Canadian Consulting Engineers
Awards 2011

BEAVER BRAE SECONDARY SCHOOL RENOVATIONS

Submitted by:

MCW/AGE
Consulting Professional Engineers

MCW / AGE

PROJECT HIGHLIGHTS

Application of Technology

The Keewatin Patricia District School Board (KPDSB) has proven to be ambitious with regard to supporting new, innovative and sustainable technologies. Because of this, several were incorporated into the design. It would be ambitious enough to employ a new innovative technology in itself. Incorporating several, untried concepts together, and ensure seamless integration with each other is truly challenging.

1. Reverse Flow Heat Recovery Ventilation – Beaver Brae was the first in the divisions, perhaps all of Northwest Ontario, to implement this new and exciting technology. As expected, being the first to take the leap from theoretical to applied technology comes with its own challenges.
2. Passive Solar Ventilation – Again, as the first installation of its kind in the region, Beaver Brae’s solar wall has proven to become another success.
3. Waterless Urinals – What is often dismissed as a janitor’s maintenance nightmare, MCW/AGE, along with the school board decided to incorporate this relatively new technology in the school. A mock up, fully functional washroom was created to test the functionality and durability of the urinals. The response was so positive, that not only are they installed at Beaver Brae, but have become the standard for all KPDSB schools when renovations occur.
4. Recirculation of Exhaust Air- the school houses two large woodworking shops which each employ a dust collection system. Every cubic foot of air extracted outdoors during the dust collection process must be replaced with outdoor air. In winter months, this air must be heated to suitable temperature prior to being reintroduced to the wood shop. By passing the exhaust air through a system of progressively efficient filtration, we were able to reintroduce this air to the shops; thereby eliminating the need to heat outdoor air, all the while maintaining the excellent working environment within.

Social / Economic / Environmental Impact

1. When designing energy savings measures, it is critical that the designer ensures that no compromise is made to the functionality or comfort of the building for the sake of energy savings. At MCW/AGE we like to borrow from the medical profession when we mandate “first, do no harm.” The alterations and energy design concepts have managed to reduce the schools operational utility budget by nearly 50%. This is a hard figure which has been proven at the meter. At the same time, student and staff absenteeism due to illness has declined. What this means is that there is more money directed to the classroom, and more students filling it on a regular basis.

2. The “open concept” of the student common area and location of the student guidance and life skills area front and centre, allows all students to feel like a valued member of the student body. The signage for the various areas spelled in both English and Ojibwa highlights the commitment to include First Nations culture and education within the school.
3. Due to the success of the sustainable design elements incorporated at Beaver Brae, it has become the flagship for sustainability throughout the division, and truly a shining star within the Divisions inventory. Design elements implemented here are now being incorporated in every one of the board’s schools, with equally positive results.

Complexity

Any renovation to an existing facility creates its own unique challenges. What makes this project truly remarkable with respect to other similar new construction or renovation projects is the fact that 97% of the secondary school was renovated, almost completely within the existing footprint, without incident or causing the closure of the school for even a single day. This even included the replacement of the domestic water service, and electrical service. Each step in the renovation process had to be closely evaluated for risk of disruption to the students and staff. The key to such an undertaking was flawless communication. At each step, the school’s administrative team was consulted and apprised of all conditions, schedules and scope of task; ensuring that the staff and student population were fully aware of all potential issues which may have affected their daily operations.

Completing a major renovation at a functioning school over several calendar years also means that program changes are bound to occur. When this happened, the owner/consultant/contractor/user groups had to work together to quickly modify spaces within the school to suit the new program, again, to ensure a seamless transition.

Owners / Clients Needs

Throughout the design and construction process, MCW/AGE was extremely proud to work hand in hand with the Keewatin Patricia District School Board. The result of extensive collaboration was the successful completion, on budget and one year earlier than the anticipated completion date.

This allowed the ultimate clients, the students of Beaver Brae, to enjoy and benefit from the completed renovation to their school earlier.

The replacement of the existing outdated mechanical and electrical equipment with newer, smaller more efficient models created more free space which could be utilized for storage and maintenance. Space for these types of uses are often not funded by education ministries and normally have to be paid for out of division budgets.

FULL PROJECT DESCRIPTION

MCW / AGE

BEAVER BRAE SECONDARY SCHOOL RENOVATIONS
KENORA, ONTARIO

Introduction

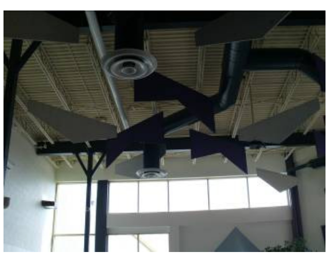
Beaver Brae High School in Kenora, Ontario is one of the largest schools within the Keewatin Patricia District School Board. As with many of the schools in the district, it has had numerous additions over the years in keeping with the ever-changing demographic and curriculum demands. The original wing was constructed in 1962, with additions in 1964, 1989, 1992 and 2000. The resulting building measures just under 120,000 ft^2 and provides academic, vocational, and life skills studies to almost 1000 students.

