Studio Bell

Home of the National Music Centre

Stantec

rjc Engineers

Allied Works Architecture


Studio Bell +60 Bridge connecting the East and West Buildings

Allied Works Architecture

What's inside

Allied Works Architecture

> **"The design for Studio Bell was truly a collaborative process, and it has been thrilling to see our vision come to life."**
>
> - Andrew Mosker,
> National Music Centre President and CEO

Providing a new home for music in Canada

A cultural institution dedicated to Canadian music, Studio Bell is an iconic piece of architecture in Canada. It is a museum, performance hall, interactive music education centre, recording studio and broadcast centre.

From the very beginning, the project attracted global attention. In 2009, The National Music Centre held an international design competition to select a design worthy of their vision. They wanted a building unlike any other in the world – an iconic piece of architecture for Canada, and the world, that would celebrate and support music and musicians in Canada.

Architect Brad Cloepfill said, "We travelled around the world looking at different music institutions. We looked and looked for precedents and models and we learned bits and pieces from things, but there's nothing like it."

Indeed there was nothing like it, and there still is nothing like it. The project has won awards from day one, including a World Architecture Award in the Future Cultural Category, and several Consulting Engineers of Alberta Awards of Excellence for Stantec and RJC's work.

MAKING IT WORK

Every element of this building, with its bold design, is a testament to structural and mechanical engineering excellence, showing a high degree of creativity and innovation. While design is so often based upon precedence, much of this building's design challenges the norm because there is no precedent to refer to. This is a truly unique building with relatively little in common with conventional buildings.

Allied Works Architecture

> “Realizing a building with such complex form and surface geometry only happens if the team members understand and support the project’s architectural goals…..I think the end result speaks positively for itself and the team’s efforts.”
>
> - Dan Koch
> Associate Principal, Allied Works Architecture

rjc
Engineers

Innovation and Technical Excellence

Read Jones Christoffersen Ltd.(RJC) – Structural Engineer

As the structural engineering consultant, RJC faced a daunting task. The project and its many elements were unlike any other – a non-typical building requiring very atypical solutions! The most significant structural challenges were:

- Incorporating a condemned historic building
- Designing a buildable structure when everything is curved and/or inclined
- Designing a bridge 65 feet above an active roadway
- Achieving the architect’s vision of the vessels ‘floating’ with minimal support
- Framing a column free theatre with sloping walls
- Designing a five-storey cantilevered feature stair

INCORPORATING A CONDEMNED HISTORIC BUILDING

Given its historical context, saving the King Edward Hotel was very important. The most historic aspect of the hotel was the original brick veneer. Saving the hotel and making it a building worthy of incorporating into the world class Studio Bell\ was a challenge.

To save the historic fabric and make the interior structure worthy of a world class building, all exterior brick walls were taken down. In meticulous detail, every brick was catalogued and assigned a serial number with its location noted. The bricks were cleaned, and the exterior reconstructed using the original brick and design. The interior structure was rebuilt to modern standards.

DESIGNING A BUILDABLE STRUCTURE WHEN EVERYTHING IS CURVED AND/OR INCLINED

One of the most striking aspects of Studio Bell is that everything is curved and/or inclined. The geometry is incredibly complicated and introduces additional lateral forces on the structure which would not normally need to be considered.

RJC went through a value engineering exercise to determine what structural system would deliver the envisioned aesthetics, while being as cost effective and constructible as possible. As this process advanced, the structure become a steel framed building.

The connections for Studio Bell were incredibly complicated – members don't frame into each other at 90 degree angles like most buildings; multiple members frequently framed together at a single node at different inclinations, angles and twist orientations. The team had to work very closely to work out the details of how to economically achieve the desired geometry.

