CANADIAN CONSULTING ENGINEERING AWARDS 2012

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Energy Environment Experiential Learning, University of Calgary

DIALOG®

ENERGY ENVIRONMENT EXPERIENTIAL LEARNING, UNIVERSITY OF CALGARY, CALGARY, ALBERTA

The Energy Environment Experiential Learning (EEEL) project is being submitted for excellence in mechanical engineering. The project responds to the necessity for modern, high caliber undergraduate learning environments at Canada's premier university campuses. This new University of Calgary facility, which opened in September 2011, is student-centric, providing opportunities for hands-on and experiential learning in both individual and collaborative settings. The 26,200 square metre, five storey facility provides instructional space for expanded programs in energy and environments, new laboratories for biology and chemistry, as well as space for the administrative centre of ISEEE (Institute for Sustainable Energy, Environment and Economy) and SPS (School of Policy Studies).

EEEL serves as a learning environment demonstrating that nothing is truly 'thrown away' and that a building has impacts upon itself, its users, the immediate landscape, the region and the world beyond. The theme of science on display means teaching spaces are available for view through generous internal and external glazing. Building structural, mechanical and electrical systems are exposed for teaching and demonstration.

ENVIRONMENTAL IMPACT

The Energy Environment and Experiential Learning (EEEL) project has been designed to LEED® Platinum requirements, the LEED® application process is underway. A fundamental goal of the design team is the provision of a highly sustainable building and landscape. The design team's over arching effort was to minimize EEEL's use of energy, water and material resources and optimize indoor environmental quality wherever feasible.

MECHANICAL ENGINEERING AND ARCHITECTURE ARE CALLED TOGETHER

EEEL was designed as a facility that interacts with the visitor through a "science on display" theme that attempts to illustrate the concepts of energy use, sustainability, and their effect on the environment. As a result, we have designed a facility that showcases off-the-shelf technology, melded with advanced energy reduction features, to enhance the user experience and owner's operational flexibility. Specific users include: Chemistry, Biology, Geoscience, Chemical, Civil and Mechanical Engineering. Our contribution through the integrated design process helped yield a building that is innovative, environmentally progressive, and possesses a superior indoor environment. The design team's maximization of daylighting and views, careful solar harvesting and low impact mechanical systems, demonstrate to users, and the university, that this building is unique.

The building incorporates innovative European based low energy approaches to conditioning the spaces. The approach uses exhaust air heat/cool recovery, displacement ventilation and radiant heating/cooling panels to distribute fresh air and highly effective heating and cooling for enhanced indoor air quality and occupant comfort. Base cooling for the building areas are with a radiant chilled slab for a non-intrusive but highly effective conditioning system. Additional cooling/heating in laboratories are provided by overhead radiant cooling/heating panels that also provide a platform for acoustic absorption and light bounce for indirect lighting fixtures. Radiant heating panels also serve as light shelves, increasing daylight penetration throughout the floor plates.

The central exhaust concept includes collecting all building exhaust and routing it to a central high plume, dilution exhaust system at roof level. Classrooms and office areas relieve into the central atrium space through low velocity transfer air openings where it will either be exhausted through terminal air units that will be open in cold weather or via natural ventilation through the central solar chimney vents at the top of the clerestory, which will be open in warmer weather. During moderate weather, exhaust fan energy is significantly reduced with this strategy. Under normal conditions, general exhaust air from the atrium is reused for service spaces such as communication rooms and janitor closets prior to being exhausted from the building.

ENERGY ENVIRONMENT EXPERIENTIAL LEARNING, UNIVERSITY OF CALGARY, CALGARY, ALBERTA

Chilled water for the facility's air handling system and radiant cooling units is produced at night (when ambient temperatures are lower) with evaporative cooling towers. The chilled water produced at night is used to precharge the thermal mass of the building overnight and also stored for the next day's use in an on-site stratified chilled water storage system. The air system for the under seat displacement ventilation provided in the 180 seat lecture hall is supplied ventilation air through a ground coupled earth tube system. Buried 4.5 metres below grade the 45 metre long, 1.2 meter diameter concrete tubes precool in air in summer, and provide preheating of outdoor air in winter. Exhaust/supply heat recovery supplements the earth tube preconditioning system. The mechanical systems provide high ventilation effectiveness, superior thermal comfort, enhanced building acoustics, and better energy performance than traditional approaches.

Advanced energy modeling was used to simulate energy use, daylighting effectiveness, and optimize the design of the energy systems. Thermal comfort modeling was used to optimize the façade design and mechanical heating and cooling systems. Full commissioning by DIALOG is verifying that the building operates as designed.

The cooling systems at EEEL are designed to impose minimal loads on the existing district tunnel systems, by using a combination of chilled water storage, overnight generation of chilled water, pre-cooling of structural thermal mass, and a high performance envelope.

EEEL tracks what spaces are being used, what spaces are empty, and actively responds. Both the lights and the supply air system are tied to occupancy sensors that tell them when rooms are occupied. When rooms are empty, the lights turn off, and supply air levels ramp down to save energy.

EEEL exemplifies the kind of spatial and engineering services flexibility that are required for Level 2 laboratories that are always subject to change. It also shows how Mechanical Design innovation in ventilation, cooling and servicing can be done in an economical manner to produce energy-efficient facilities. EEEL is achieving 10 out of 10 credits for LEED® energy efficiency.

