Wood Innovation and Design Centre

PRINCE GEORGE, BC

A TECHNICAL CASE STUDY

woodWORKS! Program of the Canadian Wood Council

Canadian Wood Council
Conseil canadien du bois

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WIDC ENVIRONMENTAL BUILDING DECLARATION

Similar to Environmental Product Declarations (EPD) that provide information on components used in the manufacture of construction materials and products, Environmental Building Declarations (EBD) are now being developed and used in Europe. EBD information is presented in a table that identifies the impacts on the environment and human health across a range of categories, and applies them to the Life Cycle Analysis (LCA) of whole buildings. LCA is a cradle-to-grave analysis of the material effects of structure, envelope and interior partition assemblies, and operating energy and water use, over a 50-year period.

The Wood Innovation and Design Centre is one of the first buildings in North America for which an EBD has been prepared. The whole-building LCA was conducted by the ATHENA Sustainable Materials Institute and was commissioned to identify the environmental performance of the building.

The assessment was conducted in conformance with the Committee for European Standardization (CEN) standard EN 15978 which, while European in scope, is quickly becoming the standard for whole-building LCA worldwide. ATHENA applied its North American interpretation of EN 15978 to meet the purpose of the assessment for the WIDC.

Seventeen indicators covering environmental impacts, resource use, waste, and output flows leaving the system were evaluated. In addition, various contribution and sensitivity analyses were carried out, and are presented along with additional information, including the impact of carbon sequestration, the substitution of wood for concrete, and other avoided impacts and burdens occurring beyond the 50-year life cycle.

While the EBD presents only the objective findings of the analysis, the ATHENA organization has stated that the “public disclosure of its embodied environmental footprint puts WIDC on the leading edge.”

The EBD and the full ATHENA report are available at: http://www.athenasmi.org/news-item/ new-environmental-building-declaration-for-widc/

INTRODUCTION

With a height of 29.5 metres, the Wood Innovation and Design Centre (WIDC) is the tallest contemporary wood building in North America. Located in the city of Prince George in northern British Columbia, the WIDC was conceived as a showcase for local wood products and as a demonstration of the province's growing expertise in the design and construction of large wood buildings.

The building has eight levels (six storeys, plus a ground floor mezzanine and a rooftop mechanical penthouse). The lower levels will accommodate faculty and students enrolled in the new Master of Engineering in Integrated Wood Design (MEng), to be launched by the University of Northern British Columbia (UNBC) in January 2016 and the new Centre for Design Innovation and Entrepreneurship to be launched by Emily Carr University of Art and Design in fall 2016. Academic facilities include a research/teaching lab that will support the design, fabrication and testing of wood products; a 75-seat lecture theatre; classrooms; a student lounge; gathering and meeting areas; and a learning resource centre. The upper floors will provide office space for public and private sector organizations associated with the wood industry.

Over the long term, the WIDC will advance wood education and innovation in the province, enhance expertise in wood manufacturing, product development and engineering – all of which will help to expand opportunities for international exports of products and services. In addition, its striking presence in the heart of the city will assist in the revitalization of downtown Prince George.

This case study describes the most important innovations that were implemented to meet design and safety criteria in what is a new class of buildings for British Columbia. These innovations included:

- A set of site-specific regulations to ensure life safety and structural integrity;
- The use of vertical cross-laminated timber (CLT) elements (including mechanical, elevator and stair shafts) to provide lateral stability to the structure;
- The use of double layer CLT floors to meet structural requirements and contribute to acoustic isolation and efficient services distribution;
- The use of superimposed (end grain-to-end grain bearing) columns to control shrinkage over the height of the building; and,
- The use of high strength proprietary connectors to speed construction and improve structural performance.

Figure 1 shows the siting of the WIDC in downtown Prince George (right).

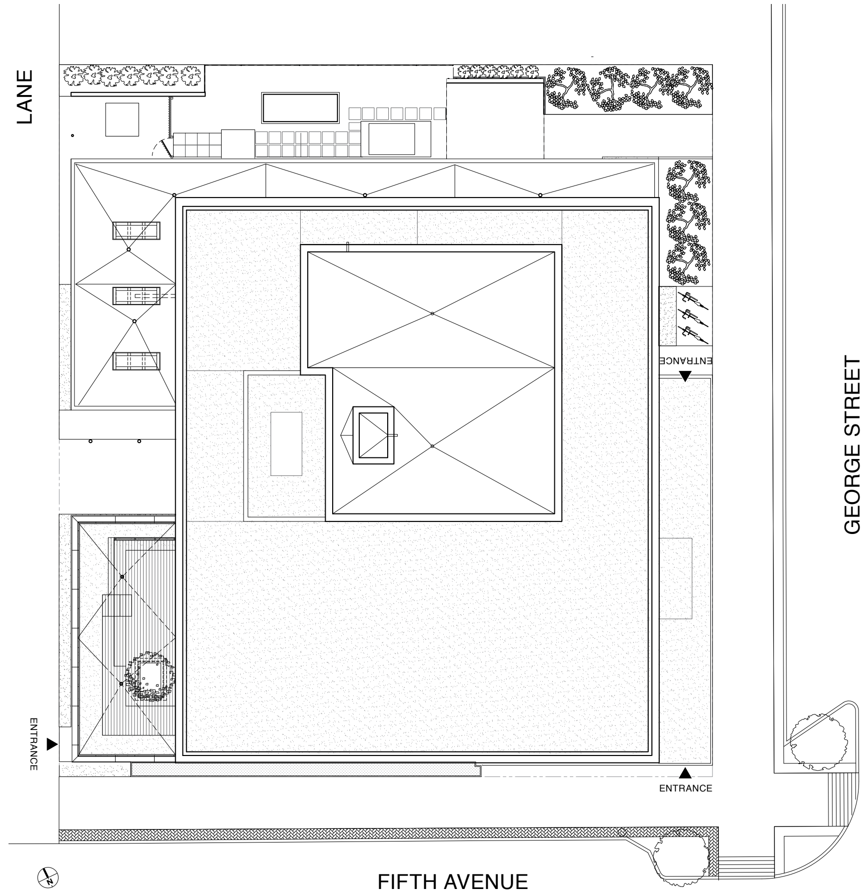


Figure 1: WIDC site plan
Michael Green Architecture Inc.

