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American Shotcrete Association

Shotcrete MAGAZINE

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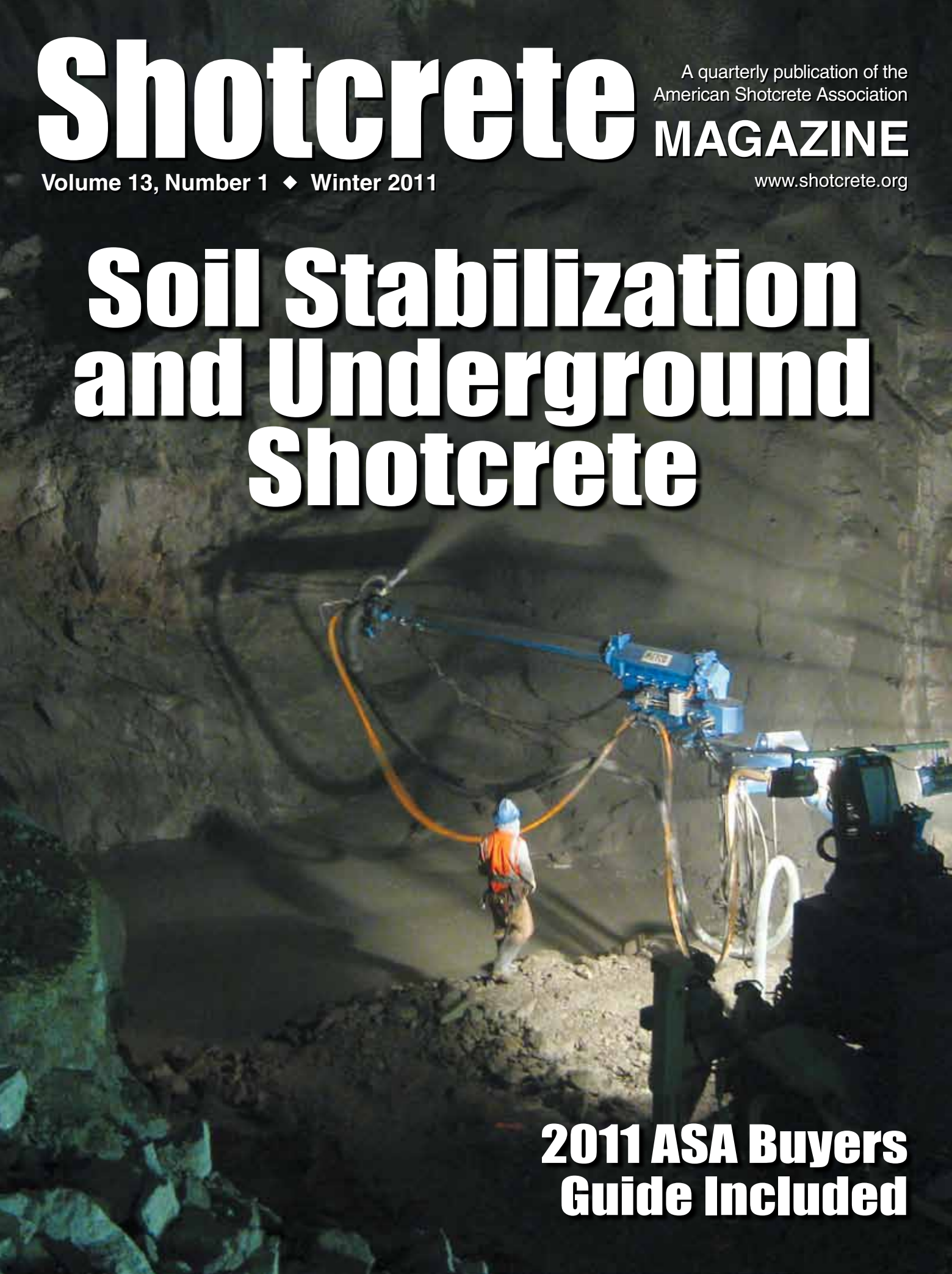
www.shotcrete.org

Soil Stabilization and Underground Shotcrete



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Shotcrete MAGAZINE

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Features

Departments

On the cover: Spraying concrete onto excavated ground at high velocity. Photo courtesy of George D. Yoggy.

Shotcrete—A Proven Process for the New Millennium

Restructuring the Certification Process

By Patrick Bridger

Since ASA was formed, our industry has greatly benefited from the decisions made by ASA's Board of Direction. Consistent with this group has been its strong vision and leadership. These qualities have been especially evident over the last 12 months as the Board took on the very large task of restructuring how ASA administers the ACI Shotcrete Nozzleman Certification program.

In early 2009, the Board became aware of, and began to examine, some potential shortcomings and industry confusion related to ASA's system for administering certification and education sessions for nozzleman certification. By March 2010, the Board made the decision to develop a plan to restructure the process. The next step was to form an experienced and talented task group to conduct an in-depth review of the then-current process, identify areas for improvement, and develop a detailed plan for moving forward.

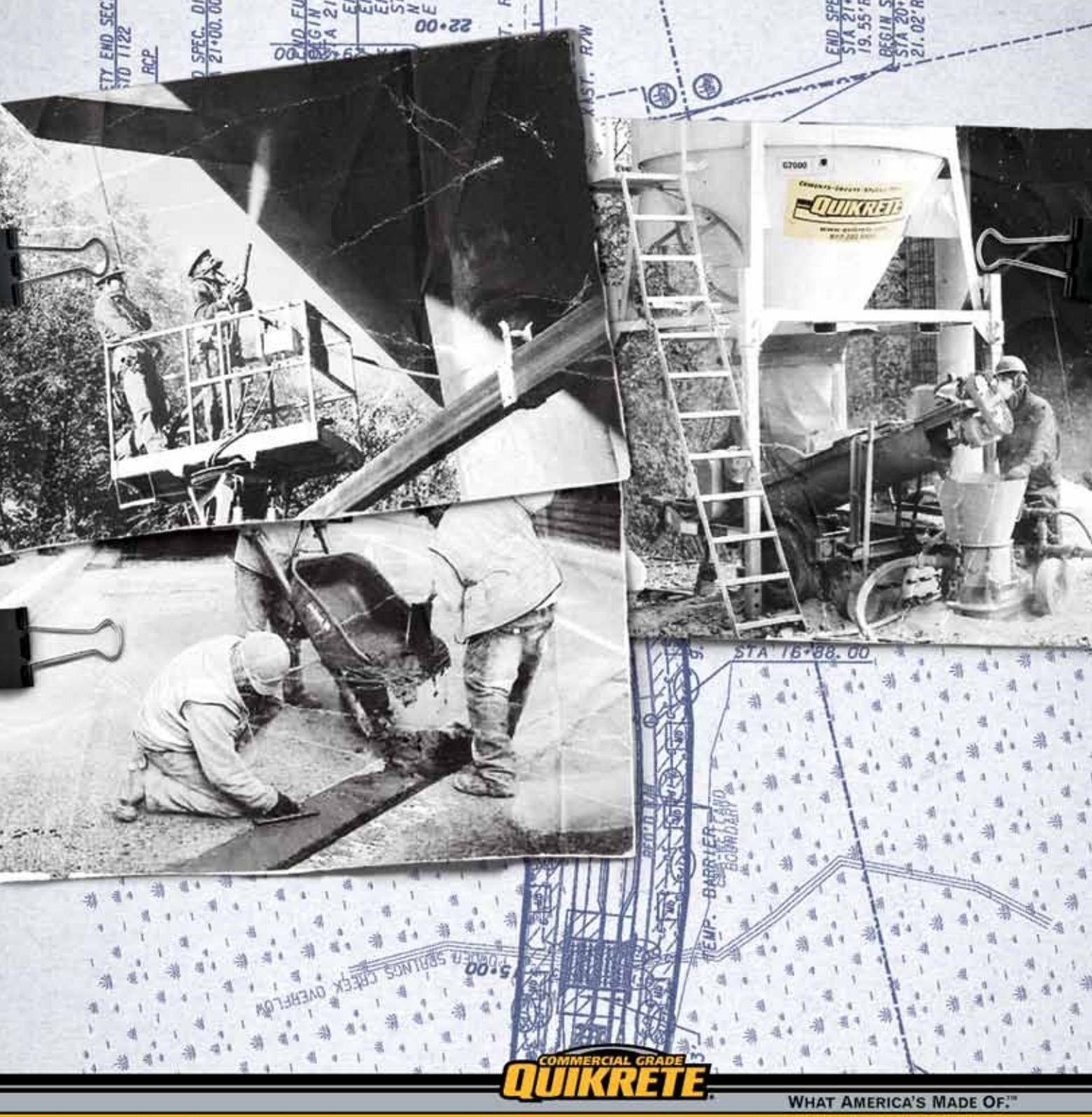
After many long months of hard work by numerous individuals, a detailed and comprehensive plan was assembled. The finished plan was presented to the full Board at the ASA fall meetings in Pittsburgh, PA, where board members voted unanimously to approve the restructuring and its related policies.

There are numerous restructuring goals, but three of the most significant ones are as follows:

- Minimize the administrative work load on Examiners to allow them to be as objective as possible and to focus specifically on the task of evaluating participants;
- Create a consistent and even playing field for all parties pursuing certification with standardized costs and timelines; and
- Create a system of continual evaluation of Examiners and ASA for proactive improvements.

It is my belief that these goals and many others have been fully addressed by the restructuring. ASA's process for administering the ACI Shotcrete Nozzleman Certification program is now significantly more transparent, objective, and consistent. For detailed information on the restructuring changes, visit the Certification section of the ASA Web site at **www.shotcrete.org**.

My thanks to everyone who contributed to this giant step forward for ASA and the shotcrete industry. It continues to be very inspiring to work with a Board of Direction that not only possesses great vision and planning but also directly tackles tough topics and simply gets the job done.



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What ASA's Certification Changes Mean to You

By Chris Darnell, ASA Executive Director

As mentioned in the President's Message, ASA has fundamentally changed how it administers certification and education sessions given in support of the ACI Shotcrete Nozzleman Certification program.

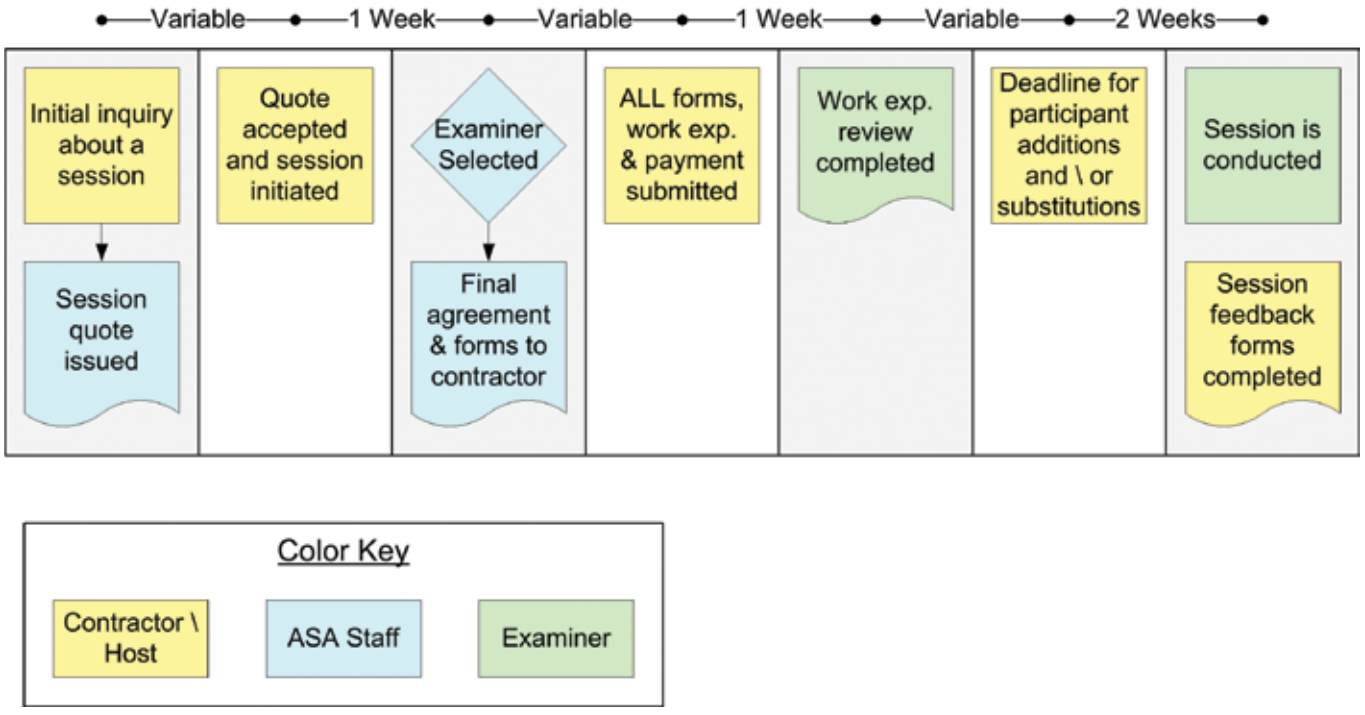
Full information on the changes, including the new policies and forms, can be found on the ASA Web site in the Certification section. I strongly encourage anyone with a current or potential future interest in nozzleman certification to spend some time reviewing this information. With that said, the following areas merit attention due to the significance of the change:

Default costs, timelines, and options for certification/education sessions are communicated up front. Listed on the ASA Web site in the Certification section is a complete price list for all items that make up a certification/education session. An individual or organization interested in a session will contact ASA staff and communicate the details of the session (for example, dry- or wet-mix, location, date, number of participants, and full- or half-day Education session), and staff will provide a detailed quote.

The individual or organization pursuing a certification session does not decide who will act as the session Examiner. In the past, a list of Examiners was given to interested parties; and it was up to them to contact an Examiner and coordinate all details. Under the new system, the selection of the session Examiner is an internal process overseen by staff.

Under the new system, we are working hard to identify and document any relationship between an Examiner and the

ASA Certification Session Process & Timeline



organization (and its participants). Part of the internal selection of an Examiner for a session is determining if a conflict of interest exists for a potential session Examiner.

All session coordination efforts and financial transactions will occur directly with ASA, not the Examiner. As mentioned in the President's Message, one of the primary goals of the new system is to relieve the Examiner of forces that might pressure his objectivity while also freeing him up to specifically focus on evaluating candidates pursuing certification.

The program's prerequisite work experience must be documented on ASA work experience forms. The ASA work experience forms require detailed documentation of work history making up the required number of hours. If you are considering Nozzleman Certification at any point in the future, I strongly encourage you to download a copy of the ASA work experience forms and begin documenting hours now so that you are prepared when you do decide to pursue certification.

The certification process will take a minimum of 4 to 5 weeks. This time period begins at the point of deciding to set up a session and concludes on the actual session testing date. "Rush" sessions in a shorter period of time are not possible, with no exceptions.

This means that certification through an ASA session can no longer be pursued at the last minute. Instead, the process now requires some forethought and planning. If you or your organization thinks there is the possibility in the future of bidding on a project requiring ACI Shotcrete Nozzleman Certification, do yourself a favor and begin pursuing certification as early as possible.

Again, I encourage you to view the full information on the restructured process for an ASA-sponsored Certification and Education session on the ASA Web site at **www.shotcrete.org** in the Certification section. The ASA Board will continue to closely monitor the new process for required changes and improvements; and, as always, ASA staff is available to answer any questions you may have.

We believe that the parties pursuing ACI Nozzleman Certification through ASA will find the new system more consistent in its application and much simpler to access, understand, and plan for.

So what are you still waiting for?

It's time to get your nozzlemen trained and certified!

The American Shotcrete Association, in partnership with the American Concrete Institute, has developed a comprehensive program to upgrade the knowledge and skills of shotcrete nozzlemen and to facilitate ACI examination and certification. Provide your clients with the assurance that your nozzlemen have demonstrated that they have the capabilities to perform the job right—the first time!

To learn more or to schedule an ASA training session and an ACI Shotcrete Nozzleman Certification examination, visit www.shotcrete.org or call (248) 848-3780.

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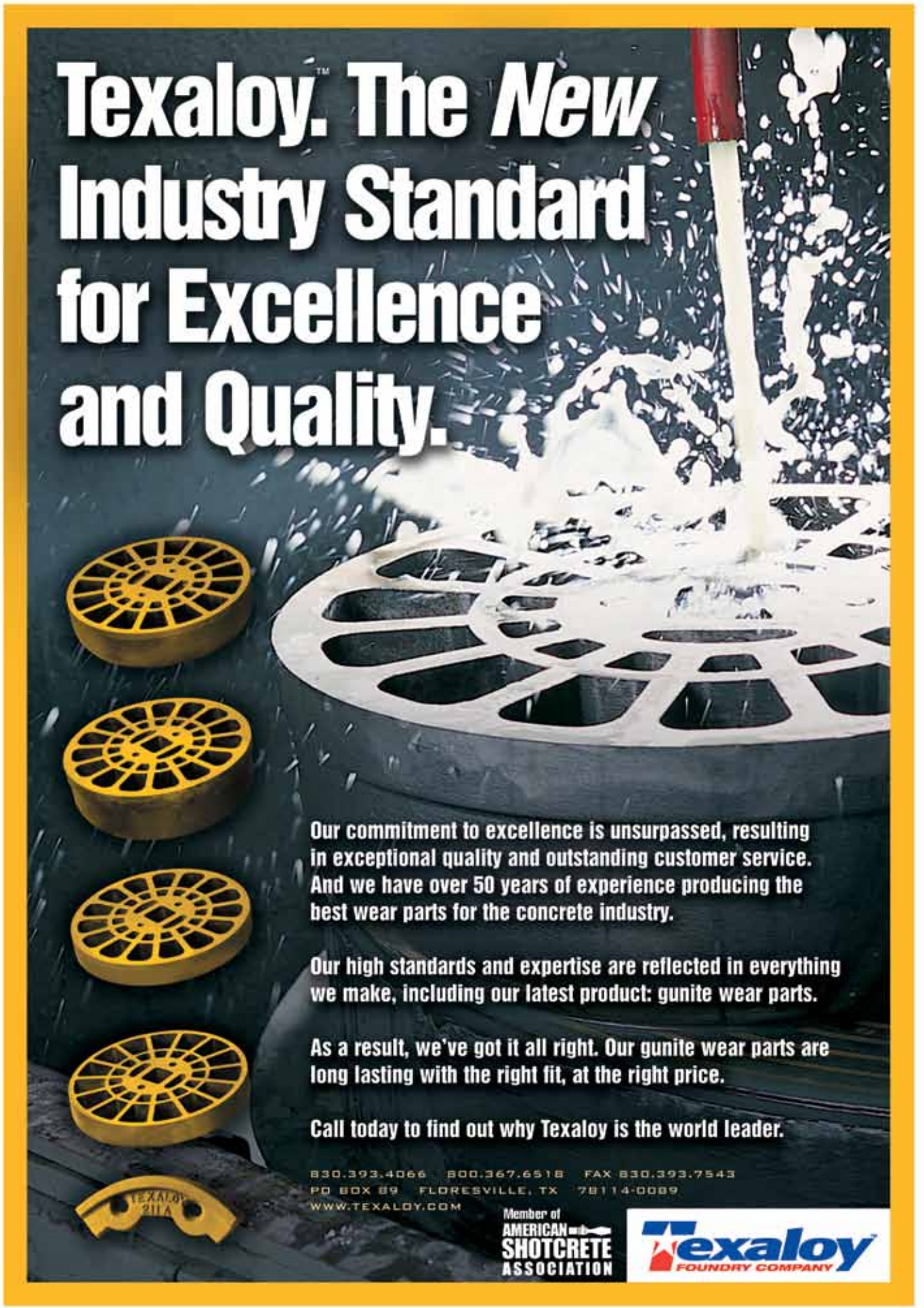

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Underground Shotcreting

By George D. Yoggy

Many tunnels and mines constructed throughout North America in the last 20 years have successfully used shotcrete as a major element of support during excavation and as part of the lining system. Shotcrete has reached the century mark, and its use to build new concrete structures and restore and repair existing structures is well known and documented. Although this versatile method of placing concrete is widely accepted by the construction industry, shotcrete for ground support in tunnel and mine operations is perhaps less known by the general contracting community. Underground shotcreting, however, consumes the largest volume of concrete of all pneumatic applications. Today, nearly all tunnels under construction in North America will use shotcrete as part of their support system. And rather than a cast-in-place concrete lining, a shotcreted final tunnel lining, installed after the ground support system is in place, is also practical and gaining acceptance.

When shotcreting underground, the nozzle operator must address joints in the rock and assure proper coverage to provide support to the ground

Technical Advancements

The development of rotary-type gunning equipment in the 1950s, which allowed continuous material feed, higher outputs, and the use of larger aggregate mixtures, is the greatest contributor to the wide use of shotcrete for ground support in tunnel construction.