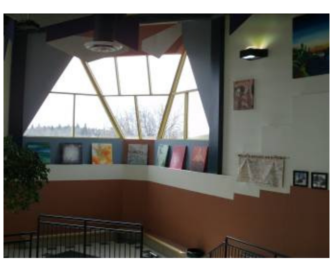
Although meticulously maintained, many of the schools electrical, mechanical and building finished systems were showing signs of age and nearing their functional life expectancy. Early in 2006, a dialogue was established between the Owner and design group to devise a plan for the comprehensive upgrade of the school. The result was an extensive architectural, mechanical and electrical renovation that saw changes to 97% of the school.

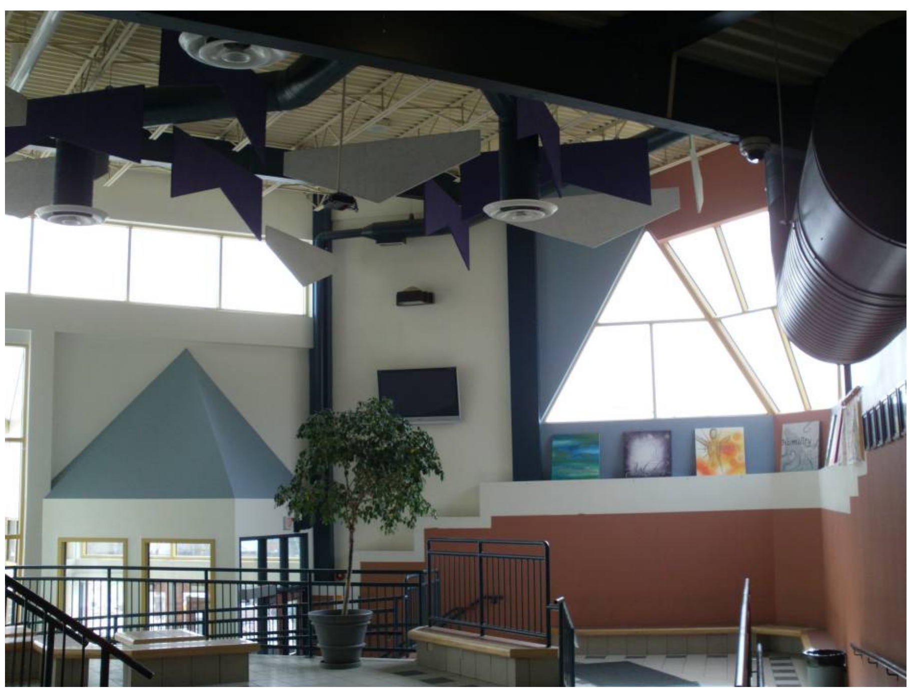
Throughout the conceptual design process, MCW/AGE worked closely with the school board, Architect (Habib Architects Inc) and staff and student representatives to develop a strategy which would allow a better flow to the school; endeavouring to minimize the segmented feel that a building with numerous additions over time tends to exhibit.

The addition of a central atrium allows students to gather for numerous educational, recreational and social interaction. Centrally locating the new student services and life skills area, and making it a focal point of the school allows all students to feel like an important member of the student population. *Refer to the following pages for photos.*

Supporting the daily activities of the students and staff are leading edge electrical, mechanical and architectural designs intended to enhance the learning process, and reduce the energy consumption, thereby reducing the schools carbon footprint.







Student Atrium

Student Atrium

Building Envelope

More and more, building envelope (walls, windows and doors) systems are an integral part of any building construction. Walls must be constructed to maximize thermal resistance and minimize infiltration, or air passing through. Windows must be selected to both allow the appropriate amount of necessary daylight, as well as reduce both solar gain and outward heat transmission. Doors must be selected to minimize heat loss and seal out cold drafts.

As one may expect with any building constructed over 40 years ago, utility costs were not as influential as they are today with construction techniques and materials reflecting such. For this reason, extensive window, door and building envelope upgrades took place to improve the building envelope and optimize the mechanical and electrical upgrades.

The following are the pre-construction and post-construction average attributes:

	Old	New
Wall thermal resistance	R4	10
Window thermal resistance	.86	.58
Window shading coefficient	.9	.56

Shading coefficient is an indication of the percentage of direct sunlight that is reflected by a window, and therefore prevented from entering a building. Better windows have a lower shading coefficient. MCW/AGE worked in conjunction with the architectural team to analyze window selections to optimize efficiency while ensuring budgets were maintained. The result was a building envelope which is far more efficient than ever before.

Mechanical Systems Introduction

Once the building envelope modifications were selected, the mechanical systems design began. This is an existing school and the renovations were not limited to unitary equipment replacement. Every piece of unitary equipment (boiler, air handling unit, water closet, etc.) was replaced as well as their corresponding ductwork, piping and the like. Several options were investigated, including geothermal heat pumps.

The school division has utilized heat pumps in several other schools, but has not been able to benefit from their efficiency, due to higher than expected maintenance costs, and less than stellar longevity. The initial cost of installation of the ground loop system, consisting of numerous deeply drilled wells, also proved problematic.

Due to the increased capital cost, higher maintenance and unproven reliability, geothermal heat pumps were eventually removed from the conceptual design.

