# ROYAL ALBERTA MUSEUM


CANADIAN CONSULTING ENGINEERING AWARDS

DIALOG®


# DESIGN AND THE STORY OF ALBERTA

Royal Alberta Museum (RAM) is the largest museum in Western Canada, collecting and displaying both the human history and natural history of Alberta for over 50 years. After outgrowing their original home in west-central Edmonton, the Government of Alberta made the decision to move the Royal Alberta Museum to a new location in downtown Edmonton. The blank canvas in the heart of the city presented a unique opportunity to create a perfectly-suited facility with more space for displays, growing collections, and state of the art research labs.

The design is a continuous narrative—a dialogue between inside and out—between the city, the building and nature. There is a dynamic weaving of interior and exterior spaces. Nature is brought into the building through the gardens, and the building extends out into the landscape. It looks upward to the broad Alberta sky and out to the city beyond.

The architecture gives primacy to the stories, the artifacts and the objects of the museum. The engineering systems respond to and support this vision. The building is designed to enhance the experience of visitors and museum staff. It is a place to explore and connect—to Alberta, to ideas, and to people.

The Royal Alberta Museum not only tells the story of Alberta through its galleries, it also actively preserves and collects the natural and human history of Alberta. Behind the scenes, there is a hive of activity researching, inspecting, restoring, preserving. This wide range of activity presents a variety of environmental, structural and electrical conditions to design for.

**CREDITS**

DIALOG
Structural Engineering, Mechanical Engineering, Electrical Engineering, Architecture, Interior Design, Landscape Architecture

LUNDHOLM AND ASSOCIATES
Museum Planning

WILLIAMS ENGINEERING
Civil Engineering

LEDCOR DESIGN-BUILD (ALBERTA) INC.
Design-Build Contractor

# ENTRANCE LOBBY

The Museum's Entrance Lobby and Group Arrivals area is the central node for all activities, and includes artifacts, information, and access to experts. From here begins an iconic Albertan museum experience. It is an extension of the outdoors, tying the exterior and interior elements together.

The Entrance Lobby roof is structurally framed with long-span beams and joists to minimize the columns required. Built-up architecturally exposed steel girts provide elegant lateral support to the curtain wall system on most exterior walls. A grid of hanging points is provided throughout the lobby space, allowing hanging exhibits and gallery "teasers" to be hung from the ceiling.

The Entrance Lobby mechanical systems are completely integrated into the design, providing the required heating, cooling, and ventilation without distracting from this prominent public space. Radiant floor is installed throughout the lobby and functions in both heating and cooling seasons. Trench heaters with a playful pebble pattern run along the glass perimeter, supplemented with mullion heaters to keep the windows clear and patrons comfortable on cold days. Displacement ventilation gently flows out from behind metal panels to spread along the floor, providing ventilation air to the occupied zone and pushing contaminants up to the return intake at a high level. The system supplies air at a very low velocity which prevents drafts blowing on visitors and staff.

Part of the ceiling lighting is arranged as constellations over the Manitou Stone and comes alive at night with controlled lighting. The clean lines and surface of the ceiling further provide opportunities for the Museum to project images and tell stories as day turns to night. An image of lightning referencing the Alberta landscape is abstracted and laser cut into metal panels that wrap around The Roundhouse and draw visitors to the admissions desk. Lighting illuminates this surface from behind, accentuating the "prairie lightning" effect.

## FEATURE STAIR

A spiral cast-in-place concrete feature stair located in the entrance lobby acts as the focal point of the space and provides access to the second level Natural History Gallery. This swooping staircase clear spans nearly 18 linear meters from a single concrete wall located near the base of the lowest landing all the way up to the second floor.

The stair's spiraling architectural form was inspired by the iconic Maligne Canyon in the Rocky Mountains.

This substantial and complex stair required significant collaboration between numerous subtrades and designers. The result is a stunning and functional concrete art piece that would not have been possible without this high level of collaboration. The stair was designed to resist the applied shear, bending, axial, and torsional forces, but also to limit vibrations due to pedestrian traffic. Reinforcing had to be carefully positioned throughout the cross section to perform structurally while avoiding over-congestion for the trades. Mechanically, the sprinkler line was cast into the stair itself, eliminating exposed sprinkler lines on the underside of the stair. The completed feature stair is a beautiful and functional concrete piece of art which is truly one of a kind.

