2012 REFERENCE GUIDE:
Wood Use in Low-Rise Educational Buildings – Ontario

February 2012

Patrice Tardif Consulting for Ontario Wood *WORKS!*

Canadian Wood Council
Conseil canadien du bois

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Ontario Wood *WORKS!*

60 Commerce Court
P.O. Box 5001
Office W113
North Bay, ON P1B 8K9

Toll Free: 1 866 886 3574

wood-works.org

Cover Photo:
Robert Stefanowicz
Richmond Christian School, Richmond, BC

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Executive summary

Wood-frame construction is an important option for school buildings as well as an important choice toward meeting a sustainable future for Ontario. The facts behind this statement are demonstrated by first exploring how wood-frame construction addresses the three major components of sustainable development: what is best for the environment, what is best for the economy, and what is best for society. Factors that owners, funding partners and design teams must consider when developing a project will then be identified, above and beyond sustainability objectives. In practical terms, the impact of building code requirements, geography, and climate on budget and construction scheduling are explored.

Wood construction systems and their components available for use in low-rise school buildings in Ontario are introduced. Site-built and pre-fabricated options, including the innovative cross-laminated timber system, are explained along with the benefits that can be expected from each. The requirements of the Ontario Building Code (OBC) as they pertain to wood construction are elaborated upon.

All references to the Ontario Building Code are based on an extensive review of the OBC as it pertains to wood use in low-rise educational buildings undertaken by code experts Morrison Hershfield for Ontario Wood *WORKS!* Parts 3, 4 and 5 of the OBC were reviewed to identify pertinent conditions, limitations or restrictions. The report of their analysis is attached in its entirety as Appendix B *(page 33)*.

Unsprinklered one and two-storey school buildings up to 2,400 m^2 can be built entirely with wood construction systems, provided certain requirements are met; adding sprinklers to these buildings brings that maximum area up to 4,800 m^2. With the use of firewalls to compartmentalize a larger building into a series of connected smaller buildings, this maximum area can be considerably increased.

A requirement for non-combustible construction does not necessarily imply that school buildings must miss out completely on the benefits of wood construction systems, such as heavy timber roof systems or wood interior elements and finishes. There are also alternative options for complying with OBC requirements which allow for the use of developing wood technologies.

The importance of a wood construction system in terms of benefits to building users and to the environment is explored in detail. Beneficial attributes of wood as a building material include its renewability and its natural ability to capture CO_2 from the atmosphere and lock it away in its fibres; that it is sourced from sustainably managed Ontario forests; that manufacturing efficiencies result in a more responsible use of energy and reduced pollutants to the atmosphere when compared with other major building materials; these attributes all help to mitigate climate change.

The benefits of a wood construction system during the construction phase, in terms of material delivery times and optimized construction scheduling are also explored, along with benefits during the life of the building. Some of these benefits are a result of wood's natural thermal and acoustical properties; others, such as durability and adaptability, result from wood's natural properties combined with the correct use of the products. There are also less quantifiable though equally important effects, such as the warmth of a natural system and its impact on the learning environment. Five case studies, four schools across the country, and one in the United States, are included to help demonstrate these benefits.

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Introduction

Deer Lake Community School, Deer Lake ON Kindergarten – Grade 10
Photo: Smith Carter Architects & Engineers Inc.

The province of Ontario boasts an important inventory of publically funded school buildings – 4,900 of them. Elementary and middle schools account for 4,000 of these, with secondary schools making up the difference. These school buildings are owned by their respective school boards, of which there are over 70 across Ontario. Whether in downtown cores, the suburbs, small towns, or northern Ontario and First Nations communities, these buildings fulfill an important function – that of educating Ontario's future generations. Low-rise school buildings are the staple of communities, particularly in city suburbs and small towns throughout Ontario. They are often important to their neighbourhoods as a location for community activities and potentially even as post-disaster shelters.

Educational buildings need to respond to the rigors imposed by school and community activities; they must be built *within the budget*, and last as long as possible. To insure this, they need to be durable and adaptable to changing needs and shifting populations; they need to be easy and affordable to maintain; they need to make sense in the context of Ontario's building fabric and economic reality.

Wood-frame construction is an important construction option for school buildings as well as an important choice toward meeting a sustainable future. The Ontario Ministry of Education has itself revised school curricula to include environmental education in an effort to impart to its students the importance of sustainability concepts such as responsible stewardship.[1] In 2010, 7% of Ontario's total capital expenditures went to the construction of educational infrastructure.[2] Over $1 billion is slated for school improvements and capital projects over three years starting in 2011. It will be important to insure the best use of those funds in the creation of sustainable learning environments for Ontario's students. The use of wood construction systems in school buildings is a means to that end.

Buildings Covered by this Guide

This guide has been prepared particularly with low-rise school buildings in mind, that is to say elementary, middle and secondary schools found throughout Ontario. It was not prepared with university buildings in mind, per se, although much of the information contained herein is applicable to low-rise school buildings found on university campuses. In fact, the information is applicable to a broad range of low-rise educational buildings, including those found in remote communities which serve multiple functions, such as schools with combined community centres or adult education complexes and municipal libraries. Informed decisions on construction systems for these and other buildings start with an understanding of the underlying theme in any present-day endeavour, sustainable development.

Haliburton School of the Arts, Fleming College, Haliburton, ON
Photo: Diamond & Schmitt Architects Inc.

1 Ontario Ministry of Education, Shaping our Schools, Shaping our Future, 2007
2 Statistics Canada data, February 2011.

Sustainable Development

One cannot make any decision in today's business climate without taking into consideration the concept of sustainable development, which considers the use of resources for human consumption in such a way as to insure ample resources for future generations.[3] The importance of sustainable development in the context of making decisions on construction systems is made all the more significant when considering the fact that 50% of all resources taken from nature are used in the construction of the world's structures.[4]

True sustainable development requires making decisions that consider three important aspects, often referred to as the triple bottom line of sustainable development: what is best for the environment, what is best for the economy, and what is best for society. Wood-frame construction addresses all three of these components.

Brittney Dawney, Queen's University Student
Photo: The Working Forest

What's best for the environment?

What's best for the environment in the context of constructing low-rise school buildings? The responsible use of resources is one obvious answer. Responsible stewardship tenets espoused by Canada's education sector recommend the use of renewable resources whenever possible.[5] Wood is the only major renewable resource used in construction systems.

Nearly 90% of Ontario's forest land is Crown land (publically owned). All Crown forestland is required to be sustainably managed according to the 1994 **Crown Forest Sustainability Act**,[6] thereby assuring the "protection and sustained use" of Ontario's forest lands. This insures a healthy and viable forest resource for future generations.

It is also important to consider the impact of buildings on the natural environment, often referred to as *environmental footprint*. When considering the environmental footprint of materials manufactured for use in the construction of buildings, wood products have been scientifically shown, using life cycle assessments,[7] to yield clear advantages over other construction products. More environmental benefits from the use of wood can be found in the section entitled ***The Benefits of Wood Buildings*** *(page 14)*.

Mar-Span Truss Inc., Drayton, ON
Photo: Steven Street

What's best for the economy?

What's best for the economy in the context of constructing low-rise school buildings? There is no argument that insuring a healthy and sustainable economy in any region requires the validation of local industry. Ontario's forest sector is a key component of the province's economy, valued at $12 billion. Statistics from 2009 show that nearly $3 billion of this amount is attributed to lumber, engineered wood and other manufactured products, and another $1.8 billion to the value-added sector, which includes such products as furniture and cabinet manufacturing.[8] Making use of local industries and their products in the construction of school buildings keeps the Ontario economy strong.

3 Development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" is the definition coined by the Brundtland Commission. See the United Nations **Report of the World Commission on Environment and Development**, General Assembly Resolution 42/187, 11 December 1987.
4 Source: United Nations Environment Programme
5 Ontario Institute for Studies in Education, **Climate Change & Sustainable Development: The Response from Education in Canada**. 2009
6 The Act requires that Ontario's forests be managed as per the **Forest Management Planning Manual** (2009) which lists forest sustainability as the primary objective of forest management.
7 A scientific measure of the environmental impact of a product throughout its entire life.
8 For more information, go to **Ontario Wood**.

What's best for society?

Microtel Inn & Suites, Parry Sound, ON
Photo: **Henry B. Lowry**

What's best for society in the context of constructing low-rise school buildings? For a strong society, people need to be engaged – both at work and at home. When local industries are not validated, the result is a workforce that migrates out of our communities thereby eroding the very fabric needed for a strong society. The Ontario forest industry supports more than 200,000 direct and indirect jobs in over 260 Ontario communities.[9] Of these communities, 40 depend primarily on the forest sector for their survival and another 63 would be severely affected should it disappear. The use of local industries in the construction of school buildings not only keeps the Ontario economy strong, it employs its citizens and helps to create the strong communities that are needed to sustain Ontario's society.

Deciding on the Construction System

Sustainable development tenets help to direct the decision making process, but many other factors must be considered when embarking on the design of a building, any one of which could impact on the decision of construction system.

Regulatory Considerations

Of paramount importance when entertaining a construction project are the requirements of local building codes. In Ontario, buildings must meet the requirements of the 2006 Ontario Building Code (OBC).[10] Low-rise educational buildings fall under the Assembly Occupancy, Group A – Division 2 of the OBC. The construction system chosen must assure the safety of students, teachers and the public as they move through the building.

The minimum requirements set out in the OBC for safety in buildings help project owners and designers determine what construction systems are appropriate and allowable. There are two methods for complying with OBC requirements, either through acceptable solutions as defined in the main part of the code, Division B, or through alternative compliance paths. In using the latter method, solutions proposed must be shown to meet the intents of the acceptable solutions outlined in Division B. All aspects relating to permissible structural wood use in educational buildings are elaborated upon in the section entitled ***Wood and the Ontario Building Code*** *(page 10)*.

Geographic Considerations

Where a school building will be located may affect the choices that need to be made with respect to a construction system. Construction materials are typically more readily accessible and quickly delivered in urban centres, no matter what the construction system chosen. For areas at a considerable distance from major urban centres or far north, however, modes of transportation and timelines for the delivery of materials, and the availability of local labour, can have an impact on a project.

Whether delivered by road, rail, water, or as is the case with the far north, ice roads during the winter months, material delivery can affect the construction schedule of a school building. The facility of sourcing and working with wood construction systems has proven that it is often quicker and easier to build with wood, regardless of the season or the location, even in those locations where the construction season is shorter and colder temperatures prevail. In addition, local labour capable of erecting wood structures can be found in all regions of the province.

Certain geographical characteristics which could potentially affect construction system choices for a project include soil properties and the importance of seismic activity in the area. The weight bearing capacity of the soil in certain areas can dictate the height of a building and the area it can occupy; it can even preclude the

9 Ibid.
10 The **Ontario Building Regulation 350/06**.

Angus Glen Community Centre – Aquatics Centre, Markham, ON

Even at an RH of 80%, the moisture content (MC) of wood products remains well below the MC that would result in mould growth or decay. Unlike other materials, wood is not affected by water purification chemicals used in pools.

Photo: A-Frame Studio

use of heavy construction systems. Areas subjected to seismic activity have an important impact on the requirements imposed on structures as well, particularly the engineering details. Lightweight, flexible wood construction systems provide the optimal solutions in myriad applications, especially when faced with such complex circumstances.

Budgetary Considerations and *The Program*

It is primarily the budget that determines the scope of any project. The choice of construction system, the complexity of the design and the time needed for its completion will be in large part dictated by budgetary considerations. The program of a school building, however, can be quite predictable.

Whether publically or privately owned, most school buildings must meet a very similar program. All need classrooms, auditoria, cafeterias and often a kitchen; they need gymnasiums, lockers, washroom facilities, and administrative offices, including staff quarters; there are often libraries and laboratories associated. Specialty schools could require more specialized spaces such as sound insulated music practice studios or dance studios, or even pools or hazardous material laboratories.

School buildings often need to accommodate the public, whether during a sports event, for recitals or for various community activities. Certain sports programs in secondary schools may require large indoor arenas, e.g. for football, soccer or hockey. The beauty of a wood construction system is its ability to meet the needs of smaller spaces, such as classrooms and offices, combined with its flexibility to accommodate the needs for uses requiring larger spans, such as gymnasiums or arenas.

What should not be ignored are operating and maintenance costs once the building is delivered. Although not a part of the construction budget, the building design and materials choices have a direct impact on how a building will "age." The costs associated with the maintenance and repairs for a building once it is in use can be optimized by making the right materials choices up front.

Richmond Christian School, Richmond, BC

Wood construction systems have the flexibility to meet the needs of smaller spaces as well as the clear-span requirements of larger spaces.

Photo: Robert Stefanowicz

The Design / Construction process

Construction systems are typically chosen early in the design phase of a project. The decision made may be based on a recommendation from the architect or it may be dictated by the client. The program, including all the potential uses of schools buildings, is also a big factor in the choice of construction systems. School buildings accommodate a lot of people, consistently, probably more than in any other type of facility. Movement through the building must be optimized and the necessary sight lines created to assure the safety of users, whether students, teachers or the public, no matter what the activity.

Design teams must take into account all potential uses of a school project in the context of the budget, the building code, the proposed location of the building and when delivery is needed. The decision on which construction system to use must be made early in the process as that decision will have consequences for the design itself, as well as on construction scheduling and the allocation of funds to different aspects of the project.

Material delivery lead times and how many trades may be needed on a site will have an effect on construction scheduling and costing. Longer lead-times for material deliveries engender greater risk for falling prey to price fluctuations. The coordination of numerous trades on a site has the potential of severely complicating construction scheduling. The season or seasons during which the project will be undertaken will impact on site protection needs and energy costs during construction.

