WOOD: INNOVATIVE DESIGN SOLUTIONS AT UBC

UBC WOOD CONSTRUCTION GUIDELINES

SITUATED ON A FORESTED PENINSULA ON THE WESTERNMOST POINT of Vancouver along the Pacific coast, the University of British Columbia campus is a 1,001 acre (405 hectare) community of academic, residential, commercial, agricultural and operational facilities. University policies and guidelines have adopted stringent sustainability performance criteria that all building projects and development initiatives must comply with. As part of UBC's Campus as a Living Laboratory (CLL) initiative, UBC is developing a sustainability lens for new projects, which determines and evaluates the potential environmental, social and economic impacts of construction and building operations, including methods to measure long term progress.

The University has determined (through studies such as lifecycle assessment) that wood is an optimal building material due to its structural, aesthetic and environmental characteristics. These qualities make wood construction essential in supporting UBC's goals to create buildings designed to have a net-positive impact on their environment and the lives of their human inhabitants. Wood is considered one of the primary structural materials in the design of all academic buildings on campus.

As a Canadian public university, UBC is effectively its own legal entity with sole jurisdiction over its land, buildings and infrastructure. Provincial legislation, The University Act, grants the UBC Board of Governors, in consultation with the UBC Senate, the power to manage, govern and maintain all development on the University campuses in Vancouver and Kelowna. Each campus, therefore, operates similarly to a small municipality regulating building and development. As with any other municipality, development at UBC is governed by a number of overlapping policies, codes, and regulations, established at the local, provincial and national levels.

The most important regulation for building construction projects at UBC is the British Columbia Building Code (BCBC), a provincial code that regulates the design and construction of new buildings, and alterations and changes of use in existing buildings. It provides minimum standards intended to protect the life and safety of building inhabitants and the general public. For wood construction, the BCBC addresses mainly the structural and fire safety performances of the building systems and components.

FACTS

- The BCBC is based on the model National Building Code of Canada and is comparable to other provincial level building codes in form and function. It also contains variations from the model code that are specific to B.C.'s built environment and needs.
- The BCBC is to be used, where applicable, in conjunction with complementary regulations, such as the British Columbia Fire Code, the Model National Energy Code for Buildings and the Canadian Electrical Code.
- Until 2006, the BCBC was written as a series of prescriptive requirements, which outlined how specific building components were supposed to be designed or built under a given set of circumstances. To utilize a design strategy or material not specifically prescribed under the code, an equivalency to the prescribed strategy could be made. However, a lack of standardized criteria for demonstrating and approving equivalencies increased the challenges for design teams and projects seeking to build in unconventional ways.
- In 2006, the BCBC became an objective-based code that explicitly identifies the functions and objectives of code provisions. Prescriptive and non-prescriptive requirements are given as acceptable solutions. Alternative solutions are permitted, provided that they meet the applicable intended functions and objectives. Similar to equivalencies, alternative solutions are required to demonstrate equal or better performance than the corresponding acceptable solutions.
- Under the BCBC, basic types of building construction are classified as either non-combustible or combustible, based on the types of materials used for the structure and other primary assemblies. The regulations and requirements of basic building construction types are based on a number of criteria, mainly the type of major occupancy (primary uses of the building), the total building height and floor area, and extent of a fire suppression system, such as sprinklers. Academic buildings are typically required to be of non-combustible construction.
- Under the BCBC, building materials are classified as non-combustible or combustible based on whether they meet the criteria outlined in CAN4-S114, "Determination of Non-Combustibility in Building Materials," a set of standards produced by the Underwriters Laboratory of Canada (ULC).
- The BCBC defines heavy timber construction as "combustible construction in which a degree of fire safety is attained by placing limitations on the sizes of structural members and on thickness and composition of wood floors and roofs, and by the avoidance of concealed spaces under floors and roofs."

The Forest Sciences Centre, completed in 1998 at UBC, integrated wood construction throughout the building to showcase wood as both a structural and aesthetic material. To achieve compliance with the prescriptive building code requirements of the time, code consultants utilized two primary concepts: the enclosed space and the combustible construction equivalencies.

