Shotcrete MAGAZINE

A quarterly publication of the American Shotcrete Association

Volume 17, Number 4 ◆ Fall 2015

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Shotcrete MAGAZINE
Volume 17, Number 4
Fall 2015

Features

Departments

On the cover: 1920s Gunning Crew

Conventional?

By Marcus H. von der Hofen

I was reviewing a job the other day that was an absolutely perfect application for shotcrete. When I contacted the engineer, he immediately said he didn't want gunite, he wanted concrete. As I started to explain that I would be placing ready mixed concrete using the shotcrete method, I could tell that I wasn't going to convince him that "Shotcrete is Concrete."

I thought to myself, how could it be in this day and age, that an engineer of a large firm would have this position? Unfortunately, the truth is that he is not in the minority, but very much in the majority when it comes to understanding shotcrete. Shotcrete, in many eyes, is a material—not a method of placing concrete. This is a completely understandable position, as a great deal of industry leaders have promoted that shotcreting can enhance properties, create superior in-place material, and is better than cast-in-place concrete. This may be accurate, but is it what an engineer is really looking for most of the time? They are looking for "industry standard," "as-specified," and "conventional." They are not interested in breaking new ground. Every time we attempt to separate shotcrete (pneumatically placed concrete) from cast-in-place concrete, I'm not sure we are helping ourselves.

We call cast-in-place the "conventional" method of placement and shotcrete "unconventional." Why? Is it more conventional to place pool walls with two-sided forms? Is it more conventional to repair the underside of a deck with form and pump? A skateboard park? A tunnel arch? Seismic shear wall? Soil nail wall? Basement wall? Structural concrete has been placed by the "shotcrete method" in these situations every day for decades. The fact is that the majority of the aforementioned situations, and many others, use shotcrete as the "conventional method."

ASA is looking forward to producing literature that can be used by college professors to add basic information about shotcrete to their existing concrete curriculum. We have a lot of work ahead of us to get this into production, along with many other educational materials. We need your help at the committee level to get this done. It's high time the future engineer, owner, and architect is "taught" that shotcrete is a proven conventional method instead of having to learn it on their own.

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ASA Underground Committee

By Axel Nitschke

My name is Axel Nitschke and I'm the Chair of the newly reorganized ASA Underground Committee. I'm also a fairly new member of ASA. My previous contact with ASA was very limited until one of our projects won the Outstanding Shotcrete Project Awards last year and I attended the Outstanding Project Awards Banquet. I met a lot of colleagues whom I knew already from past underground projects, but here they were all in one spot and I recognized the potential of ASA for myself and my company. I showed interest in actively participating in the Underground Committee and learned that the Underground Committee was inactive and that the position of the Underground Committee Chair was vacant. ASA asked me whether I would be interested in chairing the Underground Committee and I thankfully agreed.

I'm telling this little story of mine to highlight that not everybody is aware of the activities of ASA and some ASA members may be hesitant to become active within ASA. It is important to spread the word and let your professional contacts know how much high-quality, hands-on information about shotcrete they can gain and how valuable the contacts made through ASA can be.

One of the first acts as Committee Chair was to develop and define the mission statement of the underground committee. The mission statement of the underground committee is:

"To educate and promote the use and proper application of shotcrete to the underground construction and mining industry." The mission statement sounds pretty straightforward, but I would like to discuss it in more detail. I spent my entire career working on underground projects in very different roles, such as a researcher, tunneling contractor, claim and risk manager, designer, consultant, and construction manager—to name just

the most important. I worked on the contractor's side, the owner's side, and as an external expert. Because my area of expertise is conventional tunneling, the vast majority of these projects included shotcrete. Actually, shotcrete is currently probably the most important construction material used in conventional tunnel construction and rehabilitation projects, after classical hard rock tunneling. The education of all parties involved and the promotion of the capabilities of shotcrete is of the utmost importance to match the expectations with the executed work. However, the quality of the final product is highly dependent on the proper application. This of course includes the craftsmanship of the nozzleman and the crew on site, but also includes the proper design, inspection, and QA/QC. The proper application of shotcrete in the wider sense is a team effort of everybody involved in an underground project.

Civil construction and mining are two different industries. Despite the fact that they look very similar, they are in fact very different. While the purpose of a civil project is primarily the provision of an underground space, the underground activities in mining are mostly just providing temporary access. While the driver of civil projects is longevity, the driver in mining is an investment in a means to reach other goals—that is, the product mined. Therefore, the mission statement splits underground construction and mining. However, the technical challenges of the shotcrete logistics and application, with the additional challenge to place concrete overhead on a natural surface, are the same in both.

The successful application of shotcrete underground depends on a holistic view and understanding of the project. Everybody involved in the process—owner, designer, contractor, subcontractor, and supplier—has to understand and respect the special needs and capabilities of what can and can't be done. Bringing the different parties together, learning from each other, and then working together on the successful completion of underground projects—that's the goal. If you would like to participate in the ASA Underground Committee, please contact me, Axel Nitschke, Shannon & Wilson. I'm looking forward hearing from you.

The mission statement of the underground committee is: "To educate and promote the use and proper application of shotcrete to the underground construction and mining industry."

New Opportunities—Certification for Nozzlemen-in-Training

By Charles S. Hanskat, PE, ASA Executive Director

It's been a busy summer for our nozzleman certification program with many ASA-conducted sessions across North America, and the first in Australia, where we conducted an ASA/ACI session that certified 11 wet-mix nozzlemen from Australia and New Zealand. Certification of new shotcrete nozzlemen and recertifications of existing nozzlemen continues to be strong. We now have 1399 certified nozzlemen listed on the ACI certification verification website.

Bigger news, however, is the finalization of a shotcrete nozzleman-in-training (NIT) certification in ACI's certification policy. The concept for the NIT certification started several years ago in ACI Committee C660, Shotcrete Nozzleman Certification. After many drafts and committee balloting, the NIT provisions were approved late this summer by both ACI Committee C660 and then the Certification Programs Committee (CPC).

The Nozzleman-In-Training Program

This new program allows the starting nozzleman who can show at least 25 hours of hands-on nozzling work experience to participate in the ACI certification program. As with all new ASA/ACI nozzleman certifications, they must take the full-day ASA classroom education, and ACI written exam and performance exam(s) in the shotcrete processes and orientations they are pursuing certification in. Upon successful completion, they receive a NIT card issued by ACI. They are also listed on the ACI certification verification website as NIT in the process and orientation they completed. The NIT option has been added to the online description of the ACI shotcrete nozzlemen certification program, but with the caution to specifiers that "The Shotcrete Nozzleman also possesses substantially more shotcrete work experience in actual dry- (or wet-) mix shotcrete field applications than a Shotcrete-Nozzleman-in-Training."

Completion of the remaining field experience hours to reach the minimum of 500 required for full nozzleman certification should be under the supervision of an ACI-certified nozzleman, essentially as an apprentice. The NIT is required to maintain a detailed log to record hours on the nozzle until they accumulate the required minimum of 500 hours for full certification. The NITs have 5 years to accumulate and document the additional hours of field shooting experience. Upon completion of the

minimum of 500 hours, within 5 years, they must obtain their employer's sign off and submit the entire log to ASA for verification by the examiner-of-record.

Upon verification, they may be upgraded to a certified ACI Shotcrete Nozzleman in the process(es) and orientation(s) reflected in the verified work experience for the remainder of the original NIT certification term. After the original 5-year certification, these individuals would then qualify for recertification and follow the procedures for ACI Certified Nozzlemen. If they are not able to submit the remaining 500 hours prior to their 5-year anniversary, they will no longer be searchable in the ACI verification site and can either wait until 500 hours are met to test for full nozzleman certification or retake the exams for another 5 years to complete the hours within the NIT designation.

Nozzleman-In-Training Log

This is a project-based record of the NIT's placement hours. ASA has developed and posted on our website a PDF form to facilitate the NIT completing the required log of their hours. Each project requires a project page followed by the NIT Project Shooting Log, which details their shotcrete placement experience. The Shooting Log entries are required by the ACI policy to cover no more than 1 week's work. The ASA forms are available as an online PDF form (**www.shotcrete.org/education/index.htm**). The PDF form can be filled in on a computer and then printed, or a blank form can be printed out and filled in by hand. Also, the ASA Board approved development of an online webpage available to ASA NIT members who have participated in an ASA-sponsored certification session to log their projects and hours in an online database.

Additional Changes in C660 Nozzleman Certification Policy

In addition to adding the NIT provisions, C660 made a significant modification to the work experience requirement. The revised policy requires: "For ACI Shotcrete Nozzleman certification, 500 hours of verified work experience as a nozzleman, with at least 100 hours in the process and orientation for which certification is sought is a prerequisite." This means that nozzlemen attempting to shoot overhead panels must have at least 100 hours of experience shooting overhead.

We are excited to see the NIT option finally come to fruition, and offer nozzlemen starting out in their careers official recognition by ASA and ACI. As always, ASA members are highly involved with ACI shotcrete technical and certification committees and will continue to strive to make the work products from those ACI sources reflect successful practice and contribute to advancing our industry.

Eleventh Annual Outstanding Shotcrete Project Awards Banquet

Vdara Hotel and Spa
Vinoly Ballroom
Tuesday, February 2, 2016

6:00-7:00 p.m. Registration, networking, cocktails, and hors d'oeuvres
7:00-11:00 p.m. Plated dinner and awards ceremony
Further networking and cash bar available after the awards ceremony

- Architecture/ New Construction
- Infrastructure
- International Projects
- Pool & Recreational
- Rehabilitation & Repair
- Underground

Eleventh Annual ASA Outstanding Shotcrete Project Awards Banquet

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Date: Tuesday, February 2, 2016
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7:00-11:00 p.m. Plated dinner and awards ceremony, followed by cash bar networking reception.

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Choosing Your Wet or Dry Shotcrete Equipment Wisely

By Raymond Schallom III

Contractors just getting into the shotcrete business or inexperienced contractors may buy the wrong equipment just because the specification calls for it or a good salesman talks them into it. The seasoned, experienced shotcrete contractor already has the equipment for their proficient crews and knows what system (wet or dry) will work best for the project. Experienced shotcrete contractors and crews know that pneumatically applied concrete material projected at high velocity onto the surface will flow around the reinforcing bars and has excellent surface bond.

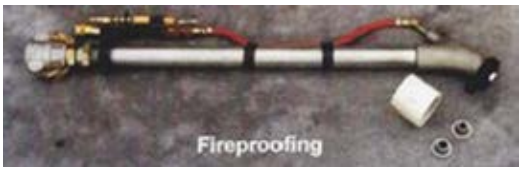

Fig. 1: Fireproofing nozzle setup

Fig. 2: Plastering nozzle setups

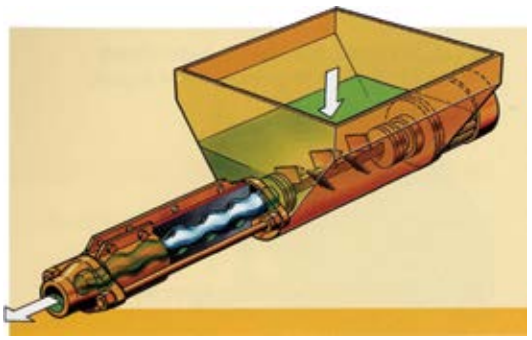

Fig. 3: Rotor stator pumps were designed for plaster, stucco, fireproofing, and later to replace the hawk and trowel for patches vertically 1 in. (25 mm) thick with no reinforcement. These nozzles and pump are not recognized by ACI as shotcrete equipment

Low-velocity applications, which are sometimes specified and advertised as a shotcrete system, were developed for spraying plaster, stucco, fireproofing, and the replacement for the hand-applied hawk-and-trowel method of 1 in. (25 mm) thick or less vertical patching with no reinforcement. The low-velocity method cannot pump any type of macro- or microfibers through the machine or through the nozzle tip, does not have the material velocity to wrap around the reinforcement properly, and has a limited pumping distance from the pump to the nozzle of 150 ft (46 m) before it starts to wear on the rotor. The low-velocity system cannot spray overhead without having the nozzle 2 to 4 in. (50 to 100 mm) from the surface and cannot properly encase reinforcement vertically or overhead due to the lack of material velocity. Figures 1 through 3 show different plaster and fireproofing nozzles and a rotor stator pump, which only pumps fine aggregate mixtures to cut down on the rotor wear. The air hose to the nozzle is typically 3/8 in. (9 mm) ID diameter with a 1/4 in. (6 mm) ID pipe into the tip of the nozzle for adjusting a splatter type spray pattern held at 2 to 4 in. (50 to 100 mm) from the surface. Not enough air volume (cfm) is able to pass through the 3/8 in. (9 mm) hose and 1/4 in. (6 mm) pipe to increase the speed of the material to reach a high-velocity spray pattern.

The article "Proper Selection of Equipment and Nozzle for ACI Shotcrete Nozzleman Certification"[1] talks about what ACI recognizes as the correct nozzle setup and equipment required for nozzleman certification. The American Concrete Institute (ACI) C660 Shotcrete Nozzleman Certification Committee put together the CP-60(09),[2] "Craftsman Workbook for Shotcrete," which covers the equipment, nozzle setup, and distance from the receiving surface. The ACI Shotcrete Subcommittees have written many documents over the years which outline the areas discussed previously. ACI documents[2-6] also provide guidance on selecting the correct high-velocity shotcrete equipment and nozzle setup. There is even a section on air requirements for both wet and dry shotcrete in ACI 506R-05,[4] Table 3.1, and Sections 3.4, 3.4.1, and 3.4.2.

