WOOD USE IN BRITISH COLUMBIA SCHOOLS

A PRACTICAL REPORT FOR SCHOOL DISTRICTS, ADMINISTRATORS, AND DESIGN PROFESSIONALS

thinkspace   Fast+Epp

Over the last 10 years, there have been more than 50 K-12 schools across British Columbia that have incorporated wood into their buildings.

For more information about British Columbia schools using wood products, visit naturallywood.com.

Wood Use in British Columbia Schools was commissioned by Forestry Innovation Investment Ltd.

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Norma Rose Point Elementary School, Vancouver – Photo © Ema Peter Photography

EXECUTIVE SUMMARY

Wood, particularly in British Columbia, is an inherently valuable resource for the design and construction community, with a huge opportunity to increase its use in both new construction and renovations and upgrades.

Wood is an amazingly useful and resilient material. Thanks in part to advances in the industry, wood can now be used in applications that were traditionally reserved for concrete and steel – and it should be a regular part of our architectural, engineering and construction vernacular.

One sector that deserves special attention when it comes to an increased use of wood in design and construction is the education sector, with a focus on K-12 schools.

Each school project, regardless of whether it is new construction, an addition / expansion, or a retrofit, represents an opportunity to further the provincial and federal governments' desire to reduce carbon emissions and footprints, work towards net-zero and support local forest-based economies.

Additionally, school districts have ready access to homegrown technology that is leading edge, globally.

In other words, there are many reasons to use wood in schools.

AUDIENCE

This report has been written for a variety of different audiences. As a result, it contains a broad spectrum of information.

Audiences include:

- Individuals in a position to influence the decision to use wood in school construction. Given the current structure for construction funding for schools, that will be individuals working at the school district level who can shape project definition reports or design criteria for both new schools and renovations.
- Individuals working within various federal and / or provincial government ministries who deal with timber, education, or other related sectors.
- People who are part of the school district administrative structure, or public K-12 education system in general, but possibly not directly involved in the decision making process.
- Members of the design community (architects, engineers, planners) who see the opportunities for using wood in schools.
- The mass timber industry, looking to expand markets and tap into opportunities to grow business.
- Individuals associated with private or independent schools, who can adapt much of the information regarding the benefits regarding wood use to their own situations.
- Individuals with a general interest in advancing their knowledge about new design and construction methods within the public education sector.

STRUCTURE OF THE REPORT

This report is broken down into eight sections. They are as follows, and cover the topics outlined:

1. Introduction: An overview of the use of wood, and wood in schools in particular.

2. Types of Wood Construction in Schools: The structural applications of wood in school construction, as well as non-structural applications.

3. Case Studies: A series of case studies on the various types of wood construction used in schools.

4. Utilizing Wood in School Construction: The nuances of using wood in school construction.

5. Building Codes: The various building codes that affect the use of wood in schools, and most notably, the changes in these codes since the first iteration of this report in 2018.

6. Advances in Wood Use Technology: Advances in the design and fabrication of mass timber, and engineered mass timber using in construction.

7. Conclusions: Conclusions for the report.

8. Acknowledgments: Project team acknowledgments.

METHODOLOGY

This report is predicated on one authored by Stantec and Fast + Epp in 2018. Some of the themes and concepts in the 2018 report have influenced this report, but the overwhelming majority of the work in this document is original content.

This is very much a work of collaboration. More than a dozen subject matter experts have contributed their time to this endeavor: architects, engineers, code consultants, sustainability consultants, quantity surveyors, and wood industry experts. Each has brought their own strengths, skills, and professional experience to bear.

The goal for this document has been to create a useful guide for individuals or organizations curious about the use of wood in schools in British Columbia. It is intended for experts and novices alike who are part of the community that builds, maintains, and works in schools.

The document is laid out to provide a broad overview of this very large topic, as well as introducing some current case studies to provide ideas for future projects. It also explores topics that affect decisions when designing and building with wood in schools.

The use of wood in design and construction in general, never mind schools in particular, is such a broad topic that it is not possible to tackle all aspects of the discussion in one report.

This is not intended to be a definitive work on wood use in schools, but rather a tool to spark conversations and ask questions about what could be possible.

Due to the constantly evolving nature of this topic – especially as related to building codes in various jurisdictions – all information in this report should be independently verified through the local Authorities Having Jurisdiction (AHJ).

EXPLORING NEW TOPICS

The 2022 report is not intended to be a section-by-section update of the 2018 report. As such, it will cover some topics from the previous report but will exclude others, and introduce a few new ones.

These changes are because technology and techniques have evolved, as have demands from end users – including school districts.

This report will focus on commonly accepted practices and approaches at the time of writing, with the provision that this sector is constantly evolving.

Bayview Elementary School, Vancouver – Photo © Wade Comer Photography, courtesy naturallywood.com

DEFINITIONS

Air-transported moisture: Air-transported moisture is the vapor content of air as it leaks out of, or into, a building. Air leakage is caused by a combination of holes through the building envelope and one of three driving forces: wind, stack effect, or mechanically-induced pressure differences (fans) between the inside and outside of the building. Left untreated, this can cause condensation that can eventually lead to rot. Air-transported moisture is managed with a continuous air barrier in the building envelope, built with interconnected air-impermeable sheet goods, caulks, sealants, and spray foams.

Authority Having Jurisdiction (AHJ): Governmental agency or sub-agency that is responsible for adopting and enforcing laws and regulations for construction. The provinces, territories, and municipalities pass legislation that references the relevant building code to enact building and fire regulations, and the AHJ enforces this.

Assembly occupancy: This is based on the British Columbia Building Code, and is where a group of people assemble and occupy a given space; schools are considered “assembly occupancy” buildings.

Alternative solution: This relates to the British Columbia Building Code and is an approach that requires an interpretation of the intention of the building code rather than using a prescriptive approach. It can include a construction method that differs completely or partially from those given in the Acceptable Solutions or Verification Methods.

BCBC: The British Columbia Building Code.

Braced frame: Steel or wood braces used in any number of different configurations to resist lateral loads.

Brisco panels (secondary laminated LVL): Glued laminated veneer lumber that is cut into columns, beams and wide panels.

Bulk water: Rain, runoff, and other significant water flows.

Capillary water: Capillary water moves under tension in porous building materials or through narrow channels. Capillary water damage is often harder to detect and can result in significant damage if not addressed. Capillary action can best be controlled by providing a capillary break such as plastic, metal, damp-proofing compound, or another impermeable material, or by leaving air spaces that are too large for capillarity to occur.

Charring rate: The rate at which wood burns and creates a layer of protective char around the core of wooden construction members. This rate is used in the calculation for fire-resistance rating of wood members.

Composite / hybrid panels: These are mass timber panels comprised of multiple materials or elements connected together for composite action to provide greater strength and stiffness. Timber-concrete composites comprised of concrete topping over mass timber panels are one common type of composite panel.

Cross-laminated timber (CLT): Glue-pressed dimensional lumber arranged in layers 90 degrees to each other for stability. CLT may also provide two-way span ability due to the alternating layers. Panels are fabricated up to 2 to 3.5m wide and 12 to 15m long to allow for transport. Dimension / length can be restricted by transportation, not manufacturing or use.

Dimensional lumber: This is also referred to as solid sawn wood. It is milled from logs and kiln dried to reduce the moisture content. Member sizes vary with nominal dimensions used for imperial unit designations (i.e. 2” x 4” nominal refers to 1 ½” x 3 ½” actual dimension).

Dowel-laminated timber (DLT): Wood dowels are used in lieu of nails to attach pieces of dimensional lumber on edge to one another, creating larger panels. Similar to nail-laminated timber (NLT).

Ductility: A material's ability to deform permanently under stress without failing.

Engineered lumber: This uses parts of wood fibre, gluing and arranging it into structural elements to achieve greater capacity, more stability, and less vulnerability to moisture.

Encapsulation: A means by which to protect mass timber or other combustible material by using non-combustible elements. Typically, the timber or other material is covered with fire-rated gypsum wall board to ensure the structural elements provides the necessary fire rating requirements.

Fire resistance rating: The time in minutes or hours that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria.

Glulam: A structural engineered wood product comprised of layers of dimensioned lumber bonded together with durable waterproof adhesives; these can be columns or beams.

Glue-laminated timber (GLT) panels: Similar to glulam beams, GLT panels use regular stock dimensional lumber that is glue pressed and placed flat. This system is one-way due to the member arrangement all running parallel to the span. Plywood is typically placed over to create a horizontal diaphragm for lateral resistance. Panel sizes are dependent on panel thickness, but are typically 0.6m wide and 12 to 15m long to allow for transport. Dimension / length is typically restricted by transportation, not manufacturing or use.

Heavy timber: A term used by building codes to denote minimum wood member dimensions deemed to meet the relevant fire rating of 45min. Columns, beams, joists, and decking dimensions are provided, and relate to specific code building types, sizes, and occupancy allowances.

Hybrid mass timber: A construction type that utilizes both mass timber and at least one other primary building material, such as concrete or steel to create a structural assembly.

Impact insulation class (IIC): The degree of soundproofing of the impact noise of a floor or ceiling assembly

I-joist: Arranged dimensional or engineered wood elements that are formed in an I-shape to achieve greater efficiency and stiffness when compared to dimensional lumber. They are typically used for floor and / or roof joists.

Innovative products: New products and fasteners that are being introduced in the wood use marketplace regularly; accepted use will vary by jurisdiction.

Laminated strand lumber (LSL): Smaller wood chips are arranged to create pressed panels that are typically cut into beams, headers, and tall wall purlins. This is occasionally used as mass timber panels where available.

Laminated-veneer lumber (LVL): Laminated-veneer lumber, such as plywood, is made up of multiple thin layers of wood assembled with adhesives and is typically used for beams, headers, and tall wall purlins.

Lateral force resisting system (LFRS): The system used by the building to provide lateral support. This can include wood shearwalls, braced frames, or moment frames. Reinforcing existing LFRS or adding LFRS elements is common when seismically upgrading a building.

Light wood framing: Also referred to as traditional wood frame. It uses dimensional lumber to construct walls, trusses, built-up beams, and posts. Gang-nailed trusses can use dimensional lumber to achieve longer spans.

Load bearing: A construction element that supports the primary structure, e.g., load-bearing wall / beam.

Long Range Facility Plan: A long-term planning document created by school districts to outline requirements for their facilities. A long-range facilities plan (LRFP) forms the basis for capital investment decisions for school facilities.

Mass plywood panels (MPP): Sections of plywood and LVL veneer pressed into panels up to 24" (600 mm) thick.

Mass timber: Mass timber typically consists of wood components (i.e., dimensional lumber, plywood, etc.) that are glued, nailed, or fastened together into larger panelized elements that are used for walls and decking (floors / ceilings), and on occasion, wood beams.

Moment frame: A rectilinear assemblage of beams and columns that resist lateral loads, primarily by bending movement and shear force in the frame members and joints. Steel frames are the most common type and can be used when open areas are needed. They consist of column with fixed connections to stiff beams. Wood moment frames are also possible but require special detailing and additional analysis.

Nail-laminated timber (NLT): This uses dimensional lumber that is nailed together on edge to create larger panels. The panels may be prefabricated on or off-site or nailed in place. Plywood is typically placed over NLT to create a horizontal diaphragm for lateral resistance.

NBCC: National Building Code of Canada

Non-load bearing: Areas where framing does not support the primary structure (i.e., partition walls).

Oriented strand board (OSB): Adhesive is added to wood strands and then pressed in specific orientations to create a large sheathing panel. OSB is typically used for a lateral diaphragm and exterior sheathing.

Parallel strand lumber (PSL): Arranged wood strands that are glued and pressed together to form larger beam and column members.

Plywood: Wood veneer pressed together to make larger panels. Plywood is typically used for structural sheathing, exterior sheathing, or millwork.

Post-and-beam: A traditional form of wood construction using beams and columns. Walls are typically limited to the perimeter of the building, which may consist of brick, concrete, or wood frame.

Project Definition Report (PDR): The feasibility study that defines the scope, scale, and budget for a school project in British Columbia.

Racking: Deformation that can occur at the corners of wall structures when forces act on it transversely. This can result in a lateral displacement relative to the bottom structure.

Sheathing: Structural sheets, typically plywood or OSB, applied to floor or wall framing in light wood framing construction or on NLT / GLT panels. Sheathing is often used to provide lateral resistance (i.e. shearwall or diaphragm).

Shearwall: A structural system composed of braced panels to counter the effects of lateral load acting on a structure. Wood shearwalls use plywood sheathing over light-framed walls; concrete shearwalls are also common.

Sound transmission class (STC): A rating of sound isolation of a building assembly; the higher the STC rating, the better sound isolation the assembly demonstrates.

Thermal performance: This defines how well an assembly can retain heat. It is commonly expressed in the construction industry as a U-value or R-value.

Thermal bridge: The area or component of an object that has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer.

Vapour diffusion: The movement of water as a gas. While building assemblies get wet through all four forms of water movement, once water gets in the main way it gets out is diffusion. So, building assemblies should be built to dry through diffusion.

Wood First Act: The Wood First Act, which was passed in 2009, requires provincially funded projects in British Columbia to use wood as the primary construction material.

Wood First Program: The Wood First program focuses on advancing wood use and innovative wood construction technologies in British Columbia and establishing the province as a showcase for wood products in construction, interior design, and daily living.

Samuel Brighouse Elementary School, Richmond –
Photo © Andrew Latreille, courtesy naturallywood.com

1. INTRODUCTION

WHY WOOD?

Wood has been used as a structural and finishing material for building projects for a millennium. Over time, it was replaced by brick, concrete, and steel, particularly in the commercial building sector. There has, however, been a renaissance in the use of wood as more than just a finishing material.

There are numerous benefits to building with wood, especially in the province of British Columbia. It can be locally sourced from sustainable, renewable, and certified forests, while also supporting the provincial economy and communities across British Columbia.

Wood creates optimal living and working environments for building occupants, while still meeting code and building requirements for safety and performance.

There are also significant sustainability benefits to using wood for construction (a lower carbon footprint when compared to concrete), as well as an ability to store (sequester) carbon in the building once it is complete and keep it out of the atmosphere.

The way that we can use wood has been enhanced in recent years thanks to technological advancements. Engineered wood products, mass timber, and hybrid building systems allow architects and engineers to design larger, taller, and stronger structures out of wood.

British Columbia is in a unique position to facilitate an increased use in wood, thanks to an abundance of natural timber resources: there are more than 41 million hectares of certified forests in British Columbia. The province also has a well-established timber harvesting and milling industry.

Beyond that, British Columbia is also home to an increasing number of companies that specialize in the use of wood in a wide array of building typologies. These companies have grown in size and ability over the past decade, and are constantly learning and innovating to push the boundaries of wood design and construction.

As noted above, there is also an environmental benefit to using wood in construction. The province has set ambitious targets for reducing greenhouse gas emissions 40% below 2007 levels by 2030, and 80% by 2050 as part of the CleanBC climate plan.

Those targets will be met by reducing pollution and waste, while simultaneously identifying and exploring new technologies and opportunities to meet climate goals. One way to do that is to build out of wood, and there is financial support to do just that.

The CleanBC Building Innovation Fund "supports research, demonstration and development of low carbon building materials, construction methods and building components to make them more affordable and accessible to British Columbians."[1]

The opportunity and the support is there – people just need to commit to the use of wood rather than relying on steel and concrete because it is familiar.

GOVERNMENT SUPPORT

The government of British Columbia has been working to promote the use of timber in construction for more than a decade. One of the earliest initiatives was the Wood First Act, passed in 2009.

The goal of the act was to "facilitate a culture of wood by requiring the use of wood as the primary building material in all new provincially-funded buildings."[2]

Since then, Wood First and other provincial initiatives have helped grow the adoption of wood in the province's building sector.

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1 https://commons.bcit.ca/ecocitycentre/files/2021/02/Slide-deck_Ecocity-Webinar-Embodied-Emissions-Bldgs-2021-Feb-23.pdf

2 https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/00_09018_01

In 2009, British Columbia was the first province in Canada to adopt code provisions for six-story light frame wood construction, and in 2019 introduced code provisions for seven to 12 storey encapsulated mass timber construction.

It has been assisted by support from various organizations, including Forestry Innovation Investment (the sponsor of this report), Wood *WORKS!* BC, the newly formed Office of Mass Timber Implementation (OMTI), and the Mass Timber Advisory Council, all of whom have promoted, facilitated, and championed the use of wood in the province.

OMTI is somewhat unique, as a provincial cross-government hub whose mandate is to take mass timber from niche to mainstream. OMTI's focus is increasing local supply of mass timber by removing barriers and exploring opportunities for innovation in the forestry, manufacturing, construction, and trade sectors.

This will help drive an overall transition to more high-value forest products and manufacturing, as well as support the integration of mass timber into mainstream construction.

The provincial government further underscored its commitment to mass timber in summer 2020, when it announced that it intended to promote the use of mass timber in capital construction programs.

British Columbia is a leader in the use of mass timber as an innovative way to reduce the carbon footprint of our building sector while supporting good jobs for people in communities across the province.
– George Heyman, Minister of Environment and Climate Change Strategy

The announcement was intended to provide economic stimulus in the wake of COVID-19, with forestry workers and First Nations cited as primary beneficiaries of the program, but there was also a nod to the opportunity to advance CleanBC.[1]

"British Columbia is a leader in the use of mass timber as an innovative way to reduce the carbon footprint of our building sector while supporting good jobs for people in communities across the province," said George Heyman, Minister of Environment and Climate Change Strategy in the release.

This push to use mass timber will be particularly noticeable in major projects such as the Royal British Columbia Museum in Victoria, but it is also an important part of smaller publicly-funded projects – such as schools.

1 https://news.gov.bc.ca/releases/2020PREM0033-001076

The provincial government released a Mass Timber Action Plan in April 2022, which lays out how it will drive innovation in mass timber.[2] The plan should have a significant impact on the prevalence and adoption of wood use technologies across the province in the immediate future.

WHY WOOD IN SCHOOLS?

The rationale for building with wood in British Columbia is fairly well spelled out: there are social, economic, political, and environmental reasons. The question then becomes, why should architects, engineers, and builders choose to use wood when building schools in particular?

2 https://www2.gov.bc.ca/assets/gov/business/construction-industry/bc_masstimber_action_plan_2022.pdf

Primary, elementary, and secondary schools are very much purpose-built facilities. They occasionally serve secondary purposes (e.g. community hubs or post-disaster gathering places), but for the most part they are dedicated learning environments. These buildings have traditionally been functional and in many cases, highly institutional in nature.

Material selection for the construction of schools has generally followed the predominant construction method of the day for the past century and a quarter, with wood-frame schools giving way to brick then concrete-and-steel structures.

Generally speaking, the larger and more complex the project, the less wood was used – especially for structural elements of the project.

In the last 15 years or so, however, there has been a conscious shift back towards the use of wood in buildings in general. That move back to wood is connected with the larger appreciation for the benefits of using wood for construction that were outlined above.

There are specific and tangible benefits to using wood for school construction. These benefits can be divided into two broad categories: functional and performance, with the performance benefits being more directly relatable to schools in particular.

We see the increase in mass timber schools as being tied to a few things: the influence of green building programs, understanding carbon sequestering, a renewed interest in wood generally, the Wood First policy in British Columbia, an interest in sustainability, and people learning more about materials and structure options for schools.
- Andre Lema, Manager of Business Development, Western Archrib [glulam designers / fabricators]

FUNCTIONAL BENEFITS OF WOOD IN SCHOOLS

Seismic: Wood buildings, particularly those using engineered wood products, are well suited to withstand lateral forces experienced in high seismic regions.

Speed of construction: Mass timber components can be assembled off-site at fabrication facilities and quickly erected on site, shortening the construction timeline by months in some cases, as well as increasing overall quality due to construction in a controlled shop environment.

Carbon storage: Wood products store carbon in a building over its lifespan (known as sequestering carbon), meaning that a measurable amount of carbon is not released into the atmosphere.

Reduced greenhouse gas emissions: Between production, delivery, and assembly, wood has a lower carbon footprint and greatly reduces the carbon production associated with concrete or steel buildings from being released into the atmosphere.

Cost-effective approach: Various wood construction options (both engineered and non-engineered wood products) offer cost-effective or cost-comparable approaches to steel, concrete or gypsum structural solutions, assemblies and finishes, meaning that schools can cost the same while also offering notable performance benefits.

Availability of material: British Columbia wood products are (generally speaking) more readily available than products coming in from other areas, particularly overseas destinations due to global supply chain issues that have arisen as a result of Covid-19.

Specialized consultants and trades: The growth in wood use across the construction spectrum means that there are more specialized consultants and trades available to work on school projects with wood components. This includes architects, structural engineers, engineered wood fabricators and installers, and wood construction specialists.

PERFORMANCE BENEFITS OF WOOD IN SCHOOLS

Impact on learning: Traditional school layouts, with long hallways and rows of classrooms, are no longer the norm as school districts come to understand and appreciate the benefits of 21st century learning environments. Classrooms no longer need to be the only place or space where students learn. Mass timber construction often facilitates the creation of these new, expanded, more open learning spaces in ways that are not possible using more traditional construction methods.

> ***Several recent studies have shown that the use of wood in classrooms creates a healthier environment that promotes both mental and physical well-being, and enhances learning potential.***

Health and wellness: There are clear benefits to using wood for interior finishes or having exposed wood surfaces, including reduced stress and increased productivity. Several recent studies have shown that the use of wood in classrooms creates a healthier environment that promotes both mental and physical well-being, and enhances learning potential. It turns out that biophilia, the innate connection to nature, is relevant to everyone, not just adults working in mass timber office buildings.[1]

Culture and tradition: As First Nations groups exert a greater influence on institutions and infrastructure in their communities, some of the civic buildings in these communities – including schools – are becoming places for cultural expression and celebration. This can help build a pride of place and shared heritage for students, early on in their academic careers.