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Mechanical Systems Selection

The Keewatin Patricia District School Board, being extremely ambitious towards sustainability and reduced utility consumption, expressed their strong desire to incorporate other leading edge strategies for heating and cooling the school. The following selections were a result of extensive discussion and research:

- Condensing boilers
- Reverse flow heat recovery ventilator (HRV)
- Solar wall ventilation preheat
- Demand control ventilation
- Variable frequency drives for fans and pumps
- Low consumption plumbing fixtures
- Sharing of air handling unit
- Recirculation of exhaust air
- All-encompassing DDC technology

Condensing Boilers

The existing boiler plant consisted of two steam boilers with capacity of 150 Hp and 120 Hp respectively (5,200,000 BTUH and 4,000,000 BTUH). Due to the building envelope improvements, ventilation heat recovery strategies and better performing equipment, the resulting boiler plant incorporated two hot water condensing boilers with a combined input of 2,000,000 BTUH. These were each sized at 60% of the resulting total heating load to allow for redundancy should one boiler fail. *Refer to next page for photo.*

Condensing boiler technology became mainstream in the early 2000's and relies on the boilers heat exchanger's ability to withstand lower return water temperatures, and reclaiming the energy from latent heat of absorption; normally lost up a conventional boilers chimney. The result is a boiler which is upwards of 98% efficient.

This efficiency is optimized when the return water temperature is 27°C. To achieve this, all heat transfer equipment was sized accordingly, with one exception. Sizing coils and heat exchangers to maintain this temperature is not economically feasible for the design parameters adhered to in Northwestern Ontario; therefore, the return water temperature was expected to increase along with the supply water temperature on the coldest days. To increase efficiency under this scenario, a water to water heat exchanger was designed in series with the return line of the boiler to transfer energy to preheat domestic water. This in turn increased the efficiency of the domestic hot water tanks while reducing the boiler return water temperature and therefore increasing the boilers' efficiency.

Condensing Boilers

Reverse Flow Heat Recovery Ventilator

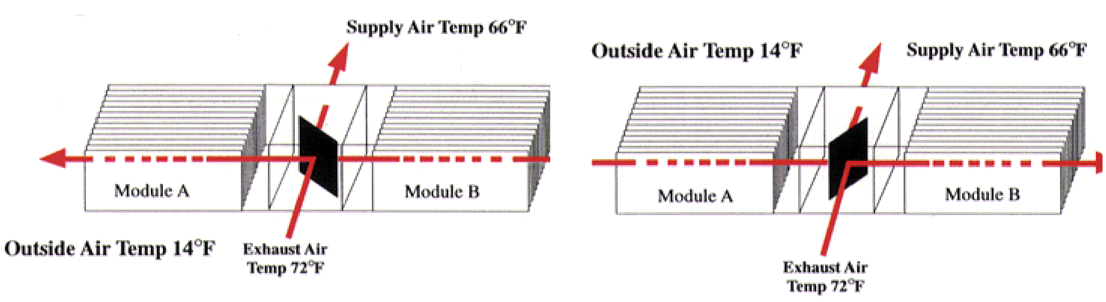
In 2005 and the spring of 2006 a new type of air to air heat recovery ventilator (HRV) was being introduced to the Northwest Ontario market. These HRVs effectively captured heat from outgoing exhaust air streams, and transferred it to incoming cold ventilation air. This concept has been in common use for years, but what was unusual about these heat exchangers is how they worked. These units, called Reverse Flow Heat Recovery Ventilators, push the warm exhaust air over a series of thin plates that have a high mass, which warms the plates. Simultaneously, they draw in cold ventilation air across a similar series of high mass plates, which cools them. Every 90 seconds, a damper in the unit changes position and the flow is reversed. The ventilation air is drawn in across the plates that were just warmed by the exhaust air stream thus warming the air, also the exhaust is directed across the cold plates that previously were cooled by the intake air stream. The huge advantage of this system is that it is self-defrosting.

The cold winters in Northwest Ontario are a challenge to most heat recovery ventilators due to moisture in the warm exhaust air condensing and freezing during the heat transfer process. Most heat

recovery ventilators overcome this through a process of bypassing air. Unfortunately this means that the cold incoming ventilation air stream is stopped periodically to permit the Heat Recovery Ventilator to defrost. On many economical units this occurs about 20 minutes out of every hour on a cold day. In a building as complex as a school which has many continuous exhausts, interrupting the incoming replacement ventilation air is not an option.

The selected Heat Recovery Ventilator has only one moving part, the damper that reverses the flow of air. Hence it is very simple to understand, detect problems and repair. Refer to Figure 1 for a display of a reverse flow HRV operation.

Figure 1 – Reverse Flow HRV Operation



First Cycle: Warm exhaust heats up Module A. Cold outside air flows through Module B, picking up heat that was stored during the previous cycle.

Second Cycle: The damper shifts. The system now draws cold outside air flows through Module A. Warm exhaust goes to Module B, which recovers energy and stores it for the next cycle.

Demand Control Ventilation

Through the evolution of the design concept, the early stage idea of recovering heat from the exhaust air streams from classrooms was altered to recover heat from relief air. Every occupied building is required to introduce a specific amount of outside air during all occupied periods. This air replaces that exhausted from washrooms, shops, science rooms and home economics, but in a facility housing 1,000 students frequently more air is required to be introduced than is exhausted. This excess air must be removed from the building to prevent over-pressurizing the facility. It is this air stream, as well as the washrooms and relatively clean exhausts from the science labs and art rooms that heat is recovered from.