BACKGROUND

British Columbia has been a leader in North America in the implementation of building regulations that permit the greater use of wood construction in larger and taller buildings.

In 2009, the BC Building Code was amended to permit wood construction of up to six storeys for residential occupancies. Elsewhere in North America, several other provinces and states, as well as the model National Building Code of Canada, are conducting their own research, with the intention of following British Columbia's lead.

The WIDC was designed to the 2012 BC Building Code as amended by the *Wood Innovation Design Centre Regulation* (the site-specific regulations as noted previously). Combined with research and testing, the regulations were developed to provide code-equivalent levels of safety to those required for similar buildings of non-combustible construction. The major criteria established for the WIDC were:

- A building area of not more than 1,125 m^2;
- A building height of six storeys, and floor areas that together total not more than 4,850 m^2;
- Not more than 30m in height measured from grade to the highest point of the uppermost roof; and,
- Major occupancy classifications consisting of:
    - First and second storeys – Group A, Division 2 assembly occupancy or Group D business or personal services occupancies;
    - Third to sixth storeys – Group D business and personal service occupancies.

Financed by the Province of British Columbia, the design and construction process was fast-tracked to meet funding criteria, and to make the most of the region's short construction season. This meant that detailed design of the superstructure was still in progress when work began on site.

The glazed curtain wall is interspersed with a combination of untreated and charred Western red cedar panels

Design began in early 2013, and construction of the concrete raft slab foundation began in August of the same year. This was closely followed by the arrival on site of the first wood members in September. By the end of October 2014, the building was substantially complete and the UNBC and common areas of the building were ready for occupancy. The upper floors were left as open, unfinished areas, to be let out as suitable tenants are secured.

In addition to utilizing a variety of locally manufactured engineered wood products, the WIDC incorporates numerous other sustainable design strategies, and has achieved LEED (Leadership in Energy and Environmental Design) Gold certification.

The primary structure is an innovative combination of glulam post-and-beam frame construction, a custom-designed CLT floor system, and CLT elevator, stair and mechanical shafts. Concrete was used only for the ground floor slab and for the floor of the penthouse mechanical room. Wherever possible, the wood structural members were left exposed. Appearance-grade Douglas fir was used for the bottom lamination of the CLT floors (visible from below), and these were given a clear coat finish.

The building is balloon-framed, meaning that the columns are superimposed one above the other, with end grain-to-end grain bearing. The beams then frame into the sides of the columns; there is no cross grain in the vertical section of the building. This technique minimizes cumulative vertical shrinkage that could otherwise impact the performance of the structure. The building systems are repeatable and expandable to other building types and sizes.

The building envelope is a combination of glazing installed in vertically laminated veneer lumber (LVL) mullions and structural insulated panels (SIPs) clad with natural or charred Western red cedar siding.

Innovative combination of glulam post-and-beam frame construction and custom-designed CLT floor system

CONSTRUCTION SEQUENCE

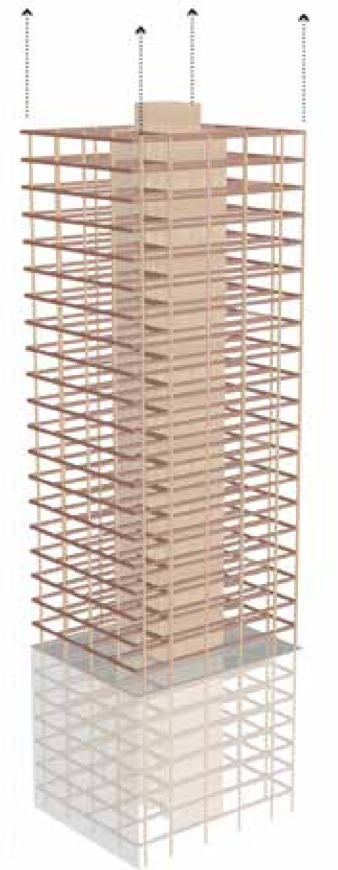
After completion of the concrete slab foundation, building construction progressed as shown in Figure 2 (below).

1 The lateral-load resistance is primarily provided by the elevator and stair core walls, which consist of CLT panels. The shear walls are anchored to the foundations using a combination of shear brackets and hold-down anchors.

2 The structure is a glulam post-and-beam system with built-up CLT floor panels. Glulam beams frame into glulam columns using proprietary aluminum dovetail Pitzl connectors.

3 Staggered CLT floor panels are installed. Upper floor columns bear directly on columns from the floor below. Laminated veneer lumber (LVL) wind columns and structural insulated panels (SIPs) followed on each floor.

4 The building envelope is set in place including curtain wall glazing and wood cladding. The roof enclosed the building with mechanical penthouse on top. Building is now enclosed for services installation and interior partition framing to begin.



5 The British Columbia Building Code restricts the height of wooden non-residential buildings to four storeys. A unique site-specific regulation allows a mass timber building of six storeys to be built for assembly and office occupancies.

Figure 2: Construction sequence
Michael Green Architecture Inc.

Red-stained plywood feature wall during construction

Installation of glulam column-to-column connector

CONNECTIONS

Foundation

The foundation for the WIDC is a reinforced-concrete raft slab that varies in thickness from 400 to 600mm (16 to 24 in.). Baseplates for the glulam columns and CLT walls were carefully positioned and cast into the slab. The contractor surveyed the location of all baseplates before, during and after the pour. This thoroughness paid off, as only one baseplate out of 80 needed to be readjusted.

