Overhead Shotcrete

by Ted W. Sofis

When you say overhead, people invariably think of fixed costs, salaries, and the general costs of running a business. People who work with shotcrete have a different perspective: to them it generally means a job with a greater degree of difficulty. Everything is magnified when shooting overhead. Velocity, water content, and shooting angles all become critical to achieving a satisfactory result. Overhead shooting requires more skill from the nozzleman and generally takes a certain mind set or determination. The reinforcing mesh must be tightly tied or anchored in place with no give or flex when pulled on, as the weight of the material is approximately 140 lb/ft^3 (2243 kg/m^3) and can easily pull from the surface, breaking the initial bond if there is any play in the reinforcement.

Overhead shooting on the underside of an elevated structure at the United States Steel, Clairton Works.

When shooting overhead, it is still important to maintain the proper shooting angles, as near to perpendicular as possible, which means that the nozzleman is directly under the spray pattern, which can cause visability problems. The rebound material that bounces off the shooting surface continually rains on the nozzleman as he shoots the overhead area. That's the downside. The positives, however, far outweigh the negatives.

First of all, overhead shooting enables one to efficiently place material overhead without the use of forms. One of the greatest advantages of the dry-mix shotcrete process is that it is blown through the hose in a nearly dry state and the water is injected through a water ring at the nozzle. This allows the nozzleman to make sensitive adjustments in the placement and mixing so there will be enough water to hydrate the material properly yet still be stiff enough to hang in place without sagging. Being placed under a high velocity provides excellent adhesion to the substrate, which enables restoration of the structural integrity of the underside of concrete or masonry surfaces. The relatively low water content of dry-mix shotcrete provides superior strengths in what is essentially a zero-slump pneumatically placed concrete. Also, this can be done quickly, which in many instances can be equally important.

Industrial Repairs

In the spring of 2005, we were called in to look at badly deteriorated concrete beams in the basement of the water treatment plant of a local chemical company near Pittsburgh, PA. The engineer had a problem: he needed to make the repairs, but the company couldn't take the facility out of service. Like many industrial facilities, the concrete beams were surrounded by conduit, piping, steam lines, and other obstructions. Replacing the beams or even forming around them was not a viable option. The beams had a great deal of reinforcing bar that was badly corroded. As the bars rusted, the corrosion scale expanded, delaminating the concrete.

After careful consideration of the situation, the engineer decided to explore the possibility of a dry-mix shotcrete repair. He worked with us to determine the necessary repairs and procedures


Union Station, Washington, DC. (Photos courtesy of Keith Stanley ***www.kestan.com****.)*

and we submitted a proposal. In the summer, the work began by chipping the deteriorated concrete from the underside of the beams. The concrete below the heavily scaled reinforcing bar was already delaminated and came off easily.

The concrete behind the reinforcement was another matter as it was difficult to remove. It was essential for a quality structural repair to get behind the metal reinforcement. After the concrete was removed to a minimum of 1 in. (25 mm) behind the bars, the reinforcing bars were blasted and coated with a rust inhibitor, Comproco ECB. The next step was to place the repair shotcrete. The product chosen was a preblended material, Shotcrete MS, manufactured by Quikrete. Using a prebagged material alleviates some of the material handling and mixing problems and provides excellent quality control. The Shotcrete MS contains microsilica, which helps the bond and reduces the permeability of the material as well as rebound. The reduction of rebound in overhead shooting is no minor issue, as the waste due to rebound can be excessive in some mixtures, sometimes as high as 40 to 50%. Choosing the right equipment also helps. For the shotcrete placement, we used Airplaco's Ridley C-10 with the medium production feed bowl, which provides a smoother feed and a little less volume. This gives the nozzleman better control and helps in tight spaces or on overhead applications. The C-10 is a heavy-duty rotary dry-mix shotcrete machine with a large air motor. The larger air motor not only gives higher production, but also allows the operator to idle the machine down and run it at a slower rate without stalling. The shotcrete installation went very well and the rebound waste using the Quikrete was minimal—less than 12%. The repairs were made while the facility was in service and none of the equipment had to be disconnected or relocated. In industrial work, "down time" is doubly expensive because the loss of production while a unit is being repaired is often more costly than the repair itself.

Architectural Repairs

While we were completing the dry-mix shotcrete repairs on the Baltimore Harbor Tunnel, the general contractor of the project asked us to look at a problem they had encountered with the rehabilitation of Union Station in Washington, D.C. Union Station is a magnificent "turn of the century" train station with a white granite exterior and stunning interior arches.

The floor system of the structure was supported by small arches made up of hollow terra cotta tiles. The mechanical contractors, apparently proceeding unchecked, had gone throughout the building breaking out tiles for their hangers, destabilizing the arches and the floor system. The hollow tiles used in the construction of the arches were no longer made and could only be found in textbooks that had gone out of print in the 1920s.

The engineer needed to know if we could apply shotcrete into the broken terra cotta cells and restore the integrity of the arches. Our suggestion was to install small pieces of reinforcing bar where needed, install 2 x 2 in. (51 x 51 mm) 12-gauge welded wire fabric and shoot a preblended sand and cement shotcrete mixture. In the deeper areas, an accelerator, Sigunite by Sika, was used. After receiving the strengths, the engineer made his calculations and submitted the recommendations to the owners. We mobilized from the project in Baltimore and arrived in Washington as quickly as possible. Due to the urgency of the situation, we worked long hours for 14 consecutive days until all the damaged arches were restored. During the restoration with the inlaid marble from Greece and artisans from Italy applying gold leaf and other interior finishes, it was gratifying to know that our work—"something that no one will ever see"—may have been one of the most important undertakings of the project.

The repair to the arches would not have been possible without shotcreting the voids and placing the material from below. Sometimes necessity provides the window to finding solutions.

Over the years we've applied dry-mix shotcrete overhead countless times on furnace roofs with vertical V-type anchors in industrial applications; the undersides of bridge decks with mesh and reinforcing bar; and on concrete beams, arches, and tunnel roofs. It's never easy, but it provides a cost-effective way to make repairs that could not be made as efficiently any other way. A good nozzleman shooting overhead can make a difficult job look easy and, in the process, achieve a better result for the customer.

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***Ted W. Sofis** and his brother, William J. Sofis Jr., are principal owners of Sofis Company, Inc. After graduation from Muskingum College with a BA in 1975, he began working full-time as a shotcrete nozzleman and operator in the steel industry and began managing Sofis Company in 1984. Over the years, Sofis Company has been involved in bridge, dam, and slope projects using shotcrete as well as refractory installations in power plants and steel mills. Sofis Company is a member of the Pittsburgh Section of the American Society of Highway Engineers (ASHE), and the American Shotcrete Association. Sofis resides in Pittsburgh, PA and has over 30 years of experience in the shotcrete industry.*