



HOW TO TEACH AN OLD DOG NEW TRICKS: BONNIE DOON LEISURE CENTRE REHABILITATION EDMONTON

Miller, Monique^{1,4}, Moayyed, Mohammad²

¹ Entuitive Corporation, Canada

² Entuitive Corporation, Canada

⁴ monique.miller@entuitive.com

Abstract: A small community focused aquatic facility, could have been levelled and built anew, but instead is undergoing a transformation. The term 'rehabilitation' does not accurately describe the level of rejuvenation undertaken to prolong and re-capitalize this facility. The project exemplifies many fundamental challenges of altering existing buildings. Not only did the building require restoration of key structural elements that suffered significant deterioration due to 50 years of use; new programming and operational requirements resulted in significant changes to all systems (mechanical, water treatment, electrical and architectural and structural). Alterations include upgrade of mechanical ventilation systems requiring the addition of two very large AHU and HRV units. Addition of the new building envelope system (recladding) requiring assessment of concrete block integrity and structural capacity of exterior walls. Upgrade to salt water treatment requiring perimeter pool gutter (surge tank, salt storage, acid room, various mechanical and electrical upgrades). How to work within the design and project delivery confines of renovating an existing building including discussion of the importance of structural health monitoring and restoration, the cyclical process of investigating structural options give the condition of a building. How current code requirements will affect the impact on the base building structure. Producing solutions that meet client needs while balancing the importance of schedule, design team requirements, constructability, and cost implications.

1 FIRST IMPRESSIONS

The first step is developing a clear understanding of the base building structure; history, construction, use, design criteria, and current condition. From there the capacity for change can be determined, and feasible design options for altering or supplementing the structure can be developed.

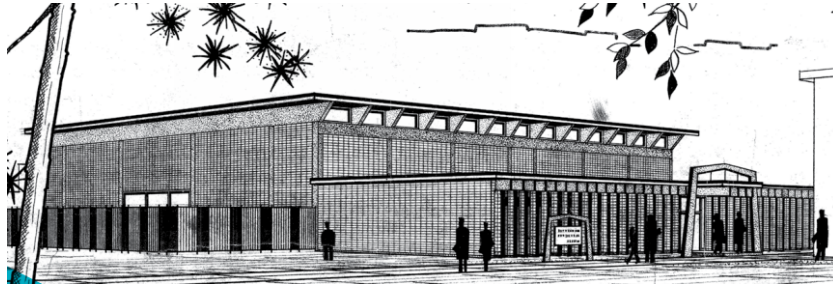


Figure 1: Bonnie Doon Leisure Center – Original Drawing Strong, Lamb & Nelson (1965)

Bonnie Doon Leisure Center was designed and built in 1965. It was originally constructed as swimming pool facility including reception/administration, men’s and women’s changeroom in the front space, swimming pool and bleachers in the natatorium area, and below grade operations including mechanical, electrical, and under pool deck utility tunnel. A whirlpool facility addition was built on the south side in 1988. The facility has remained virtually unchanged until the current rehabilitation project was undertaken in 2017.

The area of the city where the facility is located is undergoing major upgrades to bring a new major branch of the light rail transit (LRT) line from downtown to south-east Edmonton. The new LRT line will stop at the current Bonnie Doon Mall, directly east of the leisure center. Several transit-oriented developments are in progress for the Bonnie Doon neighborhood and mall site. There is also a public library, high school, public health center and link to city parks in the area. Renewal of this facility will play a key role in the urban redevelopment of this community.

The existing structure is comprised of 4 main areas:

1. Reception, administration, changerooms: This portion of the building is a 12'-2" single storey. The floor is slab-on-grade, the roof consists of precast concrete double tees that span 43' from load-bearing masonry exterior wall at the front of the building to a 32" deep masonry bond beam at the wall dividing the changerooms from the natatorium.
2. Pool natatorium: The natatorium is one large open space that contains the pool, and precast bleachers. The top of roof is at 27' and is comprised of concrete precast lin tees spanning 112' east-west between precast beams and columns located at the wall between the changeroom to natatorium transition, and the west exterior building elevation. The north, south, west, and east walls from low roof to high roof, are 10" thick stack bond concrete masonry infill between precast columns. The pool deck is a one-way structural slab spanning between the concrete pool wall, and the concrete foundation wall on the west, south and east sides of the pool. On the north side, the one-way slab spans from the pool wall to concrete beams supported on a line of precast columns at the transition from pool utility tunnel to below grade mechanical room. This line of columns is also the south support for sloped precast beams supporting the precast bleachers. The north support is the precast columns at the north exterior wall.