Over the last 40 years I have used a checklist from my article "What You Need to Know before Selecting a Wet-Mix Shotcrete Pump"[7] to help choose the right manufacturer or dealer of wet pumps, dry machines, and systems needed for either shotcrete process. Although originally formulated for wet-mix equipment, the same format of the checklist can be used for selecting dry-mix equipment as well.

Once you have selected the right manufacturer or distributor, the next step is to choose the right pump/gun to meet your job requirements. The price of the equipment will likely play a key role in your selection. It is important to research the performance and maintenance history of the wet- or dry-mix equipment under consideration. More time and money may be spent on repair and maintenance for a less expensive model than for one that is more rugged with a good track record. The checklist can be used for any civil or mining projects. Following, you will see a comparison between both processes. Advancement in material, admixtures, and equipment has made both processes almost equal. (Figures 4 through 10 are of dry-shotcrete equipment; Fig. 11 through 15 are wet-shotcrete equipment.) There are three areas you need to look at: 1) which process do you want to get into; 2) the right high-velocity nozzle setup; and 3) the correct material hose for safety and nozzlemen efficiency. Auxiliary/accessory equipment may be needed depending on project requirements. An article found on the ASA website called: "The Value of Shotcrete Accessories"[8] explains the accessory equipment.

Dry Machines

The dry equipment shown ranges from the high-velocity dry nozzle setup to all three types of dry guns (ACI lists two classes of guns: pressure vessel and rotary guns). Figure 7 is the newer version of the N-gun (pressure vessel), which was introduced back in 1909 by Carl Akeley. The Cement Gun Company commercialized the N-gun in 1910 and the word "gunite" was coined in 1912. The N-gun has 105 years of field use and is still commonly used up and down the East Coast and many other countries globally. With the sealed pressure vessel, the N-gun has shot long distances over 1000 ft (300 m) and heights of over 500 ft (150 m) without the aid of an inline booster. They have very few wear parts and older version N-gun parts can be replaced with the new present-day parts. It was built to last for at least 100 years. It takes a well-trained gun runner to run the machine. Often the nozzlemen and gun runner switch positions daily.

The rotary barrel-type gun (Fig. 5) comes in two sizes depending on the output (low production of up to 6 yd^3/h (4.5 m^3/h) and the larger gun (Fig. 8) with outputs of up to 15 yd^3/h (11.5 m^3/h). The rotary barrel has over 50 years of field experience. It is very simple to run, has direct feed, and can handle any type of synthetic fibers (micro and macro) to steel fibers with the correct barrel size. It has an external exhaust chamber that allows any excess air to bypass without bubbling up through the hopper. Dust collectors have been designed to eliminate the exhaust dust. Distances for materials up to 1000 ft (300 m) horizontally and with inline material booster distances of over 2500 ft (762 m) have been achieved. Vertical material heights of 400 ft (120 m) have been achieved without an inline material booster. These rotary guns were constructed for the civil and mining projects where the equipment wear and tear is at its highest. This type of machine was designed for a less skilled worker, who just has to feed the hopper of the machine (gun) during operation.

The bowl-type gun in (Fig. 6) has over 50 years of field experience. It is a production-type gun for sand and cement. The U-shape bowl design makes it tough to push macro-synthetic and steel fibers up through the bowl pockets into the material hose proficiently. Due to its low cost, most contractors choose this type of gun. In most setups, a 2 in. (50 mm) inline air is reduced to a 1 in. (25 mm) pipe attached to the top of the clamping plate and rubber pad seal. From there, the 1 in. (25 mm) air volume pushes the material through the U-shape bowl backup to 1-1/2 in. (38 mm) or 2 in. (50 mm) material hose. This alone reduces the volume of air flow and material velocity to distances of

Checklist for Choosing the Right Manufacturer

(reproduced from Shotcrete*, Summer 2009[7])*

- Check the years of shotcrete knowledge and experience of the manufacturer's or dealer's sales staff.
- Research the equipment's field track record from a production standpoint.
- Evaluate the manufacturer's or dealer's customer service. This is helpful for troubleshooting pump- or gun-related problems or other shotcrete-related issues.
- Check on the availability of repair parts and the sales staff's knowledge of the inner workings of the concrete pump/gun (for troubleshooting problems). The manufacturer or dealer should offer on-site setup and testing prior to startup (to make sure there is no gunning or pumping problems with the mixture proportions selected for the job).
- The manufacturer or dealer should be able to offer hands-on shotcrete training as an option (check to see how many years of hands-on training experience the trainers have).
- Identify accessories the seller offers (hoses, clamps, reducers, concrete pipe, shotcrete nozzles, or fittings and accessories needed to equip the pump/gun for a robotic arm or robotic unit or accelerator dosing systems if the job requires it).

Dry-Process Nozzle Setups

Fig. 4: These dry-process nozzles are designed to handle the high material velocity and produce adequate spray patterns; also shown are different hose coupling sets. Six of the nozzle setups have water rings with 8 to 16 small 1/16 in. (1.6 mm) holes that create a cone when the water is turned on; as the material passes through the water, the material is partially mixed as the nozzleman builds up the layers. The 2 in. (50 mm) setup water ring has 16 straight holes in it and requires more water pressure and air volume to properly mix and compact the material

500 ft (150 m) horizontally and 100 ft (30 m) vertically, even though a few contractors have pushed past the manufacturer's rated distances. Bowl guns have a short life cycle due to the wear items and the light-duty gear boxes that need constant upkeep. The missing external exhaust chamber in some bowl guns results in air being discharged back through the hopper, causing bubbling of the material and excess dusting. This type of machine was also designed for a less skilled worker, who just has to feed the hopper of the machine (gun) during operation.

Remember, it requires more volume of air to successfully convey the material through the rotary dry guns. The higher air volume is also needed to run the air motors of the machines without causing blow by (bubbling up in the open hoppers) when gunning horizontal and vertical runs, which is commonly not experienced when operating a pressure vessel type of gun. Remember to consult your manufacturer when attempting to push material horizontally and vertically long distances if you experience bubbling material up through the hopper. ACI 506R-05[4] lists the compressor capacities and material hose diameter (refer to Table 3-1 in the document). All open vessels need a minimum of 600 CFM (17 m^3/min). Some manufacturers say you can use a 365 ft^3/min (10 m^3/min) compressor provided the unit is hydraulically driven and you only have 50 ft

Dry-Process Machines

Fig. 5: Rotary guns have over 50 years in the field use. This dry gun barrel-type gun is an air over/hydraulic unit for more consistent material flow and has an external air exhaust to keep it from bubbling up through the hopper during material discharge. This gun type can push macro- and micro-steel and synthetic fibers through the gun. These guns have pushed material over 400 ft (120 m) vertically and over 2500 ft (760 m) horizontally

Fig. 6: Bowl guns have been used over 50 years in the field use. It has no external exhaust, allowing the excess air to bubble up through the hopper. The U-shaped bowl makes it difficult to push macro-synthetic and steel fiber mixtures up and through the material outlet and limits the horizontal distance the material can be pushed

(15 m) of 1-1/2 in. (38 mm) material hose while gunning horizontal surfaces. When the nozzle is above the hopper of the open vessel guns, the air requirement will always be higher due to the extra air volume needed to convey the material out and up through the mixing nozzle. The air motor on the rotary guns takes as much as 185 ft^3/min (5.25 m^3/min) of air to run it properly.

One of the biggest issues that is faced by the shotcrete contractor since the early 1970s is that

Fig. 7: N-gun or pressure vessel has 105 years of field use. It is based off the original gun design from 1907-1910 and is called the double tank or chamber. This gun allows the material to continuously flow because the bottom chamber stays fully pressurized while the top chamber is being filled. With very few wear parts, these guns are built to last forever. The pressure is still used for pushing material 500 ft (150 m) vertically and 1000 ft (300 m) horizontally

Fig. 8: This auger-feed predampener and rotary barrel gun combination is used in civil tunnels and mining projects. This is an electric feed machine for consistent material flow, along with a peristaltic accelerator dosing pump that injects the metered liquid into the water line to the nozzle for early set times of the in-place dry shotcrete material

most specifiers started writing prepackaged completely dry bagged materials in their repair specifications. This alone has deviated from the patented bulk moist sand pile and cement mixture designs that had worked for over 50 years by the Cement Gun Company and their licensees. With the use of the dry bagged material instead of using moist sand and cement mixture, it became necessary to predampen the material before it entered the gun. By mixing moist sand (with 3 to 5% moisture) and cement together, it would start the hydration process, making it easier for the nozzleman to regulate the water at the nozzle and reducing the potential for building up static electricity from material moving through the hose. By using completely dry material with no moisture, the hydration process did not start until the dry material reached the nozzle water ring. This author learned the hard way—getting hit by static electricity. I wrapped the nozzle hose with an inner tube; grounded the gun, couplings, and the hose and water valve at the nozzle; and even switched water pumps to increase the water pressure at the nozzle, which I thought would solve my problems. It never dawned on me the one key element missing was the moisture in the mixture before entering the gun. By taking a mortar mixer and a water spray nozzle to predampen the dry material, we made a crude predampener, which brought the

Fig. 9: From the original design, this rig is the original predampener and mixing rig for the N-gun and has a 50-year field experience based off the original Micon rig design. This rig can mix moist sand and cement or predampen prebagged material

Fig. 10: From the original design this rig is a shorter version of the original predampener and mixing rig with a rotary barrel-type gun and hydraulic water booster pump designed to fit into low spaces, such as parking garages. This rig can mix moist sand and cement or predampen prebagged material

material back to the original consistency (moist sand and cement). By predampening the mixture, it made the static electricity disappear and also made adjustments to the mixing water at the nozzle easier to control. It wasn't until later in my career that I was introduced to an actual continuous auger-fed predampening machine. This eliminated shoveling the mixed material into the gun (a back saver). Figure 8 is an electric combination predampener/rotary barrel gun (GM-060 for production) and a peristaltic accelerator pump for use on civil and mining work, where early set times were required. The electric version allows for consistent material flow from the mixing to the delivery. Air-driven machines fluctuate with the air demand from other equipment on the same air source.

From the original Micon mixing rig design, the rig pictured in Fig. 9 was developed as the first mixing and predampening rig available in the mid to late 1960s. In the picture, an N-gun was mounted under the material holding hopper, allowing the gun operator to continually feed the top chamber of the N-gun while the bottom chamber still stayed pressurized. With the spray bar located in the mixer, it allowed the batchman to predampen the dry sand or dry bagged material back to the desired 3 to 5% moisture. Once the batch was mixed, the batchman would open the mixer door, allowing the material to travel up the conveyor into the holding hopper above the gun. Some contractors have modified their rigs to rotary barrel-type guns for continuous feed and simplicity (Fig. 10). The art of running an N-gun (pressure vessel) is now down to well-established contractors that have several of the N-guns in their fleet.

Wet Concrete Pumps

Wet mix was introduced back in 1955 in North America and was later called the wet-mix shotcrete process by ACI. Like the dry process, the evolution of the wet-mix concrete pumps have come a long way from the mid-1950s. Pictures of the old pumps can be found in earlier versions of the ACI 506[2-6] documents.

The concrete pump shown in Fig. 12 is a medium-to-low volume swing tube pump that is capable of pumping through a 1-1/2 to 4 in. (38 to 100 mm) diameter hose depending on the project. This size of pump is an ideal shotcrete pump that can pump concrete up to 20 yd^3/h (15 m^3/h). It has a mixer on the back end to remix concrete mixtures from a truck or site mix bagged material. This wet-mix pump is designed to handle lower-volume output for repair and grouting applications as well. The pump should be capable of reducing the material outlet to a 1.5 in. (38 mm) diameter hose for repair and have the option to do low-pressure grout work. The electronic setup in the pump allows the swing tube to switch quickly between cylinders, reducing the delay between strokes and cutting down on the line surge at the nozzle.

Wet-Mix Nozzle Setups

Fig. 11: Wet-mix shotcrete nozzle setups have a minimum of 3/4 in. (20 mm) air line running into them with 8 to 16 small 1/4 in. (6 mm) air holes in the air ring for maximum material velocity. Accelerator is introduced into the air stream at the nozzle and is driven into the material by the air flow (much like the dry-process water ring). The nozzle setup at the far right has an inner material ring and outer air ring. This nozzle needs the air volume to swirl the material coming out of the nozzle tip. With the separate accelerator port, the air volume is crucial to mix it into the material as it swirls out the tip. If the air flow is low, only the outside of the swirled material will have the accelerator in it (this nozzle is a newer version of the early technology)

For medium- and large-volume projects, consider using a piston-type pump with outputs of 20 to 60 yd^3/h (15 to 45 m^3/h). A remixer in the hopper helps agitate and push low-slump mixtures toward the cylinders. Grates with vibrators on the grate help with low-slump mixtures or mixtures with fibers (special grates are available that have vibrators attached and smaller openings to help keep larger rocks out of the mixture while letting stiff mixtures or mixtures with fibers pass through it). An accelerator dosing system can be connected to the concrete pump, which can be designed to inject the proper accelerator dosage per cylinder stroke or as a standalone unit with flow control devices into the wet nozzle setup. ACI 506R-05[4] Chapter 3, Fig 3.1, and Section 3.4 on air requirements will help you establish required air needs. For the wet-mix pumps, the fibers are part of the aggregate in the concrete mixture and have an impact on how much cementitious material is required in the mixture to bind it together during pumping. How far from the actual work area will the material be conveyed? How many times will the crew have to stop/start or move throughout the day? These are just a few items to consider in planning the setup of your equipment.