CENTRE FOR INTERACTIVE RESEARCH ON SUSTAINABILITY

GROSS FLOOR AREA: 61,085 FT² (5,675 M²)
COMPLETED: 2011

WOOD CONSTRUCTION UNDER OBJECTIVE-BASED CODE

The Centre for Interactive Research on Sustainability (CIRS) is an interdisciplinary research centre that is home to a range of UBC academic and operational groups engaged in sustainability research and operations.

The four-storey building includes a large auditorium, offices, dry laboratories, a café, and service spaces such as a biologically-based reclaimed water treatment plant. The design mandate for CIRS was to create a “regenerative” building that would have a net-positive impact on its environment and the lives of its human inhabitants. CIRS is on target to achieve LEED Platinum certification and Living Building Challenge recognition. The primary structural system of the building is a heavy-timber frame. It is designed to enable open floor plans and large expanses of glazing in the walls, which maximize natural daylighting and flexibility in the workspace, creating a comfortable and healthy interior environment.

The extensive use of exposed wood and the open daylit spaces were possible under the objective-based code that allowed consultants to consider the performance of the overall design of the building and systems in meeting the required level of fire protection and life-safety for CIRS. This integrated approach is especially evident in the design of the four-story atrium, which is linked by an open staircase and considered an interconnected floor space. This design was acceptable as a code-compliant means of egress from the building because it demonstrated an ability to maintain safe conditions in the event of fire.

The intent behind fire safety design of buildings is to limit the spread of fire and smoke through the building, thereby limiting the physical damage to the structure, protecting occupants from injury and allowing sufficient time for safe evacuation. Advances in computer modelling and simulations allow design teams and code consultants to model the performance of buildings, materials and systems with a high degree of accuracy, and to create simulations that include the spread of fire and smoke through spaces, the temperature of the indoor air and of building materials, and exiting and evacuation of inhabitants under different conditions.

By modelling fire and smoke behavior in relation to the designed spaces and materials of CIRS, the code consultants were able to show that an acceptable level of protection could be achieved through the combination of alternative measures, including comprehensive fire suppression and smoke management systems. As an example, the high roof of the atrium creates a smoke reservoir and is fitted with exhaust fans that operate in conjunction with door opening devices on the ground floor to create a stack effect that channels smoke up and out quickly. The building is also fully sprinklered with a fast response system that is backed up by a secondary onsite water supply – the rainwater collection cistern.

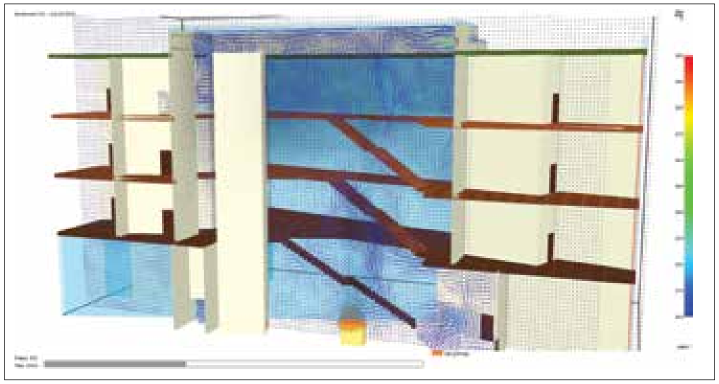
The fire sprinkler and smoke exhaust systems provide additional support for two other code compliant alternatives. First, while each level of CIRS has substantial open spaces, the wood floors provide rated separations that limit the spread of fire and smoke. Although the specific floor assembly, as described below, is not itself rated under any code, by analyzing similar assemblies the consultants were able to show that the solid wood floor design would perform just as well as any prescriptively designed 1-hour rated floor. Second, the auditorium is separated from the rest of the building by a 1-hour rated concrete wall which, along with the sprinkler and smoke exhaust systems and the ability to directly exit to the exterior, enabled the roof to be built of exposed heavy timber structure and solid wood assembly.