Material performance: There are a number of other material performance benefits to wood use in schools. This includes resiliency and durability of the material itself in an environment that is notoriously hard-wearing, improved maintenance qualities for operations teams, improved air quality for students, teachers, and staff, and improved acoustics both within and between learning spaces.

OPPORTUNITIES TO USE WOOD

There are two broad opportunities for wood use in schools: new construction and upgrades / expansions. While this section of the report focuses on public schools within the province, similar opportunities exist for private schools, independent schools, religious schools, francophone schools and First Nations schools outside the purview of the Ministry of Education and Child Care (the Ministry of Education) and local school districts.

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1 https://www.naturallywood.com/wood-performance/health/

Readers should note that information not specifically related to Ministry of Education funding or approvals is also relevant for these other types of schools.

The number of new school construction projects is constantly shifting due to new project starts and completions, but at any given time the Ministry of Education can have 100 or more major capital projects underway. That includes new school construction as well as renovations, upgrades, and expansions. Each of those is, theoretically, an opportunity to bring wood into schools. When schools that require seismic upgrades are added to the list, the number of opportunities to use wood in schools is staggering.

The Ministry of Education launched the Seismic Mitigation Program in 2004 to make schools safer in the event of an earthquake by minimizing the probability of structural collapse.

In conjunction with the Engineers and Geoscientists of British Columbia, all public schools in British Columbia have been assessed for seismic risk, identified 496 eligible schools that required mitigation through strengthening, partial replacement, or full replacement.

Through the Seismic Mitigation Program alone, the Ministry of Education has spent over $1.9 billion as of 2021 to complete 195 high risk projects throughout the province; more than 200 are still pending and listed as future priorities as of 2022.

FUNDING FOR WOOD USE

Both the federal and provincial governments are realizing the benefits of using wood for school construction, and stepping up to support the construction of mass timber school buildings with funding dollars.

In March 2021, the federal government announced a $1,482,000 investment in Vancouver School Board District #39 to support the replacement of two existing schools: Bayview Elementary School and Sir Mathew Begbie Elementary School. Those two schools are designed as mass timber schools and will be discussed in greater detail in Section 2 of this report.

According to Jennifer Whiteside, British Columbia's Minister of Education, using wood for these new schools has numerous benefits. "Students and staff deserve to spend their days in schools that are built seismically safe with sustainable products," she said.

Whiteside went on to say, "To see mass timber being used in construction is a very exciting development. This is an example of how we can work together to combat climate change and support B.C. mass timber technology while also providing the best possible learning environment for students."[1]

Funding was provided through Natural Resources Canada's Green Construction through Wood program, which promotes the use of wood in non-traditional construction projects.

1 https://www.newswire.ca/news-releases/canadian-mass-timber-to-make-vancouver-schools-more-earthquake-resistant-809732392.html

To see mass timber being used in [school] construction ... is an example of how we can work together to combat climate change and support B.C. mass timber technology while also providing the best possible learning environment for students.
– Jennifer Whiteside, Minister of Education

Although school boards are becoming familiar with the use of wood for a variety of design and construction applications, it is important to note that the Ministry of Education does not have prescriptive standards or policies on specific materials to be used for construction projects.

The Ministry acts mainly as a funding agent for construction work done on schools, while school districts have autonomy on design and material selections, and are responsible for all procurement of projects.

Mass timber is increasingly being investigated by school districts as a potential building material option during the development of business cases for new and replacement school projects.

A growing number of project definition reports (PDRs), which are the business case for school design and construction projects, are requiring an analysis of the use of mass timber and greenhouse gas reduction. Because the PDRs are commissioned by individual school districts and are based on general criteria from the Ministry of Education, there are variations from district to district on the priorities placed on the use of mass timber.

The decision to fund these two schools is – hopefully – a positive indication of things to come. Greater acceptance of wood use in schools and innovative approaches to design and construction will set the stage for further public investment in mass timber construction in schools – at both the federal and provincial levels.

> ***I honestly believe that incorporating the right mass timber products and designs could change the way we build schools forever, while setting a great example for public buildings with low environmental impact.***
> ***- Scott Comfort, CEO, Seagate Mass Timber***
> ***[mass timber designers / pre-fabricators / installers]***

Norma Rose Point Elementary School, Vancouver – Photo © Ema Peter Photography

2. TYPES OF WOOD CONSTRUCTION IN SCHOOLS

There are several ways in which wood can be used in contemporary school buildings, and design teams often choose to use a combination of wood systems to meet project requirements.

The following applications describe the range of possibilities for wood use including both structural and non-structural applications.

Light wood frame construction remains a category, whereas heavy timber and mass timber have been grouped together as one slightly broader category called mass timber.

This report also adds a new category: hybrid mass timber, which is the use of mass timber in conjunction with steel or concrete.

STRUCTURAL – LIGHT WOOD FRAMING

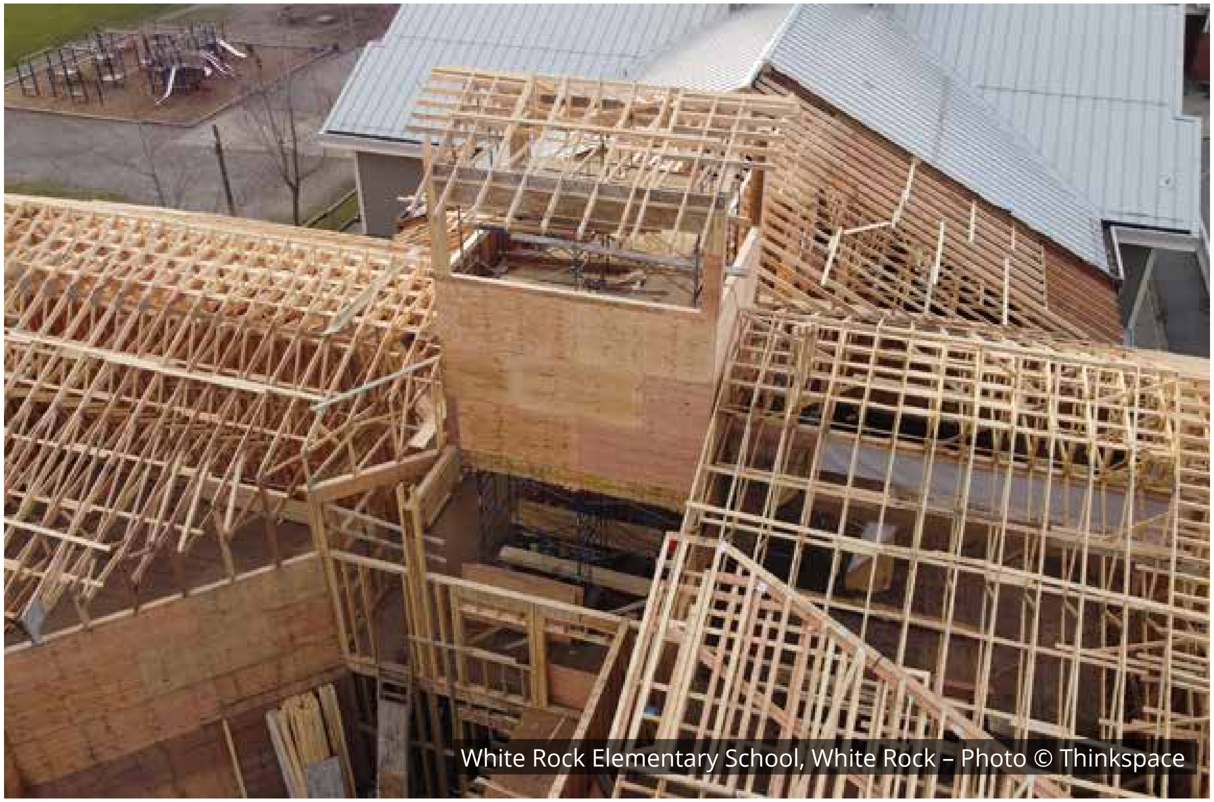
Light wood framing, which can also be referred to as traditional wood frame or stick framing, uses dimensional lumber to construct structural elements such as walls, roof and floor joists, trusses, built-up beams, and posts.

Repetitive structural members spaced not more than 600mm on centre are usually clad, sheathed, or braced on at least one side. Engineered lumber may also be used in light wood framing when dimensional lumber is not adequate to meet structural code requirements.

Light wood framing is a combustible material and can be utilized in smaller schools that qualify to be combustible in the British Columbia Building Code (BCBC). It can also be utilized in larger buildings in combination with other structural systems, such as concrete or steel.

Light wood framing can also be provided for partitions of non-combustible buildings, provided they meet the requirements in the BCBC, which restrict fire compartment size, partition size, use, and total number of storeys.

There are many benefits for constructing a school using light wood framing. Given the availability of labour and materials in British Columbia, it is often considered to be a cost-effective solution for smaller schools and schools with a repetitive floorplan.



White Rock Elementary School, White Rock – Photo © Thinkspace

With regards to construction and installation, light wood framing is easy to modify, by cutting, nailing, and gluing, which allows contractors to make adjustments more easily on site. The workability also allows for future additions such as plumbing, power, and ducting or reconfigurations of existing spaces.

With the many benefits, there are also some challenges with regards to implementing wood framing into a school setting. Floor and roof span limitations associated with common light framing materials can result in smaller spaces, due to shorter span capabilities and increased number of fixed walls compared to mass timber post-and-beam systems, or hybrid systems. These walls also limit the extent of future renovation as most walls within the building would be considered structural walls.

The added labour needed for installation can also increase schedule times when compared to mass timber construction, due to limits of prefabrication and early coordination that is possible for mass timber construction.

As most schools have very specific construction end dates in order to provide occupancy at the start of the school year, this can be an added risk for school projects using light wood framing.

Light wood framing is a good choice for smaller schools, which typically tend to be located in smaller communities or more remote regions of the province.

Wood construction takes advantage of locally available material and labour; the skills required for light wood frame residential construction are very similar to those required for school construction, so those skills can be readily transferred.

STRUCTURAL – MASS TIMBER

Mass timber typically consists of wood components (i.e. dimensional lumber, plywood, etc.) that are glued, nailed, or fastened together into larger panelized elements that are used for walls, decking (ceilings and/or flooring), and wood beams.

Mass timber members that meet the minimum dimensions outlined in Section 3.1.4.7 of the British Columbia Building Code are considered heavy timber elements.

Some building types permit the use of heavy timber construction as an acceptable solution, depending on the building use and size as noted in Section 5 of this report.

Mass timber provides greater fire resistance than light wood frame, as there is less surface area for the wood to ignite due to the larger panelized elements being used. Mass timber elements also have an inherent fire resistance rating due the protection provided to the inner core of a wooden member by the exterior wood char layer.

> ***Mass timber allows for an extended planning, coordination, and fabrication phase to roll into a very quick execution of the structural elements in the field. This can lead to reduced project overheads ... and less impact and disruption to the neighbourhood. It really has the potential to be a win for all sides of the equation***
> ***- Scott Comfort, CEO, Seagate Mass Timber***

Member sizes for mass timber are dependent on the charring rate and required fire rating requirement

Common mass timber products include cross-laminated timber (CLT), glue-laminated timber (GLT), and nail-laminated timber (NLT), with new products and fabrication technologies being developed on an ongoing basis.

The benefits of using mass timber for schools include schedule reduction, less site disturbance, aesthetics, sustainability, and increased span capabilities. When designing with mass timber, a reduction in construction time can often be realized if proper coordination and planning occurs during the design phase by means of prefabricated elements.

This can not only reduce time on site, but in turn will minimize the risk of long periods of exposed structure that can be susceptible to weather.

The pre-fabrication process also reduces the amount of site work needed, which significantly reduces the level of noise, dust, traffic, and workers needed on the job site. For most schools situated within residential neighbourhoods, this benefit can have a highly positive impact on the community.

Mass timber also proves beneficial when speed of construction is necessary to deliver a project within a specific time frame, or where the aesthetics of exposed timber is valued.

Belmont Secondary School, Langford – Photo © Barry Calhoun, courtesy naturallywood.com

A number of studies have shown that studying in an environment surrounded by exposed timber can provide better learning outcomes than a more traditional learning space.[1]

This idea of surrounding ourselves with natural materials is not a new concept, but the research to back it up and prove the benefits is relatively new.

When exposing timber, we also remove the need to provide wall and ceiling coverings, which provides a cost savings, as well as a benefit with regards to sustainability as we remove the amount of finishing materials.

We can also realize the benefits of embodied carbon when using mass timber, as the carbon released into the atmosphere for wood structural materials is much less than that generally associated with steel or concrete.

1 https://www.naturallywood.com/blog/why-wood-is-an-effective-material-for-schools/

Additionally, it is possible to sequester carbon, as mass timber elements themselves can store carbon that has been captured during the tree growth cycle.

One of the main challenges when utilizing mass timber is the need for early coordination.

The reason for this is a direct result of one of the main benefits of using mass timber, which is service integration and planning. In order to provide the benefit of expedited installation, there needs to be a high level of effort during the early design stages to coordinate details, openings, and connections.

This added effort needs to be scheduled, along with providing adequate time for shop drawing review and fabrication.

STRUCTURAL – HYBRID MASS TIMBER

Hybrid mass timber construction consists of mass timber in combination with other building materials such as steel and concrete.

The materials can be used in a composite manner, where they are bonded or fastened together to act as a single element, such as a timber-concrete composite floor systems, or they can be used independently as is generally the case for a CLT floor deck supporting by steel beams.

When considering mass timber, it can often be beneficial to study a variety of systems and materials to better understand the benefits of each application.

There are many benefits of implementing a hybrid mass timber approach, such as utilizing each materials strength for different applications. When combining timber and concrete, for example, the team may be able utilize the high compressive strength of the concrete along with the tensile strength of the timber to provide an economical solution.

As such, hybrid solutions can often lead to reduced floor depths, longer spans, or increased performance, or improved efficiency. This proves beneficial for school settings where open floor plans and future flexibility are becoming increasingly popular.

The main challenge when considering hybrid mass timber construction is ensuring that the added effort and coordination required provides enough benefit. Hybrid systems can require more coordination as multiple trades are necessary, and details need to be thought out and coordinated between various fabricators.

Where composite systems are used, there can also be added effort with regards to design and analysis, or in some cases additional testing to prove the performance of a system that has not already been adopted within local codes.

This was the case with the timber-timber composite testing completed for Begbie and Bayview Elementary schools.[1]

Hybrid systems work best where design objectives are very specific, with respect to performance, member sizes, or spans. The benefits of using materials effectively are most realized for these types of projects, although many of those characteristics can prove beneficial for more typical schools as well.

NON-STRUCTURAL – EXTERIOR USE

Wood has been used for exterior cladding on schools since the earliest one-room wooden schools were built in British Columbia. It continues to be used on all types of school buildings, both those made of structural wood and those made of concrete or brick.

Cedar planks and shingles are commonly used for cladding, and along with Douglas-fir, can also be used as cladding without treatment.

1 Shahnewaz M., Dickof C., Shou J., Tannert T., Vibration and flexural performance of cross-laminated timber – glulam composite floors, Journal of Composite Structures, Volume 292, 2022, https://doi.org/10.1016/j.compstruct.2022.115682

Other species, including spruce, fir, and pine, are generally treated, or more recently, preserved through thermal modification to improve the lifespan, strength, durability, and stability of the wood before being used as cladding.

The BCBC allows for combustible cladding (i.e. wood) to be used on exterior non-load bearing walls in a non-combustible building (i.e. concrete / steel / brick), provided that the building is not more than three storeys tall, is sprinklered throughout, the interior surfaces of the wall assembly are adequately protected, and that the assembly satisfies the criteria when subjected to testing.

Additionally, the cladding must meet the requirements for limiting distance set out in the building code. It must also meet standards for flame-spread distance as defined in the code.

Wood can also be used for soffits and canopies, although canopies and soffits extend more than 1.2 m (4') require sprinklers if under a certain height.

NON-STRUCTURAL – INTERIOR USE

Wood is typically used in school interiors as a finish surface for various applications and purposes ranging from walls, ceilings, and floors to banisters, staircases, display cases, and window frames.

Wood used for aesthetic purposes has been proven to enhance learning environments and promote biophilia for students of all ages, as noted in Section 4.

Interior wood products generally come in the form of solid wood or a wood veneer. Solid wood is cut to size either on site or in a manufacturing facility before being sent to site.

Wood veneers are thin layers (usually less than 3mm) of wood adhered to plywood, particle board, or MDF (medium-density fiberboard) cores; veneers are used to save cost over solid wood materials.

As long as wood products follow the standards in the BCBC – specifically those outlining their use on the interiors of schools – they can be used in any construction type.

Exposed wood structural elements on the interior, such as an exposed glulam column, can be either heavy timber or mass timber products.

Ta'talu Elementary School, Surrey – Image © Thinkspace

Bayview Elementary School, Vancouver – photo ©Wade Comer Photography, courtesy naturallywood.com

3. CASE STUDIES

In the following section, we present a number of case studies that provide an up-to-date picture of how wood is being used in the construction of British Columbia schools.

We will look at light wood frame, mass timber, and hybrid mass timber in some detail. These case studies are by no means meant to be a complete study of all types of wood construction used in schools, but rather an example of some of the types of construction seen in schools today.

HISTORY OF WOOD USE IN SCHOOLS

Wood-frame European schools have existed in what was to become British Columbia since the 1830s. According to a survey of schools in the 19th century, there were 45 public schools in operation in the province by 1875. Most were one-room wood-frame buildings; by 1885, there was even a plan available for a "Country School House", complete with specifications.

Small wood schools remained common through the period, but they increased in size and complexity over the ensuing decades. Two-storey, multi-room wood schoolhouses were not unheard of in British Columbia in the late part of the 19th century.

As cities became larger and schools grew in size to keep up with increasing settler populations, wood largely gave way to brick in urban centres, with the earliest brick school building built in Victoria in 1876.[1]

That did not mean that wood-frame schools disappeared, however, even in Vancouver. "Temporary" schools (i.e., those not made of brick or concrete) continued to be built in Vancouver during the inter-war period (1918 – 1939).

There was a notable shift in construction methodology in the 1920s, however, when Vancouver voters approved funding for new school construction and numerous brick schools were constructed in the years immediately following.

Wood-framed schools were eventually phased out in Vancouver over the following decades, with the end of World War II typically marking the end of significant wood school construction in the Vancouver area, at least.

1 http://www.lordtennyson.ca/uploads/1/2/4/2/12421219/vsb-2008-jan-vancouverschoolsheritagevaluefinalreport-june2007.pdf From Ivan J. Saunders, A Survey of British Columbia School Architecture to 1930, Parks Canada Research Bulletin No. 225 (Ottawa: Parks Canada, 1984), pg 4.

LIGHT WOOD-FRAMED CONSTRUCTION

Wood-framed school construction never died out entirely in British Columbia, however. It continued throughout the 20th century, although much of it took place in small or remote communities that did not have the money or resources to build larger brick or concrete schools.

Many of these small wooden schools were relatively simple structures that probably had more in common with a large house than the brick schools being built. Very few records of these schools remain, other than in community archives. Some of these schools ran until the mid-20th century (the wooden schoolhouse in 150 Mile House was open until 1958), at which time most students were bussed to larger population centres with brick or concrete schools.

Design, construction, and material advances during the 20th century have made it possible to build larger and more complex light wood frame schools, and there are numerous examples of new light-frame wood schools being built in the past 15 years, including White Rock Elementary School and Zeballos Elementary and Secondary School.

WHITE ROCK ELEMENTARY SCHOOL

White Rock Elementary School is a contemporary wood-frame K-7 school that was completed in 2007. The existing school replaced the old White Rock Elementary School, which was an amalgamation of four wood buildings constructed between 1914 and 1967. The replacement school was designed to respect the character of the old school by borrowing from its design language.

The school district decided to use wood construction when planning the new school in the early 2000s in order to keep costs down.

Residential-style wood trusses were used for the majority of floor and roof framing, while a timber strand and steel truss system with exposed wood framing for longer spans like the gymnasium.

This 4,116m^2 replacement school was designed to accommodate kindergarten to Grade 7 students, plus a district fine arts program. The exterior of the school is traditional in its appearance, effectively using clay brick, Hardi-plank, and shingle siding in a Craftsman style palette.

The classrooms are grouped in four pods around project spaces, two per floor. All 16 classrooms face the south view of Semiahmoo Bay, with support spaces occupying the north side.

White Rock Elementary was initially designed with the understanding that there was a high probability that the school would need more education space in the future as the area continued to develop and densify, and a site for a future addition was designated at the east end of the school.

In 2020, the Surrey school district did in fact decide to expand the school, and contracted the original architect to design and oversee construction of the expansion.

White Rock Elementary School, White Rock – Photo © Thinkspace

This second phase of growth also involved the use of wood framing, in order to carry over the look and feel of the first part of the school, despite the surge in lumber costs during the Covid-19 pandemic.

Early in 2020, the economics of wood framing were not as obvious due to a US house building boom, a surge in home renovations inspired by the pandemic, and supply chain issues associated with Covid. The board foot price for lumber rose by nearly 250% in one year, before starting to come back down in 2022.

This small addition was carried out on a building with a very specific architectural character, and the design followed that character in the framing and materials used. Wood allowed for fairly simple detailing to achieve the gables and detailing required of the design.

Light wood-frame construction can be used for a few reasons. Cost and expediency are often the primary drivers, as is ease of construction, which is especially relevant in more remote communities where access to a diverse range of materials and trades skilled in more technically advanced types of wood construction are in shorter supply. These factors all came into play with the Zeballos Elementary / Secondary School.

Zeballos Elementary / Secondary School, Zeballos – Photo © Wayne Alsop, courtesy of naturallywood.com.

ZEBALLOS ELEMENTARY / SECONDARY SCHOOL[1]

Zeballos is located on an inlet off the northwest coast of Vancouver Island. With a population of 107 people (2016), the village did not need a large school. The previous school was in an area threatened by a rock slide and the Ministry of Education and School District No. 84 decided to move it to a safer location.

