MORRISON HERSHFIELD

2011 Canadian Consulting Engineering Award Submission

Centennial Garage Edmonton AB

Presented to:

Association of Consulting Engineers of Canada
Canadian Consulting Engineer

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PROJECT HIGHLIGHTS

INTRODUCTION

Bus Garages are often taken for granted. Common to cities and region across the continent, they are typically utilitarian structures not synonymous with innovation, complexity, sustainability or for providing a worker friendly environment. The new Edmonton Transit System Centennial Garage breaks through this stereotype. The state of the art 29,000 m^2 facility is designed and built to support public transportation services in the rapidly-expanding south end of the City of Edmonton into the 22nd century.

The facility services more than 250 regular and articulated buses, or approximately ¼ of the entire Edmonton transit fleet, that must be washed, fuelled, maintained and stored, as well as accommodating the daily ingress and egress for these vehicles and those of staff and associated service and delivery vehicles.

It is an integrated facility which in addition to bus storage, also houses maintenance space and administrative facilities. It became operational in April 2010.

Morrison Hershfield was retained as Prime Consultant to undertake the largest consulting assignment awarded to a single firm by the City of Edmonton in 2007.

KEY DRIVERS AND CHALLENGES

Unlike many other bus facilities, Centennial Garage provides for the fleet of buses to be stored indoors. In view of the regional weather conditions, calculations determined that a heated garage would be more fuel-efficient than using the climate control of individual buses before taking on passengers.

This voluminous storage capacity and vehicular flow required large, open, column-free spaces and strategically located facilities for flexibility and ease of vehicle movement through the garage.

The resulting massive 7-acre building imposed complex structural requirements requiring over 11,500 cubic meters of concrete and 1,240 tonnes of steel. Components of the design were thoroughly integrated and also specifically designed around mechanical and electrical services for ease of future upgrades and maintenance accessibility.

Along with sustainability, design considerations identified occupant comfort and safety as primary objectives. An additional layer of complexity was added as the City of Edmonton undertook a simultaneous project to improve the perimeter roadways leading to and circling the large site.

The unique qualities and innovative aspects of this facility are an amalgam of its individual elements, from design, to materials and construction and the integration of components, which when taken together, result in a standard setting and unparalleled facility of this type.

Operational Efficiency:

The positioning and shape of the building were planned to tactically integrate with existing and planned access roads. The storage, maintenance and administration functions, and the equipment and workstations, were strategically positioned to maximize operational efficiency and minimize unnecessary vehicle and occupant movements.

Mechanical requirements in the bus storage and maintenance areas were highly specialized to facilitate the smooth flow of bus traffic through and within the facility.

An innovative low-velocity approach to ventilation, uncommon to industrial applications, was implemented to improve the stratification of fresh and contaminated air by eliminating eddies and the mixing of exhaust fumes. This reduces the build-up of pollutants and particulate matter – a particular concern with fueling and operating diesel vehicles in enclosed spaces.

An easy to maintain sloping floor system capturing run-off from wet vehicles drastically reduces the need for a multitude of internal trench systems while keeping the garage clean.

Working Environment:
The structure achieves large, bright and open interior spaces with a total of 90% of the interior of the garage having access to windows. The maintenance area features clerestory windows to draw in quality daylight in addition to daylight controls, occupancy sensors and individual task lights, so that workers can access the right light for the task at hand. There are also operable windows so that workers can moderate the temperature and ventilation of their workspace.

Internal and external re-fueling stations are designed with safeguards to protect workers and the environment.

The administration facility has office and meeting rooms, as well as amenity spaces for operations staff, maintenance workers and drivers. Amenities include a lounge, quiet room, change rooms, and laundry facilities. Exterior artwork and a courtyard are also provided.

Sustainability:
A strong LEED® Silver Certification is targeted. Centennial Garage is an extremely energy efficient transit facility. The electrical power distribution systems are designed for flexibility, expandability, adapatability and energy cost savings. The highly reflectivity roofing system reduces energy consumption, diminishing the effects of thermal expansion, and addresses wind uplift loads.

An exemplary level of performance was achieved through the use of recycled building content and regional materials. Where construction waste was generated, over 80% of the waste was recycled. A solar wall provides for building heating and maximization of day lighting into the facility takes advantage of passive solar heating. The bus wash and undercarriage wash uses the lowest fresh water rate and highest rate of recycled water that is existing in a commercially available system. The facility shares its wastewater system with an adjacent snow melt yard and there is facilitation for future use of the spring-time cooling by snow melt.

Construction complexities:
The on-going reconfiguration of the local road network necessitated carefully planned delivery of the large volumes of construction materials required.

In March 2009, Morrison Hershfield received an Honourable Mention from Canam Steel for the structural design of the SETF roof joist systems for this facility in recognition of the complex connection details between the long span roof trusses, beams and columns of this massive, irregularly shaped facility.