Sensors have been installed in the building to measure how many students are in the facility, so that the quantity of ventilation air can be reduced to the minimum necessary to provide a ‘fresh’ environment, free of contaminants from people and off-gassing from furniture and building elements such as carpets.

The volume of incoming and exhaust air is in a state of continuous flux during the day, and the relief air system must also continuously adjust to keep the building pressure neutral. To achieve this the indoor pressure is measured at various locations in the building and the fans that bring ventilation air into the building, and those that remove the relief air are continuously adjusted by altering the fan speed using

Variable Frequency Drives (VFD's) on both the supply and exhaust fan motors. This is commonly called Demand Control Ventilation in industry jargon.

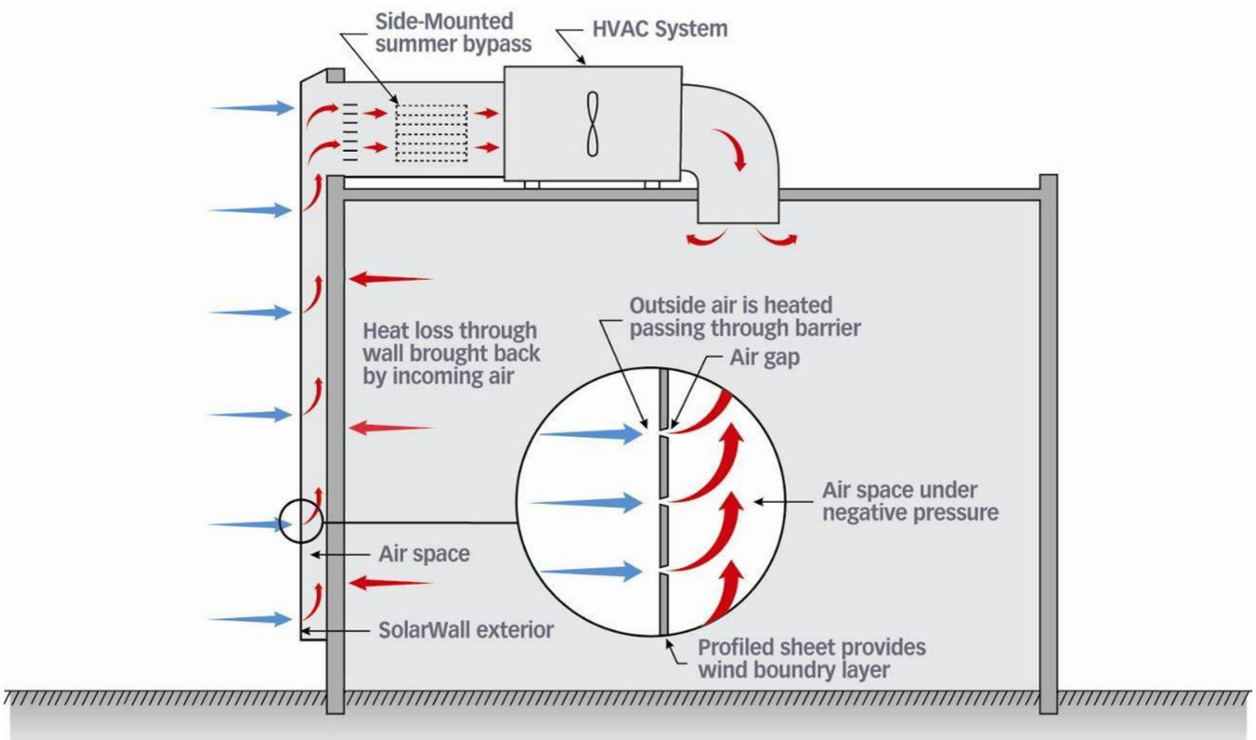
Solar Wall Ventilation Preheat

When designed for this project, passive solar ventilation preheat was relatively new, and in fact, Beaver Brae was one of the first buildings in Northwest Ontario to utilize this technology.

The basic principle is the transfer of solar energy from a dark coloured perforated metal panel to outside air, by drawing it through the perforations utilizing a fan. Likewise, energy escaping through the exterior wall from inside is recaptured and reintroduced. The result is tempered ventilation air which is then heated to design temperature by the corresponding air handling unit. The benefit is that the very cold outside air is preheated by the essentially "free" renewable energy provided by the sun, rather than other mechanical means which require natural gas or electricity. *Refer to the following photo.*

Conversely, by utilizing a system of dampers, the solar gain (heat build-up) on the wall to which the panel is attached, can be reduced in summer months thereby reducing the air conditioning loads. This arrangement has an average efficiency of 70%-75% of the captured solar energy. Refer to Figure 2 for a display of a solar wall system.

