FACILITIES ASSESSMENT
South and Lowell City Pools
Structural Assessment February 2022

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Background

This Structural Assessment is provided as a follow up to the Feasibility Study Lowell City Pool completed jointly by Aquatic Design Group and Cushing Terrell dated June 2021.

As indicated in the previous Feasibility Study the Lowell City Pool is a valuable asset to the City of Boise and the neighborhoods in the vicinity of the current pool. This existing facility has historically served the area well but is now nearing the end of what would typically consider its useful life. As a result, this Structural Assessment was performed in an effort to determine the feasibility of potentially incorporating this existing pool facility into future long-term plans for the Lowell pool site.

Structural Information Available

Design documents for the original pool structure were not available. General information for the existing pool facility was however available via plans titled "Remodel of Lowell and South Pools" dated March 1992 prepared by Armstrong Architects.

The existing plans showed geometric layout of the pool structure drawn to scale, without providing overall dimensions. Key notes on plan sheets included legend numbers reflected on plans, illustrating existing and new work, and components of the structure. There are no design loads specified on the documents as would be standard practice today.

These existing drawings did not contain info pertinent to the structural design of the pool required to analyze the existing pool structure. As a result, Cushing Terrell worked with the City of Boise and ATLAS to perform a GPR survey of the existing structure to identify the following general structural design parameters:

- Pool deck thickness and reinforcement
- Pool floor thickness and reinforcement
- Pool walls type, thickness, and reinforcement
- Connection between pool deck and walls