CONCLUSION

The Edmonton Transit System Centennial Garage is a modern, highly functional, and welcoming new facility that brings together a series of innovative applications, use of materials and techniques to produce a the latest in transit service technology, equipment and operational efficiencies. It accommodates future growth. Staff are proud to work at Centennial Garage.

PROJECT DESCRIPTION

The Centennial Garage is a notable project on numerous fronts. The following pages detail how the project meets the judging criteria in the 2011 Canadian Consulting Engineering Awards program.

NEW APPLICATION OF EXISTING TECHNIQUES, ORIGINALITY AND INNOVATION

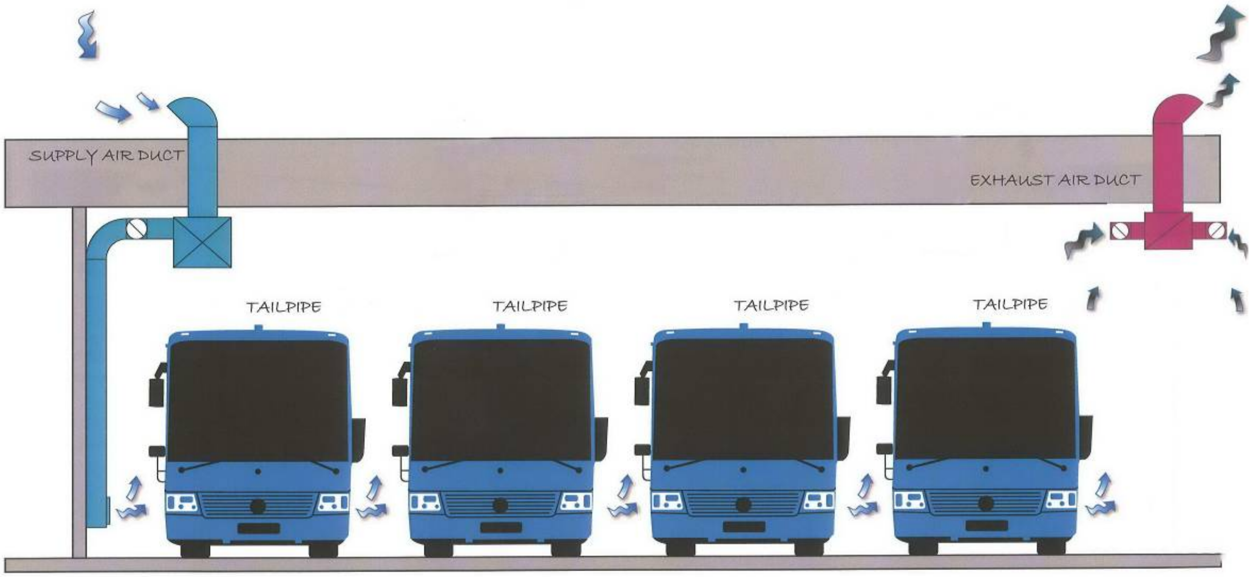
Approximately 22% of a person's lifetime is spent at work. Through imagination, innovation and the new application of existing techniques, the City of Edmonton Centennial Garage successfully provides a great work environment for employees.

GARAGE VENTILATION

Proper ventilation is critical in a diesel bus environment for the health and safety of employees. Mechanical engineers came up with an innovative design that is not commonly applied in industrial applications to satisfy indoor the air quality requirements. After developing multiple permutations through mechanical modelling, they determined that the best solution was a low-velocity approach.

The advantage of low velocity introduction supply air is the elimination of eddies and the mixing of exhaust fumes that can be caused by jets of fast moving air. Eliminating the entrainment of exhaust fumes keeps the atmosphere in the storage area clearer by improving the stratification of the contaminated and fresh air.

As illustrated in the drawing below, the bus storage area is supplied with make-up fresh air via direct rooftop units at the ASHRAE recommended rate of 7.5 L/S/M2. This supply air is ducted along one side of each storage bay, through the means of a perforated plenum at the floor, whereby the air exits at low velocity providing fresh air to the occupancy level. Exhaust is then ducted above the buses along the opposite side to the supply air and the layout provides a gentle sweeping motion of air movement across the bus lanes. This innovative approach effectively ensures a safe and effective indoor air quality for staff.



Sweeping Motion of Air Movement across Bus Lanes

HEATED FLOOR TREATMENT

In order for a bus to depart, the garage temperature has to be at least 10 degrees Celsius, as the buses do not get winterized. Thus, the need for a heated storage facility was dictacted.

The bus storage area is heated with an in-floor radiant heating system, a first application of this type for the Edmonton Transit System. This heating system contains more than 128 kilometers of in floor piping installed within a 225 mm thick concrete slab. A special surface texturing was created to provide a durable, low maintenance, non slip floor. As it is a relatively innovative floor treatment, Clark Builders provided a test patch with differing screed methods. ETS was then able to sample the surfaces and choose the best application for their needs.