Water Efficiency Strategies

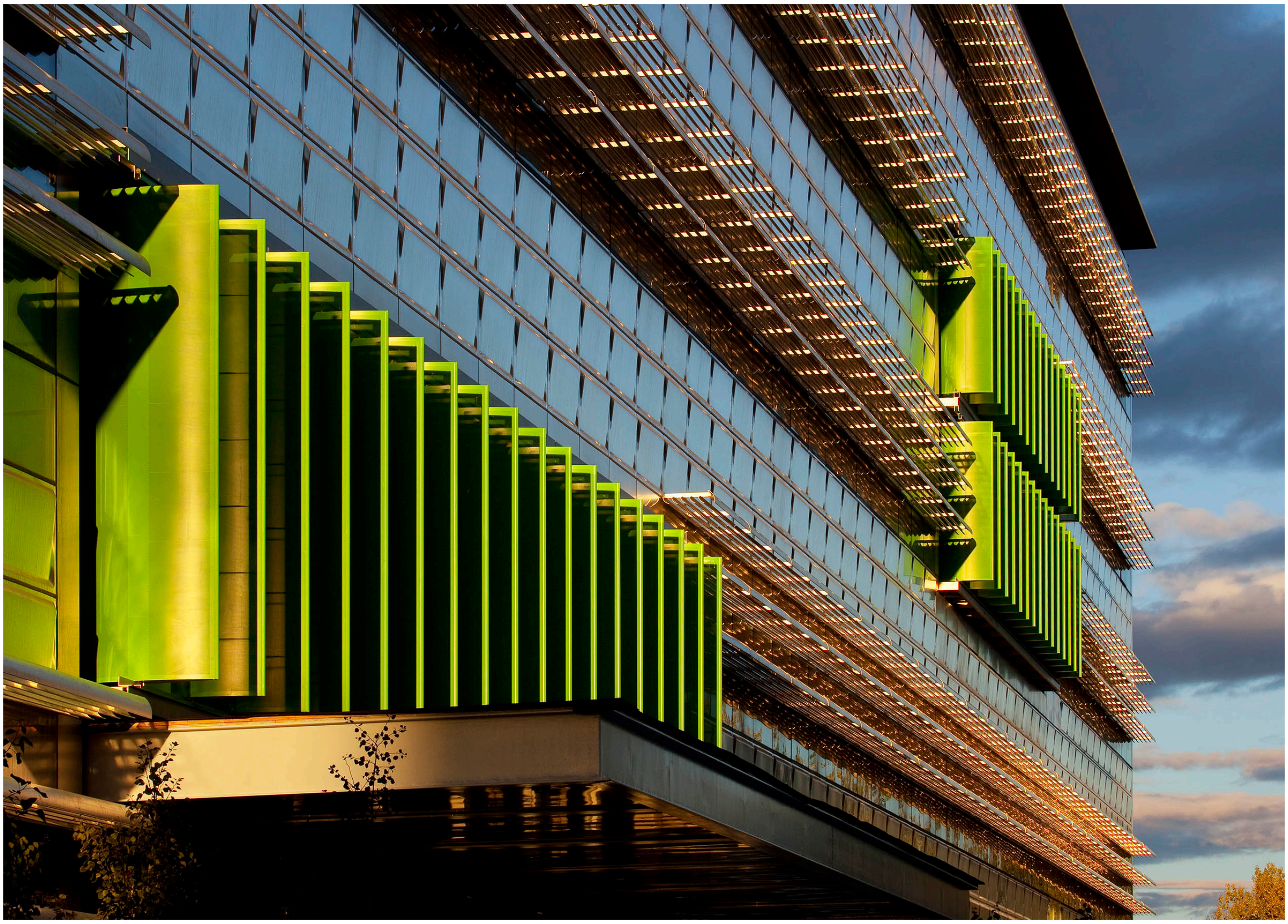
Water use strategies are intended to allow EEEL to not only reduce its overall consumption of water resources, but most especially, to minimize the use of potable water resources wherever possible. Roof drainage is routed through cyclone trash filters and directed to an external 300 cubic meter storm water cistern. Water is delivered through a variable speed pumping system and piping network for re-use in flushing toilets and urinals. When captured rainwater volumes are insufficient to meet demand, cistern water is augmented with campus post processed river water. The university utilizes river water for condenser water in the central chiller plant, the water is used a second time to augment the stormwater cistern. The use of water-efficient plumbing fixtures such as infra-red controlled dual flush toilets and pint flush toilets stretches the amount of stormwater available for flushing purposes. EEEL is able to reduce its potable water consumption by 64%

The building has a significant number of labs requiring an acid waste drainage system. The waste from each lab is collected centrally and routed through an acid dilution system to ensure that the waste is PH balanced prior to discharge to the city sewer system. The majority of the dilution is accomplished by rerouting grey water waste from public washroom hand washing basins though the acid dilution tank prior to discharge to sewer, saving a significant volume of potable water which is normally used for dilution duty in conventional laboratories.

CONCLUSION

Today the project stands complete, with a construction cost of $145.5 M. EEEL was a very fast tracked project where initial design allowed for construction to start earlier than normal. The contractors had an important input to the design team, ensuring systems, materials and processes were economical and able to meet tight schedules for occupancy in the fall of 2010 and completion by September 2011, meeting the Registrar's schedule. EEEL is currently on track to achieve the owner's target of a LEED Platinum designation with the Canada Green Building Council.

