

## Building Swimming Pools with Shotcrete Using the National Spa and Pool Institute (NSPI) Manual: Reinforcement of Shotcrete Pools/Plastering

By Denis Beaupré **Introduction**

The objective of this paper is to discuss some aspects of shotcrete pool construction, using Chapter 7, "Pool Structure," of the *NSPI Builders Manual* as a guide. The author came into contact with this manual after being asked, on behalf of ASA's Education Committee, to prepare a shotcrete pool class session for the NSPI annual meeting on November 28, 2001, in Phoenix, Arizona. This paper is also to be discussed at that conference.

### Concrete technology

Before getting into the details of the pool construction, I would like to first make a comment on the *NSPI Manual's* content, at least regarding the portion related to concrete and shotcrete. The chairman, Rizzo, and the other authors, Baron, Eden, Biscornet, Hope, Brumfield, and Romano, have done a good job in preparing this manual, especially

the section on the fundamentals of concrete.

I think shotcrete craftsmen should read and study this 15-page section. It is complete, and, most importantly, it has been written with technical terminology that can be understood by most shotcrete or pool craftsmen. As Chairman of the American Shotcrete Association's (ASA) Education Committee,

I will try to work out some agreement with NSPI to have these pages reprinted in a later issue of ASA's *Shotcrete Magazine*. Every nozzleman would benefit from studying these pages before taking the ACI Nozzleman Certification written exam.

### Pool reinforcement

The *NSPI Builders Manual* defines three types of concrete pools: first, shotcrete; second, cast-in-place concrete; and third, masonry block pools. Shotcrete pools often contain some cast concrete, mostly for floors and stairs. They are also often coated with mortar or plaster prior to painting. The *NSPI Builders Manual* also provides minimum requirements for floor/wall thickness, reinforcing bars, etc. It also recognizes the differences in climate between the southern and northern states. The minimum requirements are thus different throughout North America.

To a structural engineer, the minimum steel requirements in the *NSPI Builders Manual* appear low. The minimum steel requirement in the south is a #3 bar spaced every foot (#3 @ 12-in. (300 mm) O/C) vertically and horizontally. This represents a steel ratio (area of steel divided by area of concrete) of 0.16% for a 6 in. (150 mm) thick wall and 0.12% for an 8 in. (200 mm) thick wall. This is less than the usual minimum requirement of 0.2% steel required for crack control of reinforced concrete in most structural standard specifications.

In the north, the NSPI minimum steel requirement is to use #4 bars with similar spacing (#4 @ 12-in. (300 mm) O/C). This repre-



Figure 1: Example of steel layout for a pool being constructed in the city of Quebec. Note the two layers of #10M steel (between US#3 and US#4) spaced at 8 in. (200 mm) in both directions.

sents a steel ratio of 0.29% for a 6 in. (150 mm) thick wall, 0.22% for a 8 in. (200 mm) thick wall, and 0.17% for a 10 in. (250 mm) thick wall. These steel ratios are closer to the usual 0.2% steel ratio specified for reinforced concrete structures.

Although the use of #3 bars does not meet the minimum steel ratio required in most structural specifications, it is reported to have performed well in many pools where ground conditions are satisfactory. One must remember that this steel layout is only a minimum; anybody is free to use larger bars (#4 instead of #3), or reduce bar spacing to get a higher reinforcement ratio. The practice is also valid for cast-in-place concrete pools.

In shotcrete construction, #3 bars are often used because they are three times as flexible as #4 bars, which allows for ease of bending to fit pool contours. However, the #3 bars are more likely to deform and vibrate during shotcrete shooting. This increases the potential for shotcrete delamination, or poor bond between steel and shotcrete, and effort should be taken to try to minimize vibration when possible.

In order to increase the steel ratio, there are two options one can choose. The first choice is to increase bar size or reduce spacing. For shotcrete, it might be a better idea to increase bar size from #3 to #4 instead of reducing spacing. Of course, in curved areas with a short radius, it might be easier to use #3 bars rather than #4 bars, because they are easier to bend in place to fit the pool shape. If that is the case, reducing the spacing between bars is a better way to obtain the recommended steel ratio. An example would be to use #3 bars @ 10 in. (250 mm) O/C for a 6 in. (150 mm) thick wall, or #3 bars @ 7-in. (175 mm) O/C for a 8 in. (200 mm) thick wall, for a steel ratio of 0.2%.

