WOOD: AN INTEGRAL PART OF A NET-POSITIVE BUILDING

CENTRE FOR INTERACTIVE RESEARCH ON SUSTAINABILITY





THE UNIVERSITY OF BRITISH COLUMBIA is committed to leadership in sustainability in both education and operations. It has developed the Campus as a Living Laboratory (CLL) initiative, a university-wide program utilizing the Vancouver campus as an incubator for sustainable technologies, systems and strategies. The whole campus is an ideal test-bed because of its size—1,001 ac (402 ha)—and its mix of academic, business and residential development. As part of the CLL initiative, demonstration projects can be researched and developed, and applied to communities beyond UBC. The Centre for Interactive Research on Sustainability (CIRS), one of the flagship projects of the CLL initiative, is being studied to explore the role of buildings in maintaining environmental integrity and human well-being.

CIRS is an interdisciplinary academic centre; the building is home to multiple research projects and the subject of ongoing studies on the long-term effects of sustainable design, construction and operation. Passive design strategies are integrated with high-performance systems following a regenerative framework; which challenges buildings to be restorative forces in their environments instead of being labelled "less bad" or "more efficient." CIRS is expected to be UBC's first Leadership in Energy and Environmental Design (LEED®) Platinum Building, and is on track to receive Living Building Challenge recognition. It is also envisioned as a new baseline in sustainable buildings, for other projects to strive to surpass.

REGENERATIVE DESIGN

REGENERATIVE DESIGN IS AN EMERGING ALTERNATIVE to current design and construction practices. While green buildings try to reduce harmful environmental impacts, regenerative buildings seek to go beyond that by improving both the natural environment and the lives of their human inhabitants. In regenerative design, building contexts are carefully evaluated for potential alternative and renewable resources, with the intent to limit reliance on municipal utilities, making more resources available for others. Designs integrate building systems and passive strategies to achieve a high standard of total performance. Considerations of environmental impacts are included, measured with tools such as life cycle assessment (LCA) and life cycle costing (LCC).

The regenerative design process implemented for CIRS was based on overarching goals to achieve net positive performance in environmental and human terms. Wood is an important component in these efforts because of its inherent environmental benefits; and because people respond well to exposed wood and perceive the space as warm, comfortable and friendly. This is reinforced by a recent study by FPInnovations and UBC[1] that has shown that the visual presence of wood indoors reduces stress reactivity in the sympathetic nervous system (SNS) of building occupants.

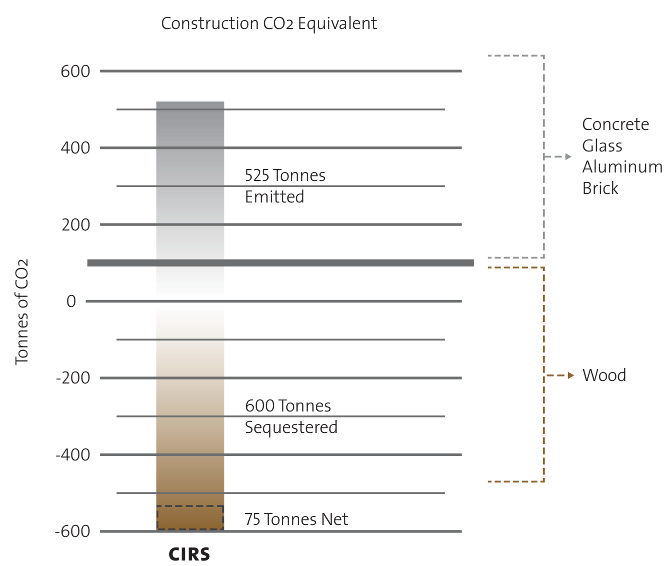
CIRS inhabitants are able to directly control many of the indoor environmental conditions that impact their comfort, such as access to daylight, natural ventilation and control over localized air temperature and air flow. Additionally, each inhabitant is asked to sign a voluntary sustainability charter to uphold practices that optimize the building's net positive aspects. Their active involvement and feedback are critical to the building's performance and energy efficiency.

