

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 Unfortunately, the majority of them are outdated and don't contain language that prevents improper shotcrete techniques or materials.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

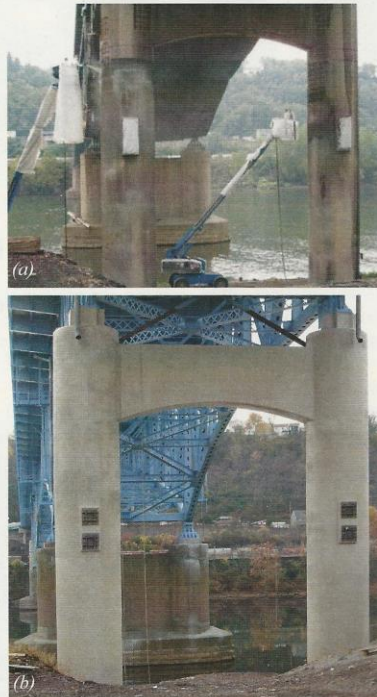


Fig. 1 (a) and (b): Two large, round bridge piers being repaired and returned to their original contour using shotcrete

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

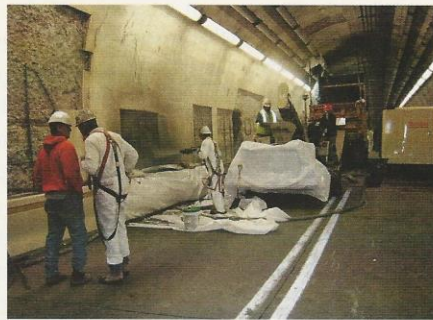


Fig. 2: Shotcrete being installed in the Liberty Tunnels by ACI Certified Nozzlemen using a predampener and a sufficiently sized air compressor. No damage to the tunnel was done by dust

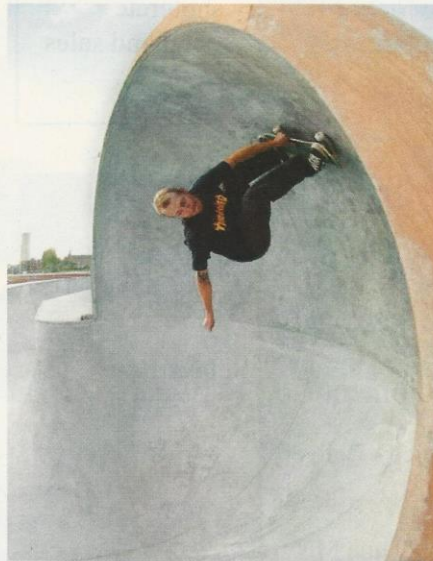


Fig. 3: Team Pain's Construction Superintendent, James Hedrick, testing the freshly placed "capsule" at the Kortrijk, Belgium, skatepark



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.

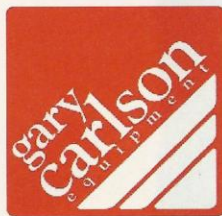


Dennis Bittner is a Construction Products Representative for The Quikrete Companies. He has been involved in both wet- and dry-mix process projects in multiple arenas of shotcrete construction, with an emphasis on bridge and tunnel projects for State Departments of Transportation (DOTs) and the rail industry. In addition to being an ASA Corporate member, Bittner sits on the Board of ASA and the ICRI Pittsburgh Chapter. He can be reached at dbittner@quikrete.com.

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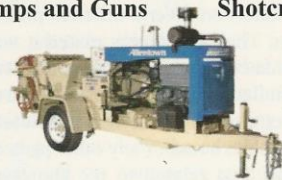
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Goin' Underground

Creating a Wine Cave

By Jason Zignego

The perfect temperature for storing wine is between 58 and 61°F (14 and 16°C). In Springfield, MO, where temperatures vary 80°F (44°C) between January and July, there's only one way to assure those ideal wine storage temperatures: go underground. For one private homeowner, the appreciation for wine extends to the construction of a wine cave under his home for storage and enjoyment of his collection. Drawing on the talents of architects, engineers, cave contractors, and a wine cave consultant from Napa Valley, this personal tribute to fermented grapes is being built with extensive use of shotcrete.

