The Durability of Shotcrete—Looking Back at Projects from 30 to 40 Years Ago

By Ted Sofis

Anyone who has ever had to remove old gunite from a bridge or an overpass knows how incredibly difficult it can be to tear out. When the durability of shotcrete was selected as the theme for this issue of *Shotcrete* magazine, the idea came up to look at some older projects. I mentioned that there were projects that we did 20 to 40 years ago that are still holding up well. With questions that engineers ask regarding shotcrete being a viable and accepted option for concrete repairs, nothing could be more relevant. So I decided to revisit a few of those projects and take a look at them today.

There aren't any secrets or shortcuts for achieving good results. Surface preparation is very important. Care has to be taken to remove the deteriorated concrete back to good, sound material. If you gun over bad concrete, you'll end

Fig. 1(a): Dry-process shotcrete repairs on 31st Street Bridge in Pittsburgh, PA, were done in 1973 over bottom two-thirds of this pier. Architectural details were maintained and shotcrete repairs remain in good condition 42 years after they were installed

Fig. 1(b): This pier on Pittsburgh side of Allegheny River required extensive repairs and shotcrete also remains in very good condition

Fig. 2(a): Arches and parapets of this single-arch bridge in Bridgeville, PA, were badly deteriorated before shotcrete repairs in 1977. Dowels and reinforcing bars were installed and dry-process shotcrete placed across arches on both sides of bridge

Fig. 2(b): Concrete on both sides of parapets under capstones were badly deteriorated. They were chipped out then replaced with dry-process shotcrete 38 years ago

up with a poor result. Shotcrete is concrete—the only difference being the method of placement. The mesh and reinforcing steel has to be securely anchored and tied in place, so there is no movement or flex when the shotcrete is gunned. Otherwise it can pull from the surface, especially in overhead applications. Good workmanship is necessary, as are wetting down the receiving surface prior to gunning to get a saturated surface-dry (SSD) condition; using good gunning techniques; ensuring a good, consistent shotcrete mixture; allowing the shotcrete to get its initial set before starting to cut-down and finish the surface; and making sure the shotcrete is properly cured.

The 31st Street Bridge

The oldest of our projects that I revisited was the 31st Street Bridge in Pittsburgh, PA. The bridge spans the Allegheny River and Herr's Island, now referred to as Washington's Crossing. We were general contractor for the rehabilitation of the bridge and the work was done in 1973 and 1974. The project required steel repairs and extensive shotcrete repair work to the piers of the old bridge. The sand and cement was mixed on site with 3.5 ft^3 (0.1 m^3) of sand to one bag of cement. The mixture was measured in 1 ft^3 (0.03 m^3) wooden boxes as a quality-control measure. For the dry-process shotcrete placement, we used a Jetcreter, an early straight drop feed rotary gun. I remember the project well because I worked on the concrete tear-out crew during the removal stage and on the gunning crew during shotcrete placement. The most difficult part of the job involved cutting and finishing the architectural details on bridge piers. The bridge has undergone additional rehabilitation work in recent years for steel repairs and to replace the bridge deck, but the shotcrete installed on bridge piers 42 years ago remains intact and in good condition.

Bridgeville Arch Bridge

The second job, in Bridgeville, PA, involved dry-process shotcrete repairs to a concrete arch bridge that we rehabilitated in 1977. On both sides of the bridge, the concrete arch was badly deteriorated. We removed the concrete to a depth of 14 in. (350 mm) from the edge of the arch. Because of the depth of the repair, dowels were installed across the entire arch and reinforcing bars were installed. In addition to the arches, the concrete parapets were also badly deteriorated. So the deteriorated parapet concrete was removed, leaving the capstones in place. The shotcrete was then gunned in place and finished to grade. Considering the condition of the bridge when the repairs were done in 1977, it is remarkable that after 38 years, it has held up so well. When shotcrete is placed properly, it's as durable as any concrete repair.

