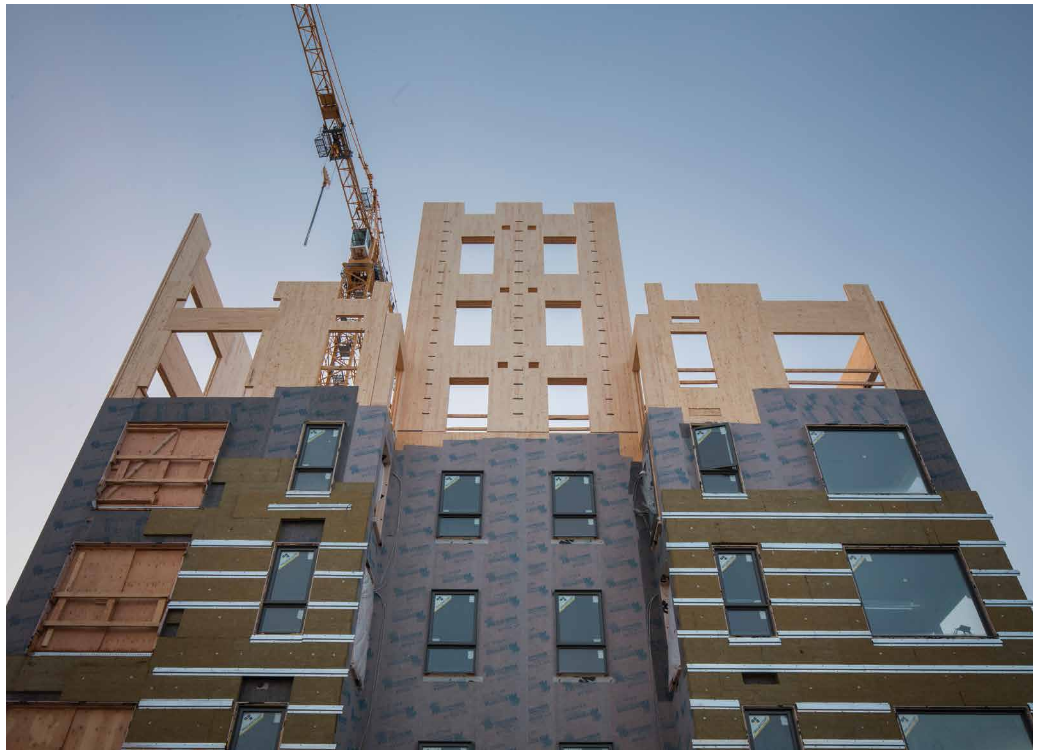
Construction times can be up to 25% faster for Mass Timber systems compared to traditional tall building construction. Because most of the building elements can be fabricated off-site, Mass Timber building sites are more compact, quieter, and cause less disruption to the surrounding neighborhood compared to reinforced concrete buildings.

Source: Western Archrib; Glenora Westblock

"The performance of a well designed building envelope will extinguish the concerns of one building structure over another… For the vast majority of conditions, the approach to designing an envelope for a tall Mass Timber building will be no different or only very moderately different than designing an envelope for a tall concrete building".—Michael Green, 2018



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Completed in 2017, Origine is a 13-storey Mass Timber building in Québec City. Origine is one of the first tall-wood residential buildings in Canada. *Source: Stéphane Groleau for Nordic Structures*

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Origine features Mass Timber materials from the first floor to the thirteenth. The load-bearing walls, floors, and the roof were built from CLT, with glulam posts and beams throughout the structural system. *Source: Stéphane Groleau for Nordic Structures*

Mass Timber Goes Tall

Engineers have the ability to vary the species composition and the number of layers in Mass Timber products, so it is relatively simple to meet the needs of any given project. Because products like laminated veneer lumber (LVL) and cross-laminated timber (CLT) offer this versatility, builders can select the right species and thickness to meet different strength characteristics and specifications. Similarly, laminated strand lumber (LSL) and glue-laminated columns (glulam; GLC) can be produced in almost any length or diameter required, again, depending on the desired engineering requirements of the project they are being produced for.