Full Project Description



ENERGY ENVIRONMENT EXPERIENTIAL LEARNING

UNIVERSITY OF CALGARY

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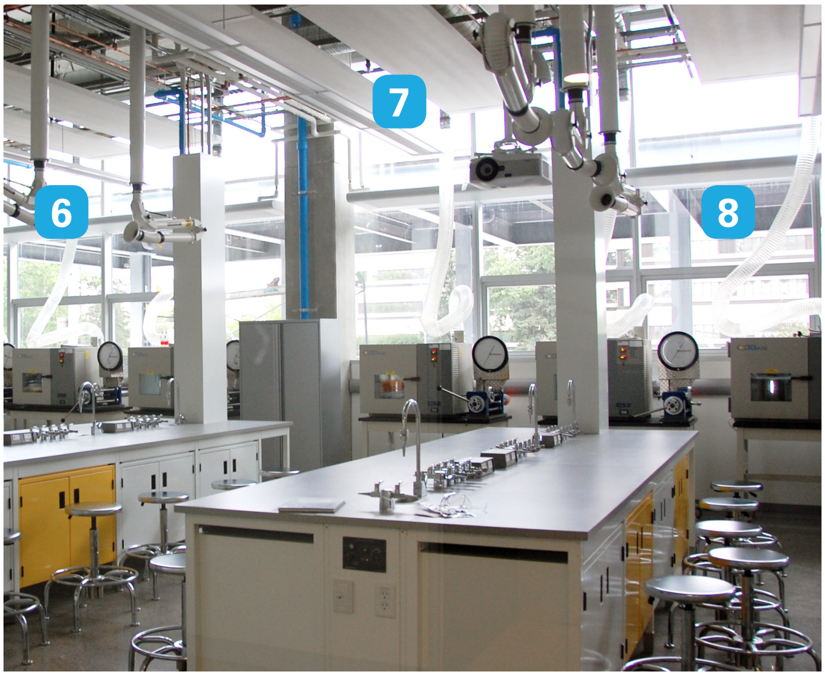
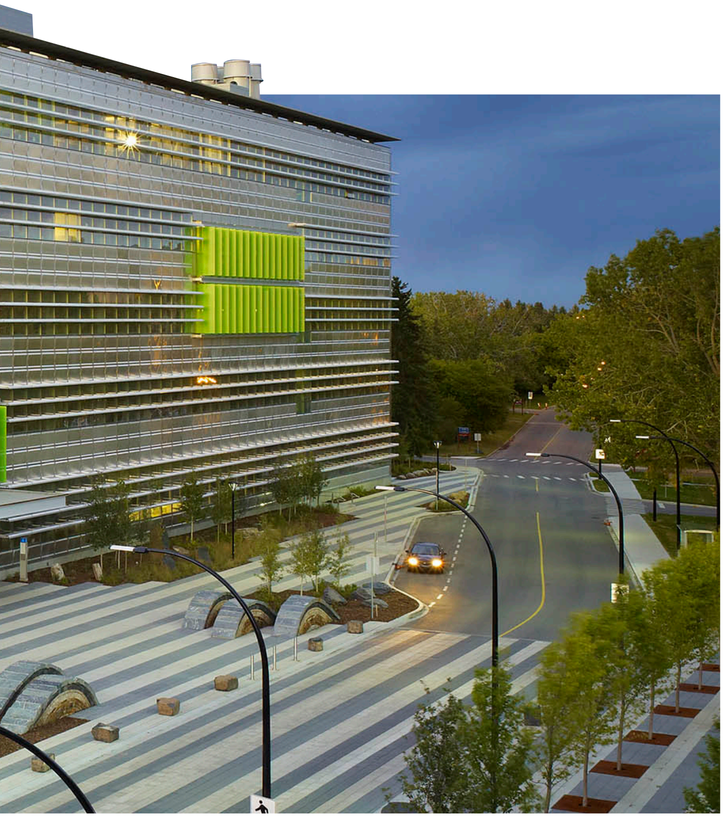
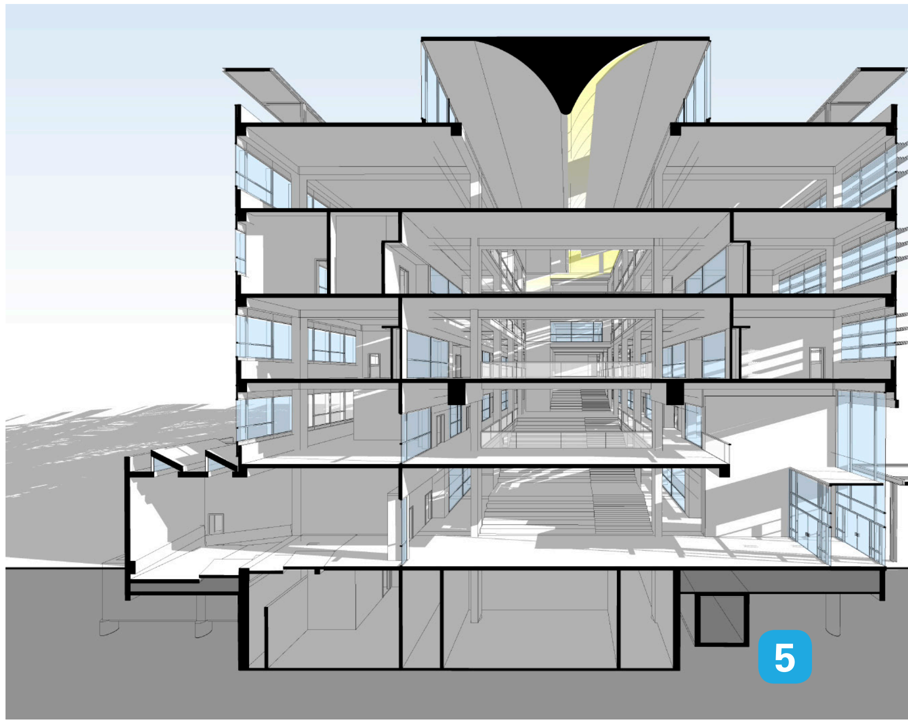