## THEATRE

Travelling to the southwest corner of the lobby and up a long single-span staircase formed with steel trusses, you will find the museum theatre. The theatre provides the opportunity for group learning and special presentations at the museum. The theatre ceiling plays upon the patterns of geological layers in our Rocky Mountains. It begins on the walls and folds over at the ceiling with shifts and breaks to accommodate the theatrical lighting and house lighting. The ceiling system also accommodates some of the complex mechanical and acoustical systems for the space.

The second level theatre cantilevers over the main entrance to the Museum, providing generous cover and signalling the presence of the Museum as part of the Arts District. The cantilever structure is formed with storey high HSS steel trusses concealed within the side walls of the theatre. The total cantilever length is over 10 metres and supports the weight of the theatre plus the stone clad walls.

The theatre and theatre lobby is served with the same air system as the lobby. Displacement ventilation is distributed from circular grilles below the seats and from the front of the stage. The low velocity displacement diffusers are essential to maintain the required acoustics within the theatre. Radiant panels are integrated into the ceiling systems and chilled sails are installed over the stage. Lighting in the theatre is provided by dimmable LED fixtures controlled through the theatrical dimming system to allow it to be properly sequenced with show lighting.

# GALLERIES

The Museum's Galleries share the story of Alberta through exploring and learning. RAM has five galleries: the Feature Gallery, the Human History Gallery, the Natural History Gallery, the Children's Gallery and the Bug Gallery.

Preservation of collections was critical to the design at the Museum. For example, water could severely damage the collections; therefore, air HVAC systems are exclusively used in the collection storage and exhibit spaces. Multiple mechanical rooms are located throughout the building to limit the amount of water overhead and provide easy maintenance accessibility to the equipment. To mitigate the risk of water damage from sprinklers, each space is separately monitored as a standalone zone and piped through an isolation valve box located adjacent to the door. Temperature and humidity set points are also very important in these spaces, so there are two sensors monitoring each zone.

The Children's Gallery is located along the west side of the building and is visible from the adjacent avenue. The space is designed to feel like a tree fort in Alberta's Boreal Forest. The image of Aspen tree leaves is abstracted and laser cut into metal panels that form the outer surface of the space. The sloped steel HSS columns that support the roof represent tree trunks in the forest. In one case, the steel column is the rainwater downpipe to drain the oval roof. Large nozzle diffusers distribute air to the space and add to its playfulness. The columns and metal panels reference the Alberta landscape during the day, and at night, backlighting transforms the Gallery into a spectacular glowing lantern.

The Feature Gallery will showcase travelling exhibits that require a very high level of air control, including user adjustable temperature and humidity set points. There is a dedicated air handler for this space which will be able to function in both exhibit and non-exhibit modes. Steel Warren trusses span 25m over the feature gallery to support offices above without interior columns. The HSS trusses were designed to support significant hanging loads and minimize vibrations from office activities above.

In-floor electrical raceway systems are provided in all galleries to facilitate the distribution of power and data services and to provide flexibility for exhibit changes. The raceway systems were cast directly into the cast-in-place concrete two-way spanning slab and required a high level of coordination and planning.

# COLLECTIONS AND LABORATORIES

As part of the Museum's mandate to preserve the history of Alberta, there is a significant back-of-house collection storage area where many of the researchers and laboratory technicians work. What's exciting about this museum is the intention to provide views into some of these behind-the-scenes rooms, such as the bug lab and demonstration lab.

Mechanically, the collection storage spaces are treated similar to the exhibit areas. Every collection, exhibit and lab space has a valve isolation box to allow the user to quickly isolate that branch in the event of a leak or break in the piping systems. The labs include multiple exhaust components such as fume hoods, extraction arms, laminar flow hoods, and general room exhaust. The lab exhaust system utilizes a heat recovery coil to capture energy exiting the building. Off gassing of the collections and introduction of outdoor air pollutants is a legitimate concern, therefore all recirculated and fresh air is brought through pre-filters, gas phase filters and final fine filters.