DESIGNING A BRIDGE 65 FEET ABOVE AN ACTIVE ROADWAY

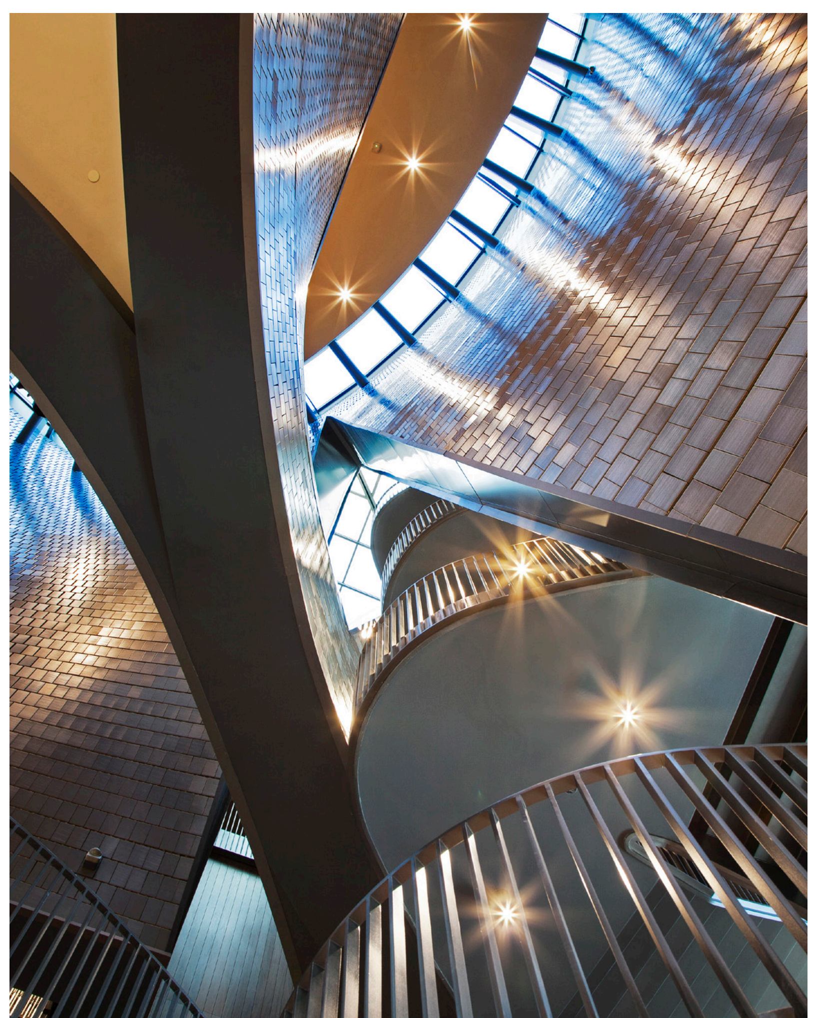
The bridge connecting the east and west buildings of Studio Bell is 65 feet above an active roadway, and presented one of the most complex problems for the structural design. The connection was incredibly challenging because of the way the bridge introduced loads into both buildings; the upper floors of each building wanted to move toward each other in response of the weight of the bridge. Furthermore, there were torsional displacement challenges with both buildings under wind load. Trying to do what was 'always' done, detailing an expansion joint, for a very unconventional building was creating more problems than it was solving...so an unconventional solution was proposed – what if there were no expansion joint?

