Stainless Steel Replacement

Community Swimming Pool for the City of South Gate, California

By Richard Hess, S.E., SECB, F. ASCE

This is about the design and construction of a swimming pool. The unusual circumstances and the problems encountered that the reader may find interesting include:

1) The pool's side walls are made of stainless steel covered by a PVC coating.

2) It is located inside an existing building on shallow foundations that were not constructed in accordance with the record drawings.

3) The original pool was designed in the 1970s as a conventional reinforced concrete wall and slab construction, and then changed to an aluminum wall and floor construction without corresponding construction documents.

4) The fill material between the 13-foot deep pool and the shallow building foundations, less than ten feet distant, turned out to be uncompacted granular material that collapsed upon removal of the original pool, necessitating shoring for the building.

For the owner, the City of South Gate, the overall design of the pool was based on the following criteria:

1) The first priority for the South Gate pool was the recreational element – providing for non-swimmers and recreational swimmers, including wheelchair enabled persons.
2) The existing configuration, with ⅓ shallow water and ⅔ deep water was to be reversed, providing ⅔ shallow water.
3) Primary users include: recreational swimmers (largest group), lap swimmers and children of all ages that are not "water safe" and who prefer shallower water, four high school swim teams holding 25-meter competitive events, a growing water polo group, divers at the high school level, and swim teams at the club level.
4) Occasional users include: swimmers in competitive 25-meter events and aerobic class attendees.
5) Preferences for pool features included a large set of entry stairs, an accessible ramp, a diving well to meet high school standards, maintaining the 3-meter diving board, starting the shallow end at a depth of 36 inches to increase slowly to deeper water.
6) A lap swimming area that was at least six feet deep.

The size of the pool was fixed by the dimensions of the existing building and requirements for access and viewing stands. The pool building area is 200 feet by 111 feet 3 inches wide, and the pool is 164 feet long by 75 feet wide. The depth at the deep end is 13 feet and it is 3 feet at the shallow end.

One of the key advantages of the type of construction chosen, which incorporates prefabricated wall panels, is that the side walls are not dependent on the surrounding soil. In fact, these pools can be constructed partially or entirely above ground, as was done for the 2004 Olympic trials held in Long Beach, California. In that project, the pool was temporarily placed on a large asphalt parking lot.

For the Long Beach project, the slope of the lot was compensated for by varying the thickness of the concrete foundation, which was poured over a waterproof barrier to facilitate later removal. Since the foundation was not embedded, lateral forces on the pool walls were resisted by carbon steel straps laid on the lot surface, connecting one side of the pool to the other. The surrounding deck was a wood and steel platform built to the level of the top of the pool. With minor modifications, that could have been a permanent installation with the advantage of having all of the piping and electrical conduit readily accessible.

Most swimming pools built in California are constructed by excavating to the desired depth in natural or compacted engineered soil, placement of reinforcing steel and then shotcreting concrete walls. When this is not feasible because of the lack of adequate soil conditions, formed concrete walls are usually employed.

Formed concrete walls were designed for the community pool in the City of South Gate, California, which is located approximately ten miles south of downtown Los Angeles. The original gymnasium and pool were built in the mid-1970s. However, for reasons unknown at this time, the concrete floor and walled pool were not built and, in their stead, sheets of welded aluminum were placed on the bottom and aluminum walls up to approximately thirteen feet high were installed around the perimeter. Now there are no drawings or calculations available for the design of the original aluminum pool.

This apparently was not entirely satisfactory, primarily due to leaking seams at the joints between aluminum sheets, because a complete stripping of the coating on the aluminum panels was done during a renovation project in 1995 when new coating and paint were applied. However, problems continued until finally, ten years later, it was decided to completely replace the pool.

Swimming pools are contracted for on a design-build basis. When bids were solicited for this location, a concrete pool with gunite walls was questionable because of the unknown soil material that existed inside the perimeter of the building foundations. When the existing

