

Shotcrete Pool Inspection— Checklist

By Chris Zynda

Swimming pools have been around for over 100 years, and the water-containing pool shells have been built in many different ways, including fiberglass, concrete block, vinyl-lined, and concrete. We must remember that a swimming pool is a large investment and, like any



Fig. 1: A pool wall installed with wet-mix shotcrete before the pool floor has been placed. As a result, the pool floor is now contaminated with the rebound and cuttings from the shotcrete operation. This sloppy material sitting on the floor has not been vibrated or consolidated and must be considered as waste material and removed. Leaving this material in place would weaken the pool structure and significantly reduce the long-term durability of the pool shell. Unfortunately, incorporation of rebound and cuttings in the pool shell is the cause in 95% of swimming pool failures



Fig. 2: The shotcrete (wet-mix process) floor being installed first

structure, needs a good foundation and quality construction to last for the decades intended.

Shotcrete (wet- and dry-mix process) is the most common method for placing the concrete in swimming pool floors, coves, and walls. Quality shotcrete placement creates the foundation for a lifetime concrete shell. The first step in shotcrete pool construction is to understand the two processes—wet-mix and dry-mix—used in shotcrete placement. After a specific process has been selected for the project, the owner or the engineer or designer responsible for qualifying the contractor and their field performance should put together an evaluation checklist as shown below.

Preconstruction

1. Pool contractor: years of experience with overall pool construction.
2. Past shotcrete pool projects of similar size and scope.
3. Shotcrete contractor experience: years of experience and projects of similar size and scope.



Fig. 3: Another pool floor being placed first with a concrete boom pump and the placement crew vibrating the concrete and screeding to the desired height. Installing the floor before the walls helps to guarantee no cuttings or rebound will be used in the structure. Also, note that a board is used at the edge of the floor to create a consistent joint. This allowed the joint to be prepped with water blast at 0.25 in. (6.35 mm) roughness before shotcreting the wall

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Fig. 4: Experienced ACI Certified Nozzleman shooting a beam—no cuttings will be reused in the structure. Also, note the blue tarp providing protection from overspray

4. Shotcrete nozzleman should have a minimum of 3 years of experience and hold a current ACI nozzleman certification in the process being used.
5. Listing of the type of equipment: dry-mix gun, wet-mix pump, and air compressor size (minimum 250 cfm compressor for wet-mix and 500 cfm for dry-mix).
6. Concrete mixture design: minimum 4000 psi (28 MPa).

During Construction

7. Proper setup of grades (including set wires for floor, walls, beam, and lights).
8. Prepare templates for radius sections (no steel stakes allowed in soil that may contact reinforcement).
9. Shooting sequence (cast or shoot floor FIRST).
10. **NO rebound, cuttings, or spoils to be incorporated in fresh concrete sections.**
11. **All joints must prepped in the first 30 minutes.**
12. Air lance used for shotcrete application.
13. Predampen subgrade or substrate before shooting.
14. Consider the shooting sequence for attached spa or wading pool.
15. Production rate (how many days for shotcrete placement).
16. Proper disposal of rebound removed from pool during shooting.
17. Proper curing.
18. Shotcrete materials, testing, and placement should meet the guidelines of ACI 506R-16, “Guide to Shotcrete.”



Fig. 5: ACI-certified nozzleman shooting walls with air-lance (blow pipe) tender cleaning the floor/wall joint before shotcreting so no rebound is used in the structure. Also, note the floor was completed first. The reinforcement at the bottom of the wall is for a bench that will be shot after the wall is complete. The contractor will need to clean all rebound and cuttings out from the bench area before shooting it



Fig. 6: When checking reinforcement, make sure the bars have proper clearance and cover. Reinforcing bars should be separated to meet the requirements of the project specifications and applicable local building codes. Stagger laps when possible to avoid bundling bars at contact laps, as seen at the top of the reinforcement in this image. Non-contact lap splices are preferred in shotcrete applications. Preconstruction shotcrete test panels may be required for contact laps that exceed No. 4 (No. 13M) reinforcement



Fig. 7: Plumbing is a major component of most pools. Often, the plumbing components need to be placed in a way to allow for proper shotcrete placement. Enough room needs to be provided in the design for the plumbing, skimmer, lights, and reinforcing steel; pools take a lot of pre-planning with a qualified contractor and experienced crews

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Safety

19. Hard hats, safety glasses, boots, dust mask, or respirator.
20. Proper coverage of worker's skin against exposure to cement.
21. Screen must remain in place over the hopper of the wet-mix pump or dry-mix rotary gun while in operation.
22. Scaffolding: properly sized, supported, and braced (no jiffy jacks allowed).