For the superstructure, ETABS software (a 3D object-based modelling and visualization tool that enables designers to quickly explore and compare alternate design approaches) was used to model the lateral system.

As a result of this analysis, the design team decided to use a CLT core for the building (comprising elevator and stair shafts and the mechanical service chase). The panels of these core elements are connected using self-tapping screws to create continuous shear walls. The shear walls are anchored to the foundations using a combination of shear brackets connected to the panels with self-tapping screws and hold-down anchors (photo: right) connected to the panels using the ductile HSK system.

Two types of connections were used to secure the slab-level columns to the concrete slab. Most used an embedded plate cast into the concrete slab (as described above) and a matching column base with a thick vertical fin plate (beveled for welding) that was factory installed into the base of the glulam column using self-tapping screws or epoxied HSK connectors (photos: far right). This allowed for precise placement of the columns. Where anchor bolts were used, the base connection was designed as a pedestal, and detailed to permit factory installation to the base of the glulam columns.

CLT core panel showing a tie-down connector

Placement of column for welding to the baseplate

Column-to-Column

As previously noted, the WIDC is constructed using a balloon-framed system. This means the columns are continuous (but spliced at each floor) and the beams are attached to the sides of the columns (Figure 3).

As well as reducing vertical shrinkage to only 1mm per floor, this removes the beams and floor system from the load path of the columns. Because the crushing strength of wood perpendicular-to-grain is only one tenth of that parallel-to-grain, this strategy is critical for the successful design of taller wood buildings.

The hold-down nuts for the column-to-column connections were tightened using a special tool made from a magnet and a ratcheting box wrench. At completion, the access holes were filled with a wood plug to conceal the bolts (photo: right).

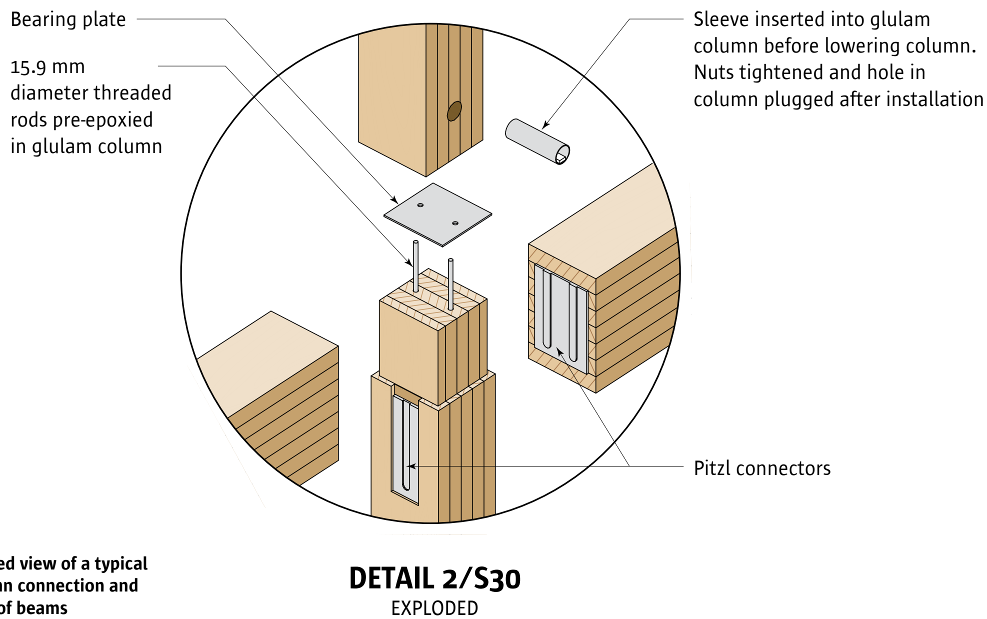


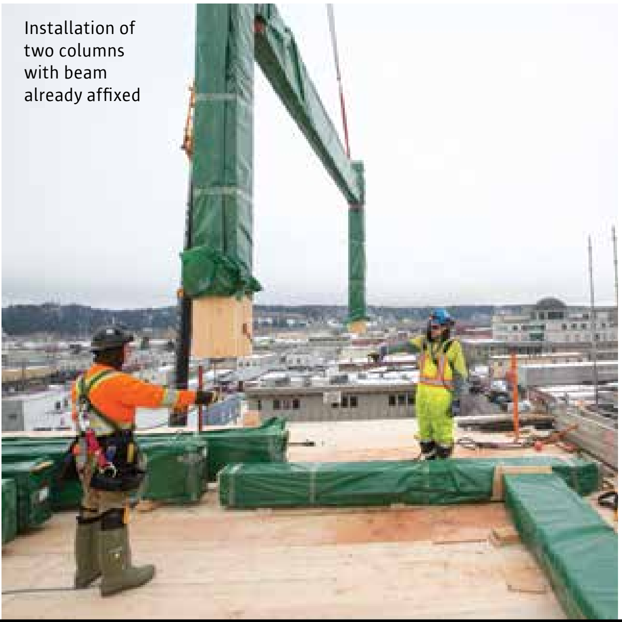
Figure 3: Exploded view of a typical column-to-column connection and the attachment of beams
Credit: Structurlam

Wood plug installed to conceal the column-to-column connection

Beam Framing

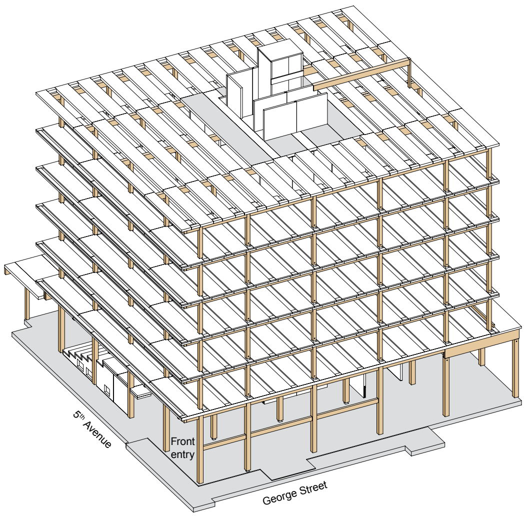
The glulam beams frame into the glulam columns (see Figure 3 on previous page and Figure 4 below) using dovetail connectors, allowing the columns to run continuously from the foundation to the roof. The dovetail connectors (Pitzl) were installed at the glulam plant (photo: far right).