Figure 2 – Solar Wall System



Variable Frequency Drives for Fans and Pumps

Unitary equipment such as fans moving supply air and pumps moving heating water are typically sized for maximum capacity of the system based on detailed calculations. For example, the fan in an air handling unit is sized for the air quantity required for cooling; as more air flow is required across a cool surface (cooling coil) than a warm surface to allow heat transfer. In this application, cooling is not required throughout the year, so savings may be achieved by reducing the capacity of the fan, the corresponding air quantity, and therefore energy required, when cooling is not required. When strictly ventilation air or heated air to increase space temperatures is required, fan speed may be reduced by as much as 70%.

Plumbing Fixtures

Water conservation is achieved through the use of water conserving plumbing fixtures. All lavatories and sinks are equipped with point of use 1.9 litre per minute (LPM) aerators to limit water flow. All lavatories utilize electronic sensors to limit water flow to the exact length of time hands are under the faucet. The units were specifically selected so that they did not continue to operate, but only for a few seconds after the hands are removed.

Water conserving 6 L per flush water closets that also utilize electronic sensors were utilized. The urinals are waterless, meaning that no water connection is required to flush. Instead an environmentally friendly chemical is located in the drain which allows the passage of urine, but blocks the odours caused by sewer gas within the piping system. These urinals have the potential to save up to 150,000 litres of water annually.

Sharing of Air Handling Unit

In a secondary school, the gym is often one area which sees extreme variations in occupant numbers, as well as the nature of the occupation. For example, it may see a group playing pick up basketball at lunch period, one class of 30 students for a Phys Ed class during the day, to a school social function or sports tournament in the evening or weekend.

Most, if not all jurisdictions, mandate that the ventilation, heating and cooling unit be sized for the larger, more active group regardless of the frequency of the event. This results in larger equipment which is harder to “turn down” when not required, resulting in over ventilation and ultimately wasted energy.

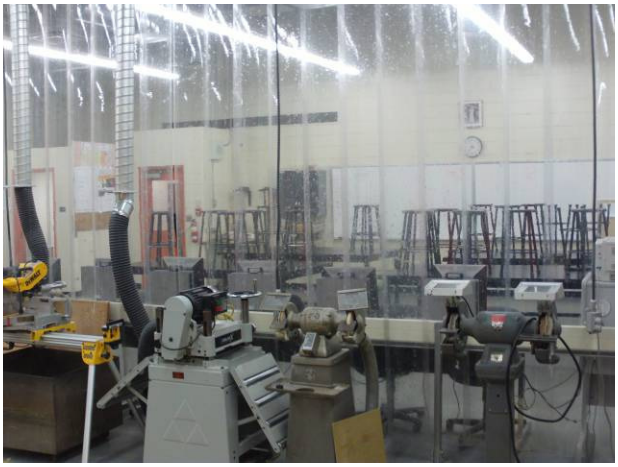
Another fact, is that when large groups are using the gymnasium, other areas of the school are not in use. By utilizing a system of dampers, the school is able to divert air from the air handling unit serving the administration area, when increased capacity is required for the gym. This is easily accomplished through the school’s building automation system (BAS). The result is smaller, more cost effective and efficient equipment. This arrangement was tested prior to project completion, when the school held their convocation ceremony in the gymnasium. It performed flawlessly.

Recirculation of Exhaust Air

The school contains two woodworking laboratories, each of which employ a dust collection system to remove dust and particulate matter from the air and workspace. In a typical application, that air is exhausted outside, and the corresponding volume of outdoor air is introduced. This air is required to be heated or cooled accordingly. *Refer to photos on next page.*

At Beaver Brae, the exhaust air is filtered by three levels of filtration, the final being HEPA (high efficient particulate air) filtration which removes 99.97% of airborne particles. This method of reclamation eliminates the need to heat or cool makeup air, while maintaining the excellent quality of the working environment.

