

# Centre of Excellence in Sustainable Building Technologies and Renewable Energy Conservation

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The main purpose of the Okanagan College Centre of Excellence in Sustainable Building Technologies and Renewable Energy Conservation (COE) is to educate students in the design, installation and maintenance of sustainable green building technologies. To achieve this goal the COE, as a building, will lead by example, being at the forefront of sustainable construction and creating an agent for progress in green building design in North America.

The building targets the Living Building Challenge<sup>i</sup>: a new extreme benchmark for sustainable construction. The Challenge includes an all encompassing set of green requirements, including net-zero water use, net-zero energy, and locally sourced materials avoiding a red list of significant, widely used yet environmentally hazardous construction materials. This article considers specifically how the building envelope responds to the requirements of net-zero energy and material selection.

## High performance envelope

Although located in a semi-arid climate with an average annual temperature of 9°C, the building still has a net heating load. Therefore a high performance building envelope is the first step to target net-zero energy. Insulation values of R28 and R40 are provided on the walls and roof respectively, and a maximum air leakage rate of 5m<sup>3</sup>/hr per m<sup>2</sup> is required. Higher values for insulation in the walls and roof could have been targeted, but the design team chose to set realistic modelling targets that allowed for possible cold bridges and air leakage, and conserve the limited budget for use in more vulnerable areas where a greater return might be achieved.

Doors are typically prone to poor air leakage and poor insulation values. Therefore the number of external doors in the COE is minimised, and reduced to single leaf whenever practical. All entrance doors have vestibules to reduce drafts and heat loss.

Heat loss through the windows accounts for 50% of all heat loss through the external envelope of the COE.<sup>ii</sup> To help offset some of this heat loss, all windows and curtain walling will use argon-filled triple-glazing.

While the heavily articulated building form increases the area of external envelope and hence heat loss; it also allows the building to capture winter solar gain, daylight, and natural ventilation with a net benefit to the overall energy equation. The south orientation of the glazed entrance wing and some of the classrooms allows low level winter solar gain to be captured, reducing the heating loads on the building. Summer solar gain is shaded by large overhanging roofs and brise soleil. The capture of daylight and natural ventilation reduces lighting and ventilation requirements and hence further reduces the energy demands of the building.

High ceilings and tall windows are used to maximise light penetration into offices and classrooms. North and south-facing windows are typically used, with only small punctured windows facing west where necessary to bring light into darker corners. The west light is problematic for afternoon summertime solar heat gain and wintertime glare, while south-facing glazing is more easily controlled with the use of conventional brise soleil. Internal high-level light shelves are also used to bounce south light deep into the plan. High level clerestory windows are used to throw light into the larger volumes of the gymnasium and workshops. All occupied work spaces within the building are within 9 m of a window offering daylight, views and natural ventilation.

Where natural illumination is not easily achieved, light-pipes are incorporated to bring light deep into these spaces. Further to this, some areas use a prototype system, developed by the University of British Columbia, that actively tracks and collects sunlight and ducts it horizontally into the deep plan spaces.

Typically, single aspect opening windows provide natural ventilation to a depth of 6 m into any space, before the air starts to warm and rise above head height. This is improved by the articulated plan increasing the penetration of natural ventilation further into the building. This works well in combination with the radiant heating/cooling within the floor slabs, as the chilled slab keeps the incoming fresh air cooler and close to the floor, penetrating further into the building before rising.

A series of five 14 m high ventilation chimneys along the spine of the building are designed to boost the natural ventilation and draw fresh, external air deeper into the building plan. These chimneys will utilise the natural stack effect of warm buoyant air to draw air through the building, creating an estimated natural flow rate of 1000 l/s per chimney at peak conditions. Optimal periods for the solar chimneys are shoulder seasons (spring and fall) and in the morning and late afternoon during the summer. When outdoor temperature exceeds the chimney temperature the ventilation will be mechanically assisted. This ventilation is made possible by the orientation of the chimneys to the prevailing south-north winds, and by the use of glazed panels above the roof level to utilise solar gain to heat the rising air. At peak summer month conditions the glazed panels alone will increase chimney air flow rate by as much as 100%.

When winter temperatures and peak summer temperatures make it inefficient to use un-tempered air for natural ventilation, the building will operate in closed mode. In order to maintain simple operating systems and reduce costs, all windows are manually operated. Thus closed mode will be indicated to the building occupants by simple red/green lights throughout, as has been successfully used elsewhere. This system in turn will make the users of the building part of the control system for the building envelope and further assist in the goal of the COE as an agent for change.

