Inadequate Reinforcement in Swimming Pools

By Michael Reeves

Over the past 15 years, backyard swimming pools have changed immensely. Once just a place to jump in and cool off, pools have now evolved into entire backyard design masterpieces. From basic free-form pools to multiple-tier pools elevated out of the ground with negative edges and endless possibilities, pools today need to be engineered and built properly to enhance their lifecycle.

One of the key steps to building a structural swimming pool is the proper placement of the steel reinforcing bars. Reinforcing bars are the most commonly used reinforcement in swimming pools. Most pools use the wet- or dry-mix shotcrete process with single-sided forms. In shotcrete, the concrete has a very high compressive strength but the embedded reinforcing bars are needed for the concrete shell to withstand the expanding, bending, or flexing from loads on the pool. The embedded reinforcing bars not only provide structural strength to the concrete pool shell, but also help stabilize the freshly shot concrete to build up walls.

Fig. 1: Not enough reinforcing bars, and improper layout

In this article we are addressing reinforcement, but issues such as concrete compressive strength, forming, and watertightness of pool shells are also key to an overall successful project. ASA has developed a series of Position Statements establishing industry best practice for shotcreted pools. ASA Pool and Recreational Shotcrete Committee Position Statement #1, "Compressive (Strength) Values of Pool Shotcrete," details why shotcrete must have a minimum compressive strength of 4000 lb/in.^{2} (28 MPa) for serviceability and long-term durability. Often the reinforcement layout depends on proper formwork or subgrade preparation and ASA's Position Statement #6, "Forming and Substrates in Pool Shotcrete," can provide very helpful guidance.

In swimming pools, No. 4 (No. 13M) reinforcing bar is the minimum size bar that should be used. Depending on the design, we see a lot of pools with No. 5 bars (No. 16M) and No. 6 bars (No. 19M) in the reinforcing steel layout to strengthen the concrete due to higher loadings. This may happen when the pool is being supported on pilings, needs to withstand groundwater, or if there are exposed, free-standing walls.

When installing reinforcing bars in a swimming pool, it is not simply running random pieces of steel bar at non-specific locations where the concrete is going to be placed and expect it to serve its purpose. Reinforcing steel should be placed in accordance with the pool design and generally needs to meet American Concrete Institute (ACI) standards for structural concrete.

ACI 350, "Code Requirements for Environmental Engineering Concrete Structures," provides mandatory requirements for design of concrete liquid-containing structures and is often applied to pools. Also, ACI Committee 506, Shotcreting, has established a subcommittee to develop a guide to proper use of shotcrete in the pool industry.

ACI 350 has specifications for proper cover (distance from the bar to the closest surface), minimum spacing, splices, tolerances, and so on. If you are unsure of the proper amount and spacing of reinforcing steel needed, consult with a structural engineer experienced in pool design to design a reinforcing steel layout that will ensure a quality, durable swimming pool structure. When the reinforcing steel is properly designed and placed, it works together with the concrete to create a pool shell which will resist the pressures of internal loads from the contained water, and external loads, like soil that impact the wall.

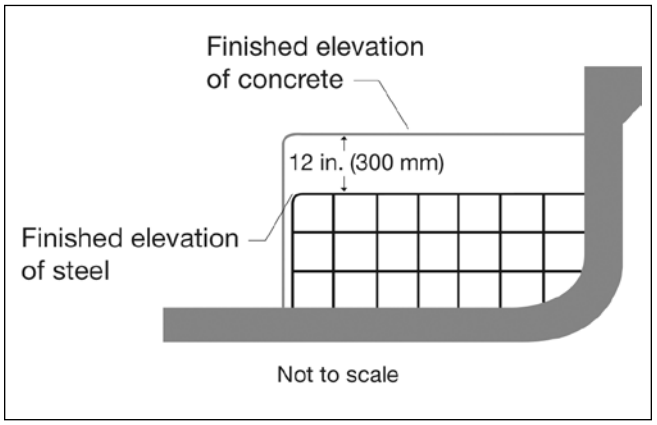

Fig. 2: Incorrect reinforcing bar layout for bench

Unfortunately, we run into problems with incorrect reinforcing bar placement more often than we would like. As you can see in Fig. 1, there is not adequate reinforcing steel in the beam of the pool. The pool beam should not be sitting on top of the soil, and the reinforcing should have extended almost to the forms. There is about 12 in. (300 mm) between the closest reinforcing and the form boards. Without reinforcing bars to provide support, this section is basically a plain concrete cantilever that will eventually crack from settlement. The same goes for installing the reinforcing steel for the pool walls and floor. Typically, pools use a minimum of reinforcing bars spaced at 12 in. on center, each way. However, there are many projects that call for 8 or 6 in. (200 or 150 mm) spacing. Another place where we often see a lack of reinforcing bars is in the bench or a sun shelf area of a pool (Fig. 2). The reinforcing steel in this sketch is set too low, which will result in 12 in. of unreinforced concrete and create a high potential for cracking. Maintaining the proper amount of steel in the concrete is critical to the structural integrity of a pool.