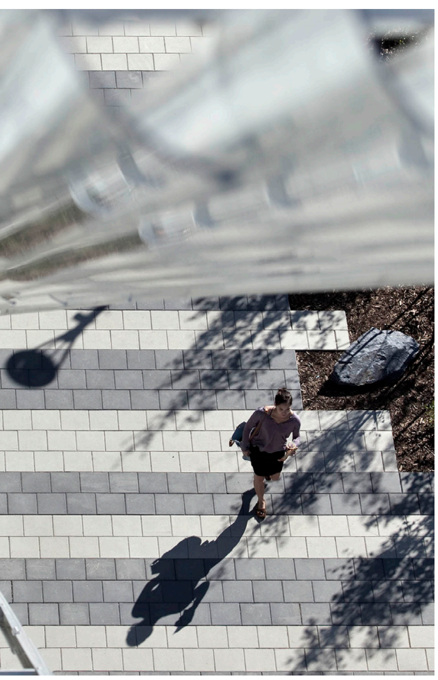
Legend

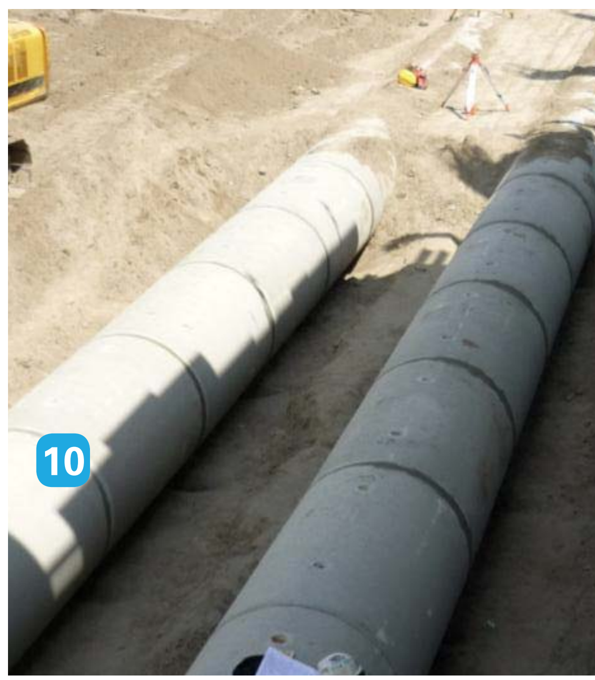
1. East/West Slash Shade
2. Limited East/West Facing Glazing
3. Triple South Fixed Shades
4. Automated Sun-Tracking Shades

ENERGY ENVIRONMENTAL EXPERIENTIAL LEARNING, UNIVERSITY OF CALGARY

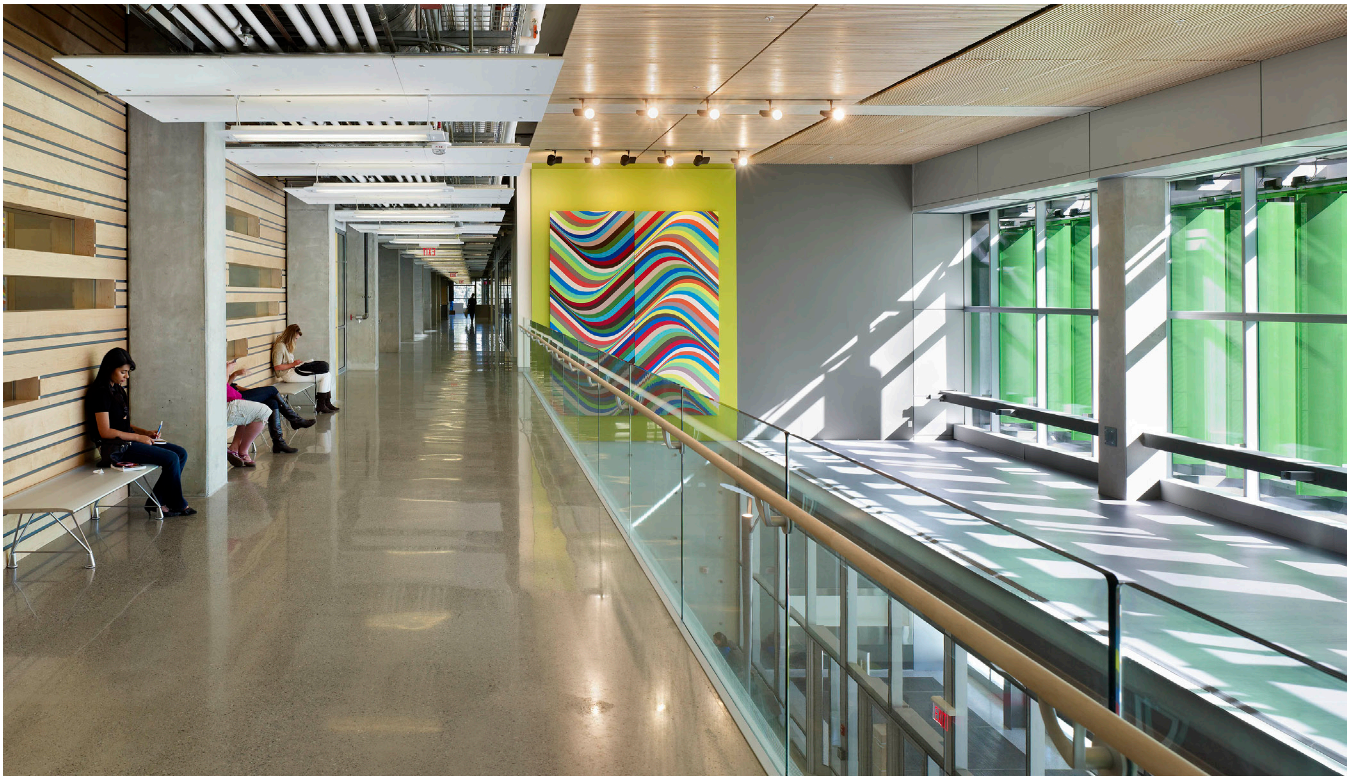








5. Daylight Retention Study
6. Snorkel Exhaust
7. Cooling/Heating/Acoustic/Light Bounce Panel
8. Perimeter Heating Panel/Light Shelf
9. Radiant Tubes Ready for Concrete Topping
10. Earth Tube Intake Air Preconditioning