All things being equal, even if the cost of the materials for two different acceptable construction systems were equal, inherent material properties can have an impact on the funding allocation to different aspects of a project. The weight of a system is a good example. Heavier superstructures require more robust foundations and footings than lighter superstructures. Extra time is needed for added reinforcement in the more robust foundations; added materials and more time lead to added costs. The extra funding needed for the foundations to support the superstructure must be taken from another aspect of the project.

The construction system chosen can actually have a positive effect on construction scheduling. Pre-fabricated wood construction systems described in the next section can reduce construction times and lead to significant savings. Heavy timber systems, also described in the next section, can be left apparent and hence reduce the time and costs required for finishing materials and future maintenance.

The quicker a project is completed and the building occupied, the more positive is the impact on the budget.

The quicker a project is completed and the building occupied, the better it is for the owner's pocketbook, yet choices made before construction even starts will have an impact on the building's use, such as the replacement of materials over time, the ease of maintenance and operating energy costs. Design considerations need to take these factors into account when making a choice of construction system as durable choices will lead to long-term benefits long after the construction phase is completed.

Wood Construction Systems for Low-Rise Educational Buildings

There are several options to consider when choosing a wood construction system. Whether a light wood-frame, heavy timber, pre-fabricated or other specialty system is chosen, the structural design values of each product is established by the design standard for wood construction, CAN/CSA-O86, *Engineering Design in Wood*, as cited in Section 4.3 of the OBC, *Design Requirements for Structural Materials*. Each wood construction system is comprised of wood elements or systems that are assembled in such a way as to meet the requirements set out in the OBC. Individual elements are governed by product-specific standards, most of which are also cited in the OBC.[11]

Structural Wood Products

Structural wood products can be divided into several categories, each with their specific characteristics.

Structural Wood Product Categories

Category	Definition	Examples/Uses
Dimension Lumber	lumber elements that are no less than 38 mm and no more than 102 mm in their smallest dimension	studs, joists, rafters, decking or planks
Non-Proprietary Engineered Wood Products	products having undergone processes which impart enhanced or more predictable properties for which recognized standards are cited in building codes	glued-laminated timber (glulam), plywood, oriented strand board (OSB), light-frame trusses
Proprietary Engineered Wood Products	engineered wood products that require additional testing to demonstrate compliance[12]	I-joists, parallel strand lumber (PSL), laminated veneer lumber (LVL), cross-laminated timber (CLT), laminated strand lumber (LSL)
Heavy Timber	lumber elements or engineered wood products (such as glulam, PSL or CLT) that are no less than 140 mm in their smallest dimension	columns, beams, heavy timber trusses; wall, floor or roof slabs (CLT)

11 Standards for wood products used in environmental separations can be found in Division B, Section 5.10 of the OBC. Other standards referenced throughout the OBC are also cited in Section 1.3., *Referenced Documents and Organizations*.

12 Compliance is typically sought through the evaluation service of the Canadian Construction Materials Centre (CCMC).

The various products listed above, among others, are used in combination to detail wood construction systems and are all readily available in the Ontario marketplace. Engineered wood products (EWPs) are the result of advancements in manufacturing technologies and merit a special introduction. They represent an efficient use of resources as they use more of the tree and can use smaller, faster-growing trees, even species that wouldn't typically be used in structural applications. With excellent dimensional stability and load-carrying capacities, EWPs can span longer distances than similarly sized elements in dimension lumber and, since they are manufactured to a specific size, site waste is reduced. EWPs are increasingly prevalent components in wood construction systems.

Wood Construction Systems

The particulars of a project identified prior to and during the design phase may point to one construction system over another. There are several wood construction systems to choose from that meet the needs of most, if not all, low-rise school buildings. While it is true that buildings can be built using only one construction system, more often than not combinations of the following systems form the basis for design solutions.

Timmins Library, Timmins, ON
Light wood-frame construction
Photo: Claude J. Gagnon

Light Wood-Frame Construction

Light wood-frame construction is defined by the use of small wood members (typically dimension lumber framing elements, I-joists and pre-fabricated wood trusses) that are relatively closely spaced, in combination with sheathing or decking, a combination which provides the strength and rigidity needed for the structure to withstand loads and forces. This economical system's success in the North American housing industry is well accepted. Its strength and flexibility, however, make it suitable for much larger construction projects.

There are two principal approaches to light wood-frame construction; the more commonly used platform framing and the seldom used balloon framing. With platform framing, floor assemblies are built separately from wall assemblies. With balloon framing, vertical load-bearing elements are continuous from the top of the basement wall to the underside of the roof structure. Both systems use elements that are easy to handle and which create a space for the installation of insulation, as well as sturdy surfaces for the application of exterior and interior finishing materials. Pre-fabricated wood trusses used for roofs with these construction systems allow for an endless variety of roof forms. Major advantages to consider with light wood-frame construction include: the availability of a very experienced work force in virtually every corner of the province, shorter lead-times for materials and a better buffer against cost fluctuations.

North Bay Regional Health Centre, North Bay, ON
Heavy timber roof in a non-combustible building
Photo: Ed Eng

Post and Beam Construction

Post and beam construction, often referred to as heavy-timber construction, is defined by the use of heavy timber elements that are spaced far apart, thereby creating large, barrier-free spaces. These elements can be joined using traditional wood to wood joinery, although to achieve higher capacity connections mechanical metal connectors can be installed (either exposed or concealed). The construction method for roof and floor systems in heavy-timber construction is similar in arrangement to steel construction, using various levels of wood elements to create the planar surfaces.

One of the beauty's of post and beam construction is just that, its beauty. The structure can be left exposed thereby acting as the construction system *and* the finishing system at the same time. There is no need to bring in drywall and other finishes which can result in significant cost savings. Another advantage includes the obvious ability to create large clear spans, as are needed in gymnasiums and auditoriums. The space created is also easily adaptable when flexibility is needed. Should a school's needs change, partitions can be added or removed and repositioned without needing to modify the structure.

A significant advantage of a heavy timber construction system lies in its inherent ability to remain structurally intact for a certain period when exposed to fire. It is for this reason that model building codes, like the OBC, accord fire resistance ratings (FRR) to large wood elements that meet the heavy timber minimum size requirements, without any additional treatment. This fact actually allows for the use of heavy timber roof systems in certain buildings required to be of non-combustible construction. This will be expanded upon in the code section of this document.

Microtel Inn & Suites, Parry Sound, ON
Factory-built panelized wall systems allowed framing to be completed in 60 days without compromising quality, consistency or cost effectiveness.
Photo: Henry B. Lowry

Pre-manufactured and Pre- fabricated Construction

Components or systems that are constructed off-site in controlled environments are referred to as *pre-manufactured* or *pre-fabricated*. These construction techniques result in reduced exposure to rain, snow, and excessive heat or cold, not only for the materials but for the workers as well, and also result in enhanced detailing. On site, waste is reduced and there is a greater control over the construction schedule.

Engineered wood products (EWPs) are technically pre-manufactured elements; they have become staples in wood construction. Products such as I-joists, glulam, LVL and light wood-frame trusses are made of smaller elements that are fashioned together in a manufacturing setting under very controlled conditions which impart to those products the very properties that they are revered for: dimensional stability, increased strength to weight ratios, and ease and speed of erection, with very little waste since they require only minor adjustments on site.

Pre-manufacturing taken to the next level, that of pre-fabricated systems, results in some of the self-same benefits as those found with EWPs, only on a larger scale. Pre-fabricated systems are quicker and easier to install which often results in an earlier occupation date. Entire buildings can be built using one pre-fabrication technique, or a combination of standard framing practices, pre-manufactured components and pre-fabricated systems can be used. The nature of a project's particularities will help to identify optimum solutions.

Panelized Systems

Complete walls, floors and roofs can be pre-fabricated or *panelized* in a controlled environment. These pre-fabricated systems are essentially light wood-frame construction with all of its benefits – light-weight, easy and quick to install, economical – taken in out of the rain. Weather is eliminated as a factor to contend with so quality control and detailing are enhanced. Panelized components can be fabricated to virtually any size or shape thereby creating a limitless potential for architectural expression.

5-Storey Apartment Block
Pre-fabricated floor system installation
Photo: Boise Cascade EWP and Carronvale Timber Frame

Winter Games. 2010 Olympic Legacy Affordable Housing Program:
Initial Use: Whistler Village Temporary Accommodations. Single-storey modules, each containing 3 to 4 bedrooms, hotel style, were combined and assembled to house officials during the 2010 Olympic and Paralympic games.

Once panelized components are delivered on site, they can be swiftly lifted into place and assembled. Work then progresses much as on any conventional construction site, only the building can be closed and protected nearly from the onset. This has a big impact on the moisture exposure for the building during construction but also addresses another common problem on construction sites – the theft of materials. Since panelized components are pre-fabricated off-site, there is no need to stockpile construction materials on-site and organize for their protection, either from the weather or from looters.

The use of panelized components succeeds in condensing the time needed on the construction site. This can have a positive impact on a project's financing costs and can also speed up building occupation.

Modular Systems

Pre-fabrication can be taken to yet another level, that of whole systems, thereby maximizing the benefits of a controlled environment, such as better quality control measures for environmental separations and improved construction detailing. These systems are pre-fabricated entirely off-site and delivered as completed *modular* units. These units will define the architectural character of a building and can be combined into any configuration. Modular systems were perfected in the housing industry but now the non-residential sector is benefiting from the expertise that was developed.

By their very nature, modular systems lend themselves to phased construction. Units come complete with rough wiring and plumbing installations, plus the outside walls bear all the loads so the interior spaces are ultimately flexible. Each unit can be self-sustaining and construction can proceed in stages. Another benefit is the ability to reconfigure the units for change of use at a future date. An example of this is the temporary accommodations provided for athletes, officials and team representatives at the 2010 Olympic Winter Games in Whistler, BC

Second Use: Permanent Social Housing Facilities (Surrey Social Housing)
Single-storey modules were disassembled and relocated following the Olympic Games to six BC communities where they were reconfigured to form six different housing projects, from 1 to 4 storeys in height.
Photos: WEQ Britco LP

Modular systems are particularly suited to short timelines or to areas where labour is difficult to find. In remote communities where the delivery of materials is a challenge and labourers are at a premium, time and ease of erection are of utmost importance. In the far north, foundations can be built during the summer season and modular units brought in once the ice roads are operational. Very little time is needed on-site; once the foundations are in place, the modular units are simply installed, electrical and plumbing services are hooked up and finishing can commence; quick installation and finishing means quicker occupancy.

The newest and possibly the most innovative pre-fabricated system uses cross-laminated timbers. This system is described in the following section.

Cross-Laminated Timbers

Cross-laminated timbers (CLTs) are an innovative wood product developed in Europe during the last two decades and now available and manufactured in Canada. They are composed of alternating layers of boards (typically from 3 to 7) stacked at 90º to each other, much as plywood veneers are, and subsequently either glued together or mechanically fastened to form large panels. Panels are available in various thicknesses up to 245 mm, and up to 3 m high and 15 m long. They are combined to form the basis of a pre-fabricated building system.

Due to the nature of the manufacturing process, CLTs have improved dimensional stability with increased strength and stiffness in both directions, giving the panels a 2-way action much like is found with pre-stressed concrete slabs, only with less weight. CLT panels are used as wall, floor and roof slabs. The typical benefits of pre-manufacturing combined with CLT systems' particular advantages, such as good thermal and sound insulation and excellent behaviour under seismic loading, create a fast and effective building system with immense possibilities. CLT buildings have already been built in England in record time with minimal site waste.

Open Academy, Norwich, England
The CLT structure for the 3-storey Open Academy building was erected in 17 weeks and saved the program 18 to 20 weeks overall. The sports hall was erected in 4 days.
Photos: Ramboll UK (left) and Kier Eastern (right)

With a CLT construction system, all major structural aspects are completed before the panels arrive on site. Computer controlled precision using Computer Numerical Controlled (CNC) machines for cutting openings in wall components makes it possible to start installing doors and windows as soon as the panels are assembled and levelled, thereby greatly reducing the operational time of the construction site. In addition, since no concrete works are needed after the foundation is poured, work during the winter months is facilitated. With a CLT construction system, site waste is reduced to a minimum and building occupation is timely.

Several CLT buildings have already been built in Canada and several are under construction in various jurisdictions across the country; all used the alternative compliance path of the pertinent building codes. Code and standard provisions are currently under development for CLT in Canada based on the European experience and extensive Canadian research.

Permanent Wood Foundations

Permanent wood foundations (PWFs), referred to as "preserved wood foundations" in the OBC, are a complete load-bearing wood-frame alternative for foundations in low-rise light wood-frame construction. They can be used for full basements or when only a crawl-space is required. PWFs, whether site-built or pre-fabricated, use pressure treated dimension lumber and plywood panels for their fabrication.

Elkford Community Centre, Elkford, BC
The first commercial application of CLT tall wall panels in North America.
Photo: Associated Engineering Ltd.

PWFs are installed on a granular drainage layer which results in improved moisture control around and beneath the foundation with no need for drainage (weeping) tiles. In addition, the moisture barrier detailing used contributes to a dry interior which can be easily insulated for maximum energy savings. The floors for basements using PWFs are typically pressure-treated wood floor systems or concrete floor slabs.

PWFs provide a cost-effective alternative for foundation systems in conjunction with light wood-frame construction systems. They are easily installed in winter and, since only one trade is required on-site, construction scheduling is more efficient. PWF materials can also be easily transported, making this form of foundation a good choice for remote communities. Proper detailing is of paramount importance, however, and the expertise of installers must be assured. A reference book entitled *Permanent Wood Foundations* is available from the Canadian Wood Council.

Technical Resources

The **Canadian Wood Council** (CWC) has been Secretariat to the CSA-O86 Committee responsible for maintaining and updating the wood design standard since it was first developed in the 1950's. The CWC develops technical information related to the design and construction of wood structures in Canada and produces technical publications as well as design software to assist the design community in detailing wood components and construction systems. **Ontario Wood *WORKS!***, an industry-led CWC initiative, has technical personnel available to assist owners and design teams in realizing wood construction projects in the non-residential construction sector in Ontario. The Wood *WORKS!* team provides information on wood and wood use in buildings through workshops, seminars and case studies.