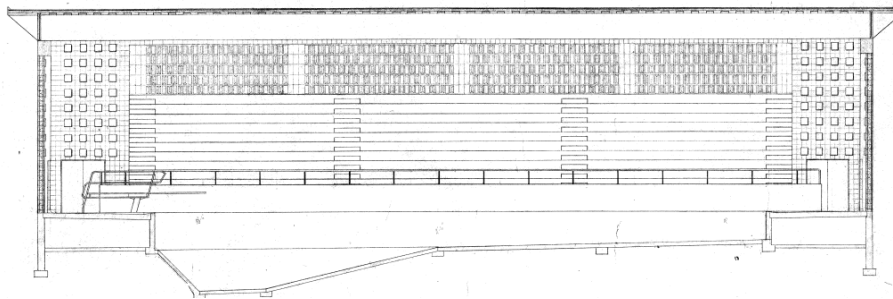


Figure 2: Section through natatorium – Original Drawing Strong, Lamb & Nelson (1965)

3. Below grade mechanical: The space below the natatorium deck is a tunnel around the perimeter of the pool. The tunnel is formed by the foundation and pool walls, pool deck and slab on grade below. The tunnel is 4' tall inside, and houses the pool mechanical, electrical and aquatic equipment including lights, pool skimmers, and natatorium ventilation ductwork. On the north side of the pool, the tunnel opens into a below grade basement space 7'-4" below the pool deck, that houses the building's mechanical room and secondary washrooms. The 'ceiling' space is the underside of the precast concrete bleacher structure that slopes from the tunnel area up to the north wall. The mechanical room houses all aquatic, electrical and mechanical services for the pool and building.
4. Whirlpool: An addition to the main structure, the whirlpool portion has a below grade mechanical area specifically for the whirlpool, sauna, and shower. The floor is slab on grade. The roof is open web steel joists spanning from south exterior masonry wall on concrete foundation wall and strip footings, to the original exterior south wall.

1.1 Gravity System

In the Natatorium the basic gravity system consists of precast roof tees spanning to precast beams supported on columns with spread footings. The pool deck spans from foundation wall to the pool wall. Both supported by strip footings. In the administration area, the precast roof beams are supported by the exterior loadbearing masonry wall on strip footings and masonry bond beams spanning between precast columns at the transition to the natatorium.

1.2 Lateral Load Resisting System

The lateral load resisting system is formed by the roof diaphragm and exterior infill masonry shear walls. The masonry infill also spans horizontally transferring out of plane wind loads to the precast columns. Exterior masonry infill walls in the direction of lateral loads act as shear walls and transfer loads to the precast columns and foundation wall.

1.3 Design Loads

Although base building structural drawings were available, no structural design information for the original building is known. Presumably the building was designed in accordance with the 1960 NBCC. The code changed in 1965, when the available base building drawings are dated, however it is unlikely that the 1965 design requirements were integrated prior to final design and construction. If this is the case, drift from the upper roof to low roof would not have been taken into account in the design. Also, the base snow load in Edmonton since 1960 has increased by approximately 50%. Based on 1960 code, the pool likely would have been designed as an assembly area, and due to the exits directly off the pool, the deck would have been considered an emergency exit way. Our assumption moving forward was that the deck was designed to 4.8kPa. By assessing the various deck spans/reinforcing on each side of the pool, we were able to confirm the slab capacity was sufficient for 4.8kPa.

2 GETTING ACQUAINTED

With a clear understanding of the building's structural components, determining the current condition provides a baseline or framework for rehabilitation and the capacity for change. Where is it at, and given that information, where can we take it?