The development of the New Austrian Tunneling Method (NATM) in the late 1950s, as well as similar engineering philosophies, has contributed to making shotcrete a vital part of tunnel support and lining. NATM and the Sequential Excavation Method (SEM) are systematic design and support methods that integrate the behavior of the geology and monitoring of the performance of support during excavation and construction. Shotcrete, a primary component of the tunnel construction system, results in time and cost savings and allows greater use of underground space. Several soft ground and "mixed face" tunnel projects presently being constructed are possible because of this technology.

Over the last two decades, advancements in concrete technology, shotcreting equipment, and application methods have contributed to the growth of shotcrete as a primary support element in tunnel and mine applications. Advances in the wet process, particularly in the use of admixtures, have allowed higher volume capabilities, more versatile mixture designs, and more effective use of steel fibers as integral reinforcement. The dry-mix process, however, is still effective and efficient in some areas of tunneling and is the predominant method in many parts of the world for ground support in mines. Because access to deep mine areas is limited (usually through a vertical shaft that may extend to depths of several thousand feet), delivery of a dry mixture from the surface to the point of placement eliminates the set time limitations of wet shotcrete. On some projects, transporting materials to the point of use can take hours or days.

Why Shotcrete Is Ideal for Ground Support

The American Concrete Institute (ACI) defines shotcrete as "…concrete or mortar applied to a

surface at high velocity." Spraying concrete onto a surface at high velocity is, in theory, the perfect concrete placement method. Individual aggregate particles of various sizes, coated with cement paste, are driven into place to form a void-free mass of fully compacted concrete. This strong, dense, well-bonded material is ideal for rock and ground support and lining.

Tunnels are generally permanent or long-term structures designed as conduits for cars and trucks, trains, water, waste, or power. Mine openings are typically designed to have shorter life spans because their primary purpose is to allow retrieval of minerals. The role of shotcrete is similar in both applications—to serve as a structural support element alone or in harmony with other support systems.

Excavation of rock or ground to form a tunnel can take place in several ways, nearly all of which can use shotcreting as support to maintain the opening. Shotcrete is most often used in drill-and-blast excavations but is also applicable in mechanical excavation of soft ground or mixed-geology conditions, such as recent projects in Seattle and ongoing tunnels in San Francisco and near the U.S. Capitol.

During the excavation process for a mine or tunnel, the ground is disturbed, sometimes violently. After a section or "round" is excavated, shotcrete is applied as an initial cover to prevent the rock from reacting to a changed environment. Early application of shotcrete effectively seals the ground against air slaking (a change in moisture and plastic properties) and assists in distributing forces in the surrounding rock or ground mass. When shotcrete is sprayed onto the surface, the mortar and fines-dominated matrix fills tiny fissures and openings that occur naturally or have resulted from the excavation process.

Depending on a variety of conditions, such as the size of the opening, rock mass quality, and rate of tunnel advancement, additional support elements may need to be installed. As Fig. 1 shows, rock anchors or bolts are commonly used to work in concert with shotcrete. Often, two or more layers of shotcrete are applied, depending on the design criteria, construction cycles, and tunnel end use. Welded-wire fabric, traditionally used as part of the first step in ground support in tunnel construction, has now been almost totally replaced by the use of steel fibers in shotcrete. Steel and some synthetic fibers are also being used to replace mesh in mine excavations.

Mixture Design Requirement

To meet the requirements for ground control in the difficult, often hostile underground environment, concrete mixtures that are to be applied to surfaces using the shotcrete method must be carefully designed to satisfy exacting criteria. The contractor will be responsible for conducting a variety of preconstruction tests to prove performance, and the concrete producer is responsible for supplying a mixture dictated by project requirements and conditions. Attention to such factors as the water-cement ratio, cement and aggregate proportioning, environmental conditions in the tunnel or mine, time/life cycle of the concrete, and use of chemical admixtures is extremely important to achieving a quality product.

To ensure proper adhesion on vertical and overhead surfaces, set accelerators are introduced into the nozzle to alter the setting characteristics of the shotcrete

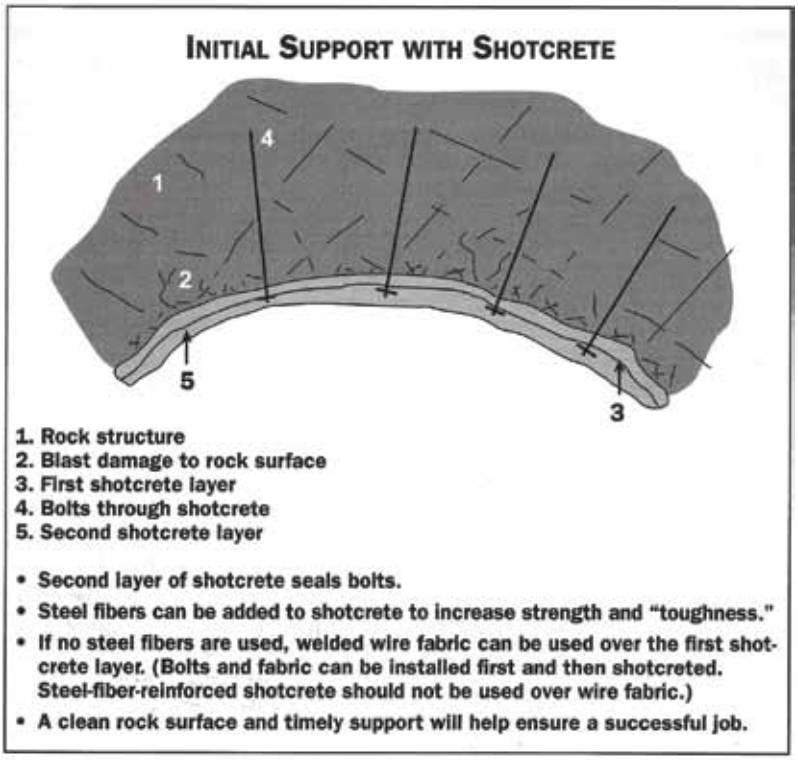


Fig. 1

Today, nearly all tunnels under construction in North America will use shotcrete as part of their support system

Modern transit projects require large caverns for stations. Shotcrete and modern shotcreting equipment make this possible

The conveying and application systems for shotcreting, both wet and dry, typically use hoses and nozzles with inner diameters of 2 to 3 in. (50.8 to 76.2 mm). Therefore, all mixtures must be designed with a maximum aggregate size of 3/8 in. (9.53 mm). Because mixture designs for shotcreting consist of small aggregate, more surface area to coat requires high cementitious content and careful attention must be given to water requirements, particularly in mixtures for wet process. Water-reducing admixtures are a must for producing quality material that will be pumpable and capable of passing through reduction components between the pump piston and the hose and hardware used for placement.

Mixture designs for dry-process shotcrete must contain properly graded aggregates and known moisture content. When oven-dried, packaged materials are used, predampening with control is a must. How water and additives are measured and introduced into the mixture and at the nozzle are very important considerations for quality and performance. Dosing of accelerating additives at the nozzle for the wet process must be exact and controlled. Therefore, pre-job tests involving the engineer, contractor, materials supplier, and equipment supplier are essential.

Silica fume improves the performance of all shotcrete by reducing rebound, increasing density, and greatly improving bond. Its microparticles of cementitious material adhere better than plain cement to the roughened rock surface left by the excavation process and enhance the overall performance of shotcrete for rock support. Because of its fineness, however, silica fume demands more water than ordinary cement mixtures and requires special care in design of mixtures. The contractor must know how to introduce admixtures that will allow lower water contents, improve pumpability, and control accelerator dosing requirements.

Shotcrete mixtures are generally designed to be flowable, pumpable, and sprayable for easier application. But because underground shotcreting requires application of concrete to vertical and overhead surfaces, these plastic characteristics must be reversed almost immediately after the shotcrete leaves the nozzle to assure that the material adheres to the rock surface and builds strength quickly.

Set-accelerating additives introduced at or near the nozzle are used to alter the setting characteristics of shotcrete in a matter of minutes. And modern chemistry used for this purpose is safe and user-friendly to the applicator and the concrete.

Challenges of Working Underground

In some parts of the world, it is possible for a tunneler to employ specialty shotcrete contractors. But due to the complexity of underground shotcreting, safety risks, equipment requirements, and access problems associated with excavation and advancement cycles, few shotcrete contractors specialize in tunnel projects.

Shotcreting in a tunnel requires that the applicators know as much about the rock surface and its general makeup as they do about the concrete being applied. The complex, broken rock surface dictates that the nozzleman or robot operator "read" the rock so the direction and buildup of shotcrete will form a complete, homogeneous member. Whether a wet or dry

process is used, rebound and overspray must be monitored and controlled. Ninety percent of all shotcrete rebound occurs in the first 10% of application. As the larger particles in the mixture strike the hard surface and bounce off, they shed their cement paste coating, driving the fine, rich mortar matrix into the intricate surface (refer to Fig. 2). This filling of joint planes binds together loose or partially supported fragments of rock and prevents further deterioration and movement. As the layer of concrete builds, a structural member is created with predesigned and predictable results, without the aid of forms. The shotcreter must also anticipate where dust and overspray may coat a surface and interfere with concrete bond or sound concrete buildup. These are but a few important steps in assuring quality and performance.

Other factors contributing to successful tunnel shotcreting include:

- A clear understanding of the concrete components and mixture design;
- A clean rock surface to ensure bonding of the concrete and filling of fissures and surface breaks;
- Careful planning of the batching, transport, and application time for the concrete based on the logistics of the project;
- A familiarity with the conditions and safety requirements of the underground environment; and
- Proper and ample training and education. This is not a do-it-yourself construction method!

Shotcrete can perform many useful functions in underground construction because its mixture design can be adjusted to accommodate the demands of the project, the equipment used for placement, and the environment in which it is applied. As in all areas of concrete construction, however, successful and proper application requires both sound theoretical knowledge and a great deal of practical experience.

George D. Yoggy *has been directly involved in shotcrete and concrete applications for more than 40 years. Yoggy retired from Master Builders in 2000 and is a consultant to the tunnel and shotcrete industries. He lectures at various training programs on the use of shotcrete, is an approved ACI Examiner, and serves on several technical committees for ACI, ASTM International, ASA, and the American Underground Construction Association. He continues to be an active participant and respected leader in industry initiatives.*

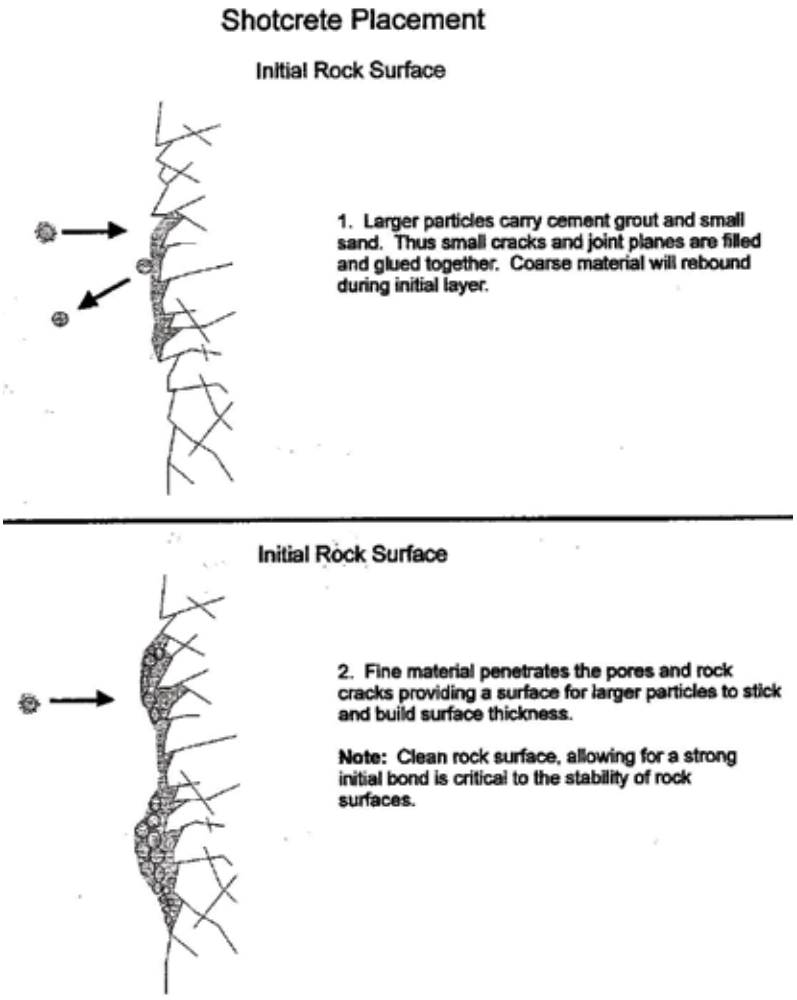


Fig. 2

Spraying concrete onto excavated ground at high velocity effectively fills surface fractures and joints and assists in distributing forces in the surrounding rock mass

Shotcrete in China's Longest Tunneling Project

By Kelly Blickle

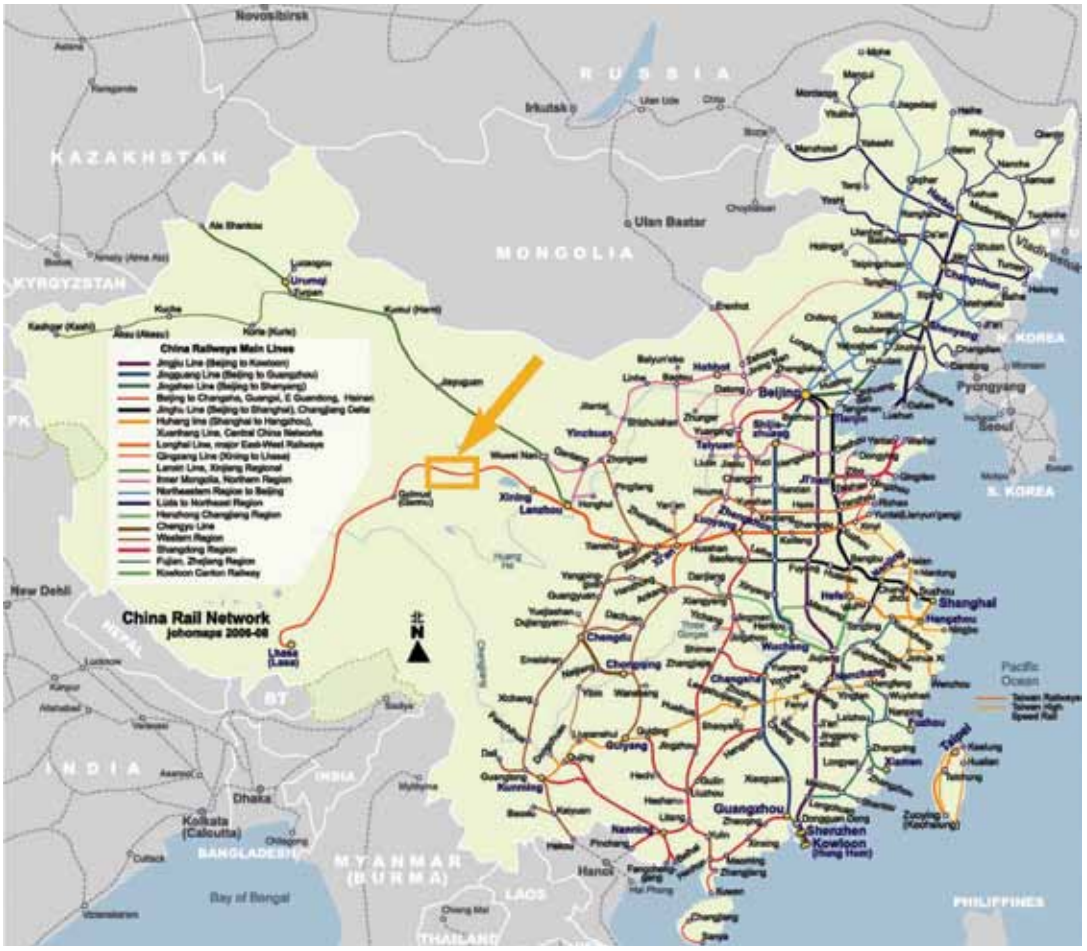
In the Guanjiao Mountains of western China, at an average altitude of 11,483 ft (3500 m), two parallel railway tunnels 21 miles (33 km) long are being constructed. This is the longest tunneling project ever undertaken in China, and the world's longest high-altitude railway tunnel.

The tunnels form part of a 506 mile (814 km) long transportation route inaugurated in 1984 connecting Xining, the capital of the Qinghai Province, and the city of Golmud, situated further west. Between 2000 and 2005, the railway line was extended by 709 miles (1142 km) from Golmud to Lhasa, capital of the Tibet Autonomous Region (Tibet Railway).

Faster to Tibet

The new tunnel structure will replace the older, 2.5 mile (4 km) long Guanjiao Tunnel situated 984 ft (300 m) higher, which is only accessible via very windy access tracks. Thanks to the perfectly straight route through the mountain situated at a lower altitude, journey times will be shortened considerably, and fuel savings will be significant. The sections of the new Guanjiao Tunnel have been designed for train speeds of up to 99 mph (160 km/h).

The two single-track tunnels, which are 131 ft (40 m) apart, are driven up from all four entrances to create an excavated cross section of approximately 967 ft² (90 m²). Progress is made both with the use of tunnel-boring machines and the New Austrian Tunnel Method (NATM), which integrates behavior of the geology under load and the monitoring of the performance of support during excavation and construction. There are a total of 11 inclined shafts with a length of



Survey of the main Chinese rail lines

9.5 miles (15.26 km) and one auxiliary pilot tunnel of 6 miles (9.8 km) in length parallel to the main tunnel. As part of tunneling operations once excavated and with walls strengthened by shotcrete, the side wall and base are built by moving a few yards at a time.

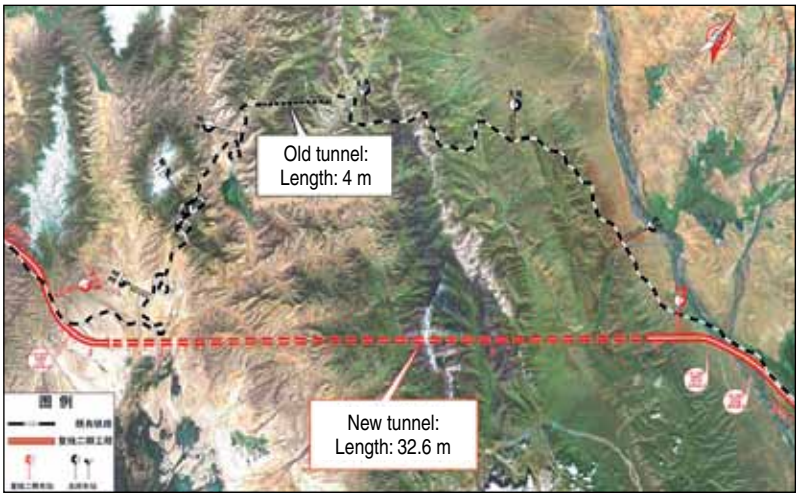
The biggest difficulty of the tunneling project at this altitude is dealing with groundwater and controlling the deformation of the rock section of the carboniferous slate. The construction costs for the new Guanjiao Tunnel come to $376 million U.S. or 2.5 billion Renminbi in Chinese currency. Up to now, about one-half of the tunneling job has been finished—12 miles (19.5 km) at the entry side and 9 miles (15 km) at the exit side.

Shotcrete Equipment and Strategy

There are currently two complete PM 500 PC concrete spraying systems reinforcing the excavation at the entry side of the Guanjiao Tunnel for the China Railway 16 Bureau Group. These units are comprised of the dosing pump, spray arm, concrete pump, and air compressor, all mounted on one carrier. Mobilization after each excavation is integral to this project. Each of the concrete spraying system's four-wheel-drive and four-wheel-steer carriers allows them to quickly and easily move around the job site.

With 56 ft (17 m) vertical and 49 ft (15 m) horizontal reaches, the spray arms allow precise and smooth movement for accurate placement of the shotcrete without the need to move the unit once it is set up. The combination of the spray arm with the high-precision spray head allows the operator to accurately apply the shotcrete. Operating the boom by remote control allows increased maneuverability around the unit, which enables a safe viewing of the entire application area.