Wood and the Ontario Building Code

All school buildings fall under the Assembly Major Occupancy classification in the OBC, more precisely, under Group A, Division 2.

The *Ontario Building Code* (OBC) governs the design and construction of buildings, including school buildings, within the province of Ontario. Aspects of the OBC that are pertinent to wood use in structural applications for low-rise school buildings are explored in this section. The Morrison Hershfield (MH) report entitled *Use of Wood in Educational Buildings – Application of the Ontario Building Code*, Appendix B *(page 33)*, provides more detailed information on intent of the OBC requirements as regards the use of wood in school buildings. For definitive information, refer to the OBC documents.

The current iteration of the OBC, with pertinent amendments to date, came into force December 31st, 2006; it sets out the minimum requirements pertaining primarily to health, safety and accessibility issues for buildings and their use. All school buildings fall under the *Assembly Major Occupancy* classification in the OBC, more precisely, under Group A, Division 2 – *Assembly Occupancies not Elsewhere Classified in Group A*. The parts of the OBC governing wood use in Group A, Division 2 school buildings, whether a new building or an addition to an existing building, fall under the following sections:

- **Part 3:** *Fire Protection, Occupant Safety and Accessibility*;
- **Part 4:** *Structural Design*; and
- **Part 5:** *Environmental Separation*.

Renovations and modifications to existing school buildings are handled slightly differently. The extent to which Parts 3, 4 and 5 govern such works is defined in Part 11 of the OBC, *Renovations*.[13]

School Buildings Allowed to be Built Using a Wood Construction System

Part 3 of the OBC lays out the governing factors for the admissibility of wood construction systems in Group A, Division 2 school buildings. These factors deal primarily with the size of the building (building area) and the number of storeys (building height), as well as street access [14] for firefighting and whether automatic sprinkler systems are installed. The incidence of basements and/or mezzanines also has some repercussions on the minimum requirements. The requirements for fire-resistance rating (FRR) of any major assembly (floors, walls, roofs) will be as a consequence of these various factors.

Since wood products fall under the OBC definition of *combustible* materials, i.e. products that do not meet the requirements of CAN4-S114, the *Standard Method of Test for Determination of Non-Combustibility in Building Materials*, combustible construction requirements elaborated upon in the OBC shape the use of wood products as primary structural components in school buildings. This being said, when non-combustible construction is required, the OBC does not preclude the use of combustible components outright, as the terminology might suggest.

Combustible construction allows for the unlimited use of structural wood framing as well as wood-based interior finishing, exterior cladding, and partitions or blocking materials provided certain requirements are met, such as specified levels for flame spread ratings. Many combustible elements are allowed in non-combustible buildings as well, provided certain requirements are met. Some of these permitted elements are not limited in their use, such as finished flooring and millwork.

13 Part 11 of the OBC was not evaluated in detail for this document.

14 A *street* is defined by the OBC as a highway, road or other type of thoroughfare that is at least 9 m wide and is accessible to "fire department vehicles and equipment."

Combustible Construction Requirements

Individual school buildings are permitted in combustible construction up to 2,400 m^2 for an unsprinklered building, and up to 4,800 m^2 for a sprinklered building, with relevant conditions and requirements. According to the OBC, however, buildings with a larger footprint area can be divided into separate portions or *compartments*, with each compartment being considered as a separate building, through the use of firewalls. This allows each of the resultant buildings to be considered independently. If the area of the resultant *buildings* meets the area requirements for combustible construction noted above, each can be built using wood-frame construction.

Fire-resistance ratings (FRR) are sometimes required for major assemblies. The maximum FRR for such assemblies, when required, is 45 minutes. Heavy timber construction can be substituted for any such fire-rated assembly. Floors above basements, and their supports, always require a minimum 45-minute FRR, and fire-retardant treated wood roof assemblies are allowed in unsprinklered school buildings in lieu of a 45-minute FRR for the roof assembly when certain height and area limits are met. Unsprinklered buildings require firefighting access to be provided from 1 to 3 facing streets, depending on their size. For sprinklered buildings, the principal entrance is required to be within 15 metres of a street or access route without any other facing street requirements, no matter what the size of the building.

Aside from the major occupancy requirements affecting permissible building size and FRR requirements, the OBC includes other provisions intended to limit the spread of fire in buildings. For example, whenever non-combustible fire separations are used to compartmentalize a combustible building into smaller area units or to separate major occupancies, combustible construction elements that abut or are supported by the fire separation must not compromise the structural integrity of the fire separation under fire conditions. Foamed plastics used in buildings, typically in the form of insulation, require thermal barrier protection if they would otherwise be exposed to an occupied space. Certain wood-based panels, such as plywood and oriented strand board (among others), can be used for such protection in buildings permitted to be of combustible construction.[15]

The OBC includes detailed requirements for fire stops or blocks in partition walls and fire-retardant treatment of various elements. There may be restrictions on combustible projections to the exterior depending on site conditions, and the fire-protection ratings of wood fire doors are dependent on building height and/or the FRR of walls or partitions in which they are installed. Flame-spread ratings of interior finish materials are specified for all finish materials to be used on walls or ceilings in a building. Nearly all wood products used as finish materials meet the maximum flame spread rating requirements.

Details on the above-mentioned requirements as well as requirements for minor components are outlined in the MH report *(page 33)*; the definitive reference is the OBC.

Individual school buildings are permitted in combustible construction up to 2,400 m² for an un-sprinklered building, and up to 4,800 m² for a sprinklered building, with relevant conditions and requirements. Constructing firewalls between such buildings of combustible construction, when joined together, allows for even larger schools to be built using wood-frame construction.

Non-Combustible Construction Requirements

Non-combustible construction, according to the OBC, refers to a type of construction that uses "non-combustible materials for structural members and other building assemblies." Notwithstanding, many wood components or systems are permitted in buildings required to be built using non-combustible construction systems. Worthy of specific mention is the permissibility of using a heavy timber roof system along with its supports (e.g. columns and beams) in any building, regardless of construction type, that is no higher than two storeys and is sprinklered (with certain provisos). Ground-level open walkways projecting from or between non-combustible buildings are also permitted in heavy timber (with certain provisos).

All building materials have restrictions placed on their use by the OBC. In the case of wood components or systems in non-combustible construction, their use is sometimes restricted by building height, the minimum dimension of a component element and the importance of the immediate area of its intended

According to the OBC, one and two-storey schools required to be of non-combustible construction can use heavy timber construction for the roof system and its supports if the building is sprinklered.

15 Wood-based panel thermal barriers must pass a standard fire test for at least 10 minutes in order to be allowed to protect foam insulation used in non-combustible construction.

The Royal Conservatory, Koerner Concert Hall, Toronto, ON
Wood interior finish in a non-combustible building
Photo: Tom Arban Photography

use as a means of egress. Use can also be affected by whether the building is sprinklered and pertinent fire-protection and fire-resistance ratings of adjacent building elements, as well as by distance to the property line. There are flame-spread rating requirements for interior finishes, walls, ceiling and sometimes floors, among other specified restrictions. Most wood finish materials can meet flame-spread rating requirements for walls and floors. The restrictive flame-spread ratings for ceilings limit the use of wood ceiling finishes, however, and often require the use of fire-retardant treated wood.

The following combustible elements are permitted in non-combustible school buildings, as are various minor components (not listed here), with restrictions as specified in the OBC and outlined in the MH report:

- **interior uses:** partitions, fire-stopping in wall assemblies, doors, finished flooring, stage flooring, raised platforms (need fire-stopping) and their subfloors, wall and ceiling finishes, wood trim and millwork;
- **roof systems:** roof sheathing and supports, roof shingles, and other roof shakes and components such as cant strips and nailing strips;
- **exterior uses:** exterior fire-retardant treated cladding, window frames, wood canopies over building entrances, walls and ceilings of exterior exit passageways, heavy timber projections.

It is important to understand all requirements for the permissible use of the combustible elements mentioned above. Detailed requirements can be found in the MH report, Appendix B *(page 33)*; the OBC is the definitive reference.

Structural Requirements for a Wood Construction System

Part 4 of the OBC lays out the requirements for the structural components of buildings in order to assure their capacity for resisting expected loads and effects for their intended use and occupancy. The design loads are based on geographic location and exposure effects such as climatic conditions or seismic potential; they are not material specific. All buildings, no matter what construction system is used, must be designed to meet the same design loads. Each of the major building materials (wood, concrete and steel) is governed by a material-specific design standard – for wood, that standard is CAN/CSA-O86 *Engineering Design in Wood*.

In the case of a major event when people must leave their homes, school buildings are often used as post-disaster centres. For this reason, elementary, middle or secondary schools are classified under the High Importance Category in the OBC. This category requires that buildings be designed to withstand higher loads than would buildings classified under the Normal Importance Category. This holds true no matter what construction system is used.

The OBC has specific requirements for the use of construction materials, including wood, as components in seismic force resisting systems. Shear walls may have height and width restrictions imposed based on

Laurentian University – Vale Living With Lakes Centre, Sudbury, ON
Exterior wood cladding
Photo: Terence Hayes Photography

the building type, the seismic considerations and the resistance required. Typically, wood construction systems are not limited by seismic considerations in 2-storey buildings and often demonstrate superior performance, even in higher structures, when subjected to such forces.

Certain specialty structural wood products are allowed by the OBC. Preserved wood foundations (PWF) are permitted for buildings using light wood-frame construction. Treatment of the materials in the PWF system must follow the requirements of CSA-O80 Series *Wood Preservation*.

Environmental Separations

Part 5 of the OBC lays out the requirements for building elements or systems that are used to separate different environments to which a building might be subjected. These elements and systems are referred to as environmental separations. Examples of such elements are wall or roof systems, and doors and windows that separate the inside environment of a building from the outside; or wall and floor systems that separate different major occupancies within the same building. The requirements deal primarily with the migration of heat, air or moisture through these separations.

All wood products used in environmental separations, along with their method of installation, must meet the applicable standards specified in the OBC under Section 5.10 *Standards*.

Alternative Solutions

As previously mentioned, there are two acceptable methods for complying with OBC requirements. Division B defines *acceptable* solutions. The second option, through alternative compliance paths, is a project-specific option. Each option is equally valid to demonstrate compliance to the objectives of the OBC. Division C of the OBC contains information on documentation requirements for submission of an alternative solution for consideration.

For an innovative or a proprietary wood product or process to be accepted for alternative compliance as it relates to structural design, the requirements of CAN/CSA-O86 Clause 13, P*roprietary Structural Wood Products – Design*, and Clause 14, *Proprietary Structural Wood Products – Materials and Evaluation*, must be met and acceptance granted by the authority having jurisdiction.

Édifice Fondaction CSN, Quebec City, QC
The only 6-storey office building of post and beam construction in North America, allowed using the alternative compliance path of the National Building Code of Canada.
Photo: Gilles Huot architecte

Clause 13 of CAN/CSA-O86 outlines how to demonstrate an equivalent level of performance when compared with the acceptable solution outlined in Division B. This includes demonstrating that the product meets the requirements of OBC Part 4, *Structural Design*, as well as the pertinent sections of CAN/CSA-O86. The equivalence of a proposed solution is predicated on the following: the solution must be shown to meet the requirements of a recognized standard, it must subscribe to on-going re-evaluation and quality control activities that demonstrate consistent compliance, and it must adhere to an independent third-party quality assurance program.[16]

Clause 14 of CAN/CSA-O86 applies to the derivation of design values for proprietary structural products based on applicable standards. The design values derivation methods are directed at manufacturers and their engineers to provide assurance that the proprietary design values are consistent with the intent of Part 4 of the OBC.

The Morrison Hershfield report (Section 4.2.1 *page 49*) outlines a successful alternative solution application in another jurisdiction for an exterior cladding product. It is a practical example of compliance strategies and the limitations that may be imposed to confer acceptance. A hypothetical alternative solution for demonstrating compliance to flame-spread ratings of interior finishes is described to demonstrate the various strategies than can be employed to demonstrate compliance (Section 4.2.2 *page 49*).

Several complex alternative solutions have been successfully challenged in other jurisdictions. These alternatives were not for introducing an innovative product per se but for introducing an innovative concept, that of exceeding building size and height restrictions for combustible construction. The province of British Columbia evaluated and subsequently made changes to the BC Building Code to permit the use of wood-frame construction in 6-storey residential buildings (2009). In the province of Quebec, a 6-storey wood post and beam commercial office building was awarded an alternative compliance path.

Demonstrating compliance for alternative structural solutions is a complex process, as it requires consideration of several fundamental factors for occupant and building safety. It can also be quite costly.[17] Research is currently underway on the fire and structural performance of large wood buildings. This is expected to result in future building code changes across Canada that will likely affect many building types, including educational buildings.

Future Considerations

The process is currently underway for two relevant proposed changes to the National Building Code of Canada (NBCC) on which the OBC is based. One proposed change deals with the allowance for fire-retardant treated wood cladding using a different testing method than is currently specified in the OBC to demonstrate compliance. Another proposed change deals with a relaxation of the thickness requirements for wood finishes in specific applications where the product already meets the flame-spread rating requirements. Changes will potentially be proposed for the permissible height of heavy timber construction and the NBCC is currently evaluating increasing permissible storeys for wood-frame construction above the current four storeys. See MH report Section 5 *(page 51)* for more details on these activities.