Mass Timber buildings weigh approximately 25% less than that of traditional reinforced concrete buildings. This is the result of a smaller foundation size that reduces the impact of seismic forces or high winds. This high strength-to-weight ratio means that a Mass Timber building will perform better during an earthquake compared with a reinforced concrete structure. Mass Timber materials weigh a quarter of the weight of reinforced concrete panels, resulting in much lower gravity and seismic loads on the structure. When considering the strength of different building materials, a 20-storey structure built with 35 MPa reinforced concrete, for example, could just as well be built with solid wood panels and glue-laminated columns.

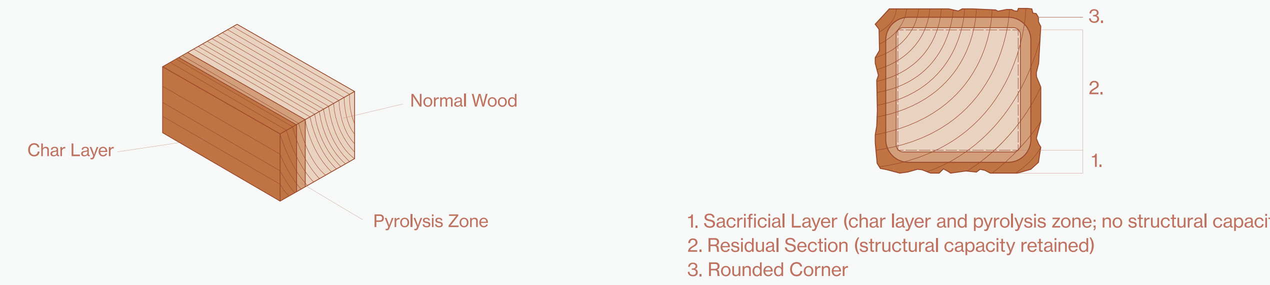

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Figure 4
The exterior char layer, labeled as layer 1, is designed to be sacrificial. As a result, the internal layers of the timber panel retain structural integrity and, therefore, are not affected by the fire.

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Not only can Mass Timber designs and materials facilitate buildings that are strong and durable enough to reach heights of 18 stories, but they also offer the fire safety rating needed to do so. *Source: naturallywood.com*

Mass Timber & Fire Safety

Timber frame houses are highly susceptible to fire. These wood homes are constructed from 2×4, 2×6, 2×8, and 2×10 dimensional lumber. Because of the small diameter of the wood and the gaps between studs and floor joists, dimensional lumber burns quickly. Once the fire penetrates spaces within a building, the structural integrity of walls and floors is rapidly compromised. Because of this, building codes limit wood buildings to less than 6 storeys in height.

Because of the bulk and length of the materials involved, Mass Timber construction bypasses the issues of gaps and spaces within walls and floors—the very situation that allows a fire to penetrate conventional wood buildings. Larger pieces of lumber, like that Mass Timber components, burn significantly slower than smaller pieces of typical dimensional lumber. In fact, as Mass Timber elements burn, their outside layers blacken and char. This charring limits the fire's accessibility to the fuel source (the wood) and delays penetration into the timber. Typical char rates of 0.65 mm/min for CLT and LSL panels and 0.65 mm/min for glulam columns would result in a minimum of 1-hour fire endurance for the entire structure, equivalent to or better than other types of construction including reinforced concrete. In a 1984 study, E.L Schaffer showed that structural steel begins to lose strength at 350°C—the typical ignition temperature of wood—and is reduced to 60% of its original strength by 550°C.

Structural elements can be designed with a "sacrificial outside layer" that chars during the hottest of fires while maintaining adequate structural integrity. For this reason, Mass Timber offers the fire-resistance rating necessary to protect a structure from collapse and sufficient time for the occupants to safely exit the building. A residential building taller than 18 metres is classified as a "high building" under the applicable fire code. Under these requirements, floor and load-bearing wall assemblies must have a minimum 2-hour fire resistance rating and be fully sprinkler protected—an achievable condition with CLT floor and wall panels. Obviously, the level of potential fire exposure being considered here would be a "worst-case" scenario; in the real world, even tall wood buildings have a supplementary sprinkler system. Typically, sprinkler systems operate to slow burning and lower the temperatures within a building. Slow burning charring, coupled with contemporary sprinkler systems, minimizes the impact of fire in a home.