The new building needed to accommodate approximately 70 students, ranging from kindergarten age to Grade 12 students, as well as serve as a drop-in centre for pre-school students and a meeting hub for the community.

Completed in 2013, the replacement school uses light wood-frame construction for the main structure because both the materials and the construction labour force were available regionally.

The school is T-shaped and built on one level, with five classrooms, a kindergarten, library, full-size gymnasium with adjacent kitchen, and staff offices.

1 For a comprehensive profile on Zeballos school, go to https://www.naturallywood.com/project/zeballos-elementary-secondary-school/

It was agreed from the outset that we should use as much wood as possible for this project. Light wood-frame construction with some pre-engineered elements was the most cost-effective solution.
– Peter Skilton, Operations Supervisor, School District No. 84 (Zeballos)

The gymnasium is in the centre, with classrooms in the wings; the design allows the gymnasium, kitchen, and one set of washrooms to be closed off to host potlatches and community events. The internal arrangement of the building is traditional in nature, with self-contained classrooms (as opposed to project spaces and common areas).

A washed-out bridge complicated construction as the temporary replacement bridge had a weight restriction that allowed only for the use a small crane. This crane was able to lift the light-frame engineered wood roof trusses used for the gymnasium.

These trusses were supported by full height (six metre) laminated veneer lumber stud walls and prefabricated roof elements. This reduced the time required to frame and cover the building thereby dramatically reducing exposure to the elements during construction.

This part of Vancouver Island sees significant rainfall which factored into the design. The building features a steeply pitched metal roof, with deep eaves, to keep water off the vertical wood siding. An overhang on the front side of the building is supported by wood posts to create a sheltered space for outdoor activities.

KWAKIUTL WAGALUS SCHOOL[1]

Light wood-frame construction schools are typically functional in approach and conventional in design although this is not always the case, such as when there is a larger budget for the project, or there is a cultural impetus for expanding the design palette.

In these schools, wood makes an appearance as a thematic element, not just a structural component of the building. One particularly elegant example of the ways in which wood can be used for form as well as function is the Kwakiutl Wagalus First Nation school in Port Hardy.

Western red cedar is the tree of life for the Kwakiutl First Nation and is abundant in their ancestral home on the northern end of Vancouver Island. It is a seminal part of Kwakiutl culture, so the idea of incorporating it into the design and construction a new school for kindergarten to Grade 7 students was a natural choice.

Early in the design process, members of the Kwakiutl community, including the chief, council, elders, teachers, and future students provided information on the traditional use and importance of western red cedar, particularly in the construction of a ceremonial Big House.

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1 For a comprehensive profile on the Kwakiutl Wagalus school, go to https://www.naturallywood.com/project/kwakiutl-wagalus-school/

As a result of this collaboration, western red cedar became a major structural component of the building rather than simply a decorative element.

For example, the heart of the building – the school's multi-purpose room – takes its form and structure from that of a traditional Big House, with four cedar posts supporting four cedar beams.

This room has an abundance of indirect daylight illuminating the cedar walls and ceiling. Also showcasing cedar are the interior walls, which are clad with vertical cedar planks in reference to the traditional style of cladding used in Big House architecture.

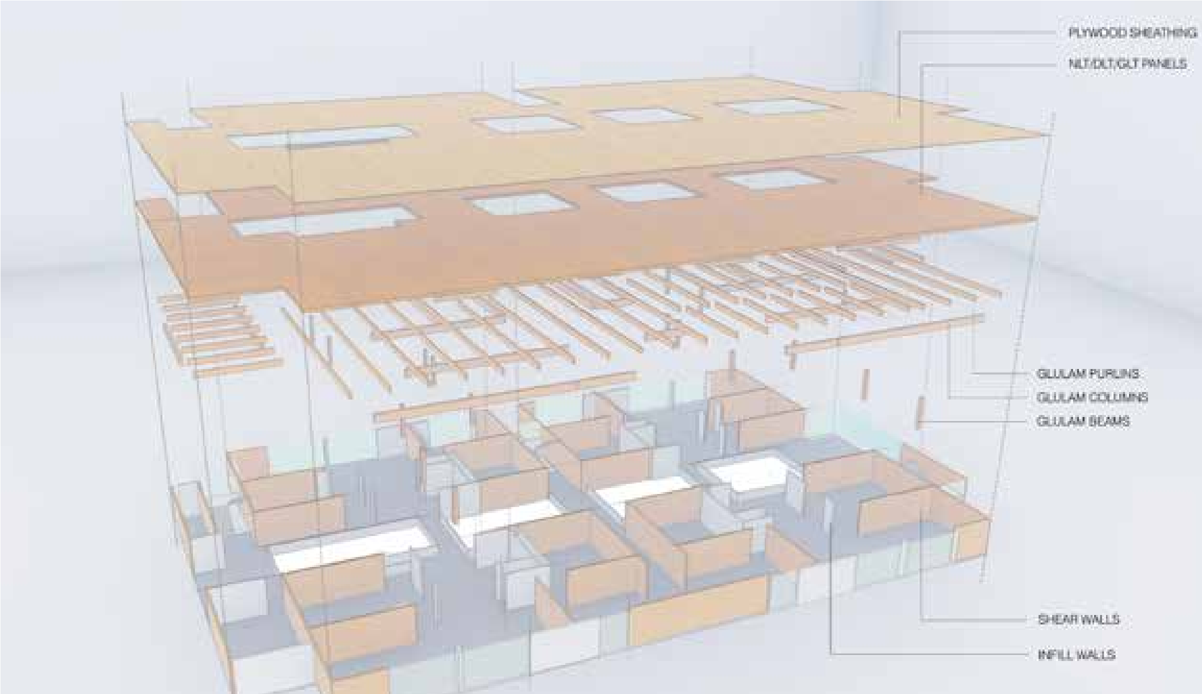
The natural cedar is the school's best feature. The foyer exemplifies the living culture of the Kwakiutl, where students learn how they will contribute to their community and world at large.
– Marion Hunt, BSW, Education Administrator, 99 Tsakis, Kwakiutl Band

The school was completed in 2016 using several wood construction techniques: light wood frame, panelized construction, post-and-beam construction, and prefabricated wall systems.


Kwakiutl Wagalus School, Port Hardy – Photo © Lubor Trubka Associates Architects.

These reflect the importance placed on the use of cedar heavy timbers for the post-and-beam applications, as well as opportunities to simplify and economize construction of certain spaces.

The team used an all-wood prefabricated wall system for the gymnasium, allowing a small local crew to erect it in 19 days. The lumber and Douglas-fir glulam roof was fabricated on southern Vancouver Island and transported to Port Hardy, where it was erected in nine days.



3D view of layout and wood structure of one level in a theoretical four-storey school. Image © Thinkspace

Various species of timber are used throughout the building. Cedar is used for posts, beams, and cladding, while Douglas-fir is used for doors and windows, birch for veneer finishes, and maple for the sports floor.

Douglas-fir glulam purlins and I-joists frame the exposed wood roof, while custom acoustic panels mounted on the ceiling are made of kiln-dried spruce-pine-fir (SPF) turned on its edge to manage sound. Several massive round timbers give the grand foyer an impressive presence.

Pre-fabrication is an important technique in mass timber / wood construction projects, as it allows the construction team to get the building water-tight much more quickly than might otherwise be possible.

This can mean savings of a few days on smaller projects up to months of time in large-scale projects, which translates into significant financial savings in the cost of construction.

THEORETICAL MULTI-STOREY SCHOOLS

The push for wood use in schools has increased in the last 25 years, as awareness about the benefits of building with wood has grown among the design and engineering community.

Despite a growing interest, the British Columbia Building Code presents a significant roadblock when it comes to larger schools.

The BCBC limits the height of combustible buildings for school building types (i.e. wood schools) to two stories, creating a barrier to the development of taller and larger wood schools; new schools would likely be taller to allow a smaller footprint at a time when land is becoming increasingly valuable.

These larger schools would not currently be allowable under the BCBC, without additional considerations and alternative solutions.

A team from Thinkspace® Architecture Planning Interior Design and Fast + Epp structural engineers challenged the assumptions at the base of the combustible building restriction in a report for Wood *WORKS!* BC that was titled, "Design Options for Three- and Four-Storey Wood School Buildings in British Columbia" (2019).[1]

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1 https://www.naturallywood.com/resource/design-options-for-three-and-four-storey-wood-school-buildings-in-british-columbia/

This study focused on the use of different wood framing systems and their implications on the design of three- or four-storey school buildings.

The desire for this study was driven, in part, by the understanding that land for schools in urban centres is becoming increasingly scarce, and large-footprint one- and two-storey schools may not always be possible.

The research team also felt strongly that architects and engineers have a responsibility to explore new techniques to address the ever-pressing concerns of climate change and sustainability.

Wood design and construction was seen as one viable way to tackle to this issue.

The team designed a prototype multi-storey high school that embodied the 21st century learning environment, and then explored three different wood construction typologies: a light wood-frame structure; a CLT structure; and CLT shear walls with NLT, DLT, or GLT panel or panel on purlin framing.

Each of the three options was explored from structural, architectural, and code perspectives, with advantages and shortcomings outlined.

The report presented several significant conclusions addressing both realistic structural systems and their limits, as well addressing BC Building Code limitations and fire safety

Structural and architectural design for three- and four-storey schools need to consider the balance of large open span areas, shear wall requirements, the amount of glazing and maintaining the fire ratings of the construction assemblies.

Three- and four-storey wood schools are possible, when the appropriate design, engineering, technology, alternative solutions, and materials are used.

Among observations and recommendations for three- and four-story schools, the team noted:

- Three storeys is a realistic upper limit of what is feasible with a conventional light wood-framed lateral force-resisting system (LFRS) in a region of high seismicity, such as coastal British Columbia; the same design could be likely be applied to a four-storey building not subject to high seismic loading.
- CLT is more inherently fire-resistant, so this option provided greater safety for occupants.
- The third option, which consists of the mass timber (either NLT, DLT, or GLT) floor and roof panel on purlin framing system in combination with the CLT shear wall and plywood sheathed diaphragm LFRS, would require additional fire protection measures compared to CLT due to the lower wood volume of these products.

In response to the limitations in the code, particularly with respect to fire safety and occupant safety, the BC Building Code has yet to fully recognize the safety of mass timber and does not currently include a prescriptive code-compliant approach and alternative solutions are required.

In this regard, a code-compliant building does not mean the building is risk-free; rather, it means that the risks have been managed to a level that is deemed acceptable by the respective AHJ.

Therefore, to build three- and four-story schools with mass timber, designers must use alternative solutions.[1]

The report presents a number of acceptable solutions that define acceptable risks, which can be used to evaluate alternative solutions.

1 Risk Analysis and Alternative Solution for Three- and Four-Storey Schools of Mass Timber and Wood-Frame Construction - https://wood-works.ca/wp-content/uploads/2019/12/Risk-Analysis-and-Alternative-Solution-for-Three-and-Four-Storey-Schools-of-Mass-Timber-and-Wood-Frame-Construction.pdf

The team was able to demonstrate that a school building with the appropriate characteristics will provide at least the same level of performance relative to fire safety as required by the Building Code at the time it was written.[2]

Ultimately, this report shows that three- and four-storey wood schools are in fact possible, when the appropriate design, engineering, technology, alternative solutions, and materials are used.

2 https://www.naturallywood.com/resource/podcast-with-ray-wolfe-school-design/

Sir Matthew Begbie Elementary School, Vancouver – Photo © Bright Photography, courtesy naturallywood.com

By addressing concerns and questions regarding taller wood schools, the groundwork was set for these types of schools to be built.

This theoretical work underscored the need for these schools to be interconnected vertically rather than horizontally like traditional school designs. That, in turn, made schools like Ta'talu Elementary School (described below) possible.

MASS TIMBER SCHOOLS

The next evolution in the use of wood in school construction is the transition from light frame to mass timber.

Panelized mass timber elements are used for walls and decking, and on occasion, wood beams. A significant percentage of new mass timber schools are being designed around the principles of 21st century learning: critical thinking and problem solving, communication, collaboration, citizenship (global and local) and creativity and innovation.

Through extensive fire testing, mass timber and engineered wood products have proven to be suitable for meeting the stringent safety guidelines for schools.

Mass timber also provides seismic resilience; in the event of an earthquake, the CLT systems can serve as both gravity and lateral resistance for seismic forces.

Sir Matthew Begbie Elementary School and Bayview Elementary School are two contemporary mass timber school projects in Vancouver that were replaced through the Ministry of Education's seismic mitigation program.

SIR MATTHEW BEGBIE ELEMENTARY SCHOOL[1]

Sir Matthew Begbie Elementary School is a school located in northeast Vancouver that was one of 16 high-risk seismic mitigation projects announced in 2005 to proceed to planning under the British Columbia Ministry of Education's Seismic Mitigation Program.

The original school was built in 1922, with another block added in 1949. The new replacement school is 3,385 m^2 including a 414 m^2 neighbourhood learning centre, which functions as a multi-purpose space and an after-school childcare. It has capacity for 340 students in kindergarten and grades one through seven. Program features of the new school include a double-height atrium, gymnasium, classrooms, a multipurpose room, informal learning and social spaces, and exterior gathering places and play area.

The school has been designed by **hcma** with CLT structure and partitions to exceed the province's Wood First guidelines[2].

1 For more information, go to https://www.naturallywood.com/project/sir-matthew-begbie-elementary-school-seismic-replacement/

2 https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/00_09018_01

This was a response to the City of Vancouver's carbon emission reduction goals, and to have exposed, warm, durable surfaces. It will be a flagship for the Vancouver School Board as one of the district's first CLT schools.

Begbie has several sustainability features:

- Pursuing LEED® Gold certification.
- Wood First initiative.
- CLT for durability, structure, and warmth (aesthetic and feel of wood in the space – e.g. mental benefits for users).
- Solar photovoltaic array on the roof.
- Life cycle cost analysis of wood.
- Overhang to provide sun-shading.
- Approximately 1,025 tonnes of carbon are embodied in the wood.

Delivering a building that had strong biophilic elements was important for the project team. Elementary schools serve children at important stages of their developmental and educational journeys, and the natural wood aesthetic at Begbie promotes biophilia, which is especially beneficial for the educational environment.

The natural hues and abundant sunlight of exposed timber on both walls and ceilings within large areas of the building provide a warm and inviting environment for students, staff, and teachers.

Several design and pre-fabrication methods were used to speed up construction time and minimize disruption to both students and the neighborhood.

CLT and connectors were fabricated off-site and delivered to site for storage for easy erection. A tent was built to shelter the timber from rain and weather. Innovative and efficient hybrid systems have also been implemented to achieve the desired architectural form, creating a beautiful and welcoming community building.

Structural engineers, Fast + Epp also partnered with the University of Northern British Columbia and the University of Alberta to conduct a series of testing programs for improved material and performance efficiency. The successful integration of these innovative systems may lead the way for future school designs.[3]

3 Shahnewaz M., Dickof C., Shou J., Tannert T., Vibration and flexural performance of cross-laminated timber – glulam composite floors, Journal of Composite Structures, Volume 292, 2022. https://doi.org/10.1016/j.compstruct.2022.115682

Shahnewaz M, Dickof C, Tannert T., Seismic Behaviour of Balloon Frame CLT Shear walls with Different Ledgers., Journal of Structural Engineering, Volume 147, Issue 19, 2021. https://doi.org/10.1061/(ASCE)ST.1943-541X.0003106

Daneshvar H, Niederwestberg J, Dickof C, Chui Y., Structural behaviour of deep CLT lintels subjected to concentric and eccentric loading., Journal of Building Engineering, Volume 43, 2021 https://doi.org/10.1016/j.jobe.2021.103101

COSTING AT BEGBIE

Begbie Elementary is still under construction as of spring 2022. The design team was able to provide information on costing, and while it only applies to this project, it does offer some useful insights into the choice to use of mass timber in contemporary school construction.

Early budget indications for this project suggested that traditional construction methods were going to be expensive: the cost of concrete for another school district project tendered at the start of design for Begbie exceeded budget expectations by up to 15%.

Competition with the private condominium industry was driving up concrete construction costs, while US government-applied tariffs to steel imports was also pushing prices above more typical escalation.

This provided an opportunity for the team to see whether mass timber construction could be a reasonable cost alternative. The school district engaged the services of a CLT installer during the design development phase to support the consultant team and provide rigour to the scope and costs of building with CLT. Structural modelling was provided, along with advice on connection details. Also provided was the site sequencing and mobilization information, along with accurate contractor costs' for CLT installation during project costing reviews.

A third-party quantity surveyor was brought in to produce a full project cost estimate at time of 50% construction documents, creating a Class B+ estimate. Fast + Epp also completed costing on three different structural systems – 1) CLT; (2) CLT and Steel Hybrid; (3) Steel.

This strategy gave the school district several options at different price points, allowing them to make a decision based on their priorities. Ultimately, The CLT approach was not the least expensive option, but the school district was successful with grant applications and incentives that helped cover the premium.

The National Research Council of Canada also covered a portion of the funding for wood product innovation (specifically, consultant research and development rather than wood or material costs).

BAYVIEW ELEMENTARY SCHOOL[1]

Bayview Elementary School was one of the larger brick school buildings built in Vancouver prior to World War I. The school was originally constructed in 1913-14 to accommodate the city's growing population, and enlarged in 1929.

A new 365-student, 3,500m^2 replacement school has been designed by Francl Architecture and is being built over the former school's footprint, with two major changes: a greater resistance to earthquakes and a design that embodies 21st century learning.

The compact site will be home to a preschool, two kindergarten classrooms, and another 13 classrooms for grades one through seven.

The ground-floor level of the school will house administrative offices and classrooms, as well as two multi-purpose rooms and a large gymnasium that form a neighbourhood learning centre; the upper level will contain more classrooms and the library.

One of the key elements of a 21st century learning environment is large open spaces – in some cases, spanning two classrooms or more.

At the new Bayview school, these flexible teaching spaces are made possible by a cross-laminated timber (CLT) structure supported on glulam beams or CLT walls, which carries the structural load for the building across these large spaces.

Classrooms can then be staggered and corridors widened, which then creates opportunities for break-out rooms, seating areas, hang-out space, and a large learning commons.

1 For more information, go to https://www.naturallywood.com/project/bayview-elementary-school-seismic-replacement/

There is also a financial savings to the exposed wood surfaces on this project, which do not need to be wrapped in drywall.

Not all the wood used on Bayview will be new. The design team was able to save and reuse an arched wooden window dating back to 1913, which will be used in the interior, and a pair of vestibule doors from 1929 that will be installed in the main floor corridor.

Throughout the building, exterior and structural walls, floors, and roof assemblies use CLT, complemented by glulam beams and columns. The same technique is used for an open-concept library that offers informal learning spaces and views to the school's exterior.

The gymnasium and multi-purpose rooms, implement a composite double-T design combining CLT with glulam beams to form 16-metre-long spanning panels supported on CLT walls. Much of Bayview's mass timber structure was pre-fabricated off-site.

Large panels that can be craned into place means faster construction and fewer disruptions to the surrounding neighbourhood.

Wood surfaces are left exposed where possible to add warmth and biophilic benefits to interior spaces, reducing stress and creating a more positive learning environment. There is also a financial savings to the exposed wood surfaces on this project, which do not need to be wrapped in drywall.

The exposed timber and associated connections achieve the necessary fire rating requirements through the inherent heat resistance in the wood, by sizing elements to accommodate char for the design.

Bayview Elementary School, Vancouver– Photo © Wade Comer Photography, courtesy naturallywood.com

The decision to use mass timber for Bayview has several sustainability benefits. Using locally sourced timber supports the school district's commitment to sustainability and a desire to minimize the project's carbon footprint.

The project used locally sourced timber, which means a reduced carbon footprint for the project estimated to be a net CO_2 benefit of 1,137 metric tonnes.

The project design incorporated further sustainability strategies, including a building massing and solar shading design that helps control glare and heat gains. CLT's natural thermal benefits will result in a highly efficient building envelope, reducing the need for additional insulation in the envelope.

Walnut Park Elementary, Smithers – photo © KMBR Architects Planners

HYBRID MASS TIMBER SCHOOLS

Hybrid mass timber construction combines mass timber with other materials such as steel or concrete, to make the most of the properties of each material. In this type of system, mass timber can be used where it makes sense and combined with other cost-effective materials for building assemblies.

The flexibility and performance benefits of hybrid mass timber construction make it a likely typology for meeting the complex code requirements and cost constraints for three- and four-story schools.

Two school projects, one recently completed and one just about to start construction (as of spring 2022) both exemplify the hybrid mass timber typology that is likely to become increasingly more used for school construction across British Columbia: Walnut Park Elementary School in Smithers and Ta'talu Elementary School in Surrey.

WALNUT PARK ELEMENTARY SCHOOL

Completed in September 2021, Walnut Park Elementary School in Smithers, British Columbia, holds 50 kindergarten students and 400 students from grades 1 to 7. The school includes a strong-start program space as well as two childcares with a capacity of 42 children.

The applicable building code, BC Building Code 2018, limits building area in school buildings to two storeys in height and 2,400m² in area. The building area for Walnut Park is 2,659m², so an alternative solution was proposed to isolate the additional area with a two-hour rated fire separation, with the rationale that the building is primarily non-combustible.

The new school was designed by KMBR Architects Planners and constructed on the north end of the site, leaving the existing 1967 school building undisturbed and operational until the new building was completed. A new playfield will be constructed in place of the old school building.

The entry foyer and the circulation areas are interconnected to provide physical and visual access, and at the same time, act as a light well, with the design intent to facilitate connections for the community.

This school was designed and built with a strong emphasis on 21st century learning, with small learning communities and healthy learning environments.

Classrooms were carefully organized and planned within learning neighbourhoods that support teacher and student collaboration.Collaborative learning spaces, which are communal spaces between the classrooms, are at the centre of each learning neighborhood.

These flexible shared spaces serve as extensions of the classroom environment and are made possible by the hybrid mass timber construction method.