Most of the collection spaces are distanced from the effect of climate by locating them away from perimeter walls and providing an environmental buffer space such as a corridor. Lighting in these areas are provided with UV filtering to minimize the effects of light damage to artifacts. An extensive system of photo-electric smoke detectors is installed to provide enhanced fire protection.

Floor deflections were strictly limited in all collection storage areas that utilize high-density mobile shelving. Meticulous structural design was required to limit the live load deflections of these suspended slabs to span/480 under live loads of up to 12kPa (250 psf). The compact shelving rails were recessed into concrete toppings to maintain a flat surface for moving artifacts onto shelves.

# STRUCTURAL SYSTEMS

The structure of RAM consists of reinforced concrete and structural steel members. The structure is featured prominently in the architectural design and is required to meet the strict loading and durability requirements of the museum. Recesses, depressions and cast-in service ducts are accommodated within the structure to accommodate gallery and collection displays and equipment.

Concrete was selected as the primary framing material for the museum, not only for its structural load-carrying characteristics and durability, but also as part of the architectural and mechanical design. Soil pressures acting on multiple levels of basement structure are resisted by concrete foundation walls that span up to 8m high. Construction of basement foundation walls was expedited by casting several of the walls using a shotcrete placement method, reducing the amount of formwork and dependency on crane time. Concrete two-way flat plate slabs were selected for a majority of the museum floors for a number of reasons, including their ability to efficiently and cost-effectively support the heavy loads of the displayed and stored artifacts.

Mechanically, the high thermal mass of the concrete structure and the concrete toppings on steel roof decks are used to store heat, providing inertia against temperature fluctuations. This “thermal flywheel” effect allows for reduced dependence on mechanical systems, and better protection for the collections in the event of a power outage.

The architectural design of the museum frequently showcases exposed concrete surfaces, with exposed concrete columns, slab surfaces, edges, soffits, and most significantly with two architecturally exposed concrete feature staircases.

Architecturally exposed structural steel is also used throughout the Museum and forms an important part of the design. The Children’s Gallery, entrance lobby, theatre, and collections area use ornate structural steel detailing, notably on the steel girts and exposed column connections. Steel structures are used to frame all major cantilevering floor and roof structures. The cantilever lengths range from 5 to 10 metres and support extremely high live loads (4.8 kPa to 7.2 kPa) and stone cladding panels. The overhanging structures form an important part of the architectural design, animating the massing and acting as canopies over key entrances.

# MECHANICAL SYSTEMS

The 39,000 sq m museum is designed for resiliency, reliability, temperature and humidity stability and low operating cost. A variety of technologies are used to condition a wide range of spaces, including artifact storage, workroom laboratories, galleries, community activity spaces, and administrative spaces. Edmonton is in a climate that presents unique challenges for a building that must reflect a resilient sustainable design.

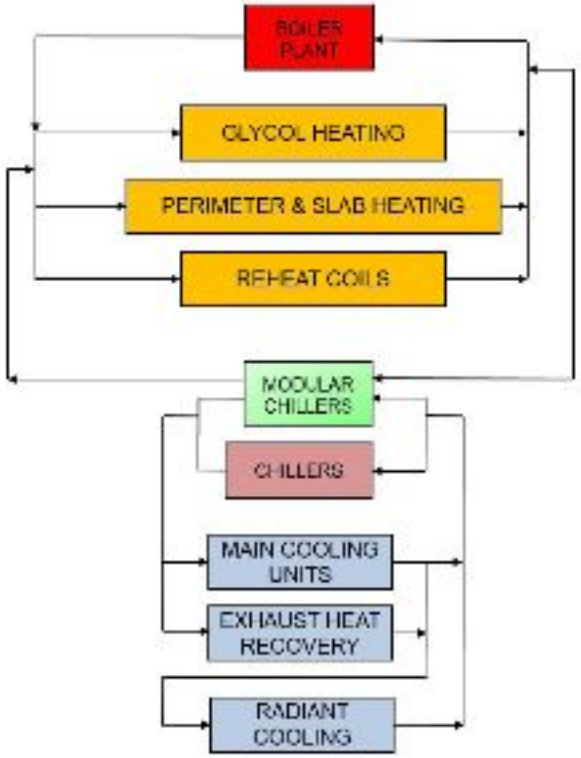
Seasonal extreme temperatures range from -46°C to 36°C, which places added stress on systems that are designed to maintain spaces at tight tolerances.