Visual review of the building and input from the city maintenance personnel, facility management and engineers did not identify any signs of global structural distress or movement. As well, the use and occupancy of the facility was not being modified, therefore assessment and remediation of the primary gravity and lateral systems was not included in the project scope. However, many areas of localized structural element deterioration were identified. Two separate investigations of the structure were performed to ascertain the level of deterioration and remediation required to be undertaken as part of the overall rehabilitation. The first investigation was of the building interior and focused on the pool deck, tunnel,

and interior precast elements. The second focussed on the exterior, primarily the precast natatorium roof structure and the masonry infill walls.

Unfortunately, as many structures, years of moisture in combination with chlorides had taken its toll.

2.1 Utility Tunnel

Evidence of water seepage from the deck slab into the tunnel below was observed, and as a result significant efflorescence and spalling/delamination was present. In some locations exposed corroded reinforcing was visible. Although localized, some areas of deterioration are significant. The likely cause of the deterioration is a failure in the waterproofing membrane primarily at the construction joists in the deck slab. The tunnel is also a small confined area with little to no ventilation resulting in a high humidity environment, add in the corrosive pool water treatment chemicals, and a prime environment for reinforcing corrosion and concrete spalling has been created.



Figure 3: Tunnel deterioration

Along the north edge of the pool deck at the base of the bleachers, the cast-in-place beam and supporting columns have also suffered significant deterioration. In this area the supporting columns extend up beyond the top of deck to pick up the bleacher beam loads. At the deck elevation, the beam was cast around the precast columns, and according to the base building drawings, top reinforcing is doweled through the precast columns, cast into the beams. The beams rest on plain steel brackets (no corrosion protection identified) embedded into the precast columns. Over the years water has worked its way through the joint between the beam and column and corroded the connection brackets resulting in significant deterioration.

2.2 Natatorium Precast Elements Supporting Roof

On the east and west end of the natatorium space, the precast roof lin tees bear on precast beams. The precast beams at the north and south elevation bear on precast columns and connect to the side of the column at the end of the beam span. The next beam is simply supported between columns. At the center bay, the precast beams cantilever over columns, meeting at the center of the building. The connections between the beams/columns are embeded steel angle supports, that have been painted repeatedly over the years. At the south and north elevations and the center bays where the beams cantilever, the beam is dowelled into the top of the columns. Moisture appears to have travelled through the exterior wall and corroded the steel connection brackets and column-beam dowels. Figure 4 shows the vertical cracking that has occurred at the top of the columns and at the connection brackets.



Figure 4: Natatorium precast beams and columns

2.3 Exterior Masonry Walls

The exterior infill walls are constructed of 8" thick concrete masonry blocks on the east portion of the building, and 10" thick concrete masonry blocks around the perimeter of the natatorium. The block cells contain vermiculite insulation. The exterior face of the block is scored to look like brick veneer. The interior surface is scored in the same manner with a square pattern. Both the interior and exterior surfaces are painted. The building doesn't have any cladding or envelope system, and joints between the masonry and the precast columns appear to be mortar on the face shell of vertical joints and a compressible substrate with sealant at the horizontal seam between the masonry and the precast beams. The space between each lin tee stem houses a window. Over the years the exterior sealant at the windows and the precast to masonry joint has deteriorated, forming a path to carry water and moisture from the exterior to interior.

All elevations of the building were observed to have areas that had been previously patched. Upon closer inspection, it was apparent that the portion of the block that protrudes to form the 'brick' pattern had broken away and in many areas been repaired repeatedly. The face shell concrete in select areas was highly degraded and had become 'soft' or easily crumbled.

The climate in Edmonton shed's light on the possible sources of this issue and the humid environment on the interior of the building. Moisture is at the source of this issue as well. Several possible methods for moisture becoming trapped in the exterior block exist:

1. Humidity: Although painted, the likelihood is the block is not completely sealed, especially given the scored surface pattern, making it challenging to coat the surface evenly. Any cracks, gaps, or expose masonry provide a path for water vapour to penetrate the blocks.
2. Water: Water due to rain and snow can accumulate on the top ledge of the fake mortar joints in the block and migrates into the block.
3. Seams: Sealant and mortar joint between the various elements are susceptible to degradation due to weather, sun, structural movements, and age. Areas where these have broken down create a conduit for moisture into the masonry block and the interior of the building.