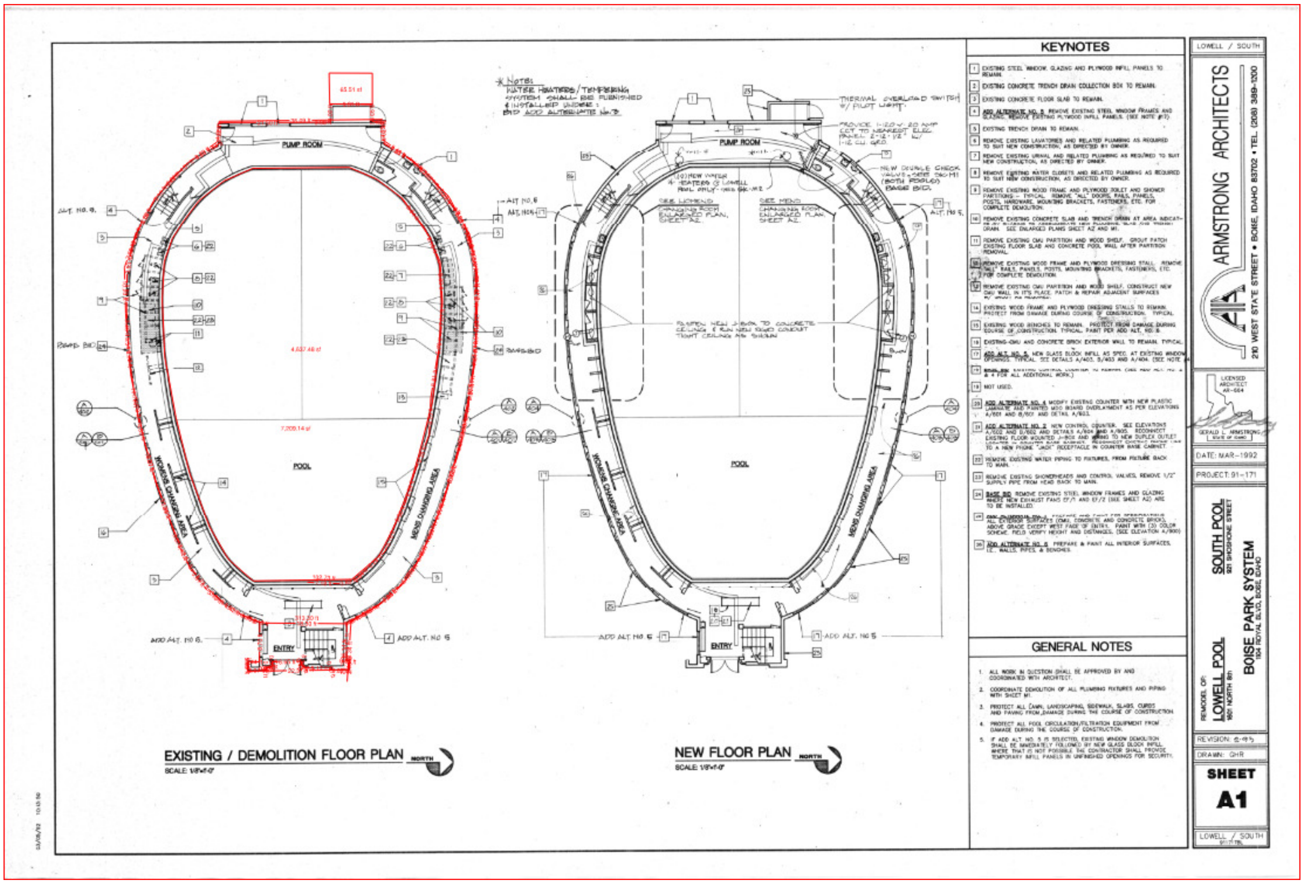

Figure 1: Existing Drawing Showing Plan of Lowell Pool

Results of this scanning of the existing structure are presented in the GPR report prepared by ATLAS dated October 2020, presented below:

The pool slab is 5 in thick, reinforced with #4@18in rebars each way. The pool slab is engulfed by 13 in thick concrete walls, reinforced with #7@4'' horizontal outer bars, #7@8" vertical outer bars, #7@4'' horizontal inner bars, and #7@24'' vertical inner bars. On the outside face, a hollow masonry wall along with the 13 in concrete wall supports a 7 in thick pool deck, reinforced with 1 layer of #4@12'' short way rebars, and #4@6'' long way rebars. 2 stairs openings (north & south) exist, along with two chlorine rooms east and west. The west chlorine room slab is 8'' thick reinforced with #4@6'' short way rebars, and #4@8'' long way rebars, supported on 6'' masonry block wall. The pool deck and pool wall do not appear to be positively attached with reinforcing as both elements contain reinforcing that appears to stop at the intersection of the two elements and does not continue into the adjacent element.

Supplemental testing of the concrete to approximate the in-situ compressive strength of existing concrete and CMU elements was performed by Cushing Terrell on 01/19/2022. Using the concrete rebound hammer, Cushing Terrell confirmed that using a compressive strength for concrete elements of 4000 psi, and compressive strength of CMU of 1500 psi was reasonable representation of the in-situ concrete.

Structural Analysis

The structural analysis presented below was performed in to evaluate the adequacy of the existing pool structure in general conformance with ASCE 41-Seismic Evaluation and Retrofit of Existing Buildings and includes analysis of the structure to resist both gravity and lateral (Wind and Seismic) forces.

As mentioned prior, structural design loads were not indicated on the available drawings. As such a finite element structural analysis of the pool using the information available presented above was undertaken to validate the adequacy of the existing structure for current code required loading as presented below:

- 10 psf superimposed dead load on pool deck
- 100 psf Live load on pool deck (ASCE 7-10 chapter 4 evaluated as a terrace/exit way)
- 50 PLF rail loading on outer wall
- Wind load ASCE 7-10 (Free Standing Wall) - 102 mph design wind speed
- Seismic load ASCE 7-10 – Chapter 15 (Seismic Design Requirements for Nonbuilding Structures
- Importance Factor 1.0

A finite element analysis model was created using the analysis software Ram Concept to analyze the pool deck, and a 3D ETABS model was created to analyze the overall structure behavior and compute the stresses on the supporting elements resulting from lateral wind and seismic forces. Elements of the structure were modeled based on limited existing drawings and field investigation findings.