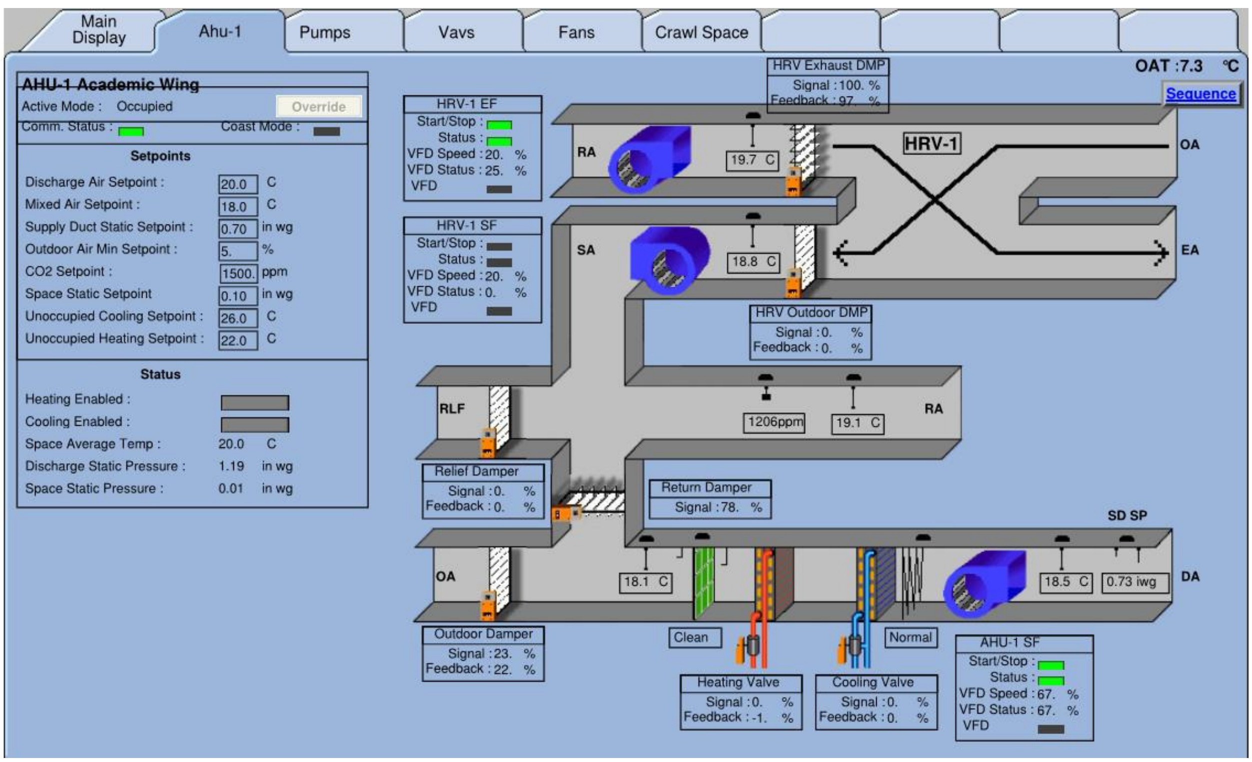
Woodworking Laboratories



All-Encompassing DDC Technology

The school utilizes a new generation BacNET DDC (direct digital control) HVAC control system to operate all aspects of the heating, cooling and air conditioning systems, ensuring the highest efficiency possible. From the thermostat on the wall to control the temperature in a classroom, to the sophisticated computer controls of the boiler and chiller plants, every function is fully controlled and closely monitored by the systems microprocessors. In turn, the maintenance staff is kept fully aware of building conditions, and notified immediately should concerns arise through the highly interactive computer graphics. *See diagram below.* The ability to manipulate and monitor the environment within the school in this manner, means reduced operating costs due to maintenance labor, and even the ability to access and alter system parameters remotely.

Figure 3 - Graphical Representation of Operating System at the Operator Work Station



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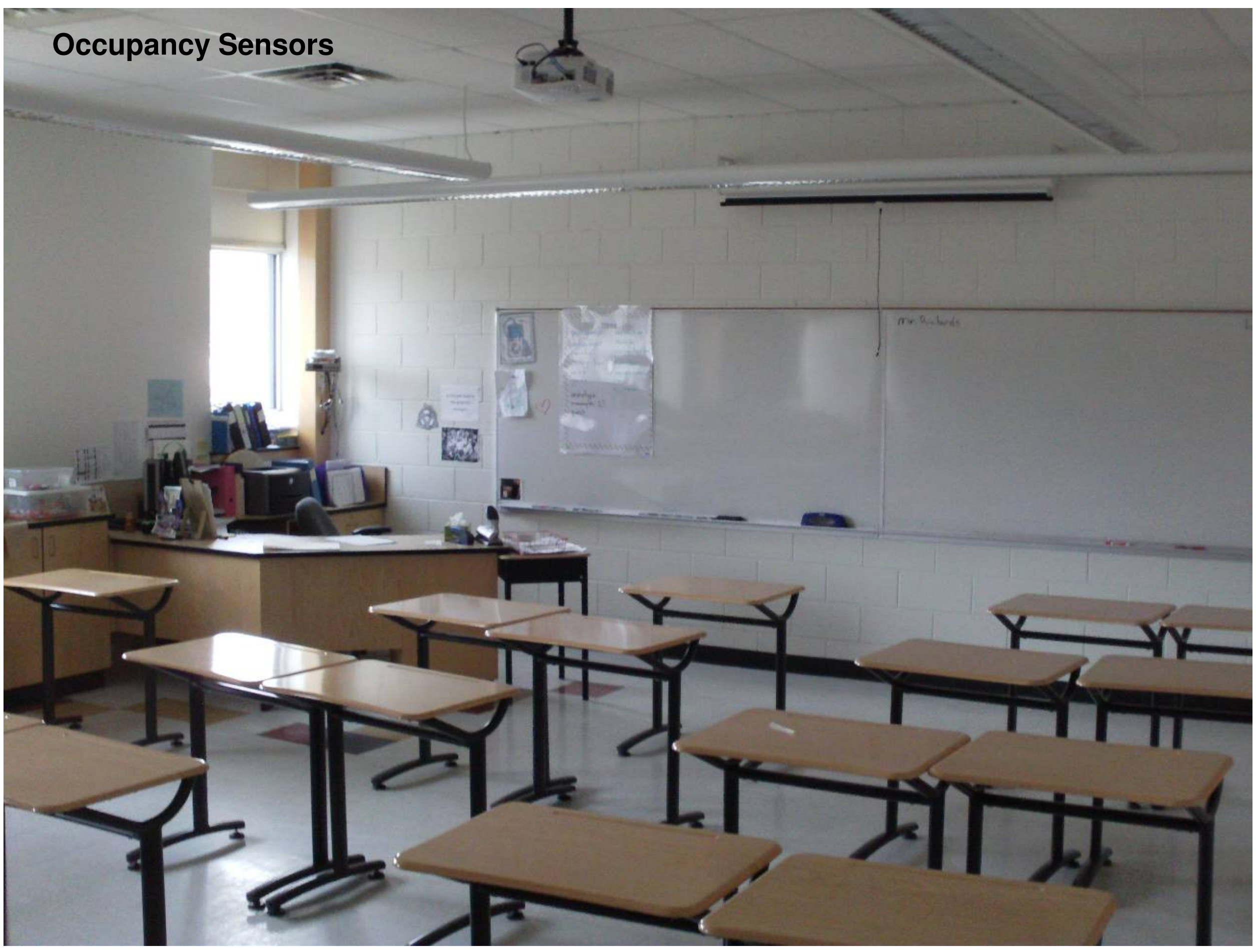
Electrical Features