During the winter months the temperature gradient varies from a maximum of -31 degrees Celsius on the exterior to 29 degrees Celsius on the interior. The relative humidity varies as well from ~40% on the interior to a range of roughly 30% to 100% on the exterior. Both the temperature and humidity gradient through the exterior walls creates a favourable environment for frost and moisture to accumulate, via means previously described within masonry. This moisture trapped due to the painted interior and exterior surfaces, in

combination with freeze-thaw cycles has led to delamination of the exterior 'brick' surface, and overall degradation of the concrete face shell.



Figure 5: Exterior masonry

Although the exterior face has degraded, the question remained whether the block integrity had suffered significantly. Repeated attempts had been undertaken to repair the exterior surface, however, the underlying cause was not overcome, requiring a more permanent solution.

3 NEW TRICKS

What is the desired result of the project? The project goals established at the onset are as follows:

1. Improve energy efficiency of the facility
2. Provide a safe and healthy environment for users and remain a destination within the community.
3. Transformation to a contemporary aquatic facility including full accessibility for patrons, meet current swimming pool standards, and conversion to a salt water treatment system.

In order to achieve these goals, the following major scopes of work were required. All having significant structural considerations.

3.1 Mechanical System

The facility ventilation was significantly lacking in comparison with current code requirements. New air handling and heat recovery units were required. The pool deck drainage was insufficient, leading to areas of standing water. Piping in the tunnel space below the deck had degraded and was leaking requiring replacement.

3.2 Conversion of Pool to Salt Chlorination System

The City of Edmonton was converting pool facilities to salt chlorination system, requiring additional aquatic equipment, including salt cells, surge tank and acid room. Typical skimmers surrounding the pool were not adequate to support the required water flow. The water level in the pool was therefore elevated to the top of the deck and overflow into a continuous perimeter gutter system independent of the deck drainage. This required detaching the one-way deck slab from the pool wall. Also, by resloping the deck to new drain locations, the dead load on the deck slab would be increased. Refer to figure 6.

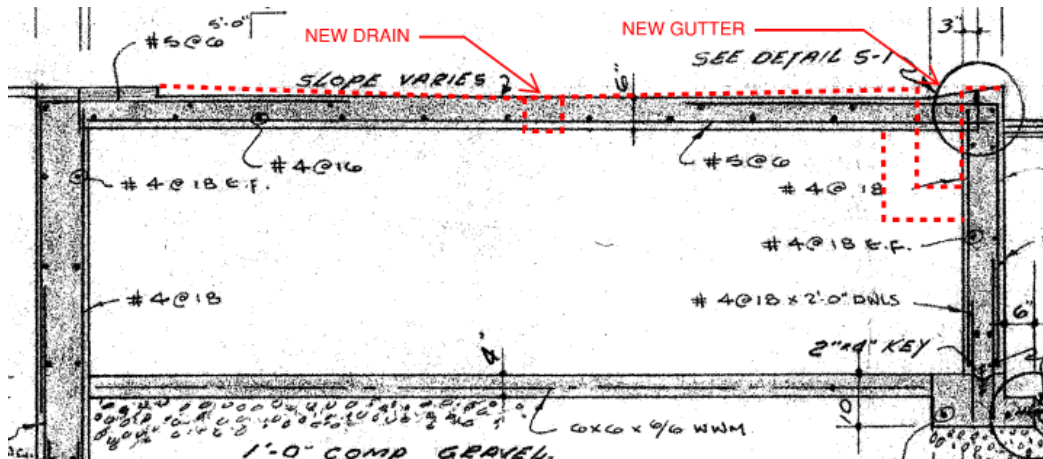


Figure 6: New Perimeter Gutter and Deck Drain Addition (Strong, Lamb & Nelson (1965))

3.3 Recladding

In order to increase building energy efficiency, modernisation of the building appearance and address the degradation and moisture issues on the building exterior, full envelope cladding was proposed. Concerns with integrity of existing masonry walls to support new cladding system were identified early on in the design process.