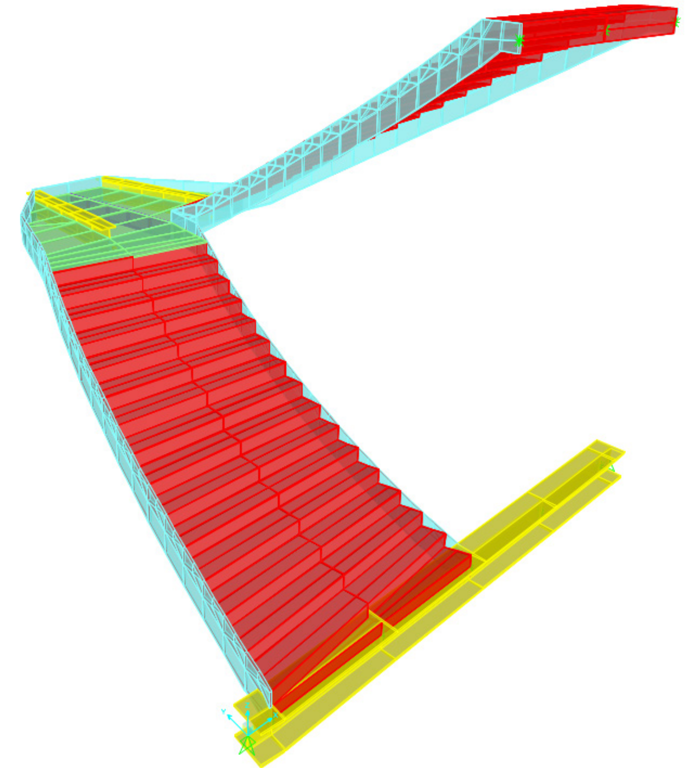
Not having an expansion joint ties the buildings together, allowing the lateral load to be shared and eliminating deflection problems. This highly innovative structural solution also allowed for the removal of torsional cross braces in the west building.

ACHIEVING THE ARCHITECT'S VISION OF THE VESSELS 'FLOATING' WITH MINIMAL SUPPORT

Allied Works designed six towers, or 'vessels', as separate gallery spaces within the east block that are linked together by interior bridges at each level. From the main floor, patrons are able look up and see the roof and the skylights of the six storey building – there are no floors in the center of the building. Achieving this vision required an impressive lateral system.

The upper floors of the east building are each composed of six distinct areas separated by large 'interstitial' spaces that permit unobstructed views between the ground floor and the ceiling. These individual floor areas are tied together by mini bridges that permit patrons to cross the 'interstitial' spaces at each level. Since only three of the six floor areas at any level are tied directly to a lateral force resisting concrete core, the mini bridges also have to provide lateral support to the remaining three areas. This was critical not only to resist wind and seismic loads, but also to resist the lateral thrust resulting from the inclined geometry of the gravity framing.





Dynamic Analysis Model of Stairs

Over all of this is a large skylight feature known by the project team as the "Enormadome" - a quasi-elliptical ring of skylights measuring 31m long and 18m wide. Structural support for the Enormadome, along with the roof area in its interior, was provided by a curved structural steel truss sitting on top of the roof. The truss in turn was supported on the inclined columns of the main building. Providing lateral bracing for the top chord of this ring truss was a significant structural challenge.

FRAMING A COLUMN FREE THEATRE WITH SLOPING WALLS

The theatre space required RJC to transfer several columns from above. The columns came down but couldn't continue past at any point – they had to be transferred out to the framing below the theatre space through the narrow and inclined 270mm thick theatre walls. RJC detailed super narrow leaning trusses on either side that transfer all of the columns. The narrow leaning trusses are hidden in the walls, with only millimeters to spare.

RJC also had to use composite steel sections using smaller shapes rather than larger shapes that would not fit in the space available. The solution had to be strong enough to achieve the structural requirements, small enough to fit into the 270mm wall width and stiff enough to not buckle. The fact that the trusses are also sloping means that they want to fall over, requiring a high degree of detailing to secure them in place. To further complicate things, the inclined trusses are supported eccentrically by 650mm thick strong walls. These are in turn supported on a series of concrete transfer beams.

The result is an eccentric transfer, upon a transfer, upon a transfer - creating a concern with compound deflection. If the column were to land on something that has a high degree of compound deflection next to a column that doesn't, it would cause the floor to slope significantly.

To alleviate this concern, RJC had to very accurately estimate the amount of deflection each individual element of the system had, to ensure the system as a whole remained stiff enough to satisfy maximum deflection requirements at the upper levels. Full building models were created and cutting edge methods of estimating concrete deflections were used.