There are several factors that dictate the proper selection of a concrete pump: type of project;

Wet-Mix Pumps

Fig. 12: An Allentown Powercreter 20 is shown with a hydraulic mixer attachment. The attachment is being used as a remixer for concrete supplied by a mobile, or a volumetric mixer for site batching to achieve a consistent mixture for pumping operations. A vibrating screen was installed to reduce the risk of plugging the 1.5 in. (38 mm) hose due to randomly occurring large aggregate particles. The electronic control technology produced a continuous flow of concrete material that allowed the nozzleman to apply a uniform shotcrete layer to the walls with very little line surge. The unit can pump concrete containing up to 1 in. (25 mm) stone mixes through a 4 in. (100 mm) hose

Fig. 13: Reed C50HP concrete pump can be reduced down to a 2 in. (50 mm) hose for shotcrete work or up to a 5 in. (125 mm) hose for concrete pumping

pumping distance; hose size; type of application; quantity of material to be pumped; production rate desired; and use for the multiple applications other than shotcrete, such as grouting or concrete placing.

All three trailer-mounted concrete pumps (Fig. 13 through 15) are for medium- to large-volume output projects. Remember, all concrete pumps were designed to pump large aggregate mixtures. There are pumps on the market that were designed to pump harsh stiff mixtures and small aggregate mixtures, which also can pump large aggregate mixtures. You have to look at the line surge between strokes, how well the mixture can be drawn into the cylinders for discharge, whether the hopper has an agitator remixer, and a grate

Fig. 14: Schwing 750 trailer pump setup for easy maneuvering in and around the jobsite can be reduced down to a 2 in. (50 mm) hose for shotcrete work or up to 5 in. (125 mm) for concrete pumping

Fig. 15: Allentown Powercreter Model 40 pump with hydraulic outriggers can be reduced down to a 2 in. (50 mm) hose for shotcrete work or up to 5 in. (125 mm) for concrete pumping. The electronic swing tube control allows for faster shifts between cylinders, thus reducing the line surge to the nozzleman

that has a vibrator (a vibrator on the hopper face only compacts the concrete, allowing all the water to rise to the top). These are just a few issues with the wet pumps. One needs to keep in mind that only about 18 yd^3/h (14 m^3/h) can be pumped through a 2 in. (50 mm) hose unless you are pumping cement grouts. An average manually applied shotcrete application produces between 6 and 15 yd^3/h (5 and 11 m^3/h) of pneumatically applied concrete. Hose sizes of 2, 2.5, and 3 in. (50, 65, and 75 mm) are typically used for robotic applications. The outputs for robotic applications range from 20 to 30 yd^3/h (15 to 23 m^3/h).

Shotcrete Application Breakdown between Both Processes

The breakdown comparison between processes in Table 1 may help with your decision making. The dry-mix process requires more volume of air than the wet-mix process, but is easier to stop, start, and move than the wet-mix process. All areas other than the equipment and maintenance costs of dry-mix are about the same. Admixture technology has

Table 1: Shotcrete Application Breakdown between the Wet- and Dry-Mix Process

Wet-mix 50-plus-year track record	Comparison	Dry-mix 50- to 105-year track record
****	Equipment costs	**
****	Operation	**
****	Material distance	****
***	Maintenance	*
****	Performance	****
****	Material volume	***
****	Quality control	****
**	Flexibility	****

made the wet-mix process more desirable on larger projects because it requires smaller air compressors, produces no dust, has substantially higher output production, and produces less rebound.

An article on "Equipment Maintenance"[9] contains three checklists of spare parts and wear items, which routinely cause the most delays or job shutdowns. This short article has many helpful suggestions to prevent what this author once went through in using shotcrete equipment in field conditions. Using the "Daily Wet-Mix Shotcrete Checklist"[9] from the article as a template, one can create a dry-mix daily checklist as well. If you have ever been on a job where the work came to a stop because no one had spare wear items near the pump or gun, and the crew had to wait for someone to bring them the spare wear parts, not only do you lose production time but it's also the equipment and labor time that really adds up.

Summary

The purpose of this article is to inform specifiers or contractors about choosing the right wet-mix or dry-mix equipment for the project size. It

can be a valuable selection guide for those who are looking to purchase wet-mix or dry-mix equipment for the first time or for the experienced shotcrete contractors looking to purchase new equipment. It can give specifiers guidance on equipment characteristics that may be appropriate for a particular project. Dry-mix shotcrete has over a 105-year track record and wet-mix shotcrete has a 50-plus-year track record. Both processes are well-proven methods of placing concrete at high velocity and at an economical sustainable price. Logistics play a key role in the process that will work the best for the project. The means and methods of shotcrete placement should be left up to the contractor. In the end, it does not matter which process is used as long as the material specification is met. Ultimately it is the owner of the project who benefits the most from the quality and economy of using shotcrete on their job.

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Mobile Batching of Shotcrete

By Mason Guarino and Tom Norman

Site foreman to the local ready mix plant dispatcher: "Hi, we ordered concrete 30 minutes ago and were wondering where the truck is?" Local ready mix plant dispatcher to the site foreman: "Oh, sorry about that, we are running behind. He is batching now and will be on site soon," or maybe, "Oh, sorry, due to tomorrow's rain, one of our large customers moved up a big job and we will get to you in about 3 hours." The variations are endless, but it usually means we'll be waiting for concrete. At least for our company, these comments have been relatively common in all of our experiences with ready mix concrete suppliers, not just with shotcrete. We wanted to gain more control over our concrete deliveries and the simplest answer was to buy a batch plant and a truck. So we did, only it was a mobile batch plant mounted on a truck—a volumetric batch plant. Once we started running our own batch trucks, we were then able to get rid of the ready mix delivery headaches and have more control over our concrete needs. At South Shore Gunite Pools & Spas, Inc. (SSG), we have been able to successfully batch both wet- and dry-mix shotcrete and use the trucks in a few different ways.

The driving factor behind using mobile batching trucks was to be more profitable. If our concrete costs less, our bids can be less and we can win more jobs. However, once we started working with the batch plants, we realized that we could also be more efficient and, in turn, become more profitable. Because we control the trucks, we always know where they are and do not have to wait for a promised ready mix concrete truck to show up late or not at all. The truck driver is our employee, so he will work with our crews as part of the team rather than someone who just wants to empty his truck as fast as possible and move on. On large projects of 150 yd^3 (115 m^3) or more, we are also able to park a portable cement silo and an excavator next to the mobile batch trucks and create an on-site batch plant to be even more efficient. We do not need to shut down for 15 minutes every 8 to 10 yd^3 (6 to 8 m^3) to swap the concrete trucks. We can shut down and restart when needed—not at the whim of a concrete supplier.

Fig. 1: On-site dry-mix batching truck

SSG is a pool company that uses both the wet- and dry-mix processes. We prefer the dry-mix process on the smaller projects under 50 to 60 yd^3 (38 to 46 m^3). We use Airplaco mobile batch plants on our smaller projects (refer to Fig. 1). The Airplaco mobile batch body is mounted to, in our case, a triaxle heavy-duty truck that can legally drive around with a 77,000 lb (35,000 kg) total weight. These dry-batch trucks produce material quickly and efficiently to supply the Gunite Supply C-10 gun we use on all of our dry-mix projects. These trucks are easy to calibrate with the manufacturer-provided calibration bin. One of the benefits to the dry process is that when the truck is empty, they can be cleaned up more quickly and throughly than a wet-batch truck or a conventional concrete truck. When the job is done, it is also very easy to clean the area around the gun that has dry sand and cement, as opposed to a pile of wet material. When working in residential backyards, being quick and clean is helpful. We have been running three dry Airplaco mobile batch trucks for close to 15 years now. The trucks fill up on a regular basis at one of our two cement silos. The sand is kept dry under a sand barn and when not in use the trucks are parked under a roof to keep the sand from getting too-wet, because too-wet sand will really clog up a gun.

SSG uses the wet-mix process to do the work on the larger projects, as it is roughly twice as fast as the dry process. When walls start to get thick, it's nice to have the higher productivity. SSG uses a Cementech mobile batch plant for all of the wet-mix batch work we do. Ninety-five percent of our wet-mix mobile batch work is on large jobs, where we set up a Cementech portable silo and an excavator next to the truck (refer to Fig. 2). If

Fig. 2: On-site wet-mix batching setup

the shotcrete receiving surface is ready to start shooting on the day we pull in with the equipment, we can typically set up the truck, silo, and excavator, then have the silo filled and aggregate deliveries made, then calibrate and start shooting by 1 pm at the latest. Using this setup on larger projects really relieves stress for the crew leader and allows him to concentrate on the job rather than worry about concrete deliveries. In this scenario, the excavator operator is able to monitor the raw material quantities and let the crew leader know when more of anything is needed or make the orders themselves. Just be sure to swap back and forth between nozzlemen if shooting for an extended period of time.

Our mixtures for the dry-mix trucks are a simple concrete sand to cement ratio. The wet-mix trucks are very customizable and can add all the ingredients that your mixture would need. The manufacturers are very eager to provide a product that will suit your specifications. Our wet-mix truck has separate fine- and coarse-aggregate bins and a cement bin along with three admixture tanks. We use air-entraining and water-reducing admixtures, as well as an Acti-Gel slurry. We like the Acti-Gel because it provides many of the benefits of fly ash. Also, when using a batch truck, using fly ash would require an extra powder hopper and a separate silo, while the liquid slurry Acti-Gel is just added using one of the liquid admixture tanks.

Having about 7 years of experience operating the wet-mix batch trucks, we can't stress enough the importance of calibrating and checking the settings regularly. There are a significant number of moving parts and calibration items on these trucks that can move off setting on their own—sometimes when a cobble works its way through the system or even when someone just bumps up against something. Calibrating confirms the accuracy of the materials in the mixture to achieve the desired results but it also makes you go through all of the moving parts to check that everything is working the way it is supposed to. The site-batching process makes you put your hands on everything to ensure proper operation and accuracy.

Some of the other benefits include saving on raw materials. A concrete truck will often turn around with hundreds of dollars of material that you paid for because you either over-ordered to ensure completion or misjudged the quantities and over-ordered by accident. When the portable batch trucks are done with the job, you just clean the mixing auger and go top off the material bins on the truck for the next job. There is never the worry of getting a load of concrete that has been hydrated too long or is getting too hot, as none of the materials are mixed until you are ready to use them. Don't worry about the quality of concrete on hot days or when you have long hauls before it gets to you. These trucks are commonly used by the military and night-time highway work crews for placing high-performance concrete, and by SSG for all of its shotcrete work. We are very happy with how they work, the flexibility and profitability they bring to our jobs, and look forward to using them for years to come.

***Mason Guarino**, Vice President of South Shore Gunite Pools & Spas, Inc. (SSG), started in the pool industry when he was 14, learning how to install reinforcing bar. Since then, he has worked on all phases of swimming pool construction. Guarino has worked full time with SSG since receiving his BS in construction management from the Wentworth Institute of Technology, Boston, MA, in 2009. Guarino currently serves on ASA's Board of Direction and is an ACI Certified Nozzleman.*

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Materials Handling Underground

By Craig McDonald and Julian Peña Cruz

Materials and equipment handling can be challenging in any industry. Movement of materials and equipment in an underground environment, however, has its own unique challenges. Once supplies arrive at the surface of the jobsite, they must be sent underground through a network of tunnels to the work site where the supplies are required. For some mines and tunnel projects, access underground is available by a ramp from the surface. For others, access to an underground worksite may only be available through a vertical shaft with an elevator or cage that travels from the surface to the various levels. In either case, the shaft or ramp usually becomes a literal bottleneck in the process of getting materials to the worksite.

Like all jobsites, each mine or tunnel project has its own unique challenges. Shallow mines with ramps from the surface have the ability to use bulk haulage equipment to transport shotcrete materials and equipment to the heading. In the case of wet-mix shotcrete supply, material is delivered in trans-mixers, which travel via the ramp to the worksite or heading. For dry-mix supply, bulk bins mounted on underground haulage vehicles can be used to transport bulk dry-mix shotcrete to the worksite (refer to Fig. 1).

Fig. 1: Bulk dry shotcrete hauler/sprayer

Most bulk haulage equipment designed for shotcrete or concrete can carry between 4 and 9 yd^3 (3 and 7 m^3) of material per load. The drum or bins are charged on the surface and driven underground via the ramp, where they are discharged and then returned to surface so the process can be repeated. This type of delivery method is reliable and efficient. However, many mines and tunnel projects do not have the luxury of being able to use it due to lack of ramp access.

Mines and tunneling projects serviced only by a shaft often use bulk bags or super sacks of preblended material to overcome shotcrete supply challenges. Bags containing 2200 to 3300 lb (1000 to 1500 kg) of material are shipped to the site on pallets, where they are stored until used. In most cases, the site is accessible by road and shotcrete materials can be delivered directly on flatbed trucks. In certain cases, however, extremely remote sites require a more challenging strategy. Some remote northern mines, for example, can only be accessed by "ice roads" made popular through the television show *Ice Road Truckers*. For other remote locations, the only economically viable solution is to transport the material by boat. In both of these cases, the dry-mix material should be packaged in heavy-duty bulk bags with the additional protection of an inner polyethylene barrier. This added protection will reduce the possibility of moisture (in the form of water or snow) from coming in contact with the dry shotcrete material and causing the mixture to hydrate prematurely.