The learning commons acts as the hub of the school and serves as the venue for social activities, presentations, performances and informal learning – as well as lunch break space. It is designed as a welcoming, open space in the school's main circulation that will support individual and group work.

The glulam beam structure provides natural light and generous spaces, and where possible the designers left the glulam beams exposed.

The glulam structure, along with an ample use of wood in the school's interior, was a commitment at the onset of the project to contribute to climate action and a recognition of the benefits exposed wood has on the well-being of the students and teachers.

One of the challenges facing the design team was that the 2012 Ministry of Education Area Standard document, does not reflect contemporary 21st century learning pedagogy and current curriculum mandate in that project spaces are not defined in the Area Standards.

As a result, the team had to implement some creative solutions for spaces allocation and distribution. The project did provide a unique opportunity for the design team to bring awareness to and share knowledge with this northern community about the latest philosophy and typology in space planning for learning environments.

This school made use of a hybrid steel and timber structure, which combines both wood and steel to meet code requirements for the type of building.

The team used a hybrid structure for the vertical load bearing system, with structural steel columns, glulam purlins and beams, a composite steel floor deck and steel roof deck. The lateral force resisting system was comprised of plywood-sheathed light-wood frame shear walls.

The school is designed to LEED® Gold equivalent standards. An energy model was created to optimize the design, both in terms of capital cost, energy performance, and reducing carbon footprint of the building.

The model identified a bundle of measures such as variable volume unit ventilators, air-to-water heat pump, high performance glazing and building envelope that would improve efficiency and help meet sustainability targets. The net result is high efficiency building systems and equipment.

TA'TALU ELEMENTARY SCHOOL

Ta'talu Elementary School in Surrey will be the first three-storey, hybrid mass timber elementary school in the province. The project was initially planned as the first net zero operational carbon ready school in the province, and follows some of those design principles; ultimately, the project did not receive the funding necessary to be built to net zero standards.

This project's very existence is predicated on the theoretical three- and four-storey school study noted above, and its construction is highly anticipated within the design and engineering community.

This large three-storey hybrid mass timber elementary school will provide learning spaces for 80 kindergarten students and 575 grades 1 to 7 students, plus on-site childcare facilities. The building will consist of three stories of stacked learning neighbourhoods on the east and west ends of the building, with each learning neighbourhood made up of four or five classrooms opening onto a shared project space.

Between the learning neighbourhoods is the shared program, which is distributed on all floors. The shared program includes a learning commons, multi-purpose room, administration areas, and a gymnasium, each connected to the learning neighbourhoods by a central atrium. The atrium and shared program form the heart of the school, providing wayfinding and visual connection to students on all floors.

The school was gifted the name "Ta'talu" by the Semiahmoo First Nation, which means Little Campbell River. It will be located within the Little Campbell River watershed in Surrey, and both the interior and exterior design have taken inspiration from the river and its surrounding environment.

Construction for the school will be accomplished using a mix of mass timber, light wood framing, and steel construction. The predominant structure will be post-and-beam glulam, with light wood framing. Load-bearing members (beams and columns) will be mass timber. Stacked floor plans allowed for increased structural efficiency.

Other load bearing assemblies, namely flooring, will be made of non-combustible materials, while shear walls will be light wood framing.

Hybrid mass timber was chosen as the main structural material for the school because it matched the school's sustainability ambitions to reduce carbon emissions – in addition to the added aesthetic, biophilic, and enhanced learning properties that wood construction offers.

Ta'talu Elementary School, Surrey – Image © Thinkspace

An embodied carbon analysis conducted by RDH Building Science during the construction documents phase compared the sustainability impact of the new hybrid building with the fully steel option that was abandoned at schematic design.

According to the report, the total global warming potential of the steel version of the building would be 283kg/m^2 CO_2eq, 27 kg/m^2 CO_2eq (9.5%) higher than that of the wood version – in short, meaning that the wood version would be more environmentally sustainable. The main difference in the global warming potential between the two building typologies came from the roof, beams, and columns.

Due to the current status of the BC Building Code, which does not allow for three-storey interconnected occupancy for schools, the team was required by the AHJ to provide an alternative solution. Steel construction will be used where required by the alternative solution, namely the vertical circulation areas (the stairs and elevator) and the gymnasium (an Alternative Solution for Mixed Construction and an Alternative Solution for Interconnected Space).

COSTING AT TA'TALU

The costing process for Ta'talu was similar to Begbie. At the very start of schematic design, design team developed three structural systems for review: 1) steel, 2) mass timber, 3) hybrid mass timber.

All three options, including the sketches illustrating the implications of each structural system on the school's finishes was sent to the quantity surveyor for costing at the 50% schematic design stage to determine how to proceed. The hybrid option was selected after this exercise because it offered the best mix of desired elements and performance.

Ultimately, it was a risk proceeding with a hybrid system because of cost uncertainties related to construction market fluctuations at the time, but mass timber supported School District No. 36's vision of reducing carbon emissions for this project and the District chose to proceed on that basis.

An important note is that unlike both Begbie and Bayview, the school was not funded for mass timber construction, but both the School District and the design team wanted to explore the potential of the structural system that aligned with the project's sustainability ambitions.

OPPORTUNITIES AND GENERAL LESSONS LEARNED IN BUILDING WITH MASS TIMBER

There are often opportunities to learn on projects, and the Begbie project was no exception. The fact that these lessons were learned in 2021 and 2022, on a mass timber school project, makes them particularly relevant to this report.

This project provided many opportunities for the architects from **hcma**, as well as the rest of the project team. First was that an accelerated construction schedule was possible due to the use of pre-fabricated timber components.

The pre-fabrication approach, where sections were built off-site at the fabrication plant and then brought to site ready to be assembled expedited the erection and enclosure process significantly; precise manufacturing tolerances also accelerated construction.

The faster construction time, which meant less time set up on site as well as reduced manpower hours, provided the School District with significant financial savings.

An added benefit, which was noted earlier, was the relatively quiet nature of construction thanks to the pre-fabricated nature of the project. Fewer truck deliveries to site was a positive experience for this established neighbourhood.

One of the key lessons learned by everyone on the project is that warmth from exposed wood truly does create a welcoming environment.

LESSONS LEARNED WHEN BUILDING WITH MASS TIMBER (FROM THE PROJECT ARCHITECT'S PERSPECTIVE)

- The experience of the team is important, and they need to be in contact with a CLT manufacturer during design.
- Engage a CLT modeling firm at the beginning of design.
- Provide no less than four pre-qualified CLT sub-trades for inclusion in the specifications.
- Specifications must request the contractor to provide a moisture protection letter as a submittal prior to CLT delivery, to cover moisture management and mitigation from delivery to time of full building enclosure.
- Architectural and structural specifications need to be comprehensive (assume proponents have no experience with CLT installation), and responsibilities need to be very clear.
- Specifications need to outline the contractor's responsibility for coordinating CLT panel delivery times and storage.
- Specifications need to outline the contractor's responsibility for providing third-party moisture testing reports.
- Specifications need to outline the contractor's responsibility for coordination of roofing and exterior envelope sub-trades.
- Specifications need to outline the contractor's responsibility to coordinate with Roofing Contractors Association of BC (RCABC) regarding acceptable roofing applications in order to mitigate moisture issues.
- An Integrated Project Delivery or Construction Management type of contract might want to be considered by the School District or project team looking into mass timber construction, given the amount of pre-planning and coordination required for a CLT project.

Belmont Secondary School – photo © Barry Calhoun, courtesy naturallywood.com

4.UTILIZING WOOD IN SCHOOL CONSTRUCTION

WOOD AND SCHOOL DESIGN

In British Columbia, wood is part of the economy, culture, and tradition of building. As such, schools here have historically used wood and continue to use wood in ways that benefit learning environments.

Building with wood is not unlike building with other materials. It requires similar consideration of cost, procurement methods, schedule, performance over time, and the impact on the environment – but there is no doubt that wood has some distinct advantages given its natural characteristics and recent advances in wood technology.

Schools, perennially facing budget tension, are under additional pressure due to rising land costs. It is typical for schools to be a minimum of two storeys and it is becoming more common to see three- and four-storey schools. Wood is well suited to this type of building form and the diverse types of spaces that make up schools can benefit from wood structure.

School spaces, such as classrooms, gymnasiums, and learning commons, require clear and open spans. Wood as a structure can accommodate both the short-span and long-span spaces, while also allowing for the differences between classrooms, which tend to be repeatable special modules, and gymnasiums and learning commons, which often are singular and unique for each school.

Norma Rose Point Elementary School, Vancouver – Photo © Ema Peter Photography

Schools are also a unique building type as they range in size and are considered assembly occupancy buildings. A big question is often, "Can wood meet the life safety standards for these types of buildings?" Wood does provide appropriate safety through its char ratings or encapsulation as well as various lateral force resisting systems that offer considerable ductility.

Today's school interiors can also benefit from materials such as wood. In line with 21st century learning and the British Columbia curriculum, schools are being designed to create a sense of place for students and to allow for diverse types of collaboration.

Wood, as a natural and local material, lends itself to creating a sense of connection with the neighbouring environment in British Columbia. Research has also shown that wood creates a relaxing atmosphere that is suitable for creativity and collaboration, major tenets of 21st century learning.

Lastly, a school needs to stand the test of time. Schools being designed and built today are typically designed with a minimum of a 50-year life span; many will be expected to last much longer than 50 years.

The use of wood can contribute to the school's longevity as well as the ease of maintenance and day to day requirements.

Wood is a resilient and durable material, as well as a contributor to reducing embodied carbon and an improver of indoor air quality, all point to reasons to utilize wood in schools.

PRIORITIES WHEN CONSIDERING WOOD USE

School design in general begins with an understanding of the project vision and needs.

This initial phase is the starting point for considering how and where wood is used. The option to use wood for the structure of the school is considered during the initial pre-design or PDR phase where the budget and scope is determined.

Owners often want to use wood for the superstructure of the school due to its aesthetics, sustainable qualities, and scheduling opportunities.

Publicly funded schools in British Columbia are now reviewing wood as a structural option in consideration of the Wood First Act, as well as due to the opportunity to reduce a school's carbon footprint.

The specific needs of the individual school are defined by the age group and number of students the school supports. There can also be community needs that define additional space needs in a school. These spaces in public schools are currently called Neighbourhood Learning Centres (NLC), and they can support childcare, libraries, or other community-based spaces.

The ways in which wood is incorporated into the school as a structural element or as a finished component varies depending on the configuration of the spatial needs.

There is no threshold for the use of wood or mass timber in school projects. It is a decision made by school districts and government based on building code requirements and funding.

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KEY CONSIDERATIONS AND PROCESSES WHEN CONSIDERING WOOD FOR USE IN SCHOOLS	
Project vision	• Using wood can support the project vision and project needs, i.e. to be more sustainable or have a reduced carbon footprint.
Social and cultural impacts	• Use of wood can relate to the history or cultural of a place, e.g. First Nations heritage, or local connection to forest industry. • There often is a history of craft and technologies related to wood as well as a connection to modern uses of wood.
Cost	• What are the costs for the project, and does wood as a structure make economical sense. • Knowledge or comfort of the design team to accurately cost wood components. • Does the use of wood beyond the structure make sense in terms of both operational and construction costs. • The use of wood can speed up the construction schedule, which can save on overall project costs. • Market fluctuations, as with any material, drive the cost of wood.
Procurement and construction	• Access, or lack thereof, to local suppliers and building trades. • Schedule can be impacted due to required lead time for fabricated timber products.
Sustainability	• Using wood reduces the project's carbon footprint, and allows for reduced embodied carbon and the opportunity for carbon sequestration.
Performance	• Enhances indoor air quality. • Improves health and wellness for all users. • Durable approach.

These days, mass timber is accepted as a main construction element, not just a finishing product. It's a legitimate structural element now, and mass timber projects are growing in size and scope as a result.
– Andre Lema, Western Archrib

We are now seeing some schools being funded for mass timber due to direction from multiple government bodies to seek low carbon solutions.

A major new elementary school project on Vancouver Island that is being designed by Thinkspace Architecture is an example of a recently funded school that is specifically targeted and / or funded to be fully mass timber, and the unit rate funding has allowed for the cost differences.

Design decisions are being made at all stages of a project, and the owner will evaluate options based on a multitude of criteria.

IMPACT ON LEARNING

Schools have evolved in their layouts, size, and approach to education delivery as populations have grown in urban and suburban centres.

Traditional schools, where the focus is on the classroom and the learning is teacher-led differ greatly from the current approach to education and school design, which places students at the centre of the learning experience. This, in turn, affects the way that schools are designed and built.

In the new 21st century learning environment, Cs (creativity, critical thinking, collaboration, and communication) are the learning paradigm. Core Competencies in British Columbia are sets of intellectual, personal, and social and emotional proficiencies that all students need to develop to engage in deeper learning.

The teaching and learning spectrum evolving today means that classrooms are no longer the only place of learning. Integrated spaces such as shared learning spaces, project spaces, learning commons, break-out rooms, outdoor learning, and specialized spaces such as gymnasiums, science labs, etc. are all learning spaces now.

The diversity of learning spaces relates to various sizes of student cohorts learning at different times, and the understanding that there are a multitude of learning styles and types of students.

The latest British Columbia curriculum for public K-12 school includes the following topics, which impacts the spatial design and layout for schools.[1]

Personalized learning: The design of British Columbia's curriculum provides flexibility to inspire the personalization of learning and addresses the diverse needs and interests of British Columbia students.

Ecology and the environment: Revisions to the Science curriculum were made to ensure better representation of ecology and environmental learning.

Indigenous perspectives and knowledge: Indigenous culture and perspectives have been integrated throughout all areas of learning. For example, place-based learning and emphasis on Indigenous ways of knowing reflect the First Peoples Principles of Learning in the curriculum.

Historical wrongs: The curriculum includes the history of the Asian and South Asian communities and their contributions to the development of our province—as well as the injustices they experienced.

Flexible learning environments: British Columbia's curriculum provides teachers with great flexibility in creating learning environments that are relevant, engaging, and novel. Flexible learning environments consider local contexts and place-based learning.

The curriculum places an emphasis on diverse learners and inquiry-based learning and moves schools further away from traditional teaching paradigms. This is reflected in the fact that learning is recognized to take place everywhere, demanding more active and diverse teaching spaces.

1 https://curriculum.gov.bc.ca/sites/curriculum.gov.bc.ca/files/pdf/supports/curriculum_brochure.pdf

Wood provides many benefits that can help support the current curriculum and meet student, teacher, and parent expectations for learning environments.

That takes shape in several ways:

- Wood as a structure offers a flexible approach to school layouts and design, and the ability to create the diversity of connected spaces that create school communities.
- Certain arrangements of wood (e.g. regular dropped beams, fluted panels, etc.) help to mitigate the sound levels in these learning spaces, which have open floor plans and are much more active environments than the classrooms of the past.
- Wood positively impacts learning by providing many health and wellness benefits. The emphasis on individual learning, such as the inclusion of students with special needs, requires an environment that is both calming and welcoming, and caters to the health and wellbeing of all occupants.
- When wood is used in finishes, environments are enriched both visually and from a tactile perspective. Such complex environments have been shown to increase performance on intelligence tests, while other studies have shown that people judge spaces more favorably when wood is present, perceiving wood interiors as warm, inviting, and relaxing.[1]

In addition, the use of wood encourages sustainable thinking among students by creating a tangible connection to the natural world while contributing to a lower embodied energy and a better environmental make-up than other structural approaches.

1 https://schoolconstructionnews.com/2017/05/23/wood-schools-can-nourish-learning/

HEALTH AND WELLNESS[2]

School designers are increasingly turning to wood to create learning environments where students can learn and thrive. This comes after growing evidence that incorporating natural elements, such as wood, into interiors can provide a range meaningful physiological and psychological benefits (Mayo, 2017).

As people's lives have become increasingly disconnected from nature, research is proving how much we rely on our relationship to the natural world to feel physically and emotionally well (Schiebel, 2022).

2 For more information on this topic, see https://www.naturallywood.com/resource/podcast-with-graham-lowe-biophilia-wood-workplaces/ and https://www.naturallywood.com/blog/can-building-with-wood-and-natural-materials-improve-our-health/

As further emphasis is put on buildings for health and wellness and the importance of biophilic design becomes widely recognized, more school designers and educators are looking to incorporate these ideas into learning environments.

This innate connection to nature is known as biophilia, a concept popularized by American biologist, E. O. Wilson in the 1980s. The theory of biophilia asserts that humans have an innate affinity for natural environments that developed as people's senses evolved to utilize nature as a source of nourishment, shelter, security, and restoration.

Designers and advocates for health and wellness have taken note of biophilia. The WELL Building Certification, a leading global framework for building health and wellness, incorporates biophilic design principles into its certification requirements. For a building to achieve WELL certification, it must support the cognitive and emotional well-being of its occupants.

Biophilic design is a key component of the WELL Building 'Mind' theme. A building must connect occupants to nature via natural materials and imaging aesthetics, as well as natural elements such as plants, water, daylight, or nature scenes to meet this theme's requirements (International WELL Building Institute, 2022).

The WELL certification reflects the numerous studies in health care and workplaces that show biophilic environments reduce anxiety and improve attentiveness and cognition. More recently, researchers have also found positive impacts on student learning when classrooms include biophilic features, such as wood finishes (Determan, 2019).

As further emphasis is put on buildings for health and wellness and the importance of biophilic design becomes widely recognized, more school designers and educators are looking to incorporate these ideas into learning environments.

Using wood in schools is a natural choice in meeting health and wellness goals and incorporating biophilic principles into classrooms. Wood creates a feeling of warmth and calmness. This is not just anecdotal – there are studies that compare interiors that use wood to interiors with other finishes (Fell, 2011).

Sustainability consultants, Terrapin Bright Green's paper *The Nature of Wood: An exploration of the science behind biophilic responses to wood*, takes a deep dive into the science of why people prefer wood.

It concludes that wood supports a biophilic experience "partially through association with life, partially through scent and touch, a bit through color, and largely due to the inherent patterning of wood grain" (Browning, 2022).

This research, which is well supported in numerous publications, when combined with wood's ability to store more carbon than other materials and subsequently offset the carbon footprint of schools, makes for a very strong case to use wood in school construction.

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CULTURE AND TRADITION

The latest British Columbia school curriculum includes a greater emphasis on Indigenous perspectives and knowledge, which aligns with the province's Declaration on the Rights of Indigenous Peoples Act and the national goals of truth and reconciliation. Increasing the success of students, especially Indigenous students, requires the inclusion of Indigenous languages, cultures, and histories in the curriculum.

Indigenous peoples are the original inhabitants of the place that we now call British Columbia. First Nations hold thousands of years of knowledge about these lands, the use of forests, and wood technology. This connection to traditional knowledge is supported when we use wood in schools in ways that reflect the building and cultural traditions of First Nations. Advancements in wood and wood products can be married with architectural traditions and Indigenous design to incorporate First Nations principles in modern schools.

Culture and tradition often inform the future. In the case of wood, the technology and use of wood is constantly evolving to reflect how we see ourselves and our relationship to wood. Wood construction and detail can create a strong architectural expression symbolic of First Nations culture. It can also be a key symbolic element that connects us to the natural world.

The following are approaches that can highlight wood's connection to culture and tradition in schools.

Exposing wood structure: Special effort is consistently made in First Nations schools with large wood components to highlight the use of wood as a prominent structural element, as well as for interior and exterior finishes.

Using traditional wood construction techniques: A number of construction techniques used in First Nations schools are traditional in nature, including carving, shaping, and assembling of timbers.

Highlighting wood elements: Spaces like multi-purpose rooms and learning commons at the heart of the building can use indirect daylight and illuminate wood materials on walls and ceilings.

Including interior wood elements: Interior walls can be clad with cedar planks, a reference to the traditional cladding used in Big House architecture.[1]

Using local wood resources: Wood products can also be milled on-site using a portable mill and the wood can be used for siding, shelving, trims, and benches. This wood can come from a Nation's traditional territory or the project site itself.[2]

1 For a recent example, see https://www.naturallywood.com/project/kwakiutl-wagalus-school/
2 For more information on this approach, see https://www.naturallywood.com/project/hesquiaht-first-nation-place-of-learning/

Targeting sustainability: Wood can be a renewable local resource used to clad, finish, and landscape structures.

Employing a community-based approach: The project can include training for members who work on the project.[3]

Applying principles of co-design: This model calls for architects working with Indigenous communities to listen extensively to community members and meaningfully incorporate their design ideas.[4]

COST

COST EFFECTIVENESS

Wood has long been a cost-effective solution for school buildings. It was traditionally used in the form of light wood framing, but the increased uptake of mass timber has allowed for other larger and more complex design solutions.

Mass timber is gaining traction on other forms of construction with savings stemming from program efficiencies through off-site fabrication, along with reduced operational costs due to enhanced thermal performances inherent in some types of wood construction.

3 To learn more, see https://www.naturallywood.com/blog/indigenous-skill-building/
4 For more information on this approach, see https://www.naturallywood.com/project/lalme-iwesawtexw-sea-bird-island-community-school/

Consequently, mass timber construction pricing is becoming increasingly competitive as more suppliers and construction expertise come on line.

CONSTRUCTION COSTS

While the total cost for light wood-frame construction may be comparable with other structural materials such as concrete and steel, reduced labour costs can make it the least costly option for low-rise buildings.

For larger buildings, mass timber construction is becoming more cost-competitive with steel and concrete construction, but construction costs are often tied into market fluctuations.

Overall, mass timber project costs can benefit from efficiencies gained from pre-fabrication and reduced time on site. Other potential cost savings can result from reduced finishing times and costs when structural elements, such as CLT panels or glulam beams and columns, are left exposed to showcase wood features as opposed to being wrapped in drywall.

Mass timber construction costs are subject to several criteria, including:

Building Code requirements: Since mass timber is a combustible material type, the approach for satisfying the Building Code requirements for its use should be understood early on in the project to ensure that the resulting cost implications are captured appropriately.