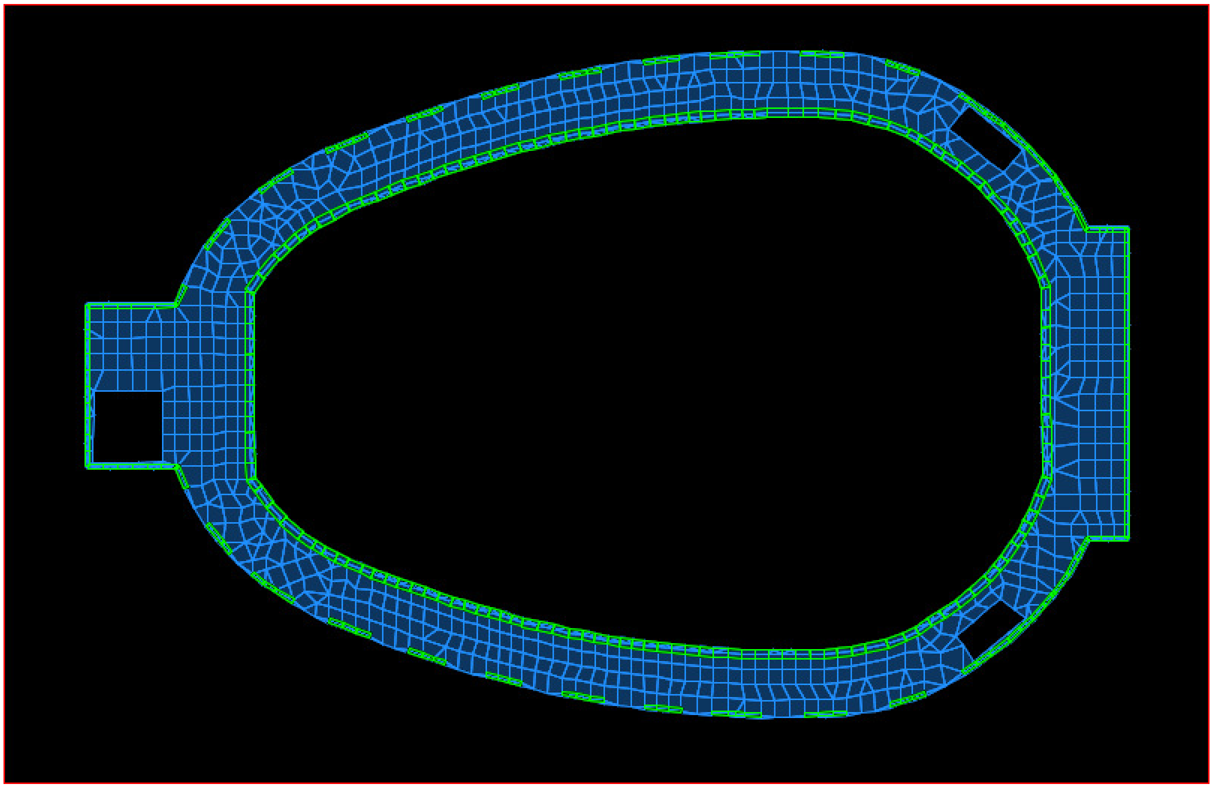

Figure 2: Plan of Ram Concept Design Model of Lowell Pool

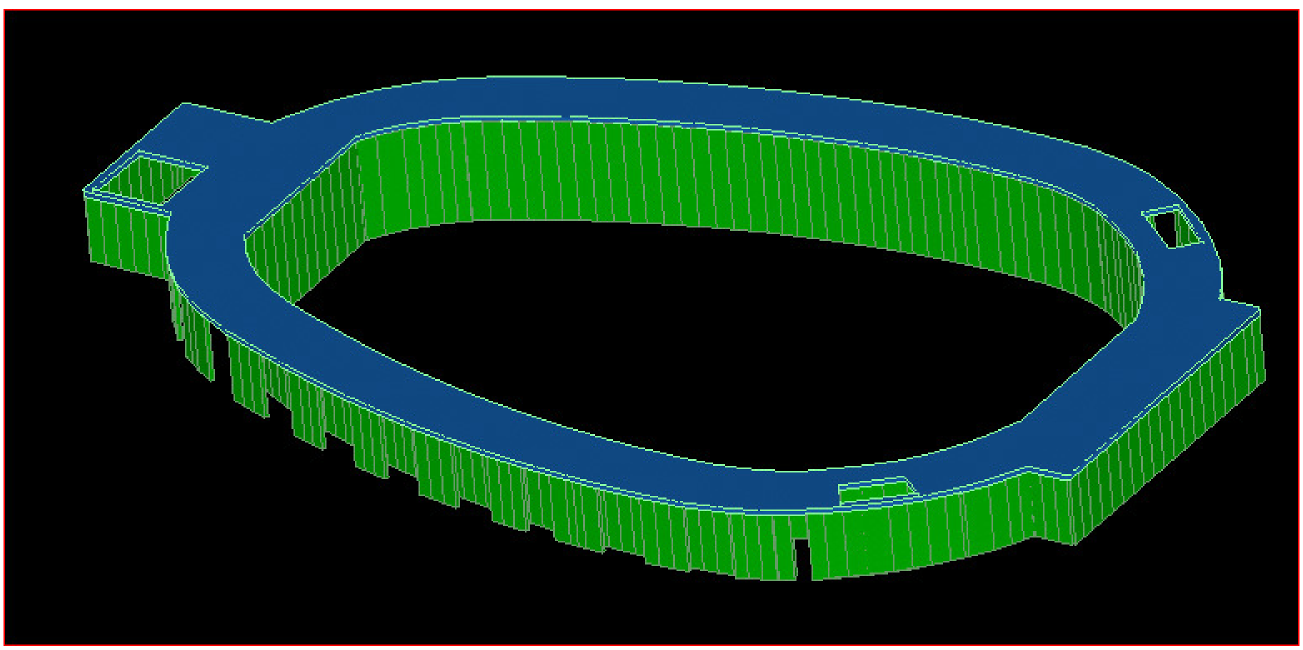

Figure 3: 3D View of Ram Concept Design Model of Lowell Pool

Load combinations followed by ASCE 7-10 for the Basic Combinations (LRFD) were applied to investigate the performance of the structure related to current design philosophy. Modeling sequence used the following approach. The model was evaluated as cracked concrete, reducing the moment of inertia by a factor of 0.35, applying LRFD load combinations of dead and live load. Applicable rebar based on field investigation was incorporated. The slab passed the strength checks regarding shear and moment, hence rendering the pool deck safe. Slab stress in all areas did not exceed the design capacity of φVc based on a 4000psi concrete strength. In addition, flexural stresses of the slab in all areas did not exceed the design capacity of φMn. Moreover, flexural reinforcement provided exceeded the minimum required by ACI code (0.0015xAg = 0.23 in^2/ft < #4@12'' = 0.21 in^2/ft), as well as the spacing of rebar (18'' max). Also, shrinkage and temperature rebar provided exceeded the minimum required by ACI code (0.0018xAg = 0.15 in^2/ft < #4@6'' = 0.42 in^2/ft), as well as the spacing of rebar (18'' max). Long term deflection

The concrete pool wall was conservatively evaluated as a retaining wall in Ram Elements software, retaining 12 ft of water. The wall was modeled based on the field investigation, with appropriate thickness, height, and rebar. Applicable dead and live loads were incorporated into the model, along with lateral loads from water. Although findings indicate that pool deck and pool wall do not appear to be positively attached with reinforcing, it was still assumed that the pool deck braced the wall at the top, hence a pin-pin wall system. Based on the analysis, the pool wall meets design capacity, in which shear and moment capacities were not exceeded. Moreover, longitudinal reinforcement provided exceeded the minimum required by ACI code (0.0015xAg = 0.23 in^2/ft < 1.2 in^2/ft), as well as the spacing of rebar (18'' max). Also, transverse rebar provided exceeded the minimum required by ACI code (0.0025xAg = 0.39 in^2/ft < 3.6 in^2/ft), as well as the spacing of rebar (18'' max). In addition, the pool wall was checked in EnerCalc as a concrete beam against impulsive and convective seismic forces (see figure 5). Both loads were applied in conjunction with a lateral load due to the water in the pool. As such, the pool wall was confirmed to have adequate strength and passed all checks required in terms of strength and serviceability.