Wine caves have been constructed for more than a hundred years in northern California's Napa Valley, where land values are high and the evaporation from wine kegs can result in up to

10% product loss in 2 years if humidity isn't properly controlled. Wine makers consider humidity over 75% for reds and over 85% for whites to be ideal for wine aging and barrel storage. Humidity in wine caves ranges naturally from 70 to 90%. "Ideal wine temperature is between 58 and 60°F (14 and 16°C)," explains wine cave consultant Brady Mitchell, a hands-on cave construction specialist from Napa (refer to Fig. 1). The temperature 45 ft (14 m) under the home of the Missouri wine aficionados' new home is 60°F (16°C). "Perfect," states Mitchell.

Excavation into a hillside below the home site began in 2012. Bacchus Caves (The Woodlands, TX) dug the tunnels, including a 150 ft (46 m) long shaft that will be used for wine storage. A 2 ft (0.6 m) diameter cutting head attached to a hydraulic excavator broke up the

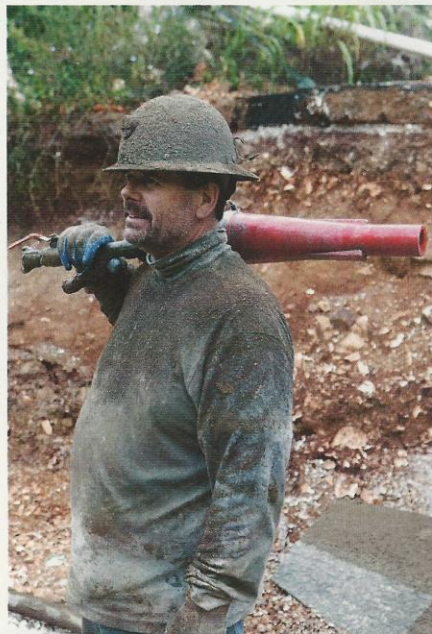


Fig. 1: Brady Mitchell is a modern-day cave man who specializes in wine cave construction, having built many in the Napa, CA, area

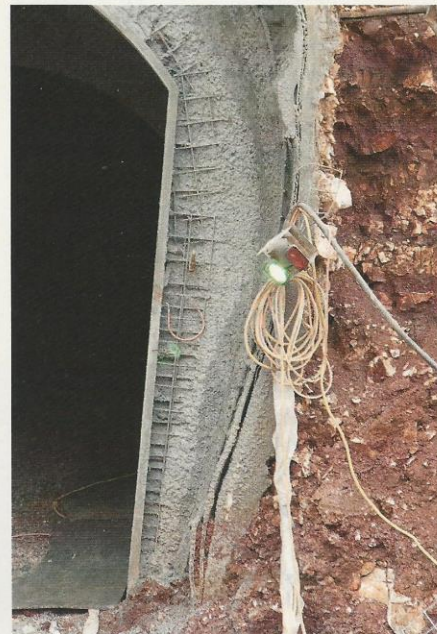


Fig. 2: Dry-mix shotcrete was used for structural support during excavation

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limestone and red clay earth. A skid steer removed the spoils. Dry-mix shotcreting was used for soil stabilization. "Because they would excavate then shotcrete sporadically, they elected to use the dry-mix method because it could be applied on demand without a pump and ready mix truck standing by," Mitchell explained. The Quikrete product used for dry-mix shotcreting is a specially formulated microsilica-enhanced, portland cement-based, high-strength structural material (refer to Fig. 2).

Over the 2 years of excavation and shotcreting by Bacchus Caves, their efforts resulted in the 10 ft (3 m) diameter x 150 ft (46 m) cask storage tunnel, a 17 ft wide x 15 ft tall x 23 ft long (5.2 x 4.6 x 7 m) bottling storage room, an 18 x 15 x 40 ft (5.5 x 4.6 x 12 m) tasting room, a 17 x 15 x 48 ft (5.2 x 4.6 x 15 m) dining room with butler's pantry, and 10 x 10 x 30 ft (3 x 3 x 9 m) wine library. "The excavation and shotcreting moved pretty slowly because it is clay soil with huge suspended boulders interspersed throughout the area," Mitchell explained. "They did have a cave-in for an area we were calling the "Grotto," which was finally abandoned." The cave has two portals: the outside entrance, and an access point from the basement of the house with a spiral staircase and elevator (refer to Fig. 3). Hundreds of cubic yards of the dry-mix shotcrete were consumed during the process. "Every couple of feet, they would apply a structural coat of shotcrete and then reapply additional coats over previously applied shotcrete as they came back out," said Mitchell.