NAHB Research Center Study – 2002
*Data was collected for one year on two identical unoccupied houses, one in steel-frame one in wood-frame. Although the steel house had more insulation, the wood house was more economical to heat. For more information, refer to the **NAHB Study**.*
Graphic: NAHB Research Center

The Benefits of Wood Buildings

Aside from meeting building code requirements, the choice of a building system can also bring about certain benefits. The effect that the choice of a wood construction system has on the overall project budget and advancement of works can be easily recognized. Wood products are readily available and competitively priced in the Ontario marketplace. Shorter lead-times for material delivery, along with the ease and speed of erection help to optimize the construction schedule thereby shortening the time needed for delivery of the project. Shorter construction schedules result in cost savings.

16 Division C has provisions for some exceptions under OBC Part 5. Refer to the MH report Section 4.1 *(page 48)* for more information.
17 Refer to MH report Section 4.2.3 *(page 50)* for more information.

There are other less intuitive benefits that can arise from the choice of any particular building system that are no less important. The choice of a wood construction system brings with it many unseen benefits, even before the wood products get delivered to the construction site.

Renewable – Naturally

Inherent characteristics of wood fibres translate into benefits for the environment, for wood products and for any building in which they are ultimately used. Benefits start in the forest. As trees grow, they naturally absorb carbon dioxide through photosynthesis. When a tree is harvested, the absorbed carbon is locked away in the wood products made from that tree for the life of the products. Sustainable forestry practices to which Ontario forests adhere insure a continuation of that cycle and, in so doing, help to offset climate change.

Manufacturing Efficiencies

The harvesting and processing of trees for the manufacture of wood products requires less energy and is less polluting to the air and to water than resource extraction and manufacturing processes are for any other of the major construction materials. This can be demonstrated using the scientific method of life cycle assessment which evaluates the impact through all stages of a material's life in an effort to quantify the impacts on the environment.[19]

A typical 216 m^2 wood-frame house sequesters 28.5 tonnes of carbon dioxide, an amount equal to the emissions of a small car over 7 years.[18]

The sustainable harvest of forest resources insures a continued supply of wood products into the future. Wood waste at the manufacturing level is burned to generate energy during the manufacturing process, which in-turn reduces the demand on finite fossil fuel reserves. By the time a wood product makes it to the construction site, it has helped to reduce carbon emissions to the atmosphere by having sequestered carbon in its fibres, by having used less energy during its manufacture and by having a cleaner manufacturing process, plus it has helped to conserve fossil fuels.

Climate change and energy conservation are important if somewhat intangible and less immediate benefits. Wood products also have many benefits that can be understood on a more practical level.

Wood Properties and Their Benefits

Certain properties of wood as a material translate into tangible benefits for the user of wood products. One positive attribute of wood is that it is a poor thermal conductor, for example. Wood fibres can be compared to a box of straws – they are filled with air. Since air is a poor conductor, so then are wood products. This leads to the low thermal conductivity of wood products and a reduction in thermal bridging, a contributor to heat loss in buildings. These inherent insulating properties of wood products, combined with the ease of insulating wood structures, results in lowered energy costs during the life of a building – a very practical benefit.

Bill Barber Complex, Callander, ON
Wood roof structure over an exterior rink
Photo: Evans Bertrand Hill Wheeler Architecture Inc.

The cellular structure of wood fibres leads to another beneficial property for wood products: enhanced acoustical performance. Air-filled wood fibres act as attenuators to sound transmission making wood products desirable in situations where acoustics play an important role. This cellular structure also leads to the hygroscopic nature of wood products and their ability to handle fluctuations in moisture without affecting structural characteristics. This is particularly beneficial in facilities with swimming pools or ice rinks.

18 The basis for this calculation is average U.S. car and light truck gas mileage and average U.S. annual driving distances. The variability in how many years of driving 3,200 gallons of gas is worth varies from approximately three years for the largest SUV to 11 years for a small hybrid. Source: FPInnovations.

19 For more information on life cycle assessment of building products and systems, go to the **Athena Sustainable Materials Institute** website.

When a wood building is properly designed and detailed, and is appropriately maintained, its life-span can be limited only by the changes in use that it may be subjected to over its lifetime.

The fire resistance properties of heavy timber are of particular significance. Minimum thicknesses for heavy timber construction specified in the OBC are based on the char rate of wood. The char layer created when a heavy timber element burns actually acts as a barrier and helps to maintain the strength and structural integrity of the wood within that layer. For this reason, heavy timber elements meeting the minimum thickness requirements receive a 45-minute fire resistance rating, and require no added treatment.

There are added benefits to using a wood construction system that are brought to light during the construction phase of a project.

Construction Benefits

As previously mentioned, material lead-times are important to construction scheduling. The ready availability of wood products, combined with the relative ease and speed of construction for wood construction systems often have a positive impact on the final delivery date of a project. These benefits are compounded when pre-manufactured and pre-fabricated elements and systems are used. The use of engineered wood products and pre-fabricated systems also leads to reduced waste on-site. The coordination and disposal of construction waste can be a timely and costly endeavour.

The benefits of wood construction systems do not end when the building is delivered to the owner for its intended use. The choice of a wood construction system continues to garner benefits throughout the useful life of a building.

Following Delivery

Lee Valley Tools, Toronto, ON
Turn of the century wood building located on King Street in Toronto.
Photo: Max Torossi

Lower operating costs afforded by wood buildings are of obvious interest to building owners. Owners also want to be assured that their building will last and fulfill its intended purpose for years to come. When a wood building is properly designed and detailed, and is appropriately maintained, its life-span can be limited only by the changes in use that it may be subjected to over its lifetime. The durability of wood buildings is evidenced by the myriad of centuries-old buildings found around the globe. There is no need to look further than North America, however, where wood buildings, whether residential or non-residential, have longer life-spans than buildings built using any other construction system. The ease with which a wood building can be adapted for changing needs is in large part the reason for this longevity.

In the case of school buildings, changes in population and the number of students that a school district will need to serve can change over time. The adaptability of wood structures makes it possible to expand or make modifications to the existing structure to more easily accommodate for a changing student population. In this way, a wood building can be given a new life long after its originally intended purpose disappears. When that end does arrive, however, elements of wood construction systems can be reclaimed, recycled and reused in other buildings or re-manufactured into other useable wood products.

A less tangible but no less important benefit of a wood building and its use is the potential for creating warm and inviting environments, especially when wood elements can be left exposed. The atmospheres created in school buildings using such systems are reported to be conducive to learning. Students' concentration and even grades are said to be improved in environments where natural wood elements are present.

Case Studies

On the following pages are five brief reports on school projects built using a wood construction system. These projects, found primarily in Canada, help to demonstrate the many benefits to owners and users of making the choice to use wood for the primary construction system.

The five case studies are:

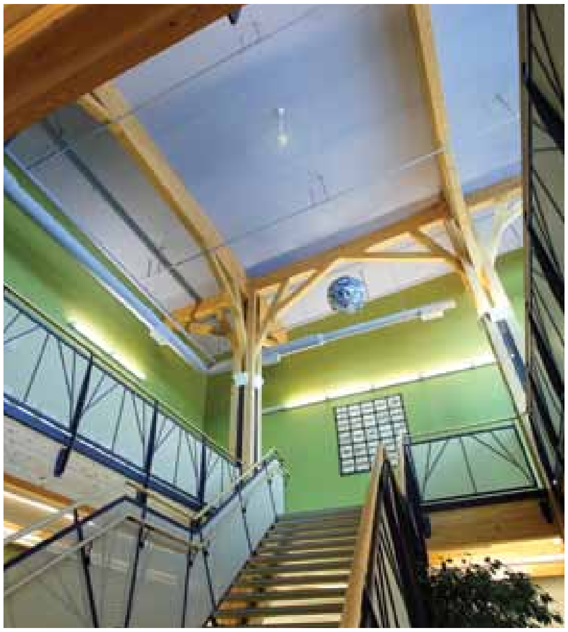
- **École secondaire catholique de la Vérendrye** *(page 18)* in Thunder Bay, Ontario;
- **Richmond Christian School** *(page 20)* in Richmond, British Columbia;
- **Crawford Bay Elementary-Secondary School** *(page 22)* in Crawford Bay, British Columbia;
- **Centre de formation et de transfert technologique sur les pratiques forestières** *(page 24)* in Dolbeau-Mistassini, Quebec;
- **El Dorado High School** *(page 26)* in El Dorado, Arkansas, United States.

CASE STUDIES

École secondaire de la Vérendrye

The École secondaire catholique de la Vérendrye was completed in 2004 for the Conseil scolaire de district catholique des Aurores Boréales, a District School Board serving the francophone community in Thunder Bay, Ontario. The $9.4 million secondary school (grades 7 through 12), which also houses the School Board's offices,[20] came in on budget and was awarded the *Canadian Wood Council – Ontario* Wood *WORKS! 2004 Green by Design Award*.

The Vérendrye school is a 2-storey, 4,830 m^2 sprinklered building. It is primarily a heavy timber glulam structure in combination with light wood-frame construction. The principal architect, Michelle Gibson at FORM Architecture, made the decision to go with wood in large part to cut down on the thermal bridging in exterior walls, a main advantage of wood construction systems, and the ease with which extra insulation could be added to the 2"x8" wood-frame construction system. The use of wood framing for wood and roof systems and interior partitions also added to the sound performance of the facility.



A major benefit of the wood construction system was the speed with which the project could be completed. Fast material delivery allowed for an expedited construction schedule. The framing proceeded without delay and the building enclosure, or *shell*, was completed faster than would have been possible had a traditional steel construction system been used. Plans to expand the school in the future made the choice of wood construction all the more appropriate as it would facilitate the building's adaptability for the eventual expansion.

20 The School Board offices are considered as a second major occupancy, *Group D Business and Personal Services*, since they are not subsidiary to the school major occupancy.

The only non-combustible structural element in the school is a 2-hour masonry fire wall which serves a dual purpose. It separates the two major occupancies of the building, the administrative School Board section and the school itself. It also acts to compartmentalize the building, thereby bringing the building area down to what is permissible for combustible construction according to the Ontario Building Code.

The school qualified for Natural Resources Canada's Commercial Building Incentive Program (CBIP).[21] The School Board received financial compensation for the project by reducing energy consumption needs for the facility to 25% lower than specified in the Model National Energy Code for Buildings, as well as by meeting other requirements set out in the CBIP Technical Guide.

This school building is a true expression of sustainable development's three main tenets:

- the use of local renewable materials – a responsible and sustainable environmental choice;
- the use of local manufacturing promoting sustainability of the area's economy;
- the use of local labour fostering pride in community needed for a strong society.

Special Features:

- 2-storey atrium with tree-like heavy timber support structures
- all maple handrails and trim in the building
- exterior decorative wood frieze (fir plywood backing, cedar trim)

École secondaire de la Vérendrye
Photos courtesy of: FORM Architecture Engineering

21 CIBP was a national financial incentive program in place from April 1998 to March 2007.

CASE STUDIES

Richmond Christian School

The Richmond Christian School in Richmond, British Columbia was completed in 2008 and serves 300 secondary school students in grades 7 through 12. The $6.15 million school project received a Citation Award at the *2009 CEFPI*[22] *Pacific Northwest Region Pinnacle Awards*.

The Richmond School is a single-storey, 3,500 m^2 sprinklered building with a mezzanine. It is primarily a glulam post and beam structure and light wood-frame techniques were used as infill for the walls and roof. The design team at KMBR Architects Planners Inc., who worked on the project in collaboration with Allen + Maurer Architects, felt it important to go with wood as it was an environmentally sustainable material that would help to control costs as well as the construction schedule.

Although the design team did not register for any formal certification through green building rating programs, design strategies used were consistent with the intent of these programs. The use of wood as a local material with low embodied energy[23] was a conscious and important choice for the design team. The solid wood and MDF interior finishing materials were chosen for durability and low VOC[24] emissions. The structure is left partially exposed in the classrooms and fully exposed in the gymnasium and entrance, which helped to create the non-institutional character desired by the design team.

The added benefit sought with the use of wood for the structure and finish materials was the creation of an aesthetically pleasing and healthy environment, seen as vital in fostering a sense of well-being in its students and staff.

22 Council of Educational Facility Planners International

23 The embodied energy of a product refers to all of the energy required, both direct and indirect, for raw resource extraction, manufacturing and installation.

24 Volatile organic compounds.

CASE STUDIES

Special features:

- The building's multi-purpose gymnasium and assembly hall form a central feature of the Richmond Christian School building. The full-height translucent wall on the north side of the space provides all the lighting needed for daytime activities.
- The school also includes drama studios, technical shops and a library.

Richmond Christian School, Richmond, BC
Photos courtesy of: KMBR Architects Planners Inc.

CASE STUDIES

Crawford Bay Elementary-Secondary School

The Crawford Bay Elementary-Secondary School was completed in 2009 for School District # 8 in Kootenay Lake, British Columbia. The $12.7 million combined elementary and secondary school project (kindergarten through grade 12) replaced the existing school which had served the small 500-person community since the 1940's. The Crawford Bay School has won several awards, including the *2009 SAB*[25] *Canadian Green Building Award*, the *2009 Fortis BC PowerSense Conservation Excellence Award*, and the *2010 Canadian Wood Council – BC* Wood *WORKS! Wood Design Award*.

The 3,170 m^2 single-storey sprinklered building was the first school to receive a LEED® Gold rating[26] in the province. It is primarily a glulam post and beam structure in combination with light wood-frame techniques used in much the same way as in the Richmond Christian School, for infill of wall and roof structures. The design team at KMBR Architects Planners Inc. wanted a sustainable project that would be economically feasible and socially responsible while demonstrating environmental stewardship. A wood construction system, using locally grown and milled wood materials whenever possible, made the most sense, particularly when considering the historic importance of forestry to this rural community. Wood had the structural qualities needed with the aesthetic appeal desired.

The simplicity of the post and beam structure facilitated the use of local labour and expertise. Many of the wood elements perform double duty, both as a structural member and as a finish material, which had a two-fold impact on costs. Extra finishing materials and the labour required to install them were not necessary in those areas where the structure was left exposed. In addition, the use of non load-bearing partitions within the post and beam grid rendered the interior space ultimately flexible should future needs require.