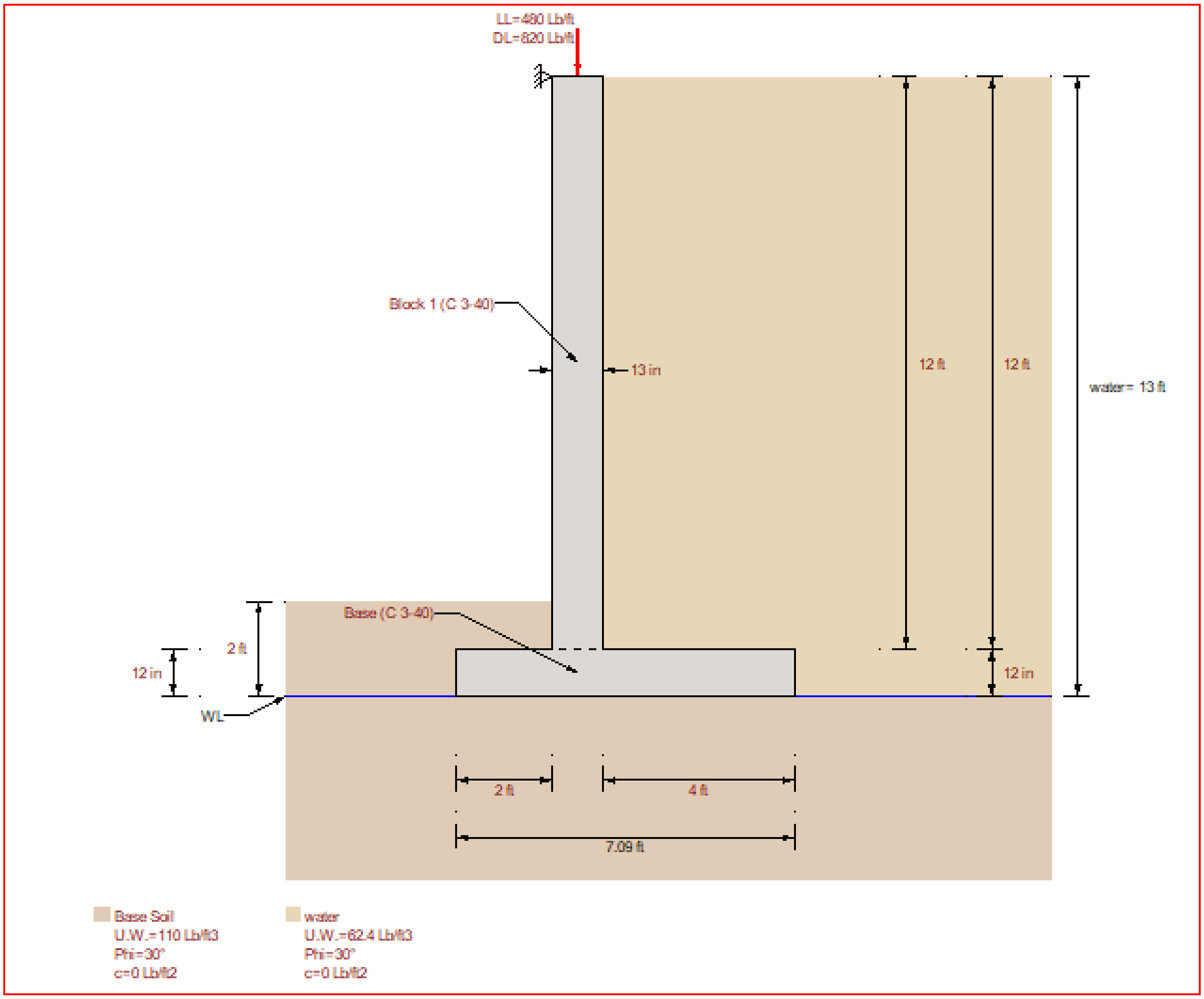

Figure 4: 2D View of Ram Elements Design Model of Concrete Pool Wall

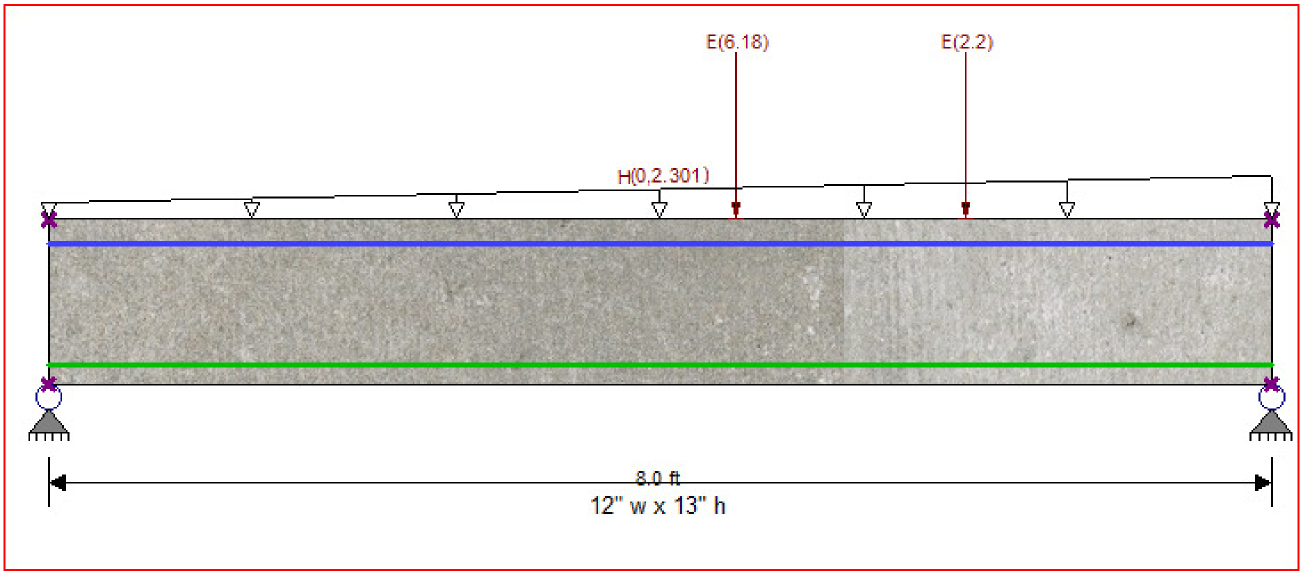

Figure 5: 2D View of EnerCalc Pool Wall Modeled as Beam

The outer CMU wall was evaluated for gravity and out of plane loads in Ram Elements software as an 8 ft tall wall, pinned at top and bottom. Based on field investigation and existing drawings, the CMU wall is a 6'' hollow unreinforced wall. In addition to dead and live loads, a 19.2 psf out-of-plane lateral wind load was applied based on ASCE 7-10 freestanding wall section. The wall's capacity was adequate to sustain the applicable loads.

Figure 6: 2D View of Ram Elements Design Model of Outer CMU Wall

No information was available regarding existing foundations; however, no major deficiencies were observed on the foundations. Typically for buildings on conventional foundations the likelihood for building movement or settlement typically decreases with time as the supporting soils consolidate under building loads. As a result, structures of this age will have typically exhibited signs of settlement if existing foundations are not adequate. With no significant foundation related deficiencies observed these existing foundations have performed well and would be expected to demonstrate similar performance into the future. Structural design of future additions/renovations would typically not impose more than five percent of additional load on these existing foundations as permitted by code.

An ETABS model was created to analyze the overall building behavior against gravity and lateral loads. This includes a total seismic force of 72 kips applied at center of pool in both orthogonal directions due to impulsive and convective seismic forces in addition to seismic force due to the weight of the water within the pool. Seismic forces were calculated using ASCE 7-10 chapter 15.7 (Tanks & Vessels).