Mass Timber: Low Impact, Sustainable Living

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Why Mass Timber?

As we search for more sustainable ways to live our lives, it only makes sense that we also consider where we live, how it is constructed, and how we can reduce our impact on a significant level. Mass Timber projects present the chance to develop, design, and build our community for the future. This paper shows how Mass Timber construction redefines the limits of traditional development and lays a path for the appropriate industry response to the challenges of a changing world. There is room for urban growth without contributing to the threat of a warming planet, but it takes smart design, sustainable materials, and a responsible approach to building. Luckily, Mass Timber construction offers us an opportunity to accomplish these goals. Outlined here is our ten point summary—as described throughout this whitepaper—for building for the next generation.

↖ Across BC, the development and construction industry is embracing Mass Timber. Tresah, a 12-storey building by Mike Geric Construction, will be Victoria's first-to-market Mass Timber development.

1. Carbon Master

The manufacturing of Mass Timber materials produces very little carbon, and the carbon that the original tree captured and stored over time is maintained within the final wood product. Rather than creating or releasing carbon, Mass Timber buildings actually hold carbon within their structure. Choosing Mass Timber, then, is choosing to minimize emissions during the material production process and to cumulatively reduce the amount of carbon in the atmosphere by reusing what would otherwise be wasted timber breaking down on the forest floor.

2. Touching Lightly

The construction and weight of Mass Timber elements enable the structure to have a lighter foundation and less impact on the ground. From a geotechnical perspective, Mass Timber can provide a building solution for changing soil conditions that would limit steel or concrete construction.

3. Seismic Genius

Mass Timber is engineered to be strong and dense, yet it weighs considerably less than concrete or steel. Along with wood's inherent flexibility, ductile connections, and thickness, the load on the foundation is greatly reduced, making its seismic performance outstanding.

4. Superior Insulator

Wood has natural insulating properties; the rate at which the material conducts or transfers heat is quite low. The fabrication of Mass Timber is extremely precise, allowing the members to fit together perfectly, resulting in a tight exterior envelope. Mass Timber not only creates a more comfortable environment but also reduces your personal consumption along with your energy bills.

5. Fire Safe

In the event of a fire, Mass Timber products only char on the outside, forming an impermeable layer to protect the interior of the building. Tests have proven that Mass Timber materials—due to the sheer size and strength—achieve a nearly damage-free performance during a fire.

6. Faster Build Time

Mass Timber minimizes delays during construction because components are pre-engineered, fabricated off-site, and ready to be installed on arrival. The construction process for Mass Timber buildings is faster, quieter, and less disruptive to the neighbourhood.

7. Lower Cost of Construction

A light impact on the ground, a low product weight, a small build-site option, and a low carbon emittance during the production all contribute to the reduced cost of Mass Timber construction. Carbon pricing is expected to increase, which will also increase the cost benefits of working with Mass Timber versus concrete and steel.

8. Sound Performance

Building component mass is one of the main factors affecting sound transmission. Because the floor and wall components of Mass Timber buildings are so large, the sound transmission is reduced greatly, resulting in a comfortable, quiet living environment.

↗ Tresah—located in Victoria, BC—uses the striking Mass Timber structure to transform its interior spaces.

9. Happiness & Well-Being

Studies link exposed wood in buildings to the improved health and well-being of the occupants living there. The presence of wood elements in the built environment reconnects us with nature, supports creative thinking, and reduces stress reactivity through restorative properties.

10. Stellar Embodied Energy

Besides the carbon-reducing benefits of Mass Timber materials, the air and water pollution produced in the production of composite wood is minimal. Comparatively, the waste created by Mass Timber is consistently less than that emitted by materials like concrete and steel. To this end, the little waste that is produced can be reused in other architectural elements, Mass Timber products, and biofuel.

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