4 HOW TO GET THERE

Once the structural system and current condition are known, the process of designing for the clients needs within the framework of what is known can begin.

4.1 Mechanical Units

The challenges associated with the new mechanical units stemmed from lack of available space to locate them. The mechanical and electrical room would not have sufficient space due to the new equipment required for the salt chlorination system as well as electrical room, acid room and code required equipment clearances. Several locations were proposed, one being to locate the new units on the low roof of the building. Structurally, this posed a big challenge for many reasons. Originally, three new units were proposed, two heat recovery units and one air handling unit. The additional weight due to the units was approximately 130kN. All units would accumulate snow drift around the perimeter and would occupy almost the entire low roof. Because reinforcing would be required for the units and associated drift, by code the drift from high to low roof would also have to be considered. The base snow load in Edmonton had also increased by roughly 50% since the 1960 code. The drift from the high to low roof alone was calculated to be 6.25kPa and extended 8m onto the low roof. Refer to figure 7. What seemed like a straightforward solution proved to have major impacts to not only the roof, but all elements of the gravity system supporting this roof when current code requirements were accounted for. Ultimately, the design team and the city agreed to locate the new mechanical units on pile supported exterior slabs at the south-east corner of the building.

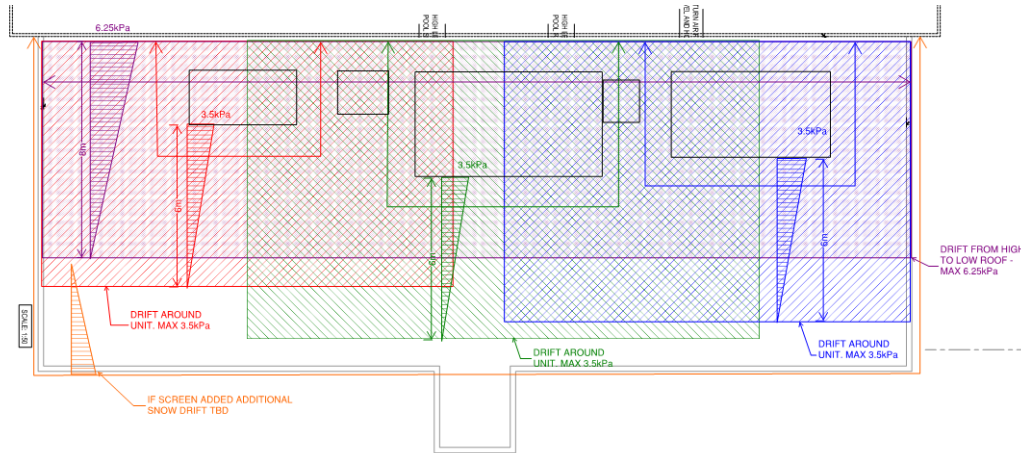


Figure 7: Additional loads due to new rooftop units

4.2 Perimeter Gutter

The gutter support system exemplifies the iterative, collaborative design process. The design objectives for the gutter system were developed over the course of schematic and design development:

Conserve as much space as possible in the utility tunnel space below the deck for aquatic, mechanical and electrical services, eliminate need for temporary shoring, reinstate structural support for one-way deck slab, maintain existing pool lights, keep solution constructible.

The first option explored was to create a concrete gutter structure spliced with the existing slab and dowelled into the pool wall. Due to the condition of the existing slab from the structural review and considering the deck span (up to 14'-2"), we opted for support system creating a clear load path and preventing the potential for deflection and cracking issues. Also, the system could be incorporated to act as the temporary slab shoring, eliminating the need for temporary shoring design and assembly onsite. The cut edge of the slab would be supported on a steel w-section spanning between steel columns, supported on shallow spread footings. A concrete gutter would be cast against and supported by the w-section through bearing and composite behaviour using nelson studs. The pool gutter would be supported at the pool wall with reinforcing dowels. Several layers of water protection were incorporated into the final solution including new water proofing membrane, water-stop at all seams or joints in the new concrete, and C-1 concrete mix, with crystalline waterproof additive.