The supply of air from the onboard air compressor provides the high velocity needed to spray the concrete and to provide the compaction, bond, and strength benefits of shotcrete. The concrete pump and additive dosing pump are controlled by an onboard computer regulating the synchronization of the air, concrete, and additive. With these three components being accurately



This map illustrates the windy course of the old 984 ft (300 m) high running track and the position of the two new single-track tunnels, which are considerably longer (Note: 1 m = 3.28 ft)
Illustration courtesy of China Railway 16 Bureau Group

Transport of the shotcrete unit crossing a pass situated at an altitude of about 11,843 ft (3500 m)

Concrete Spraying System Technical Data	
Working height of the SA 14 telescopic spraying arm	13 to 56 ft (4 to 17 m)
Delivery rate of the double-piston shotcrete pump	Maximum 39 yd^3/h (30 m^3/h)
Volume of the additive tank	0.26 + 264 gal. (1 + 1000 L)
Delivery rate of the additive metering unit	8 to 185 gal./min (30 to 700 L/min)
Compressor output	14 yd^3/min (11 m^3/min)
Volume of the water tank	52 gal. (195 L)
Concrete pipeline	3 in. (80 mm)
Nozzle	2 in. (50 mm)
Power cable	164 ft (50 m), 328 ft (100 m) optional
Pump and boom operation	Cable remote control (radio remote control optional)
Drive output of the carrier vehicle, among other things, with four-wheel-steering, all-wheel drive, rotating cab	101 hp (75 kW)

delivered, high-quality shotcrete and spraying output are ensured in the project.

Low Temperatures and Lack of Oxygen Take Their Toll

At temperatures as low as –33°F (–36°C) and atmospheric pressure reduced by one-third, the tunneling operations at an altitude of 11,089 ft (3380 m) put a strain on workers and machine operators. Typical symptoms experienced by site staff include shortness of breath, exhaustion, headaches, and nausea. In case of emergency, there is oxygen equipment available at the construction site.

The compressor output of the shotcrete unit at this altitude is still at 100% (the result of air volume × pressure remains constant), and the low static pressure has an effect on the suction in the shotcrete pump, at least in theory. At a maximum delivery rate of 39 yd^3/h (30 m^3/h), however, this loss in output cannot be detected in practice.

Of course, the low temperatures are a problem (the annual average is below 32°F [0°C], especially during the winter months. This also results in the formation of ice in the tunnels, which means that the aggregates, additives, and water must be stored in a way to prevent freezing.

This operator familiarizes himself with the remote control of the modern concrete-spraying system

Job-site crew just before starting up the shotcrete unit

Project Completion

With a planned construction time of 5 years, completion is scheduled for 2012.

The side wall and base construction follow once the tunnel is excavated

Kelly Blickle *is a Marketing Services Manager for Putzmeister America, Inc., based out of Sturtevant, WI. She manages the day-to-day operations of the company's marketing department. Blickle has held various positions at Putzmeister America after joining the company in 1999 and received her bachelor's degree in marketing from the University of Wisconsin-Whitewater. She can be reached at (262) 884-6387 or by e-mail at blicklek@putzam.com. Putzmeister America manufactures a complete line of truck-mounted concrete boom pumps, separate placing booms, truck-mounted telescopic belt conveyors, and trailer-mounted concrete pumps, as well as mortar, grout, shotcrete, plaster and fireproofing pumps and mixers, industrial pumps, tunneling machinery, and pipeline systems.*

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Wet-Mix for a Traditionally Dry-Mix Application

By Chuck Pulver

When it comes to the mining industry, the use of the shotcreting process is relatively new to coal mines. The dry gunite method is currently used for constructing explosion-proof seals, ventilation overcasts, and for covering the roof and walls in some permanent openings such as conveyor drifts, ventilation corridors, and employee walkways. Until now, the only application method used has been dry-mix.

The problem with using dry-mix shotcrete in a coal mine is that it generates significant dust. It is normally brought in and loaded into the gun in 50 to 80 lb (23 to 36 kg) bags. Coal mines must be very well-ventilated to remove potentially explosive coal dust and traces of methane gas that can be in the air. Because of the high volume of ventilation air that is required, it is inevitable that the guniting dust will be carried into the ventilation air stream and cause problems for any personnel that are working downstream of the gunite process. In addition, handling numerous pallets of dry material underground adds logistical issues.

The limitations and problems with using wet-mix shotcrete are mainly in the equipment setup. Coal mines are very particular about any type of equipment used underground. Any diesel engine must be permissible and electrical equipment must be intrinsically safe. The availability of intrinsically safe or permissible wet pumps is almost nonexistent in North America; therefore, traditional shotcrete pumps are not allowed within the mine. Not being able to bring a regular concrete/shotcrete pump into a coal mine means that the mixture needs to be pumped from the surface down to the location to be shotcreted in the mine, which can be approximately 1500 ft (458 m) of horizontal distance after descending the shaft.

In discussion with various people in the shotcrete and concrete industries, it was decided that with the proper mixture design, the concrete could be pumped a considerable distance to the nozzle. Therefore, working with our ready mix supplier and an admixture supplier, we came up with an initial mixture design and tweaked it a few times to get a mixture that looked acceptable for long-distance pumping. We had recently pumped a similar mixture with the same pump to construct a ventilation seal in a coal mine but had problems with plugging in the horizontal section of the line. This revised mixture would need to be more flowable and eliminate the plugging problem.

We assembled our team consisting of our concrete supplier, his laboratory personnel, and our admixture supplier and got together at the concrete supplier's laboratory. Because our admixture supplier had experience sending shotcrete mixtures long distances vertically, they helped us with a good starting point for our mixture. We ended up with a mixture that had an initial slump of 5 in. (125 mm). A set stabilizer was added because it would take approximately 1 hour of travel time from the ready mix plant to the mine and then there was the potential waiting time at the mine. We decided to add a high-range water-reducing admixture (HRWRA) to the truck just before discharging to get the slump-spread between 23 to 25 in. (585 to 635 mm) just before pumping. A viscosity modifier was also added at the mine site. After initial laboratory tests, larger 5 yd^3 (3.8 m^3) loads were tested so that they were mixed in the trucks. We shot the new mixture on a concrete wall on the surface to see how it would pump and to dial in the right dosage of alkali-free accelerator. After that, we were pretty much set to go.

The first opportunity to use wet-mix shotcrete in a coal mine came in October 2010, and it was to line a tunnel just near the bottom of the shaft at a mine in West Virginia. The dimensions of the tunnel somewhat varied but were—on average—16 ft (4.9 m) wide x 7.5 ft (2.25 m) high and 350 ft (105 m) long. The tunnel's walls and roof were exposed coal and had been covered with a limestone dust, as per Mine Safety and Health Administration (MSHA) requirements. The limestone dust is intended to extinguish a fire if an ignition occurs.

Roof bolts were installed in the roof, walls, and floor of the tunnel and welded-wire mesh was attached to the roof and walls. Approximately the last 20 ft (6 m) of the tunnel was supported with only the bolts and no welded-wire mesh as a test to see if the wet mixture would only adhere to the coal.

The pump was positioned on the surface near the shaft head frame. The pump outlet was reduced to 3 in. (76 mm) and a 3 in. (76 mm) diameter steel pipe was run from the pump, 1000 ft (305 m) down the shaft, and approximately 350 ft (107 m) horizontally out to the area to be shotcreted. A guillotine concrete valve was installed at the shaft bottom so that the workers underground could shut off the material flow without needing to empty the entire column of shotcrete mixture from the top of the shaft when they wanted to interrupt the material flow. The pipe was reduced to 2 in. (51 mm) and a 150 ft (45.72 m) flexible hose was added at the shooting area. A nozzle was used at the end of the hose.

Compressed air was already available in the mine, so a separate compressor was not required. A peristaltic accelerator pump with a variable speed drive was set up underground and drew the accelerator from 55 gal. (208 L) plastic drums. These were located in the area where the application would take place and deliver it to the nozzle. Electricians at the mine installed mine phones at the pump on the surface, at the concrete valve, and in the nozzleman's area underground. These phones were on a dedicated line to ensure immediate communication from the nozzleman to the pump operator.

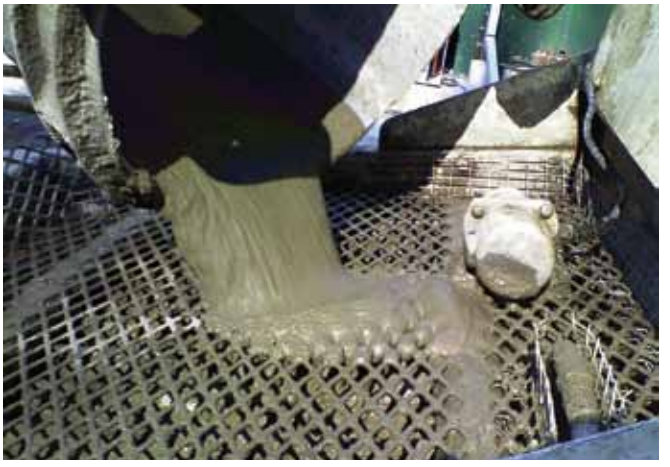
Because this was the first attempt at applying wet shotcrete in a coal mine from the surface, a lot of time was taken to make sure everything went well. The trucks were ordered but were limited to three trucks of 8 yd^3 (6.1 m^3) each per day just in case the line did plug and time ran short to shoot all the material.

The shooting went well over a period of 10 days—including shooting over the coal without the welded-wire mesh—and the mine was very pleased with the lack of dust and the smoother appearance of the wet-mix material once it was applied. The wet mixture also generated 10% less rebound than the dry-mix would have, reducing preparation for the subsequent floor pour. Finally, after the shotcreting was completed, the same mixture was pumped down to pour the floor in the same tunnel. It was a self-leveling mixture and did not require much finishing.

There have already been rumblings about shooting another area further into the mine in the same manner. As the horizontal component of the material pumping lengthens, this operation will become more challenging. If we have continued success with this method, we may be pumping wet-mix shotcrete mixtures as far as 1500 ft (458 m) horizontally after going 1000 ft (305 m) down the shaft within the next year, but those challenges and experiences will be material for a future article.

A 22 in. (559 mm) slump-spread shotcrete mixture

Pump with 3 in. (76.2 mm) pipe to shaft



Pumping a high-flow shotcrete mixture

Chuck Pulver *is the Manager of Pumping Services for Strata Mine Services Inc. in St. Clairsville, OH. Strata Mine Services Inc. is a major contractor servicing and supplying the coal mining industry. Visit the company's Web site at www.strataworldwide.com.*

Equipment Selection—The Key to a Successful Soil Nailing Project

By Craig McDonald

There are many things to consider when selecting the appropriate equipment for a soil nailing project. The job location may be in the center of a bustling city or in a remote area of wilderness miles away from any type of services. Each will present its own unique challenges that will determine the process and therefore the equipment being used.

Wet-mix shotcrete supplied by a local ready mix supplier can be a simple and viable option, provided that all the site logistics are in place. If the concrete trucks are able to access the site as required and can reach within close proximity to the area to be sprayed, the wet-mix process is often the way to go. The wet-mix process can allow for continuous, high-production application without the need for secondary equipment such as water-booster pumps, lift trucks, and high-volume air compressors (greater than 185 ft^3/min [5.24 m^3/min]). Wet-mix equipment also operates with less wear parts when compared to the equipment used in a dry-mix application. In many cases, wet-mix concrete pumps provide a quick, efficient, and reliable option for spraying concrete.

In many cases, however, access to a continuous supply of wet-mix shotcrete may be limited or the job site may not be accessible by concrete trucks at all. In these cases, because of its flexibility, dry-mix shotcrete will often be a preferred method of placement. Once delivered to the site, prepackaged, dry-mix shotcrete can be stored and used as required, and when material is available "on demand," productivity can be dramatically improved. The dry-mix process is also beneficial if material placement is intermittent. Shotcrete placement can easily be stopped and restarted without emptying hoses or cleaning out machines.

Another advantage of the dry-mix process over wet-process shotcrete is the ability to convey shotcrete material over long distances. The thin-stream process allows material to be easily conveyed over 985 ft (300 m) horizontally from the location of the actual pump and up to 330 ft (100 m) vertically. This benefit is of particular importance when access to the face is difficult or the distance from the pump to the face is excessive. Consideration should be given, however, to the compressed air requirements. Air-driven equipment will require a minimum 375 ft^3/min (10.62 m^3/min) air compressor, and for larger machines and long distances, air compressors of up to 1000 ft^3/min (28.32 m^3/min) may be required. Also, water pressure exceeding 75 psi (0.52 MPa) will be required to ensure a sufficient, consistent supply of water at the nozzle.

Equipment selection options may start at the machine (wet-mix pumps versus dry-mix machines), but they also extend to the point of placement. Handheld spraying is the most common method for placing shotcrete; however, as the area being sprayed gets larger and particularly higher, the need for equipment to assist in the nozzling process increases. Tools such as scissor lifts and boom lifts are often used to assist the nozzleman in reaching areas that cannot be shot from the ground level.

Spray arms can also be used to apply shotcrete on areas that cannot be reached by a nozzleman. Shotcrete spray arms can reach heights ranging from 10 ft (3 m) to over 72 ft (22 m) and are operated via remote control. Spray arms still require the use of a shotcrete pump and can

Shotcrete spray arms can reach heights ranging from 10 ft (3 m) to over 72 ft (22 m) and are operated via remote control

be used with both the wet-mix and dry-mix processes. There have been many different adaptations for mounting spray arms on mobile equipment. Most equipment manufacturers sell spray arms already mounted on carriers. Spray arms have also been mounted on rail cars, excavators, tractors, on the buckets of load-haul dump equipment, and even on the front of pickup trucks. Of course, proper engineering is required to ensure that the host carrier can accept the weight of the boom, provide sufficient counter-weight, and also be able to withstand the additional forces applied during the shotcrete application process. Remote-controlled spray arms provide a safe and simple means of spraying concrete in areas that cannot be reached by a nozzleman.

Similar to most construction equipment, the equipment used for soil nailing can range from rudimentary machines to the latest technology involving programmable logic controller (PLC) spray arms that operate on a preprogrammed spraying pattern. Once the machinery is matched with the task at hand, even the largest shotcrete projects become more manageable and cost-effective. If in doubt, never hesitate to contact your local shotcrete equipment expert to help match your equipment needs to your project.

Craig McDonald *is a Sales Manager for the Mining Markets Division of King Packaged Materials Co. Equipment. The wet- and dry-mix shotcrete process, as well as the mixing and placing of dry-mix concrete and grout products, are his areas of expertise. He is a graduate of the Mechanical Engineering Technology program at Canadore College, North Bay, ON, Canada.*

Shotcrete as a Long-Term Solution to Power Canal Wall Stabilization

By Tara Brown, Patrick Giroux, and Joe Hutter

Located in central Ontario's cottage country and founded in 1914, the Peterborough Utilities Commission (PUC) operates as a not-for-profit organization providing safe and reliable supplies of electricity and water to the city of Peterborough, ON, Canada. Restructuring in 2000 led to the PUC becoming part of the Peterborough Utilities Group, and it continues to operate as such.

In April 2008, PUC, in partnership with Trent Rapids Power Corporation (TRPC), began construction of The Robert G. Lake Generating Station, an 8.0 MW run-of-the-river hydroelectric generating facility on the Otonabee River. The powerhouse and southern portion of the power canal were to be situated within the city of Peterborough on land leased from Trent University. The intake structure and northern portion of the power canal were to be located within the nearby township of Smith-Ennisclaire-Lakefield.

The project included the following key features:

- An intake structure located adjacent to the west end of the Lock 23 Dam and Lock 22 Dam;
- A 3445 ft (1050 m) long power canal on the west bank of the river between the Lock 23 Dam and Lock 22 Dam;
- A powerhouse containing two 4.0 MW turbines; and
- A 44 kV substation and power line injecting energy into the local distribution grid of Peterborough Distribution Inc.

The initial power canal design called for the excavation of near vertical walls into the bedrock. During excavation, TRPC made some observations that differed from what was expected on site. The two most critical observations were inconsistencies in the elevation of the bedrock and unexpectedly poor bedrock quality. These observations led the team at TRPC to enlist the services of a

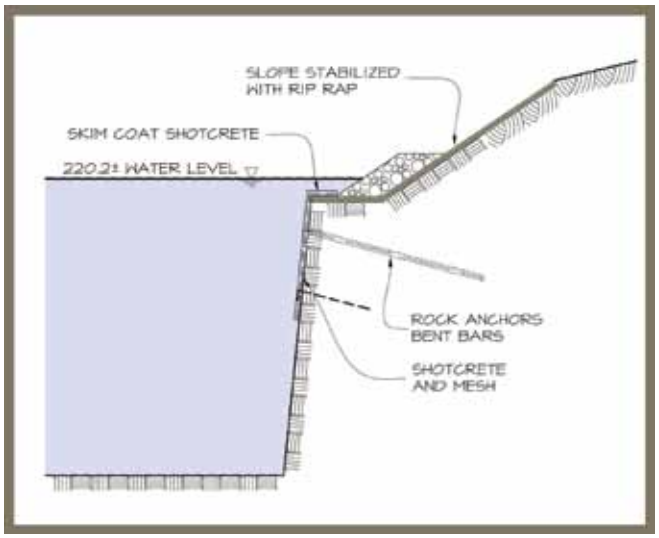


Fig. 1: Excavate overburden, install rock anchors and mesh, and apply shotcrete to the weathered rock

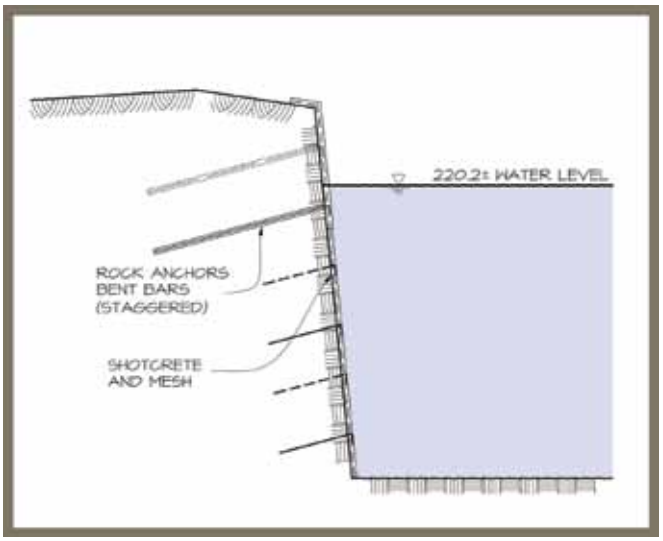


Fig. 2: Install rock anchors and mesh and apply shotcrete to the full height of the canal

Mississauga, ON, Canada-based consulting firm specializing in excavation shoring, underpinning, and foundations design.

The design engineer's initial scope was to inspect the rock quality and provide a design that would provide erosion protection of the canal banks and prolong the usable life of the canal. The results of the rock quality evaluation indicated three distinct classifications of bedrock. These classifications were categorized as:

- Rubbly limestone—a loose mass of rough, angular fragments of limestone, influenced by plant life and hydrological effects;
- Limestone with clay—interbedded limestone and clay with less decomposition than the rubbly unit; and
- Limestone—a consolidated unit.

Subsequent to the rock evaluation, design engineers submitted four optional approaches to address the issues related to poor rock quality. Each option was dependent on the amount of available space along the edge of the canal. The slopes that were initially specified would lead to excavation encroachment onto neighboring private property.

The first option involved initial excavation to sound rock, after which the slope would be cut back to 1.5H to 1V, followed by the installation of rip rap. The second option was to install a precast retaining wall, cut back the slope to 1.5H to 1V, and install rip rap. The third option (Fig. 1) was to excavate the overburden, install rock anchors and mesh, and apply shotcrete to the weathered rock. The fourth option (Fig. 2) was to install anchors and mesh and apply shotcrete to the full height of the canal.

Option 1 was selected in areas where there was enough room on the property to cut the appropriate slope and was limited to some areas along the east bank of the power canal. Option 2 was selected along the west wall, where there were limited options due to the location of the existing dyke. Rip rap was used in conjunction with this option to protect the slope of the dyke. Option 3 was

selected for some areas where more space was available, but multiple designs were used to fit the allowable property space. Rock anchors, mesh, and shotcrete were used to cover the remaining unstable rock surface. Option 4 was the only feasible option for the area along the west wall of the canal, where there was minimal available land between the power canal and the river (Fig. 3). With this option, the entire rock surface had to be covered with shotcrete to prevent future erosion.

In the spring of 2008, a contract for the construction of The Robert G. Lake Generating Station was awarded to a company from Lévis, QC, Canada, and the shotcrete portion of the contract was then subcontracted to a Quebec City company. After they were awarded the contract to apply the shotcrete, subcontractor representatives met on site with the general contractor, design engineer representatives, and materials supplier technical staff to confirm their recommendations related to application logistics, shotcrete mixture design, and scheduling. The subcontractor preferred the option of dry-mix shotcrete, primarily because of the difficult access and rough terrain along the banks of the canal. The flexibility offered by preblended, bulk-bag materials also allowed the shotcrete crew to carry an inventory of shotcrete material on site (Fig. 4). Access to the materials improved the subcontractor's ability to schedule shotcrete application and also allowed them to start and stop when and where required without equipment cleanup and wasted shotcrete material.