Lighting Controls

The challenge of planning the lighting for the school rested largely with the requirement for multifunctional space. While the building has to provide an ideal learning environment for students it also needs to be flexible as the school may service other functions in the community. In addition the school must operate efficiently, using energy in an efficient manner and leaving the minimal impact on the environment. Lighting controls helped to meet all those challenges.

Occupancy sensors were utilized in all rooms that shut off the lighting when the room is not occupied. *Refer to photo below.* Additionally individual controls are provided in every room thereby allowing the user of the room to select the lighting level most appropriate for the learning assignment or to take advantage of the sunlighting that may be bathing the room on that given day. The simple act of controlling the lighting, albeit manually, takes advantage of the need to enhance the learning environment specific to each visual task.



Occupancy Sensors

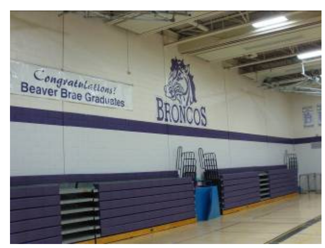
Luminaire Selection and Lighting Design

The most energy efficient light sources were utilized for the specific applications. Also the design was “tuned” such that the correct luminaire was provided for the specific task. MCW/AGE Consulting Professional Engineers’ lighting design incorporated the latest research that determined that the greatest energy savings in lighting design will come as a result of application specific lighting! *Refer to photos on the following pages.*

Application specific lighting designs were utilized incorporating T-8 fluorescent light with electronic ballasts throughout all classrooms and offices and compact fluorescent luminaires, standardizing on a 26 watt lamp was utilized in corridors and other non-classroom spaces. T-5 fluorescent lighting was used throughout the gymnasium with multiple switching options so that light levels would easily be selected for the specific gym usage. *Refer to photos on the following pages.*

Corridors

MCW / AGE



Gymnasium

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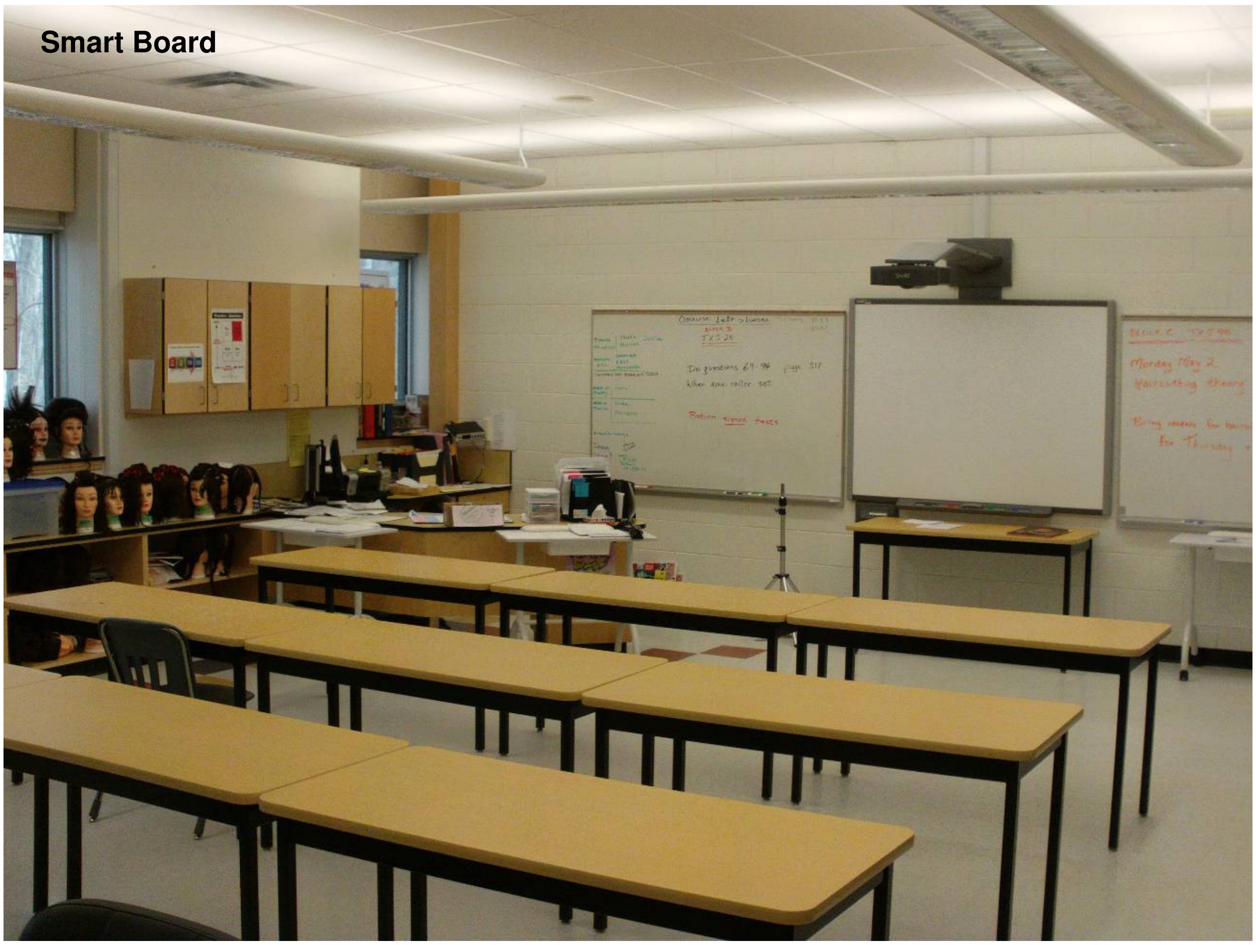
Additional Features