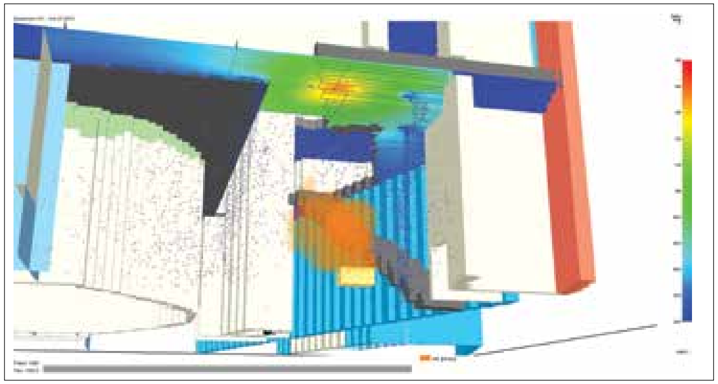
CIRS STRUCTURAL FACTS

- The heavy timber wood structural frame consists of rectangular Douglas-fir glulam columns and beams, supporting a floor system of SPF (spruce-pine-fir) dimensional lumber, laid on end and gang nailed together, covered in a single layer of plywood.

- Lateral resistance is provided through two systems: conventional concrete and plywood shear walls and a moment frame system combined with spandrel panels constructed as box beams of dimensional lumber and plywood.

- The structure below-grade and surrounding the large auditorium on the ground level is non-combustible construction, cast-in-place concrete.





A computational fluid dynamics (CFD) modelling program simulates and assesses the behavior of fire and smoke, as well as the temperature of interior spaces and building components. The calculations include information on the effects of both the passive aspects of the building (such as the shapes of the spaces and types of materials) and the active systems (such as sprinklers and smoke management systems).

THE NEW STUDENT UNION BUILDING

GROSS FLOOR AREA: 203,925 FT² (18,946 M²)
COMPLETED: 2014 (TARGETED)

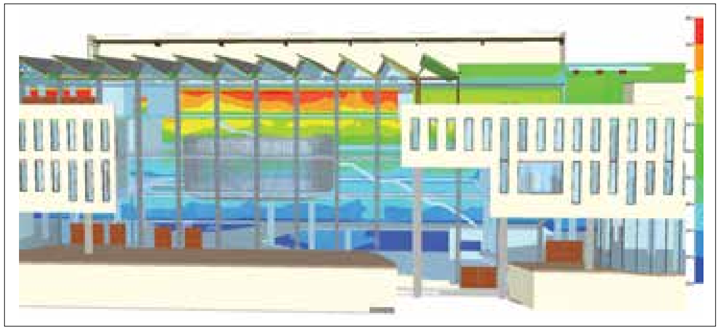
WOOD STRUCTURE IN NON-COMBUSTIBLE CONSTRUCTION

The new Student Union Building (new SUB) is a five-floor addition to the existing Student Union Building.

It will house the Alma Mater Society (AMS), and will also include clubrooms, food and retail services, rentable spaces, a theatre, counseling services, and a roof garden for urban agriculture. An open central atrium space, called the Agora, is located along the western side of the building and connects the divergent programs within the new SUB. It includes central circulation for the building, in the form of open stairs and elevated walkways, as well as places for social gathering and informal learning, including a theatre space. The new SUB is targeting LEED platinum certification, while incorporating elements of the Living Building Challenge.

While the primary structure of the new SUB is concrete and steel, within the atrium, wood is used as a structural element in strategic and highly visible locations. Because the wood is used as discrete elements within the non-combustible construction, the primary concern is that they maintain structural integrity in the case of fire at a similar standard of performance as the overall building structure. Fire modelling and analysis were performed to ensure that the design of the wood products would maintain the required 1-hour fire rating, and that the potential exposed surface temperature and radiant flux levels of the wood materials would stay below the threshold of wood ignition temperatures. Supplementary fire protection measures include enhanced sprinkler coverage in proximity to wood elements and 1-hour rated coating covering the metal connections between the wood elements and the non-combustible construction.