When transporting shotcrete by boat, smaller volumes are best shipped in 20 ft (6 m) shipping containers, which generally hold a maximum of 53,000 lb (24,000 kg). For larger volumes, bulk bags can be directly loaded into the hull of a vessel dedicated specifically for shotcrete material transport (refer to Fig. 2).

Whether a remote mine site in the far north or a local tunneling project located a few miles (few km) from the production plant, preblended, ready-to-use bags of shotcrete must be stored on-site until the surface crews are required to transport the material underground to the shotcrete crew. Once the material is delivered to the worksite, the shotcrete crew will be able to begin the shotcrete

placement process. If a well-planned worksite strategy is in place with appropriate material handling equipment, excellent lighting, and a well-trained shotcrete crew, the only limiting production factor will be the capacity of the shotcrete placement equipment.

Some mines in northern Canada have had success supplying bulk preblended dry materials underground via the shaft and cage through the use of cassettes (removable bulk bins that can be interchanged on an underground haulage vehicle). These cassettes can be charged with preblended materials on the surface from a storage silo and sent underground via the cage. For a project with ramp access, an underground haulage vehicle (designed specifically for carrying the cassette) can off-load an empty cassette and reload a full cassette so the material can be hauled in bulk directly to the worksite. As is the case with delivery using bulk haulage equipment, the elimination of bulk bags and pallets is an obvious benefit for bulk haulage and cassette delivery.

For cassette delivery, the negatives are the capital costs of the cassettes and, of course, weight. Most cassettes will weigh 6600 to 11,000 lb (3000 to 5000 kg), which reduces the amount of shotcrete material that can be delivered per trip by that amount. By contrast, bags and pallets weigh very little.

The use of a slick-line or bore hole from surface to a location underground has become a popular option for transporting both dry- or wet-mix shotcrete on mining and tunneling projects. This option eliminates the costly use of ramp or cage time, eliminates the need for bags and pallets, and allows bulk delivery of wet- or dry-mix shotcrete in an efficient, timely manner. The biggest detractor from the use of slick line or bore hole delivery is the high capital cost related to the haulage equipment and the installation of a slick line or bore hole. Depending on depth, the cost of a lined bore hole or slick line can reach well into seven figures, making it impractical unless large volumes of shotcrete are anticipated for a long period of time. Mines with a long anticipated life that use shotcrete for primary ground support are excellent examples of situations that can financially justify the installation of a bore hole or slick line. For a mine that may possibly require possibly hundreds of thousands of cubic yards (cubic meters) of shotcrete during its operational life, the high initial investment can pay dividends over the life of the mine by reducing the use of the shaft time, ramp time, and worker power required to facilitate moving materials either in bags and pallets or cassettes.

All things considered, there is not one system that can be effective for all locations. All sites have their own unique requirements and challenges.

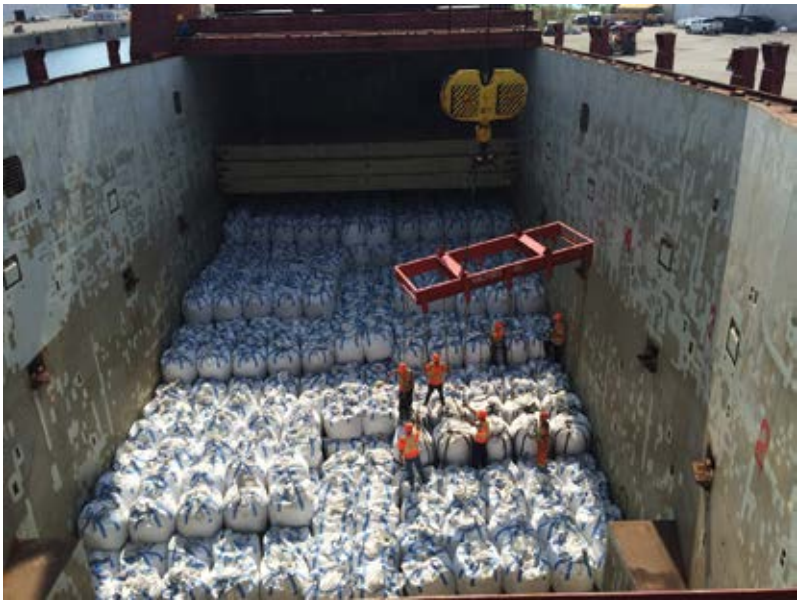

Fig. 2: Preblended dry shotcrete being loaded into a ship's hull

Ingenuity has brought us to the point where bins on the surface equipped with level sensors automatically refill underground silos and inform the supplier on their own. However, sometimes there is no substitute for keeping it simple and going back to—or staying with—the basics.

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.*

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Wet-Mix Shotcrete — with the Flexibility of Dry Mix

By Walter Betschart

Have you ever thought to yourself, "Is there a way to shoot wet-mix shotcrete in a more flexible way and with less cleanup?" There is one.

Wet-mix shotcrete, as per common knowledge, requires rather large pumps with pistons or worms. Concrete is mechanically pushed to the nozzle as a dense stream. At the nozzle, air and accelerator (if required) are added to project and compact the material to the substrate.

Worm pump machines can deliver concrete with maximum aggregate sizes of 0.15 in. (4 mm) and are typically used for repair and surface finishing projects. The output is typically up to 5 yd^3/h (4 m^3/h).

Double-piston pump-based machines also supply a dense stream of concrete to the nozzle and can be virtually pulse-free when shooting. This type of machine can produce high outputs from 5 to 33 yd^3/h (4 to 25 m^3/h), being particularly suitable for large tunnel construction or where substantial structural volumes are required.

A third possibility, not well known in North America, is wet-mix shotcreting with rotor machines. Rotor chamber pumps of Aliva®, which are commonly known for their use with the dry process, have been further developed over the years to also shoot wet-mix concrete. They are being successfully used for wet shotcrete application in mining and civil construction throughout Europe, as well as many other parts of the world.

Aliva rotor machines, basically the same as in the dry process with the help of compressed air, blows wet concrete from the pump to the nozzle where the accelerator (if necessary) can be injected. The capacity of this type of equipment ranges between 0.90 to 25 yd^3/h (0.7 to 19 m^3/h), depending on the size of the equipment and the volume of the rotor installed. They are capable of delivering concrete to the substrate at a regular rate and almost free from pulsation.

Shooting wet-mix concrete with rotor pumps does have advantages that simply cannot be dismissed:

- Whenever you have a job where you know there will be many stops and interruptions, with a rotor machine there will be no complications. As concrete is blown to the nozzle, simply let the hopper go empty and the compressed air in the hoses and pipes will do the rest. There is no concrete loss when stopping the machine. The machine itself can quickly be washed down with a hose. No high-pressure water jet is needed.
- As mentioned before, Aliva rotor machines offer a great range of output capacity. A well-chosen machine type and size and its accessories will enable you to do anything from small concrete repairs up to slope or tunnel stabilization with the same equipment. This comes in handy in confined and narrow areas such as wastewater and water tunnels.
- Midsize rotor pumps with capacities from 1 to 13 yd^3/h (0.75 to 10 m^3/h) are very compact and fit on the bed of almost any truck. With weights between 1400 and 2600 lb (640 and 1200 kg), these machines are easier to handle than large piston pumps.
- Small and midsize rotor chamber pumps are also available with an air-driven motor. This eliminates the need for electricity and offers a good solution at places such as carbon mines, where no sparks are wanted.
- Steel and synthetic fibers can also be processed, as well as aggregate up to 0.5 in. (13 mm) with a small rotor and 0.75 in. (19 mm) with a big rotor.
- If needed, there will always be the possibility to change from wet to dry concrete without making any changes on the machine. Merely replacing a small piece at the gun gives you that flexibility at a very low cost.

Aliva rotor concrete spraying machines are perfectly compatible with mechanical manipulators such as AL-302.1 telescopic spraying arms or AL-101 Quick Connect spraying heads that can be attached to a wide range of excavators or backhoe loaders of any brand. With the help of manipulators, you will be able to reach a high output and thus fully take advantage of the potential of Aliva rotor pumps.

Hoses for shotcrete with rotor pumps are generally much easier to handle. As the concrete is blown through the hose instead of being pumped, this eliminates the heavy concrete mass in the

hose. Furthermore, rotor pump hoses do not have to withstand more than 1200 psi (8 MPa); therefore, their design does not need to be as tough as the hoses for piston-pumped concrete. This makes rotor pump hoses less rigid, lighter, and above all, a lot cheaper.

The technology behind a rotor machine is not as sophisticated as with a pump. Maintenance and operation are very easy; one worker can service the equipment in less than half a day. For the actual shotcreting, as few as two operators per team can manage the feeding of the machine and the shotcrete placement.

With the relatively small dimensions of the equipment, they can be mounted on many carrier vehicles. Together with a spraying arm, you can build your own spraying system without having to invest a lot of money.

Rotor pumps in general are less prone to problems when the concrete is not continuously good quality—that is, oversizes or mixture of the aggregates. As long as the concrete is not too sticky (fine grain not more than 5%), a rotor machine will be able to convey it. Generally, there is no problem if the slump is lower than typically used for shooting with piston pumps. Also, there is no need to keep pipes or hoses lubricated; thus, no line lubricant chemicals are needed.

To pump concrete with a piston pump, a higher content of cement is often used for the lubrication

Fig. 1: Practicing slope stabilization with wet concrete in Arequipa, Perú, with an Aliva-257

Fig. 2: Slope stabilization with Aliva-257 in Quito, Ecuador. One of the new roads leading to the new airport

Fig. 3: Stabilizing rocks with wet concrete with Aliva-257. Here, the new Converto manual spraying gun is used

The following are samples of projects where rotor pumps were successfully used:

Metro de São Paulo, Brazil – Extension of Line 2, Lot 3

Shotcrete application: Ipiranga Station
Approximate Volume: 10,000 yd^3 (7600 m^3)
Equipment used: 2 Aliva 262, 1 Aliva 263
Contractor: Construtora Norberto Odebrecht

DAEE – Underpass Castelo Branco Freeway, Brazil

Shotcrete application: 1000 ft (300 m) tunnel with 16.5 ft (5 m) diameter
Approximate Volume: 2000 yd^3 (1500 m^3)
Equipment used: 1 Aliva 263
Contractor: DP Barros & Viatec

Currently there are many more projects in construction with the use of rotor pumps. The decision was taken to work this way precisely because of their robustness, flexibility, and simple operation.

of the pipes and hoses, resulting in more cement in the mixture than is needed for structural strength. The quantity of the fines, especially the cement, can also be reduced. Rotor machines work well in a wide range of material up to plain aggregates without any additional lubrication with fines.

Rotor machines are very durable, long-lasting pieces of equipment. It is not unusual to find 30-year-old equipment still in perfect working condition. As you can see, there are many arguments to start thinking about using rotor pumps for your next shotcrete job.

Two good examples for a successful use are construction and extension projects in Brazil. As the conditions of the jobsite were not always very favorable, the subcontractor Albau Construtora Ltda. decided to do the job with rotor machines instead of pumps. The main reasons for this decision were the constantly changing quality of the concrete, repetitive interruptions of the supply of the concrete due to traffic, and bad organization at the jobsite. The decision to use a rotor machine was more than justified as Albau Construtora Ltda. had the possibility to suspend the shooting without major losses and less organizational hassles.

Walter Betschart *is an Area Sales Manager since 2005 with Sika/Aliva Equipment. For the past 5 years, he has been head of the order processing department. Betschart is currently stationed in Panama, responsible for the Latin American Market.*

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A Team Approach to Any Project is the Best Approach

By Darin Cielocha

In the industry of restoration, one thing can be said that continues to ring true: "No two jobs are exactly the same." McGill Restoration knows that all too well. The company's history and experience spans over the past three decades and they have skilled craftsmen that range from trades such as laborers, carpenters, masons, painters, concrete finishers, and shotcrete nozzlemen. With that kind of lineup, there's not really a whole lot you can't tackle in the world of restoration!

In the Midwest, it's not uncommon for people to respond to a call for some help from their neighbors. In this case, McGill Restoration was asked to help out the company neighboring their warehouse in Lincoln, NE. It just so happens that this neighbor is one of the largest grain receiving/storage facilities in the state. Interstate Commodities (ICI) is based out of Troy, NY, and has several grain receiving/shipping terminals located across the East Coast and upper Midwest regions of the United States. With a rising demand for storage capacity, ICI contracted McGill Restoration to reline and strengthen a grain silo that had been determined to be structurally deficient for grain storage.

Challenges:

- Getting assistance from local ready mix producer to help develop a suitable wet-shotcrete mixture that could be pumped over eight stories—straight up.
- Working with a local structural engineering firm to develop a relining strategy and survey of the structure.
- Providing enough illumination for crews to see what they were looking to accomplish.
- Having restrictions to work with only air-driven tools and hoists while working on the inside of the silo.
- Using a suspended scaffolding system that would accommodate being close enough to the wall to dowel and tie reinforcing bar, and far enough from the wall for a nozzleman to work.
- Being safe at all times!