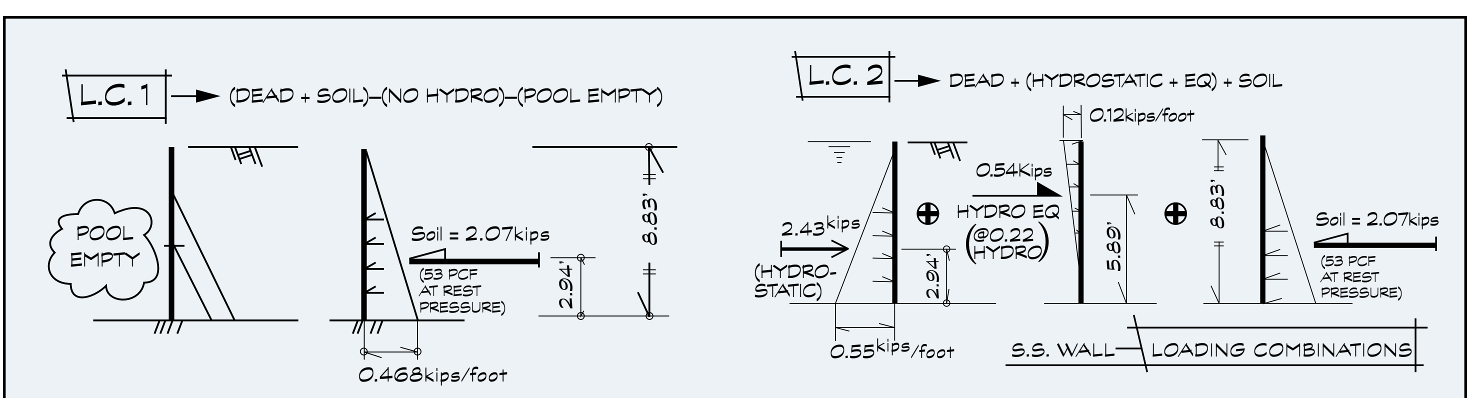

Figure 1: Controlling design conditions.

pool was removed, could the surrounding soil be counted on to make normal cut and shoring possible and leave the building foundations with adequate lateral support?

Competitive bids were returned utilizing three types of construction: I) Shotcrete; II) Formed concrete; and III) Stainless steel wall panels. Since construction would take place inside the existing gymnasium building, which is supported on shallow foundations, the shotcrete option meant that, after the existing pool was removed and the building foundation shored, the area might have to be filled with compacted earth fill. The inner area would then be cut out and removed so that the shotcrete could be applied to the free-standing walls. This would require a very large volume of soil being brought in, and then being removed from the building.

Figure 2: Building foundation shoring struts supported on concrete pads at deep end of pool, before placement of pool foundation forms and reinforcing.

Figure 3: Footing reinforcing at step down to deep end of pool.

Both the stainless steel and the formed concrete wall options would require a minimum amount of excavation beyond the existing pool wall. However, as would be expected, the prefabricated steel wall panels would be more economical and take less time to construct, and this option resulted in the lowest bid. In addition, there was less disruption to the existing facility and less potential damage to the building due to installing a series of three-foot wide panels rather than constructing formwork, installing reinforcing steel, and then stripping and removing formwork for the walls.

The stainless steel pool was proposed by DWR Construction Inc., who has built many similar pools on the west coast. The prefabricated panels were manufactured by Myrtha Pools/A&T Europe S.p.A. in Italy to plans made and approved locally.

A geotechnical investigation was performed by Arroyo Geotechnical of Anaheim, California, in August, 2007. Two borings to a depth of approximately 26 feet were made, near the southwest corner of the building where the deep end of the pool was located. Due to constraints posed by the existing gymnasium building, soil borings were made only on the outside. Therefore, the amount of soil compaction inside the building was unknown.

The soil at the borings consisted of primarily silty sand. The upper ten feet was fairly dense, underlain by approximately 15 feet of less dense material over more dense material. The water table was 24 feet below grade.

When construction commenced, it was found that, after removal of the aluminum walls, the area between the pool and the building foundation was filled with uncompacted material. This material caved in, exposing the building footings on the south and east sides.

Figure 4: Footing poured, encasing base of shoring strut to be left in place.

When it was discovered that the soil inside and adjacent to the building foundation was unstable, the contractor called the structural engineer to observe the condition and recommend a solution. The construction of the building foundation did not follow the construction drawings that were provided. The footings were not as deep as was shown on the plans, therefore their area of influence now intersected the foundations for the new pool. The solution consisted of installing diagonal strut posts bolted to the building foundation and to concrete footing pads which would be incorporated into the pool foundations (*Figures 2 through 5*).

Stainless steel pools, and stainless steel liners for damaged pools, have been used in Europe and in Japan for many years. Their popularity in Japan is at least partly due to their ability to withstand displacement due to earthquakes, in which concrete and FRP pool linings have failed. In Europe, it has been reported that a stainless steel pool structure has been in service for over 40 years without sign of deterioration.