PROJECT ATTRIBUTES

ENVIRONMENTALLY SUSTAINABLE INNOVATION

The project has been designed to **LEED® Platinum** requirements; the LEED® application process is underway. A fundamental goal of the design team was the provision of a highly sustainable building and landscape, a landmark which brings a sense of pride to students, faculty and the community at large. Design and construction strategies (through to building occupancy and operations) are intended to reduce the impact of the building on the environment and resources and to provide users with opportunities to experience and learn about the buildings systems. The design team's over arching effort was to minimize EEEL's use of energy, water and material resources wherever feasible and maximize indoor environmental quality.

Throughout the design process, particular attention was paid to three key University sustainable priorities which were established prior to any design effort:

- Water use reduction
- Life cycle analysis and building durability
- Energy use reduction

All of the site strategies allow EEEL to serve as a considerate, responsible and beneficial neighbour to the campus and surrounding community for the entire life of the building by reducing erosion consequences and light trespass, enhancing biodiversity by returning the site to a native ecology, and improving the overall environmental quality by eliminating heat islands.

Geology on display

North of the building is a long, winding ridge that transforms into a bench. This is an interpretation of an esker – which is formed when a melt water stream running under a glacier deposits sand and gravels, leaving a ridge behind once the ice recedes.

At the main building entry there are folded **stone features** rising from the ground. These are interpretations of anticlines, which are favoured locations for oil and gas drilling because low-density hydrocarbons float to the top of the fold and pool below the surface cap.

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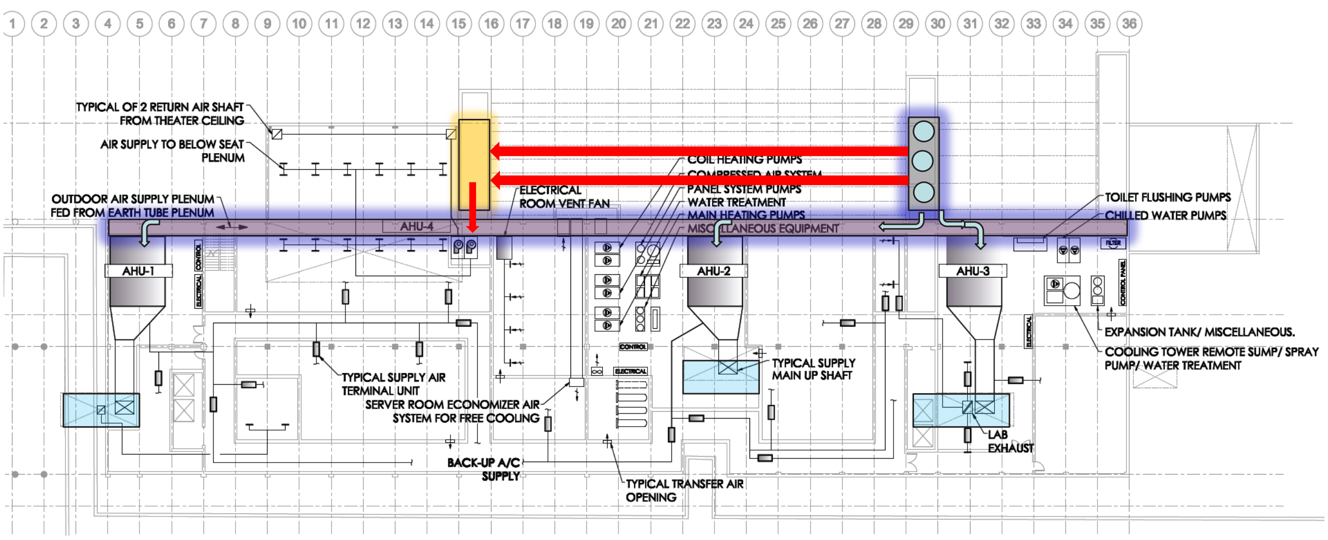
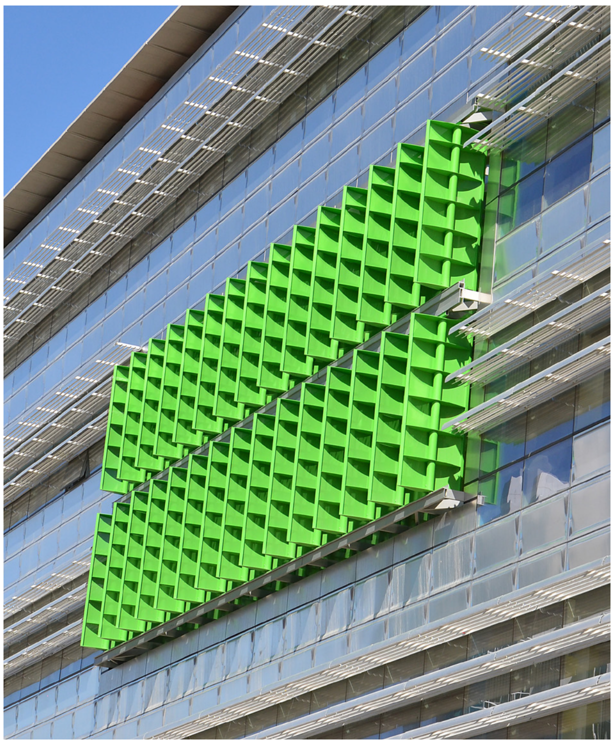
The building has a significant number of labs requiring an acid waste drainage system. The waste from each lab is collected centrally and routed through an acid dilution system to ensure that the waste is PH balanced prior to discharge to the city sewer system. The majority of the dilution is accomplished by **rerouting grey water waste** from public washroom hand washing basins though the acid dilution tank prior to discharge to the sewer, saving a significant volume of potable water which is normally used for dilution duty in conventional laboratories.