Mixture Design

One has to sometimes overcome the parity in the construction industry of "what worked on the last job, will probably work again on the next job!" This is especially true when it comes to wet-shotcrete mixture designs that have been used over the years across the great plains of the Midwest. Portland cement is one of our greatest building material resources in Nebraska, and we have some of the country's best-paved roads and highways. Unfortunately, although many of the ready mix producers are great at producing concrete for cast-in-place concrete applications, many ready mix producers lack the knowledge of the proper portions of portland cement to use in a wet-shotcrete mixture design as well as the right proportion and/or gradation of aggregates. So, with the help and willingness of Rod Leber (General Testing Lab Manager for NEBCO Inc.) and Oscar Duckworth (Valley Concrete Services), we were able to design a concrete mixture well-suited for our application. We lowered our concrete mixture costs by crafting the right proportions of portland cement, fly ash, and admixtures. The gradation of aggregate was probably the most challenging. Most of the aggregates used in concrete mixtures in our part of the country tend to be heavy on the sand-gravel side. To use a larger aggregate (1/2 in. [13 mm]), we had to consider using limestone. Limestone is one of this region's most available type of aggregate sources, and provided the additional sieve size of aggregate we were needing to round out our mixture design. By adding the 1/2 in. (13 mm) limestone aggregate, we were still able to produce a very pumpable and workable mixture. By bringing together the ready mix producer and contractor along with a little help from ASA, we made a winning team to overcome this project challenge.

Current Condition of the Structure

Many of the grain storage facilities that were built across the Midwest in the 1950s to 1960s were built using slipform construction methods. This method of construction during this period of time did not vary the thickness of the wall from the base of the structure to the roof. So, the condition of the grain silo we were looking at relining was constructed of 8 in. (200 mm) walls from the

footing to the roofline of the silo. The structure was 110 ft (34 m) to the roof and 30 ft (9 m) in diameter. This one silo that we were contracted to reline was singled out by ICI because of the blower/ventilation system that this silo was equipped with. Bringing this silo back online by early summer was critical to help meet the demand for needed storage for the beginning of the area's wheat harvest. Additional repairs to other grain silos at this facility are being evaluated for future relining projects.

For analysis and design of the strengthening for the 110 ft (34 m) structure, we brought Vance Behrens, PE, SE, Principal of Structural Design Group in Lincoln, NE, onto our team. His structural evaluation of the silo gave us guidance on the additional load capacity we could put on the structure while cutting access holes into the sides of the silo, as well as the roof's capacity for rigging suspended scaffolding inside the structure during construction. He also provided a design for the reinforcing bar size and spacing for the shotcrete lining on the interior walls. ACI 506.2-13, "Specification for Shotcrete," was the construction specification used for shotcreting the lining of the silo and the shotcrete mixture as well.

Proper Tools and Lighting

Beyond the use of a Reed B50 concrete pump, 170 Ingersoll/Rand compressor, and a few hundred feet of pipe and hose, four ACI Nozzlemen (Rich Hodtwakler, Ben Russell, Matt Russell, and Ron Stricklett) and their crew produced a game plan to place 140 yd^3 (107 m^3) of shotcrete on the inside of the grain silo. We had a few other things to contend with first.

Working in and around grain storage facilities can be one of the most dangerous working environments. There are strictly enforced "no-smoking" polices at these facilities. If caught smoking on the premises, it is an automatic firing offense. Grain dust is highly combustible, so as a contractor, one is not allowed to use impact tools, drills, and suspended scaffold hoist (motors) that are electrical-driven. This posed another challenge, as it meant all tools used on this project had to be air-driven. This caused a slight reduction of production on the project as a whole, but safety is always our first concern.

Because working in a grain silo is very much like working in a tunnel, we had to generate our own lighting (refer to Fig. 1). The lighting had to follow strict guidelines as well. Our lighting had to be explosion-proof-rated and generate enough illumination for us to work. Abrasive Blast Supply Inc. proved to be a very good resource for what we needed. They were able to provide us with a directional LED light that provided 10,000 lumens, which was suitable for explosion-proof and hazardous working conditions. These types of lights can be run off 120-volt AC power and stay cool to the touch.

Fig. 1: Working on the 30 ft (9 m) diameter grain silo requires special equipment. McGill Restoration had to use specialized, blast-proof lights to generate enough light for their crews to safely complete their work

Round Hole, Square Peg

McGill Restoration has decades of experience when it comes to constructing scaffolding or other aerial lift equipment on high-rise buildings, bridges, water tanks, and many other types of structures. Because they do not make curved suspended scaffolding systems, laying out a configuration that is conducive to a cylindrical shape was challenging. You need to design the scaffolding system to maximize your working area to get close enough to place dowels and tie-reinforcing steel in the walls, but also have enough spaced on the scaffolding deck for the nozzlemen to control their placement distance. A decagon-shaped suspended-scaffolding system design was constructed to a 28 ft 4 in. (8.6 m) diameter for the duration of doweling and tying

Fig. 2: Crews work to tie reinforcing bar on the interior of the grain silo to help support the new 5 in. (127 mm) shotcrete liner that will be installed

steel (refer to Fig. 2). When it came time to start shooting shotcrete, the deck configuration was reconfigured to a 26 ft 4 in. (8.0 m) diameter. This allowed our nozzlemen an adequate distance from the wall for placement of the 5 in. (125 mm) shotcrete lining.

Weight restrictions on a suspended scaffolding system is a key element to consider when understanding a job's productivity. One must consider not only the weight of the crew members but also tools, hoses, and materials, as well as their distribution across the system. Also, configuring the suspended scaffolding system for the proper number of hoists and operating system is essential in powering the system in a controlled lifting/lowering operation.

Safety Training Put Into Practice

One can never speak often enough on how important it is to have safety be the culture in a company and on their jobsites. It starts at the top of the company and filters down to the workers in the field and then back to the top—looking for affirmation that your workers are working safe. All of our superintendents, foremen, and field crew are equipped with hardhats, safety glasses, safety harnesses, face shields, and respirators. The first day they come to work, they have to go through a safety and orientation class. Planning, team work, and a culture of safety makes our crew as productive as possible. Near misses and close calls test a company's culture and spirit, but at the end of the day, it's good to know that our workers make it home safe to their loved ones.

That's the true measurement of a job well done!

Darin Cielocha *has over 20 years of experience in working with owners, design professionals, and construction materials in the United States and Canada. He has an extensive knowledge base of working with masonry, plastering/stucco, waterproofing, high-performance coatings, and structural concrete repairs. Cielocha is currently a Vice President for McGill Restoration, based out of Omaha, NE, and works with many of the company's primary customers in developing repair and maintenance strategies. He previously worked for BASF Construction Chemicals as a Territory Manager from 2004-2013. In his role as Territory Manager for BASF Construction Chemicals, he managed the territory of Nebraska, South Dakota, and Western Iowa. He also had additional responsibilities as a Power and Infrastructure Specialists for Nebraska, North Dakota, South Dakota, Western Iowa, Kansas, Missouri, and Southern Illinois. Prior to his employment with BASF, Cielocha was a Territory Manager for Ash Grove Packaging (formerly United Products) from 1994 to 2004.*

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Shotcrete Delivery System—A Football Perspective

By Nathen Bent

"SET…HUT…HIKE." Football season is upon us again. In football, the goal is to march down the field and score as many points as possible. In shotcrete, the goal is to get the job done safely and go home to our friends and families at the end of every day. Shotcrete workers can be seriously injured, crippled, or possibly killed doing their job. I personally have seen nozzlemen lifted well off the ground due to the pressures of a plugged hose.

Pregame Meeting

Your shotcrete team could be playing together for months, if not years. The team knows the plan completely, versed on all safety practices and procedures outlined by the company manual. The nozzleman has years of experience, and the finishers are the "best in the business." But we are continually inviting an "unknown celebrity" onto the team. Somebody who may know nothing about your game plan of shotcrete: the concrete mixer driver. Doing the best they can, they will try and run over the pump, or the operator. They will park in the neighbor's driveway, who is already mad about the construction. Adding water without permission for any reason is a favorite game-changing play of your new teammate. The most consistent contribution of play is not paying attention and running the pump low or empty. Pumps must be kept full. Pumps that are not full are prone to produce "slugging" or uneven delivery to the nozzleman. "Slugging" will tire the nozzleman quickly and with the interrupted delivery, the nozzleman can get frustrated and lose focus. Many times I have seen this occur; the irritated nozzleman turns to say something, and WHAM—the pump kicks in and throws the nozzleman off balance, possibly resulting in an injury.

Fig. 1: A few pieces of metal pipe can greatly improve work station safety

First and Goal

Pumping low-slump concrete over distance can result in very high pumping pressures. One of the easiest ways to start lowering pressures is by the use of a slick line or rigid pipe instead of a rubber hose. Although it involves some calculation and a great deal of clamps, it is effective and safe. The pipe is easy to clean and disassemble as you pump during the day, making washout at the end of the day safer as well. Some of the highest consistent pressures are right out of the reducers, where we see considerable hose whip close to the concrete pump operator and concrete mixer truck driver stations (refer to Fig. 1). A 90-degree elbow and two lengths of pipe greatly reduce pressure and increase operator safety.

Offense

A simple thrust chain installed to reduce pumping system surge is a safety must. Broken elbows and reducers at the rear of the pump, during pumping operations, can be deadly. The surging of the pumping process is easy to see, but the strain on the ends of the reducers and

Fig. 2: A great example of a thrust chain setup

elbows under the clamps is often overlooked. Misalignment through movement of the pumping system during pumping can put a huge strain on the components at the rear of the pump (refer to Fig. 2).

Defense

Surging with a rubber hose needs to be closely monitored; when positioned over a concrete curb or a sharp rock, friction can quickly wear a hole through the rubber hose and the hose can then burst under pressure. Rubber hoses can "walk off" scaffolding, causing great injury to the nozzleman, finishers, and other nearby construction workers. The use of a scaffold hook is a simple way to make sure this does not happen. It is easily adjustable anywhere on the length of the hose to give the nozzleman the range he/she needs to work. Use several hooks if necessary to hold the weight of the hose while moving along the scaffolding (refer to Fig. 3).

Final Drive

Metal system parts wear from everyday use. Be sure to thoroughly inspect all parts on a daily basis.[1] Another great way to ensure the operator's safety is with the use of an elbow shield or blowout protector on the main reducing elbow at the rear of the pump (refer to Fig. 4). The

Fig. 3: This hose quickly wore down against a concrete corner and burst

Fig. 4: This elbow failed due to excessive force being transmitted by the pumping system

routing of the pumping delivery system should be considered with everyone's safety in mind. Making sure that construction equipment of any kind does not run over the delivery system is critical. During pumping, running over the system can cause bursting, plugging, and surging that may injure the nozzleman. If construction equipment must pass over the pumping system, relieve pressure and decouple the system, and then recouple after the equipment has been moved. In addition to the exterior damage to a rubber hose, the inner liner of the hose may become damaged and rupture at a later date without warning.

Fig. 5: Parts wear from everyday use. Inspect daily to prevent accidents

Postgame

It seems so simple, the act of shotcreting—you put the concrete in the pump over here, and it comes out over there. In its simplest forms, yes, that's true, but we all know the very real dangers associated with what we do. Take time to double-check everything, to make sure everyone gets to go home a winner (refer to Fig. 5).

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Nathen Bent *is an ACI Certified Nozzleman and ACI Field Testing Technician. Bent is the Owner of Coastline Drilling, an international specialty foundations contractor. His involvement in national and international projects range from infrastructure projects in the Americas to sustainable shotcrete worker housing in Zambia. Bent seamlessly brings together on-site team building and new technology integration. He currently lives in northern California with his family.*

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Rapidly Deployable Shotcrete System

for the Structural Stabilization of Shock-Damaged Structures

By Anne Oberlink and Robert Jewell

The Department of Homeland Security was formed as a consequence of the terrorist attacks on September 11, 2001. The protection of the nation's critical infrastructure was made part of their mandate, and included in their mandate is the rapid repair and stabilization of shock-damaged structures. In response, the National Institute for Hometown Security, a subcontractor of the Department of Homeland Security, awarded a contract to the University of Kentucky Center for Applied Energy Research (UK CAER) and Minova USA Inc. This contract called for development of a material that gains structural strengths very rapidly, as well as the development of a corresponding deployment system to stabilize and repair shock-damaged structures to avoid catastrophic failure. A fast-setting material is imperative to an emergency situation because the faster first responders can stabilize a collapsed structure, the safer they make it for themselves, and for the people that are potentially inside the structure that may need help.

The system and material developed by the UK CAER and Minova USA Inc. consists of a delivery vehicle capable of shotcreting prepackaged, rapid-setting, fiber-reinforced dry-mix shotcrete material. Tekcrete Fast® is a material that was developed for this process, and is a specially designed, rapid-setting, and high-performance dry-mix shotcrete. This system will stabilize structures such as airport runways, tunnels, bridges, and dams that have been shocked and damaged by explosives, or seismic activity, before they fail. Tekcrete Fast M®, a low-dust version for underground mining, has also been developed by Minova USA Inc. Both Tekcrete Fast and Tekcrete Fast M are available at Minova USA Inc.

Introduction

The rapid stabilization of shock-damaged structures falls outside the purview of normal construction practices due to the critical time issue and the nature of the damaged structure. The stabilization of damaged structures requires materials and equipment that can be rapidly deployed to place materials that have very rapid-strength development. These materials need to be placeable at a distance to provide some degree of safety to the responders. In addition, the materials must be able to adhere to structural surfaces that have not been properly prepared and conditioned, and may also be highly fractured, dusty, wet, and very possibly hot or extremely cold.

The technology for the rapid delivery of large volumes of cementitious materials to vertical or even overhead surfaces currently exists. Pneumatic delivery (shotcreting) has been used in construction for over 100 years. Shotcreting has played a major role in structures such as the Washington DC Metro subway system and the England to France undersea rail connector (the Chunnel).