Fig. 3: Option 4 was the only feasible option for the area along the west wall of the canal where there was minimal available land between the power canal and the river

Fig. 5: Prior to the application of shotcrete, rock anchors were installed in a staggered vertical 5 ft (1.5 m) by horizontal 5 ft (1.5 m) pattern

Fig. 4: The flexibility offered by preblended, bulk-bag materials also allowed the shotcrete crew to carry an inventory of shotcrete material on site

Fig. 6: An ACI-certified nozzleman was part of the shotcrete crew, as specified by the design engineers

The specified shotcrete mixture was a silica-fume-enhanced, air-entrained dry-mix shotcrete and was used throughout most of the project, except in areas where moving water required the use of an accelerated mixture. The shotcrete was applied at a specified thickness of 4 in. (100 mm).

Prior to the application of shotcrete, rock anchors were installed in a staggered vertical 5 ft (1.5 m) by horizontal 5 ft (1.5 m) pattern (Fig. 5). The anchor lengths were 5 ft and 12 ft (1.5 and 3.6 m), depending on the quality of the rock. Welded-wire mesh (5 x 5 ft [1.5 x 1.5 m]) was then attached to the anchors. Installation of the mesh served two purposes: first, to improve the energy absorption of the shotcrete; and second, to improve the adhesion of the shotcrete to the poorer quality, fragmented rock.

An ACI-certified nozzleman was part of the shotcrete crew, as specified by the design engineers (Fig. 6). They used a dry-mix shotcrete machine to place over 32,000 ft^2 (3000 m^2) of shotcrete throughout the canal. The subcontractor chose a shotcrete machine that featured rugged construction and high-volume output (up to 10 yd^3 [8 m^3] per hour).

Through the use of shotcrete, the engineer's design achieved the objective to provide erosion protection of the canal banks and prolong the usable life of the canal. The project was completed in December 2009 and will be expected to produce and annually inject approximately 30,000 MWh into the local electrical distribution system of Peterborough Distribution Inc.

The Robert G. Lake Generating Station has a renewable energy contract with the Ontario Power Authority (OPA) for a 40-year term. This green-energy project will provide the electricity needs of approximately 3000 homes and annually offset 20,000 to 30,000 tons (18,144 to 27,216 metric tons) of carbon dioxide.

The Robert G. Lake Generating Station

Engineer
Isherwood Geostructural Engineers

General Contractor
CRT Construction Inc.

Subcontractor
Cimota Inc.

Material Supplier
King Packaged Materials Company

***Tara Brown** has worked as a Geologist for Isherwood Associates for 3 years. She previously spent 5 years in mineral exploration and oils and mining. In 2002, she received her BS in geology at St. Francis Xavier University in Antigonish, NS, Canada. Brown started at Isherwood Associates in 2008 as a Niche Consultant in the geostructural field. Isherwood Associates is widely known as being on the design team for Toronto landmarks such as the CN Tower, the Skydome (Rogers Centre), the Canadian Opera Company, and the Sheppard Subway. The company also plays a role in most significant excavations in Ontario. Isherwood is a large player in the North American geostructural design market and has completed work in Mexico, the Caribbean, Canada, and the U.S.*

***Patrick Giroux** is the General Manager for Cimota Inc., a Quebec-based contractor specializing in shotcrete and concrete repair. He is a civil engineer graduate from Sherbrooke University, Sherbrooke, QC, Canada. He received his degree in civil engineering with an emphasis on cement and concrete technology and shotcrete repairs from Laval University, Quebec City, QC, Canada.*

*ACI member **Joe Hutter** is the Vice President, Sales, for King Packaged Materials Company, Burlington, ON, Canada. He has more than 20 years of experience in the cement/shotcrete industry. He is the current Vice President and active member of ASA and has chaired the ASA Marketing Committee since its inception.*

Shotcrete Calendar

JANUARY 17, 2011
ASA World of Concrete Annual Committee Meetings
Las Vegas Convention Center
Room S225
Las Vegas, NV

Sustainability Committee
8:00 a.m.-9:00 a.m.
Education Committee
9:00 a.m.-10:00 a.m.
Pool & Recreational Shotcrete Committee
10:00 a.m.-11:00 a.m.
Underground Committee
11:00 a.m.-11:30 a.m.
Safety Committee
11:30 a.m.-12:00 p.m.
Publications Committee
12:00 p.m.-1:00 p.m.
Marketing Committee
1:00 p.m.-3:00 p.m.
ASA Board of Direction
3:00 p.m.-4:30 p.m.

JANUARY 17, 2011
The 2011 ASA Annual Membership Meeting
Las Vegas Convention Center
Room S225
4:30 p.m.-5:00 p.m.
Las Vegas, NV

JANUARY 17-21, 2011
World of Concrete 2011
Register for FREE with ASA source code A17
Seminars: January 17-21
Exhibits: January 18-21
Visit ASA at booth #S10749
Las Vegas Convention Center
Las Vegas, NV
Web site: **www.worldofconcrete.com**

JANUARY 18, 2011
The Sixth Annual Outstanding Shotcrete Project Awards Banquet
Monte Carlo Resort & Casino
2nd Floor Grand Ballroom
6:00 p.m.-10:00 p.m.
Las Vegas, NV

JANUARY 20, 2011
World of Concrete 2011 Seminar: Shotcrete Construction and Sustainability Benefits
1:30 p.m.-3:00 p.m.
Las Vegas Convention Center
Las Vegas, NV
Web site: **www.worldofconcrete.com**

MARCH 15-18, 2011
ICRI 2011 Spring Convention
Theme: "NDE & Structural Health Monitoring"
The Westin Galleria, Houston
Houston, TX
Web site: **www.icri.org**

APRIL 2, 2011
ASA Spring Committee Meetings
Marriott Tampa Waterside & Westin Harbour Island
Tampa, FL

APRIL 3-7, 2011
ACI Spring 2011 Convention
Theme: "Concrete—The Strength of Florida"
Marriott Tampa Waterside & Westin Harbour Island
Tampa, FL
Web site: **www.concrete.org**

APRIL 4, 2011
ASA Spring Underground Committee Meeting
Marriott Tampa Waterside & Westin Harbour Island
Tampa, FL

JUNE 5-8, 2011
2011 International Bridge Conference
Visit ASA at booth #607
David L. Lawrence Convention Center
Pittsburgh, PA
Web site: **www.eswp.com/bridge**

JUNE 12-15, 2011
ASTM International Committee C09, Concrete and Concrete Aggregates
Marriott Anaheim
Anaheim, CA
Web site: **www.astm.org**

SEPTEMBER 12-15, 2011
Sixth International Symposium on Sprayed Concrete
Tromsø, Norway
Web site: **www.sprayedconcrete.no**

NEW

Mine Visits and Safety

By Mike Ballou

Many of us in the shotcrete world have had the occasion to either visit or work in underground mines. Mining practices differ from site to site in some ways because the conditions are different in every mine; however, there are a few rules of thumb that everyone ought to be aware of before they go underground in a mine. The following is a list of some of these rules.

1. Behavior. Visitors are guests, so they should act like guests. Don't go walking around unescorted. It makes the miners uneasy. Stay with your escort. Unlike civil tunneling, mining continues at the same location for many years until the ore plays out or until the mining is not profitable anymore. Underground miners consider the mine they work at to be their domain—their home away from home.
2. Photographs. Always ask permission before you take a camera on a mine site to see if it is allowed and ask if you may take photos. Some mines let you take all the photos you want and others won't even allow cameras on the property.
3. Safety glasses and equipment. Mines and miners are very strict about safety and for good reasons, some of which you might not expect. First of all, mining is a dangerous business and miners look out for one another. Safety is not to be compromised for any reason. If they say that safety glasses, hard hats, and hard-toe boots are required, they mean it. Don't think you can remove your safety glasses so you can be more comfortable. They will tell you when you can remove them. The same goes with dust masks and/or respirators. If you are asked to wear them, keep them on. Proper footwear is not an option—it's required. Find out what the mine requires and don't try to bend the rules.
4. Proper clothing. Most mines require reflective vests and some require reflective tape on hard hats and trousers. Don't just expect a mine to furnish these items for you. If you don't have them, check beforehand to see if you can borrow some from the mine. Most mines are gracious and will provide these items for visitors, but it is always good to ask beforehand.
5. Manners and language. Miners can be a rough bunch, and language can be a bit R-rated. If you aren't able to or don't want to be exposed to harsh language, it might not be wise to venture into an underground mine. Harsh language—to some—is mine language. They are used to it, so try not to take offense to it.
6. Smoking. Some mines don't allow smoking anywhere underground. Ask first before lighting up.
7. Hard hats and hearing protection. Miners are seldom seen in any photos with their hard hats off, and that's because they never take their hard hats off unless they are in a place that allows them to be taken off. Once you see the "hard hats and safety glasses required" sign, it means you need to comply. A lot of mines require hard hats with over-the-ear hearing protection attached to the hard hat. Others simply require that you have some sort of hearing protection. Either way, find out what is required for the mine before you go underground.

Typical mining safety equipment

Why list these rules of thumb? And why take them seriously? It's simple. First, it's the right and proper thing to do. If you disobey or compromise the rules, you will usually be found out and escorted off the property, and you may even be told not to return. I've seen it happen.

So obey the rules! Be safe and not only will you prevent accidents, but you'll also prevent unnecessary and possibly embarrassing moments for both yourself and whoever invited you onto the mine site.

Mike Ballou *has been involved in tunneling and mining—including several major shotcrete projects—for the past 25 years. A civil engineer graduate, Ballou is a member of the ASA Underground Committee and serves on ACI Committees 506, Shotcreting, and 552, Cementitious Grouting. He also serves on several ACI subcommittees, including ACI Subcommittee 506-0F, Shotcreting-Underground. He works in technical sales and engineering in the tunneling and mining business and currently works for CTS Cement, Cypress, CA.*

Improve Your Shotcrete: Use Coarse Aggregates!

By Simon Reny and Marc Jolin

In the shotcrete industry, appropriate aggregate selection and specifications are often the neglected aspects of the shotcrete mixture design. Generally, people tend to rely solely on ACI 506R-05, "Guide to Shotcrete,"[1] and use either the proposed Gradation #1 or Gradation #2. This is certainly a good start, but we believe a little more can be said to support the choice. Indeed, the maximal diameter and gradation of the aggregate phase are crucial to obtain optimal properties from a given shotcrete mixture. This article is written to show and explain why the use of a coarse, well-graded aggregate phase is beneficial to the quality of the shotcrete. Although it is written especially for the dry-mix process, the principles also apply to the wet-mix shotcrete process.

Since 1989, the Ministry of Transportation of Québec has included the use of 3/8 in. (10 mm) aggregates in its dry-mix shotcrete specifications

Characteristics of the Optimal Aggregates

To obtain the best mixture for dry-mix process shotcrete, the first step is to select a gradation that follows ACI 506R-05, "Guide to Shotcrete,"[1] Gradation #1 (mortar gradation) or #2 (coarse aggregate gradation). According to ACI 506R-05,[1] the coarse aggregate size should be larger than 1/4 in. (6.3 mm). As a guideline, it is believed the best results are obtained with Gradation #2, with a maximum aggregate size of 3/8 in. (10 mm), because this is what will promote an in-place composition as close as possible to that of cast-in-place concrete.[2-4] To ensure improved properties such as freezing-and-thawing resistance, alkali-aggregate reaction resistance, and abrasion resistance, the aggregate quality should, at a minimum, meet ASTM C33. Although there is no standard regarding the maximum amount of elongated particles, it is safe to say that these particles should be minimized and controlled even more so than in cast-in-place concrete. These aggregates can have many negative effects on shotcrete, such as reducing the shootabilty, forcing reduced hose length (plug), and causing a more difficult finishability. Quality certificate reports for the aggregates should always, as with traditional cast-in-place concrete, be reviewed before the beginning of any project.

The Effect on Shootability and Paste Content of the In-Place Shotcrete

It is well known in the cast-in-place industry that, for a given mixture design, increasing the size of the larger aggregate increases the workability of the fresh concrete or, conversely, reduces the water demand. This effect is directly attributed to the fact that a larger aggregate gradation has a smaller amount of empty space that must be filled in by the cement paste. In dry-mix shotcrete, this either translates into a reduced water-cement ratio or improved placement and

reinforcing bar encapsulation properties. In all cases, the use of a coarse aggregate gradation leads to an in-place concrete composition that is closer to that of cast-in-place concrete.

There is no point in writing a "Technical Tip" on coarse aggregates without addressing the question of rebound. It is often assumed that larger particles tend to rebound more than those found in a finer aggregate gradation. Whereas this assumption may be correct, the overall rebound values found for shotcrete mixtures with a fine aggregate gradation are comparable with mixtures produced with a coarser aggregate gradation, when both are shot at their wettest stable consistency.[5] The difference, however, is that when rebounding, the larger aggregates have transferred more kinetic energy to the substrate, boosting compaction, improving encapsulation of the reinforcing bar, and increasing homogeneity of the in-place shotcrete.

In short, combined with a well-distributed gradation, larger aggregates usually generate better compaction and reduce the required amount of cement paste to an optimized level to build up a given layer of shotcrete.

Better In-Place Shotcrete Properties

In dry-mix shotcrete applications, the use of a coarse aggregate gradation reduces the in-place paste content, leaving the installed material with an increased aggregate content. If we accept the fact that the aggregates are normally the most stable component of an in-place concrete/shotcrete mixture, we can also accept the fact that they play a very positive role on concrete durability. By minimizing the cement paste content of a given shotcrete mixture, total shrinkage is minimized, which greatly reduces the risks of cracking and bond failure at the substrate and shotcrete interface.[4] Furthermore, the minimized cement paste content will also reduce the permeability and porosity of the in-place shotcrete, promoting long-term durability and

improving freezing-and-thawing resistance. Additionally, when shotcrete is chosen as a repair material, a higher content of coarse aggregate will more closely reflect that of the parent concrete, resulting in a repair material with more compatible hardened properties (for example, modulus of elasticity, coefficient of thermal expansion, and creep). This compatibility (between the repair material and the parent concrete) is a crucial factor in achieving a long-term durable repair.[6]

Other Aspects to Consider When Using High Dosages of Coarser Aggregates

It has been proven that the transportation of dry material through a shotcrete hose is more efficient when the mixture contains coarse aggregates. This efficiency can be attributed to the "cleaning effect" that coarse aggregates provide when traveling through the hose. The abrasion of coarse aggregate against the inside lining of the hose reduces the cement buildup and improves material flow. Consequently, in many cases, the use of a coarse aggregate gradation will allow the use of longer transportation hoses.

Application thickness is another aspect of the shotcrete process that should be considered when evaluating the gradation of shotcrete aggregates. The minimum thickness of any shotcrete application should always be a minimum of three times the maximum diameter of the largest aggregate. Taking into consideration that a shotcrete mixture containing aggregate measuring a maximum of 3/8 in. (10 mm) will often have traces of aggregate measuring 1/2 in. (12.7 mm), the minimum thickness at which this shotcrete mixture should be placed is 1 1/2 in. (38 mm).

In conclusion, the use of coarse aggregate in shotcrete mixtures will provide a wide range of benefits to both plastic and hardened properties. These benefits can be as simple as improved shootability and fewer disruptions due to plugging or as complex as reduced shrinkage and improved long-term durability. We must always remember, however, that shotcrete is simply a method of placing concrete. We would never design a cast-in-place concrete mixture without coarse aggregate. The same consideration should be given when designing a concrete mixture that is applied using the shotcrete process.

References

1. ACI Committee 506, "Guide to Shotcrete (ACI 506R-05)," American Concrete Institute, Farmington Hills, MI, 2005, 40 pp.

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***Simon Reny**, Eng., is Manager of Technical Services for King Packaged Materials Company, where he is responsible for all mixture design development, quality control, and technical support. He received his degree in civil engineering from Laval University in 2004. Reny is an active member of The Industrial Research Chair on Durable Repair and Optimized Maintenance of Concrete Infrastructures at Laval University; he is also a member of the American Shotcrete Association and the American Concrete Institute and is currently Vice President of the International Concrete Repair Institute's Quebec Chapter.*

***Marc Jolin** is an Assistant Professor in the Department of Civil Engineering at Laval University, Québec City, QC, Canada. He received his PhD from the University of British Columbia, Vancouver, BC, Canada, in 1999. An active member of CRIB, he is currently involved in projects on set accelerators, reinforcement encasement quality, new admixtures, and rheology of fresh shotcrete. Jolin is Secretary of ACI Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification, and a Fellow of ACI. His research interests include infrastructure durability and service-life prediction.*

ATTENTION STUDENTS

The American Shotcrete Association (ASA) is committed to its student members and their access to information, not only about shotcrete, but the entire concrete industry. As a result, we are very excited to announce that ASA has partnered with the American Concrete Institute (ACI) to expand the access and exposure for student members of both organizations to all parts of the concrete industry.

ACI has extended its offer of free Student Membership and access to its outstanding publication *Concrete International* to all ASA Student Members.

Beginning with the Winter 2010 issue, all Student Members of ACI now receive access to the electronic version of ASA's award-winning *Shotcrete* magazine.

Both organizations offer free student memberships that allow access to a wealth of information, numerous scholarship opportunities, and an important credential that demonstrates your commitment to education and an understanding of the concrete world.

ASA encourages its current student members to take advantage of the outstanding benefits of ACI's free Student Membership. You can find more information and sign up as an ACI Student Member at:

www.Concrete.org/STUDENTS/stu.htm

ASA also welcomes ACI Student Members to take advantage of ASA's free Student Membership. You can find more information and sign up as an ASA Student Member at:

www.Shotcrete.org/MembershipApplication.asp

AMERICAN SHOTCRETE ASSOCIATION

aci

American Concrete Institute®

Advancing concrete knowledge

Can Nozzleman Skill Affect Bond Quality?

By Oscar Duckworth

It is essential that a nozzleman understand how moisture affects shotcrete bond quality. Moisture conditions at the substrate dramatically influence the adhesion of a freshly applied shotcrete layer. A nozzleman must create acceptable saturated surface-dry (SSD) conditions at the substrate if bond quality is required. Shotcrete applied to a clean, roughened concrete substrate in an SSD moisture condition can form a bond that is stronger than the cohesive strength of the underlying layer.

Successful implementation of SSD moisture condition requires an understanding of the properties and behavior of the shotcrete mixture. A qualified nozzleman must possess a fundamental knowledge of these properties.

It is the skill of the nozzleman in executing SSD moisture conditions during placement that will ultimately determine the quality of the shotcrete bond.

- What is the SSD condition?
- How can a nozzleman know when SSD conditions are acceptable?
- What if SSD conditions are not met?
- What is SSD?

SSD describes the best possible moisture condition for an existing concrete, masonry, or stone substrate prior to applying a fresh shotcrete layer. SSD conditions provide necessary moisture to promote acceptable adhesion to the substrate surface.

The nozzleman is the person responsible for establishing SSD conditions. He is the only person who can see these conditions on the substrate as the shotcrete is applied. SSD conditions can be difficult to maintain, and a qualified nozzleman must recognize visual cues that indicate acceptable SSD conditions.

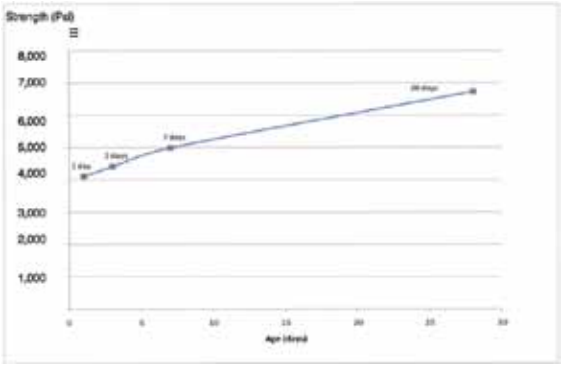

Fig. 1: Shotcrete typical strength gain.
Note: 1 psi = 0.0068 MPa

Impact Energy Affects Bond Quality

A nozzleman must place shotcrete with sufficient velocity. Shotcrete applied at high velocity to a substrate create bonding conditions that are unique to the shotcrete process. Shotcrete mixture particles are sprayed on the substrate at a velocity that can exceed 300 ft/s (91 m/s). Impact energy at the substrate surface effectively embeds a rich, tightly compacted paste layer within the surface irregularities of the substrate. This point of contact between the freshly applied shotcrete paste layer and the substrate surface is referred to as the bond plane. The high-quality paste layer—firmly embedded at the bond plane—is the ideal condition to form a strong bond. Moisture conditions at the bond plane and within the substrate, however, will determine the embedded paste's ultimate bond strength. Adequate hydration of the paste layer is a key factor in achieving bond quality.