[1] *Fell D.2002. Consumer Visual Evaluation of Canadian Wood Species. FPInnovations, Vancouver, Canada.*
Rice J, Kozak Robert A, Meitner Michael J, and Cohen David H; 2006 Appearance Wood Products ad Psychological Wellbeing, Society of Wood Science and Technology

CIRS' FOUR ENVIRONMENTAL NET-POSITIVE AREAS ARE:

- **CONSTRUCTION CARBON:** The total carbon sequestered in the wood structure of the building is greater than the total carbon emitted during extraction, manufacturing, transportation and installation of all other building materials (see chart below);
- **ENERGY:** CIRS harvests and returns to campus more renewable energy than it takes from the electricity grid and therefore lowers the overall energy consumption of the campus;
- **OPERATIONAL CARBON:** CIRS uses no fossil fuels to operate its building systems and by supplying the campus with renewable energy, it lowers the overall natural gas consumption and greenhouse gas (GHG) emissions of the campus;
- **WATER:** CIRS harvests and treats rainwater to meet all its potable water needs and cleans and recycles all the wastewater it generates, as well as some additional campus sewage. Stormwater that cannot be used as a source of potable water is redirected to recharge the local aquifer.

NET-POSITIVE CARBON CONSTRUCTION (DESIGN ESTIMATE)



ARCHITECTURE

DESIGN PROCESS

CIRS was designed using an integrated design process (IDP), centered on a series of interdisciplinary charettes. This produced a number of innovative and synergistic building design strategies to meet the regenerative goals of the project. For example, one of the charettes generated the idea of using the rainwater collection cistern as an on-site backup water supply for the CIRS fire suppression system, supporting the viability of the CIRS heavy timber structure.

Building information modelling (BIM) and energy modelling software were important parts of the design process. The programs allowed the team to coordinate details between disciplines and compare different combinations of systems and design strategies. The BIM model is now used in the ongoing research on the operations of the building, assisting in asset management and monitoring and documenting energy and resource use.

BUILDING DESIGN

CIRS is located within the campus core precinct of UBC's Vancouver campus. It is a four-storey U-shaped building that wraps around a large auditorium, above which is a living roof. The two wings of the "U" contain offices, labs and work spaces, including the Policy Labs, the BC Hydro Theatre, the Loop Café and the Solar Aquatics biofiltration facility, an ecologically based wastewater treatment plant. Facing West Mall is a four-storey day-lit atrium with dramatic exposed glue-laminated (glulam) structural framing and staircases.

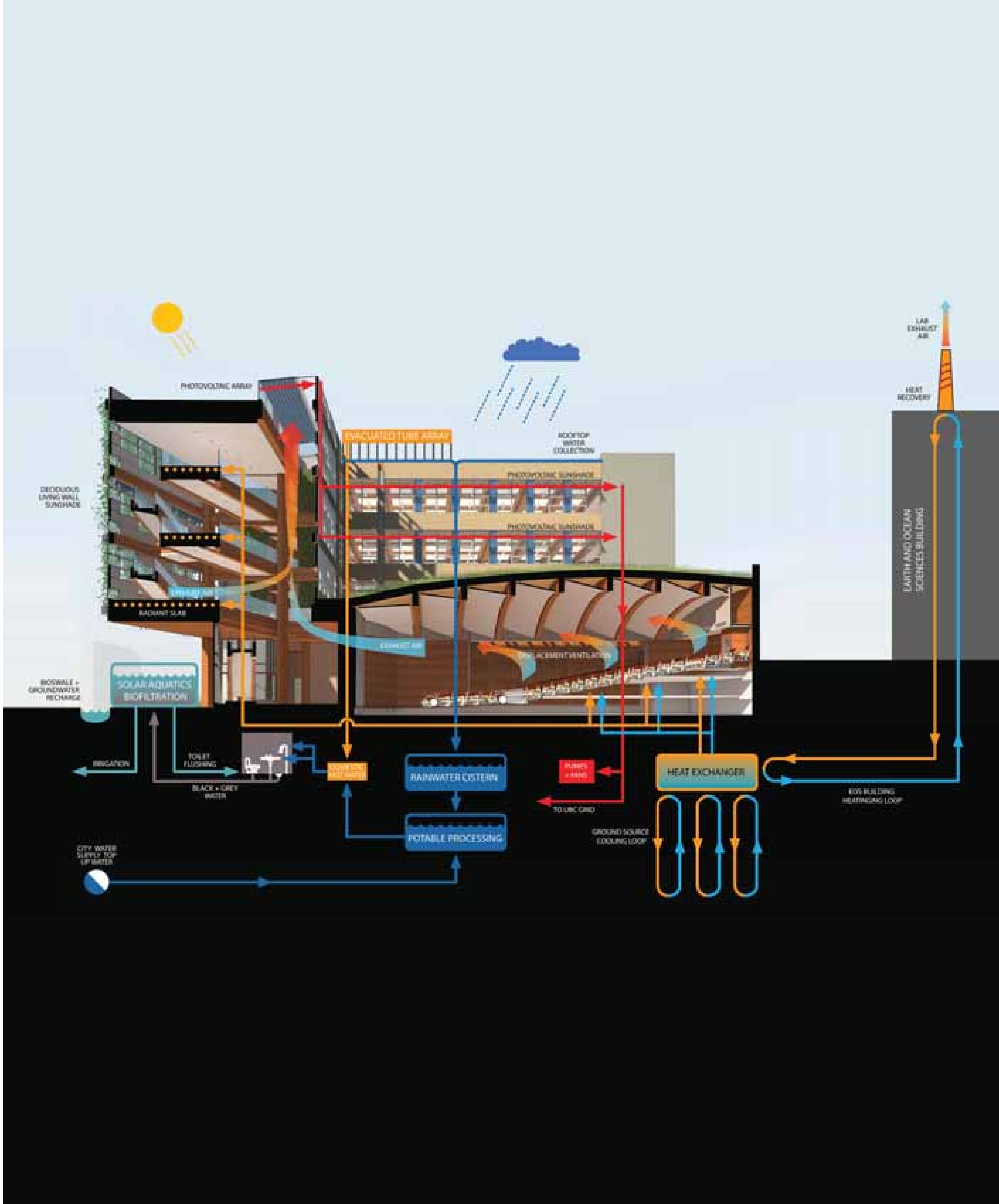
CIRS was designed to meet exemplary sustainability goals and high performance targets and to be both cost-effective and replicable. The overall design emphasizes simple forms and materials, exemplified by the exposed wood structure and visible connections. As this is an academic building, durability and flexibility were priorities. The regular rectilinear structural grid creates large column free interior spaces, which can be subdivided easily for different uses over the intended 100 year life of the building. High ceilings and many operable windows along the south and north sides of the office/lab wings allow for significant amounts of daylight and natural cross-ventilation in the occupied areas. Wood is also used in many non-structural applications through the building, most notably as an interior finish in the form of hemlock veneer panels in the Auditorium and as an exterior cladding in the form of stained western red cedar panels, which provide a vibrant contrast to the other primary cladding material, white concrete brick.

