

The Need for Shotcrete Provisions for State DOTs

By Dennis Bittner

Many State Departments of Transportation (DOTs) have tried shotcrete in the past and had a negative experience. That negative experience has led them to dismiss shotcrete as a viable repair method for highway applications. I've read multiple state shotcrete specifications. Unfortunately, the majority of them are outdated and don't contain language that prevents improper shotcrete techniques or materials. There have been many advances in the shotcrete industry over the past years, and many state specifications simply haven't kept up with those changes. These specifications clearly need to be updated to keep up with the times.

Shotcrete repairs, like all repairs, should be accompanied by a strong state provision. If a company is hired to repair a bridge deck using a rapid-set material, each state has a provision (a method of repair that must be followed). Generally, these provisions tell the contractor exactly how to perform that work. Layout of the repair, demolition, reinforcement guidelines, material requirements, and finishing techniques are included in the provision. Frequently, shotcrete provisions give much less direction to the contractor—sometimes providing no direction as to the placement of the material. Let's discuss common objections and misconceptions about the shotcrete process held by many DOTs. I'll also cover the importance of key items to include in a state provision, and how they can help guarantee a successful project.

One objection to shotcrete is a concern over quality of work. There are several elements to a well-written provision that help ensure the level of proficiency of the applicator. First, ACI Certified Nozzlemen should be required. This certification must be understood. It guarantees the nozzleman meets a basic level of shotcrete proficiency and experience. Beyond the certification requirement, language requiring an experience level possessed by the nozzleman, supervisor, crew, and the contractor commensurate to the project are advisable. Prequalification test panels should be shot and tested. The material and equipment to be used on the job should be used to produce those panels. Also, the panels should be in the same orientation as the work to be performed—vertical and overhead as applicable. All of these points should be included in a provision.

Another common objection to shotcrete is the belief that shotcrete is not structural. Oftentimes, shotcrete is referred to as a mortar. Obviously, there is a misconception about the strength of the material. Shotcrete is not a product; it is a process—a method of placing concrete. The material used in the shotcrete process is by definition and composition concrete. Shotcrete commonly reaches 28-day strengths between 6000 and 10,000 psi (41 and 69 MPa). These strengths are in excess of commonly used concretes on highway structures, which typically don't exceed 4000 psi (28 MPa). Shotcrete is the industry standard in the



Fig. 1(a) and (b): Two large, round bridge piers being repaired and returned to their original contour using shotcrete

mining and tunneling industry. It is used to structurally support mine shafts and rail tunnels. In addition, countless highway bridge piers and decks have been repaired successfully with shotcrete, without structural failures (Fig. 1(a) and (b)). It is important that a shotcrete provision discuss materials and performance requirements to ensure the proper mixture designs are used to achieve the desired results.

Dust is a concern on shotcrete jobs. The use of a predampener greatly reduces dust in dry-process shotcrete. When using dry-process shotcrete, a predampener adds 3 to 5% of the total water to the material prior to introduction into the shotcrete machine. This allows hydration to start, improves cohesion, and increases adhesion. The addition of microsilica to shotcrete mixtures has also helped to reduce dust by increasing adhesion. Excessive dust can also be a symptom of insufficient airflow. It is important that proper equipment, specifically air compressor size, type of shotcrete machine, and the use of a predampener in dry process be addressed in a state provision. While dry-process shotcrete is not completely dust-free, generally the demolition portion of a shotcrete project creates more dust than the shotcrete process itself. One type of project where dust is a specific concern is highway tunnels. The main concern is dust getting into the fan house and damaging equipment. The Liberty Tunnels in Pittsburgh, PA, were repaired with shotcrete. Over 1000 yd³ (914 m³) of dry-process shotcrete were placed in the tunnels on several different phases of construction. The dry-process material was microsilica-enhanced and a predampener was used during installation. With careful attention to materials and equipment there was absolutely no damage to the fan house or any other parts of the tunnel from dust related to the shotcrete process. In the event that work needs to be performed in an extremely dust-sensitive area, wet-process shotcrete is also an option. Dust concerns can be addressed in a provision by specifying proper equipment and mixture designs (Fig. 2).

Another concern is that shotcrete can't be finished to match the existing adjacent concrete surfaces. Shotcrete has a very low water-cement ratio (w/c) and low slump. This means shotcrete is stiffer and slightly more difficult to finish than traditional concrete one may see in a floor pour. However, multiple finishes can be achieved on shotcrete. Depending on the project aesthetics, the fresh shotcrete can be left with the natural gun finish, screeded or cut to the proper thickness, floated with a wood or rubber float, given a broom finish, or even given a smooth steel trowel finish. When shooting preconstruction panels, an inspector can have the contractor show a variety

of finishes on the panels and make the appropriate selection from those examples.

There are concerns that shotcrete can't be used to replicate complicated shapes or large, round bridge piers. This is blatantly untrue; in fact, the creation of complex, irregular shapes is a distinct advantage of using shotcrete to creatively and efficiently create these types of sections. There are several ways to restore the original shape of a structure using shotcrete. Finish surfaces can be set using pins, pencil wire, or trim. Jigs can be constructed to match an original shape. Shotcrete is commonly used to create rockscapes in zoos, water parks, or pools. It's also used to build complex, double-curved shapes to very tight tolerances for structures such as skate parks and even Olympic



Fig. 2: Shotcrete being installed in the Liberty Tunnels by ACI Certified Nozzlemen using a predampener and a sufficiently sized air compressor. No damage to the tunnel was done by dust



Fig. 3: Team Pain's Construction Superintendent, James Hedrick, testing the freshly placed "capsule" at the Kortrijk, Belgium, skatepark



Fig. 4: Artificial rock made by shotcrete in the Al Ain Wildlife Park & Resort, UAE. Winner of the 2011 ASA Outstanding International Shotcrete Project

bobsled tracks. These are all structures with difficult shapes and angles that are successfully and efficiently constructed using shotcrete (Fig. 3 and 4).

So why would a state DOT be interested in shotcrete? In short, it is an extremely efficient and cost-effective way to place vertical and overhead concrete. It often provides significant cost savings and generates superior results to traditional cast-in-place concrete. By creating the option to use shotcrete, a state DOT has another tool in their

repair toolbox. It all starts with a well-written shotcrete provision. The American Shotcrete Association (ASA) has experienced staff and committee members who can assist in developing a state's provision. ASA also offers in-house education at no cost to state DOTs. If you are involved with a state agency and would like assistance in developing or updating your provisions, or seek to learn more about shotcrete through an in-house educational seminar, please feel free to contact ASA at www.shotcrete.org.



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