An alternative to encapsulation is an approach that uses the charring rate of the wood itself and is a performance approach to the building code and eliminates the additional costs of encapsulation.

Early commitment to mass timber design: A mass timber design should be considered during schematic design, as translating another structural system into a mass timber design after that point is inefficient and can add unwarranted costs. Making the decision early during the design process also helps to realize cost savings from the efficiencies of mass timber.

An integrated design approach: This reduces construction costs when using wood, as the more details that are resolved in the design stage, the more cost-effective the construction will be.

Established pre-fabricated and site-fabricated elements: The integrated design team should pay careful attention to material tolerances and understand what elements are pre-fabricated versus site fabricated.

Material interfaces: Detailing the areas where different materials interface is critical to ensure a cost-effective build.

Sk'elep School of Excellence, Kamloops – Photo © Derek Lepper Photography, courtesy naturallywood.com

Designating a key person from the contractor's team to coordinate between mass timber and the steel fabricator can ensure the contractor is properly coordinating and reviewing the connections and detailing of the pre-fabricated elements.

Site coordination of mechanical, electrical, and plumbing (MEP) services: MEP services require careful coordination. The owner should consider a design specification that asks the builder for a dedicated team member for site coordination of the MEP with the mass timber structure, as many of the penetrations can be pre-fabricated.

Stacking the structure: Stacking the structure when schools are higher than one storey reduces costs due to efficiencies in directly transferring gravity loads. A simple massing and stacked structure also leads to a building envelope that is easier to detail and build. An efficient building envelope improves thermal bridging and energy performance, which ultimately leads to lower operational costs.

OPERATIONAL COSTS

Schools routinely seek to reduce their operational energy costs, as this is a sizable expenditure for every school district. There are also increasing demands for more energy-efficient buildings to help meet school districts' sustainability targets.

The school area, site, and program are all being tested at the capital budget development stage, and this is the time to review structural options – including the use of wood.

Wood schools can be designed to meet or exceed the demanding energy-efficiency requirements of school districts, and they can do so in a cost-effective manner.

Wood is less thermally conductive than concrete or steel, which means that wood construction is less affected by thermal bridging (the unwanted transfer of heat in or out of a building through structural members penetrating the building envelope) and has a lower thermal conductivity when compared to steel or concrete structures.

Nevertheless, many of the measures that can be taken to significantly reduce energy costs have less to do with building materials and more to do with construction strategies for building envelope – regardless of material – as well as the selection and efficient use of equipment and HVAC systems.

Wood buildings can offer long-term durability, but they do require maintenance, as do all types of buildings. Wood typically reduces vandalism compared to other materials, likely due to its perception as a finish material.

Furthermore, because wood construction involves few exposed steel elements, it does not suffer from corrosion, cracking, and spalling problems associated with steel and concrete construction.

Maintenance for wood buildings can also be greatly reduced if the wood is properly designed and detailed to reduce its exposure to water and direct UV.

CAPITAL BUDGET DEVELOPMENT

The initial pre-design or PDR phase is where the budget and scope are determined for school construction. The school area, site, and program are all being tested at the capital budget development stage, and this is the time to review structural options – including the use of wood. The consideration for the cost of the structure is a first step in the choice of whether to use wood.

British Columbia's Ministry of Education is increasingly asking consultants to include mass timber analysis in PDRs studies for larger schools and additions. Hence, school districts are having to incorporate mass timber analysis into their business cases for new schools.

Generally, municipalities are receptive to mass timber schools when using a prescriptive approach to the British Columbia Building Code requirements. Mass timber schools of one or two storeys are highly viable and desirable, but still require municipal approval in most cases.

When considering schools larger than two storeys, some municipalities require more information to feel comfortable with a performance-based approach to meeting the BC Building Code.

As noted in Section 2 of this report, three-storey wood schools are possible and currently in development, but they require some discussion with the Authorities Having Jurisdiction.

The effort and time to work with municipalities should be factored in when considering the overall project schedule at the PDR phase.

Although alternative solutions may require more effort and discussions with municipalities, there is industry acceptance that mass timber buildings have up to 25% schedule savings compared to steel and concrete construction,[1] which is also a consideration for schedule and budget during the initial capital budget development stage.

Some recent examples of mass timber school buildings in British Columbia that are taller than two storeys and use a performance-based approach to satisfy the BC Building Code are:

- Wilson School of Design at Kwantlen Polytechnic University, Richmond - four storey hybrid mass timber.[2]
- Robert G. Kuhn Centre at Trinity Western University, Langley - four story hybrid mass timber.
- Ta'talu Elementary School, Surrey - three storey hybrid mass timber elementary school (under construction and anticipated completion in spring 2024).

The Ministry of Education currently uses unit rates based on construction costs and considers location factors and escalation factors as well as other site circumstances.

Once a public school project has been funded, the design team and owner (i.e. the school district) can explore other applications of wood products, such as non-structural finishes.

1 For more information, see Technical Guide for the Design and Construction of Tall Wood Buildings in Canada https://web.fpinnovations.ca/tallwood/

2 From a building code perspective, post-secondary buildings are the same building type (A2 assembly occupancy) buildings as schools. This applies to both of these post-secondary projects.

British Columbia's Ministry of Education is increasingly asking consultants to include mass timber analysis in PDR studies for larger schools and additions.

This is a costing exercise that considers finishes for acoustics, durability, and use, and monitors the cost of itemized items against the project funding amount.

There is a fine balance between wants and needs, as budgets are fixed after the PDR phase. The design team wants to create the best building possible, and the school district wants to create healthy buildings that can be delivered on budget. This is where mass timber and wood are important to consider as appropriate choices for schools.

PROCUREMENT STRATEGIES

The procurement strategies adopted by many of the larger school districts in the province are not particularly well suited for the delivery of relatively new and innovative building systems such as mass timber.

Some of the challenges typically observed in these strategies include establishing cost expectations on generic budgeting data that does not reflect materiality, construction approach, or market conditions unique to the project at hand.

As an example, the funding models within the Project Definition Reports (PDRs) used by the Ministry of Education for new school projects can be problematic in a few ways:

- They often involve design-bid-build contract arrangements for all projects regardless of the proposed construction approach, building configuration, and project-specific challenges.
- They use generic (and often dated) lists of pre-qualified general contractors in invitation-only bidding processes. No emphasis or preference is given to contractors with strong skill sets and portfolios with specific building typologies, particularly mass timber.
- They assess proposals received by contractors almost solely based on price.

Perhaps the most important step towards achieving the desired goals for a new school building is starting with a realistic project budget.

School planning groups often have strong desires to explore mass timber construction and sustainability ambitions that they would like to achieve, but budgetary pressures lead them to abandon these goals for the sake of satisfying other project priorities.

If specific goals related to materiality (i.e. mass timber), sustainability, or construction duration (i.e. pre-fabrication), etc. are to be realized, then it is critical for the planning group and its design team to identify and incorporate these elements into project budget in the initial stages of the project.

Perhaps the most important step towards achieving the desired goals for a new school building is starting with a realistic project budget.

The project team should also be sure to include scope items tailored to the proposed construction approach within the project specifications, as part of the project scoping exercise.

Scope items for mass timber school construction can include:

- Construction modeling or "digital twinning". This service should be included in the contractor's scope since the level of pre-planning resulting from this modeling is critical in preparing for the successful execution of heavily pre-fabricated systems like mass timber.
- Detailed sequencing plans, including laydown areas and erection timing / sequencing for pre-fabricated elements.
- Weather protection plans.
- Field testing of moisture content during construction as well as acoustic and vibration testing of the completed structure. These testing requirements should also identify measures to be implemented if the specified performance levels are not met.

Once a realistic construction budget is set, an appropriate project delivery model for the specific nature and challenges of the proposed project should be selected.

Some alternate delivery models that work well with mass timber construction include:

- Design assist.
- Construction management.
- Early engagement of timber trades.

Departing from the tradition design-bid-build arrangement can be particularly advantageous for smaller school groups with less in-house project management resources and expertise (e.g. independent school organizations or smaller school planning teams).

External parties within the project team can be used to help guide the school group through design considerations, expectations during construction with respect to duration and disruption, and the bidding process.

Finally, the project team should assign appropriate weighting within their selection criteria for the following considerations when assessing contractors for wood school buildings:

- The contractor's experience with proposed building typology (i.e. the specific timber system used, not just generic wood or school construction experience).
- The contractor's experience on school buildings with their team selected for the project, specifically the timber erectors and material suppliers.
- The erector's experience with the proposed building typology.
- The contractor and timber erector's relationship with the material supplier.

SPEED AND EASE OF CONSTRUCTION[1]

Schedule is always a concern in school construction, and selecting a mass timber structure can often increase both speed and ease of construction.

Decreased construction time reduces disruptions to the site / neighbourhood and provides advantages in northern climates where weather makes construction difficult during winter months.

Construction schedules working with the school year are also a consideration. Factors to consider include whether the students will be attending school in a building immediately adjacent to the construction site, or a previous school will be demolished and require temporary relocation of the students.

Reducing construction timelines, and where possible limiting construction time to the length of the school year (and summer breaks on either side, if necessary), offers a great benefit to projects.

1 For more information, see https://web.fpinnovations.ca/tallwood/. The principles that affect speed and ease of construction with tall wood buildings also apply to schools.

Bayview Elementary, Vancouver – Photo © Wade Comer Photography, courtesy naturallywood.com

Light wood frame or mass timber construction is often fast, especially when compared with concrete or steel construction, meaning that it may be possible to complete the bulk of the project within these timeframes.

While the erection of steel framing itself is similar in speed to light wood frame construction, floors in a steel-framed building are usually finished with a structural topping concrete poured onto steel deck, and it is this step that reduces the overall speed of construction.

Light wood-frame construction may be slowed by poor weather conditions due to concerns with moisture during construction, but this is also an issue with concrete construction.

Heavy timber and mass timber construction is also fast when compared with concrete construction. It does not require falsework and formwork, the laborious on-site placement of rebar, and curing time for concrete prior to the placement of additional levels.

Furthermore, concrete and propped steel construction uses poured concrete over a steel deck for the floors, and this requires time to cure before it can support the weight of subsequent structural elements.

In a mass timber system, wood elements are typically pre-fabricated off-site in a controlled environment, resulting in higher levels of quality control, faster assembly on site, and a reduction in construction waste.

Pre-fabricated wood elements are delivered to the site and fastened to connection pieces that have been fixed. Although this process can dramatically speed up the construction schedule, it is dependent on a reliable supplier that can meet the demands of the project. While reliability is increasing dramatically in British Columbia and across North America, it does vary somewhat by region and product.

In terms of construction, techniques for mass timber construction can be quickly learned, with more and more contractors self-performing the installation. The number of experienced general contractors and specialty erectors across British Columbia and North America has increased dramatically over the last few years.

Furthermore, the numbers of trades and workers on site can be reduced if an all-wood system is designed (i.e. wood walls, columns, floors, and roofs), further increasing construction efficiency.

Constructability can also be an important factor in small communities or remote locations where labour may be more difficult to secure. Skills for light wood-frame construction, available from residential construction in small communities, can be easily adapted to construct mass timber schools as well.

Wood construction is quieter and less disruptive than concrete construction. This benefits existing schools that are left in place while new facilities are built, as well as neighbourhoods where these schools are being erected.

One good example of this is Begbie Elementary School in Vancouver, as discussed in Section 2. The new school was built directly beside the existing school building while it was still in operation. The Vancouver School Board was amazed at how quiet construction was compared to other similar projects with other municipalities. In those projects, construction was a significant distraction to existing school operations.

Another consideration for school construction is the space available on site. Light wood-frame buildings are constructed from dimensional lumber and other light-weight wood products, which require little staging area on site and can be delivered in a small number of delivery trucks.

Mass timber may require a larger staging area for larger beams, columns, or panels on-site, or off-site if space is restricted. This can also be managed by maximizing pre-assembly as well as adequate pre-planning for truck delivery to be coordinated with placement of the panels.

Most schools have playgrounds, fields, or parking lots that can be used for temporary staging areas for mass timber panels, if necessary.

AVAILABILITY OF MATERIALS AND TRADES

Wood construction can offer benefits over steel and concrete due to the availability and accessibility of wood materials (particularly dimensional and engineered lumber used in light wood framing) and skilled trades in British Columbia.

This also holds true for wood frame construction carpenters and supporting trades, whereas it can be more challenging to find a qualified crews for concrete or steel construction, especially in remote areas or small communities. There are additional costs to bringing in out-of-town trades, and these costs directly impact the project budget.

The increase in wood in schools over the last decade has also been made possible because there is simply greater product availability.

More fabricators and a wider variety of products have come to market, while previously available products, such as GLT, NLT, and CLT have expanded distribution across North America.

NLT fabricators have set up mass production at a number of plants in Canada and the US, improving quality control, increasing production volumes , and increasing the interest from a broad range of contractors.

Additionally, a new product, dowel-laminated timber (DLT), similar to NLT but fastened with wood dowels, has also become available in North America through two fabricators in British Columbia: StructureCraft and International Timberframes.

Glued products like GLT and CLT continue to expand their market share of new construction, with a significant increase in the number of suppliers in British Columbia and North America.

Structurlam in British Columbia and Nordic in Quebec have been joined by Kalesnikoff, which now operates in British Columbia, and there are several other CLT suppliers across North America.

New glued products, including mass plywood panels (MPP), have also entered the market, further expanding the engineered wood products available to designers.

These new products and suppliers have helped to level the field. The manufacturing efficiencies and operational scale of North American mass timber suppliers are now able to meet the demands of the local markets .

Wood construction can offer benefits over steel and concrete due to the availability and accessibility of wood materials, as well as skilled trades.

CARBON EMISSIONS

Buildings impact the environment at all stages of their life, beginning with raw material extraction and processing, and ending with disposal or recycling.

Traditionally, the building industry has focused on assessing a building's environmental impact after it has been constructed and is in operation, but this approach captures only a portion of the energy use, greenhouse gas emissions, and environmental impacts of the building.

Considering the entire life cycle of a building ensures that both operational environmental impacts and embodied environmental impacts are assessed.

OPERATIONAL CARBON

Throughout the use phase of a building's life cycle, buildings consume energy for a variety of end uses (heating, cooling, ventilation, lighting, equipment, etc.), and this energy consumption in turn has associated GHG emissions.

While many loads such as lighting and equipment are typically dependant on the building type and occupancy, the heating energy – one of the largest end uses in British Columbia schools – is a function of the building enclosure design.

Wood as a material is less thermally conductive than concrete or steel, and as a result buildings with wood structural elements that penetrate the enclosure are typically less impacted by thermal bridging.

That being said, best practices are to keep insulation outboard of structural elements and reduce thermal bridging regardless of structure type and therefore the finished enclosure of wood, steel or concrete structure buildings can all have the same thermal performance for the same installed insulation.

Minimizing thermal bridging is an important step in high-performance building design; by minimizing thermal bridging, the effective thermal resistance of the building enclosure is improved, which is essential to achieving a low TEDI, low heating energy consumption, and low GHG emissions.

Furthermore, by minimizing thermal bridging and ensuring high effective thermal performance of the building enclosure, radiant temperatures remain more consistent throughout interior spaces of the building, which improves thermal comfort for occupants.

Wood is therefore beneficial to the design of high-performance, sustainable buildings, but it is still important to focus on the fundamentals of building science – continuity of the air, vapour, and thermal (insulation) control layers, regardless of the structural materials.

BRITISH COLUMBIA ENERGY STEP CODE[1]

British Columbia is taking steps to increase energy efficiency requirements in the British Columbia Building Code to make buildings net-zero energy ready by 2032. Net-zero energy buildings produce as much clean energy as they consume on an annual basis. They are up to 80 percent[2] more energy efficient than a typical new building, and use on-site (or near-site) renewable energy systems to produce the remaining energy they need.

A net-zero energy ready building is one that has been designed and built to a level of performance such that it could, with the addition of solar panels or other renewable energy technologies, achieve net-zero energy performance. As discussed in Section 2 of this report, Ta'talu Elementary School was designed to be net-zero energy ready.

The British Columbia Energy Step Code, a part of the British Columbia Building Code, supports the effort to make buildings net-zero energy ready. The British Columbia Energy Step Code is a voluntary provincial standard that provides an incremental and consistent approach to achieving more energy-efficient buildings that go beyond the requirements of the base British Columbia Building Code.

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1 For more information, see https://energystepcode.ca/
2 Better Buildings BC. CleanBC Net Zero Energy Ready Challenge. https://betterbuildingsbc.ca/new-construction/net-zero-energy-ready-challenge/ Accessed 2022/03/15

It does so by establishing a series of measurable, performance-based energy-efficiency requirements for construction that builders can choose to build to, and communities may voluntarily choose to adopt in bylaws and policies.

The performance-based energy efficiency requirements, or targets, fall into two main categories for Part 3 buildings:

- Total Energy Usage Intensity (TEUI), which quantifies the amount of annual site energy use normalized by conditioned floor area in kWh/ m^2/year.
- Thermal Energy Demand Intensity (TEDI), which quantifies the total annual demand for space and ventilation air heating normalized by conditioned floor area in kWh/ m^2/year.

A low TEUI is best achieved by a holistic design approach that prioritizes a high-performance building enclosure, accompanied by high-efficiency mechanical and electrical systems.

A low TEDI, however, can only be achieved by a well-insulated and airtight building enclosure coupled with high-efficiency heat recovery ventilation.

Furthermore, under the British Columbia Energy Step Code, buildings that do not incorporate mechanical cooling must reduce the risk of overheating by implementing passive cooling strategies.

The new standard empowers builders to pursue innovative, creative, cost-effective solutions, and allows them to incorporate leading-edge technologies as they come available.

When buildings target higher energy performance, wood is often chosen because it is less conductive and therefore helps meet stringent targets via well insulated building enclosure assemblies.

There are targets for schools – both K-12 and post-secondary – but currently only Step 1 is defined. It is likely that additional steps will be defined in future.

EMBODIED CARBON

As trees grow, carbon dioxide is drawn from the atmosphere and stored in forest soils and biomass. As a result, wood products store carbon that was previously in the atmosphere, and growing trees is a process of carbon sequestration (storage).

There are, however, GHG emissions associated with the harvesting, transportation, and manufacturing of wood products, not to mention the construction and disposal processes.

Furthermore, as a significant portion of the carbon captured by trees is stored in the soil, the forest management strategy also plays a role in determining the life-cycle embodied carbon of a given wood product.

Although the manufacture of wood products requires less total energy than the manufacture of most alternative materials and less production energy than a functionally equivalent amount of metal, concrete, or brick[1], wood products still contribute to a building's embodied carbon (the carbon dioxide (CO_2) emissions associated with materials and construction processes throughout the whole lifecycle of a building).

Not all wood products are equivalent and may not result in the same amount of embodied carbon. Selection of wood products for buildings should consider a variety of factors, such as the type of wood, extraction, and manufacturing processes, the distance wood products are travelling, and whether the forests from which the products originated are managed sustainably.

As a result, a life cycle approach must be taken in order to accurately understand the environmental impacts of wood products in buildings.

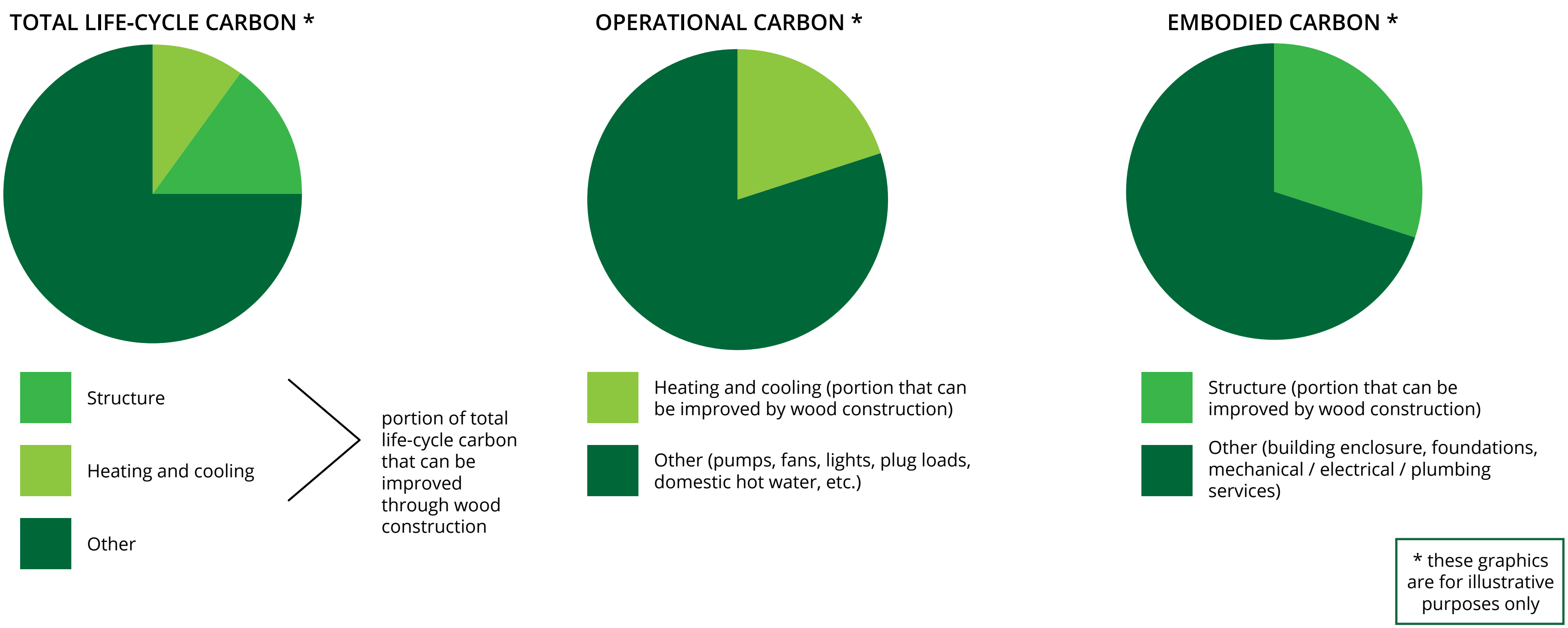
It is important to consider wood structure as one of many design strategies that can be combined to achieve low embodied carbon buildings. Historically, the narrative of wood use in buildings as it relates to embodied carbon has focused on the substitution of light-frame and mass timber components in place of concrete, steel structural components, and

1 Sathre, R. and O'Connor, J. 2010. A Synthesis of Research on Wood Products & Greenhouse Gas Impacts 2nd Edition. FPInnovations. Technical Report TR-19R. https://www.canfor.com/docs/why-wood/tr19-complete-pub-web.pdf

potentially other building enclosure and surface finish materials.