Hydration Requires Moisture

Shotcrete does not harden by drying, but by a chemical reaction initiated by portland cement coming into contact with moisture. This reaction is referred to as hydration. The hydration process slowly converts the shotcrete mixture's water/cement paste into a solid structure that binds all of the mixture's separate aggregates together into a single mass. The integrity of chemical bonds formed within the paste is responsible for most of shotcrete's hardened properties.

Hydration requires adequate moisture to develop strong chemical bonds. If there is insufficient moisture within the mixture, hydration cannot occur and the mixture will not gain strength. If adequate moisture is available, the hydration process will slowly generate stronger, thicker crystalline bonds within the paste, and the mixture will steadily gain strength for

approximately 28 days on average (Fig. 1). Adequate moisture within the mixture must be maintained throughout the 28 days for the shotcrete mixture to reach its maximum strength potential.

An Improperly Prepared Substrate Will Stop Hydration

Shotcrete bonding qualities are strongly influenced by moisture levels at the surface and within the existing substrate.

A nozzleman must properly saturate the substrate prior to shotcrete placement. Saturation is required to prevent the existing substrate from absorbing excess moisture from the fresh shotcrete paste at the bond plane. If too much moisture is lost to absorption, and if moisture is not "stored" by saturation within the substrate, hydration within the freshly embedded paste will quickly stop. The low-strength paste will not generate acceptable bond quality. This is why shotcrete will not reliably bond to a dry substrate. SSD conditions require that the substrate be adequately saturated; this means that the substrate will no longer easily absorb water applied to its surface. This may take time, especially in hot, dry, or windy conditions. Specifications often require a constant wet condition for a number of hours prior to placement. The use of sprinklers or a soaker hose can be useful in achieving proper saturation (Fig. 2).

Although moisture is required for hydration, excess surface moisture at the bond plane will reduce bond quality. Much of the quality of the shotcrete product depends on the quality of the mixture's water/cement paste. A paste created with less water will be of a higher quality than a paste containing more water. Relatively small changes in the water volume within the paste can dramatically influence the strength, durability, and adhesion properties of the mixture. When establishing SSD conditions, surface water on the substrate (this will readily transfer to your hand if touched; refer to Fig. 3(a)) will compromise bond quality by increasing the paste's water-cement ratio (*w*/*c*). This will weaken the paste layer at the bond plane, and a weak paste layer will degrade the bond. Excess surface water is a bond breaker. The application of shotcrete to a visibly wet surface should be avoided.

Surface-Dry Condition

After the substrate has been saturated, a surface-dry condition is achieved by allowing the substrate to evaporate back to a damp—but not wet—surface moisture condition. This is easily identifiable by the substrate's dark or green color (the color of fresh shotcrete) and, if touched, will not transfer water to your hand (Fig. 3(b)). SSD conditions only exist for a short time and can be difficult to maintain in hot, windy weather. If the substrate color changes from a dark color back to the light color of dry shotcrete, the SSD condition has been lost. The surface must be rewetted and allowed to evaporate prior to shotcrete placement. The nozzleman must recognize these visual cues to maintain acceptable SSD conditions (Fig. 4).

The ideal SSD condition is attained when the existing substrate is adequately saturated and will

Fig. 2: A soaker hose can be useful in establishing saturated conditions prior to the application of an additional layer of shotcrete

Fig. 3(a): Wall section shortly after saturation. Note its shiny surface; when touched, water is easily transferred to your hand

not absorb excess moisture from the freshly embedded paste at the bond plane. Additional moisture stored within the substrate will allow hydration sufficient time to develop a strong chemical bond to the substrate. The substrate surface must be in a surface-dry condition, free of surface water that will weaken the adhesive properties of the freshly embedded paste. It is only when SSD conditions are met that pneumatically applied shotcrete's natural bond qualities are optimized. Nozzleman skill can affect bond quality. It is the skill of the nozzleman in executing SSD moisture conditions during placement that will ultimately determine the quality of the shotcrete bond.

Fig. 3(b): Wall section in surface-dry condition. When touched, water is not transferred to your hand

Fig. 4: Wall section at left is in SSD condition. Section area at right has lost SSD condition; additional moisture must be applied to right section prior to shotcrete application

Summary

- The nozzleman must possess an understanding of the SSD condition and moisture effect on bond quality.
- The nozzleman is in the best position to ensure that satisfactory SSD conditions are met as shotcrete is applied.
- The nozzleman's skill in implementing SSD conditions during placement is an essential element in achieving high bond quality.

Checklist

- Create good bonding conditions at the substrate. A clean, roughened substrate is required. Cure, form release, or smooth textures on the substrate are bond breakers.
- Use proper nozzle techniques to generate strong impact energy. A good bond requires impact energy.
- Saturation takes time. Plan ahead, use sprinkler or soaker hoses, or allow adequate time to effectively saturate the substrate.
- Rewet as required—SSD conditions do not last. The nozzleman must recognize visual clues to maintain SSD conditions during placement.

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ACI CP-60, 2009, "Craftsman Workbook for ACI Certification of Shotcrete Nozzleman," American Concrete Institute, Farmington Hills, MI, 126 pp.

*ACI Certified Nozzleman **Oscar Duckworth** is an ASA and ACI member with over 15,000 hours of nozzle time. He has worked as a nozzleman on over 2000 projects. Duckworth is currently an ACI Examiner for the wet-and dry-mix process. He continues to work as a shotcrete consultant and a certified nozzleman.*

Typical bond strength test

Test Number	Core Depth (in)	Core Length (in)	Shotcrete Thickness (in)	Gage Reading (psi)	Applied Force (lb)	Core Diameter (in)	Core Area (in^2)	Tensile Bond Strength (psi)	Failure Mode	Comments
1	2-3/4	2-1/4	2-1/4	1578	818	2.75	5.94	138	50% shotcrete/substrate bond line, 40% substrate, 10% clip	Core contained a wire reinforcing clip impression that may have weakened the bond strength. Bond line appeared relatively smooth (low CSP).
2	2-7/8	2-7/8	2-3/4	4423	2404	2.75	5.94	405	60% shotcrete/substrate bond line, 40% substrate	A few small voids in the shotcrete on the side of core
3	2-5/8	2-1/4	1-3/4	5308	2897	2.75	5.94	488	100% substrate	Shotcrete well consolidated and well bonded to substrate. Core contained wire reinforcing with 1 inch cover
4	2-5/8	2-1/2	2-1/2	3447	1860	2.75	5.94	313	80% substrate, 20% shotcrete/substrate bond line	A few small voids near surface of shotcrete, Core contained wire reinforcing with 1-1/4 inch cover
5	2-5/8	1-1/2	2-1/2	4917	2679	2.75	5.94	451	100 % within shotcrete layer	Failure occurred within shotcrete layer at wire reinforcing. Remainder of core was removed by chipping to determine shotcrete layer thickness. Core contained wire reinforcing with 1-1/4 inch cover.
6	3-0	2	2 +	1832	959	2.75	5.94	162	100 % within shotcrete layer	Failure occurred within shotcrete layer at wire reinforcing. Core contained wire reinforcing with 2 inch cover.
							AVERAGE	326	psi	

Bond strength is commonly measured by coring through the shotcrete layer and into the substrate. A tensile load is applied to the core and it is pulled to the point of failure. The measured load failure divided by the core surface area provides a numerical bond strength. Both wet- and dry-mix shotcrete applications produce very good bond strength, typically 150 psi (1 MPa) or higher.

Note: Do not use bonding agents in shotcrete applications. Bonding agents interfere with shotcrete's natural bonding qualities and can create unreliable bonding.

Skatepark Designs Elevate Shotcrete Craftsmanship

By Mark Leone

In the past decade, there has been an explosion of shotcrete skateparks popping up in parks, recreation areas, schools, churches, and even under bridges. While skateparks have been around for close to 40 years, it is only recently that master builders have emerged in the specialized placement of smooth, consistent shotcrete. As many nozzlemen are also active skateboarders, the complexity of shapes and skate terrain is continuously being pushed to new levels. One of the most complex features found in today's skateparks is the large, interconnected, amoebic-shaped pools specifically proportioned for skateboarding called "combi-pools" or "flow bowls." With skateboarding roots closely tied to backyard pool skating, it's no surprise that the design of many of today's modern skatepark bowls seem to mimic inground swimming pools. In fact, many elements found in backyard pools are being replicated in modern skatepark designs. Some of these elements include skimmer boxes (also called "death boxes"), tile bands, entry steps, and bullnose coping.

Overview of the recently completed skatepark in Glynn County, GA

A skater grinds the volcano in Glynn County, GA

There is, however, one key difference between skatepark bowl and swimming pool construction. Skateparks do not have the added plaster layer. Although most skate bowls borrow similar methods for excavation and earth shaping, reinforcing bar frequency, and bond beam design, that is where the similarity ends. In swimming pool construction, the shotcrete is placed and rough-cut to the desired shape and allowed to set. Later, a separate layer of plaster is applied that creates a uniform, smooth surface. For skatepark use, however, this plaster coat does not have the strength to withstand the repeated abuse of skateboards and BMX bikes and will quickly chip, causing a major safety concern and a maintenance nightmare.

Therefore, the challenge faced by skatepark builders is to manage the placement and shaping of the shotcrete on highly complex curves while ensuring that the finish is smooth-troweled to a consistent and even riding surface that meets very tight radial tolerances (within 1/8 in. [3 mm]). If you can imagine a skateboard wheel with an average diameter of 2 in. (52 mm) carrying a 150 lb (68 kg) skater rolling at speeds upward of 15 mph (24 km/h) it's easy to see the importance of creating a smooth, predictable riding surface. What may initially appear as chaos on a construction site becomes a symphony of efforts upon closer inspection, as the nozzleman is constantly making adjustments while coordinating sequencing with a team of shapers and finishers—all working to ensure that the finished walls are sculpturally perfect.

Overview of flow bowl in Glynn County, GA

Skater jumps bowl gap in Glynn County, GA

Ultimately, the success of a skatepark project requires the coordinated effort of a dedicated team of shotcrete professionals who are not only experienced in the application process, but who also grasp the importance of meeting very finite tolerances required in skatepark construction. To ensure that the tight specifications are met, many teams have developed custom ladders and radial wall templates and adjusted mixture designs to ensure that the end product is laser-accurate and butter-smooth.

Skater pumps teardrop hip in Glynn County, GA

Above and below:
Hardcore Skateparks COO Jeff Araiza

Night shot of Louisville Extreme Park, KY

***Mark Leone** is the Vice President of Design for Hardcore Skateparks. In addition to being an active skateboarder, Leone received his BS in landscape architecture and has spent the last decade managing the development of shotcrete skatepark projects for public agencies across North America.*

Pool Engineering Inc.

Engineer: the word itself often conjures up amusing images of pocket protectors, aquarium-thick glasses, or words that nobody but the engineer understands—you know the type. Today, many structural engineers in particular are involved in concrete and shotcrete projects.

These are the guys who tell YOU, despite all your experience working in concrete and shotcrete, what their engineering books and computer programs tell them you need to keep your projects standing though a myriad of stresses due to nature and the laws of physics. Often known to be stubborn, engineers have clashed with designers and builders since the evolution of engineering.

As the largest engineering firm in the nation specializing in pools and backyard features, Pool Engineering Inc. strives to embody the exact opposite of the tunnel-vision, book-trained engineer.

Founded in 1992 by Owner and President Ron Lacher, PE, CBP, Pool Engineering Inc. has risen to become a leader in the swimming pool industry by truly understanding how swimming pools come together from the ground up.

Though trained as a civil engineer, Lacher began building swimming pools early in his career and over the course of the next decade, created one of Orange County, California's most respected pool construction firms.

In the early 1990s, seeing a need for better service in the small niche that provides structural engineering services for pool builders, Lacher started Pool Engineering Inc.

Now, nearly two decades later, Pool Engineering has a staff of 18, including five licensed civil engineers, that provides structural engineering for over 100,000 swimming pools in California, Washington, Oregon, and Arizona, as well as thousands of structural designs for related backyard structures such as retaining walls, patio covers, decks, and fireplaces.

Known for its extraordinary customer service and a staff very knowledgeable about construction, Pool Engineering has simplified the structural engineering process for swimming pools by standardization. Hundreds of plans for pools and other landscape features have been developed simplifying permit attainment for most pools. Also, Pool Engineering has custom design teams that crank out pool builders' wildest custom creations, from elaborate grotto waterfalls that would make Walt Disney himself envious to patio cabanas large enough to dwarf the Taj Mahal.

What clients appreciate the most, however, is that Pool Engineering understands not only what contractors go through in the field but also how to help them develop practical solutions that are economical to build and strong enough for the tough building codes in the seismic areas of the western U.S., yet aesthetically pleasing enough to satisfy the pickiest Beverly Hills homeowner. This dedication to its customers is what makes Pool Engineering Inc. the remarkable success it is today.

Standardized, proven designs for the typical backyard pool based on the experience of over 100,000 installations

Complicated structural designs based on experience from installing over 100,000 pools

Structural designs for difficult locations

Experts in structural design and hydraulics for vanishing-edge pools

ASA New Members

CORPORATE MEMBERS

Delta Industrial Services Inc.
Delta Junction, AK
Primary contact: **Mike Crouch**
mike@deltaindustrial.com
www.deltaindustrial.com

RCS Consulting & Construction Company Inc.
Ripley, WV
Primary contact: **Raymond Schallom III**
rschallom@rcscoinc.com

Val-Mar Inc.
Mirabel, QC, Canada
Primary contact: **Matthieu Hudon**
mhudon@val-mar.ca
www.val-mar.ca

CORPORATE ADDITIONAL INDIVIDUAL MEMBERS

Kathleen Schallom
RCS Consulting & Construction Company Inc.
Ripley, WV

INTERESTED IN BECOMING A MEMBER OF ASA?
Read about the benefits of being a member of ASA on page 62 and find a Membership Application on page 63.

AMERICAN SHOTCRETE ASSOCIATION

Changes Made to ASA's Process for Administration of the ACI Shotcrete Nozzleman Certification Program

During the Fall ASA meetings in Pittsburgh, PA, the ASA Board finalized a significant reorganization of ASA's Administration of the Nozzleman Certification and Education programs. More details on these changes can be found in the Staff Editorial of this issue. Copies of the new policies and related forms can be found in the Certification section of the ASA Web site at **www.shotcrete.org**.

AMERICAN SHOTCRETE ASSOCIATION

Zhang Named to ASA Board of Directors


Lihe (John) Zhang

During the Fall ASA meetings in Pittsburgh, PA, last October, the ASA Board nominated and unanimously approved **Lihe (John) Zhang** to serve the remaining term of past Board member Howard Robbins. Zhang, PhD, PEng, LEED AP, is a Materials Engineer for AMEC Earth & Environmental.

While still involved with ASA, a recent position change took Robbins out of the shotcrete industry. As a result, Robbins stepped down from the ASA Board.

Zhang is a member of American Concrete Institute (ACI) Committees 506, Shotcreting; 544, Fiber-Reinforced Concrete; and ASTM C09, Concrete and Concrete Aggregates. As a LEED Accredited Professional, he has been involved with ACI Committee 130, Sustainability of Concrete, for the use of supplementary cementitious materials in concrete.

Zhang has been a very active member and leader at ASA. He is the Co-Chair of the ASA Underground Committee, Chair of the ASA Scholarship task group, a member of numerous other ASA committees, and a past author in *Shotcrete* magazine.

Visit and Participate in ASA Activities at World of Concrete 2011

ASA will be working hard to promote the advantages of shotcrete to the concrete world at the World of Concrete (WOC) show in Las Vegas, NV, January 18-21, 2011. Make plans to participate in six ASA functions at the show.

First, **ASA will have a manned 20 x 30 ft booth in the South Hall (#S10749)**. Responses to this new booth format at the 2010 show were very positive, with a record amount of shotcrete information distributed and inquiries answered.

Second, ASA will be conducting a **90-minute seminar titled "Sustainability of Shotcrete Construction" on Thursday, January 20**. The seminar will be conducted by two prominent ASA members: Charles Hanskat of Concrete Engineering Group (ASA Board member and Chair of ASA's Sustainability Committee) and Chris Zynda of J.J. Albanese Inc. (ASA Board member and ASA Past President).

Third—and new this year—**ASA will have an informational booth in the "GreenSite" pavilion in the Central Hall**. The GreenSite pavilion focuses on sustainability and will provide an excellent opportunity for ASA to promote the exceptional sustainability advantages of the shotcrete process.

Fourth, the winter **ASA committee meetings will be held on Monday, January 17, in Room S225 at the Las Vegas Convention Center**. These meetings offer participants the opportunity to network with colleagues, provide input on shotcrete materials and publications, and become a part of ASA's overall mission.

A complete schedule of meetings and times can be found on the ASA Web site calendar at **www.shotcrete.org**.

Fifth, **the ASA Annual Membership Meeting will not be part of the Awards Banquet this year**. Instead, the meeting will occur at 4:30 p.m. in Room S225 at the Las Vegas Convention Center. The meeting will immediately follow the ASA committee meetings taking place in the same room.

Lastly, the **6th Annual ASA Outstanding Project Awards Banquet will be held at 6:00 p.m. on Tuesday, January 18, in the Grand Ballroom of the Monte Carlo Resort & Casino**. This enjoyable evening will include a cocktails and hors d'oeuvres reception, a plated dinner, and an awards presentation of the winning project for each award category: Architectural, Infrastructure, International Projects, Pool & Recreational, Rehabilitation & Repair, and Underground. Registration information can be found on the ASA Web site at **www.shotcrete.org**.

ASA Graduate Scholarships Awarded

For the 2009 to 2010 academic year, ASA has awarded graduate scholarships to **Rodrigo Valbuena Tovar** and **Jean-Michel Royer**. Each student will receive a stipend of $3000 (USD) for tuition, residence, books, and materials for the 2010 to 2011 academic year.


Rodrigo Valbuena Tovar

Tovar received his BS in civil engineering from the National University of Colombia in 2001 and received a degree as a Specialist in Project Management in 2006 from Pontificia Bolivariana University in Colombia. Tovar is currently working toward earning his MS in civil engineering from the University of Texas in San Antonio. In Colombia, Tovar participated in several concrete research projects on new construction materials and techniques and has received honorable mention for his thesis, "The Use of Mini-Roundabouts for Control of the Traffic of Intersections in Bogotá." Tovar plans to receive his master's degree and pursue the benefits of the shotcrete process as a civil engineer.

Royer received his BS in civil engineering from Laval University in 2009 and is currently working toward earning his MS in civil engineering from the same university. Royer worked as a Research Assistant for 2 years on concrete and shotcrete at Laval University, was a member of the Steel Bridge Competition Team with the American Society of Concrete Engineers (ASCE), and was a winning member of the Laval University canoe team. Currently, Royer is a Teaching Assistant for a concrete structure course at Laval University and plans to keep teaching during his professional career.

Established in 2008, the purpose of the ASA Graduate Scholarship Program is to identify, attract, and assist outstanding graduate students pursuing careers within the field of concrete with a significant interest in the shotcrete process. For a complete description of these awards, requirements, and directions, visit **www.shotcrete.org** and click on Grad Scholarships.

Allentown Shotcrete Technology Celebrates 100th Anniversary

Allentown Shotcrete Technology, Inc., celebrated its 100th anniversary by hosting an event for its customers and employees at its facility in Allentown, PA, on September 24, 2010.

Festivities included keynote speakers Patrick Bridger, Allentown's President; Chris Darnell, Executive Director of the American Shotcrete Association (ASA); and Dr. Marc Jolin from the University of Laval, Quebec, QC, Canada.

"We are so proud to have achieved such a special milestone," said Bridger. "As industry pioneers we are thrilled to have been providing you with a century of shotcrete solutions. We could not have done it without every one of you, our domestic and international customers, distributors and subsidiaries, as well as employees."

"Today very few companies are able to succeed in business for 100 years," Bridger continued. "We are very proud of our longevity, and see it as a testament to our reputation for quality and the value we have brought our customers."

Allentown showcased a wide range of equipment models including the N-Type Pneumatic Gun, which is a modern version of the original Cement Gun that was patented in 1911. As a commemorative keepsake, Allentown presented each attendee with an N-Type Pneumatic Gun freestanding medallion.

For more information on Allentown and its products, contact Allentown toll-free at (800) 553-3414 or visit their Web site at **www.allentownshotcrete.com**.

Allentown Shotcrete Moves Operations to Putzmeister America

To take advantage of the larger facilities and support available, Allentown Shotcrete Technology, Inc., is moving its operations to Putzmeister America, Inc.'s headquarters in Sturtevant, WI.

"Allentown will still operate as an independent business but with the added benefits of the production and logistics capacity here in Sturtevant," says Dave Adams, President and CEO of Putzmeister America.

Specializing in shotcrete, mortar, and concrete placing equipment for various industries, Allentown has doubled in size since being acquired by Putzmeister America in 2007.

"We're celebrating our 100th anniversary, and it is our goal to continue to expand Allentown worldwide so we can be influential in the next 100 years of shotcrete, mortar, and concrete-placing technology advancements," says Patrick Bridger, President of Allentown. "Being located at Putzmeister America will help us achieve that goal."