DESIGNING A FIVE-STOREY CANTILEVERED FEATURE STAIR

The stairs are a very key architectural feature – open and curved like so much of the building. The stairs are supported at each floor level by mini bridges. Each stair run features an intermediate landing extending into the interstitial space, but without support, creating the impression of a floating landing.

RJC completed extensive analysis to ensure the stairs would feel solid. Dynamic analysis was completed to study the performance of the stairs. The result: the stairs feel like cast-in-place concrete stairs (though they are steel) and there is almost no perceptible vibration and they look just as the Architect intended.

Building Community

Studio Bell offers a free after school drop-in "jam" program for youth and hosts international Artist in Residence to help musicians explore and create new works.

Stantec

Innovation and Technical Excellence

Stantec – Mechanical Engineer

ADVANCED COORDINATION AND INTEGRATION

Studio Bell's unorthodox shape posed many challenges to the design team, requiring significant coordination efforts to maintain the architectural vision. Our Integrated Design Process was utilized, ensuring cohesiveness within the project team and design. Stantec had regular meetings with architecture, electrical, structural, the construction manager, and the client throughout the full design process.

Stantec collaborated heavily with the mechanical contractor through the design-assist process. Constant dialogue with the contractor about constructability, provided overall cost certainty and allowed for the optimization of mechanical systems. Building information modeling (BIM) processes were heavily used during design and construction. A construction model was created for all major mechanical rooms, facilitating the coordination of the mechanical systems in the available spaces and the crossing between mechanical and structural components in the narrow spaces connecting the different mechanical rooms. Digital representation made identifying potential issues simple-allowing for coordinated solutions to be developed before the start of construction.

These models also enabled the owner to visualize the final product and provide input to the design to ensure proper space was provided to maintain the equipment.

AESTHETIC AND FUNCTIONAL SYSTEMS

All the mechanical systems have been designed to be visually minimalistic, unobtrusive, and coherent with the design of the building. Linear slot diffusers were used for the many aesthetically critical areas, and were aligned with the floor and ceiling to be as nondescript as possible. We matched return air grilles with supply where possible, to maintain symmetry and continuity. In the galleries, ducts, pipes, diffusers, and other pieces of equipment, were painted black to be virtually invisible past the wire mesh ceilings. Sensors and other controls were selected based on their ability to seamlessly blend into the surrounding environment.