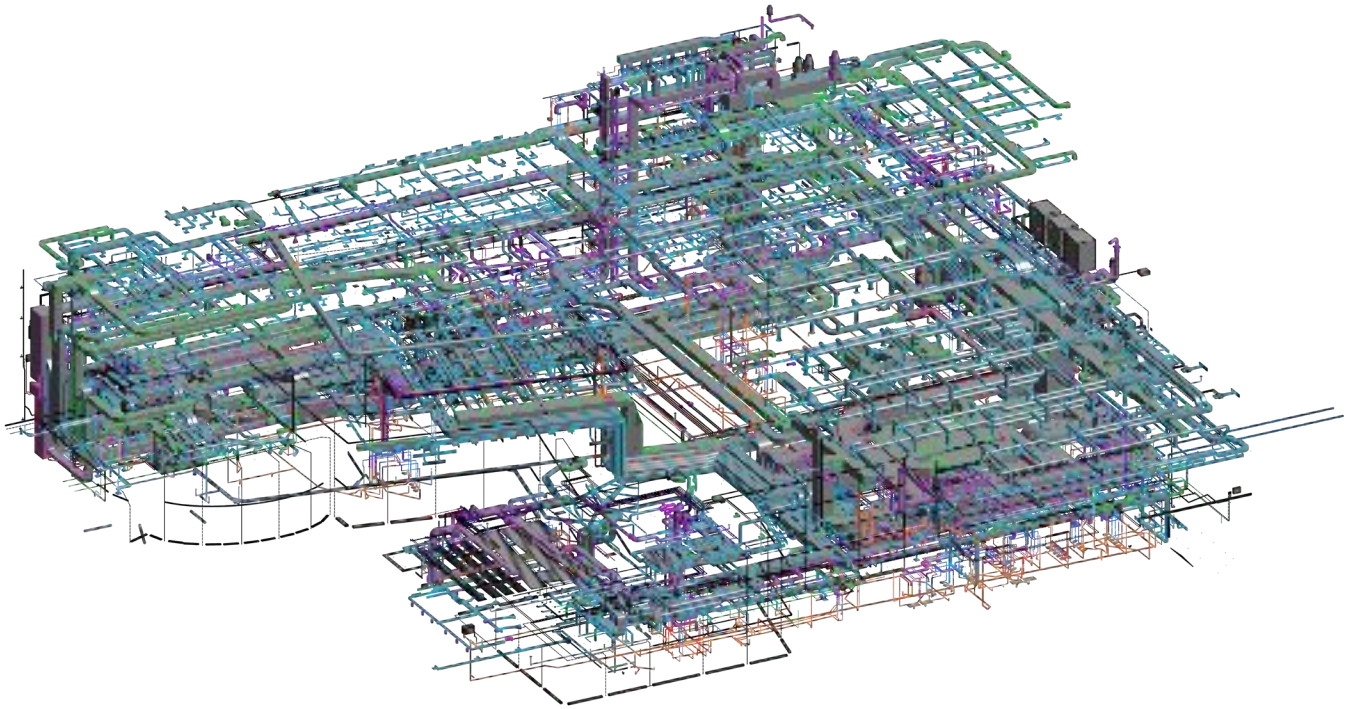
Seven air handling systems located in two basement fan rooms combine to deliver a peak volume of over 140,000 L/s to the facility. All critical air handling units are dual 50/50 units to allow for continued temperature and humidity control upon single unit failure or maintenance.