Although switching to a wood structure does typically result in lower embodied carbon, it should be noted that this is only one element of the building design.

Therefore, school districts may need to find other ways or reasons to pursue mass timber or hybrid mass timber designs.



LCA reports for softwood lumber and CLT wood products manufactured in British Columbia are available here: http://www.athenasmi.org/wp-content/uploads/2022/01/CtoG-LCA-of-BC-Surfaced-Dry-Softwood-Lumber-20210331-1.pdf and http://www.athenasmi.org/wp-content/uploads/2022/01/CtoG-LCA-of-BC-CLT-20210414-1.pdf

LIFE CYCLE ASSESSMENTS

LCAs provide a holistic approach to assessing the environment impacts of a product from cradle-to-grave, allow for the identification of major contributors to product or building emissions, and may allow for environmental comparisons of different products with similar functions.

A comprehensive LCA must follow the requirements and methods set out in an industry-recognized standard or guideline to produce reliable or comparable results.

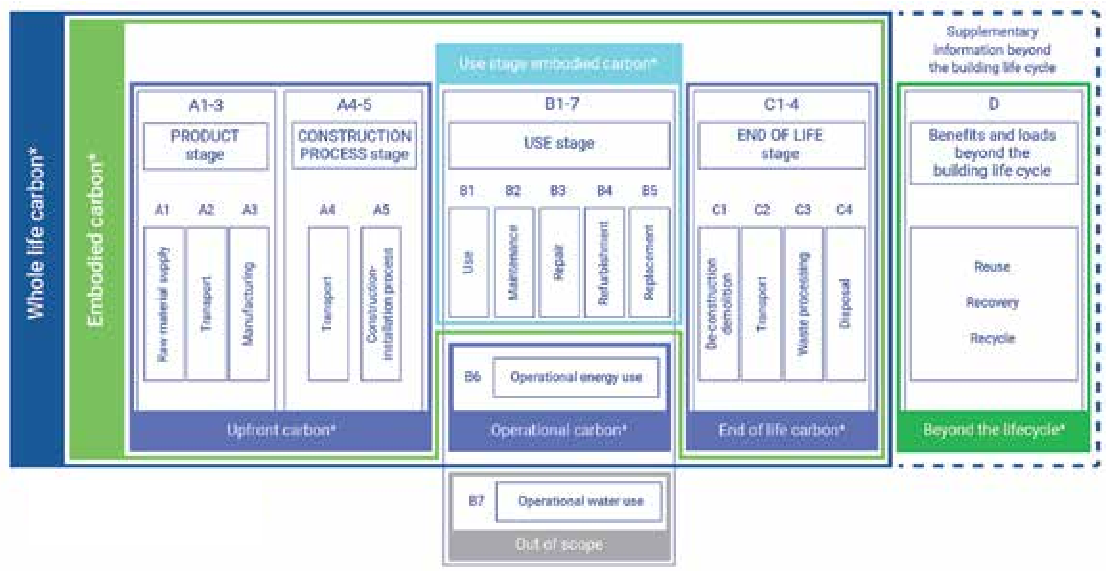
Current best practice is to follow EN 15978:2011 Sustainability of construction works - Assessment of environmental performance of buildings, which provides rules and guidelines for conducting and reporting whole-building LCAs.

The National Research Council Canada (NRC) published a set of Canadian guidelines titled *National Guidelines for Whole-Building Life Cycle Assessment* in 2022. While these guidelines are based on the European standard, it is anticipated that the NRC guidelines will become the main reference for LCAs in Canada in the coming years.[1]

LCAs for new British Columbia schools are not a requirement at this time, but they may be performed voluntarily in support of project goals or in one of the following three situations:

- If the project is required to comply with the City of Vancouver Green Buildings Policy for Rezonings, and choose to pursue Path B – Low Emission Green Buildings.
- Projects seeking to comply with the Zero Carbon Building Standard.
- Projects seeking to achieve points in the Building Life-Cycle Impact Reduction credit in support of LEED® certification.

Ideally, a comprehensive LCA would include all building components, but due to variations in analysis standards and regulations, as well as limitations in available data, analyses typically are limited in scope to include only foundations, primary structure, and building enclosure, while excluding interior finishes, partitions, and building services (such as mechanical, electrical, and plumbing systems).



To account for the overall environmental impacts of a building, a Life Cycle Assessment (LCA) is used to address all resources entering and all waste leaving (i.e. emissions) at each stage of a building's life from cradle (raw material extraction) to grave (disposal). The above diagram, from the World Green Building Council, illustrates the stages of a LCA. The stages of a building's life cycle can be viewed here: World Green Building Council. Building Embodied Carbon Upfront. 2019. Available at https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf Accessed 2022/02/07

1 https://nrc-publications.canada.ca/eng/view/object/?id=f7bd265d-cc3d-4848-a666-8eeb1fbde910

Analysis of operational energy consumption and GHG emissions is much more commonplace in the building industry and is built into federal and provincial building codes in Canada.

Within British Columbia, the British Columbia Building Code (BCBC), British Columbia Energy Step Code (Step Code), and City of Vancouver Building Bylaw (VBBL) all require energy modelling for new schools.

The Step Code and VBBL use a performance-based approach, requiring energy modelling to demonstrate compliance with prescribed performance limits, based on the jurisdiction and building type.

These limits establish the maximum targets for the proposed design, and include total energy usage intensity (TEUI), which describes the annual site operational energy consumption, as well as thermal energy demand intensity (TEDI), which describes the annual demand for space and ventilation heating.

The City of Vancouver goes one step further, also setting GHG emission intensity (GHGI) targets, which reflect the annual GHG emissions.

HEALTHY FORESTS AND SUSTAINABLE WOOD SUPPLY

Forest management plays a significant role when considering wood as a sustainable building material for schools. In British Columbia, the province's multi-faceted sustainable approach to forest management includes stringent laws, skilled forestry professionals, comprehensive monitoring, compliance, and enforcement.

Independent studies have shown that British Columbia has some of the most stringent forest legislations. One study examined forest legislation in 14 international jurisdictions and showed that British Columbia's laws and legislation cover all 16 elements of sustainable forest management.

The study, by Indufor, reported that, "Canadian forest management frameworks for public forests exceed certification standards in the promotion of sustainable productivity of natural forests (with a strong emphasis on sustainable harvest levels, prevention of forest conversion, and protecting forests from fires and pests) and protecting the ecological and conservation values of forests."[1]

A second study compared British Columbia with seven of the same jurisdictions and found British Columbia's forest management and conservation regime is one of the most advanced in the world.

The peer-reviewed study by the University of British Columbia reported, "British Columbia ranks high (among the jurisdictions studied) on several key sustainable forest management parameters with legislation and forest management regimes aimed to meet the environmental, social and economic needs of current and future generations."[2]

In addition to strong legal protection of its forests, British Columbia has one of the highest rates of third-party forest certification, representing 9% of all the world's certified forests.[3]

In Canada and British Columbia, there are three third-party certification systems for sustainable forest management: Canadian Standards Association's Sustainable Forest Management Standards (CSA), FSC, and Sustainable Forestry Initiative (SFI). The CSA and SFI standards are recognized by PEFC.

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1 Comparing B.C. to the World: Forest Regulation and Certification. 2016; https://www.naturallywood.com/wp-content/uploads/2020/08/comparing-bc-to-world-forest-regulation-certification_factsheet_naturallywood.pdf. Examining the Linkage Between Forest Regulation and Forest Certification Around the World, Indufor, 2009; Comparing British Columbia with the World, Indufor, 2004.

2 State of British Columbia's Forests: A Global Comparison, naturally:wood, 2020, https://www.naturallywood.com/resource/state-of-british-columbias-forests-a-global-comparison/ Original report Forests. Volume 11. Issue 3. March 2020., University of British Columbia, https://www.mdpi.com/1999-4907/11/3/316

3 https://www.naturallywood.com/topics/forest-management-in-british-columbia/

PERFORMANCE OF WOOD IN SCHOOLS[1]

As noted in other sections of this report, there are numerous large-scale benefits to using wood in school design and construction. There are, however, specific performance advantages to using wood that are often overlooked.

They include factors such as durability and resilience, weather and elements, building envelope design, surface treatments, air quality, acoustics, sound separation, and sound absorption. When viewed in conjunction with sustainability, speed, cost, aesthetics and biophilia, the case for using wood in schools is even stronger.

DURABILITY AND RESILIENCY

Innovations in wood-based building technologies have increased the capacity of wood to be a highly durable product in a wide range of applications. The result is an increase in the availability of wood products and the development of related construction technologies.

Wood structures perform excellently seismically and better thermally than steel and concrete structures. As such, community schools, which are often used as post-disaster facilities, are logical candidates for wood construction.

Various government levels, from federal to provincial to individual school boards, support the use of mass timber in schools. This was demonstrated recently with the new Begbie and Bayview schools, which were scheduled to be replaced because they were not seismically sound – and were replaced with mass timber schools. Federal funding for this project underscores the belief in, and support for, this type of construction.

Wood in high traffic areas can also be made durable with surface applications of metal corner guards, kicks, and rails that are typically used in non-wood buildings. Wall coverings using wood sheet products in high traffic areas are economical, easily replaced, and protects the school walls from abuse and typical wear-and-tear.

Using wood for structural framing allows a lot of versatility in finishes, which can be a cost-effective method of achieving a variety of architectural finishes for different purposes.

This can range from simple partitions made of wood to impact-resistant assemblies that offer protection in high-traffic areas such as interior corridors.

WEATHER AND THE ELEMENTS

One of the biggest concerns when building schools from wood is the way that it performs when exposed to the elements.

Management of exposure to water is required for schools with mass timber structures, but this is true for most other building materials as well. Wood can handle high humidity without compromising its structural integrity, and with proper design and detailing, wood schools can match the durability and resiliency of schools made from any other material.

Fortunately, wood-frame buildings and envelope assemblies can resist damage from moisture and provide decades of service equivalent to other building types if they are properly designed and built.

Water movement into, on, and through buildings is natural and expected, but there can be decay of wood when there is long-term exposure to high levels of moisture – if that moisture is not allowed to evaporate. Deterioration can happen even if a small amount of moisture penetrates the wood fibres and can not evaporate.[2]

As a result, it is important for the project team to carefully consider the building's final design and weather protection for the various wood elements during construction.

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1 For general information on building healthy schools, see http://www.edu.gov.on.ca/eng/policyfunding/greenschools_guide.pdf

2 https://www.thinkwood.com/wp-content/uploads/2019/08/Think-Wood-Publication-100-Projects-UK-CLT.pdf

Pre-fabricated wood floor and walls come from factories to the site, and need to be protected from the time the wood leaves the factory until the time the building is enclosed.

A moisture mitigation plan that is part of the procurement strategy is key to moisture management during the construction phase, as sealants applied in the factory as a first coat is only part of a moisture mitigation strategy for construction.[1]

Moisture that is not properly managed can enable organisms to grow and lead to decay of the timber building elements. Moulds that grow in wet conditions are also notorious for their contribution to poor air quality and potential impact on human health.

Mould usually signals a deficiency in a building's moisture management program. The key to controlling decay is controlling excessive moisture, which is done through design, site and construction planning, species selection, and surface treatments.

A plan for controlling moisture during construction is critical and should be considered part of the design teams specifications when using wood for schools.

Bayview Elementary School, Vancouver – Photo © Wade Comer, courtesy naturallywood.com

1 https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovation, Wood Innovation Report, pg 98.

Decay resistant wood, such as western red cedar, is another way to combat moisture issues. Most construction lumber is not naturally decay resistant, but it can be treated with preservatives through pressure treatment. Properly treated wood can have five to 10 times the service life of untreated wood.

Preservative-treated wood or naturally decay-resistant wood is typically used for applications such as cladding, shingles, sill plates, and exposed timbers or glulam beams, where moisture tolerance is necessary.

Since 2016, chromated copper arsenate (CCA) pressure treated wood has been phased out of school building construction and the National Building Code and Canada Standards Association have worked to eliminate unsafe pressure treated materials from schools.

There are, however, still some applications where pressure treated wood is required in school construction and safer alternatives have been created. For example, thermally modified lumber utilizes heat and steam to produce a dimensionally stable, relatively decay-resistant wood that is non-toxic.

BUILDING ENVELOPE DESIGN

The best way to prevent mould from forming inside a school is to keep the water responsible for mould growth out of the building. The strongest defense against water infiltration is a well designed and constructed exterior wall assembly.

The BC Building Code governs the design of the exterior envelope to ensure wall assemblies can deflect, drain, and dry moisture. Measures are taken to protect wood used in an application that will frequently be wet for extended periods. Wood buildings require detailing, such as overhangs and canopies, to provide the first line of defense against water; scuppers can also be detailed to direct and discharge water away far away from the building.

Wood can also be used in a building envelope to drastically reduce thermal bridging. Thermal bridging happens when heat moves through a building envelope through conduction. Wood is a poor conductor and can be a better approach for indoor/outdoor conditions, such as envelope projections, than steel or concrete.

Insufficiently insulated steel and concrete can provide a thermal bridge and invite moisture and condensation into the building envelope. Using properly insulated mass timber instead drastically reduces the chance of thermal bridging.

The Mass Timber Building Enclosure Best Practice Design Guide[1] provides straightforward design guidance for architects, contractors, and building developers who are designing and constructing mass timber buildings in any region of the US and Canada.

This guide provides best practice enclosure design principles for mass timber enclosures, including roofs, walls, and floor / soffit conditions.

SURFACE TREATMENTS

There are a variety of paints, stains, varnishes, and water repellents that can be applied to wood products to provide some protection against moisture uptake and extend its lifespan.

These coatings cannot be considered substitutes for preservative treatment, however. Regardless of the coating used, regular maintenance is required to maintain the integrity of the finish.

The durability of wood can easily be increased through simple maintenance strategies such as annual inspections and minor repairs to signs of water damage or ingress.

1 https://learnbuildingscience.com/products/mass-timber-enclosure-overview

AIR QUALITY

Indoor air quality is an important consideration when choosing materials for schools. Children spend most of their days in classrooms or other educational facilities.

Every year, children spend roughly 1,300 hours in school buildings. That is a significant amount of time to be breathing in everything from the airborne environment, so strategies – both active and passive – that increase ventilation for students are important.[1]

Ventilation, air filters, indoor air, and the use of outdoor air have become even more important in recent years in light of the Covid-19 pandemic. Although wood does not impact the actual air supply, it is an important consideration when it comes to air quality.

Good indoor air quality includes control of airborne pollutants, introduction and distribution of adequate outdoor air, and maintenance of acceptable temperature and relative humidity.

According to the US Environmental Protection Agency, children suffer from higher rates of asthma, allergies, and are more susceptible to environmental toxins than adults, which underscores the importance of air quality in schools.[2]

The natural properties of wood can enhance a building's indoor acoustic environment and make it a particularly good choice for the design and construction of schools.

One way that wood products can improve indoor air quality is through the moderation of humidity. Wood is porous and it absorbs moisture when humidity levels are high and releases moisture into the air when humidity levels are low, effectively balancing interior moisture and humidity and creating a more pleasant environment for occupants.[3]

Another way that wood products can help improve air quality is through ease of cleaning. Wood is a hypoallergenic material and is easy to clean, preventing buildup of dust, particulates, and other allergens.

There had previously been concerns that urea-formaldehyde glues used in primarily in wood panel products, such as particle board, medium density fibreboard (MDF), and hardboard can produce off-gases and release volatile organic compounds when left unsealed, negatively affecting indoor air quality.

Wood products used in building interiors have greatly improved in recent years, however, by reducing or eliminating the use of urea-formaldehyde glues.

Wood-based panel products are now required to have reduced volatile organic compounds and are third-party certified.

A study on the effects of wood on indoor air quality in hospitals, where indoor air quality is critical, concluded that adding wood-based panels did not have a measurable effect on the volatile organic compounds in the air.[4]

1 https://www.naturallywood.com/blog/why-wood-is-an-effective-material-for-schools/
2 https://www.epa.gov/iaq-schools/why-indoor-air-quality-important-schools

3 https://www.naturallywood.com/wood-performance/health/

4 Nyrud, Anders & Bringslimark, Tina & Englund, F. (2011). Wood use in a hospital environment: VOC emissions and air quality. European Journal of Wood and Wood Products. 70.10.1007/s00107-011-0578-3

SOUND IN SCHOOLS

Sound in a school environment is particularly important for a number of reasons, including making sure teaching and learning spaces are designed to promote sound clarity and intelligibility for speech-based communications, while not allowing sound from adjoining spaces to cause intrusion or disruption to learning activities that require concentration.

The acoustic design of the core learning areas, commons, performing arts and ancillary spaces at the school will also require a delicate balance of sound absorption and reflection to ensure conditions that provide both student comfort as well as speech intelligibility for all educational uses.

ACOUSTICS

The natural properties of wood can enhance a building's indoor acoustic environment and make it a particularly good choice for the design and construction of schools.

Acoustical design considers several factors, including exterior noise ingress from the building location and orientation, as well as the isolation or separation of noise-producing functions and building elements.

The Sound Transmission Class (STC), Apparent Sound Transmission Class (ASTC) and Impact Insulation Class (IIC) ratings are all used to establish the level of acoustic performance of building products and systems. The different ratings can be based on standardized laboratory testing, field testing of the as-built assemblies or calculated using methodologies described in the NBCC.[1]

Wood construction and specialty wood products can offer a variety of acoustic solutions for the wide variety of school buildings that exist: libraries, performance theatres, shops, classrooms, gymnasiums – and can also provide solutions to design considerations when conflicting spaces are adjacent to each other.

The acoustical separation of spaces for educational purposes is very important in schools. Wood assemblies can be manipulated in various ways through geometry and construction details to meet the appropriate acoustic performance and separation of spaces from one another.

SOUND ABSORPTION

The acoustic absorption of reflected soundwaves within spaces is important in schools, in that it maintains high levels of speech intelligibility (or understanding) and ensures that the space can not be so loud that it prevents learning or disrupts concentration.

Exposed CLT panels and wood surfaces are not particularly absorptive, in and of themselves. Wood finishes in combination with acoustic insulation can, however, be applied to walls and ceilings in areas such as libraries and study spaces, and can also be used in any space throughout the school to control sound transmission.

Although wood alone does not absorb sound to any significant degree, there are many engineered wood products available for acoustic absorption treatments.

Typically, these products use wood as a surface material or as a component (such as linear slats), with perforations and an additional membrane layered materials behind to absorb sound.

Fabric-wrapped wood-frame panels are often more durable than resin-hardened panels, and the air gap between the insulation and the fabric enhances acoustic performance.

These products and approaches would typically be used on ceilings and walls in order to absorb sound and make the space less reverberant.[2]

1 https://cwc.ca/how-to-build-with-wood/codes-standards/building-codes/acoustics/

2 https://www.naturallywood.com/wood-performance/acoustic/

SOUND SEPARATION

Wood is composed of many small cellular tubes that are predominantly filled with air. The natural composition of the material allows the wood to adequately resist the transmission of sound through the structure and provides it with the ability to dampen vibrations.

A range of STC ratings for walls, wood frame floor or mass timber floor assemblies can be achieved depending on the needs of a space.[1]

Walls: Common strategies to increase STC ratings include a double row of studs or increasing the layers of gypsum board in a wall assembly, as well as the addition of a resilient channels to support the gypsum.

Floors (framed): The addition of a resilient channel along with a lightweight gypsum to the underside of the structural framing, or a concrete topping to create a composite assembly can help improve the sound transmission of floor assemblies.

Floors (mass timber): When mass timber is used for school floor assemblies, acoustical membranes and different floor finishes can be utilized to increase sound attenuation from impact noise. When using mass timber, not all assemblies are created equally and the ability for sound separation control varies. Research has shown that CLT performs slightly better than DLT or NLT due to the cross laminations, which increase the material's mass.[2]

SOUND REFLECTION

Wood can also be used as a reflective material for sound. That means wood can be used in school spaces such as theatres or music rooms, due to its reflective properties, and can be manipulated and design optimized to ensure sound is diffused or evenly spread within a space.

Wood panels and wood material are commonly installed in walls or ceilings, adding aesthetics as well as serving as a design feature for enhancing sound reflection providing a natural timbre and liveliness to music performance and choral singing.

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1 https://cwc.ca/how-to-build-with-wood/codes-standards/building-codes/acoustics/

2 https://building.ca/feature/whats-old-is-new-acoustical-considerations-as-wood-buildings-make-a-comeback/

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5. BUILDING CODES

WHAT DOES THE CODE DO?

The British Columbia Building Code (BCBC) governs the design and construction of most buildings in British Columbia (the Vancouver Building By-law governs the City of Vancouver). The BCBC provides minimum standards for health, safety, and general welfare including structural integrity, mechanical integrity (including sanitation, water supply, light, and ventilation), means of egress, fire prevention and control, and energy conservation.

Building codes require all building systems to perform to the same level of safety, regardless of the material used – wood, steel, or concrete.

Under the BCBC, school buildings fall under the Major Occupancy Classification Group A Division 2 (Group A-2). This classification is used to determine which BCBC requirements will apply to the design and construction of a school.