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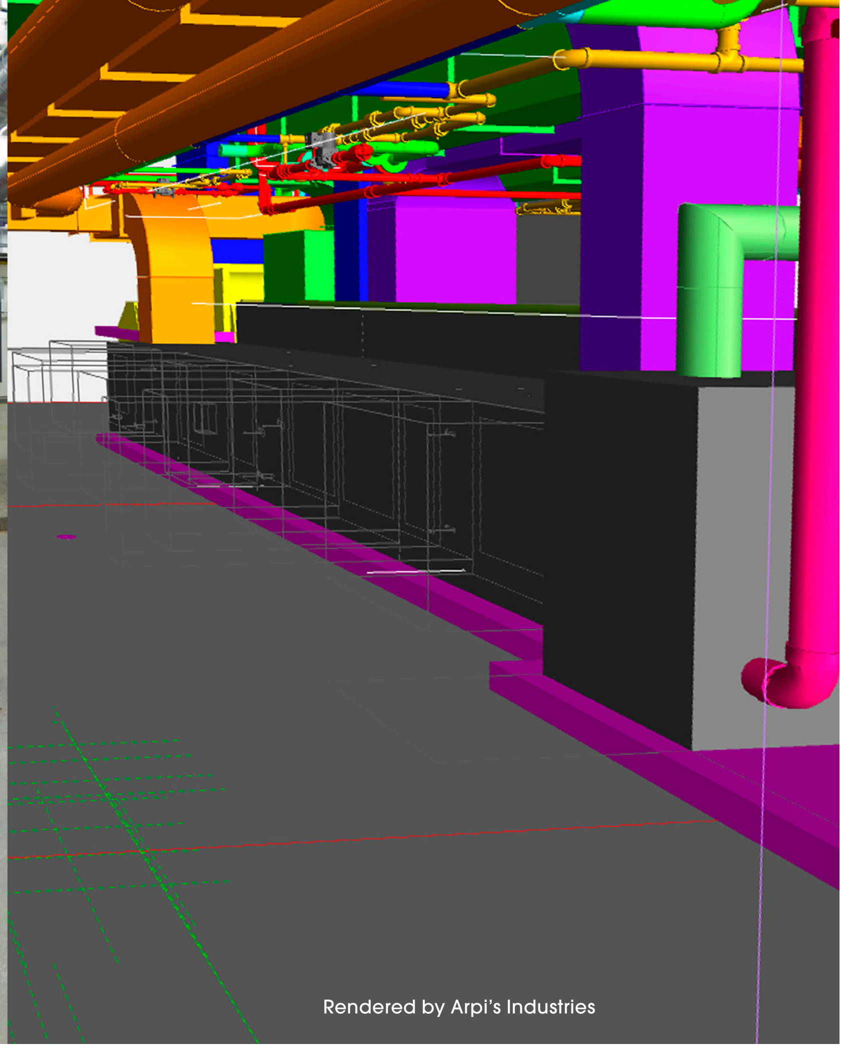

Rendered by Arpi's Industries

For example, in the case of a fire, smoke will rise several floors through the large open atrium collecting at the highest point. Using the smoke exhaust system from the mechanical room penthouse, the smoke is then pulled in between the terra cotta tiles, where it is expelled from the building. The makeup air is provided through automatically opened doors on the ground level, which are interlocked with the fire alarm system. Based on a computational fluid dynamics model (CFD) of several different fire scenarios, the system exhausts smoke at a rate that provides an ample amount of time for occupants to egress. This design has been deemed an appropriate "Alternative Solution" to the Alberta Building Code 2006, providing a functional smoke exhaust system that appropriately complements the building's aesthetics without compromise.

USING ENMAX'S DISTRICT ENERGY SYSTEM

Tying into the Enmax district energy system contributed to the building sustainability. Being connected to this system provides extremely hot water to two high temperature heat exchangers. Located in the underground parkade, each sized at 1800kW. By using the district energy system, we facilitated the removal of traditional heating boilers from the building, eliminating a major source of emissions. The district energy hot water is generated at the Enmax Downtown District Energy Center located across the street from Studio Bell.

IMPROVED ENERGY EFFICIENCY, REDUCED ENERGY AND OPERATING COSTS

Energy reduction and cost savings were considered during each phase of our design development. Stantec selected a chiller with free cooling capacity, which supplies chilled water without the use of compressors, when outdoor conditions permit. This leads into an overall reduction of energy and associated costs during cold days of the year. Stantec worked closely with the energy modeling team to determine the effects of the building envelope on the mechanical systems. The entire building envelope was modeled to analyze and account for the effects of thermal bridging on the building environmental conditions, especially in the areas requiring precise control. Our analysis of the building envelope model allowed for optimal sizing and costing of the systems.

ACOUSTIC CONSIDERATIONS

In addition to aesthetics, safety considerations were at the forefront of the functional systems design. Ensuring a positive experience for occupants and visitors required systems that minimize sound transfer. These noise sensitive spaces include recording studios, performance spaces, galleries, and offices. To accommodate for these needs, we installed ducts that were sized for low velocity air with: silencers, acoustic lining, exterior acoustic lagging and sealing at penetrations through walls and structure to eliminate both break-in and break-out noise transmission from air movement and mechanical equipment operation. We selected low noise equipment and grilles to meet the required conditions. Mechanical equipment was consolidated and localized in the mechanical penthouses, avoiding the need for any mechanical equipment in the sensitive spaces. Due to the effective acoustic design, the Noise Criterion (NC) rating achieved by the acoustic design in key areas was as low as NC 15. This noise criterion rating is comparable to a whisper from six feet in a quiet library.