Each system consists of variable speed return fans and three stage air filtration. All coils utilize a glycol/ water solution to safeguard against winter freeze up. During unoccupied hours, flow rates are halved in order to conserve energy.

The central energy center uses a hybrid plant of condensing and conventional hot water boilers, augmented with heat recovery from a modular chiller plant. The modular chiller is augmented by dual water-cooled chillers served by three roof mounted cooling towers with remote indoor sumps. Humidification is provided to humidity critical spaces from a central lower pressure steam boiler system. The heating, humidification, and cooling plants are designed for N+1 redundancy on all critical components for enhanced standby capacity.

Plant Concept



# ELECTRICAL SYSTEMS

The museum required electrical systems that not only had to bridge architecture and function, but also had to comply with specific requirements and desired sustainable strategies. The power, lighting and fire alarm systems are three major components of the electrical engineering design.

To ensure a reliable source of power for the operation of the museum, the power service to the building consists of dual primary power feeders (13.8kV) from two separate utility substations.

Power is automatically transferred from one primary feeder to another in the event of a loss of power in the designated main feeder. Even though the utility power service in Edmonton is one of the most reliable in Canada, a diesel fueled emergency generator is provided in case of a total failure to the utility network.

The generator is sized to accommodate all life safety systems and critical building loads, as well as to provide power redundancy for the mechanical systems serving the collections.

The lighting design for the Museum provides a comfortable atmosphere for visitors and staff. The lighting has been designed to complement the architecture, revealing different elements of design in the daytime versus the night. The lighting design uses energy efficient fixtures with automated lighting control to minimize power consumption.

The design includes programmed schedules for the gallery areas, occupancy controls in areas with occasional occupancy, and daylight sensors to dim and/or turn the lighting off when daylight is sufficient to illuminate the space.

To facilitate the protection of visitors and exhibits, a microprocessor based fire alarm system is provided. The system utilizes automatic alarm initiating devices such as heat detectors, smoke detectors, sprinkler flow switches, open-area smoke imaging detectors (OSID) and aspirating smoke detection. Fire alarm signaling is provided by speakers and strobe lights located throughout the building.

# SUSTAINABILITY

Sustainability and our environment are key themes throughout RAM, and are the central drivers behind many of the architectural and engineering choices. Preservation and conservation our natural Alberta environment was treated equally as important as the preservation and conservation of Alberta's history.

While the project mandate was to achieve LEED® Silver, it actually achieved LEED® Gold Certification, which is a testament to the collaboration and commitment to sustainability by the project team. The building boasts many sustainability strategies that make it a uniquely environmentally conscious museum:

- The project is in a high-density area service by transit. Sustainable transport is encouraged by ample bicycle storage and a minimal amount of on-site parking
- Low-flow plumbing fixtures are provided, saving over 35% on water consumption
- Unique HVAC design maximizes energy recovery while providing tight environmental controls for temperature and humidity
- Condensing boilers and water-to-water heat pumps provide efficient heating and cooling
- Energy-efficient lighting is controlled with automatic sensors for occupancy and daylight
- Selection of materials that contain recycled content, are produced locally and comply with VOC requirements
- The building is designed for a 100-year service life
- Mechanical systems utilize the heat rejected from spaces requiring year-round cooling (such as Electrical/Communication rooms) in the radiant floor and reheat coil loops
- Heat recovery coils are installed on the exhaust systems
- Controls use $CO_2$ and occupancy sensors, as well as building schedules to reduce air volumes when able
- Portland cement, a constituent in concrete, is replaced with recycled fly ash, a hazardous pozzolanic byproduct of coal combustion
- Recycled waste glass cullets are incorporated into many of the exterior slabs as a decorative aggregate
- The high thermal mass of the concrete slabs and concrete roof toppings reduces heat losses through the building envelope, leading to major reductions in energy use in mechanical heating and cooling systems

## CONCLUSION

Royal Alberta Museum is designed to tell the story of Alberta, inside and out. Engineering precision, sustainability and our environment are key themes that respond to the architectural vision. Completed on time and on budget, the result is an impressive place to explore and connect—to Alberta, to ideas, and to people.