Numerous rapid-setting cements are commercially available. They are used for rapid repair of surfaces such as bridge decks, pavements, and commercial floors, as well as structural repairs of vertical and overhead surfaces. Few of these products are specifically marketed for use in shotcrete applications.

The majority of rapid-setting cements are based on, or at least contain, portland cement as a principal component. Other components are added that help provide early strength, such as high-alumina cement (HAC), organic polymers, chemical accelerators (which can also be added during concrete batching), and calcium sulfate hemihydrate (for example, gypsum plaster). Mortars prepared with some of these cements can achieve compressive strengths of 6.8 to 13.8 MPa (1000 to 2000 psi) within 1 hour. However, portland cement mortar and concrete typically require many weeks of proper curing to reach significant levels of their ultimate strengths, even when used with set accel-

Fig. 1: (a) Compressive strength of mortar cubes; (b) cylinder coring; and (c) flexural strength testing of shotcrete beam with fibers

erators. Also, high early strengths require the use of large proportions of portland cement in the concrete mixture, which can lead to high heat evolution, excessive shrinkage of the material, and cracking. The cost also increases substantially with increasing cement content.

Alternatives to portland cement are also capable of rapid strength development. These include calcium sulfate hemihydrate, and calcium sulfoaluminate (CSA) cements. Unlike portland cement, these rapid-setting cements can gain 75 to 80% of their strength within 1 day, which means less cement can be used in the mixture to achieve comparable early strength. CSA cement and calcium sulfate hemihydrates can also be fabricated, for the most part, from coal combustion by-products (CCBs). These CCBs include fluidized bed combustion spent bed materials and forced air oxidation flue gas desulfurization by-products—that is, synthetic gypsum, which potentially represents both a cost advantage, as well as an environmental advantage.

Development and Testing of CSA-Based Shotcrete

A primary consideration of this project was the rate of strength development (compressive and tensile), bonding strength to the damaged surfaces, and short-term dimensional stability. Other considerations include heat generation, pumpability, ease of use, stiffness of the set material, and cost.

CSA cements are of interest mainly because they gain strength very rapidly. They also require lower energy to produce, with significantly lower CO_2 emissions than portland cement. CSA-based shotcrete materials can be formulated so that they have lower cement content than portland-based shotcrete, a higher water-cement ratio (*w*/*c*), low viscosity, and yet still achieve very high early strength. This is due to the nature of its principal cementitious hydration product: ettringite. These properties are difficult to achieve with portland-cement-based rapid-setting materials.

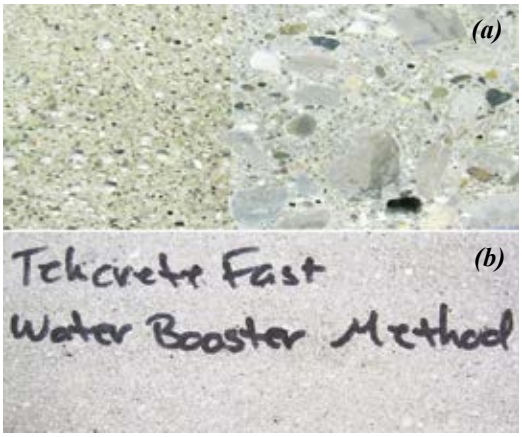

Fig. 2: (a) Tekcrete Fast bonding to OPC; and (b) showing no visible laminations after curing

In addition, the high *w*/*c* of CSA cement shotcrete, coupled with the low heat of hydration of plaster cement, offers a capacity to manipulate the heat of reaction of these materials within a wide band of strength and set parameters. Heat generation is critical in the rapid placement of masses of highly reactive cementitious materials. These cements also offer the potential of lower overall costs.

Once the CSA-based materials to be used in the shotcrete were developed and tested, they were used to fabricate shotcrete mortars and concretes. After an initial round of screening, specimens prepared from selected mixtures were tested for strength and dimensional stability. When determining what tests to use to evaluate the chosen mixtures, it was important to keep in mind that the sprayed-concrete material must provide structural strength within an hour, and bond sufficiently to any substrate or surface under any conditions long enough to provide the necessary assistance to first responders. Therefore, in addition to the standard cement/concrete testing—that is, compression and stability testing of ASTM standard cubes, cylinders, bars, and cores; flexural strength beam testing; tensile testing; rapid freezing and thawing testing; resistance to carbonation testing, and so on, as seen in Fig. 1 and 2—the variations

of heat production based on cement thickness, calorimetry measurements for reaction time of CSA cement phases, slant-shear test, pulloff tests, and time-of-set were a few of the additional tests also used during the project.

After years of research, Tekcrete Fast was developed. Worldwide patents have been filed jointly by the University of Kentucky and Minova USA Inc. Tekcrete Fast is a CSA-based, fiber-reinforced material that achieves structural strengths in minutes—that is, a beam in a bag. It can be used in conventional, dry-process shotcrete equipment as a one-bag system. As mentioned previously, it also has the ability to adhere to any structural surface, whether it is fractured; dusty, as the dry-mix shotcrete nozzleman will spray water before the Tekcrete Fast and will thereby quickly remove any dust accumulation; or wet, regardless of temperature. These features are ideal for use by first-responders, as there is usually little time to prep the surface to be sprayed. It can also be used to repair bridges and roadways, overpasses and runways, and more. Tables 1 and 2 show the average compressive strength and flexural strength for Tekcrete Fast.

Equipment and Delivery Vehicle Development

We have found that there are many issues to be addressed in determining which shotcrete delivery

Table 1: Average compressive strength for Tekcrete Fast in MPa (psi)

Specimen type	Compressive strength, MPa (psi)						
Cores	15 minutes	30 minutes	1 hour	3 hour	1 day	7 days	28 days
	17.2 (2500)	24.1 (3500)	31.0 (4500)	41.4 (6000)	55.2 (8000)	62.1 (9000)	75.8 (11,000)

Table 2: Average flexural strength for Tekcrete Fast in MPa (psi)

Specimen type	Flexural strength, MPa (psi)		
Cores	3 hours	1 day	7 days
	17.2 (2500)	24.1 (3500)	31.0 (4500)

Table 3: System Comparisons

Component	Dry Mix	Wet Mix
Cost	Low to moderate; for example, $10,000	High; for example, $50,000 to >$100,000
Production rate (via Nozzle Person)	Moderate; 5 yd^3/h (3.8 m^3/h)	High; up to 16 yd^3/h (12.2 m^3/h)
Complexity	Air compressor, water	Pump, compressor, water, plus
Material control	Good	Good
Single bag mixture	Yes	Yes
Required clean-out	Simple, blast nozzle with compressed air	Must clean mixer, pump, hose
Fiber capable	Yes	Yes

system to use with the material. Wet-mix systems deliver the material as a paste, and compressed air is used to accelerate the concrete. Strong advantages include the ability to precondition the materials with a better control of heat and high delivery rates. However, highly reactive slurries can be difficult to manage and, based on our own experience, flash set can cause catastrophic equipment failure.

Shotcrete can be reasonably divided into two types or systems—"dry mix" and "wet mix"—and each system has advantages and disadvantages (Table 3).

Wet-mix systems are, as implied, produced with cement and water. The mixture is prepared in a mechanical mixer and then the wet concrete is pumped through a hose—the end of which is equipped with a high-pressure pneumatic nozzle. The water and cement mixture passes through the hose and into a mixing nozzle chamber, where the nozzle accelerates the mixture to give the high velocity needed for impact consolidation. In dry-mix systems, the dry material is exposed to a water stream at the nozzle where mixing occurs, while also providing the high velocity needed for impact consolidation. Several different dry-mix nozzles were investigated (refer to Fig. 4) and tested throughout the project, and all commercially available nozzles performed very well.

A dry-mix delivery system was determined to be best for the delivery of Tekcrete Fast due to the simplicity, the use of single-bag product formulations, and the ability to use very rapid-setting materials. A variety of dry-mix systems were tested throughout the project, including the Reed SOVA and the Meyco Piccola, and they all worked very well for this process.

Additionally, the delivery system was designed to be a rapidly deployable, low-cost, integrated structure that can be engineered into a facility, or a vehicle deployed by first responders to stabilize damaged structures. Ideally, the system would be maintained in a state of readiness in areas that are considered to be high-risk targets, which could include major subway systems, roadways, airports, or other critical infrastructure. The delivery vehicle is comprised of five essential components: water supply, air supply, cementitious material, a dry-mix shotcrete system, and the inline water heater for use in cold conditions. It has been determined that Tekcrete Fast will cure much quicker when the water is warm.

Fig. 4: Test nozzles

The mobile delivery system that has been used previously was deployed on a trailer. The hitch end of the trailer houses the static components—that is, the air compressor, water tank, and generator (if needed). The working area of the trailer houses the dynamic components that will require operator access—that is, the dry-mix gun, water booster pump, hose reels, and material supply (refer to Fig. 5 and 6). This deployable delivery vehicle includes everything needed for first responders to stabilize shock-damaged structures, all on the back of a flatbed trailer. In addition, this delivery system will also work in nonemergency situations, allowing for easy deployment of all equipment and material for repairs of any type.

Disaster City Demonstration—College City, TX

In November 2014, a civil engineering demonstration of Tekcrete Fast and its dry-mix shotcrete delivery deployment system took place in Disaster City, TX. Disaster City is a 52-acre

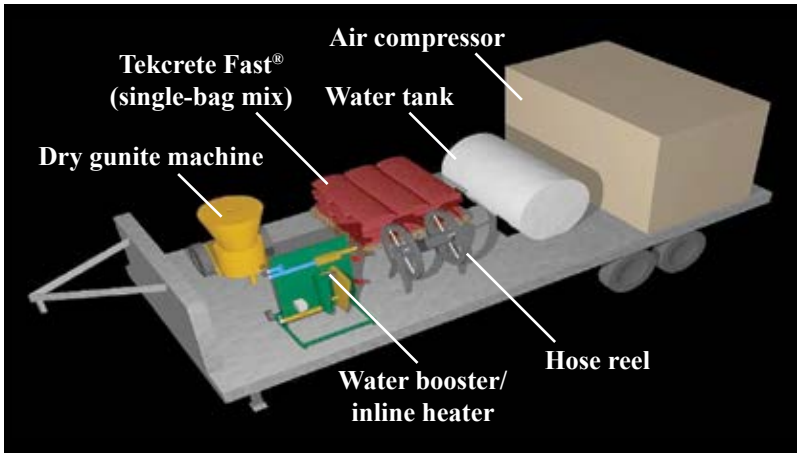

Fig. 5: Schematic of vehicle layout

Fig. 6: Actual delivery vehicle

training facility located in College Station, TX. It includes an extensive array of disaster scenario simulations for training emergency response professionals. Disaster City includes full-scale, collapsible structures designed to simulate various levels of disaster and wreckage, ranging from shock-damaged structures to chemical plant fires and overturned passenger trains, which can be customized for the specific training of any group.[1] The UK CAER and Minova USA Inc., with the help of Carl Baur, CCS Group LLC of Millstadt, IL; Jeff Saunders, the Director of the Texas Task Force 1 of the Texas A&M Engineering Extension Service (TEEX); and Dr. Peter Keating from the Texas A&M Civil Engineering High-Bay Structural & Materials Testing Laboratory, demonstrated the repairing and testing of damaged or wrecked reinforced concrete vertical beams, simulating catastrophic shocks from an explosion or earthquake to a building or parking-garage-type structure. The demonstration was to show that Tekcrete Fast and its dry-mix shotcrete delivery deployment system can help first responders to stabilize such a structure, so they can get in and out quickly and safely, and to bring any victims of said catastrophic wreckage the help they need.

The reinforced concrete vertical beams that were intentionally formed with a missing section and a purposefully damaged beam were placed into the ground and were repaired with Tekcrete Fast. All concrete beams used in the demonstration had been placed several months in advance

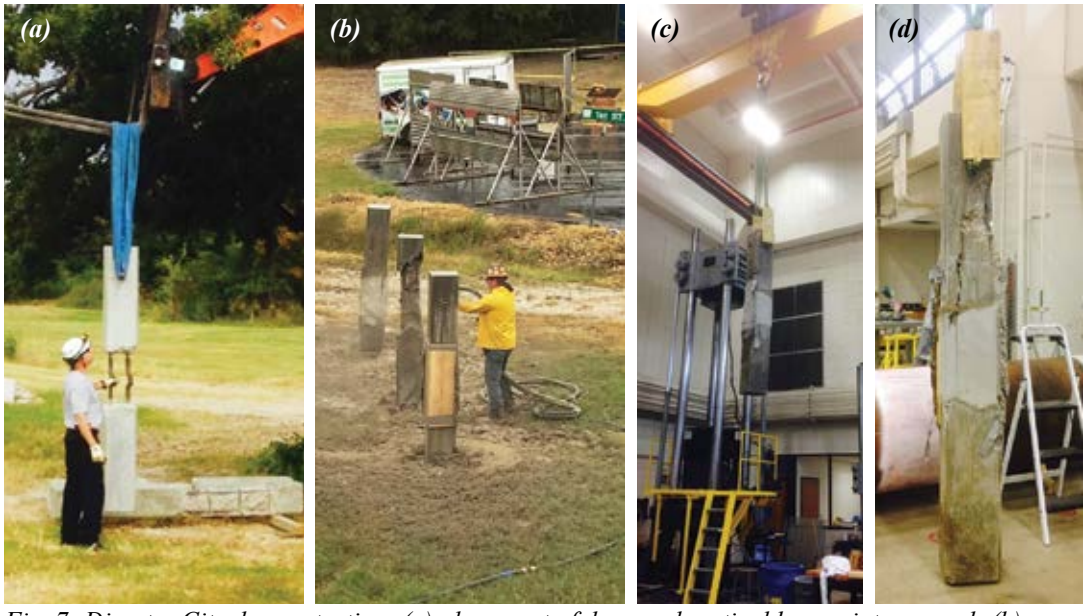

Fig. 7: Disaster City demonstration: (a) placement of damaged vertical beams into ground; (b) shotcrete repair of damaged beams; (c) compression testing of repaired beams; and (d) repaired beam after compression testing, showing that beam failed outside of repaired section

of the demonstration to make sure that they were fully cured and at full strength. The beams had a column cross section that was 12 x 12 in. (300 x 300 mm), with the length of the damaged area on two of the four columns being approximately 18 in. (450 mm) long. The third column was damaged a day or two before the demonstration by bending it until it cracked. The fourth column was left whole and used as a control beam during testing. Once spraying was finished, the repaired beams were immediately removed from the ground and taken directly to the Texas A&M Civil Engineering lab for testing. The entire process for this demonstration, including shotcreting the beams, getting the beams out of the ground, and transferring them over to the high bay lab for testing, took less than 5 hours. With less than 5 hours of curing time for the Tekcrete Fast section, the beams tested were shown to fail outside of the repaired section—that is, the original concrete failed while the section repaired with Tekcrete Fast did not. This is shown in the far right picture in Fig. 7, and Fig. 8 shows the bonding of Tekcrete Fast with the concrete beams.