"Smart Board" Technology

Each classroom was fitted with new, interactive "smart boards" which enable the teacher to share multimedia information with the students. The controls and interface for each board is incorporated into the teacher's desk eliminating unsightly and dangerous cords and equipment on the floor. *Refer to photo below.*



Sound Field Systems

Each classroom employs a wireless voice amplification system which allows the teacher's voice to be heard clearly within all areas of the classroom. This is further enhanced by the ventilation systems relatively noise free operation.

BEAVER BRAE SECONDARY SCHOOL RENOVATIONS
KENORA, ONTARIO

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Keewatin Patricia
DISTRICT SCHOOL BOARD

Kim Carlson, Facilities Manager
Dryden Office

February 23, 2011

Testimonial Letter: Re 2011Awards of Excellence in Consulting Engineering

To Whom It Concerns:

MCW/AGE was a major partner in the successful complete of a very complex and lengthy renovation of the Beaver Brae Secondary School in Kenora, Ontario.

This facility is approximately 118,816 sq. ft. with 950 students and as most of our large schools; was constructed in a number of phases. The core of the building was established in 1962 with additions 1964/1989/1992 and 2000.

MCW/AGE was involved at the early consolation stage with staff/students and public on the building inefficiencies and school/community needs. In this process MCW/AGE developed strategies and early design concepts. Once MCW/AGE finalized a building audit of the school, in May 2003, all mechanical/electrical components, functional/code deficiencies and opportunities for the facility where identified. The building being over 41 years old, there were major mechanical and electrical improvements required to bring the school to the highest standard operating principle of KPDSB in developing a superior learning and working environment for our students and staff.

The mechanical and electrical systems in the school were in dire need of improvement and renewal. The terminal heating units in the classroom areas of the school consisted of steam heated unit ventilators that have far surpassed the end of their useful life span. These units were a highly inefficient use of energy with little or no heating controls. There were steady occupant complaints of hot and cold spots inherent to a system of this type and age. These units were regularly shut off because of noise within classrooms and when fully functional only meet minimal fresh air requirements of occupants. There were no provisions for heat recovery within these areas.

MCW/AGE did an analysis and modeled four different options for centralized heating systems to be considered. All models were presented with capital costs and their individual operational cost at present energy prices.

This project has introduce a high volume air exchange and coupled with the high efficiency heat recovery. The students and staff of the school are experiencing a massive improvement in the interior environment of the school and school administration has seen a noticeable decrease in absenteeism from both the staff and student body since completion.

The installation of two high efficient condensing gas boilers, DDC controls and high efficient heating/cooling recovery systems has reduced the natural gas operation cost of the school almost in half. This is a savings of approx. $50,000 to $60,000 annually that can be relocated from operations to classroom.

A solar wall constructed along the south face has reduced the heating cost and allows for the downsizing of mechanical systems that support a new atrium.

The plumbing piping systems in all areas of the school have been replaced and new low flow/motion censored washbasin fixtures and water fountains installed. All urinals have been replaced with waterless fixtures and a grey water reclaim system is being installed this summer to further reduce water consumption at the school.

This was a massive undertaking that took place over three years while school remained fully open and operational.

MCW/AGE organizational skills completed this complex project without a single incident from staff/student body or a missed day of school. The budget remained on track and important timelines were met successfully. Their flexibility and adaptability resolved many issues as they arouse from both the school and contractors involved.

MCW/AGE is the key player in finishing this school and making it the flagship in our system and communities regarding mechanical and electrical design, reducing our environmental impact while still achieving a superior learning environment and reducing operational costs.

Yours truly,

Kim Carlson
Facilities Manager

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