Typically, frame elements comprising two columns and one beam were assembled in a horizontal position and then erected (photo: below).



Installation of two columns with beam already affixed

Figure 4
Credit: Structurlam



Factory installation of dovetail connector to a beam end
Credit: Swanky Photography

CLT Panels for Elevator, Stair and Mechanical Cores

The floor system was supported at the core walls (photo: below top) using laminated strand lumber (LSL) ledgers and self-tapping screws (photo: below bottom). The lower screws were oriented at 45° to capitalize on their strength when loaded in withdrawal.

LSL ledger supporting the floor at the vertical CLT core wall

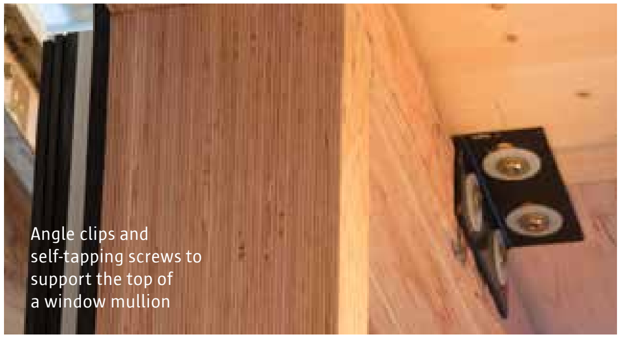
Self-tapping screws readied for attaching a ledger to the CLT core

Miscellaneous Connections

In addition to the connectors described in the preceding sections, other standard types were used as shown (photos: below).

Floor-to-beam bracket connection

Angle clips at core CLT intersection



Angle clips and self-tapping screws to support the top of a window mullion

Stock beam hanger

Steel beam screwed into a pocket in the core CLT panel

FLOOR SYSTEM

The WIDC floor system consists of two layers of CLT panels, running parallel to each other and connected together compositely to form a corrugated structural section. The panels in each layer are laid with gaps between them, creating a series of chases in which services can be concealed.

The chases in the upper and lower layers enable pipes to be laid within the cavities (see Figure 5). This arrangement leaves the underside of the CLT panels exposed.

Plywood covers were installed over the upper panel cavities immediately after CLT installation to provide an even walking surface (photo: below left of centre). They were removed as required to install services and then acoustic subflooring and finish flooring were installed (photo: below left of centre). Cavities between the lower CLT (ceiling) panels were covered by removable slatted wood panels (photo: below left).

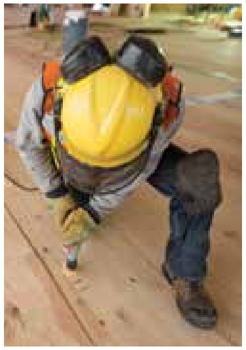
Where the upper and lower CLT panels intersect, they are joined together using the HSK connection system. This involves short saw-cuts through the edges of the panels creating a continuous vertical kerf. A perforated metal plate is then placed in the saw-cut and the void is filled with epoxy glue (photos: below centre). The result is an extremely strong and elastic connection that creates a composite structure in which the upper and lower panels act together.

Foam was injected at the ends of the saw-cuts to seal any discontinuities in the interior of the CLT panels. This was done to prevent leakage of adhesive and to ensure that the correct amount of epoxy had been used. The epoxy was injected from the top of the floor with the injection nozzle located at the bottom of the saw-cut to push air up and out of the cavity. Visual verification and volume measurements were used to ensure the HSK perforated plates were fully encased with epoxy.

Figure 5: Section through the floors
Credit: Michael Green Architecture Inc.

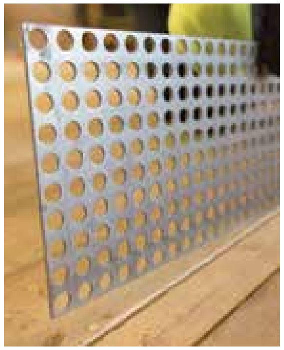
Ceiling cavities in the Level 1 demonstration area contain lighting and fire suppression systems concealed by a removable wood-slat finish

Ceiling showing the underside of overlapping CLT panels and the service chases on the floor with plywood covers in place



Saw kerf (left of the worker) ready for HSK plate insertion

Epoxy injection for securing the HSK plate



Insertion of HSK plate

Installation of services below CLT floor

FIRE SAFETY

Design for fire safety was based on the BC Building Code and the site-specific regulation created for the Wood Innovation and Design Centre.

Fire Safety During Construction

The risks and hazards on a construction site differ in both nature and potential impact to those of a completed building because they can occur at a time when the safeguards that are designed to be part of the completed building are not yet in place. Building codes focus on protecting the occupants of completed buildings. In addition to meeting any provincial regulations for fire safety during construction, there are best practices that should be applied.

To this end, the Canadian Wood Council has developed best practices[1] for buildings under construction. For example, 24-hour security is not usually a code requirement, but is a way of reducing the risk of vandalism, theft or arson, and for detecting problems before they grow out of control. In the case of the WIDC, the contractor, PCL, worked with the Prince George Fire Department to develop a series of fire safety practices to be implemented during construction. Twenty-four-hour security was provided, and stand-pipes for firefighting were installed as building height increased. In addition, 'hot works' were minimized during construction; for example, crimped pipe connections were used in lieu of soldering to eliminate the possibility of an accidental fire.