PRECISION HUMIDITY AND TEMPERATURE CONTROL

In addition to noise constraints, many of the galleries also have strict temperature and humidity ranges to prevent the degradation of the displays and artifacts. We divided the building's internal HVAC design zones into distinct categories based of the ASHRAE classes of control for museums, galleries, libraries, and archives. Each space category utilized diverse systems to meet the required environmental conditions. For galleries and art storage spaces with the tightest humidity and temperature control (+/- 1°C and 5% RH), a dedicated precision unit serves each zone. These units provide humidification and dehumidification capabilities and reject excess heat into a condenser loop. Precision instrumentation monitors each space and ensures environmental conditions are compliant with space requirements.

Studio Bell's gallery spaces are exposed to the atrium and present slight uncertainties when it comes to precise control of the temperature and the humidity. Our solution addressed this by introducing a slightly positive pressurized system that creates a directional air flow from the galleries to the atrium. This ensures that the less stringently-controlled air does not flow into the galleries. Studio Bell welcomed almost 6000 people during the grand opening on July 1, 2016. Despite the high and variable loads and occupants our team's design ensured that the galleries experienced no change in temperature or humidity.

SEAMLESSLY INTEGRATED MECHANICAL SYSTEMS

Unlike other buildings, Studio Bell has unique requirements that cannot be fulfilled by a single system. Following the "functional, yet beautiful" vision, many of the systems are constructed as a component of the architectural design. The lofty and open atrium spaces act as a return air pathway. As the air in atrium area is heated from plug loads and occupants, it naturally rises. The positive pressurization of the galleries feeds air into the atrium. The air is then pulled into the gaps between the terra cotta tiles and into a plenum which acts as a path for the return air and the smoke exhaust, where it is fed back into the air handling units and reconditioned. This return air pathway simulates a "chimney effect," reducing the fan energy requirements of the return air paths by taking advantage of the building's structure.

The west tower of Studio Bell is directly connected to the iconic King Edward Hotel. The west tower floors are designed to align with the historically reconstructed King Edward Hotel (King Eddie), making floor to floor height clearances narrow—as little as 2.80m. The result is minimal ceiling space for ductwork and mechanical equipment. To accommodate for the lack of ceiling space, we chose and designed a variable refrigerant flow (VRF) system with a dedicated outside air system (DOAS) that minimized the required ductwork. Interconnected with one another, the VRF units allow for heat transfer from areas of excess to areas of need. If the heat is not required within the zones, the VRF units reject excess heat into a condenser loop, to be used elsewhere within the heating and cooling system. Only when the entire system has excess heat is it rejected through a dry cooler on the roof.

34% energy savings over conventional systems

The Result

A LANDMARK FOR CALGARY AND CANADIAN MUSIC

Working with the National Music Centre was inspiring - their passion for what they were trying to achieve was infectious. They demonstrated incredible patience and perseverance to see their vision become a true gift to Calgarians and music lovers everywhere. A ribbon cutting ceremony was held on June 29th to celebrate the opening of this stunning 160,000 square foot building with five levels of exhibition space. Studio Bell opened to the public on July 1st, 2016.

"They turn their heads; they've never seen a building like this in Calgary and I think a lot of people never expected such a building to ever be built in Calgary," said Andrew Mosker, CEO and President of the National Music Centre. Truly a unique building, Studio Bell stands out as a the masterful produce of detailed coordination and collaboration between disciplines – The Globe and Mail, 'Calgary's National Music Centre is a multi-purpose monument to Canadian Music' June 29, 2016

Allied Works Architecture