“Wood is the most sustainable construction material, low-embodied energy, quickly renewable resource. From a structural point of view, the modern engineered materials such as glue-laminated timber have increased the strength of wood so that they have a much greater structural capacity. Finally, the warmth wood brings to the building – it creates an ambiance that is just fantastic.”

PAUL FAST, STRUCTURAL ENGINEER, FAST+EPP

FACTS

- The building area of CIRS is 61,085 ft² (5,675 m²) and the site is 21,614 ft² (2,008 m²) resulting in a floor space ratio (FSR) of 2.7
- The Modern Green Development Auditorium is the largest lecture theatre on campus, seating 423 people, and is a showcase for the use of wood in different applications, including structural members, interior finishes and furnishings



STRUCTURE

THE STRUCTURE OF CIRS is a hybrid system. The basement and ground level auditorium are cast-in-place concrete, with a roof of curved glulam beams supporting a solid wood roof over the auditorium. The upper floors have a frame of engineered wood members supporting a solid wood floor assembly. This floor and roof assembly is composed of lumber and plywood decking and performs to a 1-hour fire rating at each floor level. Due to the size of the members and the bulk of the system, the wood frame and assembly combination are considered to be heavy timber construction under the British Columbia Building Code. This designation allows the structure to be exposed without the need for additional fireproofing materials.

