A Scientific approach to Air Quality: Concordia University Science Complex

From day one, plans for Concordia University’s Science Complex included a mandate for improved energy efficiency, indoor air quality and safety objectives, challenging architects and designers to come up with innovative ideas that would fit into a planned budget.


Located on the Loyola Campus in Montréal, PQ, Concordia University Science Complex is a 32,000-sq. m. (344,445 sq. ft.) sustainable, academic building housing laboratories, classrooms and offices. While energy efficiency was a critical design objective for the PMA-Pellemon Joint Venture, indoor air quality (IAQ) remained a core issue throughout the design process, since it impacts both the comfort and safety of the academic community.

The science complex provides teaching and research facilities to the chemistry, biology, biochemistry, psychology and physical education departments. It is also home to the Science College and the Centre for Structural and Functional Genomic. The L-shaped building features three sectors: the eight-storey North Wing, the existing Bryan Building, which was integrated into the complex, and the four-storey South Wing. Teaching and research and development (R&D) laboratories occupy 14,000 sq. m. (150,694 sq. ft.) of the building (45 per cent) and are equipped with 250 fume hoods.

The general layout of each wing is similar. Laboratories are located within the central core of the building with offices on the
In the North wing, a public corridor separates the laboratories—located in the central core of the building—from the offices. A private, technical corridor divides the laboratories in two sections as a part of the indoor air quality design.

A perimeter. A public corridor separates these two functions, and a private, technical corridor divides the laboratories in two sections. Its purpose is to allow the distribution of services such as natural gas, compressed air and deionized water to each laboratory, and to install the laboratories' exhaust collectors. The main advantage of this layout is that the technical corridor allows the retrofit of a laboratory without any disturbance to adjoining ones.

In addition to energy efficiency, design criteria included stringent air quality and safety standards to provide researchers and students with state-of-the-art facilities, the flexibility and modularity of mechanical and electrical systems, to facilitate the adaptation of laboratories to the evolution of research programs, and the integration of "green building" principles. Operation and maintenance costs were also paramount.

**Indoor air quality requirements**

Energy efficiency and indoor air quality may seem contradictory objectives, since superior IAQ, though attainable, is usually reached at the expense of energy efficiency. This perception, however, is the result of a misunderstanding of what is expected from the point of view of IAQ.

Indoor air quality requirements are defined in ASHRAE standards 62, Ventilation for Acceptable Indoor Air Quality and 55, Thermal Environmental Conditions for Human Occupancy. Acceptable IAQ is defined in 62 as "air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80 per cent or more) of the people exposed do not express dissatisfaction." Acceptable thermal environment is defined in 55 as "an environment that at least 80 per cent of the occupants would find thermally acceptable."

These definitions refer to three aspects of air: its "quality" (i.e. the absence of contaminants and the content of fresh air circulated within a building), its temperature and its relative humidity content. A fourth aspect must also be considered when referring to IAQ: containment. While an office located in a building does not have any specific containment requirements, a laboratory located in the same building must be treated with care. Contaminants may be released during an experiment and must be controlled and exhausted outside of the building, without any chance of migration to other zones within the building.

**Ventilation system selection**

Unlike an office building, Concordia's Science Complex comprises several functions, each with different IAQ requirements. For air supply, the basic requirement is the same for all functions, the
standard industry practice being approximately 100 cubic feet minute (cfm) of supply air per person, with a fraction of those cfm being fresh outside air. The minimum fresh air required to ensure IAQ in all functions as defined in ASHRAE 62, is 20 cfm.

When it comes to exhaust, however, the picture is different: air from laboratories must be completely exhausted outside the building to avoid any risk of pollutants remaining in the atmosphere or being recirculated in the building. Therefore, laboratories require a supply of 100 per cent fresh air to ensure a balanced system. Since it does not contain the same potential for harmful pollutants, air from offices may be recirculated in the building, as long as it is mixed with enough fresh air to ensure 20 of the 100 cfm being supplied is fresh air, and that the system remains balanced.