[1]Fire Safety and Security (for construction sites) and technical bulletins about fire safety, durability, building performance, insurance, case studies, managing movement and other topics are available from the Canadian Wood Council, http://cwc.ca/publications/

Fire stopping was required at the joints between CLT panels in order to prevent the passage of fire and smoke (see page 14)

In-service Fire Safety

It has long been recognized that large timber members have an inherent fire resistance because of their slow and predictable rate of charring when they are exposed to fire. This slow rate of char is approximately 40mm per hour, allowing large timber systems to maintain significant structural capacity for an extended duration during a fire. New massive engineered wood panel and beam products, such as cross-laminated timber (CLT), parallel strand lumber (PSL) and others can take advantage of this attribute because of their large cross-section. Fire performance is further enhanced through the use of concealed connectors, whereby structural or non-structural wood elements provide protection to the vulnerable steel components.

The fire design of the CLT components at WIDC is based on the methodology set out in the Canadian CLT Handbook, which includes a chapter titled "Fire performance of cross-laminated timber assemblies". A subsequent US edition provides further guidance on the performance of joints between CLT panels. The calculation methodology is based on the standard fire exposure and is a means for predicting the expected fire resistance that would be determined when testing to CAN/ULC-S101.

The handbook uses the reduced cross-section method to estimate the residual capacity of structural members after some duration of fire exposure. A char depth is calculated based on the fire exposure time, and an additional depth is subtracted to account for the heated wood that has lost some strength, leaving a reduced cross-section. The capacity of the reduced cross-section can then be determined using the full design strength of the member.

In addition to supporting the structural loads in the event of a fire, it was also required that the mass-timber panel assemblies at WIDC resist the passage of flames and hot gases, and limit the temperature rise on the unexposed surface of the assembly in order to prevent fire spread from one compartment to another. Since wood is an effective insulator, and CLT is manufactured by laminating together individual pieces of lumber, a CLT assembly will always experience either structural failure or integrity failure before thermal failure can occur. Also, as CLT panels tend to be sealed well (through the thickness of the panel), in part because of the use of polyurethane adhesives which foam to fill voids during manufacturing, the main concern with respect to integrity failure is the joints between adjacent CLT panels or between assemblies (e.g., wall-to-floor joints).

While it was the site-specific regulation that allowed for this tall wood building to be constructed, it was the BC Building Code that governed the fire separations applicable between spaces and at the building core elements (stair, elevator shaft). In the case of the WIDC, the requirement for these separations was one hour. Engineering judgment, supported by existing fire test data, showed that the structural CLT walls, stringer panels, and landing floors within the stair were appropriately sized to provide that one-hour separation without requiring additional fire protection elements such as gypsum drywall.

The design criteria for a typical floor assembly are shown in Table 1 and those for a typical wall assembly in Table 2. In both cases, the CLT assemblies meet the one-hour fire-resistance requirements based on the calculation method.

Table 1: Sample CLT floor assembly

Assembly	Location	Specifications	Max. live load	Max. dead load	Floor span	Calculated structural fire-resistance rating
CLT Floor 2	Storeys 3-6	5-ply bottom CLT, 3 ply top Grade V2, 200 mm overlap	2.4 kPa	2.4 kPa, (1.6 kPa on 3-ply)	5.8 m	1 hr.

Table 2: Sample CLT wall assembly requiring a fire-resistance rating

Assembly	Location	Specifications	Max. live load	Max. dead load	Wall height	Calculated structural fire-resistance rating
CLT Wall 1	All floors	5-ply CLT, Grade V2, 150 mm half lap joint	200 kN/m	70 kN/m	3.5 m (pinned end conditions)	1.5 hrs.

Since there were no prescribed fire stop systems for penetrations in CLT assemblies, all penetrations and major joint configurations were tested in accordance with CAN/ULC-S115 *Fire Tests of Fire Stop Systems* as required by the BC Building Code.

The site-specific regulation required the provision of direct access for firefighting from the outside of the building at every level less than 25m above grade. Specifically, this meant at least one unobstructed window or access panel being provided for each 15m of wall, in at least one wall facing a street or lane. Consequently, every level of the WIDC, starting from Level 2, has two fire department access doors facing George Street (photo: below left).

The elevator shafts, exit stair and exit corridor walls, scissor-stair dividing walls, and scissor-stair floor assemblies required a one-hour fire separation. In addition, the scissor-stair walls, floor assemblies and the shafts around the standpipe risers (at Level 1) were constructed to prevent the migration of smoke from one scissor stair to the other.

This required careful design and proper sealing of panel-to-panel joints. Joint designs were evaluated by the team for their constructability and effectiveness in creating a smoke barrier. The most promising joint designs were then laboratory tested to confirm their effectiveness.

Elevator Shaft

The elevator shaft is comprised of CLT panels installed vertically, like other elements of the 'core' structure. The inside surfaces were site-treated with a ULC-listed intumescent coating, a treatment that expands in fire to provide a degree of fire protection (photo: below right). The treated CLT surfaces have a flame-spread rating of not more than 25. This rating is based on thin samples of Douglas fir, but more recent testing has shown that the resistance to flame spread is better for intumescent coatings applied to CLT panels due to their mass.

To function effectively, an elevator must be able to cope with the anticipated vertical movement in a tall building. The design precautions taken to minimize shrinkage (as outlined previously) appear to have successfully addressed any such problems on the WIDC project. Based on data from sensors placed in the shaft, this movement did not exceed the design tolerance. However, service technicians have had to reduce the rail sensor sensitivity to improve reliability.