Indoor environmental quality

The four cornerstones of indoor environmental quality are;

- Indoor air quality
- Acoustics
- Lighting
- Thermal comfort



All of the indoor environment strategies listed below are intended to allow EEEL to improve the quality of its indoor environment and reap the benefits of increased productivity and learning ability associated with **superior indoor environments.**

- control pollutant sources and pollutants
- provide superior acoustics, isolate noisy and quiet spaces
- optimize air quality by avoiding high VOC or toxic materials and effectively use fresh air for ventilation
- provide thermal comfort through the application of radiant heating and cooling
- provide access to daylight for all regularly occupied spaces
- use high quality indirect, glare-free light sources throughout
- monitor the building, both for teaching and for efficient allocation of resources

The design team undertook **wind studies** to optimize the location of lab and generator exhausts in relation to operable windows and the building ventilation air intakes. Rooftop outlets of exhaust sources at the east end of the roof, high plume laboratory exhaust and ventilation air intakes located three metres above grade at the east end of the north side of the building was the optimum configuration to avoid re-entrainment of pollutants into the building.

Acoustics in the spaces were optimized through the use of low velocity air distribution systems, **triple glazed windows** for greater isolation from ambient noise, and acoustically absorptive radiant cooling and heating panels systems that augmented acoustic panels.

A key component of the design which has served as a cornerstone for the building location, massing, internal plan layout and development of the exterior envelope has been **access to and harvesting of daylight**. It was a goal of the project that every regularly occupied space within the building have access to daylight. Successfully achieving this goal will both improve the quality of the indoor environment by making it more conducive to teaching and learning, as well as reducing overall building energy use by reducing the amount of electrical energy devoted to lighting, and mechanical energy devoted to removing from the building the heat produced from that lighting.

The very size of the building floor plate made this goal a challenge to achieve, as a number of rooms are 13m or more from exterior glazing. However, **massing strategies** to provide large perimeter openings, a central clerestory and light well through the centre of the building, and glazed corridors to the teaching spaces were implemented to overcome these challenges.

The east west orientation enhanced access to north and south sun, but adjacent high buildings to the south of the site restricted lower floor access to daylight during winter months. The shape of the site restricted the length of the building such that the depth of the floor plate was necessarily wider than is optimum for full floor plate daylight penetration. The solution was to introduce a central rooftop clerestory to the building, allowing sun from the roof level to penetrate the lower floors through an atrium and augment the light penetrating from the exterior wall glazing. To augment the overhead light penetration, three exterior double height spaces were located to enhance light penetration into lower storey areas.

Additionally façade spandrel panels were designed to reflect light according to the orientation of the facade. For the south facade, sunlight is redirected to the ground plane of the plaza and teaching areas around the building. As these areas have significant overshadowing from adjacent buildings, it is important to redirect all available daylight to these inhabited spaces so to increase their comfort and livability. For the west façade, the sunlight is redirected to the smaller plaza west and north of the entry canopy. For the east facade, the sunlight is redirected to the bus shelter and teaching area southeast of the building. For the north facade, as there was no direct sunlight to reflect, the panel was oriented to reflect daylight back to the sky. This has the effect of making the spandrel panels brighter than they would otherwise appear, thus making the north facade appear as if it was lit.

EEEL - Clerestory 'belly' sunny sky.

The clerestory is located directly above the **social stair, at the heart of the building**. In most situations, achieving any daylight, let alone an adequate level of daylight this far to the interior of the building would be very difficult. The key item to achieve this is the "belly" form below the clerestory. Without a belly shape, the clerestory would provide too much direct daylight to the social stair during the summer months, at a cost of high levels of heat gain and glare, During the winter, the clerestory by itself would provide little daylight penetration when it would be most appreciated. This is due to the fact that with the low winter sun angle, daylight essentially passes into and out of the clerestory without affecting the spaces below.

EEEL - Clerestory 'belly' overcast sky.

Commonly referred to as **the belly**, the large light scoop at the top of the atrium is an integral component of EEEL's daylighting strategy. The curved shape drives light deep into the heart of the building, allowing the labs and classrooms to have access to natural light from both the interior and exterior.

Automated interior blinds allow for the control of natural light in EEEL's labs and classrooms. In order to not compromise EEEL's daylighting strategy, the blinds are designed to automatically rise at the end of each class in order to make sure that EEEL's blinds are perpetually closed and unnecessarily using artificial light.

Daylighting for the 152 seat raked lecture hall was accomplished with north facing light tubes with integral automated shading devices.