Based on this, the obvious solution would have been to design two ventilation systems: one dedicated to laboratories and the other to non-lab functions (i.e. classrooms, offices, etc.). However, the shape of the building precluded this option—since the two major laboratory areas are located at the two opposite ends of the building—as did space and budgetary considerations.

Having two separate systems would also have meant less energy efficiency, since one system providing the minimum 20 per cent fresh air would have been required in the ‘normal zone,’ and a second one in ‘laboratory zones,’ meeting the 100 per cent requirement. This would entail more construction materials, equipment, space, and above all, more energy for the equipment operating the systems.

When both systems are combined, the 100 per cent exhaust requirement of the ‘laboratory zones’ is still respected, and ‘normal zones’ experience an increase in the amount of fresh air they receive, as more fresh air is admitted in the single system solution to keep it balanced.

The solution adopted was to design a variable air volume (VAV) ventilation system with terminal reheat servicing both the laboratories and non-lab functions of the North Wing, and another one for the Bryan Building and the South Wing. The North Wing system is composed of four 80,000-cfm modules, while the South Wing system is composed of two 80,000-cfm modules. In each building these modules supply air in two vertical shafts that then distribute it to the horizontal network of each floor. The VAV system was also selected because it provides more operational flexibility than a constant volume (CV) system, an important feature with laboratory fume hoods.

Another significant advantage of this combined VAV system is it provides occupants with more fresh air than is required by recognized standards. Compared to the 20 per cent fresh air usually required, the system provides 65 per cent fresh air when working at full capacity.

Lastly, compared to other types of systems, it provides more operational flexibility while meeting containment objectives, since it may be adjusted locally to provide the right amount of air at the right temperature and the right relative humidity in each room.
In building the Science Complex, the majority of offices and laboratories were designed with windows in an effort to provide natural light, cutting down on the electricity bill.

the night). In other areas (i.e. without fume hoods), there are six air changes per hour when occupied, three when unoccupied and zero during the night. These rates may be further modified according to the actual occupation of the room, and the specific requirements of seasonal heating and air conditioning loads.

Flow tracking is the main method used to control the operation of the ventilation system. Each wet laboratory is equipped with a supply box, an exhaust box and a fume hood, and all of these are equipped with flow meters used to produce a volumetric flow balance. By tracking how much air is exhausted, the system knows how much fresh air is required. Supply and exhaust boxes in dry type laboratories, classrooms, offices and other functions are also equipped with these flow meters.

Occupancy sensors installed throughout the building provide a second means to control the operation of the ventilation system while giving useful information to the building’s automation system for other control strategies (i.e. lighting). Academic and scientific research being what it is, laboratories and offices may be occupied at all times. The sensors then inform the building control system that someone is present in a laboratory and specific operations are required, for example the exhaust of the fume hood and the supply of fresh air. On the other hand, the same sensor will command the reduction of the air change rate and shut down lighting fixtures if there is no one present in the room.

Within this context, the CO2 sensors usually installed in buildings are made irrelevant since the occupancy sensors play their role. In addition, the ventilation system provides 65 per cent fresh air, an amount much higher than required by standards, making CO2 sensors doubly irrelevant.

The third method used to meet IAQ and safety requirements is containment. The ventilation system is designed to maintain specific relative air pressures in the various sectors of the building. A fume hood pressure is maintained negative compared to the room, thus creating a containment area where experiments using chemicals can be conducted safely as the fumes are drawn up to the exhaust conductor instead of being dispersed in the laboratory. The same process is applied with the laboratory in relation to the corridor. If someone enters a laboratory and creates a draft, the air and its contaminants will automatically be exhausted through the exhaust grille rather than being dispersed in the corridor.