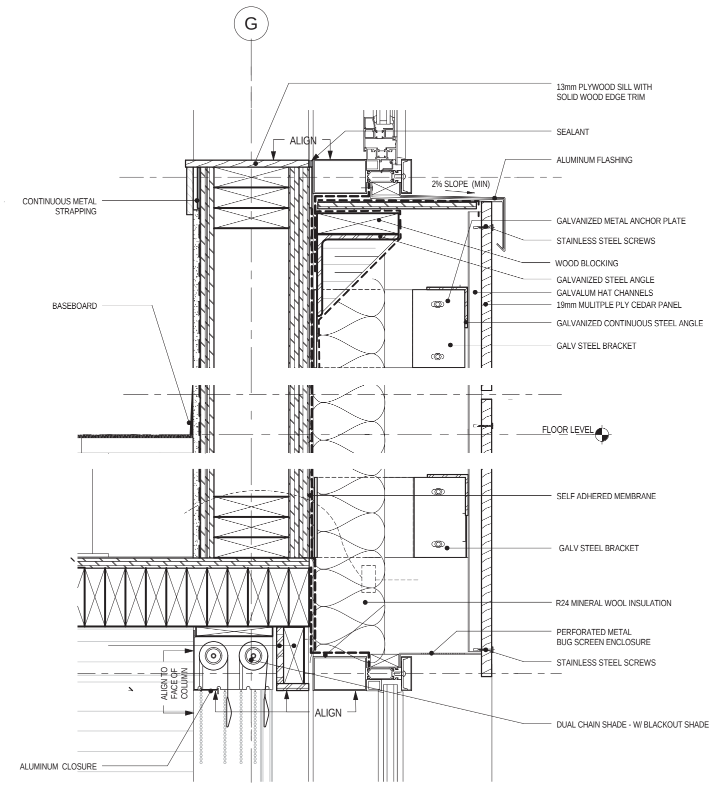
In addition to the building-wide fire suppression system, the wood members are all sized slightly larger than structurally required to handle external charring in case of fire. The charred exterior will create a layer of insulation that prevents the interior from burning, thereby maintaining structural integrity.

The vertical support is provided by rectangular glulam columns, typically sized 8.5 in x 25.5 in (21.5 cm x 65 cm), and supporting rectangular glulam beams typically sized 8.5 in x 27 in (21.5 cm x 68.5 cm). Along the wings of the building the beams span 32 ft (10 m) and are spaced 10 ft (3 m) apart. The floor system spanning between the beams is standard 2x4 dimensional lumber, laid on end, gang nailed together and covered in a single layer of plywood. The glulam and lumber underside of the floor is left exposed while the top is covered by a raised floor system with a plenum for power, data, and supplementary ventilation.

Lateral resistance is provided through two systems: conventional plywood shear walls in the direction of the short spans of the building and a moment frame system combined with spandrel panels in the direction of the long spans. The spandrel panels are constructed as box beams made of dimensional lumber and plywood and are placed between the structural members along the exterior walls. The moment frame spandrel panel combination is an efficient system that allows for the walls to be used for glazing and operable windows. This strategy maximizes opportunities for interior day lighting and allows for direct control of natural ventilation, which in turn reduces the energy demand of the building and creates an interior environment that is comfortable and healthy.

The sizing of the structural members is consistent throughout the building except in specific instances where large loads require more support. The beams and columns in the auditorium, for example, are sized to handle a long span and the load of the green roof. In typical areas the structure is sized to support a live load of 100 lbs/ft^2 (4.7 kN/m^2), double what is required by the British Columbia Building Code for these assemblies. This increased capacity supports the flexibility of the design, allowing for additional equipment and changes of use in the future.

As there is limited information on multi-storey heavy timber wood structures in North America, the rate of shrinkage was estimated during design based on recorded data for the size and composition of the wood members. As a living laboratory, the wood structure in CIRS will be monitored along with the rest of the building components. The results will provide valuable information on the long-term performance of multi-storey wood structures as part of the CIRS studies on regenerative design.



1 Wall Detail: Spandrel Box Beam and Exterior Cladding
1 : 5

FACTS

- Approximately, 33,196 ft^3 (940 m^3) of wood is used throughout CIRS including:
  - 459 ft^3 (13 m^3) of western red cedar panels
  - 7,946 ft^3 (225 m^3) Douglas-fir glulam sections
  - 20,729 ft^3 (587 m^3) softwood lumber and 4,062 ft^3 (115 m^3) of plywood for the floor decking, spandrel panels and stairs
  - Approximately 12,720 ft^3 (360 m^3) of the lumber was sourced from B.C. forests affected by the pine beetle infestation

"Sustainability is not a solution, it's a progressive journey. Simplify the objective and find simple solutions—for example, using pine beetle kill wood is not a complex, high-tech solution yet it has significant impact."

PETER BUSBY,
MANAGING DIRECTOR, PERKINS+WILL ARCHITECTS CANADA CO.