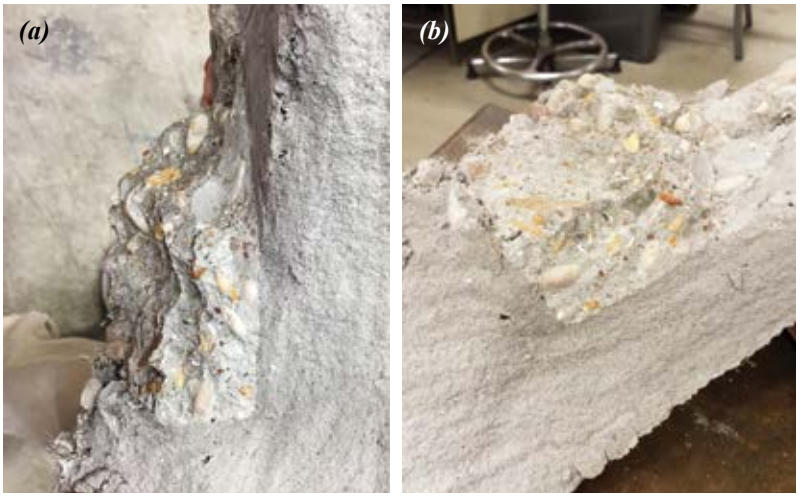

Fig. 8: Bonding abilities of Tekcrete Fast to portland cement

Conclusions

In conclusion, Tekcrete Fast and its dry-mix shotcrete delivery system has repeatedly demonstrated that it has an overwhelmingly superior rate of strength development to conventional portland-cement-based shotcrete. It has excellent bonding capabilities, and its potential for disaster recovery has been demonstrated. Tekcrete Fast is an easy, one-bag sand/cement mixture, or "beam in a bag," and has been proven to be nozzleman-friendly, with a very wide water range. The set times are very predictable, with no flash set, but with the ability to cure very quickly, within 15 minutes of shotcreting. Tekcrete Fast can be cut back and trimmed in small areas, if needed, and according to Carl Baur, "bonds like nothing I have seen in my 20 years of gunite."

Acknowledgments

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Bob Jewell *is a Senior Research Engineer for the Environmental and Coal Technologies (ECT) group at the University of Kentucky Center for Applied Energy Research. His research encompasses process development for ash beneficiation, including ash sampling techniques, the fabrication of new low energy, and low-CO_2-emitting construction materials including cements and concretes from coal by-products. Additionally, Jewell is focused on the development of smart energy-harvesting cementitious materials for civil engineering structures. He is the author of numerous technical reports and publications, as well as one patent. He has more than 10 years of energy research experience related to coal by-product use and has been a leading researcher on projects for the U.S. Department of Energy and the National Institute for Hometown Security. He received his master's degree from the University of Kentucky in 2004 in geological sciences and in 2015 received his PhD in civil engineering.*

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Safe Use of Lift Equipment in Shotcrete

By Mason Guarino

With shotcrete needed in a wide variety of locations and environments, we have often learned that aerial lift equipment is the best and fastest way to access all the places where shotcrete is placed. Lift equipment saves immense time over scaffolding and really helps you get close to the work you are doing without having parts of the scaffolding get in the way. However, working at heights can get dangerous, especially when people can easily manipulate the work platform that they are on.

There are many different types of aerial lifts but they boil down to two main types: the scissor lift and the boom lift. These tools are very basic to use when used properly. The owner's manual can be the most useful item when first using a lift that you are unfamiliar with. In addition to the potential fall hazard, these lifts can also create dangerous scenarios because they are self-propelled and some can be moved while the platform is extended. With all the dangers that these tools have on their own, we then introduce shotcrete nozzling to the aerial work platform.

The first step to using lifts safely is common sense. Common sense is probably the most important tool that a person can have when working around anything that can be dangerous. The first thing anyone should do when they first get onto a piece of lift equipment they have never used is to read the owner's manual. The manual will describe the basic safety requirements and how to operate the lift and all of its features correctly—for example, whether or not this type of lift requires a harness. All boom lifts require harnesses and typically scissor lifts do not. However, some jobsites require the use of harnesses in all lifts.

Understanding the tool is a good way to keep from hurting yourself or others. A popular thing in the construction industry is to disable safety features that are either "annoying" or "slow us down." These safety features are there for a reason and should stay operational. It is very popular to use lifts provided by rental companies and I have found that when first using rental equipment, sometimes the previous renter had disabled a safety feature and the rental company did not pick up on it when transferring to you. These are hard to spot but worth checking when going through the owner's manual on first use of the lift. Reconsider the "If it ain't broke, don't fix it" attitude because an OSHA visit would most likely not accept the "they gave it to me like this" excuse, especially if someone gets hurt. So reading the owner's manual and making sure the lift is operating correctly with all safety features operational is an important step.

Some routine misuses of common sense are when you are at the maximum height and just need to reach another foot, so you stand on a bucket or climb the railing to get that extra foot out of the lift. This is when you need to realize you do not have the correct tool for the job. There are a multitude of different types of lifts that can reach in all different ways, so if you can't reach it with the one you have, there is most likely another one out there that can. Rental company sales people are always happy to make a site visit to help you get the correct tool for the job. Typically the rental company will also provide a class and certification to all employees who will be using the lift to ensure safe operation and proficiency (refer to Fig. 1).

Before getting into shotcrete specific lift knowledge, I need to touch on driving safety. Remember that lifts are designed to have a massive amount of weight very close to the ground and you are a very light thing potentially very high off the ground or at least very far away from the lift's center of gravity, especially on a boom lift, even when retracted. There is another piece of equipment that has a very large weight on one end and a very small weight on the other end, and it looks surprisingly like a boom lift. It's called a catapult, and it is possible to use a lift as a catapult with the operator as the projectile. It is more common with boom lifts than with scissor lifts but the rules apply to both. When driving a lift,

always stay on secure, stable ground. Never drive a lift off a small ledge or step thinking that because it has off-road tires it can handle this stuff. The off-road tires are to prevent these heavy things from getting stuck on flat ground that is slightly uneven, not to go rock crawling such as one would in a Jeep. When the counterweight portion of the lift steps off the ledge or step, it will sway and try very hard to launch the operator out of the basket. Additionally, when driving up or down a hill, always keep the counterweight on the upside of the hill. If the counterweight is on the downside of the hill and the hill is steep enough, the lift can overturn and the operator could get seriously injured. Remember that with scissor lifts raised and with boom lifts you are at the end of a very long stick and when the base moves slightly, the movement of the basket is magnified immensely.

Adding shotcrete to a scissor lift adds its own issues to be careful about—primarily weight and movement. When renting a lift for shotcrete work, I like to get the largest one that will fit for the job while not causing any of its own risks and not pricing you out of the job. A larger lift is more stable because it is heavier and can typically support more weight on the work platform. The heavier lift will reduce motion of the lift caused by the nozzlemen's movements while shooting, especially with the wet-mix process, where the hose is heavier. Less movement of the lift allows for better nozzle control. Nothing in shotcrete is light; even the small parts are heavier than they look. So let's think about what a basket is really holding up. A nozzlemen weighs, on average, between 230 and 300 lb (100 to 140 kg) with their PPE, basic tools, clothes, and boots. So even before you add a concrete hose, nozzle, and concrete in the hose to the lift, you have already most likely exceeded 500 lb (230 kg), which is a common weight limit for small and medium lift equipment. Add the empty concrete hose and you get 3 lb/ft (4.5 kg/m)—say the job is 50 ft (15 m)

Fig. 1: Nozzlemen shooting a research tank from a lift. The site had terrible soil, which required an all-terrain lift with tracks instead of wheels to give safe access for nozzling and finishing

high at maximum, that is another 150 lb (68 kg) straight line from the ground to the basket, add 10 ft (3 m) of hose in the basket and another 5 ft (1.5 m) of hose because it's not perfectly straight down and you get 180 lb (82 kg) of empty hose on the basket before you add concrete. The concrete in the hose will add another 2 to 3 lb (3 to 4.5 kg/m) per foot, getting your hose weight upwards of 360 lb (160 kg) that the basket is supporting as well. You should also be sure to tie the hose off well to the basket to support it. Also, it is a good idea to tie a rope from the basket to the halfway point on the hose to give the hose more support and reduce the swinging motion of the hose while shooting. Based on these weights, you would want a minimum 1000 lb (450 kg) weight limit basket in a lift (refer to Fig. 2 and 3).

Fig. 2: Nozzlemen using scissor lift instead of scaffolding to gain access to the 270 ft (82.3 m) perimeter research tank project

Fig. 3: Using the lift on the research tank allowed us to easily reach the 20 ft (6 m) heights and move along quickly and safely

It is also a tempting idea to tie the nozzle to the handrail on the boom lift to allow for shooting with less fatigue of the nozzlemen. This may work, but if the shotcrete needs to encapsulate reinforcing bar well, the nozzlemen should really be holding the nozzle to provide the precise nozzle motion needed for good encasement. Additionally, if the nozzle is tied off, the higher pressures of wet-mix shotcreting can add higher risk if the nozzle plugs. If seriously high volumes are needed, I would recommend a shotcrete robotic arm over a boom lift. Finally, make sure the hose is safe. If the hose gets kinked or crushed under any moving parts or the tires, this can cause a dangerous situation for the nozzlemen when flow restarts suddenly after the constriction is removed. It can also weaken the hose and make it more prone to breaking in the near future.

In summary:

- Use common sense;
- Read the manual; and
- Use the lift per the manufacturer's directions.

Following the lift guidelines and being fully aware of the loads on the lifts and maximum safe reach, along with and the basic safety rules, will keep everyone in and around the equipment safe.

***Mason Guarino**, Vice President of South Shore Gunite Pools & Spas, Inc. (SSG), started in the pool industry when he was 14, learning how to install reinforcing bar. Since then, he has worked on all phases of swimming pool construction. Guarino has worked full time with SSG since receiving his BS in construction management from the Wentworth Institute of Technology, Boston, MA, in 2009. Guarino currently serves on ASA's Board of Direction and is an ACI Certified Nozzleman.*

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 website, **http://shotcrete.org/pages/products-services/technical-questions.htm**.

Question: *We have 18 ft high, 12 in. thick (5.5 m high, 205 mm thick) walls to shotcrete and need horizontal cold joints to place the shotcrete in three pours (three height sections). How do we create the joint?*

Answer: Shotcrete is routinely used in creating retaining walls or soil-nailed walls in this fashion. Designers and inspectors often confuse placement of multiple layers of shotcrete in building out a section with cold joints experienced in cast-in-place concrete construction. Unlike cast-in-place concrete, shotcrete provides thorough consolidation and densification by high-velocity impact of fresh concrete material on the receiving surface. The high-velocity impact of shotcrete on a hardened, previous shot layer (or existing concrete surface) provides a strong abrasive blast to open up the surface, and then provides an immediate exposure of that hardened surface to fresh cement paste. As a result, shotcrete exhibits excellent bond to concrete and previously shot surfaces. Thus, the structural action between the sections acts as a monolithic section without any weakened planes.

In shotcrete construction, surface preparation between layers to provide full bond is important. ACI 506.2-13, "Specification for Shotcrete," specifically addresses this in the requirements of Section 3.4.2.1 and 3.4.2.2 that require:

3.4.2.1 When applying more than one layer of shotcrete, use a cutting rod, brush with a stiff bristle, or other suitable equipment to remove all loose material, overspray, laitance, or other material that may compromise the bond of the subsequent layer of shotcrete. Conduct removal immediately after shotcrete reaches initial set.

3.4.2.2 Allow shotcrete to stiffen sufficiently before applying subsequent layers. If shotcrete has hardened, clean the surface of all loose material, laitance, overspray, or other material that may compromise the bond of subsequent layers. Bring the surface to a saturated surface-dry condition at the time of application of the next layer of shotcrete.

An experienced shotcrete contractor should routinely provide proper surface preparation between shotcreted sections, and use skilled crews with ACI certified nozzlemen to place and cure the shotcrete placements.