The structural design of a prefabricated stainless steel pool typically receives more scrutiny from plan checkers because of what is often considered a novelty in both construction and in material, and also because it must be designed to stand alone with net forces in either direction. It must be designed to resist active or at rest soil pressure when the pool is empty, putting the support struts in tension. It must also support water on the inside with the possibility of inadequate or no soil support on the outside.

A more critical case, at least in theory from some jurisdiction engineers, is the case of the full pool with seismic excitation and at rest soil pressure outside. Although the argument can be made that these

For more information on the effects of operating conditions and maintenance on the choice of stainless steel pools, see *Swimmingly Stainless Pool Design* by Catherine Houska and James Frits, December 2005, The Construction Specifier.

Due to the structurally indeterminate stress relationships with these prefabricated panels, brackets and support struts, RISA-3D Version 7.0.0 was used in the analysis of the members supplied by the manufacturer. However, since stainless steel has a different stress-deformation relationship than carbon steel, none of the currently available finite element software procedures are applicable without special adaptation to the input based on first estimating where you will be

Figure 5: Foundations and partial slab at deep end of pool - showing diagonal shoring struts for building foundation.

are rather extreme combinations of possible conditions, it has been found that it makes little difference in the final design. This allowed designers to obtain plan check approval without drawn out educational effort, or changes and reruns of the calculations.

Project Participants:

Owner: City of South Gate, California
Paul Adams, Director of Parks & Recreation, Department of Parks & Recreation
Steve Costley, Recreation Superintendent, Department of Parks & Recreation
Abdulla Ahmed, Senior Engineer, Public Works Department of Engineering
Contractor: Douglas Roberts, President, DWR Construction Inc, Los Alamitos, CA
Architect: Meg Beatrice AIA, Principal, Architecture M Inc, Long Beach, CA
Structural Engineer: Richard Hess, President, Hess Engineering Inc, Los Alamitos, CA
Pool Design: Thomas Anderson, President, Water Design Inc, Murray, UT
Pool Manufacturer: Trevor Tiffany, President, Myrtha Pools USA Inc, Sarasota, FL
Geotechnical: Ross Khiabani, President, Arroyo Geotechnical, Anaheim, CA

on the stress-strain curve and then adjusting to the computed results. The controlling design loading conditions are shown in *Figure 1* (*page 33).*

The material for the pool was AISI 304 stainless steel with R_{P02}, unit charge of shifting from proportionality 0.2%, considered F_Y, equal to 26 KSI and R_M, unit charge of breakage at traction, considered F_U equal to 70 KSI.

The RISA-3D analysis provided stress checks for the plate, vertical Z brackets at panel edges, horizontal channel braces and diagonal angles. The unit code check for the diagonal angles was 0.89 for the tallest (8-inch) panels. The other member checks were 0.60 or lower.

The Type 304 panels, which are approximately three feet wide and of any height up to 8 feet, are coated with polyvinyl chloride (PVC). The panels are bolted together at their vertical edges. A smooth, watertight joint seal is created by solvent welding the PVC on the two panels together. The pool markings are painted on the PVC after the panels are erected and joined.

Figure 6: Stainless steel pool wall panels in place with partial supporting struts at deep end of pool.

Where the pool depth exceeds the maximum panel height of 8 feet, the extension down to the 13-foot depth is made partly by a sloped section of the footing concrete below the panel base and by sloping the concrete slab.

The footings are stepped so that the panel height can be obtained in several different heights, such as 8-6-4 feet, in a pool with a shallow and a deep end. The pool slab can be sloped along the length of the wall, so that part of it abuts the concrete foundation and part abuts the stainless steel panel. A slot is formed at the slab-wall interface with a slip liner to allow placement of an epoxy sealant, which is then overlain by the PVC liner.

Figures 2 and *3 (page 34)* show the site after the original pool was removed and shoring was installed to support the building structure. *Figures 4* and *5 (pages 34 and 35)* show stages of footing and slab construction, including the incorporation of the shoring base into the pool foundation.

Figure 6 shows some of the deep end panels in place with a single strut at each joint. Once these are in place, they are adjusted for height and side fit, and if required by the dimension of the pool, the remaining open space is measured for the final fit in pieces to close the perimeter.

Figure 7 shows the completed pool when, after opening ceremonies, the public was invited to try it out. At that time, mechanical adjustments were still being made to the water pumping, temperature and chemical injection systems for final automatic operation.

In spite of the difficulties encountered in dealing with the unknown site conditions, the final supporting structure, although buried and hidden, should provide many decades of useful service to the community.▪

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Figure 7: Opening of pool for community use on weekend before 4th of July holiday.