Schools are important facilities in small communities and Crawford Bay residents wanted more out of theirs. The community took the initiative to raise funds so that their new school's program could be

25 Sustainable Architecture and Building
26 Leadership in Energy and Environmental Design green building rating program

expanded to include a community fitness centre, a pre-school and day care facility, and a number of multi-purpose rooms. The building has become a hub for community activities, with facilities in use not only during the day, but evenings and weekends as well. This wood building served to mobilize a community; residents became involved on many levels. It has become for them a source of pride and is contributing to a sustainable future for Crawford Bay.

Special features:

- Bolted connections of the building's timber superstructure allow for disassembly and reuse of components in the future. This is an excellent way of assuring a continued life for materials long after the useful life of the building in which they were originally installed.

Crawford Bay Elementary-Secondary School, Crawford Bay, BC
Photos courtesy of: KMBR Architects Planners Inc.

CASE STUDIES

Centre de formation et de transfert technologique sur les pratiques forestières (CFTTPF)

The Centre de formation et de transfert technologique sur les pratiques forestières (CFTTPF) was completed in 2011 for the Commission scolaire du Pays-des-Bleuets in Dolbeau-Mistassini, Quebec. The $1.98 million vocational college was a finalist for two different 2011 cecobois[27] awards of excellence, *Institutional Project Greater Than 600 m²* and *Exterior Cladding*. The School Board wanted a wood building for the school as members felt it was important to promote the use of wood for a school that would be training the forest industry's future workforce. The architectural consortium of Emond Kozina Mulvey architectes (EKM) and Le Groupe D.P.A. saw wood as the environmentally responsible choice and needed no convincing.

The CFTTPF is a 684 m^2 single-storey unsprinklered building. A heavy timber glulam construction system was chosen, with a "baked" or "torrefied"[28] wood exterior cladding, a product that requires less maintenance than most wood sidings.[29] All of the wood used in the project was locally harvested and all wood products were locally manufactured. The design team wished to emphasize the importance of using local renewable building products that had less of an impact on the environment than other building materials.

The possibility of using the structure as the finished material was used to advantage; suspended ceilings and drywall finishes were omitted allowing for full expression of the wood structure and additional cost savings. The design team took full advantage of passive solar benefits in order to reduce operational energy requirements in this northern Quebec community. They optimized building massing and orientation thereby maximizing wind protection and natural lighting.

The torrefied wood cladding was chosen for the building because of its durable characteristics, comparable with that of Western Red Cedar. It was a local product and would require maintenance on a 5-year cycle to protect the colour from UV ray degradation. Although aluminum or vinyl sidings may have required less maintenance, their environmental footprint was seen as an undesirable *cost* by the design team.

27 Centre d'expertise sur la construction commerciale en bois – the Centre for Expertise in Non-Residential Wood Construction (unofficial translation)
28 Torrefied wood refers to a high heat treatment used to enhance certain characteristics of wood without the need for chemical treatments. Information can be found from individual manufacturers.
29 Western Red Cedar appears to have similar characteristics to that of torrefied wood.

Wood is the material of choice for Andrew Kozina, principal architect for the project at EKM architectes. He states: "I would be happy to design only wood buildings. To the extent that the code permits, I recommend wood structures for all construction projects. It is the most environmentally responsible choice and its use results in an energy efficient structure that has unparalleled warmth and beauty."

Special features:

- At nearly 500 m^2, the large four-bay garage is the school's primary classroom – a mechanics training workshop where students are taught how to maintain and repair the machinery used in forestry operations. The 2-hour firewall between the garage and the rest of the building provides the required compartmentalization to allow for an unsprinklered wood construction system for the school.

Centre de formation et de transfert technologique sur les pratiques forestières (CFTTPF), Dolbeau-Mistassini, QC
Photos courtesy of:
Emond, Kozina, Mulvey, architectes – DPA Daniel Paiement architecte

CASE STUDIES

El Dorado High School

When the El Dorado High School was completed in 2011 it was the largest wood school in Arkansas and one of the first to make extensive use of wood in the State's history. This is significant as Arkansas did not allow wood in schools until a policy change in 2008. The original steel and concrete design for the 29,960 m^2 secondary school came in at over $60 million (US) which created a problem for the El Dorado School District. This estimate would not allow them to meet their target budget as it would have curtailed the State's funding contributions for the project. Richard Brown, principal engineer at Engineering Consultants in Little Rock, proposed the wood structure that would eventually result in a $44 million budget. This was a 26% cost savings when compared with the steel and concrete solution typically used in such a large complex.

The 2-storey fully sprinklered building has an exposed heavy timber glulam structure in all the large and open public spaces. Once the decision was made to go with heavy timber, Blakely Dunn, principal at CADM Architecture, wanted the structure to remain apparent; forestry is an important part of the economy in this area of Arkansas, and local manufacturing was used whenever possible. Initial thinking was that they would still use steel for the floor and roof systems, however; it was what they knew. While working with the construction managers at Baldwin & Shell during the pre-construction stages, more economies were discovered by going with wood framing throughout the building, even for those areas that would not be visible. The use of light wood-frame systems for the interior and exterior load bearing partitions, plus I-joists systems for the second floor and roof shaved $2.7 million off the original budget.

They were also able to get the fire resistance rating required and maintain the acoustical performance of the floor by topping the wood system with concrete, while still maintaining a cost savings.

Special Features:

The El Dorado High School has many "wow" factors, a term used repeatedly by Superintendent Bob Watson, all which create a safe and warm environment for the 1,350 students and staff.

- There are 7.3 metre-wide, 2-storey high "Main Street" corridors running down each of the four arms of the building that are lit by huge skylights. These "arms" meet at a 16.5 metre-diameter, 2-storey octagonal circulation area, the exposed glulam structure for which is topped by a five-metre-diameter skylight.
- The school has a 2,200 seat, 2,800 m^2 basketball arena that is spanned by open glulam bowstring trusses which create a dramatic interior. The change from steel to wood in the arena roof alone saved the budget $60,000 and according to Dunn, "we got a huge aesthetic benefit."
- The school also has a 450-seat performing arts theatre. Maple deflector panels are used throughout the theatre to acquire the desired acoustical performance. Wood is given expression in the structure as well as the finishing materials throughout the school creating an atmosphere where students want to be.

There may not be many schools as large as the El Dorado example with such a varied program. What is significant, however, is the cost savings that can be expected by going with a wood construction system, whether the building is modest or not so modest. Couple this with being able to validate local industries and thereby have an effect on local economies and community support and it makes even more sense.

El Dorado High School, El Dorado, Arkansas
Photos: Dennis Ivy, courtesy Wood Works

Summary

An increased use of wood construction systems in Ontario schools would benefit users and owners alike. The options for wood construction systems available in the Ontario marketplace should be used to advantage. It has been demonstrated that these systems make sound economic and environmental sense. The Ontario Building Code allows for the use of wood construction systems in low-rise school buildings and their use is in the best interest of Ontarians for a sustainable future.

Although this document concentrated predominantly on the use of wood construction systems in low-rise school buildings, benefits can be gleaned from the use of such systems in many different educational facilities, from university buildings to community colleges, from student dormitories to learning centres, from research facilities to sports arenas.

The environmental benefits to the planet that are inherent with the use of renewable wood products cannot be ignored but it could be argued that the students and staff of school facilities built with a wood construction system are the real winners. They get a healthy, warm, and natural environment in which to learn and grow.

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Acknowledgements

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Appendix A – Web References

Here are the web references in sequential order, as they appear in the document.

Reference Name	Web Address
Shaping our Schools, Shaping our Future	www.edu.gov.on.ca/eng/teachers/enviroed/shapingSchools.pdf
Statistics Canada data	www40.statcan.gc.ca/l01/cst01/busi01g-eng.htm
Report of the World Commission on Environment and Development	www.un.org/documents/ga/res/42/ares42-187.htm
Climate Change & Sustainable Development: A Response from Education in Canada	www.hilaryinwood.ca/pdfs/research/ESD%20in%20Canada%202009.pdf
Crown Forest Sustainability Act 1994	www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_94c25_e.htm
Forest Management Planning Manual 2009	www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/286583.html
Ontario Wood website	ontariowood.ca/en/forest-industry
Ontario Building Regulation 350/06	www.e-laws.gov.on.ca/html/regs/english/elaws_regs_060350_e.htm
Canadian Wood Council Homepage	www.cwc.ca
Ontario Wood WORKS! Homepage	www.wood-works.org/Ontario%20Wood%20WORKS/?Language=EN
Athena Sustainable Materials Institute website	www.athenasmi.org/
NAHB Steel vs. Wood Study	www.toolbase.org/PDF/CaseStudies/steel_vs_wood1.pdf
Crawford Bay & Richmond Christian Schools – Case Studies	cwc.ca/documents/case_studies/BC_Schools.pdf
FORM Architecture, Ésc. de la Vérendrye	www.formarchitecture.ca/#/home/education/la_verendrye
FPL Wood Handbook, Chapter 18	www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter_18.pdf
Ontario Building Regulation 350/06	www.e-laws.gov.on.ca/html/regs/english/elaws_regs_060350_e.htm
El Dorado High School Case Study	woodworks.org/files/PDF/publications/Case_Studies_and_Design_Examples/El-Dorado.pdf

MORRISON HERSHFIELD

USE OF WOOD IN EDUCATIONAL BUILDINGS
APPLICATION OF THE ONTARIO BUILDING CODE

For:

Ontario Wood *WORKS!*

Proposal No. 2123039.00 January 27, 2012

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MORRISON HERSHFIELD

1. Introduction

1.1 Introduction

Morrison Hershfield Limited (MH) has been retained by the Canadian Wood Council on behalf of Ontario Wood *WORKS!* to document the application of the Ontario Building Code for use of wood in educational buildings and identify limitations, conditions or restrictions on the use of wood in educational buildings. In addition, opportunities for alternative solutions or changes to future editions of the Ontario Building Code have been explored.

1.2 Scope and Methodology

This report presents the provisions of the 2006 Ontario Building Code (as amended to date) which are relevant to the use of wood in educational buildings and the limitations, conditions and limitations on the use of wood in such buildings. Our understanding of the project is based on the request for proposal for the project and discussions with Woodworks.

This report is based on a review of applicable Parts 3, 4, 5 and 6 of the Building Code and MH's experience in interpreting and applying the Building Code.

1.3 Limitations

Comments and conclusions within this report represent our opinion, which is based on an examination of the documents provided, our Code analysis and our past experience. In issuing this report, Morrison Hershfield does not assume any of the duties or liabilities of the designers, builders, owner or operators who may use the information herein for the design or construction of a building. Persons who use or rely on the contents of this report do so with the understanding of the limitations of the documents examined. Such persons understand that Morrison Hershfield cannot be held liable for damages they may suffer in respect to the design, construction, purchase, ownership, use or operation of a subject property.

2. Ontario Building Code

2.1 General

The Ontario Building Code (O.Reg. 350/06) is a set of regulations made under the Building Code Act (1992) (Ontario) and sets out the technical requirements for construction of buildings. The Ontario Building Code is a set of minimum requirements for safety in buildings that address objectives of safety, health, accessibility, property protection, resource conservation, environmental integrity and conservation of buildings.

The 2006 Ontario Building Code (OBC) came into force December 31, 2006. Several amendments to the Code have come into effect since this time. All references to the OBC in this report are to the 2006 edition including all amendments to the date of this report. A new edition of the Ontario Building Code is expected in 2012.

The Code references and paraphrases in this report are for convenience only. For the authoritative text of the Building Code regulations the official version of Ontario Regulation 350/06 as amended should be referenced. Official copies of Ontario's regulations can be found on the Government of Ontario e-laws website.

2.2 Application to Educational Buildings

The provisions identified in this report are specific to the use of wood in educational buildings.

Educational buildings are part of the assembly major occupancy (Group A) which is defined as "*the occupancy or the use of a building or part of a building by a gathering of persons for civic, political, travel, religious, social, educational, recreational or similar purposes or for the consumption of food or drink*". An educational building containing classrooms, lecture halls, library, gymnasium etc. is considered an assembly building. It is noted that teacher and administration offices within an educational building are considered a subsidiary occupancy (Group D, business and personal services occupancy) if they are integral to the principal occupancy.

Schools or educational buildings are considered to be a general type of assembly occupancy referred to as Group A, Division 2 major occupancy. Regardless of the size of building, a new educational building or an addition to an educational building will be governed by life safety provisions of Part 3 "Fire Protection, Occupant Safety and Accessibility". Part 9 of the OBC "Housing and Small Buildings" does not apply to educational buildings of any size.

Part 4 "Structural Design" and Part 5 "Environmental Separation" will also apply to educational buildings. Other Parts of the OBC will apply to educational buildings, however these Parts do not influence the use of wood.

Renovations and modifications to an existing building of educational use is subject to Part 11 "Renovations" which defines the extent to which other Parts of the Code apply to that renovation or modification. Renovation projects governed by Part 11 require careful evaluation to determine the extent to which wood structural and construction materials can be retained or extended. Under Part 11, it is possible to reuse, relocate or extend the use of wood materials when the renovation is considered a "basic renovation". A basic renovation is considered one where it is intended to retain the existing character, structural uniqueness, heritage value, or aesthetic appearance of all or part of the building, and where the construction will not adversely affect the early warning and evacuation systems, fire separations, the structural adequacy or create an unhealthy environment in the building. Under Part 11, a building of wood construction over 3 storeys in building height that is changed from another major occupancy to a school or educational building is required to be sprinklered. The requirements of Part 3 will be applicable to an addition to an existing educational building. Compliance alternatives under Section 11.5 provide for the continued use of existing wood building elements to be retained under certain conditions and subject to the approval of the Chief Building Official.