### **Timber construction**

British Columbia (BC) is currently facing a major pine beetle epidemic. This small beetle, spreading unchecked due to milder winters, attacks pine trees and kills them by introducing a fungal infection, leaving vast areas of red forest. After two-three years the needles drop and the trees turn grey. In this grey-attack stage the structural value of the lumber significantly reduces. If left un-harvested, the beetle killed forests will eventually burn, releasing the carbon that has been sequestered over decades back into the atmosphere. However, in most cases this wood is not FSC certified.

It is estimated 14.5 million hectares in BC are either red or grey stage infected; in some areas over 80% of all pines are beetle killed.<sup>iii</sup> So in addition to the widespread environmental havoc this infestation has wreaked, many small BC communities are facing serious economic hardship in coming years. It was therefore clear from the outset that this building needs to respond to the social and environmental factors of the immediate availability of large volumes of non-FSC lumber from beetle kill forests. The project design team has established with the ILBI acceptable parameters for the use of wood harvested from beetle killed forests.

Once it was decided to incorporate a timber-framed construction, BC Building Code requirements, and the proximity of the Penticton airport navigation beacon, dictated that the building be no more than two storeys in height. The decision to use wood construction resulted in a relative low embodied carbon footprint, calculated at 1770 Tonnes compared to 2235 Tonnes or 3360 Tonnes for an equivalent steel or concrete framed building respectively.<sup>iv</sup>

Within the gymnasium the sprung timber floor is not suitable for use with a radiant heating/cooling system in the floor slab beneath, as used elsewhere in the building. In heating mode the void beneath the timber floor would form a insulating layer above the radiant system, while in cooling mode the risk of interstitial condensation causing rot to occur within the sprung floor, is too great. Instead, an innovative system of composite wall panels was developed that combined a radiant heating/cooling system within a robust structural wall panel, that was highly efficient in the use of materials and reduced embodied carbon.

A 75 mm thick reinforced concrete wall panel provides the thermal mass for a radiant heating/cooling system. The pex piping is cast, while pressurised, into the concrete panel under factory conditions, and upon delivery each panel is connected into the radiant heating/cooling supply system on site. The 3.6m wide and 7.9m high concrete panels are cast between 175x266mm glulam columns, with two additional 80x190mm glulam reinforcement columns on the rear face. The composite action between the concrete and wood elements reduces both the structural size of the glulams as well as the thickness of concrete, reducing the volume of materials used and subsequently lightening the weight on the foundation piles. The typical panel incorporates 2m<sup>3</sup> of concrete and has an overall weight of 5Tonnes. An equivalent pre-cast concrete panel would be 185 mm thick and use 14 Tonnes of concrete, an increase of 280% in the overall weight.<sup>v</sup>

This is believed to be the first use of a composite concrete/glulam system in North America, and may ultimately offer an efficient alternative to tilt-up or pre-cast concrete construction that utilises significantly less concrete.

## **Conclusion**

Most sustainable buildings influence their respective societies by example, within the constraints of their primary building purpose. One of the main purposes of the COE is to train the next generation of construction professionals in sustainable technologies and renewable energy. The building will therefore have direct impact on the wider construction industry throughout Canada for decades to come.

The COE, currently nearing completion, is well poised to meet all elements of the LBC and is comparable in cost to a conventional building design in the Southern Interior of BC. This is perhaps the most significant result, that a building can be constructed to be fully sustainable without a significant cost premium. Further, the COE through its' design will influence new sustainable design and construction, and the COE will create a learning and teaching

environment that is both sustainable and synergistic. The building envelope innovations, taken together, represent the potential to influence design throughout the Pacific Northwest region of Canada and the United States and demonstrate the ability to respond to a highly demanding set of challenging conditions.

### **Design team**

Architect: CEI Architecture Planning Interiors  
Mechanical engineer: AME Group Engineers  
Electrical engineer: Applied Engineering Solutions  
Structural engineer: Fast + Epp  
Civil engineer: True Consulting  
Landscape architect: Site 360  
Sustainability consultant: Recollective Consulting  
Quantity surveyor: Spiegel Skillen & Associates  
Construction manager: PCL Constructors Westcoast Inc

<sup>i</sup> International Living Building Institute - [www.ilbi.org](http://www.ilbi.org)

<sup>ii</sup> Stewart, H, 2009. "AME Consulting Group - COE Energy Model".

<sup>iii</sup> Schrier, D, 2009. "BC Stats Environmental Statistics - Giving Dead Wood New Life: Salvaging BC's Beetle-killed Timber".

<sup>iv</sup> BuildCarbonNeutral.org, 2007. "Construction Carbon Calculator".

<sup>v</sup> Epp, G, 2009. "Fast+Epp - COE Structural Design Development Report".