Paired with the low velocity introduction of make-up air, the heated floor further improves air stratification and, therefore, air quality. The heated floor also keeps the floor dry, makes use of the convection current, and maintains thermal mass allowing for better temperature control and energy efficiency.

INTERNAL TRENCH SYSTEM

Bus facilities traditionally use some form of trench system in the floor slab to capture water runoff from wet vehicles. These cast-in-place trenches have proven to be onerous maintenance issues for building operations staff and have resulted in expensive and frequent repairs to both the slab and the trench grating. Typical standard grating does not stand up well to the heavy wheel loads imposed upon it by bus traffic. In addition sediment build-up inside the narrow trenches requires manual removal on a regular basis.

This typical scenario inspired the Centennial Garage engineering team to design a sloping floor system that drastically reduces the amount of trenches required within the facility by strategically locating large catch basins at the low points of the sloping slabs. The large catch basins incorporate sediment traps that can be easily cleaned out and serviced. This innovation has a sizable impact since Edmonton buses operate in a climatic region that receives an average of over 450 mm of precipitation each year.

STORMWATER DRAINAGE DESIGN

The Centennial Garage property is adjacent to The City of Edmonton snow dump. The project engineers saw unique opportunities in this neighbouring. It allows for linking elements of the drainage system from both facilities to mutual advantage. A novel approach was applied in the design of a two step garge stormwater drainage system.

Firstly, the engineers designed the stormwater drainage to be collected to a single point within the gararge site. The drainage was then directed next door, to a pond in a shared lot with the snow dump, where it will be treated along with the snow melt. This innovative approach removes the possibility of overloading the standard City stormwater drainage system.

SNOW MELT FOR BUILDING COOLING

Innovative provisions were made in the design of Centennial Garage to incorporate the cool water from the snow dump settling pond as temperature relief in the storage and maintenance areas of the facility. This would allow for water from the pond to be pumped into the transit garage through heat exchangers to produce a cool glycol solution. This glycol solution would then be piped to the heat recovery coils in the makeup air units to cool the supply air. The piping is currently roughed-in under an adjacent newly constructed roadway to the building for future installation. The installation of the complete system is under discussion pending future budgetary allocations.

Once the snow melt cooling is put to use, the maintenance and storage facility would benefit from free cooling at the beginning of the warm season.

COMPLEXITY

The multidisciplinary engineering team used their skills and experience to meet the challenges offered by various elements of the massive facility.

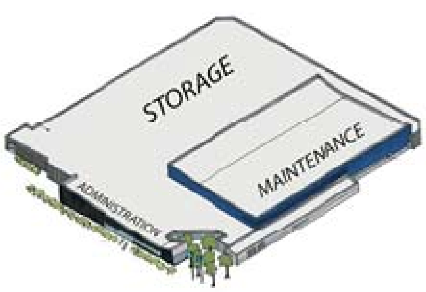
SITE SPECIFICS

The site location and characteristics presented a variety of engineering and logistical challenges. The 78,677 m^2 greenfield site is at the junction of the Anthony Henday and Rabbit Hill Road in southwest Edmonton, providing convenient access to all parts of the city as well as support for Edmonton's expansion to the south. The Geotechnical Report, completed by Thurber Engineering, dictated that the building should be one storey in height. This meant that the building would occupy the majority of the site, covering approximately seven acres, a total of 29,413 m^2 in size. Site constraints also dictated some unusual building angles.

Primary site considerations by the project engineers included the simultaneous road construction to be undertaken on the peripheral roads during the Centennial Garage construction period. Also, once fully operational, approximately 500 buses would be in and out of Centennial Garage daily and an additional 60 staff would be on site full time. As outlined below, these logistical challenges had to be taken into account during both the design and construction periods.

SIMULTANEOUS ROAD CONSTRUCTION

A layer of complexity was brought to the project as the City of Edmonton undertook a separate and simultaneous project to improve the perimeter roadways leading to and circling the large site. Morrison Hershfield worked initially with the City's consultant, Stantec, as they undertook the preliminary road design, and later with ISL as they undertook the detailed design. Rabbit Hill Road was upgraded in preparation for the construction of an overpass over Anthony Henday Road, the main ring road around the City of Edmonton. Ellerslie Road was improved from a two-lane dirt road to a four-lane paved major collector road. With road construction underway at the same time as building construction, alternate access points to the Centennial Garage site from each road had to be created at different times during the project. The ongoing reconfiguration of the local road network necessitated carefully planned delivery of the large volumes of construction materials. This required close coordination between separate project teams as the existing road network was ripped up and improvements brought into place.



TRAFFIC PATTERNS FOR BUSES

Analysis was undertaken using Autoturn software to ensure that large vehicles can be driven smoothly and efficiently both around and within the garage. The turning ratio of a bus is quite large, and with 500 buses moving in and out of the facility daily along with service vehicles; safety, efficiency and ease of access were primary concerns. Analysis was conducted on numerous scenarios including the day of the week and time of day when the maximum number of vehicles would be moved in certain formations.