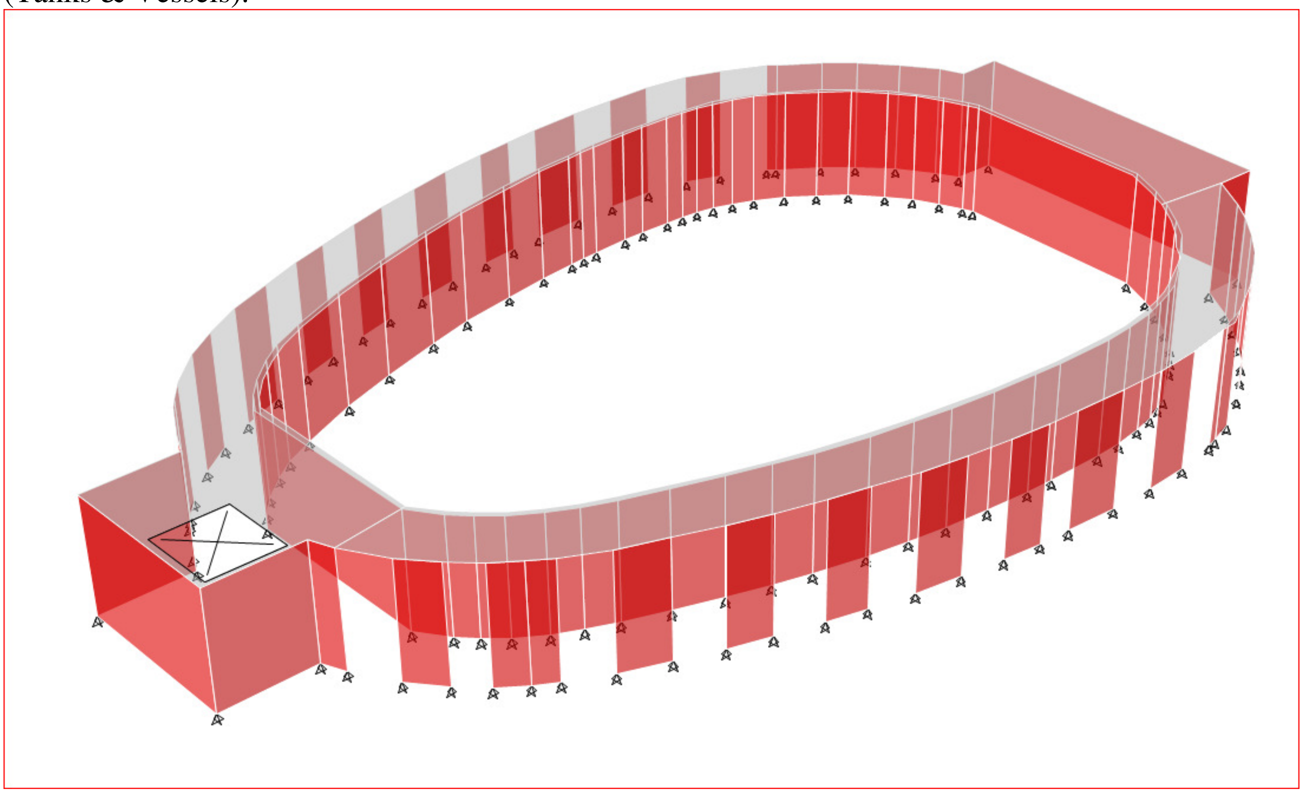

Figure 7: 3D View of ETABS Design Model of Structure

Load combinations followed by ASCE 7-10 for the Basic Combinations (LRFD) were applied to investigate the performance of the structure related to current design philosophy. Modeling sequence used the following approach: Walls were evaluated as cracked concrete and CMU, reducing the moment of inertia by a factor of 0.35 (per ACI 318 code). Pool deck was evaluated as cracked concrete, reducing the moment of inertia by a factor of 0.25 (per ACI 318 code).

Based on this finite element analysis, the existing walls of the pool were found to have adequate strength as the pool walls are below threshold level stresses that would cause the walls to experience cracking and deformation.