The move will begin immediately and will be complete by early 2011.

For more information on Allentown's move, contact Allentown toll-free at (800) 553-3414.

ASCC Safety Awards Issued

Concrete contractors with exemplary safety records were recognized by the American Society of Concrete Contractors (ASCC) at the association's Annual Conference, September 16, 2010, in Salt Lake City, UT.

The W. Burr Bennett Awards for Safety Excellence were given to Specialty Contractor Amalio Corporation, Sterling Heights, MI, and General Contractor Walbridge, Detroit, MI. These awards are presented to contractors that place the highest priority on safety. Entries were judged on 3 years of safety performance indicators, values, and trends; a self-assessment checklist of company safety practices; and detailed descriptions of safety plans and culture.

Additional awards based on the incident rate for 2009 were presented to general and specialty contractors in four categories. The incident rate represents the number of lost workday cases from the OSHA 300 log, times 200,000, divided by the number of work hours in a calendar year.

Thirty-eight contractors received awards for zero lost time due to accidents, and 43 contractors were recognized for having lowered their incident rate from the previous year; 62 contractors received certificates for achieving an incident rate below the national average.

The ASCC Safety & Risk Management Council educates contractors in all aspects of safety relating to concrete contracting and insurance matters. The council also provides oversight on safety publications and events.

For a complete listing of all winners, visit **www.ascconline.org**.

Heavy Construction Spending Increased 1.4% in August

According to a report from Reed Construction Data, heavy construction spending increased 1.4% in August 2010 to 9% above the February low point but still 4% below the stimulus-boosted peak level last fall. Transportation facilities, sewage, water, and conservation increased in August. The gains in transportation and water/sewer are stimulus driven and will be maintained, although further gains will be smaller.

Heavy construction spending is now forecast to rise about 3% over the next year, offsetting recent downward revisions. An improving economy that generates more private-site work and capacity needs will offset the combination of worsening state and local government budget positions and the continued ebbing of the stimulus impact.

For more information, visit **www.reedconstructiondata.com**.

U.S. Construction Spending Up 0.5% in September

Construction spending in the U.S. edged up 0.5% in September 2010, led by an increase in residential construction and public works, according to the Commerce Department. Economists predicted construction spending would fall 0.5%. The 0.5% gain brought spending to $801.7 billion after a revised 0.2% drop in August that was previously reported as a 0.4% gain.

Key Index Indicates Weak Construction Demand through 2011

While a slight increase in August was realized, the Architecture Billings Index (ABI) still indicates anemic demand for new construction through 2011. The index registered a level of 48.2 in August, its highest point since April. A reading below 50 indicates market contraction.

The ABI, an index compiled monthly by the American Institute of Architects (AIA), is a barometer of future construction activity. The index rose for a third straight month in August. However, the index still suggests weak demand for new construction into late 2011.

The ABI reflects an approximate lag time of nine to 12 months between design firm billings and hard construction spending.

Individual construction sector data showed that commercial/industrial projects (excluding multifamily) were the only category that showed demand growth in August, with an ABI of 50.6 using a 3-month moving average. Multifamily posted an index of 46.9; institutional, 46.0; and mixed-practice, 42.6.

Construction Costs Rise

Overall, construction costs in the U.S. have increased 1.7% year over year in October, the first significant increase since mid-2008, according to RSMeans' 30-City index. Concrete reinforcing has experienced the most significant cost increase at 6.4% over the past year. Material costs moved up 0.5% year over year and 0.6% quarter to quarter annualized. The installation subcomponent (that is, labor) was +3.1% year over year. New York City; San Francisco; Honolulu; Boston; and Oakland, CA, are among the most expensive cities in which to build.

Almost 1 Million Jobs Could Be Lost Resulting from New EPA Rules

According to an on-line report from ARI Aggregate Research, the implementation of the new U.S. Environmental Protection Agency (EPA) rules on greenhouse gases and other emissions issues could result in the loss of nearly a million jobs in the cement industry. It is believed that the new regulations might threaten the existence of a number of cement companies in the U.S.

The new standard for boilers, called the Boiler MACT, creates a standard that might be impossible for any cement producer in the U.S. to meet. In the event the installed boilers do not meet the new standard, the factories and other facilities will have to close, putting jobs in danger.

Currently, no facility in the U.S. meets the standards proposed by the EPA for portland cement. Imposition of these standards would at least temporarily close almost 20% of all American cement producers and reduce long-term cement production from 8 to 15%. This would mean that the cement needed for construction will have to be imported, primarily from China.

According to the EPW (United States Senate Environment and Public Works Committee) report on the new EPA rules, consequences of imposing the new EPA rules could result in new standards for commercial and industrial boilers costing up to 798,250 jobs, and new standards for portland cement plants with the potential to shutdown up to 18 cement plants and cost 1800 direct jobs and 9000 indirect jobs.

EPA Standards Could Add $26 per Ton to Cement Production Costs

A Portland Cement Association (PCA) Petition for Reconsideration and Administrative Stay with the U.S. Environmental Protection Agency (EPA) cites late additions to a final rule—national emission standard for hazardous air pollutants (NESHAP)—the agency issued in August 2010 without affording opportunity for public comment. The association will file a companion petition with the District of Columbia Circuit Court.

NESHAP requires cement mills to limit emissions of mercury, total hydrocarbons, hydrochloric acid, and particulate matter by September 2013. PCA estimates that compliance with it and EPA-proposed regulations could add a minimum of $26 per ton to domestic cement production costs by 2020.

"PCA supports the rising demand for portland cement through environmentally and socially responsible business practices," says CEO Brian McCarthy. "The NESHAP emission limits are very low and will not be achievable by a number of facilities. We are concerned that the rule presents a significant threat to the continued viability of many cement companies, high-paying jobs at cement facilities, and the local communities."

Industry Personnel

Putzmeister Brazil Ltda. Announces Managing Director and COO

James Focareto

Putzmeister Brazil Ltda. (PMB), a subsidiary of Putzmeister America, Inc., appoints Roberto Schaefer as Managing Director and COO.

Schaefer will manage the local production of equipment and day-to-day operations at PMB's new facility located in Atibaia, Brazil, just outside of São Paulo. He will report directly to Dave Adams, Putzmeister America's President and CEO.

"Roberto's experience in managing manufacturing companies and background in sales are valuable assets as we develop our operations in Brazil," comments Adams. "I have no doubt that he will work hard to ensure our customers know we are here to serve them for the long term."

"I'm excited to be a part of the initial growth of Putzmeister in Brazil and look forward to strengthening the local customer base," says Schaefer. "With construction in Brazil booming, especially the real estate market, Putzmeister arrived here at the right time."

"Since our equipment is manufactured with greater than 60% local materials, this also enables us to provide superior parts availability and allows our customers to get special lines of credit provided by the National Development Bank—BNDES," Schaefer added.

Putzmeister America Appoints Vice President of Finance and CFO

Roberto Schaefer

In November 2010, James Focareto became the new Vice President of Finance and CFO of Putzmeister America, Inc., Sturtevant, WI.

Based out of the Sturtevant headquarters, Focareto's responsibilities include directing the finance, information systems (MIS), and materials management functions. In addition, he will serve as a strategic and tactical advisor to Dave Adams, President and CEO of Putzmeister America, providing leadership on both financial and operational matters with a focus on growth and profitability. Focareto will report directly to Adams.

"Jim brings over 20 years of experience in manufacturing and automotive industries," says Adams. "His demonstrated abilities to perform and produce results through effective communication, planning and leadership skills make him the perfect match for his new role."

American Concrete Institute Mourns Loss of President Richard D. Stehly

Richard D. Stehly

It was with deep regret and profound sadness that the American Concrete Institute (ACI) announced the passing of its President, Richard D. Stehly. President Stehly passed away suddenly September 18, 2010, after enjoying one of his favorite pastimes—hockey—with teammates and friends.

President Stehly, who was a member of ACI since 1980, was elected President of the Institute in March 2010. During his short time as President, he championed several ACI initiatives in sustainable development regarding the use of concrete. He was a recent Chair of the Board Advisory Committee on Sustainable Development and had been extremely involved regarding the EPA's proposed regulation of fly ash disposal; he even testified on ACI's behalf in July before the U.S. House Committee on Small Business, Subcommittee on Rural Development, Entrepreneurship, and Trade.

President Stehly was a member of numerous ACI committees including ACI Committees 130, Sustainability of Concrete; 318 WA, International Workshop—Structural Concrete in the Americas; Financial Advisory Committee; and Seminar Oversight Committee. He served on the ACI Board of Direction and the Executive Committee. Additionally, he was an officer of the ACI Foundation and Creative Association Management, ACI's for-profit subsidiary, and

served on the Editorial Review Panel of the U.S. Green Concrete Council.

A Fellow of ACI, President Stehly was a Past Chair of the Chapter Activities Committee and was a member of the Task Group on International Strategy, which led to the formation of the International Committee, for which he served as the first Chair. President Stehly traveled to more than 25 countries on behalf of ACI, presenting lectures on various concrete topics to ACI chapter members. President Stehly had only days earlier returned from a 3-week international trip to India, Germany, Italy, and Poland with ACI Executive Vice President Ron Burg. Together, Stehly and Burg attended various conferences and forums, and they had the opportunity to meet with the ACI chapters of India and Italy.

"The untimely passing of my friend and colleague Richard Stehly is a tremendous loss for the concrete industry and for anyone who had the privilege of knowing him and working with him," said Burg. "His enthusiasm for the American Concrete Institute and the concrete industry was infectious, and our membership, staff, and the entire concrete industry will feel his loss, both personally and professionally."

President Stehly was a Principal of American Engineering Testing, Inc., based in Minneapolis, MN, and was a licensed civil engineer in Minnesota and Wisconsin. He received his BS degree in civil engineering from the University of Minnesota. He worked as an intern at Twin City Testing, Minneapolis, MN, while a college junior and was hired as a field engineer after graduation. He became Project Engineer, Chief Engineer, and eventually President of the firm. In 1988, he joined the Anchor Block Co., one of the few block makers using the autoclave process, as President. He then returned to the testing business by founding American Engineering Testing with three others in December 1989. He started American Petrographic Services in 1990. The businesses currently have 15 offices and 300 employees.

Kenneth C. Hover Named President of American Concrete Institute

Kenneth C. Hover

The American Concrete Institute (ACI) has announced Kenneth C. Hover, PhD, PE, as its new President.

Dr. Hover assumes the post of President of the Institute after the passing of President Richard D. Stehly on September 18, 2010. In accordance with the bylaws of the Institute, in the event that a current President is no longer able to continue his term, the Senior Vice President will complete the term.

The ACI Executive Committee, along with ACI Executive Vice President Ron Burg, and ACI's staff have expressed their support of Dr. Hover as President during this difficult time for the Institute.

"ACI has lost one of its most enthusiastic leaders, a dedicated and gifted visionary, and most of all, a good friend," said Hover. "We can assure the Institute and the industry that our first priority is the continued pursuit of Dick's presidential objectives."

Dr. Hover is Professor of civil and environmental engineering and Stephen Weiss Presidential Fellow at Cornell University, Ithaca, N.Y. An ACI member since 1980, Dr. Hover was elected Vice President of the Institute in the spring of 2009. He currently chairs ACI Committee 301-C, Concrete Mixtures, Handling, Placing, Consolidating, and Curing, and the ACI Task Group on Fly Ash Communication. He currently serves on several other technical committees, including ACI Subcommittee 318-A, General, Concrete, and Construction. Dr. Hover previously served on the ACI Board of Direction and was named a Fellow of ACI in 1992. In addition, he is a Past President of the ACI Greater Miami Valley Chapter.

A licensed professional engineer in Ohio and New York, Dr. Hover lectures nationally and internationally on concrete materials and construction. ACI has honored him with the Joe W. Kelly Award, Robert E. Philleo Award, and the Chester Paul Siess Award for Excellence in Structural Research (formerly known as the ACI Structural Research Award). He is also a winner of the ASCE Materials Division's Best Basic Research Paper Award. The Weiss Presidential Fellowship is Cornell University's highest teaching award and he has received many other teaching awards in his department and college. In January 2006 at World of Concrete, he was named one of the "Ten Most Influential People in the Concrete Industry."

All ASA members and subscribers now have access to the NEW electronic version of *Shotcrete* magazine. A link to this e-magazine is sent as an item in the "What's in the Mix" e-newsletter. To ensure that you receive access to all future issues of the electronic version of the magazine, send your e-mail information to info@shotcrete.org.

Blastcrete Equipment Company Introduces Model RD6536 Skid Steer Pump with Universal Design

With the ability to pump grout materials, 3/8 in. (9.5 mm) shotcrete, and 3/4 in. (19 mm) structural concrete mixtures, the RD6536 is a fast, efficient solution for contractors performing a variety of concrete and shotcrete applications. The unit offers a variable speed of 0 to 25 yd^3 (0 to 19 m^3) per hour. Vertical pumping distance reaches 50 ft (15.25 m) with the use of a rubber delivery line, whereas horizontal distance can reach up to 250 ft (76.26 m).

A hydraulic agitator is included in the receiving hopper. The agitator's continuous motion keeps the mixture well-blended, ensuring that aggregate and sand stay evenly suspended throughout the mixture. Not only does this result in high-strength concrete, but it also keeps the aggregate and sand from settling to the bottom of the hopper and clogging near the suction area.

To relieve pressure buildup clogs and eliminate potential damage to the pump, the RD6536 can be run both forward and in reverse. Hydraulically powered controls are located on the pump and also operate both agitator and pump speed.

The RD6536 weighs 2700 lb (1224 kg) and the hydraulic oil requirement is 18 gal./min (68 L/min) at 3000 psi (20.68 MPa). The 48 in. (1.22 m) wide frame (55 in. [1.4 m] with receiving hopper) is designed to be narrow enough to fit between the wheel wells of most standard work trucks. The unit includes forklift pockets to allow quick and easy loading and unloading from the transport vehicle.

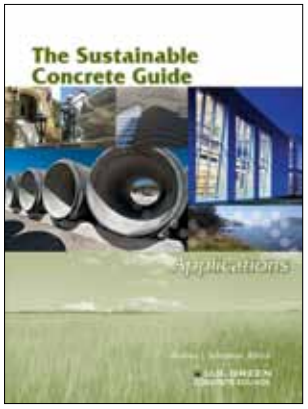
Maintenance requirements for the RD6536 are simple and take just minutes. The steel-constructed unit is designed to prevent any concrete from coming in contact with the pump's moving parts, further reducing maintenance concerns and ensuring a long service life. The primary wear part—the rubber pumping tube—can be easily replaced on the job site in about 20 minutes. And unlike other types of concrete pumps, cleanup on the RD6536 squeeze pump is fast and hassle-free. Using just water and a sponge ball, the pump can be cleaned out in approximately 5 minutes.

For more information, visit **www.blastcrete.com**.

USGCC Releases Second Guide on Concrete Sustainability with Chapter on Shotcrete

The U.S. Green Concrete Council (USGCC) has released its new book, *The Sustainable Concrete Guide—Applications*.

A companion resource to *The Sustainable Concrete Guide—Strategies and Examples*, *The Sustainable Concrete Guide—Applications* provides readers with specific sustainable benefits of concrete's various applications to assist in selecting/specifying concrete materials and products. Also included are tips and case studies on specifying concrete materials, constructing for sustainability, integrating into sustainable structures, and navigating green codes and standards. The guide is divided into five parts:



Part 1—Materials;
Part 2—Construction;
Part 3—Applications;
Part 4—Concrete in Sustainable Structures; and
Part 5—Codes.

Part 3—Applications contains an entire chapter dedicated to shotcrete, and additional shotcrete information appears in Part 4—Concrete in Sustainable Structures under the Maintenance & Repair chapter.

The book is authored by Andrea J. Schokker, Professor and Head of the Civil Engineering Department at the University of Minnesota Duluth. Schokker is a member of the Board of Direction for the American Concrete Institute (ACI) and is active in many ACI Committees, including ACI Committee 318, Structural Concrete Building Code, and Joint ACI-ASCE Committee 423, Prestressed Concrete. She is also the Chair of ACI Committee 130, Sustainability of Concrete.

"The transformation toward sustainable development provides the concrete industry with a tremendous opportunity and responsibility to inform stakeholders about our material's ability to not only enhance but also protect our planet," said Schokker. "*The Sustainable Concrete Guide—Applications* is a follow-up resource to *The Sustainable Concrete Guide—Strategies and Examples* and provides specific benefits of concrete's various applications to assist in selecting and specifying concrete materials and products to meet sustainability goals."

Also an integral part in the creation of the book is the editorial review panel of the USGCC. Past ACI President Florian Barth serves as Chair of the editorial review panel and is also the President of the USGCC. Other members include Michael Deane, Vice President and Chief Sustainability Officer at Turner Construction Company; Kevin MacDonald, Vice President of Engineering Services at Cemstone; Aris Papadopoulos, CEO of Titan America; Michael Paul, Lead Structural Engineer and Senior Consultant for Duffield Associates; the late Richard Stehly, President of ACI and Principal of American Engineering & Testing; and Wayne Trusty, President of Athena Institute International.

The USGCC was established in 2009 with the purpose of disseminating information on sustainable concrete. The organization aims to satisfy the immediate demand for resources on the role of concrete in sustainable buildings and to facilitate the development of additional sustainability-

related consensus documents. The USGCC is a division of Creative Association Management (CAM), a wholly owned subsidiary of ACI.

The Sustainable Concrete Guide—Applications is available for purchase through ACI for $85.

For more information on the USGCC, visit **www.usgreenconcretecouncil.com**. For more information on how to order the publication, visit **www.concrete.org**.

New Approved ASTM Standards

ASTM International has announced new revisions to some of its standards. ASTM C1116/C1116M, "Standard Specification for Fiber-Reinforced Concrete," has been revised to ASTM C1116/C1116M-10; ASTM C1385/C1385M, "Standard Practice for Sampling Materials for Shotcrete," has been revised to ASTM C1385/C1385M-10; ASTM C1550, "Standard Test Method for Flexural Toughness of Fiber Reinforced Concrete (Using Centrally Loaded Round Panel)," has been revised to ASTM C1550-10a; and ASTM C42/C42M, "Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete," has been revised to ASTM C42/C42M-10.

To view a document's summary page or to purchase the standard, visit **www.astm.org**.

New Specification for Tolerances for Concrete Construction and Materials (ACI 117-10) and Commentary

American Concrete Institute®
Advancing concrete knowledge

This specification provides standard tolerances for concrete construction and materials. This document is intended to be used by specification writers and ACI committees writing standards as the reference document for establishing tolerances for concrete construction and materials. The commentary content is for clarity of interpretation and insight into the intent of the committee regarding the application of the tolerances set forth therein.

For more information or to purchase this specification, visit the ACI Bookstore at **www.concrete.org**.

Shotcrete Well Represented in New Sustainability Guide

The ASA Sustainability Committee has completed work on the development of shotcrete-specific material to appear in the new book *The Sustainable Concrete Guide—Applications*. This new, important reference was released in December 2010 by the U.S. Green Concrete Council (USGCC).

"Part 3—Applications" of the book contains an entire chapter dedicated to shotcrete, and additional shotcrete information appears in "Part 4—Concrete in Sustainable Structures" in the "Maintenance and Repair" chapter.

The book contains a top-10 list of sustainability benefits for each application covered in "Part 3—Applications" and includes the following list in the chapter on shotcrete:

Shotcrete Top Sustainability Benefits

- Crane and other equipment savings or elimination;
- Labor savings of at least 50% in repair applications;
- New construction speed savings of 33 to 50%;
- Better bonding to the substrate enhances durability;
- Adaptability to repair surfaces that are not cost-effective with other processes;
- Ability to access restricted space and difficult-to-reach areas, including overhead and underground;
- Formwork does not have to be designed for internal pressures;
- Material savings through elimination/reduction of formwork;
- Complex shapes require very little, if any, formwork; and
- Speed of repair reduces or eliminates downtime.

More information on this new book can be found in the New Products & Practices feature of this issue. To obtain a copy of the book, visit the ACI Bookstore at **www.concrete.org**.

New Guide Combines Building Durability and Sustainability Criteria

A new document written in mandatory language to amend and append the International Building Code (IBC) enables local governments to adopt green building codes that address high performance and conventional sustainable features. *High Performance Building Requirements for Sustainability 2.0* includes concepts such as energy, water, and material resource conservation, while enhancing disaster resistance and setting stringent durability requirements. The criteria are organized by chapter and section consistent with the IBC format and intentionally limited to issues typically within building code, zoning, and land use officials' purview.