In order to verify that the daylighting goals were met through the strategies employed, a series of studies were undertaken to measure in tangible terms the levels of daylighting in the building. The specific studies were:

- Simulation of daylight levels to the work surfaces at all levels in order to measure conformance with LEED® requirements
- Simulate the design of the 'belly' of the clerestory to determine if both adequate daylight was being directed down to the social stair, and that heat gain from summer sun was being controlled
- Model the levels of incident solar insolation to the south façade to determine the levels of sunlight harvested energy from the façade
- Study the angle of the bent panel spandrel to maximize the amount of incident sunlight redirected to the inhabitable plaza
- Coordination of the daylighting design of the lecture hall to prevent backlighting of the podium, or direct light or glare into the eyes of the audience
- Verification that the building shading strategies were functioning effectively in terms of both allowing daylight, yet substantially reducing solar heat gain as per mechanical system design requirements to minimize building energy needed for cooling;

The integrated design process supported by extensive studies yielded a distinctive envelope design that **minimizes summer solar load and maximizes controlled daylight** within the building through the following features;

- Combination of fixed horizontal sunshades and automated exterior louvers on the south façade
- Diagonal slash fixed louvers on the east and west
- Vertical fins on the north façade
- Automated interior south fabric shades for winter glare control
- Automated exterior sun-tracking vertical louvers on the two south facing double height spaces and fixed vertical louvers on the north double height space

MECHANICAL ENGINEERING INNOVATION

The mechanical systems provide **high ventilation effectiveness, superior thermal comfort, enhanced building acoustics**, and **better energy performance** than traditional approaches. Energy performance was enanced by targeting all available LEED® energy points with over a 60% improvement over a base building designed to meet the ASHRAE 90.1 1999 energy standard.

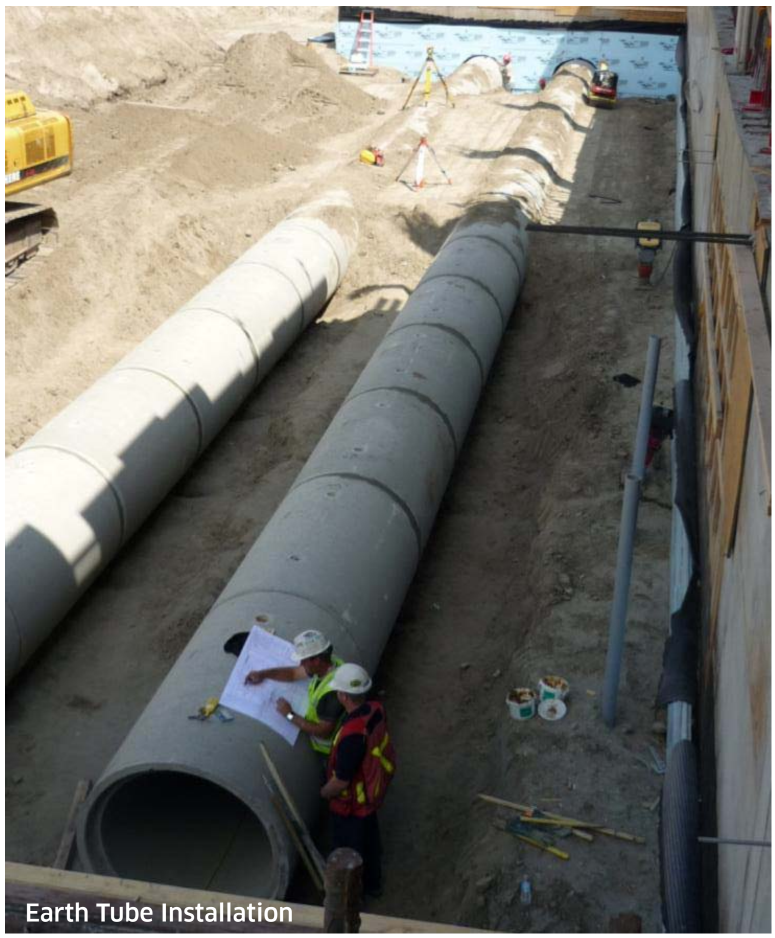
The overall mechanical system has been designed to decouple the building's main ventilation systems from the heating and cooling systems. This strategy allows EEEL to maintain the high ventilation rates required by the laboratory components without sacrificing the energy that would be required to fully heat or cool the incoming air that is constantly being exhausted out of the building.

Rather than a typical forced-air ventilation/cooling system with perimeter hot water baseboard heating, the building incorporates innovative **European based** low energy approaches to conditioning the spaces. The approach uses exhaust air heat/cool recovery, displacement ventilation and radiant heating/cooling panels to distribute fresh air and highly effective heating and cooling for enhanced indoor air quality and occupant comfort.

The outdoor air system is used to serve the ventilation air throughout the building. Three main systems are used to supply air to the building. Each system is expandable for an additional 50% of air flow without expanding the main duct distribution infrastructure. Main units feature redundant supply fan arrays and shared, looped duct distribution enhanced reliability, expandability and energy savings. The units are 100% outdoor air units with no provision for recirculation of air.

Three main vertical mechanical shafts located in the east, central and west areas of the building allow for distribution of supply air as well as collection of exhaust air for relief out of the roof. The outdoor air system uses preconditioned air from an earth duct system to reduce capital and energy costs associated with cooling and heating. The earth duct takes air from the supply air intake shafts located at the northeast corner of the building, through an earth coupled intake plenum which serves each of the three basement air handling units.