Also taken into account was the need for ETS staff to have ease of access to the maintenance area for both scheduled and non-scheduled repairs, the bus storage and parking area, and the facility and fleet operations component.

Vehicle movements were planned and controlled with meticulous precision, from the point of entry of a bus into the building, to its passing through an undercarraiage and exterior service automated bus wash system, and moving on to refueling, discharging of the fare box and then proceeding to either the indoor parking area or into the maintenance garage. This vehicular flow required large, open, colun-free spaces and strategically located facilities to maximize flexibility and ease of vehicle movement throughout the garage.

STRUCTURAL CHALLENGES AND BUILDING DESIGN

A key consideration when evaluating the most suitable framing system for this building was the construction schedule. The 24-month construction schedule required that at least one winter construction season would have to be faced by the contractor. It would be impractical and cost-prohibitive to provide winter heating for a seven acre building in Edmonton if cast-in-place or precast concrete was used as the main structural element. Structural steel proved to be the optimal choice because it could be erected under virtually any weather condistions, does not require costly winter heating and could be erected faster than concrete. As well, the 45 meter (147 ft) long clear spans necessary in the bus garage were not economically achieveable with precast concrete, but were easily met with long-span open web steel trusses.

Another factor in favour of steel as the structural material of choice is that a steel structure weighs considerably less than concrete, resulting in a lighter and more economical foundation system. Typical long span steel trusses used in the garage had double angle top and bottom chords comprised of two L8 inch x 8 inch x 1 inch back-to-back angles.

With the large, seven acres size of the facility, an economical and functional structural steel design was needed. The solution was in effect, to design four buildings, connected by expansion joints within one accessible structure. The expansion joints were strategically designed and placed to accommodate thermal movement and force. The building footprint was divided into four quadrants, with the joints allowing each quadrant to behave as its own independent structure within one envelope with allowance for two to four inches of movement. The facility required over 11,500 cubic meters of concrete and 1,240 tonnes of steel.

Important to the functional usage and circulation of buses within the maintenance area was the need to eliminate interior columns. This was achieved by designing a 45 meter long clear span roof truss system to span the entire width of the maintenance area, resulting in a truss depth of over two meters.

Open web members were also desirable so that most of the utilities and mechanical ventillation ducts and equipment could be easily passed through the open truss web. This made use of every meter of vertical space available to reduce the overall building height (thus reducing building volume and associated heating and cooling demands), while still meeting interior clearance requirements for buses and service vehicles moving within the building.

The building design incorporates many different roof heights in order to accommodate several clerestory windows around key areas of the building. This, along with some unusual angles of the building exterior walls to suite site constraints, resulted in some very complex steel framing and connection details which were carefully coordinated by the structural engineers, the steel detailer and the truss designer. In some cases more than a dozen members were framed into a single point. 3-D CAD detailing software was utilized to produce fabrication drawings and identify erection issues.

In recognition of the complex connection details between the long span roof trusses, beams and columns at many locations throughout the multi-level roofs comprising this building, Morrison Hershfield received an Honourable Mention from Canam Steel in March of 2009 for the structural design of the SETF roof joist systems. Canam Steel is the largest manufacturer of steel joists and roof trusses in Canada and one of the largest in North America.

ELECTRICAL DISTRIBUTION SYSTEMS

The electrical power distribution systems are designed for flexibility, expandability and adaptability so as to accommodate future changes without significant modifications to the basic system infrastructure, while also meeting the objective of energy efficiency. A minimum of 30% spare capacity is provided for future expansion.

Energy cost savings are also achieved by the implementation of power factor improvement, voltage drop minimization, harmonic mitigation, energy efficient equipment and effective controls techniques.

The electrical rooms are located strategically so as to minimize the length of expensive cables. Voice and data structured cabling is provided to accommodate telephone and computer networks. Coaxial cables are installed to provide cable TV from the local utility or satellite dish. Communications rooms are strategically located and connected together, and to the outside world, with multi-pair copper and fiber cables as well as coaxial cables.

Electrical life safety systems are provided to meet the latest industry and code standards. A state-of-the-art fire alarm system provides for notification and evacuation in the case of fire. LED type exit signs provide direction to the exterior of the building while minimizing energy costs and providing a longer life than incandescent. Emergency lighting battery packs and lights fed from the emergency generator illuminate required egress paths.

The electrical distribution systems also support the latest security features, including video surveillance, access controls and a public address system. Video surveillance provides coverage of critical areas, intrusion alarms provides notification of unauthorized entry, and access control restricts entry to authorized personnel only. A complete public address system is provided.

One operational feature that takes place in the fueling station area, but is probably unnoticeable to any passerby, is that as soon as the bus drives up for re-fueling, an infrared/wireless passenger counter is automatically uploading information about the total number of passengers who boarded the bus that day. This helps in the planning of bus operations to ensure quality service.