The Portland Cement Association (PCA) and the Institute of Building & Home Safety (IBHS) aligned the provisions with Whole Building Design Guide (**wbdg.org**) and High Performance Building Council concepts. Enacting and enforcing these provisions provides the basis for designers and owners to obtain certification as a U.S. Green Building Council Leadership in Energy and Environmental Design for New Construction (LEED-NC). Free downloads of *High Performance Building Requirements for Sustainability* 2.0 can be obtained by visiting **www.cement.org/codes**.

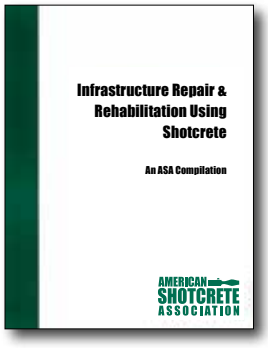
2011 International Concrete Sustainability Conference

The sixth annual International Concrete Sustainability Conference will provide learning and networking opportunities on the latest advances, technical knowledge, continuing research, tools, and solutions for sustainable concrete manufacturing and construction.

Researchers, academics, students, engineers, architects, contractors, concrete producers, public works officials, material suppliers, and concrete industry professionals are invited to attend, submit papers, and give presentations. Topics include:

- Low-Impact Development—including pervious pavements, water conservation systems, and erosion control structures.
- Urban Heat Island Reduction—including light-colored pavements, exterior cladding, green roofs, and cool communities.
- Carbon Footprint and Embodied Energy– including energy-efficient buildings, sustainable infrastructure, and cement and concrete manufacturing.
- Sustainable Development Initiatives—including process and product innovations, green building rating systems, and life-cycle assessment.

Infrastructure Repair & Rehabilitation Using Shotcrete—An ASA Compilation



This document was originally created for distribution at the last "International Bridge Conference" held in Pittsburgh, PA. Positive response to the compilation moved ASA to make the document available to the entire concrete industry.

This new compilation of papers focuses on shotcrete's use in the repair and rehabilitation of infrastructure. The 34-page black and white soft-cover book, "Infrastructure Repair & Rehabilitation Using Shotcrete," is a compilation of eight previously published papers in ASA's *Shotcrete* magazine.

Copies of the compilation are available for a special price of $9.00 U.S. Pricing includes shipping. To place an order, visit **www.shotcrete.org/RepairBulletin** or call (248) 848-3780.

INTERNATIONAL CONCRETE SUSTAINABILITY CONFERENCE
AUGUST 9-11, 2011 - BOSTON

- Recycled Materials—including ingredients, fuels, and beneficial use of byproducts for cement and concrete production, challenges, and opportunities.
- Performance-Based Concrete—including extended service life, performance-based specifications, durability, synergies, and challenges.
- Government Initiatives—including economic stimulus and incentives for sustainable technologies, green building and infrastructure spending, energy legislation, and carbon cap and trade programs.
- Private Initiatives—including sustainability initiatives by building owners and developers, opportunities, and challenges of green building.

The 2011 International Concrete Sustainability Conference, being held in conjunction with the MIT Concrete Sustainability Hub 2011 Industry Day, is scheduled for August 11, 2011. Registrants and speakers at the Concrete Sustainability Conference will have the privilege of attending both events.

New LEED Standard (LEED 2012) Draft Released

The USGBC has unveiled its next-generation LEED standard, informally dubbed LEED 2012, for public comment. The new guideline tightens many existing LEED standards, and many green-design features, such as bicycle racks and the use of recycled materials, are now prerequisites rather than optional credits.

The initial comment period closed on December 31, 2010. A second public comment period is expected in mid-2011, and the rating system itself is expected to be released in November 2012.

A copy of the draft can be obtained on the USGBC Web site at **www.USGBC.org**.

An analysis of the draft as to what is new, what has changed, and what is the same can be found in the article from Environmental Building News titled, "Your Guide to the New Draft of LEED," on their Web site at **www.BuildingGreen.com**.

GSA Mandates LEED Gold Rating for New Federal Construction

According to an article on **FederalTimes.com**, the General Services Administration (GSA) has announced that all new federal building construction projects must conform to the U.S. Green Building Council's (USGBC's) LEED Gold certification standards, with more environmentally friendly features than the previously mandated LEED Silver certification standard.

The USGBC's LEED system awards points for incorporating sustainable practices into building designs. The more sustainable features of a building, the more points it receives. A LEED Gold-rated building would need to incorporate more features such as water-efficient bathrooms, green roofs, and recycled construction material.

The highest rating is LEED Platinum.

Smog-Eating Concrete Roof Tiles

MonierLifetile, now part of the newly created Boral Roofing, has introduced "smog-eating tile," concrete roof tiles said to reduce the amount of smog in the atmosphere.

According to the company, a catalyst on the tile surface reacts with sunlight to neutralize nitrogen oxide pollutants; the leftover organic nitrogen residue rinses off the roof when it rains, where it can aid grass and plant growth.

According to Boral, a 2000 ft^2 (185.8 m^2) roof can eliminate the same amount of nitrogen oxide that a car will produce when it drives 10,800 miles (17,381 km). The technology has been in use in Europe for a few years, mainly on roads. Boral is testing it for other product offerings, including clay tiles.

Shotcrete FAQs

As a service to our readers, each issue of *Shotcrete* will include selected questions and provide answers by the American Shotcrete Association (ASA). Questions can be submitted to info@shotcrete.org. Selected FAQs can also be found on the ASA Web site, **www.shotcrete.org/ASAfaqs.htm**.

Question: *Can shotcrete be applied as a protective coating for exterior insulation over 1 in. (25.4 mm) thick exterior polystyrene/foam (blue type) insulation that is installed on the exterior side of residential precast foundation walls?*

Answer: Shotcrete can be placed against almost anything. The foam needs to be dense enough that it will withstand the impact of the shotcrete and the foam needs to be secured to the existing foundation so that it does not separate from the foundation during or after the shotcrete placement. The use of shotcrete against foam is commonly done in insulated panel housing systems and inflated dome construction.

Question: *Does wet-mix shotcrete or gunite have a higher strength? Which is better for swimming pools?*

Answer: Shotcrete placed by either the wet or dry process (commonly known as gunite) is capable of similar strengths if placed properly by experienced and qualified contractors. The choice of the process for any particular application should be left up to the experienced and qualified shotcrete contractor. Both processes are used on swimming pools with great success.

Question: *On a recent project, diversion pumps were not able to keep up with the water level during the storms over a weekend, and the culvert being relined was flooded with brackish seawater. The lining was sprayed/placed on a Thursday, and the flooding happened on the following Saturday night. How long does gunite material (dry-mix shotcrete) need to be above the water level for proper curing?*

Answer: Shotcrete must be cured by keeping it continuously moist for preferably 7 days. Therefore, once the shotcrete has reached its initial setting—say 6 hours maximum—flooding the shotcrete with water, even seawater, is the best curing possible.

Question: *Is there any time limit on how long a shotcrete wall can set before a second layer is applied for architectural details?*

Answer: There is no specific time requirement or "rule of thumb" for the time between layers or lifts of shotcrete.

If you are concerned about how quickly you can place subsequent layers or lifts, the critical concern is that the subsequent layer not be placed until the previous layer is firm enough that it will not slough or sag with the weight of the subsequent layer. This time is dependent on numerous factors, such as the fineness of the cement, which influences the set time; the temperature of the mixture; and the temperature and humidity of the area, among other factors. The decision on placement of subsequent layers or lifts should be made by the applicator.

Layers or lifts of shotcrete can be placed days, weeks, or almost any time after previous layers or lifts. The most important factor in placing subsequent layers or lifts is that the existing surface be properly prepared, roughened, and predampened to ensure a good bond between layers or lifts.

Question: *We have a 90 ft (27.43 m) shale cliff face with rock anchors; erosion under the anchors indicates that a shotcrete/steel reinforcing application is necessary. The cliff is a waterfall and major tourist attraction. The area under the anchors is about 25 ft^2 (2.32 m^2), and I am planning to install approximately 10 anchors. How can we prevent the always-present groundwater from damaging the shotcrete?*

Answer: It is difficult to place shotcrete under these conditions. Groundwater seepage can be dealt with by using a drain material behind the shotcrete and vents or weep holes through the shotcrete. Shotcrete set can be accelerated, but it is difficult, if not impossible, to place shotcrete in a condition of running water. I would suggest you discuss this with a local shotcrete contractor who can actually look at the situation and determine if it is feasible. A list of shotcrete contractors can be found on the ASA online Buyers Guide at **www.shotcrete.org/buyersguide**.

Question: *I own a two-story residential structure on a sloping lot that is a pier and grade beam construction along with a few retaining walls. The contractor wants to shotcrete the entire foundation, including the grade beams. The grading contractor was hired to do the formwork and a well-known applicator in the area will do the actual shotcrete installation. The grading contractor installed a grid of reinforcing of No. 5 bars at 8 in. (203 mm) on center for the entire project, even for the grade beams, and he mentioned that this is for the shotcrete to adhere correctly and not slough down. The walls and grade beams are all 8 in. (203 mm) wide. Is this a typical/accepted type of installation? Also, are there any requirements for blockouts or inspection-type holes at the reinforcing so that the reinforcing cover can be inspected to see that no voids have formed at the back of the walls/grade beams?*

Answer: Shotcrete is a method of placing concrete. The project you describe is typical for the type of work done by shotcrete contractors.

There are various ways to ensure that the work is done properly.

1. The shotcrete applicator could provide references for successful projects of similar or more complicated applications.
2. The local building code might require a full-time special inspection.
3. You could require that a mockup panel be constructed to the most congested conditions and shot concurrently or before the actual foundation placement. This mockup could be cored, sawed, or broken apart to show that the shotcrete is placed in a uniform manner and encapsulates the reinforcing.
4. You could install added reinforcing bar in the foundation wall and core through it after the placement to indicate the quality of the placement.

Question: *I am considering a shotcrete application for a culvert that is approximately 175 ft (53.3 m) long. The floor of the culvert will have conventional reinforced cast-in-place concrete, and I am inquiring about placing reinforced shotcrete on the walls and ceiling. The tunnel has many variations, such as bends and changes in shape. Unfortunately, the culvert is small to start with and with a reinforced 6 in. (152 mm) overlay, I am concerned about having sufficient room for the proper and safe application of the shotcrete. The culvert would have finished vertical wall heights varying between 2.9 and 5.7 ft (0.88 and 1.74 m). The finished width varies between 3.3 and 11.2 ft (1.01 and 3.41 m). Is there sufficient room in this culvert to safely place the shotcrete and achieve a dense placement, given a qualified nozzleman? I would also be specifying a finished surface in the culvert.*

Answer: This sounds very challenging, but it can be safely accomplished by an innovative shotcrete contractor. Qualified contractors can be found on the ASA online Buyers Guide at **www.shotcrete.org/buyersguide**. Shotcrete is a method of placing concrete, and perhaps you should also give consideration to use shotcrete for the floor.

ASA ANNOUNCES AVAILABLITY OF NEW ONLINE BUYERS GUIDE

New online tool offers the industry free access to products and services of the leading companies in the shotcrete industry

The new American Shotcrete Association (ASA) Buyers Guide is now available free to the concrete industry at **www.shotcrete.org/BuyersGuide**.

The ASA Buyers Guide provides a new and important tool to locate those companies that continually prove their commitment to the shotcrete process and its quality by supporting ASA through Corporate Membership.

This new service enables users to search for companies based on products and/or services related to shotcrete across seven main categories:

- Admixtures
- Cement/Pozzolanic Materials
- Consulting
- Contractors
- Equipment
- Fibers
- Shotcrete Materials/Mixtures

Searches can be further refined using over 100 subcategories and geographic criteria.

AMERICAN SHOTCRETE ASSOCIATION

www.shotcrete.org/BuyersGuide • (248) 848-3780

2011 AMERICAN SHOTCRETE ASSOCIATION Buyers Guide

The following list of ASA Corporate Members is current as of December 1, 2010.

For a current listing, including the ability to search by seven major specialties (as well as over 100 subspecialties) and states/provinces served, visit the online ASA Buyers Guide at **www.Shotcrete.org/BuyersGuide**.

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Web site: www.shotcreteplusmt.com
E-mail: shotcreteplusmt@nemont.net
Contact: Larry Mooney

Shotcrete Technologies Inc. — ADMIXTURES, CEMENT/POZZOLANIC MATL, CONSULTING, CONTRACTOR
PO Box 3274
Idaho Springs, CO 80452-3274
Phone: 303-567-4871
Web site: www.shotcretetechnologies.com
E-mail: info@shotcretetechnologies.com
Contact: Kristian Loevlie

Sika Corporation — ADMIXTURES, CEMENT/POZZOLANIC MATL
201 Polito Ave
Lyndhurst, NJ 07071-3601
Phone: 201-508-6698
Web site: www.sikaconstruction.com
E-mail: sompura.ketan@sika-corp.com
Contact: Ketan Sompura

Sofis Company Inc. — CONTRACTOR
554 Bocktown Cork Rd
Clinton, PA 15026-1142
Phone: 724-378-2670 x2
Web site: www.sofiscompany.com
E-mail: tsofis@sofiscompany.com
Contact: Ted W. Sofis

South Shore Gunite Pool & Spa, Inc.
7 Progress Ave
Chelmsford, MA 01824-3606
Phone: 800-649-8080
Web site: www.ssgpools.com
E-mail: rguarino@southshoregunitepools.com
Contact: Robert E. Guarino

Southwest V-Ditch Inc.
3625 Placentia Ln
Riverside, CA 92501-1119
Phone: 951-781-4303
Web site: www.swvditch.com
E-mail: mail@swvditch.com
Contact: Bob Shepherd

Spec Mix Inc. — EQUIPMENT, SHOTCRETE MATERIALS/MIXES
2025 Centre Pointe Blvd, Ste 260
Mendota Heights, MN 55120-1267
Phone: 651-994-7081
Web site: www.specmix.com
E-mail: nblohowiak@specmix.com
Contact: Nick Blohowiak

Stone Valley Construction Inc. — CEMENT/POZZOLANIC MATL, CONSULTING, CONTRACTOR, EQUIPMENT, FIBERS, SHOTCRETE MATERIALS/MIXES
132 Coaldale Rd
Philipsburg, PA 16866-2333
Phone: 814-342-7151
Web site: www.stone-valley.com
E-mail: kknepp@stone-valley.com
Contact: Ken Knepp

Structural Shotcrete Systems Inc. — CONTRACTOR
12645 Clark St
Santa Fe Springs, CA 90670-3951
Phone: 562-941-9916
Web site: www.structuralshotcrete.com
E-mail: jason1@structuralshotcrete.com
Contact: Jason Weinstein

Sunwest Gunite Co. ADMIXTURES, CONSULTING, CONTRACTOR, FIBERS
7045 Luella Anne Dr NE
Albuquerque, NM 87109-3907
Phone: 505-821-2549
Web site: www.sunwestguniteco.com
E-mail: info@sunwestguniteco.com
Contact: Gary O'Canna

TBH & Associates LLC
5211 NE 88th St
Vancouver, WA 98665-0931
Phone: 360-546-1600
Web site: www.tbhdrill.com
E-mail: ptapio@tbhdrill.com
Contact: Peter Tapio

Testing, Engineering & Consulting Services Inc. CONSULTING, CONTRACTOR
235 Buford Dr
Lawrenceville, GA 30046-4945
Phone: 770-995-8000
Web site: www.tecservices.com
E-mail: tmccants@tecservices.com
Contact: James Glenn McCants III

Texaloy Foundry Company Inc. EQUIPMENT
PO Box 37
Floresville, TX 78114-0037
Phone: 800-367-6518
Web site: www.texaloy.com
E-mail: jrice@texaloy.com
Contact: Jack Rice

Top Gun of Virginia Inc. CONTRACTOR
10017 Richmond Hwy
Lorton, VA 22079-2421
Phone: 703-550-9207
Web site: www.topgungunite.com
E-mail: info@topgungunite.com
Contact: Jon Slaunwhite

Topcor Services Inc. ADMIXTURES, CEMENT/POZZOLANIC MATL, CONSULTING, CONTRACTOR, EQUIPMENT, FIBERS
12025 Industriplex Blvd
Baton Rouge, LA 70809-5131
Phone: 225-753-7067
Web site: www.topcor.com
E-mail: jbaker@topcor.com
Contact: James M. Baker

Truesdell Corporation
1310 W 23rd St
Tempe, AZ 85282-1837
Phone: 602-437-1711
Web site: www.truesdellcorp.com
E-mail: kclink@truesdellcorp.com
Contact: Kurt Clink

Tyam Group
27474 Gloucester Way
Aldergrove, BC V4W 3Z4, Canada
Phone: 604-533-8088
Web site: www.tyam.com
E-mail: kenjessamine@tyam.com
Contact: Ken Jessamine

Val-Mar Inc. ADMIXTURES, CEMENT/POZZOLANIC MATL, CONSULTING, CONTRACTOR, EQUIPMENT, SHOTCRETE MATERIALS/MIXES
12775 Rue Brault
Mirabel, QC J7J 0C4, Canada
Phone: 514-832-0550
Web site: www.val-mar.ca
E-mail: mhudon@val-mar.ca
Contact: Matthieu Hudon

Western Shotcrete Equipment Inc. EQUIPMENT
HC 1 Box 193
Fairdealing, MO 63939-9708
Phone: 573-857-2085
Web site: www.wseshotcrete.com
E-mail: josephharpole@wseshotcrete.com
Contact: Joe Harpole

White's Shotcrete Inc.
3750 McCullers Rd
Loganville, GA 30052-2955
Web site: www.whitesshotcrete.com
E-mail: rwhite3448@aol.com
Contact: Robert White

Wildcat Concrete Services Inc. CONTRACTOR
PO Box 750075
Topeka, KS 66675-0075
Phone: 785-233-1400
E-mail: stuartj@wildcatconcrete.com
Contact: Stuart R. Johnson

WLH Construction Company CONTRACTOR
2000 W 60th Ave
Denver, CO 80221-6631
Phone: 303-347-8655
Web site: www.wlhconstruction.com
E-mail: wharrison@wlhconstruction.com
Contact: Warren Harrison

Wurster Engineering & Construction
34 Carrie Dr
Greenville, SC 29615-5611
Phone: 964-627-7751

www.Shotcrete.org/BuyersGuide

SPECIALTIES

The following list of ASA Corporate Members is current as of December 1, 2010.
For a current listing, including the ability to search by seven major specialties (as well as over 100 subspecialties) and states/provinces served, visit the online ASA Buyers Guide at **www.Shotcrete.org/BuyersGuide**.