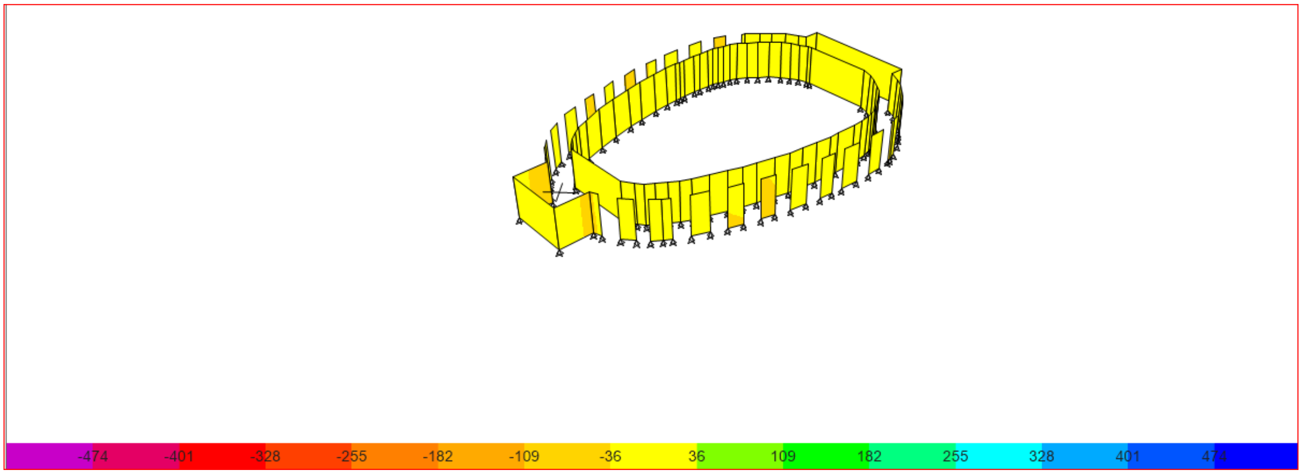

Figure 8: 3D View of ETABS Design Model of Wall Stresses due to Applicable Loads

Infill of the existing stair openings to meet current code required deck minimum deck width is feasible and addressed in the design model, providing reinforcement that dowels into the existing slab.

Potential additions to the existing facility such as addition of exterior stair towers to replace the existing stairways and incorporation of a lift would be designed to meet building codes.

Visual Condition Assessment

On January 19, 2021, a visual assessment of Lowell Pool was undertaken. During this assessment several areas were found to have evidence of deterioration as noted in the photos below. Most of this deterioration appears to be found in portions of the structure have the greatest exposure. In these areas this greater exposure has resulted in continuous wetting/drying of concrete which has led to alkali silica reaction which is a deterioration of the cement past within the concrete. That being said, none of the currently observes areas of deterioration currently present a threat to life safety. If the remaining useful life is significantly extended recommendations have been presented below to address these observed deficiencies.

Figure 5: Deck slab - Minor Topside Cracking

Figure 6: Deck slab – Bottom of Deck Deterioration due to ASR/ Exposed Rebar


Figure 7: Deck slab –Damaged Concrete / Exposed Rebar


Figure 8: Deck slab – ASR/Deck Spalling Under Fence Base Plate / Exposed Anchor

Figure 9: Deck slab – Minor Cracking at Edge of Top Deck

Figure 10: Interior Pool Wall – Minor Cracking

Figure 11: Outer CMU Wall – Minor Cracking

Recommendations

Generally, the pool structure was found to be in fair overall condition. Observed cracking/leaking of the pool does not present a significant structural concern and has been addressed in the previous Facilities Condition Assessment.

Analysis of the pool structure indicates that the existing structure has adequate capacity to meet current code prescribed design loading and as such could be renovated to extend the remaining useful life of this structure if desired.

If the life of the existing facility is extended Cushing Terrell would recommend the following repairs be made to the existing structure to extend the remaining useful life of the structure to the greatest extent practical. A list of these recommended repairs is presented below:

- Interior/Exterior CMU walls – Seal observed cracks and recoat wall surfaces to prevent water intrusion into CMU walls.
- Pool Deck
    - At areas of significant deterioration, sawcut & remove any easily removable concrete around the damaged area. Extend cut 6'' beyond damaged area to competent concrete and replace with new repair mortar.
    - Cut & remove all exposed and corroded rebar
    - Install new rebar matching cut rebar; overlap or weld to existing rebar
    - Remove dust & wash surface with water to achieve a dry surface afterwards
    - Patch damaged area with repair mortar.
    - Seal exposed concrete surfaces to minimize water intrusion into concrete and protect rebar against corrosion.