Because of the importance of the Agora to building circulation, analysis was also performed on the exiting through the space. The timed-exit analysis (TEA) computer program was used to calculate the amount of time required for occupants to evacuate the building, considering the time for fire detection and alarm, the response time and travel times of occupants, and a margin of safety. This information was based on building specific characteristics of the design of the interior spaces, the types of users and the types of events in which they are engaged during different fire scenarios. Like most academic buildings, users in the new SUB are typically students, staff, and visitors who are alert and mobile but not necessarily familiar with the layout of the building or the exits. Performance based code requirements provide a clear pathway for design teams to demonstrate code compliance and computer modelling software provides recognized and accepted performance data. These tools make it easier to use structural wood elements selectively in many building types.



A human movement simulator program is used to analyse the timed exit information along with the spatial geometries for the building, like the number and location of exits, and data on fire and smoke behavior from the computational fluid dynamics (CFD) model. The program models occupant movement in different fire scenarios, specific to the building design and user population, and determines egress time.

WOOD STRUCTURAL ELEMENTS IN THE AGORA

- Structural glulam columns on the exterior glazed curtain walls that extend from the first level (on the west side) and the second level (on the east side) to the Agora roof.
- Cross-laminated timber (CLT) panels form the solid face of the sawtooth skylight roof system above the Agora.
- CLT panels supported by glulam columns make up the pedestrian bridge walkways on the second and third levels.
- Wood stud framing is used for the load-bearing exterior walls of the suspended theatre space.

WOOD CONSTRUCTION SIGNIFICANTLY ADVANCES REGENERATIVE SUSTAINABILITY.

In recent years, UBC has been encouraging creative, code-compliant design solutions that enable the innovative use of wood in many buildings across the campus. The design approval and permitting processes for University projects requires code consultants (both as project team members and as independent reviewers on behalf of UBC) to work closely with the relevant authorities throughout the design and construction process to ensure that all parties agree on any alternative solutions for compliance with codes and regulations. This approach, made easier by the objective-based code and advances in technology, creates an environment that supports the design of project specific solutions, leading to more innovative buildings.

There are myriad sustainability benefits of utilizing wood construction in diverse applications within buildings such as carbon sequestration and support for regional, renewable resource based industries. As more projects are built that demonstrate new and innovative uses of wood, designers, code consultants, and regulators will become more familiar with the possibilities and requirements for different wood products and applications. As a larger set of precedents is developed and industry knowledge is extended, it is becoming easier to demonstrate code compliance in the use of wood construction. This may eventually lead to further changes in the building codes that facilitate the widespread use of wood across many more building types and applications.

PROJECT CREDITS

FOREST SCIENCES CENTRE

ARCHITECT
Dalla-Lana Griffin Dowling Knapp Architects (now DGBK architects)

STRUCTURAL ENGINEER
CWMM Consulting Engineers Ltd.

CODE CONSULTANT
LMDG Code Consultants Ltd.

New Opportunities for Wood Construction at the UBC Forest Sciences Centre
By Sebastian Butler, John H. Peddle, Gary C. Williams

http://timber.ce.wsu.edu/Resources/papers/4-1-3.pdf

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CODE CONSULTANT
LMDG Code Consultants Ltd.

Fire Protection and Life-Safety Building Code Concepts Report

Fire Protection and Life-Safety Performance Based Fire-Modelling/Timed-Exit Analysis Report

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NEW STUDENT UNION BUILDING

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UBC Alma Mater Society

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STRUCTURAL ENGINEER
Read Jones Christoffersen Consulting Engineers

CODE CONSULTANT
LMDG Code Consultants Ltd.

Fire Protection and Life-Safety Performance Based Fire-Modelling/Timed-Exit Analysis Report

RENDERINGS
Dialog and B+H Architects

List of applicable regulations at UBC

- British Columbia Building Code (BCBC)
- British Columbia Fire Code (BCFC)
- National Energy Code of Canada for Buildings (NECB)
- Canadian Electrical Code (CEC)
- Canadian Standards Association (CSA)
- Construction Standards
- National Fire Protection Agency Standards

Other agencies must approve building design prior to issuance of a building permit

- UBC Campus and Community Planning
- UBC Utilities
- UBC Plant Operations (institutional building only)
- UBC Health, Safety and Environment
- Vancouver Coastal Health (where food handling is proposed)
- Vancouver Fire and Rescue Services

FOR TECHNICAL INQUIRIES
www.wood-works.ca
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wood WORKS! An initiative of the Canadian Wood Council

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