PROJECT MANAGEMENT

Due to the large size and nature of this project, Morrison Hershfield utilized resources from six of its fifteen offices across North America, drawing in the required discplines and services. The project also required the assembly and management of a team of proponents outside Morrison Hershfield that specialized in all stages of development. These resources were pooled together as a one-team approach throughout all phases of design and construction, with the common goal of meeting and exceeding the client's needs. All components of the design are thoroughly integrated. The following outlines the roles of the companies involved:

Client: Edmonton Transit System and the City of Edmonton

Prime Consultant: Morrison Hershfield

- Civil
- Building Envelope
- Structural
- Electrical
- Fire & Life Safety
- LEED®
- Code

Architect: Anthony K. Eng (*Croy D. Yee Architect Ltd)*

Landscape Architect: Earthscape Consultants

Geotechnical: Thurber Engineering

Mechanical Design: Suncord Engineering *(a division of Morrison Hershfield)*

Construction Manager: Clark Builders

As construction managers, Clark Builders procured all the required subcontractors and coordinated all construction activities utilising the latest innovations in building construction. Clark Builders was pivotal in aiding Morrison Hershfield with providing value engineering, along with preparing various budgets during design finalization and then managing and controlling those budgets along with the construction schedule. In an economy when labour was stretched to the limit, Clark Builders was able to assemble a large team of their own forces to complete all the concrete foundations, flatwork and exterior cladding.

Morrison Hershfield as the prime consultant contracted Anthony K. Eng Architecture (now Croy D. Yee Architect Ltd.) to develop the architectural design. Both firms worked together with Suncord Mechanical, Earthscape Landscape Architecture and Thurber Engineering to undertake this assignment.

In addition to the project team outlined above, Morrison Hershfield coordinated bus garage construction with two consultants working on concurrent improvements to the surrounding road network.

The City and Edmonton Transit Services (ETS) played instrumental roles throughout the entire life cycle of the project to ensure specific operational needs were met. -

ENVIRONMENTAL IMPACT

ENERGY AND ENVIRONMENTAL SUSTAINABILITY

Typically bus garages are not synonymous with the word "sustainability". A strong LEED® (Leadership in Energy and Environmental Design) Silver certification level is being sought from the Canadian Green Building Council (CaGBC) for this innovative state-of-the-art facility. The achievement of this target is about doing the right things right, including utilizing the sun's energy for warmth, roughed in facilitation of snow melt for future cooling, the use of recycled water for bus washing, protecting topsoil during construction and controlling stormwater runnoff, to name a few. Water use by occupants is reduced through high-efficiency fixtures.

Energy modeling results indicate that the Centennial Garage is 33 percent more energy efficient than a typical Canadian building of its size and type. Morrison Hershfield managed a large multidisiciplinary team to ensure all components of the design are thoroughly integrated with other discipines.

The ultimate purpose of the bus garage is to support a large fleet of buses to meet the transit needs of the public. Green techniques were adopted to keep the buses clean, reliable, clean and inviting to riders in order to maintain ridership and to promote further transit use.

MATERIAL SELECTION

With the volumes of construction materials used for a facility of this size, special attention was paid to ensuring that the materials selected included recycled content, such as found in steel decking, concrete, drywall and carpeting. Wherever possible, materials were sourced from local manufacturers. For specialized elements, such as the bus hoist systems, insulated opaque panels and the Interclean Bus Wash system, the team sought out and imported unique products from outside Canada, as far away as Germany.

Furthermore, 90 percent of the numerous steel connections in the facility are bolted, allowing for the structure to be easily disassembled and the steel reused in the future for other purposes.

SPECIALIZED BUS WASH

One of the exciting sustainability features of the Centennial Garage is the undercarriage and drive through bus wash system. The most unique feature of this system compared to all other ETS facilities is the new ability to recycle the water used through an Interclean Hybrid Transit Bus Wash System (IHTBW). This specialized system reduces water consumption by more than 50 % compared to conventional bus wash systems.

The undercarriage wash systems are located at the two primary entrance lanes to the garage and the two lanes in the service bays. Using recycled water as the primary source of wash water for transit vehicles greatly reduces the total amount of fresh water required to clean large fleets of vehicles on a regular basis. This practice also reduces the subsequent waste water load going to the municipal sewage system. Fresh water is used only to mix soap and for final rinsing to ensure good quality cleaning and a spot-free rinse.

Similar Interclean System in Action

Typical bus wash systems use between 375 to 750 liters of water per bus wash cycle with some systems using even more. The IHTBW utilizes high pressure, touchless cleaning for the front, top and rear of each bus, and soft polycarbonate brushes for the sides. While the system uses a total of 570 liters of water per bus cycle wash, only approximately 80 liters of that is fresh water. Roughly 80% of the water used is recycled. This process is estimated to save the client roughly 14 million liters of fresh drinking water per year based on the annual bus washing demands at this one site using two IHTBW systems.