Radiant Tubing being laid in slab from central manifold locations



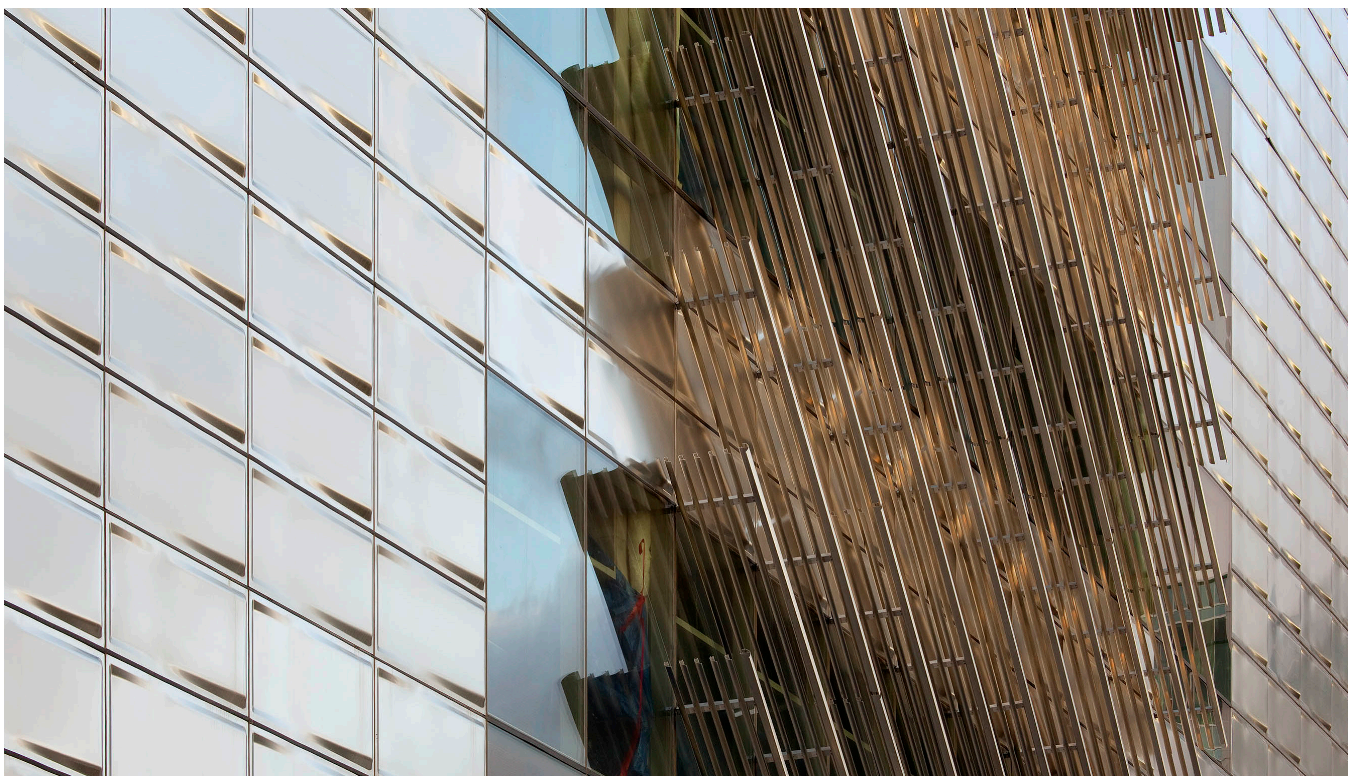
Earth Tube Installation

The system provides preconditioning of the intake air (cooling in summer, heating in winter) through geothermal exchange with the deep soil. Each of the three air handling units have an array of multiple direct drive fans housed in an integral acoustic enclosure. The fans are driven by variable frequency drives and provide energy savings, redundancy, and increased space efficiency over conventional systems

The air handling unit heating is accomplished in stages. First, outdoor air is preconditioned by the earth duct system, then it is either preheated or cooled using a glycol coil fed from the exhaust system glycol runaround system and finally heated or cooled using the glycol heating or chilled water system.

Air delivery within the building is predominantly by displacement ventilation techniques. Conditioned 100% outdoor air, warmer than conventional air conditioning system is delivered at low velocity near the floor in occupied spaces. The air fills the room from the bottom up and causes thermal plumes to be developed when the air encounters a thermal source. As the air encounters the heat of people, equipment or computers, the air becomes buoyant, rises to the ceiling and is removed from the space.

In doing so, the air delivers ventilation air directly to the breathing zone of the occupants, and efficiently removes products of respiration (CO2), odors and heat from the occupied zone. The system is **more efficient** that typical overhead dilution ventilation system in maintaining thermal comfort and good air quality and the ventilation code allows a reduction in fresh air quantity per person because of enhanced performance. In the EEEL building, this reduction of air quantity was not implemented in favor of providing ventilation air quantities to the space approximately 25% better than code minimums for enhanced indoor air quality.



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The Physical Plant will provide chilled water via the tunnel system for use by the air handling unit coils on very hot days and to be used as backup in case of cistern/cooling tower functioning under capacity or failure.

Heating for the building is served primarily by perimeter heating systems, unit heaters and perimeter radiant heating panels located in the perimeter light shelves, as well as, radiant heating slabs in main floor foyer. The U of C Physical Plant supplies high pressure hot water to EEEL via the new vault on the south side of the tunnel under the building where two low temperature hot water heat exchangers provide the building's hot water supply, and a high temperature hot water to steam generator supply's steam to the buildings autoclaves. Heating is provided through the campus high temperature water system, generated from a central cogeneration plant. Cogeneration, also known as combined heat and power or CHP, is an efficient, clean and reliable approach to generating power and thermal energy from a single fuel source. That is, it uses heat that is otherwise discarded from conventional power generation to produce thermal energy.

The differential in high temperature hot water needed for the radiant panels, the lower temperatures required for heating outdoor air, and the low hot water temperature needed for the radiant slabs has presented an opportunity to use a cascaded energy system where the return water from the radiant panels is used as supply water for heating glycol for the air handling units and then for use in the radiant slabs. The cascaded system flows from the hot water heat exchangers and perimeter heating systems to the air handling unit glycol heat exchangers to the few radiant slabs that also perform heating.

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