Fig. 8(a) and (b): Construction joints being prepared

Construction joints

Construction joints are one of the most important aspects in construction and performance of all concrete structures. Shotcrete is no different, but we do get a second chance. With pools having varying shapes and many accessory placements, construction joints (as many as 50 per pool) are a way of life. All construction joints are required to be prepped within the first 30 minutes of placing the fresh shotcrete. Preparation includes shaping the joint to a 45-degree angle, cleaning overspray from adjacent reinforcement not yet embedded, and roughening the surface of the joint with a stiff broom or brush. The joint can then stand for as long as needed before the next placement. When it is time to complete the area, the joint must be pre-dampened to a saturated surface-dry damp condition. When properly shooting and curing the subsequently placed shotcrete, the concrete will act as a monolithic section, just as if there was never a joint there to begin with. The secret in making this a joint that acts monolithically with perfect bond is the combination of the proper surface preparation of the joint and high-impact velocity (60 to 80 mph [27 to 36 m/s]) of the shotcrete stream. The shotcrete is a cement-rich concrete paste that is pneumatically driven by impact into the rough surface left by the joint preparation. No bonding agents are needed, and indeed no bonding agents should be used because they interfere with the bond of the fresh paste to the rough substrate.

Rebound

With shotcrete, the high-impact velocity used in the shooting process produces a certain percentage of material that doesn't stick and bounces off the substrate or the previously shot concrete surface. This is called "rebound" and is mostly composed of the larger rock and sand particles that did not stick to the surface. These aggregates lack the concrete paste essential for a complete concrete mixture and *MUST NOT be used in the structure.*

Cuttings and Overspray

When shotcreting, the wall section is generally shot out to and slightly beyond a grade wire, and then finishers cut the shotcrete back to the surface defined by the grade wire (refer to Fig. 4). The cuttings from the finisher cutting the shotcrete back to the grade wire lack consolidation and may be quite variable in composition. They may also have passed the setting time for the mixture design used. Similarly, overspray cleaned off formwork or reinforcement doesn't have the same aggregate and paste mixture that is desired in the concrete in place. Thus, cuttings or overspray *MUST NOT be used in the structure.*

Summary

Gathered from over 45 years of experience in swimming pool construction, I have listed some key performance aspects of the shotcrete construction process to ask your contractor. These should be your primary concerns in the construction of shotcrete swimming pools.

The first and foremost step is to use a qualified shotcrete contractor with an experienced crew.

Next, look at these key aspects of the shotcrete process:

- a. Does the contractor have the proper equipment for thorough mixing of the shotcrete material? (Dry-mix may be mixed on site or supplied in large premixed bags. Some wet-mix may be mixed on site, adding water to premixed bags.)
- b. A quality source of sand and aggregates (must be clean, washed, and well-graded and meets the ASTM requirements for concrete sand). Dry-mix aggregates entering the gun should have a 3 to 4% moisture content to help reduce dust, enhance hydration, and reduce wear on the equipment. This may require predampening equipment if the contractor is using bone-dry bagged shotcrete materials. No rebound or cuttings are to be reused in the structure.
- c. Properly functioning, well-maintained wet-mix pump or dry-mix gun and a properly sized and functional air compressor are required.

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You must have enough air flow to accelerate the shotcrete stream to a high velocity.

- d. A well-proportioned concrete mixture design. The concrete must be pumpable in wet-mix and, in either process, have adequate materials to achieve the desired strength. 4000 psi (28 MPa) compressive strength at 28 days should be the minimum acceptable.
- e. Ensure the 30-minute construction joint rule is used.
- f. Use proper curing procedures as detailed in ACI 506R-16, "Guide to Shotcrete," Section 3.6.

Although the basic concepts for construction of a pool shell with shotcrete may be straightforward, a quality shotcrete contractor must pay attention to all the details needed to make the pool shell functionally watertight and durable to last for decades. The checklists and topics covered previously certainly help to show which aspects of the work should be closely monitored. However, one of the best ways to get the quality desired

is to hire a shotcrete contractor who has demonstrated in previous work that their company has the experience, resources, well-trained crew with ACI Certified Nozzlemen, and commitment to quality and safety that shotcrete pools demand.



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