Finally, thermal comfort is ensured with the terminal reheat portion of the system. The temperature of the air circulating in the system being around 12.7 C (55 F), the role of the terminal reheat is to elevate this temperature according to the specific requirement of the occupant in the room. This allows the occupant of an office to set the temperature sensor (thermostat) at a cool 20 C (68 F), while someone else would set it at a more comfortable 22 C (72 F). The set point is a matter of personal convenience determined within the range offered by the system 12.7 C to 23.8 C (55 F to 75 F).

Energy efficiency
Concordia University wanted its new facility to be as energy efficient as possible—even more than other ones on its campuses. The project was therefore registered with Natural Resources Canada’s (NRCan’s) Office of Energy Efficiency’s Commercial Building Incentive Program (CBIP), and later with the Industrial Building Incentive Program (IBIP), which was better suited to the project’s “process” characteristics (i.e. laboratory fume hoods exhaust). The IBIP main objective is to design a building whose energy consumption is at least 15 per cent lower than the one recommended by Canada’s Model Energy Code, and 25 per cent lower when considering the process.

At Concordia’s Science Complex, these objectives are met through the addition of several measures, which can be classified in two categories: heat recovery and the selection of high-efficiency equipment. Heat recovery is extensively used throughout the building: on the exhaust networks, on the chillers, on the boilers, in the electrical and telecommunication rooms, as well as in the growth chambers and the nuclear magnetic resonators (NMR) rooms. The energy recovered from the two 900-ton, high-efficiency chillers (0.6 kWh/ton), and transferred into the low temperature heating loop, is sufficient to meet the heating (or re-heating) demand of the building during nearly half of the year.

Other high-efficiency equipment includes two 100-ton chillers, which are used for emergency purposes. These chillers are nearly
Notice of substantial performance of the contract under Section 92/Act ss. A to B.

City of Scarborough
Regional Municipality of Toronto
448 Birchmount Rd.
Scarborough

This is to certify that, the construction contract for an assembly of a building consisting of six units at the above premises was substantially performed on Jan. 12, 2003.


Name of Owner: Pars Holding Inc., Scarborough
Par:

Address of Service: 448 Birchmount Rd., Scarborough

Name of Contractor: Esmael Zamani
Richmond Hill
Per:

Address: (A) Identification of premises for preserved form. 448 Birchmount Rd., Scarborough.

Concordia's Science Complex is a 52,000-sq. m. (344,445-sq. ft.) sustainable, academic building housing laboratories, classrooms and offices. When completed this September, laboratories will occupy 14,000-sq. m. (150,694-sq. ft.) of the building.

100 per cent efficient since their heat is directly transferred in the heating loop. Direct drives and variable frequency drives are also used on motors. Efficient lighting is also used throughout the complex.

Specific operational requirements have also been defined to ensure ventilation systems do not operate uselessly. For instance, the典型 velocity of a furnace air handler is maintained at 100 feet per minute (fpm). Sensors are also installed on furnace air handlers. Their role is to issue an alarm when a sash remains open unnecessarily (an open sash consumes more energy than a closed one).

The addition of these features results in the building having an energy consumption 24 per cent lower than the one (15 per cent) recommended by the Model Energy Code, and 44 per cent lower (compared to 25 per cent) when the process is considered. A significant achievement resulting in an annual, recurrent savings for Concordia University.

Indoor environmental quality
Concordia University Science Complex is an excellent showcase of what can be achieved with a well-thought design and the clever layout of both rooms and systems.

Starting on day one, the university made its energy efficiency, IAQ and safety objectives very clear, and expected its consultants to meet them with innovative designs, while remaining within the allocated construction, operation and maintenance budgets. University representatives, being well informed with respect to energy efficiency, were aware that in some cases higher initial costs would prove more economical in the long run.

Energy efficiency was achieved without compromising on indoor air quality, thermal comfort and safety. In fact, it was achieved with even better IAQ levels than required, thus providing occupants with the comfort and safety levels expected in a modern scientific academic pavilion.«

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