3. OBC Provisions for Wood in Educational Buildings

3.1 Introduction

Provisions that influence the use of wood in educational buildings with respect to fire protection, occupant safety and accessibility, as well as structural design and environmental separations, in new construction are contained in Parts 3, 4 and 5 of Division B of the OBC.

3.2 Fire Protection, Occupant Safety and Accessibility (Part 3)

The OBC contains requirements that govern construction (including floors, mezzanines, roofs, and loadbearing walls, columns and arches) as well as the use of wood as an interior finish, cladding, and for use as a partition or blocking material.

Permission to be Combustible Construction

Generally, the OBC permits combustible (wood) construction for educational buildings up to a certain size based on criteria such as building height, building area, sprinkler protection, and number of streets the building faces (if unsprinklered). Floor, mezzanine and roof assemblies, and their loadbearing supporting structure of either combustible or noncombustible construction may be required to have a fire resistance rating depending on building size.

Where combustible construction is permitted for the loadbearing supporting structure, wood is generally permitted as an interior finish, cladding, partition or blocking material provided other requirements are satisfied. For example, wood interior finish is subject to maximum flame spread ratings. However, in some cases, specific conditions of the building location relative to property line or other buildings may influence the extent to which wood is permitted for cladding or as a construction material of an exterior wall. For example, an exterior wall in close proximity to a property line may be required to be noncombustible depending on the size of interior compartments and extent of sprinkler protection.

Requirement to be Noncombustible Construction

Educational buildings over a certain size are required to be of noncombustible construction for the loadbearing structure. Even so, heavy timber is permitted for a roof and its supports in a building otherwise required to be noncombustible for any 2 storey sprinklered building.

However, the OBC permits many combustible elements in these buildings. For example, combustible millwork and finished flooring are always permitted without exception in buildings otherwise required to be of noncombustible construction.

Combustible versus Noncombustible Construction

The requirements that govern construction in Section 3.2.2. set the context for the permission to use wood elsewhere in a building. If a building is permitted to be of combustible construction under Section 3.2.2., then there are less restrictions on the use of wood elsewhere (such as an interior finish or exterior cladding) than if the building is required to be of noncombustible construction under Section 3.2.2. This is an important starting point since it determines the extent of the use of wood even if the loadbearing structure of the building is voluntarily constructed of noncombustible materials.

Prohibition on Use of Wood

Wood is specifically prohibited in the following applications:

- Supporting an assembly that is required to be noncombustible and that is required to have a fire resistance rating
- Construction of firewalls
- Projections extending across a firewall
- Construction, as well as wall and ceiling finishes of underground walkways
- Underground covered vehicular passageways

3.3 Structural Design Using Wood (Part 4)

The 2006 Ontario Building Code (OBC) generally permits the use of wood as a structural material. The application and use of wood as a structural material in the OBC is subject to limitations based on the building size and occupancy as defined by Part 4 (Structural Design) and Part 9 (Small Buildings). In the case of educational facilities, the use of wood as a structural material is governed by Part 4 on the basis of the occupancy of these buildings, regardless of the size of the building.

Part 4 of the OBC provides a framework of procedures and requirements for determining the minimum structural loads and design standards to be applied to ensure that buildings and their structural members have sufficient structural capacity and structural integrity to safely and effectively resist all loads and effects. Parameters to be considered include structural strength, serviceability and reliability. The minimum loads specified in the OBC are primarily based on the use and occupancy of the building, as well as the building's geographic location and exposure (e.g., climatic and seismic influences). Part 4 of the OBC does not provide structural loads based on the type of materials to be used. The Code does require, however, that the design be completed in accordance with the corresponding material design standard. As such, the design loads defined by Part 4 will be the same regardless of whether wood, masonry, concrete or steel is to be used. However the design of the structure will be governed by the applicable design standard (such as CSA O86 in the case of wood design). This essentially provides the designer with the freedom to select and utilize the material(s) of their choice, subject to the physical properties and limitations inherent with that material.

Educational buildings that are likely to be used as post-disaster shelters are assigned an Importance Category of “High” according to Table 4.1.2.1.B. The OBC specifically references elementary, middle or secondary schools, however this is applicable to any educational building that is likely to be used as a post-disaster shelter. The Importance Category is applied to the calculation of specified snow, wind and earthquake loads, and generally results in higher loads relative to buildings in the “Normal” Importance Category.

In general, Part 4 of the OBC does not contain restrictions on the use of wood or timber structures, with the exception that in certain cases it does not permit the use of wood as structural components intended to act as the seismic force resisting system (SFRS). The SFRS is the part of the structural system that is designed to provide the required resistance to earthquake forces and effects (Article 4.1.8.9). Under the OBC the SFRS can be designed using wood, subject to height restrictions that are imposed in certain cases based on design parameters such as the geographic seismic zone in which the building is located, and the type of SFRS utilized. The OBC presents the allowable usages for wood in tabular form (Table 4.1.8.9) for the most common SFRS's (e.g., shear walls, moment resisting frames), with imposed height restrictions varying from ‘not limited’ to values ranging from 15 to 30 meters. Similar types of restrictions exist for the other common structural materials (i.e., steel, concrete, and masonry), again based on design parameters such as geographic seismic zone in which the building is located, and the type of SFRS utilized.

Part 4 of the OBC contains a provision for the use of wood in foundations or structures supporting soil and rock. This provision is outlined in Article 4.2.3.1. which permits wood as a material used in foundations provided that it conforms to the applicable requirements of CAN/CSA-O86. Article 4.2.3.2. provides requirements for the preservation treatment of wood used in foundations, generally stating that it must be treated with preservation in conformance with CSA O80 Series, “Wood Preservation”.

Composite lumber and panel products are permitted for use as structural members, provided that they are design and fabricated in accordance with the requirements of CAN/CSA-O86. This Standard specifically deals with two types of composite building products; glue panel web beams (box or I-section) and stress skin panels (for floor or roof constructions), provided that they are not manufactured by a proprietary process.

3.4 Use of Wood in Environmental Separations (Part 5)

Part 5 "Environmental Separation" of the OBC applies to all buildings except those within the scope of Part 9 or the scope of the National Farm Building Code of Canada. Under this context, Part 5 applies to building elements (e.g., walls, floors, roofs, windows, doors) that separate dissimilar environments. This includes both the separation between indoors (i.e., conditioned space) and outdoors (including the ground), as well as between interior spaces that have significantly different environments (e.g., between an indoor pool and classroom space).

In general terms, Part 5 deals primarily with the control of heat, air and moisture, where moisture includes the control of vapour, precipitation, surface water and ground water. Part 5 of the OBC generally does not restrict the use of wood (or other materials) provided that the materials or assemblies fulfill the prescriptive requirements for their intended function within the building envelope (i.e., control of heat, air, and/or moisture), and that any of the applicable reference standards are satisfied. The ability of a material or assembly to achieve the required performance related to the transfer of heat, air and moisture must be determined based on sound engineering principles and practices.

In the case of educational facilities, one possible application of wood in the building envelope would be as a cladding. For this example, the wood cladding must be designed and installed to provide the required protection from precipitation (Article 5.6.1.1) by,

a) minimizing the ingress of precipitation into the component or assembly, and

b) preventing the ingress of precipitation into interior space.

c) Additionally, the cladding would be required to provide a resistance to the mechanisms of deterioration (Article 5.1.4.2) that may reasonably be expected given the nature, function and exposure of the materials.

3.5 OBC Provisions for Use of Wood in Educational Buildings

The Tables in this Section document the OBC provisions for wood in educational buildings.

Part 3 provisions have been sorted into the following categories:

- Loadbearing Construction
- Envelope and Exterior Components
- Interior Walls and Doors
- Interior Finishes
- Minor Components

Part 4 and 5 provisions are listed as separate categories.

The table columns are as follows:

- Building Component: Each building component has a short identifier.
- Code Reference: The Article or Sentence containing the provision is identified.
- Paraphrase of the Provision: The paraphrase is written for maximum readability while retaining the key words of the Code provision. Detailed requirements such as tables are not repeated. The Code should be referenced for exact wording and application of requirements.
- Applicable to Buildings Required to be of Noncombustible Construction: This indicates if the provision applies to a building where noncombustible construction is <u>required</u> under Section 3.2.2.
- Applicable to Buildings Permitted to be of Combustible Construction: This indicates if the provision applies to a building where combustible construction is <u>permitted</u> under Section 3.2.2.
- Comments: Comments are provided on the application or implications of the provision.

Building Component	Code Reference	Paraphrase of Provision	Provision Applicable to Buildings… Required to be Noncombustible Construction	Provision Applicable to Buildings… Permitted to be Combustible Construction	Comments
PART 3 – COMBUSTIBLE CONSTRUCTION[1,2,3,4,5]					
1 Storey Building Unsprinklered	3.2.2.28.	• Maximum area of 800 m^2/ 1000 m^2/ 1200 m^2 facing 1/ 2/ 3 streets respectively if there is no basement • Maximum area of 400 m^2/ 500 m^2/ 600 m^2 facing 1/ 2/ 3 streets respectively if there is a basement • Rating not required for roof assembly		✔	
1 Storey Building Unsprinklered	3.2.2.25.	• Maximum area of 1600 m^2/ 2000 m^2/ 2400 m^2 facing 1/ 2/ 3 streets respectively • Mezzanines require a 45 minute fire resistance rating • Roof assembly requires a 45 minute rating • If not more than half the maximum permitted building area then a fire-retardant treated wood roof assembly is permitted (see 3.1.14.1. for fire-retardant treated roof requirements) and the fire resistance rating is waived		✔	
1 Storey Building Sprinklered	3.2.2.27.	• Maximum area of 2400 m^2 if there is no basement, no street limits • Maximum area of 1200 m^2 if there is a basement, no street limits • Rating not required for roof assembly • Rating not required for mezzanines		✔	
1 Storey Building Sprinklered	3.2.2.26.	• Maximum area of 4800 m^2, no street limits • Mezzanines require a 45 minute fire resistance rating • Rating not required for roof assembly		✔	
2 Storey Building Unsprinklered	3.2.2.25.	• Maximum area of 800 m^2/ 1000 m^2/ 1200 m^2 facing 1, 2 or 3 streets respectively • Floor assemblies and mezzanines require a 45 minute rating • Roof assembly requires a 45 minute rating		✔	
2 Storey Building Sprinklered	3.2.2.27.	• Maximum area of 600 m^2, no street limits • Rating not required for floor assemblies, mezzanines or roof assembly		✔	
2 Storey Building Sprinklered	3.2.2.26.	• Maximum area of 2400 m^2, no street limits • Floor assemblies and mezzanines require a 45 minute rating • Rating not required for roof assembly		✔	

1 Area is “building area” as defined in the OBC in all Subsection 3.2.2. provisions referenced in this table.

2 Applicable to all buildings: every floor assembly over a basement (and any loadbearing elements supporting the basement floor assembly) requires at least a 45 minute fire resistance rating (3.2.1.4.)

3 Applicable to all buildings: loadbearing elements (such as walls, beams, columns) require the same fire resistance rating as the supported assembly unless the Article specifically permits unrated noncombustible construction for the loadbearing elements.

4 Sprinklered buildings are not required to have a minimum percentage of the building perimeter facing a street, except the principal entrance must be within 3 – 15 metres of a street.

5 Wood elements are not required to meet minimum size requirements of Article 3.1.4.6. if a fire resistance rating is not required by Subsection 3.2.2.

Building Component	Code Reference	Paraphrase of Provision	Provision Applicable to Buildings… Required to be Noncombustible Construction	Permitted to be Combustible Construction	Comments
Heavy Timber Roof Construction	3.2.2.16.	Heavy timber roof is permitted in a building up to 2 storeys in building height unless otherwise permitted by Article 3.2.2.25. to 3.2.2.28. if the building is sprinklered, regardless of the type of construction specified by Subsection 3.2.2. Structural members of the storey below the roof assembly are permitted to be of heavy timber construction.	✔	✔	Any 2 storey building can have a heavy timber roof regardless of building area or type of construction required.
Heavy Timber Construction	3.1.4.5.	If combustible construction is permitted and is not required to have a fire resistance rating more than 45 min, heavy timber construction is permitted.		✔	No additional structural fire protection is required in heavy timber construction, so wood can perform as the structure and interior finish at the same time.
Heavy Timber Construction	3.1.4.6.	Heavy timber construction is defined with respect to minimum dimensions and installation details. Minimum dimensions are provided for columns, beams, girders, trusses and arches, floor and roof elements.		✔	Wood elements are not required to meet minimum size requirements of Article 3.1.4.6. if a fire resistance rating is not required by Subsection 3.2.2. for the structural element or supported assembly.
Fire-Retardant Treated Wood	3.1.4.4.	Where fire-retardant treated wood is used to satisfy the Code, the wood is required to be pressure impregnated with fire-retardant chemicals in conformance with CAN/CSA-080 Series-M, "Wood Preservation", and have a maximum flame-spread rating of 25	✔	✔	This Article clarifies that fire-retardant treated wood requires more than surface treatment.
Combustible construction support	3.1.8.2.	Combustible construction that abuts or is supported by a noncombustible fire separation shall be constructed so that its collapse under fire conditions will not cause the collapse of the fire separation	✔	✔	There is no equivalent provision to govern the collapse of non-combustible construction abuts or supports of a noncombustible fire separation.
Protection of structural members outside the exterior face of a building	3.2.3.9.	Beams, columns and arches of heavy timber construction, placed wholly or partially outside an exterior face of a building and 3 metres of more from a property line or centreline of a public thoroughfare are not required to be covered with noncombustible cladding	✔	✔	
Heavy Timber Walkway between Buildings	3.2.3.19.	A walkway connected to a building required to be noncombustible can be of heavy timber construction if a minimum of 50% of the area of any enclosing perimeter walls is open to the outdoors and the walkway is at ground level. However, walkway would be required to conform to 3.2.3.14. (wall exposed to another wall requirements) and 3.2.3.15. (wall exposed to adjoining roof requirements)	✔		Heavy timber permitted for open walkways even if the buildings served are required to be noncombustible.
PART 3 – ENVELOPE AND EXTERIOR COMPONENTS					
Roof covering	3.1.5.3.(1)	Combustible roof covering that has an A, B, or C classification determined in conformance with Subsection 3.1.15. is permitted on a building required to be of noncombustible construction	✔		Wood shingles that meet the ULC S107 test are permitted as a roof covering on a building required to be of noncombustible construction.