One of the two tiers of fire access doors integrated into the George Street façade

The CLT elevator shaft did not require any special acoustic treatment as it is not adjacent to noise sensitive areas

Stairwells

Emergency egress from the WIDC is provided by double-scissor stairways (photo: far right). As with the elevator shaft, the CLT walls and ceilings in the exit stairs were treated with a fire-retardant coating to reduce the flame spread rating to 25.

To ensure that smoke could not migrate from one scissor stair to the other, it was necessary to drill a small hole and apply sealant at each board joint in the CLT stair shaft wall, immediately above and below the stringer and landing panels. This sealed the small cracks that typically form between the boards on the outer layer of CLT panels due to shrinkage.

Building the feature stair: installation of LVL risers on the inclined LVL stringer panel

Finished feature stair in the main lobby

Stairwell with CLT walls, ceiling and floor

BUILDING ENVELOPE

The primary function of the building envelope is to mitigate or harness the environmental forces acting upon it, and to maintain a comfortable thermal, visual and acoustic environment within the building.

The most important environmental considerations for the WIDC project were:

1. **Rain.** The design objective was to incorporate rainscreen principles and to specify durable, high-quality materials to protect the wood structure and other moisture-sensitive components within the building envelope. Design of the water-shedding surface elements and the secondary water-resistive barrier was critical to managing moisture penetration from rain and other sources.
2. **Condensation.** The building enclosure consists of highly insulated wall, roof, and glazing assemblies. These assemblies, such as the triple-glazed thermally-broken curtain-wall system, already have a low risk of interior surface condensation. However, this risk was further mitigated by proper detailing of insulation to prevent thermal bridging at the wall and roof assemblies and the interfaces between the elements of the envelope.

   The potential for condensation due to vapour diffusion was managed through the use of vapour retardant elements on the interior face of the SIP panels, and a vapour barrier membrane within the roof.

   The potential for condensation resulting from air leakage was managed through the design and installation of a continuous and durable air barrier system and detailing of interface joints throughout the building envelope. The evaporation of moisture from incidental wetting or condensation is facilitated by the drained and ventilated rainscreen cladding system.
3. **Thermal comfort and temperature control.** The building envelope incorporates highly insulated wall and roof assemblies, and a triple-glazed, thermally-broken curtain-wall system, to achieve a higher level of thermal performance than that required by the building code. This high performance envelope is a key part of the overall energy efficiency strategy, and also contributes to LEED energy credits.

The primary envelope assemblies for the WIDC are:

1. **Curtain-wall.** This assembly consists of an aluminum curtain-wall system fastened to a vertically laminated LVL structural frame. The system is stick-built and site-glazed with triple-glazed units that are argon filled with low-e coatings.
2. **Cedar-clad rainscreen walls.** The wall assembly consists of structural insulated panels (SIPs) protected on the exterior with a high-performance, liquid-silicone air and moisture barrier membrane. All joints between the SIPs are sealed at the interior and exterior side and are insulated where gaps occur, for airtightness and condensation control. The SIP panels and critical barrier membranes are tied directly into the curtain-wall assembly. The panels are clad with a panelized tongue-and-groove, fire-treated cedar cladding that have either a natural or charred finish, depending on their location.
3. **Roof.** The roofs of the building are waterproofed with a two-ply torch-on SBS-modified bitumen membrane. The main roof, mechanical room roof, elevator over-run roof and one of the lower roofs are of conventional design (assembles with membrane over insulation). An accessible lower roof and ballasted area are of the ‘inverted’ type, consisting of a protected membrane roof assembly with insulation over top of the membrane.

   The roof assembly also incorporates an interior ventilated space above the CLT panels to facilitate drying, both during construction and in-service. This feature was incorporated to protect the CLT structure from deterioration in the event of excessive wetting during construction, or a roof leak after occupancy.
4. **Foundation.** The below-grade construction includes the foundation walls and a slab-on-grade. The foundation waterproofing consists of a single-ply SBS waterproofing membrane that extends up above-grade and transitions to the air and moisture barrier membrane in the wall. There is no hydrostatic pressure on this project, so the foundation slab is poured over a heavy polyethylene vapour retarder and drainage gravel.


Installation of a cladding panel with charred siding


SIP panels with air barrier membrane on the exterior face


Mounting clip on SIP panel for mounting the cladding panel

Along the footings, the general drainage provisions and perimeter drains were designed by the geotechnical and mechanical consultants. The insulation is installed vertically along the perimeter walls, conserving energy and improving thermal comfort.

The air barrier is a roller-applied liquid membrane (photo: top middle) that was tested on mock-up panels prior to installation.

The cladding panels are made of Western red cedar siding. The siding was treated with fire-retardant and then mounted on plywood backing panels (photo: top right). Some of the panels were left untreated to weather naturally. The siding on the other panels was factory-charred with a torch. The use of charred wood siding is a traditional construction practice used for centuries in many parts of the world including Finland, Austria, Japan and Switzerland (photos on following page).

Western red cedar

Untreated red cedar panels

Charred cladding

View of the curtain wall showing glazing and charred and natural Western red cedar siding

The charring was done in two passes. After the first pass, a skin layer was removed by brushing. The second pass provided the desired char consistency and depth. Testing was done to ensure the charred siding maintained the required flame spread rating of 25 or less. The charred wood cladding increases durability by providing protection from insects and moisture, and results in a pleasing architectural appearance quite unique in North America.

The charred siding was coated with a clear finish to improve moisture resistance and to minimize smudging, a concern on Level 1 where pedestrians could come into direct contact with the panels.

Window Mullions

Vertically laminated veneer lumber (LVL) was used for the vertical wind columns (mullions), with an applied aluminum veneer. The mullions support the triple-glazed curtain-wall system (photos: right).