FACTS

- The use of wood and design of the structure contributed to multiple CaGBC LEED credits, including Regional Materials, Certified Wood, Durable Building and Daylight and Views
- The use of wood contributed to multiple Living Building Challenge petals, including the Beauty and Inspiration, and Health

ENVIRONMENTAL IMPACT OF WOOD USE (POST-CONSTRUCTION CALCULATION)

Volume of wood products used:
940 cubic meters (33,196 cubic ft) of lumber and sheathing

British Columbia forests grow this much wood in:
3 minutes

Carbon stored in the wood*:
701 metric tons of carbon dioxide

Avoided greenhouse gas emissions by using wood instead of other building materials*+:
1473 metric tons of carbon dioxide

Total potential carbon benefit (avoided GHG emissions + carbon stored in wood):
2173 metric tons of carbon dioxide

THE ABOVE GHG EMISSIONS ARE EQUIVALENT TO:

(US EPA 2010)

415 cars off the road for a year

Energy to operate a home for 185 years

*Estimated by the Wood Carbon Calculator for Buildings, based on research by Sathre, R. and J. O'Connor, 2010, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations (this relates to carbon stored and avoided GHG)

+CO_2 in this case study refers to CO_2 equivalent

MATERIALS MATTER

ALTHOUGH THE PROJECT TEAM did not use them as a checklist for design, green building rating systems provide a standardized means of evaluating the project. CIRS is on track to achieve LEED® Platinum Certification, as well as Living Building Challenge recognition. Using wood throughout the project contributes to the attainment of multiple LEED credits and Living Building Challenge imperatives.

The decision to use wood was in keeping with the regenerative concept of CIRS. Wood is one of the most sustainable building materials on the planet: trees grow using energy from the sun and provide valuable ecosystem services such as releasing oxygen into the atmosphere, removing carbon dioxide from the atmosphere, creating habitats, as well as providing shade and cooling.

All of the wood used in CIRS was sourced from the sustainably managed forests of British Columbia. The spruce-pine-fir (SPF) lumber in the building comes from forests that have been impacted by the mountain pine beetle infestation. Using pine beetle wood eliminates GHG emissions from decaying trees and allows new growth to absorb more carbon dioxide from the atmosphere. Pine beetle wood is of the same structural quality as other lumber.

British Columbia has an inclusive approach to forest certification, with the majority of forests certified to one or more of the three internationally recognized third-party certification schemes: Canadian Standards Association-Sustainable Forest Management Standard (CSA-SFM), Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI). Two independent research studies have shown that British Columbia has some of the most stringent forest practices in the world. In addition to creating jobs within the province, using local materials also lowers both the cost and environmental impacts of transporting construction materials.

[2] *Comparision of Selected Forest Certification Standards, Indufor Oy, 2009*
Global Environmental Forest Policies: Canada as a Constant Case Comparison of Select Forest Regulations, International Forest Resources, 2004

"Can buildings be regenerative in the sense of producing . . . benefits to both human and natural systems? Can our activities actually improve environmental quality and human well-being? This is the research agenda for CIRS."

PROFESSOR JOHN ROBINSON,
ASSOCIATE PROVOST, SUSTAINABILITY, UBC

PROJECT CREDITS

CLIENT
University of British Columbia

PROJECT MANAGER
UBC Properties Trust

ARCHITECT
Perkins+Will Canada Architects Co.

STRUCTURAL ENGINEER
Fast+Epp Structural Engineers

MECHANICAL, ELECTRICAL AND PLUMBING ENGINEER
Stantec Consulting

LANDSCAPE ARCHITECT
PWL Partnership

WASTEWATER TREATMENT DESIGN/BUILD
Eco-Tek Ecological Technologies

WATER CONSULTANTS
Novatec Consultants

GENERAL CONTRACTOR
Heatherbrae

DIAGRAM AND RENDERINGS
Fast+Epp Structural Engineers
Perkins+Will Canada Architects Co.

ENVIRONMENTAL IMPACT OF WOOD USE CALCULATION
US WoodWorks Carbon Calculator
www.woodworks.org/design-tools/online-calculators/

PHOTOGRAPHERS
Don Erhardt
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OTHER RESOURCES

CENTRE FOR INTERACTIVE RESEARCH ON SUSTAINABILITY*
www.cirs.ubc.ca

UBC SUSTAINABILITY
www.sustain.ubc.ca

BC FORESTS
www.naturallywood.com/sustainable-forests

LEED/CANADA GREEN BUILDING COUNCIL
www.cagbc.ca

LIVING BUILDING CHALLENGE
www.ilbi.org

**The lessons learned during the planning, design and construction process of CIRS have been captured in the CIRS Technical Manual, available on the CIRS website. Many of these are transferrable beyond the UBC boundaries and can be applied to a variety of building types and contexts.*

FOR TECHNICAL INQUIRIES
www.wood-works.ca
1-877-929-9663

STAINABILITY

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