# APPENDIX A
## Structural Report

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# Crystal Pool
## Structural Condition Assessment Report

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## 1.0 INTRODUCTION

In accordance with the RFP issued by the City of Victoria, a structural condition assessment of the existing facility was performed. The purpose of the structural review was to comment on the existing structural condition as observed during visits to the site, provide recommendations as to structural repairs that may be required in the near term, and to assess and comment on the seismic capacity of the existing facility, compared with seismic design and detailing requirements mandated by the current British Columbia Building Code.

## 2.0 DESCRIPTION OF STRUCTURE

Original structural drawings for the Crystal Pool (titled "Community Aquatic Complex") by Willis, Cunliffe, Tait & Company Ltd., and dated November 14, 1969 were available for our review. The facility was constructed in 1971.

The building roof construction consists of metal roof decking supported by Open Web Steel Joists (OWSJ). The joists span between structural steel trusses, which are supported by steel wide-flange columns.

Over the main pool area, two Acrylic domes are supported by custom designed and fabricated aluminum support beams (the structural drawings refer to specifications for requirements) which are supported at the roof level by structural steel ring beams. A similar, but smaller, dome is located on the lower roof above the tot's pool at the east end of the building.

At the north and south side of the building, low roof areas consist of 6" semi-lightweight precast "core-planks", supported by steel wide flange beams, and by load-bearing giant brick masonry units at the exterior walls.

Pool deck areas and the bleachers consist of minimum 6" deep cast-in-place reinforced concrete slabs, suspended over basement areas below (deck slabs varying in thickness in order to provide floor slopes). Concrete support beams transfer floor loads to concrete columns primarily, and to reinforced concrete masonry pilasters in some locations.

At the west end, a section of raised floor has been added on top of the original concrete bleachers, consisting of steel stud pony walls and steel light-gage joists. The 1 1/2" metal decking is most likely overlain with plywood sheathing (existing rubber flooring conceal the top surface of the floor structure).

The basement floor is a 6" thick concrete slab-on-grade reinforced with welded wire mesh, while building foundations consist of reinforced concrete strip and spread footings.

The pool and gutters are constructed with reinforced concrete walls, with a reinforced concrete slab-on-grade forming the bottom of the pool.

Resistance to wind and seismic lateral loads appears to be provided by horizontal steel bracing below the roof decking, with perimeter roof trusses transferring loads to the lower roof levels. Perimeter giant brick walls transfer lateral loads to the foundations.

# 3.0 EVALUATION

## 3.1 Building Code Issues

The original building was most likely designed to meet requirements of the Building Code in effect at that time, which was the 1965 National Building Code (NBC). The floor infill area added at the west end in circa 2005 should have conformed to the British Columbia Building Code 1998 (based on NBC 1995).

Notes on the structural drawings indicate that the design snow load for the roof was 20 psf (approximately 1.0 kPa). Current snow loads in Victoria are roughly 50% higher than this, with basic roof snow loads in the order of 31 psf (or 1.5 kPa).

The current British Columbia Building Code (BCBC 2006) which is based on the NBC 2005 contains numerous changes from previous Codes, including much more onerous seismic connection and detailing requirements than those specified in earlier editions. A detailed seismic evaluation of the structure has not been completed, however based on the age and construction type of the building; we anticipate that the ability to resist seismic loads may only be in the order of 20% when compared to current Code level design forces.

The facility is not deemed a "post-disaster" facility, and therefore the Code suggests using 60% of current seismic design loads when designing a seismic upgrade for the facility.

It is also a Code requirement to provide seismic restraints for non-structural operating and functional components (OFC's). There is most likely existing mechanical and electrical equipment and interior masonry partitions that do not have adequate seismic restraints. In addition, suspended T-Bar ceilings and other Architectural elements do not currently have seismic restraints. These elements should also be addressed during any retrofit program (any new mechanical and electrical equipment that may be specified are anticipated to include seismic restraints as part of the project requirements).

## 4.0 CONDITION SURVEY AND COMMENTS

In general, existing finishes conceal much of the structure from direct view. The cast-in-pace concrete bleachers and concrete up stand balustrades exhibited shrinkage cracks of varying size. Many were hair line, while most of the larger cracks have been routed and caulked (although the caulking was observed to be absent in isolated locations). Small shrinkage cracks were observed in some of the concrete beams as well. The shrinkage cracks observed are not of structural concern, and the caulking will mitigate moisture access to the existing reinforcing steel at the larger cracks.

At the North West corner, the existing concrete bleachers have had sections cut away in order to accommodate the addition of a water slide. New structural support columns and footings were observed in the basement area, which were also added as part of the water slide installation, so there is no structural concern with the modifications to the existing bleachers.