LVL window mullion

Window mullions after glazing installation

SOUND PRIVACY

There are two types of laboratory sound tests for measuring the sound that travels from one area of a building to another: Impact Insulation Class (IIC) and Sound Transmission Class (STC). IIC tests the ability to block impact sound by measuring the resistance to transmission of impact noise or structure-borne noise (simulating footfalls, objects dropped on the floor, etc.). STC evaluates the ability of a specific construction assembly to reduce the transmission of airborne sounds, such as voices, stereo systems and television, from one built space to another.

Single and double layers of drywall, double-stud walls, insulation and resilient channels were used to achieve the required sound transmission ratings for the walls. STC ratings were required to be more stringent in certain areas to meet UNBC's own conference and lecture room requirements. To achieve these requirements, dropped noise-barrier ceilings consisting of double layers of drywall were installed in the designated rooms.

Acoustic mats and carpet were installed over the CLT floors to reduce sound transmission. Successful *in situ* sound testing took place in August 2014. All of the floor/ceiling and wall assemblies satisfy the Apparent Sound Transmission Class (ASTC) requirements. In addition, all of the floor/ceiling Apparent Impact Insulation Class (AIIC) measurements satisfy the IIC requirements.

A summary of select acoustic requirements and *in situ* test results is shown in Table 3 (right).

The lecture theatre will be used for distance learning, so it had more stringent acoustic requirements than the other spaces in the building

Table 3: Sample of acoustical requirements and results

Assembly	Source Room	Receiver Room	Design Requirement	Measured
Wall	Mechanical room Design classroom	Lecture theatre Project room	ASTC 47 ASTC 47	ASTC 48 ASTC 48
Floor	Lecture theatre Design classroom Project room	Project room Faculty office Faculty office	ASTC 42 ASTC 42 ASTC 42	ASTC 60 ASTC 53 ASTC 47
Floor	Project room Faculty office Faculty office	Lecture theatre Design classroom Project room	FII 65 FII 652	AIIC 67 AIIC 64 AIIC 53

STRUCTURAL WOOD PRODUCTS

Cross-laminated timber (CLT)

CLT is an engineered wood panel made by arranging and gluing layers of dimension lumber. Each layer is perpendicular to the next. CLT panels typically consist of three, five or seven layers. The dimensions of CLT panels are limited only by transportation constraints but they are typically up to 40 feet long and up to eight feet wide. CLT panels are typically used for floors, walls and roofs. In the WIDC, CLT panels were also used vertically for the core of the building – the mechanical and elevator shafts, and core stairs.

Glulam

Glulam is made by gluing together laminations of solid-sawn lumbers that are specifically selected and positioned based on their structural strength and appearance characteristics. Glulam is typically used for beams and columns and can be manufactured in curved sections. In the WIDC, glulam was used for the columns and most of the beams.

Laminated veneer lumber (LVL)

Standard LVL is made from layers of veneer laid parallel to each other and bonded together with moisture-resistant adhesives. LVL is typically used for beams and headers in residential and commercial construction. For the WIDC, vertically laminated LVL was used for the window mullions, entrance canopy, feature stairs, and other applications.

Parallel strand lumber (PSL)

Parallel strand lumber (PSL) Parallam® PSL is a high-strength structural composite lumber product manufactured by gluing strands of wood together under heat and pressure. It is well-suited for use as beams and columns for post-and-beam construction, and can be used for long span beams when laminated into deep sections in both residential and commercial building construction. In the WIDC, Parallam® PSL beams were used in concealed locations to transfer column loads over the main level lecture theatre and research lab.

LESSONS LEARNED

This project was designed and constructed on a fast-track schedule. As a result, some timber work was done on site that could have more effectively been done in the factory. For example, some of the connectors were installed in the field – a slower and potentially less-accurate method of working.

As noted by Nicola Logworks, prefabrication using computer numerical control (CNC) technology has the capability to precisely locate and mill openings, tapers, cuts and dimensions. In order to take full advantage of the benefits of using wood products and off-site capabilities for manufacturing, full building information modelling (BIM) and an integrated project delivery (IPD) system should be fully embraced from the start of a project.

To minimize the possibility of errors, adequate time must be allocated during the design phase to ensure all members of the project team, including all design disciplines, fabricators and manufacturers and all construction trades, have a common design platform to work from – that is to say, a single master 3D model.

Engaging in a process that involves precise prefabrication of structural elements and the integration of a variety of building systems in the factory requires a high degree of commitment and co-operation from all members of the construction team. With wood, the realization of a durable, high quality project truly is a collective endeavour.

Because most designers prefer to leave wood structures exposed for aesthetic reasons, structural elements need to be handled with care to minimize physical damage and discolouration from moisture or other sources. This generally includes protective wrapping during transportation and installation, but risks can be further reduced using 'just in time' delivery that minimizes potential weather exposure and handling requirements on site. On the WIDC project, all the exposed structural wood elements (most of which were on the interior of the building) were left untreated during the construction phase. On completion of the structure, Nicola Logworks repaired, cleaned, prepped and applied all the finishes to the exposed wood elements.

It was essential for the timber installer to ensure precise location of the vertical wood members on Level 1 to prevent cumulative errors. Concrete-to-wood base anchor systems that allow some flexibility for horizontal and vertical adjustment should be used. This allows the timber installer to handle the disparity between the tolerances allowed for concrete (± 24mm) and the tolerances attainable with wood (± 3mm depending on the length of the element). For example, threaded rods and supporting nuts, in combination with a base plate and grout, can be used to correct elevation discrepancies in the concrete.

FPInnovations installed sensors during construction that will enable researchers to monitor shrinkage, deflection, vibration and moisture during the service life of the building. In keeping with the mandate of the Wood Innovation and Design Centre, the feedback from this monitoring program will be used to inform the design of future tall wood structures, as part of the quest for continuous improvement.