After excavating and structural shotcreting was completed, 4 x 4 in. (100 x 100 mm) welded wire reinforcement was applied to the entire interior surface and spaced off the walls. The electrical conduits were placed between the two layers of shotcrete. "We placed 6 in. (152 mm) of wet-mix shotcrete for the final tunnel liner, applied in 1.5 in. (38 mm) layers," Mitchell, who is also the nozzleman, explained. "This would result in about four passes to achieve 6 in. (150 mm) of wet shotcrete applied over as much as 14 in. (350 mm) of dry mix" (refer to Fig. 4). The wet mix sped up the process by spraying at a much higher rate than dry-mix shotcrete. Screed rakes were used to contour the larger radii such as the arches (refer to Fig. 5). Hand trowels were used to knock down any high points. Three color samples were test batched for the owner. Mitchell and co-worker Rich Lederer worked together to create the organic shapes. "Nature drives the design."



Fig. 3: Exterior portal leads to 150 ft (45 m) long tunnel and various chambers to create a wine cave 45 ft (14 m) under the owner's new home



Fig. 4: Wet-mix shotcrete was applied 6 in. (150 mm) thick over welded wire reinforcement in four passes

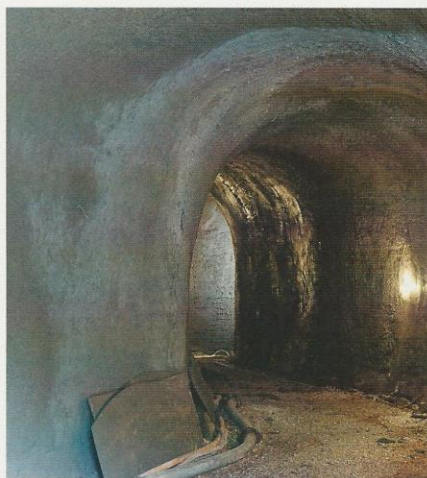


Fig. 5: Organic shape is sculpted wet shotcrete, hand-raked and troweled

Goin' Underground



Fig. 6: Schwing S17 with 180-degree discharge serves as line pump for shotcreting up to 400 ft (120 m) inside the tunnel

Wet-mix shotcrete pumping was handled by Brundage-Bone from their Springfield location. "We have pumped steadily every day in March, April, and May," Mitchell said. "The Brundage operators have been great and most of the time, the Springfield District Manager, Andy Baugh, is on-site to lend a hand." The company has been using several of their pumps on the project, including a Schwing S17 boom pump discharging directly out the back, an SP 500, and an SPT 1000 truck-mounted pump (refer to Fig. 6). All pumps are equipped with fast-switching Rock Valves for surge-free operation at the hose. Pumping distances have exceeded 400 ft (120 m) with a line diameter at 2 in. (50 mm) where it enters the shotcrete nozzle. "At the end of the day, we wash out the 2 in. (50 mm) hose and blow out the 3 in. (75 mm) line back to the pump," explained Mitchell. "Being that far from the pump, I need to trust the operator and Brundage-Bone's crew is real good. I don't feel like I have to look over my shoulder."

Mitchell hand-formed 200 recesses for light fixtures, with some 8 in. (203 mm) deep. "There is an art to forming the arches and recesses for dramatic shadows," explained Mitchell. "For utilitarian purposes, we can leave a naturally coarse finish, but this wine cave will be enjoyed by the owner and his guests so some rooms will have a smooth finish and some will be covered in plaster or woodwork." A chandelier in the tasting room will appear like a tree root growing through the ceiling. The wine library houses the bottles in racks with sufficient lighting to easily read the labels. Wine of sufficient potential will

be sourced and the barrels aged in the cave to be rotated every few months so the sediment can be drawn off. After a couple of years of barrel aging, the wine will be blended and bottled. Humidity will be carefully controlled.

For Mitchell, a 40-plus-year veteran of the wine industry (he began cleaning tasting rooms at 13), it is a satisfying construction career in an area not many people have chosen. "Most of the people in the wine cave industry know each other," explained Mitchell. "I have poured more than a million square feet of cave floors in my career. I still have a 1986 Schwing BP 750-15 back in Napa that pumped most of those cave floors and it still works fine." Mitchell will add to his cave floor square footage when he pours the cave floors with Brundage-Bone pumps later this year.



Jason Zignego, Sales Manager, Stationary Pumps, with Schwing America, St. Paul, MN, is a 20-year employee of Schwing. He started in the company as a Sales Assistant and became Sales Manager 5 years ago. He is a hands-on specialist, having worked with shotcrete pump applications his entire career. He is always available to answer any questions regarding wet shotcreting with Schwing stationary pumps; contact him at Jzignego@schwing.com.