It is also possible to have too much reinforcing steel in one area. If the reinforcing bars are not properly spaced apart, it may be extremely difficult to properly encase the reinforcing with shotcrete. Adequate spacing between reinforcing bars is critical to allow good shotcrete placement and fully encase the reinforcing bar. Without proper encasement, voids can form in the concrete around the bars that can reduce the ability of the concrete section to carry loads, and can lead to cracks or, in extreme cases, failure of the pool shell.

The placement of plumbing in swimming pools is another critical area that can create a weak section in a wall or floor (Fig. 3). The plumbing needs to be set back far enough or even outside of the pool so that it will not impair the structural integrity of the pool shell. Again, you need to be able to have proper coverage on both sides of the reinforcing bars to make sure there are no weak points in the walls or floor.

Reinforcing bars used in structural concrete has raised deformations on it, which helps keep the reinforcing bars locked inside the concrete. Special care needs to be taken to make sure the reinforcing bars are clean of any debris (such as caked-on mud or rust) to allow them to function properly. As you can see in Fig. 4, the steel and substrate are in no way ready for shotcrete.

Fig. 3: Not enough cover over the reinforcing bars

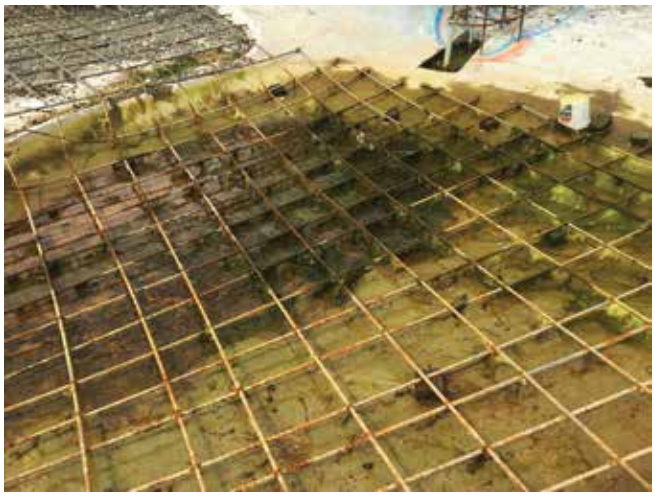

Fig. 4: The substrate and reinforcing bars are not ready for the shotcrete application

Most pools also use the in-place soil after excavation as the substrate to shoot against. As long as there is good, solid soil, this is a perfectly good substrate to shoot against. The problem arises when there is rainy weather, because unsupported soil can liquify and cave in around the reinforcing bars and, in some cases, push the entire cage of reinforcing bars into the pool. If the soil of the excavation fails, all the soil that encroached on the reinforcing needs to be cleaned out and the reinforcing resecured prior to shotcreting. If the failure of the soil significantly increases the wall thickness needed, the pool designer may need to be consulted to see whether additional reinforcing steel is required.

Fig. 5: An example of good reinforcing bar placement

The design and installation of the reinforcing bars in pools requires close attention to detail. As you can see in Fig. 5, the steel is straight, clean, and properly placed, allowing for good encapsulation. When there is a crack in the concrete pool shell, most people point to the shotcrete contractor first, and assume there is an issue with the concrete. With the issues pointed out herein, it is often not poor concrete material or placement that is the cause. When you know the proper procedures, reinforcing bar placement is not hard to do. It just takes time and attention to detail to make sure you have a strong solid cage that will do its job and hold the pool structure together, and allow for many years of use and enjoyment.

Michael Reeves *is the Vice President of GSI Pool Finishes and Gunite Specialists, serving the industry in Pennsylvania and surrounding states. He grew up in the profession and is a second-generation shotcrete contractor. Reeves is a member of the American Shotcrete Association, American Concrete Institute, Northeast Spa and Pool Association, and Association of Pool & Spa Professionals.*