Several iterations of this proposed solution were developed for various reasons stemming from an array of desired outcomes. Figure 8 illustrates the iterative design process and various gutter sections at different stages of design.

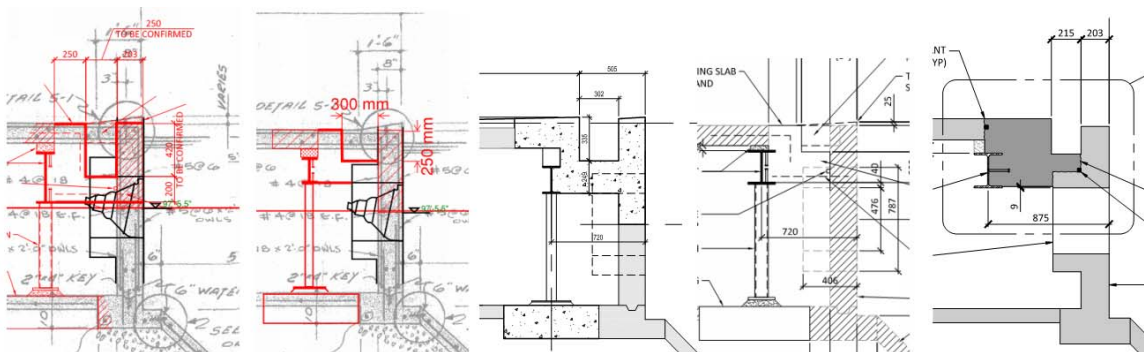


Figure 8: Gutter design process

The project delivery method was chosen as a Construction Management contract. Once the drawings had been reviewed, the CM requested that the design team entertain the option of casting the entire area below the gutter as solid concrete, which would save a certain amount of formwork costs, but increase concrete costs. The CM was also hopeful that this would eliminate the need to selectively demolish the tunnel slab for footings. After evaluating the benefits and disadvantages, this option was eliminated. At the request of the CM, the slab cut was pushed back to 900mm from the inside face of the pool wall, which would make the demolition easier and allow a worker to walk unconstrained around the perimeter of the pool and allow the new mechanical plumbing and ductwork installation in the tunnel much easier.