Project Details

Excavation

Bacchus Caves
The Woodlands, TX

Engineering

Brierley Associates
Denver, CO

Architects

Slone and Associates
Springfield, MO

Cave Finishing Contractor

Brady Mitchell
Napa, CA

Pumping Equipment

Schwing S17
SP 500 stationary pump
SPT 1000 truck-mounted pump

Industry News

and permeability characteristics. QUIKRETE Base Coat Stucco – Pump Grade is a flowable, high-workability plaster particularly designed for spray applications. It is a fiber-reinforced portland-cement-based stucco, designed to be used as the scratch and/or brown coat in a three-coat stucco application, or the first coat in a two-coat application.

The QUIKRETE Companies is the largest manufacturer of packaged concrete and cement mixtures in the United States and Canada, and an innovative leader in the commercial building and home improvement industries. QUIKRETE also offers related products through numerous wholly owned subsidiaries, including SPEC MIX®, Pavestone®, Custom Building Products®, Target Technologies®, Daubois®, and QPR®. Collectively, QUIKRETE products are manufactured and distributed from nearly 150 facilities in the United States, Canada, Puerto Rico, and South America, allowing for unsurpassed distribution and product depth. The QUIKRETE Technical Center also ensures that professionals and consumers alike are provided with the most innovative and highest-quality products available on the market. For additional information on The QUIKRETE Companies or their products, please visit www.quikrete.com or call (800) 282-5828.

Hayward Baker Expands Its Regional Presence with New Office Facilities in Connecticut

The new office supports Hayward Baker customers in Connecticut, providing enhanced services and learning seminars

Hayward Baker Inc., North America's leader in geotechnical construction, announces the opening of a new office location in Middletown, CT. The new office is conveniently situated between Hartford and New Haven. The office supports customers and projects in Connecticut, led by Brian Eastman, PE, Project Manager with oversight from Kevin Dawson, PE, New England Area Manager.

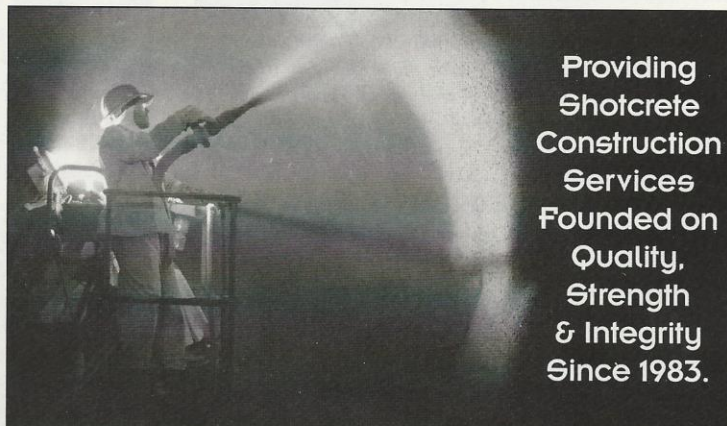
Eastman received his bachelor's degree in civil and environmental engineering, as well as a his master's degree in civil engineering with a focus on geotechnical engineering, from the University of Massachusetts Amherst, Amherst, MA, and has been employed by Hayward Baker for 5 years in the New England office. He has worked on a wide range of projects, including ground improve-

ment techniques, structure foundation support, and temporary support of excavations. Eastman is joined by Ray Smith, Superintendent, who brings more than 15 years of project experience including drilled shafts, shotcrete earth support, micropiles, and ground improvement.

According to Dawson, the opening of the Middletown office represents a commitment to serving Connecticut's diverse market of general contractors, geotechnical consultants, and commercial property developers. "We are excited to strengthen our focus in Connecticut. The new office location will enable us to offer enhanced service to our clients and expand our business in New England," he stated.

Recent local projects illustrate the wide range of foundation work Hayward Baker already performs in the region. These include aggregate pier ground improvement and drilled micropiles to support the new Earth Tower Hotel and Sky Connector at Mohegan Sun Casino, Uncasville, CT. In addition, approximately 4000 ft (1219 m) of steel sheetpile temporary earth support with internal bracing and grouted tiebacks are

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Senior Vice President and Denver Office Manager Greg Fischer stated, "We are excited to have NCTI certification as part of our condition assessment capabilities. It will allow us to better serve our clients by guiding them through the NTIS requirements and regulations. It also serves as another tool to help our clients with the important task of asset management."