Raccoon Dam and Spillway

We began rehabilitation of Raccoon Dam and Spillway at Raccoon State Park in Beaver County, PA, in 1983 and completed the shotcrete repairs in the second phase of the work in 1984. Prior to the shotcrete repairs, there had been problems with a polymer-modified patching mortar. The

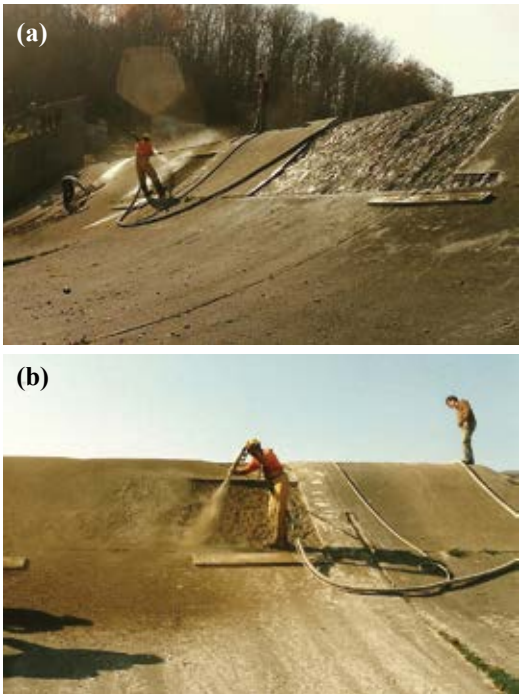

Fig. 3(a) and (b): (Before) Rehabilitation work on Raccoon Dam and Spillway (Raccoon State Park, PA) included removal and replacement of deteriorated concrete on large sections of spillway and across top of dam. These photos show dry-process shotcrete placed on upper sections of dam in autumn of 1984. Once placed, shotcrete was then cut down or rodded to grade before finishing

Fig. 4: (After) Shotcrete repairs to Raccoon Dam remain in good condition across crest of dam 31 years after shotcrete work was performed. Water flowing over crest of dam and spillway shows a relatively even flow despite the passage of years

perception of the owner's engineers was that polymer-modified patching mortar would give them a better job. After receiving our assurances, they allowed us to repair the crest of the dam with shotcrete. There were advantages to going with shotcrete. It was more efficient to transport the material through the gunning hose to the repair areas and we were able to gun the shotcrete to the full depth on sloped and vertical areas. In retrospect, it was the right decision. The shotcrete performed better than the polymer-modified patching mortar, and the shotcrete repairs have held up well over the years.

The Carnegie Museum Slope

In 1988, we began placing shotcrete to stabilize the slope behind the Carnegie Museum in Pittsburgh, PA. The museum needed additional parking and the only land available was over the hillside in Panther Hollow behind the museum building complex. Because of the valley, a parking garage was designed to sit below the back of the museum and the parking structure was incorporated into the hillside. We installed the dry-process shotcrete in sections with regular expansion joints and screeded the shotcrete to fairly regular grade, giving it a cut-down finish. With the passage of time, the shotcrete remains in very good condition.

When shotcrete is installed correctly it is as durable as any other method of concrete repair. As I stated earlier, there are no secrets for doing good work. It takes skilled personnel, an experienced gunning crew, and proper placement techniques. In my mind, the best test of durability is the test of time.

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Fig. 5(a) and (b): (Before) In 1988, dry-process shotcrete was placed for slope stabilization on hillside behind Carnegie Museum in Pittsburgh, PA. Recesses were left for precast concrete to support a parking garage that was later built over the hillside

Fig. 6 (a) and (b): (After) Dry-process shotcrete was used to stabilize slope for parking garage that was built into hillside behind Carnegie Museum in 1988. These photos of that work taken in February 2015 (27 years later) show that work remains in good condition. Sections of shotcrete slope can be seen on each level of parking garage