Building Component	Code Reference	Paraphrase of Provision	Provision Applicable to Buildings…		Comments
			Required to be Noncombustible Construction	Permitted to be Combustible Construction	
Roof covering	3.1.15.2.(1)	Every roof covering requires a Class A, B, or C classification determined in conformance with Subsection 3.1.15. on every building unless exempted by Sentence 3.1.15.2.(2)		✔	Wood shingles that meet the ULC S107 test are permitted as a roof covering on a building permitted to be of combustible construction.
Wood shingles	3.1.15.2.(2)	A roof covering is not required to have a Class A, B or C classification for a Group A, Division 2 occupancy (e.g. a school) not more than 2 storeys in building height and not more than 1000 m^2 in building area provided the roof covering is underlaid with noncombustible material	✔	✔	Wood shingle roofs that do not demonstrate the Class A, B, or C classification are permitted on small assembly buildings such as schools etc.
Roof sheathing	3.1.5.3.(2)	Combustible roof sheathing and roof sheathing supports are permitted to be installed on a building required to be of noncombustible construction (certain conditions apply such as the presence of a concrete deck, maximum height 1 m, noncombustible parapet etc.)	✔		This permits a false wood roof to be constructed above a concrete deck.
Fire-Retardant Treated Wood Roof Systems	3.1.14.1.	If a fire-retardant treated wood roof system is permitted then the roof deck assembly is required to meet CAN/ULC-S126-M "Test for Fire Spread Under Roof-Deck Assemblies". Supports for the roof deck assembly must be either fire-retardant treated wood, heavy timber construction, noncombustible construction, or a combination of these.		✔	
Roof components	3.1.5.3.(3)	Combustible cant strips, roof curbs, nailing strips, and similar components used for roofing are permitted.	✔		Standard minor wood components for roof construction are permitted in a building required to be of noncombustible construction.
Roof nailer facings	3.1.5.3.(4)	Wood nailer facings to parapets (max 600 mm high) are permitted if facings and any roof membranes covering the facing are protected by sheet metal	✔		Standard minor wood components for roof construction are permitted in a building required to be of noncombustible construction.
Wood Window Frames	3.1.5.4.(5)	Combustible window sashes and frames are permitted in non-combustible buildings if certain conditions are satisfied. Conditions related to aggregate window opening area and separation of windows by non-combustible construction.	✔		This is typically applied to vinyl window sashes and frames in non-combustible buildings, but can equally be used to permit wood window sashes and frames.
Exterior Cladding	3.1.5.5.(4)	Combustible cladding of fire-retardant treated wood is permitted in a building required to be noncombustible construction provided • Building is not more than 3 storeys in building height • Building is not more than 6 storeys in building height if sprinklered Wood cladding must be subjected to accelerated weathering test before being tested to CAN/ULC-S134 "Fire Test of Exterior Wall Assemblies".	✔		
Wood canopies over building entrances	3.1.5.23.	Wood marquees up to 7.5 metres height are permitted for noncombustible buildings. No additional protection is necessary if the building is sprinklered. Unsprinklered buildings require openings in the wall above the marquee in proximity to the marquee to be protected with wired glass.	✔		This Article permits decorative wood canopies for noncombustible buildings.

Building Component	Code Reference	Paraphrase of Provision	Provision Applicable to Buildings… Required to be Noncombustible Construction	Provision Applicable to Buildings… Permitted to be Combustible Construction	Comments
Decorative cladding	3.1.5.25.	Decorative wood cladding is permitted for noncombustible buildings if the building face has firefighting access and the cladding is fire-retardant-treated wood suitable for exterior exposure. Wood cladding must be subjected to accelerated weathering test before being tested to CAN/ULC-S102 "Test for Surface Burning Characteristics of Building Materials and Assemblies".	✔		
Combustible Projections at Firewalls	3.1.10.7.	Combustible projections such as balconies, canopies, eave projections and stairs are not permitted within 2400 mm of combustible projections or door or window openings on the adjacent building.		✔	This provision limits wood balconies, stairs, eaves etc. in close proximity to firewalls.
Combustible projections	3.2.3.6.	Combustible projections on the exterior of a wall that could expose an adjacent building to fire spread and are more than 1000 mm above ground level, including balconies, platforms, canopies, eave projections and stairs are not permitted within 1200 mm of the property line or the centreline of a public way of within 2400 mm of a combustible projection on another building on the same property		✔	Wood not permitted as cladding or as a structural material in certain circumstances in densely constructed areas.
Construction of exposing building face	3.2.3.7.	Walls that are close to property lines (i.e. that create a potential fire exposure condition to adjacent properties or buildings) may require noncombustible construction and/or cladding, wood is not permitted in these walls even if the remainder of the structure is wood.	✔	✔	The most restrictive requirements for walls at or very close to the property line are noncombustible construction, 1 hour rating and noncombustible cladding. The next category of wall construction requires a 1 hour rating and noncombustible cladding for the exterior wall.
Fire stopping in wall assemblies	3.1.11.2.	See Minor Components.	✔	✔	
PART 3 – INTERIOR WALLS AND DOORS					
Wood Elements in Partitions	3.1.5.13.(1)	Solid lumber partitions, minimum 38 mm thick and wood framing in a fire compartment with max area of 600 m² is permitted	✔		Wood framing can be used for interior partitions in small fire compartments in educational buildings required to be of noncombustible construction.
Wood Elements in Partitions	3.1.5.13.(2)	Partitions in a building of noncombustible construction are permitted to contain wood framing if: • Maximum 3 storeys • Partitions are not used as enclosures for exits or vertical service spaces	✔		Wood framing can be used for interior partitions in small educational buildings required to be of noncombustible construction.
Wood Elements in Partitions	3.1.5.13.(3)	Partitions that contain wood framing are permitted in a non-combustible building if: • The building is sprinklered throughout • Partitions are not used as enclosures for exits or vertical service spaces • Partitions are not used as to extend floor fire separations around high volume spaces	✔		Wood framing can be used for interior partitions in larger educational buildings required to be of noncombustible construction.

Building Component	Code Reference	Paraphrase of Provision	Provision Applicable to Buildings… Required to be Noncombustible Construction	Provision Applicable to Buildings… Permitted to be Combustible Construction	Comments
Wood Doors as 20 Minute Closures	3.1.8.10.(1)	Wood doors with a 20 minute fire protection rating are permitted in: • a 1 hour rated (or less) fire separation between a corridor and adjacent classrooms, offices and libraries in educational buildings • a 45 minute rated (or less) fire separation in a building not more than 3 storeys	✔	✔	Doors into classrooms, offices and libraries are generally permitted to be wood construction.
Sill and Floor coverings under Door as 20 Minute Closures	3.1.8.10.(2)	Sills and floor coverings under 20 minute rated doors are permitted to be combustible	✔	✔	
Solid Wood Door as a Closure with an Unrated Wood Door Frame	3.1.8.10.(4)	In an elementary or secondary school, a solid core wood door meeting CAN4-S113 is permitted in a 30 minute rated fire separation. An untested and unrated wood door frame is permitted if it is at least 38 mm thickness.	✔	✔	
PART 3 – INTERIOR FINISHES					
Finished Flooring	3.1.5.8.	Combustible finished flooring is permitted in a building required to be of noncombustible construction.	✔		Combustible flooring materials (wood, carpet) is permitted in buildings of noncombustible construction in most floor areas.
Raised Platforms	3.1.5.8.	Wood members more than 50 mm but not more than 375 mm high are permitted for a raised platform in a building required to be of noncombustible construction • Concealed spaces required to be firestopped • Combustible subfloor and finished flooring is also permitted for the raised platform	✔		
Stage Flooring	3.1.5.8.	Combustible stage flooring supported on noncombustible structural members is permitted	✔		
Combustible Interior Wall Finish in Noncombustible Buildings	3.1.5.10.(2)	Wood interior wall finishes are permitted if a maximum of 25 mm thick with a flame spread rating of maximum 150 (walls) throughout finish material (i.e. not just surface treated)	✔		Wood finishes are permitted in noncombustible buildings, unless other flame spread requirements supercede this permission.
Combustible Interior Ceiling Finish in Noncombustible Buildings	3.1.5.10.(3)	Wood interior ceiling finishes are permitted if • Finishes are a maximum of 25 mm thick except that fire retardant treated battens are not limited in thickness; and • Finish has a maximum flame rating of 25 or is fire retardant treated wood.	✔		Wood finishes are permitted in noncombustible buildings, unless other flame spread requirements supercede this permission depending on location within the building. Up to 10% of the ceiling area of fire compartment is permitted to have a flame spread rating of not more than 150.
Flame-spread rating of interior finishes (general)	3.1.13.2.(1)	Maximum flame-spread rating of 150 for interior wall and ceiling finishes unless otherwise required or permitted elsewhere	✔	✔	These provisions permit untreated wood as a wall and ceiling finish in general floor areas. These are the base requirements for flame spread ratings for wall and ceiling finishes that may be superceded by more strict requirements for buildings of noncombustible construction or requirements for specific areas.

Building Component	Code Reference	Paraphrase of Provision	Provision Applicable to Buildings… Required to be Noncombustible Construction	Provision Applicable to Buildings… Permitted to be Combustible Construction	Comments
Flame-spread rating of doors	3.1.13.2.(2)	Maximum flame-spread rating of 200 (doors)	✔	✔	
Flame-spread rating of interior finishes of exits and exit lobbies	3.1.13.2.	Maximum flame-spread rating of 25 for walls and ceilings of exits and exit lobbies, regardless of sprinkler protection.	✔	✔	
Flame-spread rating of interior finishes in exits and exit lobbies (exceptions)	3.1.13.2.(4)	• Where interior wall and ceiling finishes are required to have a flame-spread rating less than 150, up to 10% of the total wall area and up to 10% of the total ceiling area is permitted to have a flame spread rating of 150 • In exit lobbies up to 25% of the total wall area is permitted to have a flame spread rating of 150	✔	✔	These exemptions permit untreated wood in small areas on walls and ceilings in areas that otherwise have strict flame-spread requirements that cannot be met by untreated wood.
Flame-spread rating of interior finishes	3.1.13.6.	Interior wall and ceiling finishes have limited flame spread ratings, especially for unsprinklered buildings in specific floor areas: • Maximum flame-spread rating for walls of public corridors, corridors used by the public in an assembly occupancy, corridors serving classroom (75 if not sprinklered, 150 if sprinklered) ○ Permitted to have a flame-spread rating of 25 on the upper part of the wall and 150 on the lower half of the wall • Maximum flame-spread rating for ceilings of public corridors, corridors used by the public in an assembly occupancy, corridors serving classroom (25 if not sprinklered, 150 if sprinklered)	✔	✔	Some untreated wood species have flame spread ratings of 75 or less.
Wood trim, millwork and doors for exits, exit lobbies and corridors in a high building	3.1.13.7.(3)	Trim, millwork and doors for exits and exit lobbies in a high building are permitted to have flame spread rating of 150 and smoke developed classification of 300, provided their aggregate area is not more than 10% of the area of wall or ceiling in which they occur	✔	✔	
Wood interior finish in exits in a non-combustible building	3.1.13.8.	Restrictive flame-spread rating requirements (maximum 25) applies for the full thickness of interior finishes in exits, with the exception of doors, heavy timber construction in a sprinklered building, and fire retardant treated wood	✔	✔	
Exterior exit passageway	3.1.13.10.	The wall and ceiling finishes of an exterior exit passageway that provides the only means of egress from the rooms or suites it serves, including the soffit beneath and the guard on the passageway, is required to have a maximum flame-spread rating of 25, except that a maximum flame-spread rating of 150 is permitted for up to 10% of the total wall area and for up to 10% of the total ceiling area	✔	✔	Wood finishes must be treated for certain exterior exit passageways.
Nailing elements for interior finishes	3.1.5.6	See Minor Components.	✔		

Building Component	Code Reference	Paraphrase of Provision	Provision Applicable to Buildings… Required to be Noncombustible Construction	Provision Applicable to Buildings… Permitted to be Combustible Construction	Comments
Fire stopping for wood ceilings and floors	3.1.11.3.	See Minor Components.	✔	✔	
Fire stopping between vertical and horizontal spaces	3.1.11.4.	See Minor Components.	✔	✔	
PART 3 – MINOR COMPONENTS					
Protection of foamed plastics	3.1.4.2.(1)(a)	In buildings permitted to be of combustible construction, foamed plastic insulation is permitted to be protected by plywood (9.29.6.), hardboard finish (9.29.7.), insulating fibreboard finish (9.29.8.), particle board, OSB or waferboard finish (9.29.9.)		✔	This permits typical wood interior finishes to protect foamed plastic whereas this is typically required to be gypsum board in noncombustible buildings.
Minor components	3.1.5.2.(1) (g) and (h)	Minor combustible components are permitted including wood blocking within wall assemblies intended for the attachment of handrails, fixtures and similar items mounted to the surface of the wall	✔		
Nailing elements for interior finishes	3.1.5.6	Wood nailing elements permitted • Attached directly to or set into noncombustible backing for attaching interior finishes • Concealed space created by the wood elements is a maximum of 50 mm thick	✔		Standard minor wood components for attachment of interior finishes are permitted in a building required to be of noncombustible construction.
Millwork	3.1.5.7.	Combustible millwork permitted (includes interior trim, doors and door frames, show windows together with their frames, aprons and backing, handrails, shelves, cabinets and counters)	✔		This opportunity is applied in most buildings required to be of noncombustible construction.
Fire stopping in wall assemblies	3.1.11.2.	Fire stops are required in cavities of wood wall assemblies at every floor level and to limit maximum horizontal and vertical dimensions	✔	✔	Firestopping of wood assemblies requires additional design detailing and construction effort.
Fire stopping for wood ceilings and floors	3.1.11.3.	Firestopping is required for the concealed spaces created by wood framing members supporting wood ceilings and wood floors	✔	✔	Firestopping of wood assemblies requires additional design detailing and construction effort.
Fire stopping between vertical and horizontal spaces	3.1.11.4.	Firestopping is required at interconnections between concealed spaces in horizontal and vertical wood assemblies	✔	✔	Firestopping of wood assemblies requires additional design detailing and construction effort.
Fire stopping of horizontal concealed spaces	3.1.11.5.	Firestopping is required for horizontal concealed spaces in wood construction such as wood floor or roof assemblies (unsprinklered)	✔	✔	Firestopping of wood assemblies requires additional design detailing and construction effort.
Fire stop materials	3.1.11.7.	Firestop materials to separate concealed spaces into compartments are required to remain in place for a minimum of 15 minutes when subjected to the fire exposure as outlined in CAN/ULC-S101. If a building is permitted to be combustible plywood or solid lumber is permitted as a firestop material.	✔	✔	While firestopping of concealed spaces takes additional design and construction effort, the firestopping can be constructed of standard wood materials.