Blastcrete Equipment Company Named Finalist for Small Manufacturer of the Year

Blastcrete Equipment Company, manufacturer of mixing and pumping equipment for the refractory and shotcrete industries, is one of eight finalists for the Small Manufacturer of the Year award in Alabama. The Alabama Technology Network and the Business Council of Alabama named the winner of the award, which honors the state's leading manufacturers' accomplishments, on April 12 during the 2016 Alabama Manufacturer of the Year Awards luncheon at the Activity Center in Montgomery, AL.

"Our employees take a tremendous amount of pride in what we do here. I'm proud of them, and this is quite an honor for us," said Jim Farrell, Blastcrete CEO. "We're a family-owned business and unique in that we design and manufacture our products in-house. Our 20 employees accomplish the same things as a larger company, only on a smaller scale. That gives us the ability to not only produce great equipment but to also back it up with personal customer service."

Blastcrete is a finalist in the small manufacturers category, which includes businesses with 99 or fewer employees. The award recognizes innovation in manufacturing, commitment to excellence, dedication to employees, and community investment.

"Now in its 17th year, the Business Council of Alabama is honored to salute Alabama's best manufacturers for their valuable participation in not only the state's economy but also the economies of their employees and the suppliers who do business with them," said William J. Canary, President and CEO of the Business Council of Alabama. "The Manufacturer of the Year Awards continues to be a premier event for the BCA, the Alabama Technology Network, the Chamber of Commerce Association of Alabama, and the National Association of Manufacturers. The BCA is proud to be the exclusive affiliate in Alabama to the NAM and the U.S. Chamber of Commerce."

Jim Douglas founded Blastcrete in 1950 in Los Angeles, CA, as a manufacturer of single- and double-chamber gunite machines. Farrell purchased Blastcrete in 1983 and relocated the business to Anniston, CA. The company continues to grow as it designs and manufactures products for refractory, construction, and concrete customers throughout the world.



Blastcrete has been manufacturing safe, reliable, and user-friendly solutions for the refractory and shotcrete industries for more than 60 years. With a complete product line that consists of concrete mixers, pumps, and related products, the company serves the commercial and residential construction, ICF and SCIP building systems, refractory, and underground markets. For more information: Blastcrete Equipment Company, 2000 Cobb Ave., Anniston, AL 36202; (800) 235-4867; fax (256) 236-9824; info@blastcrete.com; www.blastcrete.com.

Cemrock Builds Seaworld Habitat with Quikrete Shotcrete and Stucco

Last year, SeaWorld San Antonio (TX) opened Pacific Point Preserve, a new realm designed to teach visitors about sea lions, harbor seals, and Asian small-clawed otters and how to protect them in their natural habitat. A critical element in creating Pacific Point Pre-

serve, which resembles a fishing wharf along the Pacific Coast, was incorporating a home for the Asian small-clawed otters, sea lions, and harbor seals. Cemrock Landscape, Inc., employed a multi-phased process using a combination of QUIKRETE® Shotcrete MS and QUIKRETE Base Coat Stucco – Pump Grade to transform an old existing exhibit into a new natural habitat.

Once the deteriorated exterior of the existing exhibit was removed and repairs were made to the underlying frame, Cemrock Landscape, Inc., spray-applied seventeen hundred 80 lb (36 kg) bags of QUIKRETE Shotcrete MS to create a structurally-sound foundation. Cemrock then spray-applied twelve hundred 80 lb (36 kg) bags of QUIKRETE Base Coat Stucco – Pump Grade over a strategically placed structural armature before sculpting stone and wood features familiar to Asian small-clawed otters, sea lions, and harbor seals. Finally, artisans used colored iron oxide pigments to give the exhibit a truly indigenous appearance.

"The QUIKRETE products proved to be a perfect fit for this unique project," said Thomas O'Keefe, superintendent for Cemrock. "The shotcrete provided a sturdy structure and the stucco adhered well to the armature, and was easily molded so the exhibit really looks like a natural habitat. In addition, by spray-applying the materials, we were able to work quickly and efficiently while minimizing waste and rework."

Despite being small and meek in appearance, Asian small-clawed otters average 6.5 lb (3 kg) and can be very destructive, so the long-term durability of the exhibit is important. As a result, QUIKRETE Concrete Acrylic Fortifier was mixed into the stucco for increased strength as well as to provide protection against continuous moisture and salt water.

QUIKRETE Shotcrete MS is a single-component microsilica-enhanced repair material that achieves more than 9000 psi (62 MPa) at 28 days, and features very low rebound