At the tot's pool area, efflorescence was observed in several locations at the inside surface of the perimeter giant brick wall which suggests moisture migration through the wall has occurred. Ceiling finishes in the same area display some evidence of moisture damage, which may indicate moisture access through the roof has occurred.

Along the top of the wall separating the tot's pool from the main pool (which corresponds to the main pool deck slab elevation), there are a number of areas where the concrete has spalled, and in some cases loose sections of concrete appear ready to break off and fall. This is a result of corrosion of the embedded reinforcing steel within the concrete due to moisture access. Similar spalling was noted along the top of the wall at the stairs leading up to the exterior door at this end of the building as well.

In the basement and boiler room areas, perimeter concrete masonry walls also displayed efflorescence in numerous areas, again suggesting that moisture is penetrating the block walls. This is not of immediate structural concern, however if moisture is allowed to access reinforcing steel contained within concrete or concrete masonry elements, the reinforcing steel may corrode.

Where existing roof structure was visible (above ceiling finishes when accessing the upper roof through the roof truss areas) the steel appeared in very good condition, with minimal evidence of surface rust observed.

In some locations at the perimeter wall, natural light was observed to penetrate the conventionally framed (wood) construction supporting the exterior stucco finishes. Subsequent destructive investigations in selected areas revealed secondary support framing for the rock dash stucco that consisted of steel members secured with tie-wire, which was heavily corroded in many areas.

At the pool deck level, structural steel support posts for the two diving boards displayed surface rust at the base of the columns (just above the pool deck). The amount of rusting has not resulted in significant loss of steel area at this time, so the structural capacity is not deemed to be significantly reduced as a result.

The steel ring beams around the base of the two acrylic domes on the upper roof displayed signs of corrosion (rust) below existing flashings. The amount of rust appears significant, however due to the size of the heavy steel sections (box sections built-up from 5/8" thick plates) the actual percentage of steel area lost due to corrosion is not anticipated to cause significant reduction in structural capacity. The connections of the dome aluminum support structure to the steel support ring beams may be more significantly affected if corrosion-induced deterioration is occurring, however we could not observe the connection details, and no drawings for the dome structure were available for review.

The supports for the suspended T-Bar ceiling within the pool area also displayed surface rust at the pool side. While this is a non-structural (or secondary structural) element the rust indicates that the supports are deteriorating, and should this deterioration continue, portions of the supports may fail at sometime in the future. Unlike the steel support ring beams discussed above, the ceiling support members have much less material, so area loss due to corrosion leads to much more significant loss of structural capacity. It is difficult to determine how much corrosion has occurred, and subsequently the remaining structural capacity is also difficult to assess. Given that the ceiling support structure is not currently seismically restrained, it may be that replacement of the corroded support members at the same time as installing new seismic restraints may be more economical than attempting to assess the existing structural elements for partial replacement

## 5.0 CONCLUSIONS

In general, the exposed structure appears in reasonably good condition for its age, but some areas require attention in the next twelve months. The concrete delaminations noted in the walls adjacent to the tot's pool pose a falling hazard which is of greater concern than the possible reduction of concrete capacity. These areas should be repaired to reduce the potential for pieces of concrete to break loose and fall.

The secondary supports for the rock dash stucco that are secured with corroding tie-wires should be addressed in the next 1 to 5 years. While there is a certain amount of redundancy available due to multiple tie-wires and multiple wraps, the corrosion observed is significant and on-going corrosion could lead to a failure. This could represent a falling hazard to areas below the stucco.

Where caulking is missing in routed cracks in the concrete bleachers, reinstating the caulking is required to provide on-going mitigation against water access to the reinforcing steel contained within the structure.

## 6.0 CLOSING COMMENTS

The existing Crystal Pool structure continues to adequately support the gravity and wind loads imposed on it, but would require structural modifications in order to meet current Building Code requirements. As discussed above, the roof design does not meet current snow load design requirements, although upgrades to the existing structure to increase the capacity to support higher snow design loads may not be deemed warranted in light of the potential costs associated with strengthening the existing steel structure.

Where renovation plans include the addition of new mechanical equipment to existing roof areas, localized structural upgrades would be required to accommodate the weight of the new equipment, as well as the local build-up of snow adjacent to such equipment.

The scope and nature of modifications required to increase the seismic capacity of the complex will be somewhat dependant on the level of upgrade mandated (60% to 70% of current Code level forces would be anticipated) and to what extent such upgrades may be installed without significant impact to the current programming requirements of the facility. New upgrades may include such items as:

- Upgraded connections of the structural steel bracing and roof truss members.
- Upgrades to member sizes in the roof bracing and roof trusses transferring lateral loads.
- Upgrades to existing giant brick walls, possibly with the installation of new reinforcing steel and grout within the existing brick, or with the addition of new concrete shear walls or other similar lateral resisting elements.
- Potential upgrades to foundations at new (or existing) lateral resisting elements.