Admixtures

Aircrete Systems LP Inc.	Calgary, AB, Canada
AKZONOBEL Functional Chemicals Elotex GmbH	Frankfurt am Main, Hessen, Germany
Blastcrete Equipment Company	Anniston, AL
Cementec Industries Inc.	Calgary, AB, Canada
Dome Technology	Idaho Falls, ID
The Euclid Chemical Company	Cleveland, OH
Fibercon International Inc.	Evans City, PA
J Tortorella Swimming Pools Inc.	Southampton, NY
Kryton International Inc.	Vancouver, BC, Canada
Multicrete Systems Inc.	Winnipeg, MB, Canada
Serafina Industries Ltd.	Southampton, NY
Shotcrete Plus Montana	Absarokee, MT
Shotcrete Technologies Inc.	Idaho Springs, CO
Sika Corporation	Lyndhurst, NJ
Sunwest Gunite Co.	Albuquerque, NM
Topcor Services Inc.	Baton Rouge, LA
Val-Mar Inc.	Mirabel, QC, Canada

Cement/Pozzolanic Matl

Aircrete Systems LP Inc.	Calgary, AB, Canada
Blastcrete Equipment Company	Anniston, AL
Boral Material Technologies Inc.	Roswell, GA
Cementec Industries Inc.	Calgary, AB, Canada
CWS Source Inc.	Brookfield, WI
Dome Technology	Idaho Falls, ID
The Euclid Chemical Company	Cleveland, OH
Lafarge North America	Bingham Farms, MI
Multicrete Systems Inc.	Winnipeg, MB, Canada
Oldcastle APG West, Inc.	Phoenix, AZ
The Quikrete Companies	Atlanta, GA
Serafina Industries Ltd.	Southampton, NY
Shotcrete Plus Montana	Absarokee, MT
Shotcrete Technologies Inc.	Idaho Springs, CO
Sika Corporation	Lyndhurst, NJ
Stone Valley Construction Inc.	Philipsburg, PA
Topcor Services Inc.	Baton Rouge, LA
Val-Mar Inc.	Mirabel, QC, Canada

Consulting

Advanced Shotcrete Inc.	Salt Lake City, UT
Aircrete Systems LP Inc.	Calgary, AB, Canada
AMEC Earth & Environmental	Burnaby, BC, Canada
Baker Concrete Construction, Inc.	Monroe, OH
Bekaert Corporation	Marietta, GA
Blastcrete Equipment Company	Anniston, AL
California Skateparks	Upland, CA
Carolina Concrete Systems, Inc.	Charleston, SC
Concrete Engineering Group LLC	Northbrook, IL
Continental Pools Inc.	Gardner, KS
Craig Olden, Inc.	Little Elm, TX
CWS Source Inc.	Brookfield, WI
Deluxe Shotcrete & Concrete Construction	Santa Rosa, CA
Dome Technology	Idaho Falls, ID
DOMTEC International LLC	Idaho Falls, ID
Drakeley Industries LLC	Bethlehem, CT
Drill Tech Drilling & Shoring, Inc.	Antioch, CA
Group Works LLC	Wilton, CT
Hardcore Shotcrete Skateparks Inc.	Joplin, MO
J Tortorella Swimming Pools Inc.	Southampton, NY

Consulting, continued

Joseph J. Albanese Inc.	Santa Clara, CA
Lafarge North America	Bingham Farms, MI
Multicrete Systems Inc.	Winnipeg, MB, Canada
The Nassal Company	Orlando, FL
Pool Engineering Inc.	Anaheim, CA
Preferred Pool Construction Services, Inc.	Kuna, ID
Ram Construction Services	Livonia, MI
REED Shotcrete Equipment	Chino, CA
Robert H Ward & Associates	South Chicago Heights, IL
Serafina Industries Ltd.	Southampton, NY
Shotcrete Technologies Inc.	Idaho Springs, CO
Stone Valley Construction Inc.	Philipsburg, PA
Sunwest Gunite Co.	Albuquerque, NM
Testing, Engineering & Consulting Services Inc.	Lawrenceville, GA
Topcor Services Inc.	Baton Rouge, LA
Val-Mar Inc.	Mirabel, QC, Canada

Contractors

Advanced Shotcrete Inc.	Salt Lake City, UT
Aircrete Systems LP Inc.	Calgary, AB, Canada
B & A Contractors Inc.	Florence, AL
Baker Concrete Construction, Inc.	Monroe, OH
Bekaert Corporation	Marietta, GA
Blastcrete Equipment Company	Anniston, AL
Boulderscape Inc.	San Juan Capistrano, CA
California Skateparks	Upland, CA
Carolina Concrete Systems, Inc.	Charleston, SC
Coastal Gunite Construction Company	Cambridge, MD
Conco Cement Companies	Concord, CA
ConCreate USL Ltd.	Bolton, ON, Canada
Concrete Engineering Group LLC	Northbrook, IL
Continental Pools Inc.	Gardner, KS
Craig Olden, Inc.	Little Elm, TX
Cruz Concrete & Guniting Repair Inc.	Manasquan, NJ
C-TEC, Inc.	York, NE
CWS Source Inc.	Brookfield, WI
DBM Contractors, Inc.	Federal Way, WA
Deluxe Shotcrete & Concrete Construction	Santa Rosa, CA
Dome Technology	Idaho Falls, ID
DOMTEC International LLC	Idaho Falls, ID
Donald J Scheffler's Construction	City of Industry, CA
Douglas Aquatics, Inc.	Richmond, VA
Drake Inc.	Waco, NE
Drakeley Industries LLC	Bethlehem, CT
Drill Tech Drilling & Shoring, Inc.	Antioch, CA
East Coast Shotcrete	West Orange, NJ
Eastern Gunite Company Inc.	Exton, PA
Facca Incorporated	Ruscom, ON, Canada
Fibercon International Inc.	Evans City, PA
Fisher Shotcrete Inc.	Higley, AZ
Group Works LLC	Wilton, CT
Hardcore Shotcrete Skateparks Inc.	Joplin, MO
Hydro Arch	Henderson, NV
J Tortorella Swimming Pools Inc.	Southampton, NY
John Rohrer Contracting Company Inc.	Kansas City, KS
Johnson Western Gunite Company	San Leandro, CA
Joseph J. Albanese Inc.	Santa Clara, CA
Knowles Industrial Services Corp.	Gorham, ME
Mar-Allen Concrete Products Inc.	Ephrata, PA
Mays Construction Specialties Inc.	Grand Junction, CO

SPECIALTIES

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For a current listing, including the ability to search by seven major specialties (as well as over 100 subspecialties) and states/provinces served, visit the online ASA Buyers Guide at **www.Shotcrete.org/BuyersGuide**.

Contractors, continued

Mid American Gunite Pools Inc.	Covington, KY
Multicrete Systems Inc.	Winnipeg, MB, Canada
The Nassal Company	Orlando, FL
Nationwide Shotcrete Inc.	Newhall, CA
Osco Gunite & Mudjacking Ltd.	Edmonton, AB, Canada
Palmetto Gunite Construction Company Inc.	Ravenel, SC
PCI Roads LLC	Saint Michael, MN
Pool Engineering Inc.	Anaheim, CA
Preferred Pool Construction Services, Inc.	Kuna, ID
ProShot Concrete Inc.	Florence, AL
Rahm Industrial Services, Inc.	Caledonia, MI
Ram Construction Services	Livonia, MI
REED Shotcrete Equipment	Chino, CA
Restek Inc.	Edmond, OK
RG Johnson Company Inc.	Washington, PA
Robert H Ward & Associates	South Chicago Heights, IL
Schnabel Foundation Company	Aurora, CO
Serafina Industries Ltd.	Southampton, NY
Shotcrete Plus Montana	Absarokee, MT
Shotcrete Technologies Inc.	Idaho Springs, CO
Sofis Company Inc.	Clinton, PA
Stone Valley Construction Inc.	Philipsburg, PA
Structural Shotcrete Systems Inc.	Santa Fe Springs, CA
Sunwest Gunite Co.	Albuquerque, NM
Testing, Engineering & Consulting Services Inc.	Lawrenceville, GA
Top Gun of Virginia Inc.	Lorton, VA
Topcor Services Inc.	Baton Rouge, LA
Val-Mar Inc.	Mirabel, QC, Canada
Wildcat Concrete Services Inc.	Topeka, KS
WLH Construction Company	Denver, CO

Equipment

Acme America Inc.	Coopersburg, PA
Advanced Shotcrete Inc.	Salt Lake City, UT
Aircrete Systems LP Inc.	Calgary, AB, Canada
Airplaco Equipment Company	Cincinnati, OH
Allentown Shotcrete Technology Inc.	Allentown, PA
Bekaert Corporation	Marietta, GA
Blastcrete Equipment Company	Anniston, AL
Carolina Concrete Systems, Inc.	Charleston, SC
ConCreate USL Ltd.	Bolton, ON, Canada
Construction Forms, Inc.	Port Washington, WI
Dome Technology	Idaho Falls, ID
Eastern Gunite Company Inc.	Exton, PA
Gunite Supply & Equipment Co.	Monrovia, CA
King Packaged Materials Company	Burlington, ON, Canada
Multicrete Systems Inc.	Winnipeg, MB, Canada
Normet Americas Inc.	Union Grove, WI
Pacific Alloy Casting Company Inc.	South Gate, CA
PCI Roads LLC	Saint Michael, MN
Putzmeister America Inc.	Sturtevant, WI
REED Shotcrete Equipment	Chino, CA
Serafina Industries Ltd.	Southampton, NY
Shotcrete Plus Montana	Absarokee, MT
Spec Mix Inc.	Mendota Heights, MN
Stone Valley Construction Inc.	Philipsburg, PA
Texaloy Foundry Company Inc.	Floresville, TX
Topcor Services Inc.	Baton Rouge, LA
Val-Mar Inc.	Mirabel, QC, Canada
Western Shotcrete Equipment Inc.	Fairdealing, MO

Fibers

Aircrete Systems LP Inc.	Calgary, AB, Canada
Bekaert Corporation	Marietta, GA
ConCreate USL Ltd.	Bolton, ON, Canada
The Euclid Chemical Company	Cleveland, OH
Fibercon International Inc.	Evans City, PA
Forta Corporation	Grove City, PA
King Packaged Materials Company	Burlington, ON, Canada
Multicrete Systems Inc.	Winnipeg, MB, Canada
Preferred Pool Construction Services, Inc.	Kuna, ID
Shotcrete Plus Montana	Absarokee, MT
Stone Valley Construction Inc.	Philipsburg, PA
Sunwest Gunite Co.	Albuquerque, NM
Topcor Services Inc.	Baton Rouge, LA

Shotcrete Materials/Mixes

Aircrete Systems LP Inc.	Calgary, AB, Canada
Blastcrete Equipment Company	Anniston, AL
Continental Pools Inc.	Gardner, KS
CWS Source Inc.	Brookfield, WI
Delta Industrial Services Inc.	Delta Junction, AK
Deluxe Shotcrete & Concrete Construction	Santa Rosa, CA
Dome Technology	Idaho Falls, ID
J Tortorella Swimming Pools Inc.	Southampton, NY
King Packaged Materials Company	Burlington, ON, Canada
Multicrete Systems Inc.	Winnipeg, MB, Canada
Preferred Pool Construction Services, Inc.	Kuna, ID
The Quikrete Companies	Atlanta, GA
REED Shotcrete Equipment	Chino, CA
RG Johnson Company Inc.	Washington, PA
Serafina Industries Ltd.	Southampton, NY
Spec Mix Inc.	Mendota Heights, MN
Stone Valley Construction Inc.	Philipsburg, PA
Val-Mar Inc.	Mirabel, QC, Canada

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AMERICAN SHOTCRETE ASSOCIATION

ASA Membership Benefits

	Corporate	Corporate - *Additional Individual*	Individual	Employees of Public Authorities or Agencies	Nozzleman	Student
Annual Dues	$750	$100	$250	$50	$50	Free
Subscription to quarterly *Shotcrete* magazine (Hard Copy)	X	X	X	X	X	
Electronic Subscription to quarterly *Shotcrete* magazine	X	X	X	X	X	X
Company & specialty information listed in ASA's online Buyers Guide	X					
Company & specialty information listed in *Shotcrete* magazine's annual Buyers Guide	X					
Links to shotcrete related government projects open for bid (*sent twice a month in the member edition of the ASA e-newletter*)	X	X	X	X	X	X
Discount on ACI Nozzleman Certification program	X					
Free advance general admittance registration to World of Concrete	X	X	X	X	X	X
Complimentary ASA shotcrete brochure each year	25		1	1		
Complimentary ASA reflective hardhat sticker each year	10		1	1		
Permission to include ASA logo on corporate letterhead and business cards	X	X	X	X		
Permission to display ASA logo on company web site	X					
Discounted Member pricing on advertising in *Shotcrete* magazine	X	X	X	X		
Free logo and link advertising on ASA website homepage for duration of each issue you advertise in Shotcrete	X					
Opportunity to submit items for Industry News and New Products & Practice sections of *Shotcrete* magazine at no charge	X	X	X	X		
Voting privileges at meetings and director/officer elections	X		X			
Discounted ASA Member prices on all ASA products	X	X	X	X	X	X
Networking and participation opportunities at Annual Membership Meeting and committee meetings	X	X	X	X	X	X
Opportunity to become a shotcrete educator	X	X	X	X	X	
All company employees have opportunity to receive discounted Corporate Additional ASA Memberships ($150 off regular membership price for each employee)	X					
Opportunity to submit entries into the annual Outstanding Shotcrete Project Awards Program	X					
Discount on ASA Underground Shotcrete Education Program	X					
ASA Promotion of nozzleman certification on a national basis in conjunction with ACI					X	
Education & promotion of your shotcrete industry to the overall concrete industry	**X**	**X**	**X**	**X**	**X**	**X**

AMERICAN SHOTCRETE ASSOCIATION

38800 Country Club Dr., Farmington Hills, MI 48331
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E-mail: info@shotcrete.org Web site: www.shotcrete.org

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❑ Employees of Public Authorities and Agencies	$50	
❑ Nozzleman	$50	
❑ Retired	$50	(For individuals 65 years or older)
❑ Student	Free	(Requires copy of Student ID card or other proof of student status)

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Company Specialties are searchable in the printed and online Buyers Guide.

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- ❑ Air Entraining
- ❑ Foaming
- ❑ Retarding
- ❑ Shrinkage Compensating
- ❑ Special Application
- ❑ Stabilizing
- ❑ Water Proofing
- ❑ Water Reducing-Accelerate
- ❑ Water Reducing-High Range
- ❑ Water Reducing-Mid Range
- ❑ Water Reducing-Normal
- ❑ Water Reducing-Retarding
- ❑ Water Repellent

Cement/Pozzolanic Materials
- ❑ Cement-Blended
- ❑ Cement-Portland
- ❑ Cement-White
- ❑ Fly Ash
- ❑ Ground/Granulated Slag
- ❑ Metakaolin
- ❑ Pozzolan
- ❑ Silica Fume-Dry
- ❑ Silica Fume-Slurry

Consulting
- ❑ Design
- ❑ Engineering
- ❑ Forensic/Troubleshooting
- ❑ Project Management
- ❑ Quality Control Inspection/Testing
- ❑ Research/Development
- ❑ Shotcrete/Gunite
- ❑ Skateparks

Contractors
- ❑ Architectural
- ❑ Canal Lining
- ❑ Culvert/Pipe Lining
- ❑ Dams/Bridges
- ❑ Domes
- ❑ Flood Control/Drainage
- ❑ Foundations
- ❑ Grouting
- ❑ Lagoons
- ❑ Mining/Underground
- ❑ Parking Structures
- ❑ Pumping Services
- ❑ Refractory
- ❑ Repair/Rehabilitation
- ❑ Residential

Contractors, contd.
- ❑ Rock Bolts
- ❑ Rock Carving
- ❑ Seismic Retrofit
- ❑ Sewers
- ❑ Skateparks
- ❑ Slope Protection/Stabilization
- ❑ Soil Nailing
- ❑ Storage Tanks
- ❑ Structural
- ❑ Swimming Pools/Spas
- ❑ Tunnels
- ❑ Walls
- ❑ Water Features

Equipment
- ❑ Accessories
- ❑ Adaptors
- ❑ Air Vibrators
- ❑ Bowls
- ❑ Clamps
- ❑ Compressors
- ❑ Couplings
- ❑ Feeder/Dosing
- ❑ Finishing
- ❑ Grouting

Equipment, contd.
- ❑ Guide Wires
- ❑ Gunning Machines
- ❑ Hoses
- ❑ Mixers
- ❑ Nozzles
- ❑ Pipe/Elbows/Reducers
- ❑ Plastering
- ❑ Pre-Dampers
- ❑ Pumps
- ❑ Robotic
- ❑ Safety/Protection
- ❑ Silo Systems
- ❑ Valves
- ❑ Wear Plates

Fibers
- ❑ Carbon
- ❑ Glass
- ❑ Steel
- ❑ Synthetic

Shotcrete Materials/Mixtures
- ❑ Dry Mix
- ❑ Steel-Fiber Reinforced
- ❑ Synthetic-Fiber Reinforced
- ❑ Wet Mix

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Company _____

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Phone: (248) 848-3780 • Fax: (248) 848-3740

Winter 2011

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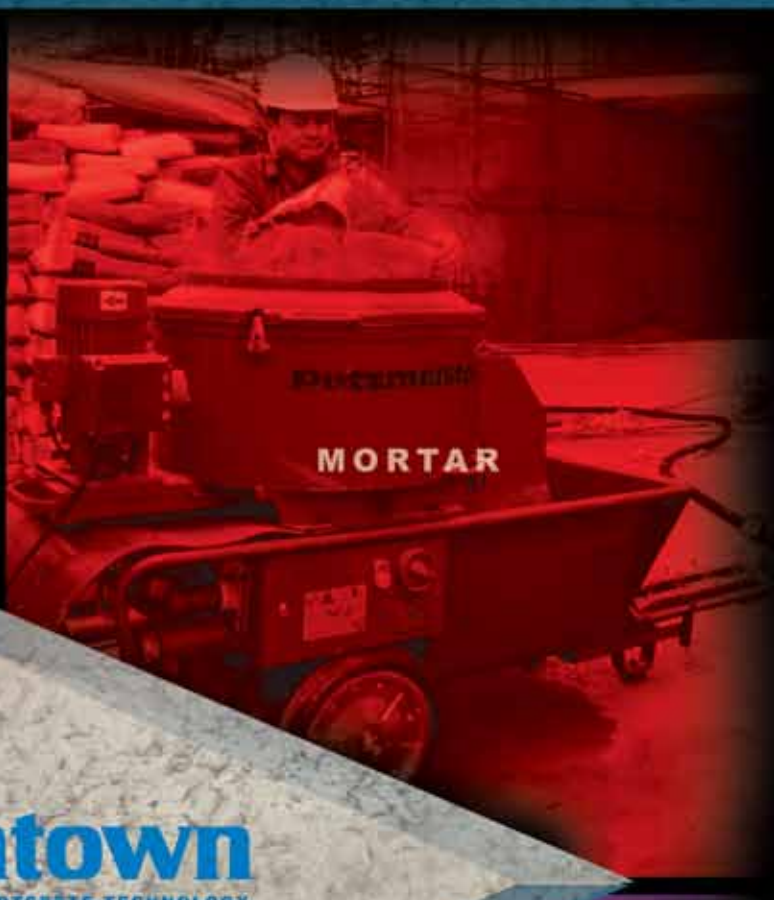

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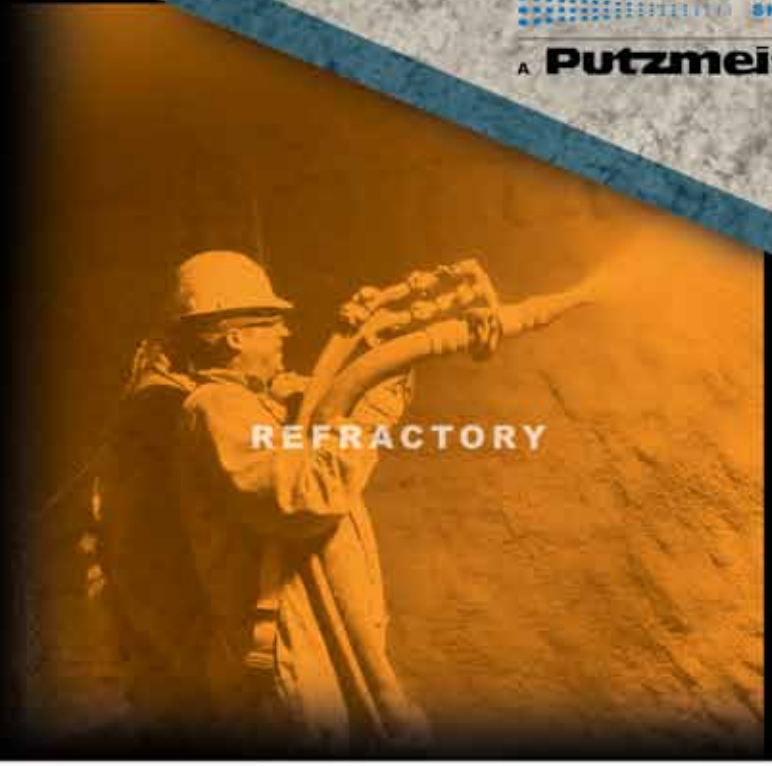

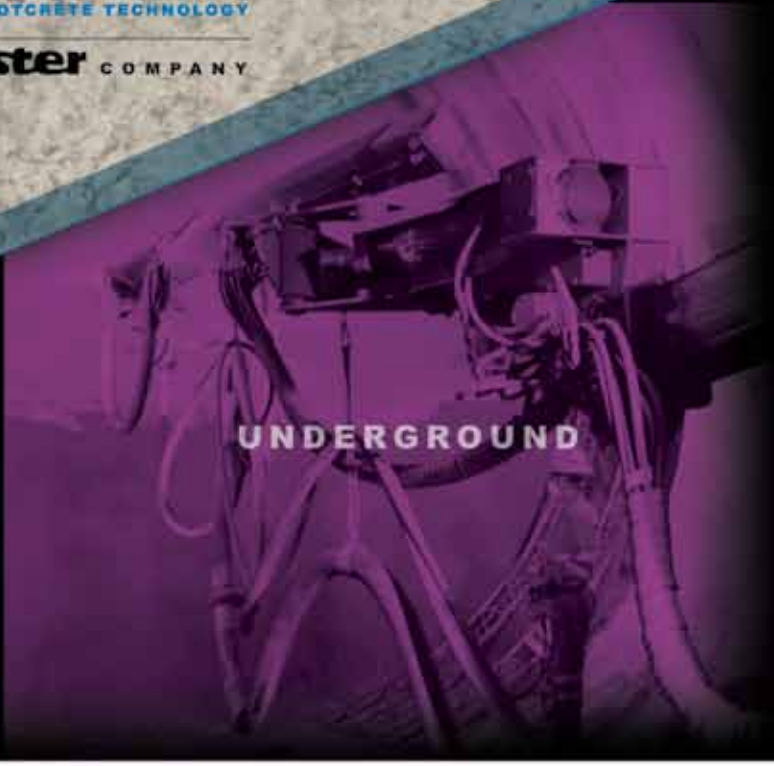

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