The purpose of the undercarriage wash system is to remove salt, dirt, mud, ice and snow from the underside of buses. With most of the dirt and slush removed before the buses are parked, the storage garage floor is much cleaner. There is less water on the floor reducing slipping hazards, and less dirt to be stirred up as the buses move through the garage. This helps to reduce the maintenance costs associated with keeping the garage clean and supports a better environment.

Equally important to washing the exterior of the buses is regular interior cleaning. The provision of clean and inviting buses to the travelling public encourages use of the transit system. The interior cleaning takes place in two separate areas of the facility; one in the service lane for daily regular general cleaning and the other located in a dedicated interior detailing area for a more thorough job that may be carried out once a week or as required. General interior cleaning starts in the refueling bay upstream of the drive through bus wash and uses specially designed vacuum systems with suspended hose reels which drop strategically at the mid/rear doors of a bus. The vacuum canisters are centrally located in a mechanical room in close proximity. The bus is then diverted to the dedicated interior cleaning bay for full treatment as needed.

ENVIRONMENTAL PROTECTION

Critical to the success of the continuous bus operation is the re-fueling system. In addition to being reliable, it is imperative that the system must be designed with safeguards to protect workers and the environment.

The system can be broken up into two main components; the tank unloading area located outside at the SW corner of the site and the interior re-fueling station. The exterior unloading area is where diesel fuel is off loaded from fuel providers and stored in two 93,000 liter underground tanks equipped with the latest in monitoring, leak and spill detection technology. The location of the tank unloading area was carefully designed to ensure that at any given time the delivery of fuel (occurring as often as every few days) would not hinder the operational flow of ETS buses during their circulation.

The interior re-fueling station is located just beyond the main bus entrance. This area is a dual lane full service station designed to safely accommodate the re-fueling needs of up to two buses simultaneously or as a back up in the event that one lane is down. The re-fueling system comprises of a Veederoot fuel master control console, metering, computer terminal, windshield washer dispenser and dry vacuum system all carefully positioned to maximize convenience and efficiency. Fuel dispenser hoses and vacuum hoses are all mounted from above in order to minimize potential tripping hazards and promote a clean and safe working environment for the staff. All fueling stations are equipped with a recessed slab depression covered with non-slip grating that drains into a separator to prevent any contaminants from entering the building drainage system.

LIGHTING

The facility uses various types of energy efficient luminaires. For office and administrative spaces; there are simple and efficient linear fluorescent troffers as well as direct/indirect linear fluorescent luminaires suspended from the ceiling in spaces emphasizing ambient lighting and glare control. For maintenance and service areas, there are linear fluorescent task lighting as well as high output linear fluorescent applications in areas with high ceilings. Fluorescent lamps are generally 32 watts T8 lamps and 54 watts T5HO with low mercury content, selected to achieve the optimum balance of efficiency and light distribution. Dimmable and non-dimmable LED recessed pot lights and wall sconces are also used. LED lights are used for exit signs and building and site signage. The garage also features natural lighting with several cleretory windows around key areas of the building.

SOLAR WALL

The building features reduced energy demands on the grid by the harnessing of free, passive solar heating from a solar wall. The solar wall covers approximately half of the entire south exterior elevation. As the sun heats up the exterior dark surface of the wall, the air trapped within the cavity warms. This warm air is drawn up through the intake section of several ventilation/makeup air units in the garage area, delivering 3600 to 6600 cfm of preheated ventilation air to the interior of the facility. The incorporation of a solar wall enables the client to save enough energy and operating costs to realize an eight year payback period. Optimization of the building envelope has allowed the facility to run at one third less energy than a comparable structure.

ROOFING

Seven acres in size, the roof is a key element achieving sustainability goals. The specifications were written to procure a roof product with a 25-year system warranty that is LEED® compliant. A roofing system provided by Soprema was selected to meet or exceed ARCA standards to achieve LEED® NC for reflectivity and to address wind uplift loads, which are typically encountered on roof systems of this magnitude.

A white roof was selected for the Centennial Garage. Dark roof surfaces tend to negatively affect the microclimate of the surrounding area and increase the cooling load requirements for a building. A white roof, on the other hand, has less interference of surrounding area, reduces energy consumption, and improves durability by diminishing the effects of thermal expansion.

In order to provide safe access to the rooftop units for maintenance and to minimize wear and tear on the membrane, roof pavers of a contrasting colour, made from recycled materials, were used for the walkway system.

RAINWATER

Rainwater is captured and collected from the massive 29,000 m2 roof for reuse in secondary functions within the facility. Outside the facility rainwater is sufficient for landscaping irrigation due to the careful selection and use of native plants.