Building Component	Code Reference	Paraphrase of Provision	Provision Applicable to Buildings… Required to be Noncombustible Construction	Provision Applicable to Buildings… Permitted to be Combustible Construction	Comments
PART 4 – STRUCTURAL DESIGN					
Seismic Force Resisting System	4.1.8.9.	SFRS Force Reduction Factors, System Overstrength Factors, and General Restrictions. – Table 4.1.8.9 provides restrictions for Timber Structures designed and detailed in accordance with CAN/CSA-086 that are imposed in certain cases based on design parameters such as the geographic seismic zone in which the building is located, and the type of SFRS utilized.	✔	✔	
Wood Used in Foundations	4.2.3.1.	Wood used in foundations is required to meet requirements of Subsection 4.3.1., which includes the design standard for wood (CAN/CSA-086), the standard for glue-laminated members and protection against termites (if known to be present).		✔	
Preservation Treatment of Wood	4.2.3.2.(1)	Where wood will be exposed to soil or air above the lowest groundwater table, it shall be treated in conformance with CSA 080 Series "Wood Preservation" and the appropriate commodity standard for the building element.	✔	✔	
Care of Preservative-Treated Wood Products	4.2.3.2.(2)	Where timber has been preservative-treated it shall be cared for as provided in AWPA-M4 "Care of Preservative-Treated Wood Products", as revised by Clause 6 of CSA 080 Series.		✔	
Design Basis for Wood	4.3.1.1.	Buildings and their structural members made of wood shall conform to CAN/CSA-086 "Engineering Design in Wood".		✔	
Design/ Manufacturing Requirements for Glue-Laminated Wood	4.3.1.2.	Glue-Laminated members shall be fabricated in plants conforming to CAN/CSA-0177-M "Qualification Code for Manufacturers of Structural Glue-Laminated Timber".		✔	
PART 5 – ENVIRONMENTAL SEPARATION					
Grade of Cedar Shakes and Shingles	5.6.1.2.	Cedar shakes and shingles installed to provide required protection from precipitation are required to meet certain grades depending on their type (western cedar or eastern white cedar) and their application.	✔	✔	
Standards for Wood Products in Environmental Separators	5.10.1.1.	Materials and components and their installation are required to meet the applicable standards in Table 5.10.1.1. where those materials or components are: incorporated into environmental separators or assemblies exposed to the exterior, and installed to fulfill requirements of Part 5 of the OBC. The table includes standards for wood products such as preservative-treated lumber, plywood, cedar shingles, softwood lumber, construction sheathing, OSB and waferboard.	✔	✔	

4. Opportunities for Alternative Solutions

4.1 Introduction

Compliance with the 2006 OBC can be achieved by complying with the provisions in Division B (referred to as acceptable solutions), or by using an alternative solution. An alternative solution is required to demonstrate the same level of performance as the acceptable solution.

The Code defines the areas that are subject to an evaluation of performance by analysis of functional statements and objectives linked to each Code provision.

Division C sets out documentation requirements for the submission of an alternative solution to the chief building official. It is important to note that compliance via an alternative solution is equally valid as compliance via an acceptable solution.

It is noted that alternative solutions are site specific and are not intended to be treated as a universal design solution. Neither is there a data base of information that documents previous alternative solutions.

Innovative or proprietary structural wood products may be permitted for use as structural members, subject to satisfying the requirements of Clause 13 "Proprietary Structural Wood Products" of CAN/CSA-O86 (and the authority having jurisdiction). Products designed in accordance with Clause 13 must provide equivalent performance characteristics such as strength, serviceability and reliability consistent with the requirements of Part 4 and the applicable sections of CAN/CSA-O86. In order to demonstrate compliance with Clause 13, a number of essential requirements must be satisfied, including the following:

- Conformance with a consensus standard developed by a recognized standards writing organization (e.g., ASTM, CSA)
- Development and implementation of a consistent methodology, based on sound engineering principles, for determining the structural design values and/or capacities of the product. This must include a provision for on-going re-evaluation and quality control.
- Incorporate a manufacturing quality assurance program, verified and supervised by an independent third-party certification organization.

In some cases, exceptions and/or reduced performance characteristics may be permitted under Part 5, provided that it can be shown or demonstrated that it will not adversely affect any of,

d) the health and safety of the building users,

e) the intended use of the building, or

f) the operation of building services.

4.2 Possible Alternative Solutions

All building solutions, including innovative design solutions or alternative materials are able to be analyzed as a possible alternative solution. However, the potential for success of any alternative solution depends on the extent to which the materials and design reflect the performance level that would be achieved by compliance with the corresponding Code provision that otherwise restricts the use of wood or the application. It is often necessary to offer compensating construction or demonstrate a clearly enhanced performance in order to demonstrate performance that is equal to or exceeds that which would be achieved by conforming to the provisions of the OBC. In addition, it may be necessary to demonstrate a measureable performance from testing, modeling or other analysis.

4.2.1 Wood Cladding Alternative Solution

An example of a possible alternative solution which was applied and accepted by an Authority Having Jurisdiction in another jurisdiction for a university research/academic building was the use of a wood cladding that had not been tested to the requirements of CAN/ULC-S134. The alternative solution relied on unique elements of the design of this specific building, including limitations on where the cladding would be used on the exterior building faces so as to avoid the potential for fire exposure from an exterior fire involving the cladding to expose windows opening to the building and doubling of limiting distances to avoid exposure to adjacent buildings.

In this case, the approval was granted on the basis of a scenario analysis, application of first principle fire dynamic analysis available for the homogeneous wood product and radiant heat calculations relative to adjacent buildings.

Approval was granted for the alternative solution on the condition that limitations were clearly noted on the permit file and a restriction on limiting distances was to be noted on title so that future development would not inadvertently undermine the solution and create an exposure condition.

4.2.2 Interior Finish Alternative Solution

An example of a possible alternative solution for wood is as an interior finish material that has a flame spread rating established by a test standard other than the standard recognized in the OBC. For example, a wood paneling product from Europe may be proposed for interior walls of the corridors in a sprinklered school that was required to be of noncombustible construction. The key OBC requirements for wood interior finish in this application are:

- Sentence 3.1.5.10.(2) permits wood interior wall finish in a building required to be of noncombustible construction. The conditions are that the wood is maximum 25 mm thick and has a maximum flame spread rating of 150 throughout the material.
- Article 3.1.13.2. also requires a maximum 150 flame spread rating for the interior finish of walls in corridors serving classrooms.
- Sentence 3.1.12.1.(1) requires that the flame spread rating of a material be determined on the basis of tests conducted in conformance with CAN/ULC-S102-M, "Test for Surface Burning Characteristics of Building Materials and Assemblies".

An acceptable solution (i.e. conforming solution) would require submission of documentation from the manufacturer demonstrating that the wood paneling has a maximum flame spread rating of 150 when tested to CAN/ULC-S102. In an alternative solution, the wood paneling that has been tested to another standard applicable in Europe would have to demonstrate that the performance of the material would be equal to or exceed that which is required by the OBC.

In order to approve the alternative solution, the authority may require analysis that compares the two test standards and demonstrates the correlation of the test results between the European standard and the ULC-S102 standard. This may be able to be demonstrated by analyzing the testing requirements including test chamber, sample configuration, flame exposure to the sample, pass/fail criteria and other conditions which may influence the performance of the material when subjected to flame. An analysis of this nature may be significantly less expensive and faster than submitting the material to an authorized testing agency for tests relative to the CAN/ULC-S102 Standard. However, the analysis may show that any one element of sample size or orientation, flame exposure or pass/fail criteria are uniquely different from the CAN/ULC-S102 test or that the accumulation of minor differences does not allow for a direct comparison. Ultimately the proponent of the alternative solution will need to prove that the flame spread rating under the European standard provides the same level of performance or better than the flame spread rating under the CAN/ULC-S102 standard.

To support the use of innovative products such as interior finishes that have not been subjected to the CAN/ULC-S102 Standard, one possible solution is for an industry advocate to accumulate test data from a variety of manufacturers and assemble a data base of results. Analysis of these industry results may lead to a correlation factor that can be reasonably expected to predict results when tested to the CAN/ULC-S102 Standard. A correlation between interior finish results for materials subjected to ASTM-E84 versus CAN/ULC-S102 is available (with limitations). A similar correlation would assist designers, manufacturers and distributors to introduce materials from other parts of the world to Canada and specifically to Ontario for use in educational buildings.

4.2.3 Wood Construction Alternative Solution

A more challenging example of an alternative solution is proposing a building to be of combustible construction where it exceeds the maximum building size permitted by Subsection 3.2.2.

This is challenging because demonstrating performance level of the building area and height limits of Subsection 3.2.2. requires a holistic exercise considering factors of occupant safety, emergency responder safety, and property protection.

This possible alternative solution requires whole scale computational fire modeling to assess the performance of wood under fire conditions as well as separate analysis of the performance of wood construction under structural loads. Although advanced computation fire models are available and are in wide-spread use as a fire protection engineering tool, significant limitations apply to these models. One of the most significant limitations is the ability to correctly model the effectiveness of sprinklers. Many models rely on overly conservative assumptions that, when compounded, may undermine the analysis as a tool to assess the performance of a material that would otherwise not be permitted by the OBC.

It is noted that extensive investigation and analysis is underway within the research community with respect to the fire performance of a large wood frame building as well as to the seismic and structural performance of wood frame construction.

5. Potential Code Changes to Promote the Use of Wood

5.1 Introduction

Potential Code changes to promote the use of wood are not unique to educational buildings. Potential changes such as wood buildings of increased size, or fewer restrictions on the use of wood as an exterior cladding have been contemplated by many Code-writing bodies.

- Recent trends in expanding the use of wood illustrate the potential for Code changes in Ontario and the application to different occupancy types.
- British Columbia Building Code – Change to Permit 6 Storey Wood Frame Residential Building

Quebec – Alternative Solution to Permit an 8 Story Office Building of Mixed Wood and Noncombustible Construction

Other changes are possible for any element of the Code which currently restricts the use of wood or which permits wood but under limitations or restrictions.

5.2 Process

Any change to the Code requires submission of a Proposed Code Change Form, identifying the current provision and the proposed change, as well as supporting documentation to justify the basis for the proposed change.

Justification for a proposed change can be developed from precedents, first principle analysis or fire modeling. A combination of justifications may be required for complex changes.

5.3 Possible Changes to the OBC

The following are examples of possible changes to the OBC to permit the use of wood:

- Modification to Article 3.1.5.5. to specifically permit the use of fire retardant wood cladding, without being tested to CAN/ULC-S134 for wood that would otherwise demonstrate a flame spread rating of less than 25 when tested to conform to CAN/ULC-S102. The material would be required to have been subjected to an accelerated weathering test (ASTM D2898) prior to testing for flame spread. This possible Code change should be supported by test data to confirm that exposure conditions are limited for a variety of wood products that demonstrate the flame spread rating less than 25.
- Removal of restrictions on thickness of interior finish material under Article 3.1.5.10. for solid wood materials that demonstrate flame spread ratings currently applicable in the Code. It may be appropriate to require the installation of sprinklers to support this relaxation. The properties of solid wood support a relaxation of the 25 mm maximum thickness since wood chars when exposed to fire and the char provides a protective layer that reduces the exposure to the full thickness. In combination with sprinkler protection, the extent to which the full thickness of wood would be consumed and contribute to the fuel load is severely reduced.
- Expanded application for the use of heavy timber is another possible change to the OBC. Current limitations on the use of heavy timber can be restrictive. For example, heavy timber roofs and their supporting structure are permitted in a building up to 2 storeys in building height. However, consideration could be given to permitting heavy timber construction for roof elements and their supporting structure for any roof element that is within 2 storeys from grade, regardless of the building height. Sprinklers would be required throughout.

Morrison Hershfield

Morrison Hershfield Limited

Dana Scherf, P.Eng.
Associate and Code Consultant

Scott Tomlinson, P.Eng.
Principal and Structural Engineer

Judy Jeske, P.Eng.
Principal and Senior Code Consultant
Fire Protection Engineer

Kevin Chouinard, P.Eng.
Principal and Vice President
Buildings, Technology and Energy

Laurentian University – Vale Living With Lakes Centre, Sudbury, ON
Photo: Terence Hayes Photography

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