The building codes applied to schools are particularly stringent, not only to protect students and occupants from harm, but also because elementary, middle, and secondary schools are likely to be used as a post-disaster shelter in the event of a major emergency.

All school buildings are categorized as "High" in importance in the BCBC and must be designed to meet the same design loads, regardless of construction type or material used.

Simply put, this means that wood structures, including schools, must meet the same standards as concrete and steel buildings to meet code requirements. In some cases, this is a non-issue (two-storey light wood-frame schools, for example), but in others it can prove to be a significant challenge to the design and engineering team (as in the case of three- or four-storey mass timber schools).

FIRE SAFETY

Fire safety requirements for schools are very specific and are outlined in the BCBC and the British Columbia Fire Code; the BCBC governs construction while the Fire Code governs operations. There are two main categories of construction under the BCBC and British Columbia Fire Code: combustible and non-combustible.

Combustible construction generally refers to wood and non-combustible refers to concrete and steel. Wood is a combustible material, but there are several ways that combustible materials can be used in a non-combustible building.

When a building is categorized as non-combustible construction, the BCBC does not prohibit the use of wood. It does, however, limit how wood can be used. For example, wood-based finishes, exterior cladding, non-structural partition walls, blocking materials, finished flooring, and millwork can still be used if the relevant requirements, such as specific flame-spread ratings, are met.

Heavy timber is a term used in the building code to refer to wood elements with a minimum dimension, determined to provide a specified level of fire safety. For the purpose of this report, heavy timber can be considered to be synonymous with mass timber used in school construction.

CHANGES TO BCBC SINCE 2018

There are two new construction articles introduced in the 2018 BCBC that prescribe six-storey combustible construction for Groups C (residential) and D (business and personal services) buildings, with a physical height of 18m.

In addition, a revision to the 2018 BCBC in late 2019 included a new type of construction: Encapsulated Mass Timber Construction (EMTC). EMTC is the process of using drywall to wrap mass timber elements to ensure the structure meets fire safety requirements. The two EMTC construction articles prescribe up to 12-storey Groups C and D buildings.

Under the six-storey combustible construction and EMTC construction section of the code, Group A-2 major occupancies are permitted – if they are below a certain height / number of storeys. Although most school buildings are of Group A-2 major occupancy and typically not more than three or four storeys, this provides additional opportunities for alternative solutions, as discussed in the next section.

The following table is a summary of the current BCBC pertaining to Group A-2 major occupancies, including those could be contained within Group D buildings (Group C has been excluded for clarity).

Const. Article	**3.2.2.26**	**3.2.2.27**	**3.2.2.57 EMTC**	**3.2.2.58**
Occupancy Group	A-2	A-2	D	D
Type of Const.	CC*	CC	EMTC*	CC
Building Height	2	2	12	6
Physical Height	Not prescribed	Not prescribed	42m	18m
Building Area	2400	600	7200m2	3000m2
Sprinklered	Yes			
Floor FRR	45min	Not prescribed	2h	1h
Mezzanine FRR	45min	Not prescribed	1h	1h
Roof FRR	Not prescribed	Not prescribed	Not prescribed	1h
Loadbearing Elements FRR	45min, or of NC const.	Not prescribed	Not less than those supported	Not less than those supported
Uses of Group A-2	N/A	N/A	To be located below the fourth storey	To be located below the third storey

* CC: combustiblc construction; EMTC: encapsulated mass timber construction

Based on the above, it is possible that, in a four-storey EMTC building per Article 3.2.2.57 EMTC to have an office on Level 4, and contain three levels of Group A-2 for school use; or in a three-storey building per Article 3.2.2.58, an office can be located on Level 3, and contain two levels of Group A-2 for school use.

These options open up the restrictions for schools of combustible construction slightly, so that a larger or taller building is permitted with an increase of fire-resistance rating.

However, the typical required fire-resistance rating (FRR) of such buildings is two hours for floors and loadbearing elements. For a 12-storey EMTC building, the two-hour FRR may be justified due to increased risk. On the other hand, a four-storey EMTC building may be rendered uneconomical if a two-hour FRR is required.

There are no existing specific Subsection 3.2.2 Articles for Group A-2 buildings between three and five storeys. In other words, a three-storey Group A-2 is required to be non-combustible with a minimum one-hour FRR.

Therefore, an alternative solution to fill the gap may be desired, as discussed below.

These code changes do not directly address the typical three or four-storey school. The new materials and construction options do, however, open up opportunities for mass timber as an alternative solution.

ALTERNATIVE SOLUTIONS APPROACH

The acceptable solutions contained in the latest BCBC prescribe a maximum two storeys of Group A-2 major occupancies (i.e., schools) when constructed using combustible construction.

Articles 3.2.2.50 and 3.2.2.58 offer one additional storey with some increase in building area, based on an increase of minimum fire-resistance rating. This is one step towards filling the design gaps under Subsection 3.2.2, but schools are restricted to maximum three storeys nevertheless.

An alternative solution approach may be desired for smaller construction of schools that are taller than three storeys under Group A-2 major occupancy.[1]

Under the National and British Columbia building codes, allowable building area and height are prescribed based on perceived risk. Small light-frame unsprinklered buildings are permitted up to two storeys, larger two storey buildings are permitted if sprinklered.

Mass timber building elements with an inherent one-hour fire rating clearly provide a level of fire safety that is superior to light frame and are arguably equivalent to one-hour non-combustible construction.

1 https://wood-works.ca/wp-content/uploads/2019/12/Risk-Analysis-and-Alternative-Solution-for-Three-and-Four-Storey-Schools-of-Mass-Timber-and-Wood-Frame-Construction.pdf

Unfortunately, the building code does not provide any prescriptive solutions for buildings of mass timber between small light-frame buildings and six-storey buildings.

Now that the building code has recognized encapsulated mass timber as suitable for high-rise buildings, there is a resulting gap in allowable areas and height options between 45 minute light frame and encapsulated mass timber, filling this gap, or essentially interpolating between 45 minute light frame and EMTC.

Essentially, the building code development committees have prioritized use of timber in high-rise office and residential buildings, and have not yet developed acceptable solutions for assembly buildings such as schools.

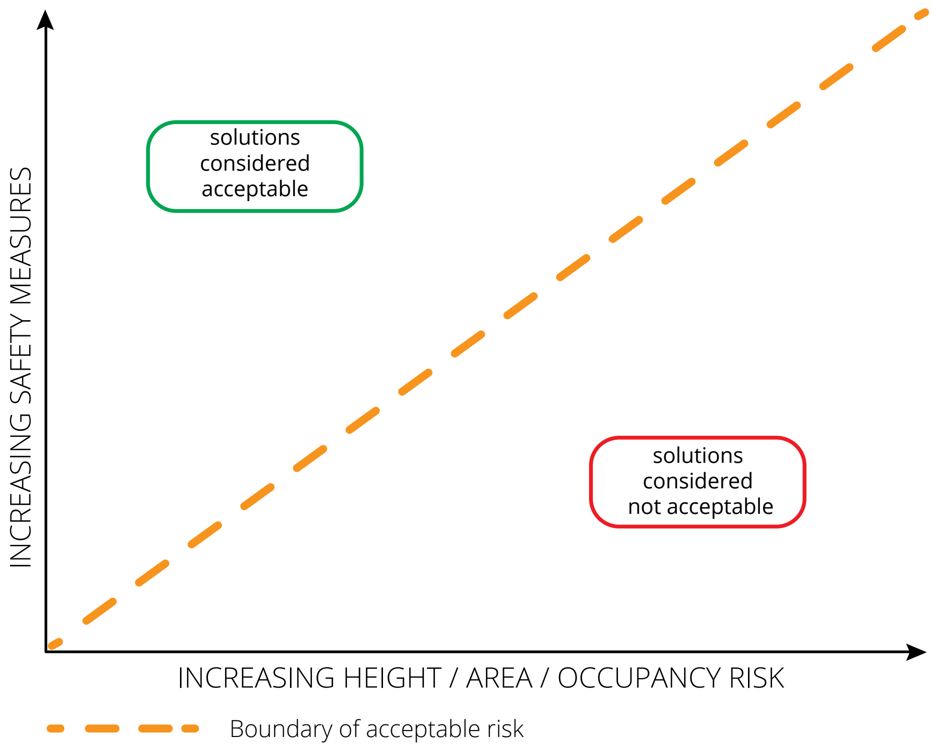
The fact that acceptable solutions for mid-rise timber schools have not been incorporated in the building code does not prohibit the development of such solutions as alternative solutions. The existing provisions under Subsection 3.2.2 actually provide guidance, or a framework, for fire engineers to develop alternative solutions for situations such as schools.

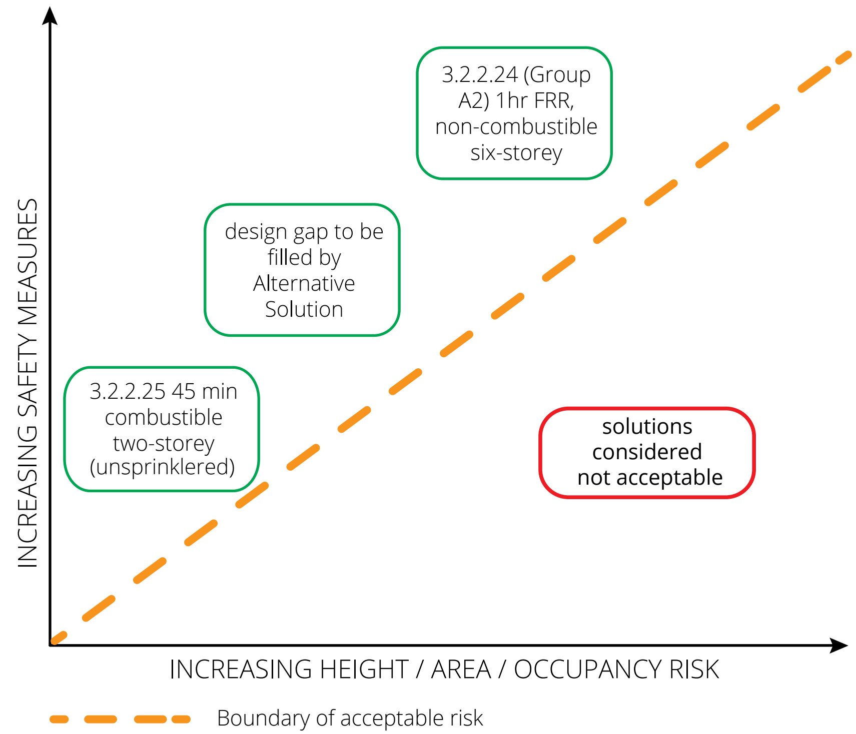
The building code is explicit that an alternative solution, properly prepared by competent professionals and accepted by the building official, is a method of compliance with the building code. The Building Code Appeal Board in British Columbia has confirmed that alternative solutions for Subsection 3.2.2, that is building height and area, are acceptable. This bodes well for mass timber school construction, and was in fact what made Ta'talu Elementary School (described in Section 2 of this report) possible.

It is understood that buildings are constructed with an acceptable level of risk, meaning that it is incorrect to state that a building constructed per the prescriptive solutions has zero risk. From the building code's perspective, there are solutions considered acceptable, e.g., the Subsection 3.2.2. articles, and there are solutions considered not acceptable.

In between the successive Subsection 3.2.2 articles generally ordered by risk and construction requirements, per each type of occupancy, it is proposed that there are solutions that can fill the gaps between some of the construction articles. The following diagrams illustrate the concept of filling design gaps through the approach of alternative solutions.

FILLING DESIGN GAPS THROUGH ALTERNATIVE SOLUTIONS





If the proposed alternative solution is determined to be above the boundary of acceptable risk, it can then define an acceptable construction requirement.

To use schools as an example, Article 3.2.2.24 prescribes a Group A-2 school to be maximum six storeys, without a limitation of its building area, using one-hour fire-resistance rated, non-combustible construction.

Article 3.2.2.25, however, limits such school to be maximum two storeys, with a building area of 1200m^2 if facing two streets, but with the liberty of using 45 minute fire-resistance rated combustible construction.

The wide gap between the prescriptive building heights and area per these two articles could be filled by an acceptable alternative solution.

For example, one-hour fire-resistance rated mass timber construction for a school of three or four storeys tall could be a reasonable solution.

An alternative solution inherently requires acceptance by the local building official. Where the local municipality does not feel it has the required level of expertise to review such an approach inhouse, it may be advantageous to involve a separate fire engineer with appropriate experience to provide a peer review of the alternative solution.

CHAR RATING AND ENCAPSULATION

One of the major concerns often cited about mass timber construction is the idea that these buildings are highly flammable, and therefore a safety risk, because they are made of wood. This is, in fact, false. As timber is consumed by fire, layers of charred wood are formed on the consumed surface following the chemical reactions of the combustion process.

The char layers act as a protective measure to reduce the impact of fire on the unburnt timber behind the char. This allows more than enough time for occupants to safely evacuate the structure and for the fire department to arrive on scene and put out the fire.

The rate of char of a mass timber element can be measured by exposing the element to a standard fire for a designated period. Annex B of CSA O86, "Engineering Design in Wood", assigns a notional char rate of 0.8mm / minute to typical cross-laminated timber elements.

The char layers are good insulators, but they do not have any loadbearing strength. As timber is consumed, its loadbearing capability is gradually reduced as more and more timber turns into char. At the char front, a small depth of timber is heated and is yet to be charred; this section of the timber is considered to have lost its strength even though charring has yet to occur.

As such, for fire exposure durations greater than 20 minutes, CSA O86 also assigns a depth 7mm zero-strength layer on uncharred timber that is directly beyond the char front.

For example, a CLT element of 175mm thick with 60 minutes of exposure will have 60 x 0.8 + 7 = 55mm of char. That means there will remain 127mm of undamaged timber that have strength at the end of the exposure.

For Encapsulated Mass Timber Construction, mass timber elements are prescribed to be encapsulated by a material that provides an encapsulation rating of not less than 50 minutes, per Sentence 3.1.18.4.(1).

Encapsulation rating is a defined term in the building code, and it measures the time a material or assembly that will delay the ignition and combustion of the encapsulated mass timber element.

For example, two layers of 12.7mm Type X gypsum board provides 50 minutes of encapsulation rating. A mass timber element with 50 minute encapsulation, when exposed to the standard fire, does not ignite or char for the first 50 minutes of the exposure period.

Using the same example, the char depth of a 175mm thick CLT with 50 minutes of encapsulation rating would be 15mm (0.8 x 10 + 7).

Requirements on the specification of structural wood products and wood building systems are set forth in the BCBC, which is concerned with health, safety, accessibility and the protection of buildings from fire or structural damage.

The building code applies mainly to new construction, but also aspects of demolition, relocation, renovation and change of building use. In addition to outlining the minimum requirements for structural, fire safety and seismic details, the BCBC also outlines product specific standards for individual elements, wood or otherwise.

The CAN / CSA-O86 Engineering Design in Wood outlines the wood design requirements for Canadian conditions. Referenced throughout the BCBC, the CSA 086 is a comprehensive set of requirements for the structural design and appraisal of structures or structural elements made from wood or wood products.

The building code is continually revised in response to new research, emerging technologies, and increased understanding about the complex factors that impact the performance of buildings.

Wood-frame, wood hybrid, and mass timber construction are resilient with a proven safety and performance record for a full range of conditions including fire, seismic, and wind, and it is highly likely that the building code will further evolve as more becomes known about the capabilities of mass timber construction.

> ***It takes a lot of knowledge sharing and discussion with the fire department within the AHJ, with the planners and inspectors to walk them through why we are meeting the performance criteria of the building code...[1]***
> ***– Ray Wolfe, Architect, Thinkspace Architecture Planning Interior Design***

SEISMIC SAFETY

A majority of British Columbia's population lives within a zone with considerable or high seismic hazard, and there are growing concerns that many of the public buildings, including schools, would be at high risk in the event of a major earthquake. In response, the Ministry of Education has undertaken the Seismic Mitigation Program to improve the safety of schools within the province.

Through this program, schools have gone through an assessment process and if deemed necessary, go through a seismic retrofit; in some cases, schools are being replaced entirely.

Wood is a suitable construction material in seismic zones because it has very specific inherent characteristics.[2] Those characteristics include the following:

Light weight: Earthquake damage is most commonly caused by seismic waves that make the ground move. Earthquake inertial forces are proportionate to a structure's mass, and with wood being lighter than steel and concrete structures, properly designed and built wood-frame structures perform well during seismic activity.

Ductility: Wood-frame structures are constructed with multiple connections and joints. These connectors create a ductile system that can flex during an earthquake, thus absorbing and dissipating wave energy.

Redundancy: Sheathing and finishes that are attached to wood structural members (such as studs and joists) provide redundant load paths for earthquake forces. If some connections fail, there are adjacent connections that can help to take the load and avoid collapse.

Strength and stiffness: Walls tend to rack (tilt) during earthquakes, but wood shear walls can provide the necessary stiffness to limit racking.

Connectivity: A structure acting as a single unit with well-defined load paths is critical to withstanding earthquake forces. In wood buildings, the structure's walls, floors, and roof framing are anchored to the building foundation with standard connections and tie-downs to resist racking and overturning.

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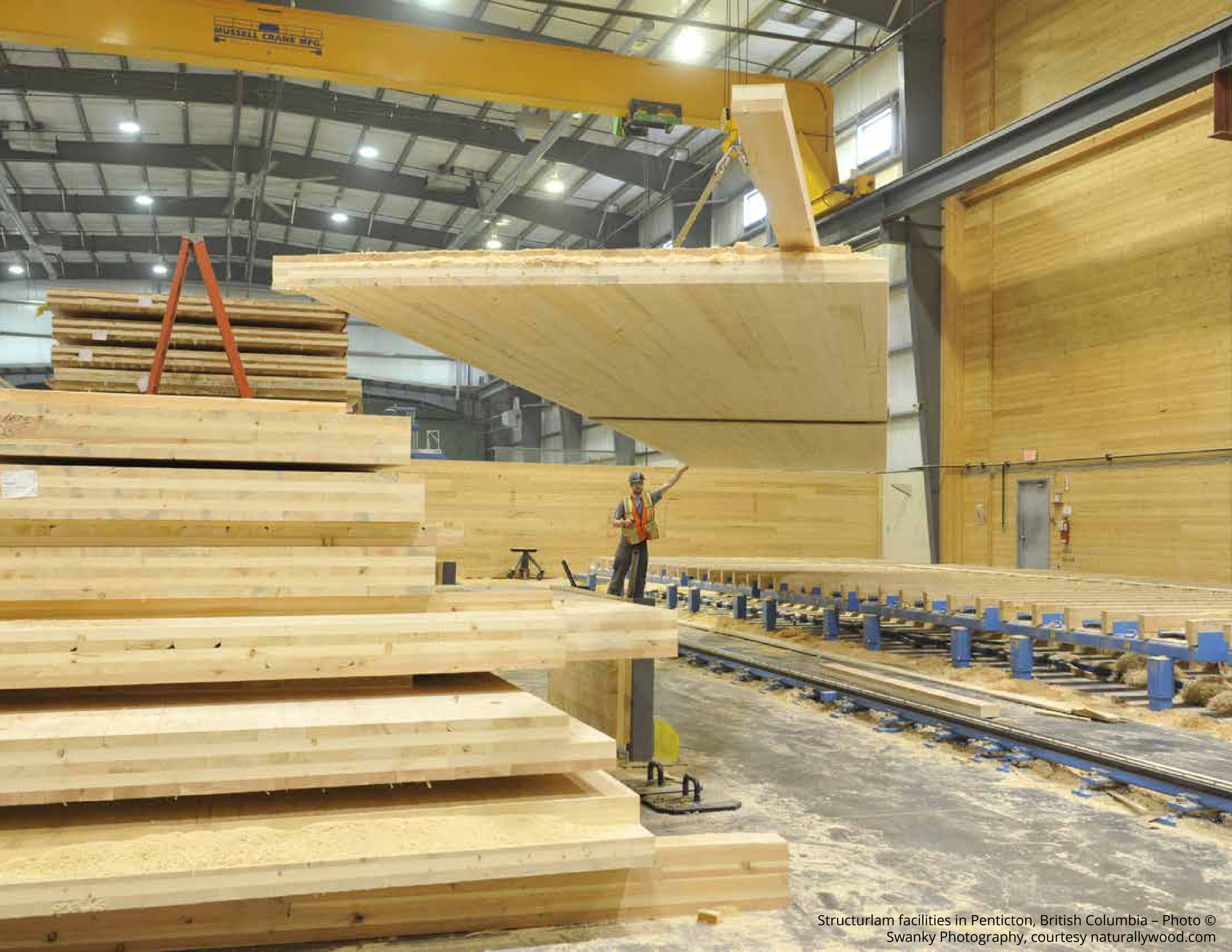
1 https://canada.constructconnect.com/dcn/podcasts/the-construction-record-podcast-naturally-wood-special-an-interview-with-architect-ray-wolfe

2 https://cwc.ca/wp-content/uploads/flipbooks/WW-Seismic-casestudy/



Structurlam facilities in Penticton, British Columbia – Photo © Swanky Photography, courtesy naturallywood.com

6. ADVANCES IN WOOD USE AND TECHNOLOGY

Technology within the mass timber and wood construction industry has been evolving rapidly over the last decade. This includes advances in fabrication, advances in structural connections and techniques, the use of building information modelling (BIM) in constructing mass timber buildings, and computer-numerically controlled (CNC) machining of mass timber elements in new construction projects.

These advances have had numerous benefits for school construction, including more resilient buildings, faster construction and building erection, less time on site, and less noise and disruption for neighbouring communities. We will explore some of the advances in mass timber technology, which further underscore the benefit of using wood in school construction.

FABRICATION ADVANCES AND NEW PRODUCTS[1]

There has been a dramatic increase in the number and variety of mass timber fabricators, connector suppliers, and experienced contractors – both in British Columbia and across North America – as mass timber construction has become more prevalent.