SOCIAL AND ECONOMIC BENEFITS

CREATING A POSITIVE WORK ENVIRONMENT

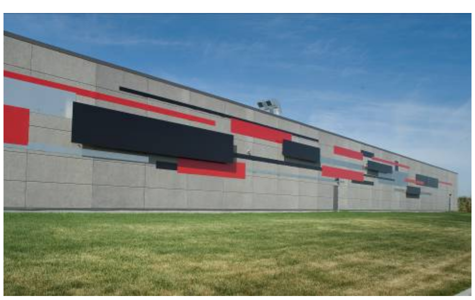
Approximately 22% of a person's lifetime is spent at work. The City of Edmonton Centennial Garage provides a welcoming, bright and safe work environment for employees. Employee comfort was a priority concern for ETS.

Common complaints at other bus garages were that the diesel exhaust fumes hindered the efficiency of the staff. With up to 250 buses operating within the heated space at any one time, Centennial Garage not only overcomes this complaint, it is designed to maintain a great indoor environment. Through the innovative ventilation system and other measures taken, diesel exhaust fumes are effectively removed, contaminants in the air have been reduced and any materials that emit VOCs (volatile organic compounds) or formaldehyde eliminated.

In addition to providing good air quality, other features were incorporated into the design contributing to the positive work environment. Drivers working multiple shifts are able to rest, clean up and meet with family, making their work environment less stressful. These features include:

- natural lighting and lighting controls
- a quiet room
- lunch room
- courtyard and exterior artwork
- change rooms
- laundry facilities
- a public address system that can be used for background music in addition to announcements

Operable glazing is abundant throughout with clerestory windows utilized around the entire storage space to maximize natural lighting. Employees also have the benefit of being able to modify the light and temperature of their workspaces, with the operable windows and lighting controls implemented for this purpose.



A photo control together with the lighting control system has been installed at the bus entrance to the facility to eliminate tunnel effect of the driver's eyes. This is a unique feature allowing the driver's eyes to gradually adjust while entering or exiting the building.

A comfortable outdoor environment, designed by Earthscape Consultants, allows staff and family members to enjoy socializing in a semi-private courtyard.

MEETING AND EXCEEDING THE OWNER'S/CLIENT'S NEEDS

The Edmonton Transit System has been provided with a bus facility designed to last over 100 years. At a budgeted cost of $82 million, the garage was delivered on time and within budget. The client was provided with a new facility to efficiently store, maintain and operate 250 diesel and future hybrid buses, enabling them to better serve the needs of their employees and the public.

Centennial Garage incorporates the latest in transit serivce technology, equipment, operational efficiencies and accommodates future growth. The building and site were designed and constructed to achieve a minimum LEED® Silver certification for environmental sustainability and energy efficient design.

Bus garages, by their very nature, are often utilitarian facilities. Centennial Garage excels in providing a safe, welcoming and pleasing work environment for ETS staff while remaining highly functional.

The building utilizes the sun for warmth, roughed in facilitation for snow cooling, and trench and drainage grating strong enough to land a plane upon. All components of the design of the massive facility are thoroughly integrated with other disciplines, with the steel structure itself built around the mechanical and electrical services for easy future upgrades and maintenance accessibility. Every detail was established with the intent to streamline bus operations, including both a drive through bus wash and undercarriage wash with recycling capabilities, ceiling mounted re-fueling hoses, automatic passenger counters. These are just a few of the many features incorporated by consulting engineers that make this facility a success.

EDMONTON TRANSIT SYSTEM – CENTENNIAL GARAGE

Indoor Environment Quality:
The design and construction of the Centennial Garage prioritizes a good quality interior environment for building occupants. This means eliminating materials that off-gas contaminants, monitoring indoor air for CO_2, and maintaining comfortable heat and humidity conditions within the building.

Common construction materials release irritating, even noxious substances into the indoor environment, such as volatile organic compounds (VOCs) or formaldehyde. Products were carefully selected to be low emitting.

low-emitting materials:

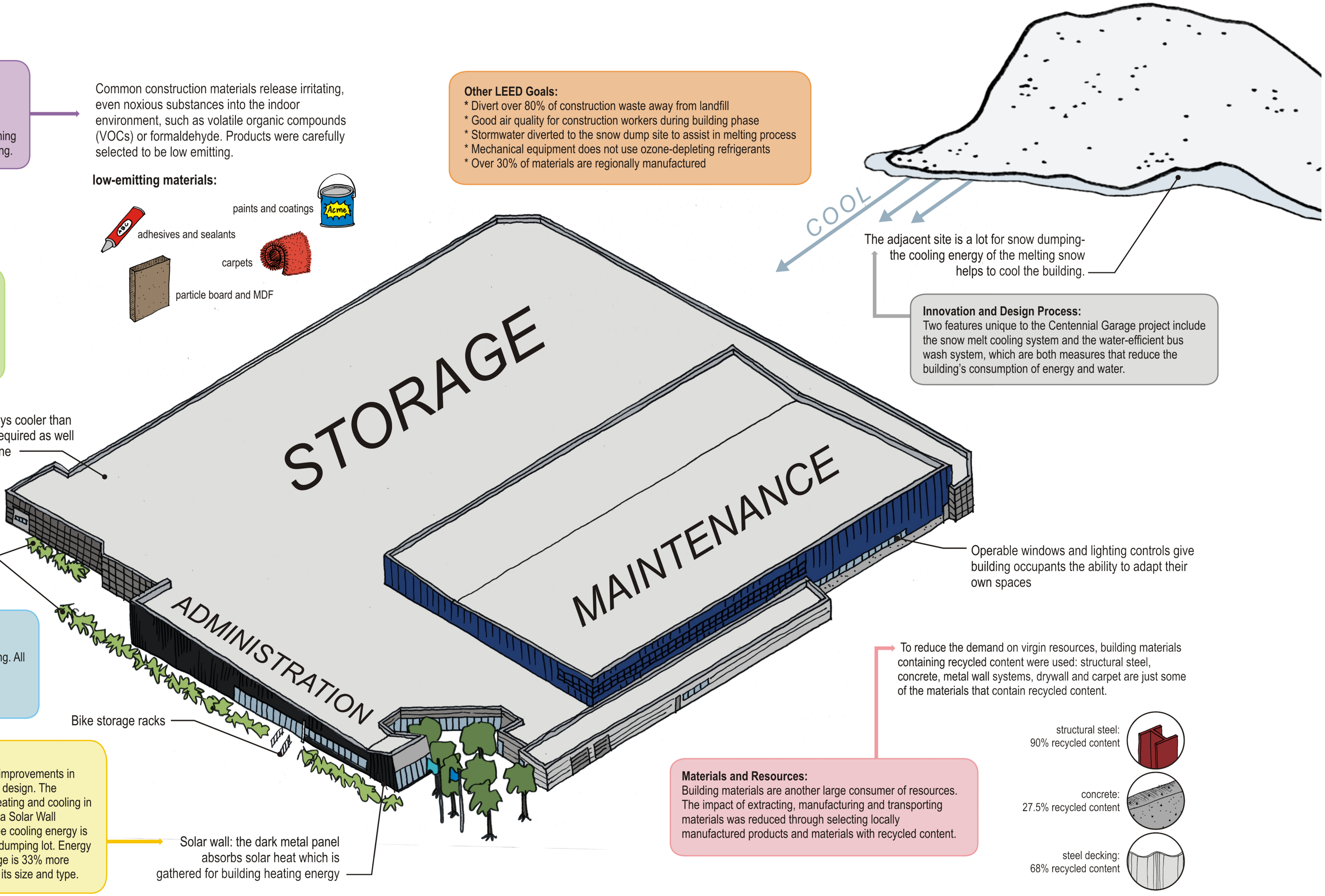
paints and coatings

adhesives and sealants

carpets

particle board and MDF

Other LEED Goals:
* Divert over 80% of construction waste away from landfill
* Good air quality for construction workers during building phase
* Stormwater diverted to the snow dump site to assist in melting process
* Mechanical equipment does not use ozone-depleting refrigerants
* Over 30% of materials are regionally manufactured



The adjacent site is a lot for snow dumping- the cooling energy of the melting snow helps to cool the building.

Innovation and Design Process:
Two features unique to the Centennial Garage project include the snow melt cooling system and the water-efficient bus wash system, which are both measures that reduce the building's consumption of energy and water.

Sustainable Sites:
Two ways in which the Centennial Garage is sensitive to the site and surroundings are the reduction of heat islands and the limiting of light pollution. Heat islands can impact the local microclimate, and nocturnal species and birds can be negatively affected by too much light in the night sky.

High albedo (highly reflective) roofing stays cooler than dark roofs, reducing the cooling energy required as well as prolonging the life of the roof membrane

Landscape plantings are specifically chosen so that they do not need to be watered, saving on water use

Water Efficiency:
The Centennial Garage reduces water use on both the administration and bus maintenance sides of the building. All washroom, shower and kitchen water fixtures are low-consumption, and buses are washed with a specialized system that cuts down on water use by more than half.

Bike storage racks

Energy and Atmosphere:
Buildings are a major consumer of resources, and improvements in energy efficiency are one of the hallmarks of green design. The Centennial Garage reduces its energy usage for heating and cooling in two different ways: free solar heat is harnessed by a Solar Wall construction on the building's south facade, and free cooling energy is gathered from melting snow on the adjacent snow dumping lot. Energy modeling results indicate that the Centennial Garage is 33% more energy efficient than a typical Canadian building of its size and type.

Solar wall: the dark metal panel absorbs solar heat which is gathered for building heating energy

Operable windows and lighting controls give building occupants the ability to adapt their own spaces

To reduce the demand on virgin resources, building materials containing recycled content were used: structural steel, concrete, metal wall systems, drywall and carpet are just some of the materials that contain recycled content.

Materials and Resources:
Building materials are another large consumer of resources. The impact of extracting, manufacturing and transporting materials was reduced through selecting locally manufactured products and materials with recycled content.

structural steel: 90% recycled content

concrete: 27.5% recycled content

steel decking: 68% recycled content