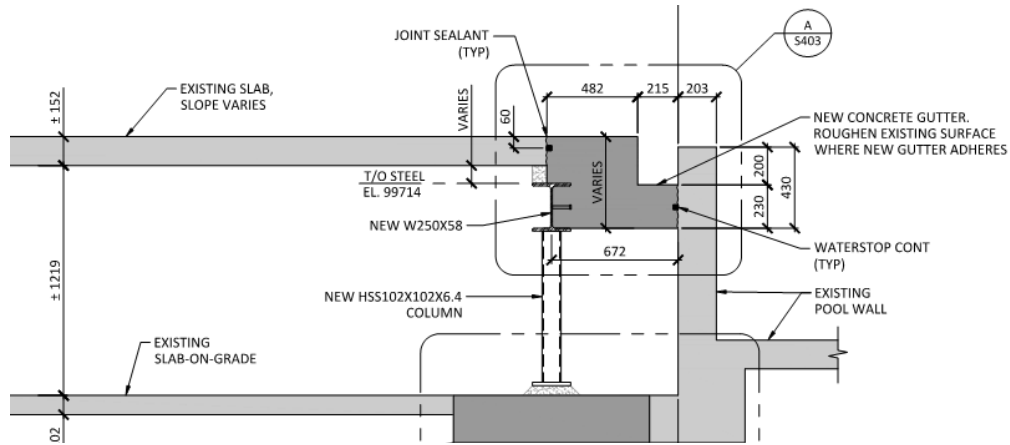


Figure 9: Final Gutter Geometry

4.3 Building Recladding

To revitalize the building's exterior appearance and protect and preserve the condition of the exterior walls, full building envelope cladding was required. Due to the level of deterioration observed on the exterior face shell of the concrete, concerns regarding successfully fastening the cladding girts to the exterior walls were identified. A building envelope contractor and anchorage manufacturer carried out anchorage loads tests on the exterior walls in all conditions identified: sound block, deteriorated block and previously repaired block. The anchors were tested to failure to determine the anchorage capacity that could be achieved in the masonry face shell. These results were provided to the cladding contractor for cladding design purposes. Destructive testing at the vertical joint between the masonry infill and precast columns was also performed. The mortar joint was consistently deteriorated. Repointing of this joint was incorporated into the rehabilitation to maintain the structural system of the building as originally designed.

4.4 Concrete Restoration

The challenges with the concrete restoration include risks associated with the actual level of deterioration once the restoration process begins. The structural integrity of the elements may be compromised more than anticipated. Consideration is required for the repair conditions, and appropriate methods to be used including shoring, constructability and appropriate patch repair materials. The repair solution must fulfill the need for future corrosion prevention as well. In our case, due to the chlorinated pool water, when the new patching material is installed there will be a differential in the chloride ion concentration in the concretes, which will promote corrosion. To address this issue, sacrificial anodes must be cast into the repair. Due to the corrosion level of the embedded bracket connections, galvanized gusset plates were designed to supplement the existing brackets. This work being undertaken at this facility shows the results of insufficient structural monitoring and regular repair as required.

5 FINAL PRODUCT

Although the project at onset was labelled as a rehabilitation, implying a restoration, the final design represents a significant revitalization and upgrade of almost all buildings systems.

The project exemplifies the challenges associated with rehabilitating and altering existing structures. Working with limited information, which is often inaccurate, requires a highly cyclical design process: evaluating various options, discovering or uncovering information as the design progresses that then influences past and future decisions.

Significant changes in building codes from original design and construction can result in significant impacts on existing structures. Changes in load requirements, architectural considerations i.e. accessibility, accommodating new mechanical, electrical and aquatic equipment all in a limited space. Consideration for constructability within the physical limitations of the building, and operational needs during construction also exist. Deferred maintenance items (leaking pool deck membrane and standing water), or band-aid solutions (repeated patching of exterior masonry), resulted in significant deterioration requiring significant restoration.

With public facilities, often a large stakeholder group is involved. In our case it included building operations, maintenance, finance, project managers, the design team, the City of Edmonton project review engineers as well as the CM. Coordination was also required with construction projects adjacent to the facility undergoing redevelopment. The large group of decision makers and project coordination resulted in a long decision-making process. Funds for public facilities are often drawn from a number of sources, therefore the final project budget and scope was uncertain until construction was underway.

Currently work onsite is only in the very preliminary stages but based on past experience risks associated with found or unforeseen conditions onsite, construction phasing and sequencing still remain and will require careful consideration to resolve.

Through significant collaboration amongst all parties, the final building design achieves the project goals and will result in a facility seemingly new, but in fact the outcome of a mindful, creative alteration of a community landmark.

Project Team

Client: The City of Edmonton

Design Architect: GEC Architecture

Structural Engineer: Entuitive

Mechanical Engineer: Remedy Engineering

Aquatic Consultant: Water Technology Inc.

Electrical Engineer: SMP Engineering

Construction Management: Chandos Construction

References

National Research Council Canada. 2014. Alberta Building Code.

Canadian Standards Association. 2014. S304.1-04 Design of Masonry Structures

Canadian Standards Association. 2014. A23.3-14 Design of Concrete Structures

Canadian Standards Association. 2014. S16-14 Design of Steel Structures

Strong, Lamb & Nelson Consulting Professional Engineers. 1965. City of Edmonton Bonnie Doon Swimming Pool

Strong, Lamb & Nelson Consulting Professional Engineers. 1965. City of Edmonton Bonnie Doon Swimming Pool

Con-Force Products LTD. 1966. Bonnie Doon Swimming Pool – Pre-cast Details

PCL Associates LTD Structural Consulting Engineers. 1987. Bonnie Doon Swimming Pool Whirlpool/Steamroom