In addition to an increase in the number of fabricators in North America, there have also been advancements in the efficiency of the fabrication process.

One of the more basic advances has been in the automation of the fabrication of nail-laminated timbers (NLTs).[2]

1 For a comprehensive list of mass timber products, go to https://www.naturallywood.com/products/

2 For more information on NLT, go to https://www.naturallywood.com/resource/nail-laminated-timber-design-construction-guide/

One of the real advantages of mass timber these days is the precision machining using CNC machines, where we can get tolerances down to an eighth of an inch.
– Julius Kettler, Field Manager, Beamcraft [mass timber installers]

NLTs are large panels made of pieces of dimension lumber nailed together on edge; they have been used in building construction for more than a century.

These panels can be made on-site or prefabricated off-site and shipped ready to install. NLT panels were traditionally made by hand, regardless of location, but over the last few years a number of Canadian specialty NLT fabricators have set up production to automate the process.

Due to a faster fabrication process, automation has allowed for an increase in production of NLTs. Automation also helps to control for other variables in the production process such as variations in the lumber, different nailing patterns, different lay-up patterns, and requirements to come up with consistent-shaped panels.

This increase in production volume and labour economies should theoretically have benefits in the cost of NLT products at the project level.[3]

NLT is only one type of mass timber that is benefiting from advances in fabrication. Dowel-laminated timber, which uses wooden dowels to connect dimension lumber, is becoming increasingly popular and is also benefiting from advances in fabrication.

3 https://canada.constructconnect.com/dcn/news/resource/2018/11/automated-nlt-process-saves-time-cost-timber-builds

Specialty NLT fabricators have set up mass production of NLT at a number of plants in Canada and the US, improving quality control of the product, reducing cost, and increasing the interest of a broad range contractors as well as architects, engineers, and end-user groups

StructureCraft, a DLT manufacturer in Abbotsford, uses automation to fabricate the company's DowelLam, an all-wood mass timber panel that can be used for floor, wall, and roof structures.

According to StructureCraft, DLT is less expensive to fabricate than CLT panels, and will cost less at a project level. This reduced cost is possible because of:

- Lower manufacturing cost due to high speed production and removal of need for gluing and associated cure times.
- Less volume of material due to structural efficiency.
- Reduced labor required on site from pre-manufacturing.
- Reduced installation time with a 'kit of parts.' [1]

Availability of mass timber products has also increased dramatically in the last five years, with more manufacturers making previously available products as well as new products such as DLT.

Glued mass timber products such as glue-laminated timber (GLT) and cross-laminated timber (CLT) continue to expand their market share of new construction, with a significant increase in the number of suppliers in British Columbia and North America.

Structurlam, in Penticton, and Nordic, in Quebec, used to be the only certified CLT suppliers in North America, but British Columbia now hosts a second major supplier, Kalesnikoff. The latter firm entered the market in 2019.

The nature of the product being offered has also changed in recent years. The new suppliers have increased the size of available CLT panels, from 10' x 40' to 12' x 60', which in turn allows for more efficient construction, longer spans, and more flexibility in panel layout.

New glued products, including include mass plywood panels (MPP), have also entered the mass timber market, further expanding the list of available options for designers.

As the manufacturing efficiencies and operational scale of the North American mass timber suppliers grow, local suppliers are increasingly able to meet the demands oflocal markets and compete with European suppliers, who at one time dominated the field.

As the manufacturing efficiencies and operational scale of the North American mass timber suppliers grow, local suppliers are increasingly able to meet the demands of local markets and compete with European suppliers.

1 https://structurecraft.com/materials/mass-timber/dlt-dowel-laminated-timber

This trend should continue as demand increases, and mass timber manufacturing capabilities improve across Canada and North America.

STRUCTURAL ADVANCES

There have been substantial structural advances in the applications of timber, and particularly mass timber in British Columbia and throughout North America, in recent years.

These advances, which have been made possible through advances in research, changes to material standards and building codes, and new levels of product certifications, further support the use of mass timber in design and construction in a broad sense, as well as the use of mass timber in schools in particular.

Changes to existing material standards have been an important part of the adoption of mass timber. The addition of CLT shear walls to the Wood Design Material Standard (CSA O86 from the Standards Council of Canada) in 2016 and further advancement in the 2019 version of the standard means that CLT shear walls are an acceptable and practical option for a Seismic Force Resisting System (SFRS).

It is worth noting that this second revision to the list of acceptable materials came after the 2018 Wood Use in Schools report, thereby presenting options to engineers and designers that were previously unavailable.

The National Building Code of Canada was also updated in the years following the first Wood Use in Schools report. The NBCC 2020 added several provisions to accommodate mass timber construction.

An associated revision to the 2018 BC Building Code in late 2019 added Encapsulated Mass Timber Construction (EMTC) provisions for buildings that, under the previous code, would not have been able to include timber.

Additionally, the NBCC 2020 has formally added CLT shear walls as an acceptable SFRS, as per the material standard's guidance. Together, the two code revisions remove many of the barriers to wood use in schools that previously existed.

There are several new products and systems that are gaining acceptance in mass timber construction and are likely to be seen in various types of mass timber buildings in the coming years.

Composite systems that accommodate longer span systems have gained prevalence in the past few years. These long spans are well suited to modern school designs and flexible spaces.

Composite systems include timber-concrete composites (TCC), where concrete poured on CLT floors is compositely connected with shear connectors and timber-timber composites (TTC), where mass timber panels like CLT are connected to timber beams to produce a composite ribbed panel.

Point-supported mass timber construction, which eliminates drop beams and support walls, has also gained traction in recent years. This approach takes advantage of the two-way capabilities of cross-laminated products like CLT by allowing the laminations in both directions to support loads.

Composite systems that accommodate longer span systems have gained prevalence in the past few years.

Significant research into the behaviour of these systems has provided additional clarity on their implementation. Innovative research also offers solutions allowing for moment connections between panels, increasing CLT flat plate span options beyond currently available panel sizes.

Seismic systems, such as multi-storey continuous CLT shear walls and timber braces, have advanced alongside the evolution of code-compliant CLT shear walls.

Innovative self-centering products and systems for improved performance-based design have also increased the seismic resilience of mass timber structures. For example, seismic engineering company, Tectonus, makes self-centering friction dampers for CLT shear walls and timber braces.[1] Post-tensioned CLT and LVL shear walls with replaceable dissipator elements also offer self-centering behaviour to improve post-seismic occupancy and resiliency.[2]

Proprietary connectors and fasteners that expedite and enhance mass timber construction are becoming increasingly accessible in the North American market.

BIM aids in coordinating the delivery of structural elements and the loading and unloading of trucks, sometimes even to the degree of position within a truck to accommodate just-in-time delivery for sites with limited space.

These connectors and fasteners, such as self-tapping screws, self-drilling dowels, and other modern (typically European in origin) timber fasteners now have more established local suppliers, allowing for simpler supply and shorter lead times for procurement.

Several new types of complex connectors are now available, including many kinds of concealed connectors that allow for a clean aesthetic and improved fire resistance for exposed conditions.

Also available are corner connectors for mass timber panel construction, specialty column connectors for point-supported construction, and glued systems for composite connections.

BIM MODELLING

Building information modelling (BIM) is a collaborative process of creating digital representations of physical spaces or buildings. It is now used regularly in the architecture, engineering, and construction (AEC) sectors as a way of designing and viewing various integrated building systems.[3]

As mass timber has gained prominence, comprehensive BIM modeling has become more valuable with several case study projects showing the advantages to schedule and a reduction in changes during construction.

Three-dimensional BIM modeling will, in general, allow all parties to better understand a building, improving consultant coordination, and avoiding conflicts between structural, mechanical, electrical, and architectural disciplines.

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1 Hashemi A, Quenneville P, Fast P, Dickof C, Jackson R, Dunbar A, Zarnani P, Case Studies on Low Damage Mass timber Structures with Risilient Connections, New Zealand Society for Earthquake Engineering Conference, 2022

2 Iqbal A, Popovski M, Post-Tensioned Mass Timber Systems, Structures Congress, 2017. https://doi.org/10.1061/9780784480427.036

3 https://www.naturallywood.com/resource/bim-for-wood-buildings/

These 3D models also generally enrich the understanding of the building by the general contractor, mass timber erector, and mass timber supplier.

The enhanced coordination and understanding by all parties will often improve project schedules, reducing time for shop drawing creation and review. BIM modeling can also be implemented by the supplier, significantly reducing the time required to create fabrication shop drawings.

BIM modeling also aids in off-site mass timber fabrication, as a comprehensive model will accurately locate penetrations, recesses, and element and connection placement (provided a fully coordinated model is available).

This allows the project to more effectively leverage the mass timber suppliers' advanced automated machinery to create these elements within mass timber panels, beams, or columns, and implement a much higher degree of off-site fabrication.

Off-site fabrication requires fewer workers and often improves both the quality of cuts and connections, as well as the quality control over all elements. Extensive off-site fabrication accommodates faster and simpler on-site erection, as well as easier installation of mechanical and electrical services.

Beyond the benefits to fabrication and coordination, BIM modeling can also support construction. Using BIM modeling and detailed construction sequencing, a 3D model can be converted to 4D model. Four-dimensional models combine a 3D model with a project schedule to create a simulation of construction activities.

All members of the construction team can access the detailed sequence for erection, simplifying coordination between trades. It also aids in coordinating the delivery of structural elements and loading and unloading of trucks, sometimes even to the degree of position within a truck to accommodate just-in-time delivery.

A 4D model can also be an excellent tool for tracking the progress of a project and adjusting the schedule depending on the status of the construction.[1]

MODULAR CONSTRUCTION

Mass timber construction is typically characterized by an assembly of component pieces. In 2018, the German city of Frankfurt am Main took this concept to the next level by building a new 2,000-student school out of modular components. The wooden modules met the design criteria and the budget of €26 million.

The project was a success and provided a short construction time, good thermal insulation in summer, excellent soundproofing, and visible wooden surfaces in the interior.

1 https://www.naturallywood.com/wp-content/uploads/bim-dfma-for-mass-timber-construction_report_bim-topics-research-lab.pdf

Each of the 210 individual modules in the new school were up to 18 metres in length and weighed approximately 20 tons. Manufacturers in Switzerland built the modules, delivered them to site, and craned them into place.

The city combined the modules in specific configurations to deliver on programming requirements, with three modules forming a 60m² classroom. It only took a few weeks for the three-storey main school building to be constructed.[2]

Since then, the concept of modules has gained favour in other cities in Germany, and Berlin recently announced that it was planning to use wooden modular construction to build 32 schools by 2025.

By February 2022, the city had finished six of the schools, and planned to complete the remainder over the next three years. The team cited the speed of off-site construction as a deciding factor in going with this approach; they estimate that construction time will be halved.

It is possible to appreciate how they achieved that speed by looking at the size of the modules. One of the schools is made up of almost 100 modules, each of which were 3m wide and 8m long.[3]

2 https://www.swisskrono.com/de-fr/products/wood-en-building-materials/prefabricated-construction/references/europe-s-largest-school-in-wood-modular-design/#/
3 https://www.metsawood.com/global/news-media/references/Pages/Sustainable-wooden-school-network-in-Berlin.aspx

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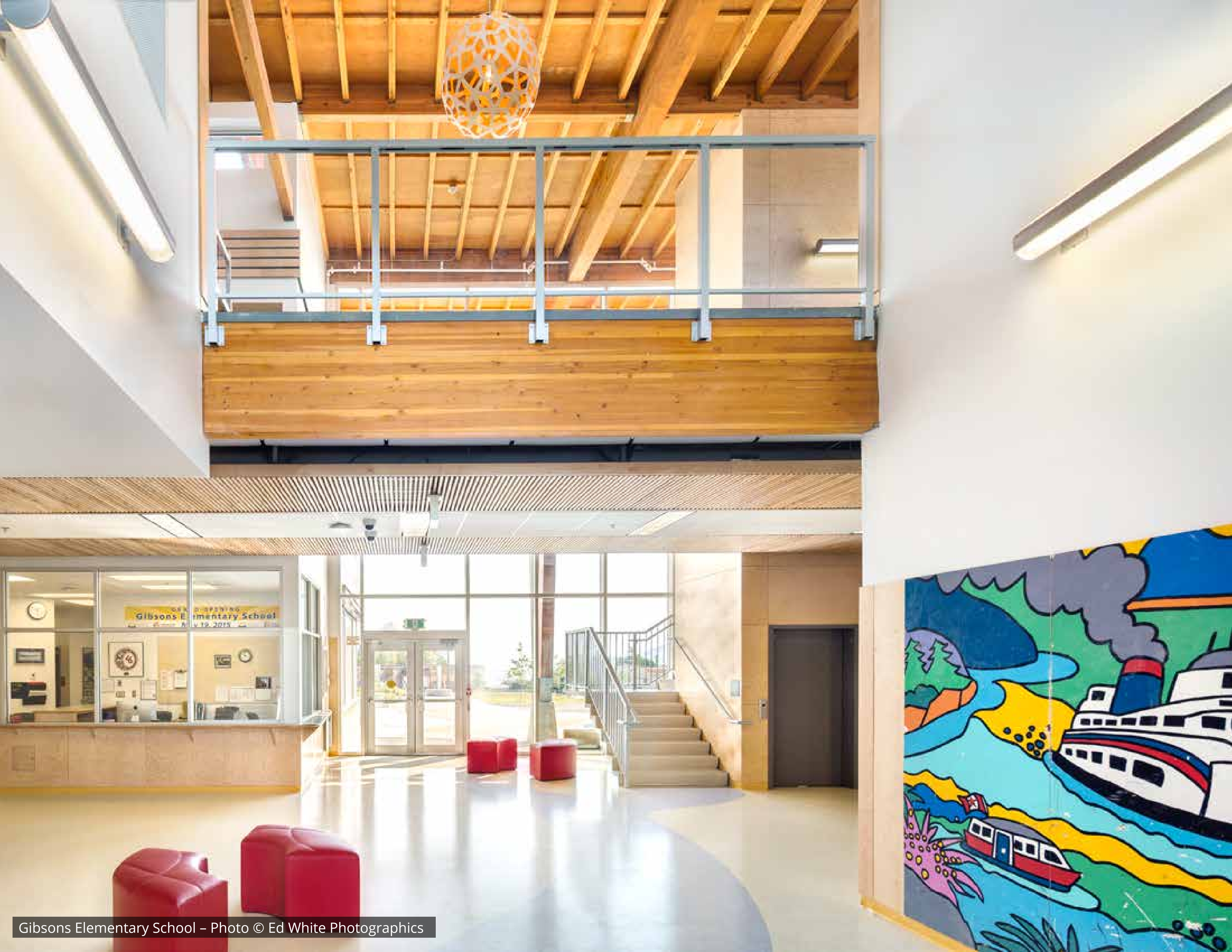

Gibsons Elementary School – Photo © Ed White Photographics

7. CONCLUSIONS

WOOD USE IN SCHOOLS HAS GROWN SIGNIFICANTLY SINCE THE FIRST VERSION OF THIS REPORT

The use of wood in schools has grown significantly in recent years. Advances in acceptance among the design community, technology, building code, governmental support, and appreciation for the use of wood have resulted in an even greater percentage of new school projects now having wood elements of varying sizes and scopes included in them.

WOOD IS A HIGHLY VIABLE OPTION FOR SCHOOL CONSTRUCTION, FOR A VARIETY OF REASONS

There are many benefits to using – and reasons for selecting – wood for school construction. It can be locally sourced from sustainable, renewable, and certified forests, which support the provincial economy and communities around British Columbia.

It is strong and durable, and easier to modify or renovate. It creates optimal learning conditions for children, as well as healthier spaces for teachers and staff.

Wood use in school construction can also lower the carbon footprint of a new building when compared to concrete construction.

Beyond that, many of the companies that are pushing the boundaries of wood design and construction are in British Columbia, meaning that school districts have ready access to homegrown technology that is leading edge, globally.

GOVERNMENT SUPPORT FOR WOOD USE IS GROWING

Provincial government support for using wood in new construction dates to the Wood First Act of 2009. Since then, the government has created various bodies, including the Office of Mass Timber Implementation and the Mass Timber Advisory Council, to drive the transition from high volume to high-value forest products, as well as support the integration of mass timber into mainstream construction.

Several government initiatives in recent years, most notably the Mass timber Action Plan, outline ways the provincial government will drive innovation in mass timber. One outcome of this plan will likely be that more school buildings will be steered towards timber construction.

Federal support for construction of the new Bayview and Begbie mass timber schools in Vancouver through Green Construction in Wood also marks a significant step towards wider acceptance of this construction method for education facilities.

HYBRID MASS TIMBER IS A VIABLE ALTERNATIVE

Hybrid mass timber is a viable alternative to both mass timber-only and concrete-and-steel construction.

It gives design teams the opportunity to create large-scale learning neighbourhoods thanks to the longer spans that are possible using mass timber beams and columns, while allowing alternative solutions to address with building code regulations that restrict the use of wood for certain types of building occupancies.

MASS TIMBER PRICING IS FLUID, BUT OTHER CONSIDERATIONS MAY OUTWEIGH COST

The Covid-19 pandemic had a significant impact on the cost of building materials (including lumber), which spilled over into the mass timber market.

Uncertainties in the cost of mass timber and fluctuations in market conditions have meant that some projects became more expensive than originally anticipated, forcing school districts to decide where their priorities lay.

In the case of Ta'talu Elementary School, the district decided that hybrid mass timber offered the best mix of desired elements and sustainability performance.

The long-term impact of these increasing costs remains to be seen, but the case for using wood in schools will likely shift from solely cost-base to include other factors.

THERE ARE NUMEROUS TANGIBLE, AND INTANGIBLE, BENEFITS TO USING WOOD WHEN BUILDING SCHOOLS

Wood, specifically mass timber, allows school designers to be flexible in their approach to layout, making it possible to create large learning neighbourhoods. Wood construction is generally faster than building with steel and concrete.

Wood also has biophilic properties that promote health and wellness among students, staff, and teachers. It supports and promotes a wide variety of cultural opportunities for First Nations.

The advantages of using wood are far ranging and undisputed. Taken together, the case for using wood in schools is compelling.

Maddaugh Elementary School – Photo © Upper Left Photography, courtesy naturallywood.com

WOOD MUST BE COMBINED WITH HIGH-PERFORMANCE, SUSTAINABLE BUILDING DESIGN AND CONSTRUCTION TO ACTUALLY SHOW SUSTAINABILITY BENEFITS

There are a number of environmental reasons for using wood, possibly including a lower embodied carbon footprint to build out of wood, as well as the opportunity to sequester carbon within the wood structure itself.

Life cycle assessment is crucial for the most accurate picture of the environmental impacts – positive and negative – of using wood products in buildings.

Furthermore, employing the fundamentals of building science are essential to create a sustainable building – using wood alone is not enough.

CHANGES TO THE BC BUILDING CODE LEAVE A GAP FOR ALTERNATIVE SOLUTIONS, WHICH DESIGNERS CAN LEVERAGE

The current version of the BC Building Code puts constraints on school buildings based on their size, and makes it more difficult to build wood schools over two storeys.

There is, however, a gap that can be filled by alternative solution(s) and design teams can use to create three- and possibly four-storey wood schools, provided they work with Authorities Having Jurisdiction to ensure that local code and safety requirements are met.

The single largest issue I see at this point [regarding broader adoption of mass timber] revolves around much of the industry and the public simply not understanding mass timber and how durable, versatile, and capable it is as a building product.
- Scott Comfort, CEO, Seagate Mass Timber

MASS TIMBER CAN PROVIDE AN ACCEPTABLE FRR WITHOUT ENCAPSULATION

Wrapping mass timber in drywall is one option to provide an acceptable fire resistance rating (FRR), but it is not the only one.

It is possible to factor in char rating and mass timber size to ensure fire safety in wood buildings. This can translate into significant cost and time savings compared to encapsulated (wrapped) mass timber structures, as well as allowing occupants to benefit from all the biophilic characteristics of the wood structure.

THE MASS TIMBER INDUSTRY IS RAPIDLY EVOLVING, MAKING MATERIALS MORE ACCESSIBLE, MORE AFFORDABLE, AND MORE TECHNOLOGICALLY ADVANCED

The mass timber industry is growing quickly as mass timber becomes increasingly popular and incorporated into more projects, both inside and outside the education sector. The increased demand means increased opportunities in the manufacturing sector, and new players are entering the market, giving designers and builders more options.

Along with that growth comes advances in both design and manufacturing, and ultimately better mass timber buildings for end users.

> *During the [team] selection process, it's important to choose a general contractor who's on board with using mass timber instead of concrete … This helps ensure collaboration and team cohesiveness.*
> ***– Julius Kettler, Beamcraft***

WOOD USE IN BOTH STRUCTURAL AND NON-STRUCTURAL APPLICATIONS BENEFITS STUDENTS, TEACHERS, AND STAFF.

Wood is used for both structural and non-structural applications in schools. Regardless of how it is being incorporated into schools, wood use – especially when the end product is left exposed to building occupants – provides numerous benefits that will make schools healthier, happier, more environmentally responsible centres of learning.

WOOD IN SCHOOLS IS HERE TO STAY, AND WILL ONLY BECOME MORE COMMONPLACE AS MORE PEOPLE LEARN ABOUT AND APPRECIATE ITS BENEFITS – BUT EDUCTION IS REQUIRED.

Government grants, school boards deciding that wood is good for their students and their environmental mandates, building code revisions that acknowledge wood as a viable option for multi-storey structures, environmental and sustainability benefits, improvements in technology and widespread acceptance of the use of wood in all building types – particularly schools – have all worked to secure wood's place in schools.

Expect to see more of it in the future as people become aware of how versatile this product can be.

Ongoing education efforts will be required, however, on the part of key industry players from the design, engineering, and manufacturing or installing sectors to push the boundaries when it comes to knowledge, acceptance and understanding of mass timber's capabilities.

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