Lobby detail


View of entrance

ADDITIONAL INFORMATION

1. *Technical Guide for the Design and Construction of Tall Wood Buildings in Canada,* 2014, FPInnovations, https://fpinnovations.ca/ResearchProgram/advanced-building-systems/Pages/promo-tall-wood-buildings.aspx#.VAhl5fldUZ4

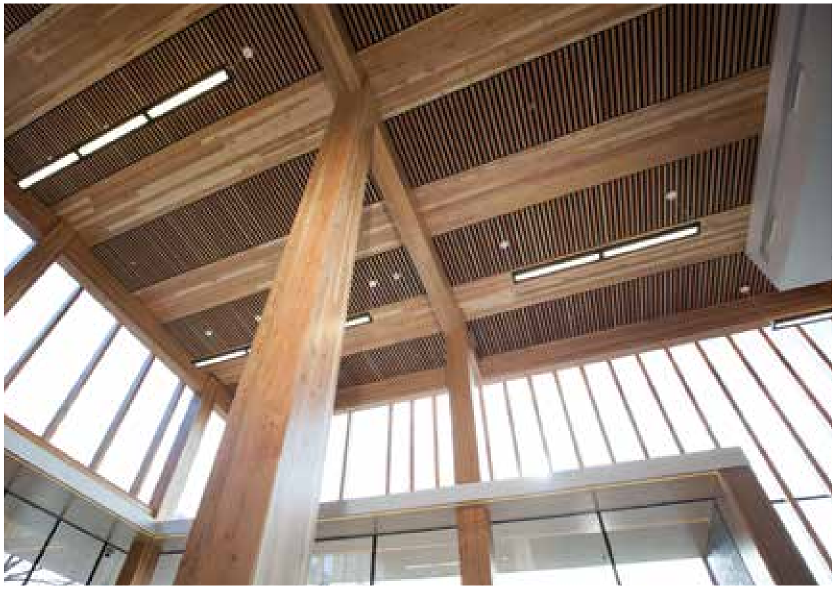
2. *CLT Handbook* (Canadian edition). The PDF version is available as a free download at https://fpinnovations.ca/Pages/CltForm.aspx#.VAhi5PldUZ4

- Chapter 1 - Introduction to cross-laminated timber
- Chapter 2 - Cross-laminated timber manufacturing
- Chapter 3 - Structural design of cross-laminated timber elements
- Chapter 4 - Seismic performance of cross-laminated timber buildings
- Chapter 5 - Connections in cross-laminated timber buildings
- Chapter 6 - Duration of load and creep factors for cross-laminated timber panels
- Chapter 7 - Vibration performance of cross-laminated timber floors
- Chapter 8 - Fire performance of cross-laminated timber assemblies - Revised Edition
- Chapter 9 - Acoustic performance of cross-laminated timber assemblies
- Chapter 10 - Building enclosure design of cross-laminated timber construction
- Chapter 11 - Environmental performance of cross-laminated timber
- Chapter 12 - Lifting and handling of CLT elements

3. *Fire Safety and Security* (for construction sites) and technical bulletins about fire safety, durability, building performance, insurance, case studies, managing movement and other topics, Canadian Wood Council, http://cwc.ca/publications/

4. *Modern Timber Connectors*, Structure Magazine, Eric Karsh, P. Eng. http://www.structuremag.org/?p=4061

View of lecture theatre



Underside of mezzanine

PROJECT TEAM

ARCHITECT AND DESIGN LEAD

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STRUCTURAL ENGINEER

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MECHANICAL ENGINEER

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FIRE SAFETY CONSULTANT

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LANDSCAPE

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ENVIRONMENTAL

Hansen & Associates Environmental
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ELEVATORS

VERTECH Elevator Services Inc.
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RISK MANAGEMENT

3SI Risk Strategies Incorporated
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SPECIFICATIONS

Carl Seldon Construction Specifications
661 Foresthill Place
Port Moody, BC

ACOUSTICS

Aercoustics Engineering, Ltd.
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GEOTECHNICAL

Geopacific Consultants Ltd.
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COMMISSIONING

Inland Technical
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Kamloops, BC

CIVIL CONSULTANT

Opus DaytonKnight Consultants Ltd.
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Prince George, BC

TIMBER INSTALLER/ MAJOR SUPPLIERS

TIMBER INSTALLER

Nicola Logworks
Box 1027
Merritt, BC
logworks.ca

GLULAM, CLTS AND MODELLING

Structurlam
2176 Government Street
Penticton, BC
structurlam.com

VERTICALLY LAMINATED LVL

Brisco Manufacturing Ltd.
2866 Brisco Road
Brisco, BC
briscoman.com

PARALLAM AND LSL LEDGERS

Weyerhaeuser
1272 Derwent Way
Annacis Island, BC
weyerhaeuser.com

NATURAL AND BURNT-CEDAR CLADDING SUPPLY

Coulson Manufacturing Ltd.
4890 Cherry Creek Road
Port Alberni, BC
coulsoncedar.com

FINISHING

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STRUCTURAL INSULATED PANELS

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insulspan.com

NATIONAL FUNDERS

Natural Resources Canada | Ressources naturelles Canada

BSLC

PROVINCIAL FUNDER

Forestry Innovation Investment

NATIONAL PARTNERS

CertainTeed SAINT-GOBAIN

StructureCraft

STRUCTURLAM INNOVATIVE WOOD SPECIALISTS

western archrib structural wood systems

Weyerhaeuser

PROVINCIAL PARTNERS

COFI Council of Forest Industries

Coast Forest PRODUCTS ASSOCIATION

ILMA

CMSA

Boise Cascade Engineered Wood Products

FOR MORE INFORMATION ON WOOD *WORKS!*, CONTACT: www.wood-works.ca • WOOD *WORKS!* HELP DESK: help@woodworks.org

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