In terms of comparing the costs of using #4 in lieu of #3 bar, consider the following: for a 30 x 20 x 6 ft pool (9 x 6 x 1.8 m), the replacement of all #3 bars with #4 bars (for a spacing of 12 in (300 mm) O/C in both directions) represents an increase in steel equal to approximately 700 lbs (320 kg). The cost to place the steel remains essentially the same; the only increase in cost is the extra weight of steel, which should amount to \$200 or less, because #4 bar usually costs less per pound than #3 bar. This might be an inexpensive insurance measure, and one that makes good sense—the drawbacks being the extra work to install the #4 bar and the difficulty of bending it on site.

## Finishing and plastering

Some cast-in-place pools, many shotcrete pools, and almost all masonry ones are coated with a plaster. This plaster is usually a cement-based mortar, which is usually applied by hand to provide the final grade and a smooth finish before painting. This operation is also referred to as plastering, and is briefly described in Chapter 12, “Interior surface,” of the *NSPI Builders Manual*. More details, mostly on troubleshooting topics, are given in the *Technical Manual* of the National Plasterers Council.

Since the finishing operations for shotcrete pools can be long and labor-intensive, it is often easier to use a final plaster layer. It also speeds up the shotcreting operations of the pool surface, which has relatively short workable life. The



Figure 2: Use of mechanical screed and finishing machine. It took a crew of three craftsmen about an hour to finish the wall.



Figure 3: Close-up of the screeding device. Note the wall in the background, made of one monolithic layer of shotcrete and fully finished (no plastering needed).

placement of shotcrete using the wet process is a relatively rapid operation, but it is often difficult for finishers, when using only hand tools, to keep up with nozzle men. Using this double-layer construction technique (shotcrete + plaster) allows the finisher only to screed the surface during the shotcreting operation to the correct grade and not to bother with the smoothness of the surface.

The plastering is usually done a few days after the pool is shot. Plastering can also be performed on old pools as a maintenance operation before repainting. In both cases, this could be compared to a thin concrete repair, and, as for all concrete repairs, proper surface preparation is very important to insure good bond.

In terms of surface preparation, the *NSPI Builders Manual* points out that after the pool structure has been completed, it is wise to acid wash and rinse it completely prior to plastering, so that it is as clean as possible. In normal concrete repair, acid is sometimes used to remove calcite as well as the carbonated layers of old concrete. This is done, at times, in lieu of sandblasting, and is done to improve plaster bond with the concrete/shotcrete. In newly constructed pools (say a few days old), the shotcrete surface is not likely to have old calcium deposits, so an acid wash is not needed. Cleaning with a high-pressure

water jet (1500 to 2000 psi) is usually sufficient to clean the surface from dust and overspray and to insure good bond if the plaster is properly applied (see *Shotcrete Magazine*, May 1999, Vol.1, No.2, pp.12-15). The use of acid for a newly constructed pool is, in my view, not necessary; it is bad for the environment and is a potential health hazard. It can, however, be used for the replastering of old pools where concrete/shotcrete carbonation has taken place.

## **New finishing and plastering tools**

In recent years, in the province of Quebec, Canada, mechanical finishing machines (Figure 2) were developed and are now commonly used on all types of shotcrete jobs, including pool construction. This mechanical equipment is used not only to finish shotcrete, but also for plastering operations. New composite pads (foam and smooth natural rubber) have been developed and tested for plaster application. Very recently, a mechanical screeding device has also been developed and used for the construction of a pool. The use of mechanical tools for plastering operations can reduce plastering time by about 50 to 60%,

which is something to think about as a reduction in labor cost.

The mechanization of finishing operations will probably reduce the number of pools built with a final plaster coat. With the finishing machine and power screed, it is easier for the finisher to keep up with the shotcrete application even with the wet-mix shotcrete process. More pools with monolithic shotcrete as a final finish (no final plaster coat) will be constructed, as in the first days of the shotcrete pool business, when the dry-mix shotcrete process was the only process used.



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