Question: *I would like to know if there is any parameter for test panel dimensions and inclination of proposed shotcrete surfaces represented by the test panels. I also would like to know if there is any specification for frequency of making test panels during the shotcrete project duration. In general, what is the specified type of panels and number of them to be specified and to what time frequency should a contractor assemble them for quality control purposes?*

Answer: ACI 506.2-13, "Specification for Shotcrete," is an excellent resource for answering your questions. ACI 506.2 addresses both preconstruction panels and test panels used for material quality control during construction. ACI 506.2, Section 1.5.1.4, requires that when preconstruction panels are required, the Contractor shall "Construct test panels for each proposed shotcrete mixture, each anticipated orientation, and each proposed nozzleman." Preconstruction test panels vary in size to adequately represent the embedded reinforcement and section thicknesses in the work to be done.

Test panels shot during construction for evaluation of material properties are covered in ACI 506.2, Section 1.6.3.1, which states: "Construct a test panel for each mixture, each nozzleman, and each work day or for every 50 yd^3 (38 m^3) placed—whichever results in the most panels. The face dimensions of a test panel shall be a minimum of 16 x 16 in. (406 x 406 mm) with a minimum depth of 5 in. (127 mm). For toughness testing in accordance with ASTM C1550, the face dimension shall be 30.5 in. (775 mm) in diameter and 3 in. (76 mm) thick. Shoot test panels in a vertical orientation only unless otherwise specified."

ACI 506.2-13 has extensive provisions for the submittals, testing, materials, and execution of shotcrete work by a shotcrete contractor. It cites many of the ASTM testing standards appropriate for shotcrete construction. We recommend you review the document in its entirety to become familiar with current industry standards.

Question: *We have an existing cut slope approximately 328 ft (100 m) high (3:1 vertical:horizontal) with cut benches and need to apply shotcrete onto the slope surface at a height of approximately 230 ft (70 m) from the road level. Is it possible to reasonably transfer and apply shotcrete mixture at such a height from the road level? What type of transfer hoses and equipment is preferable? Is dry-mix or wet-mix shotcrete preferable?*

Answer: Yes, either dry-mix or wet-mix process can and have been used at this height. Because either process can be used in these conditions, you should use an experienced shotcrete contractor who will pick the best method based on their firm's shotcrete capabilities. Factors such as the shotcrete contractor's specific shotcrete equipment, material availability, site constraints, remoteness of the location, and crew experience will influence their choice.

The Energy Innovation Center

By Ted Sofis

For many years, the Connelley Vocational School stood at the top of Bedford Avenue on "The Hill," as it is locally known, overlooking downtown Pittsburgh, PA. The vocational school was where the City of Pittsburgh Public School students learned auto repair, welding, carpentry, and other trade skills. Over the past few years, this massive complex with its classrooms and workshops has undergone a complete transformation to serve a new role as the Energy Innovation Center. The project involved the renovation and reconfiguring of the structure and the adjacent workshop areas to adapt it to meet the needs of a modern twenty-first-century building (refer to Fig. 1). The purpose of the renovation was to provide firms with both office and developmental facilities and to serve as an incubator for energy-based startup companies.

The general contractor, Mascaro Construction, faced a long list of challenges over the course of the renovation work, one of which involved the wall overlooking the Allegheny River, the Strip District, and Lawrenceville below. The old school building was built on the top of the hill, with the back of the building facing a cliff. Behind the old building was a deteriorated wall at the rear base of the structure, with a steep slope below and then another wall with a 100 ft (30 m) straight drop down to the busy highway, Bigelow Boulevard. Access was restricted and the original wall had been cast-in-place before the building was built. The engineers wanted the wall replaced, but due to access problems, such a solution would be prohibitively expensive. Michael Renna, the Project Manager for Mascaro Construction, stated that the original wall was part of the foundation and its removal and replacement was not a viable option. So they looked at other possibilities and after some consideration, decided to install pin piles and rehabilitate the wall with shotcrete.

Fig. 1: The building complex has undergone extensive renovations to transform it into the Energy Innovation Center and will serve as an incubator for energy-based startups

Sofis Company was asked to look at the project and price a shotcrete repair. Again, the access presented problems. The slope was too steep for conventional scaffolding and there was no access around the building for equipment, so it would not be possible to use access equipment such as man-lifts. With nothing above to attach cables to, the best option was to use outriggers to hang our swing stages from. The outriggers with counter weights were carried down the building's stairwells to a back door in the rear of the old school. After the outriggers were put in place with the appropriate counterweights, the swing stages were hung in place (refer to Fig. 2 through 5).

The next step involved chipping out the deteriorated concrete, preparing the substrate, and installing anchors and mesh. By using dry-process shotcrete for the repair, we were able to efficiently transport material around to the back of the building. A prepackaged shotcrete repair mortar, Shotcrete MS, manufactured by Quikrete, was used on the project. With the logistical issues out of the way, the shotcrete placement work proceeded and the wall repairs were completed.

The shotcrete repairs to the wall will give the old wall an extended functional life. The renovation of an old school building and its transformation into the Energy Innovation Center will provide efficient and affordable space for new start-up businesses in the coming years. In addition to the obvious advantage of being able to

place shotcrete on vertical walls without forming, the flexibility to efficiently transport material to access hard-to-reach areas was of tremendous value. This enabled access to congested and restricted areas that are so common in the rehabilitation of old structures.

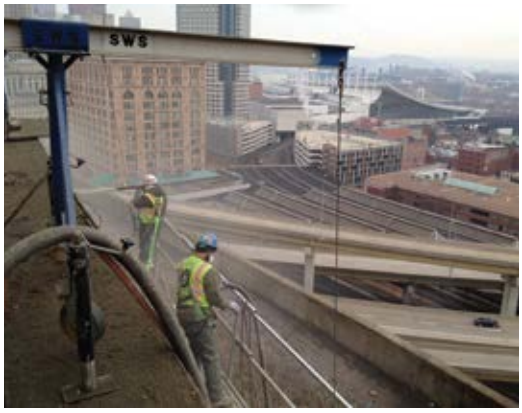

Fig. 2: Due to restricted access and nothing above to suspend cables from, outriggers were used to hang swing stages for the shotcrete rehabilitation work

Fig. 3: Shotcrete is placed with Pittsburgh landmarks the Gulf Tower and Koppers Building in the background

Fig. 4: Nozzleman on suspended swing stage, turning to his side, to get enough distance from the wall to get a good spray pattern

Fig 5: Nozzleman and cutdown man working together to complete upper areas of the eastern wall

Acknowledgements

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ASA Certified Nozzleman
Rob Svihla

Material Supplier
Quikrete Companies

Repair Mortar
Shotcrete MS

Sales Representative
Dennis Bittner

Ted Sofis *and his brother, William J. Sofis Jr., are the Principal Owners of Sofis Company, Inc. After graduating from Muskingum College, New Concord, OH, with his BA in 1975, Ted began working full time as a shotcrete nozzleman and operator servicing the steel industry. He began managing Sofis Company, Inc., in 1984 and has over 40 years of experience in the shotcrete industry. He is Chair of the ASA Publications Committee, a member of multiple other ASA committees, and an ACI Examiner. Over the years, Sofis Company, Inc., has been involved in bridge, dam, and slope projects using shotcrete and refractory installations in power plants and steel mills. Sofis Company, Inc., is a member of the Pittsburgh Section of the American Society of Highway Engineers (ASHE) and ASA.*

Northern Boulevard Crossing Tunnel CQ039

By Frank Townsend

The Northern Boulevard Crossing tunnel is a crucial link for the East Side Access Program linking Long Island Rail Road trains to Grand Central Station, New York City. It is a 125 ft (38 m) long sequentially excavated (SEM) tunnel. The tunnel is situated approximately 55 ft (17 m) below the groundwater table and was mined through glacial deposits. The tunnel alignment also crossed beneath a pile-supported, elevated railway line; a six-lane street; and an active below-grade subway structure (refer to Fig. 1 and 2).

Fig. 1: East Side Access overall project scope

Fig. 2: CQ39 Excavation

Contaminated plumes in the area also dictated the installation of a protective frozen arch above the tunnel alignment, extending to bedrock for complete groundwater cutoff. The freezing of the ground costs the New York Metropolitan Transportation Authority (MTA) $11,000 per day. Every day the liner completion could be accelerated, the more savings to the MTA. A value-engineered approach was given to the MTA to shotcrete this liner in lieu of traditional cast-in-place. This offered both savings in time and construction cost. Without the shotcrete alternative approach, an elaborate, costly, and time-consuming tunnel form system would have to be engineered, delivered, and assembled in the tunnel for traditional formed cast-in-place concrete. The contractor estimates that close to 2 months were saved using the shotcrete alternative.

Superior Gunite's scope was to expeditiously shoot the structural liner of this tunnel to then allow quickly unfreezing the ground and transfer the load from the aboveground structures. Coordination with the contractor allowed Superior Gunite crews to use the same scaffolding system used by the lathers installing the reinforcing bars, again saving time and money (refer to Fig. 3 and 4).

Challenges

Preparation of a plan and logistics were critical to the success of the project. Through a very tight relationship with our concrete supplier, Ferrara, we mapped out trucking delivery routes to mitigate the New York City traffic to avoid lost time and waiting times on trucks. Ferrara had a Quality Control representative on site to work through any possible quality control and address issues on the spot, which fortunately were minimal.

Due to the site constraints, laydown area was limited. We installed our primary and backup pumps inline so if we had mechanical issues we could easily swap the line and deal with the pump on the off-shift. This system proved important, as

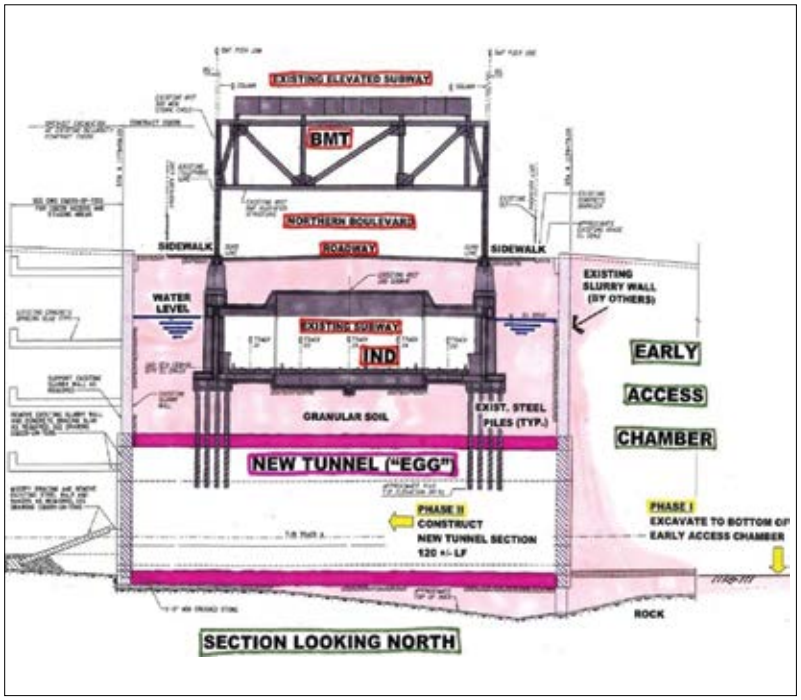

Fig. 3: Overhead load applied to the tunnel

Fig. 5: Mockup of ring girder shoot

Fig. 4: Waterproofing and ring girders being installed

Fig. 6: Shooting the mockup

three times we had to divert to an alternate pump. Because the pumps were inline, the conversion was accomplished with minimal down time.

Temporary support of the overhead structures, which had a pile foundation that would be interrupted by the tunnel, would eventually be replaced by steel tube ring girders installed to permanently carry the load of the overhead structures once the transfer occurred. The shotcrete encapsulation of the ring girders was the first issue and we proved our methods were accurately represented during the mockup for the project. Due to the size of the girders, we used a layering method and encapsulated the backs of ring girders ahead of the reinforcement being installed. We then shot the remaining thicknesses during a follow-on mobilization (refer to Fig. 5(a) and (b) and 6).

Another challenge, which was proven at the mockup stage, was the encapsulation of the No. 11 (#36M) reinforcing bar splices, which were lapped, leaving us only a 3.5 in. (90 mm) opening to shoot through.

The next challenge was shooting a 36 in. (0.9 m) thick structural liner from spring line to spring line, mostly in the overhead position and finishing the project in less than 5 days. We attacked the project by working two crews per shift and two long shifts per day, with a cleanup and maintenance shift in between, with the wall segments being installed first, then moving to shooting the overhead areas. Due to the thickness

Fig. 7: Nozzle in outer layer of reinforcement, encasing the back layer

Fig. 8: Cutting of guides and finishing

Fig. 9: Finished tunnel looking east to west under Northern Boulevard

of this liner, we used several methods to assist us in encapsulating all of the reinforcement. We placed the shotcrete with unique techniques developed by our team specifically for this application (refer to Fig. 7 and 8).

All in all, Superior shot 1463 yd^3 (1118 m^3) and finished the tunnel with two shifts to spare. From the complexity of the tunnel reinforcement system, the large thickness, and the overhead application, the coordinated teamwork from Schiavone/Kiewit JV and Superior Gunite's team made this a huge success. The freezing operation was turned off early and the load from the six-lane thoroughfare on top, with an overhead train line running 500 trains per day, continued. This was the first part of a much bigger project to bring the Long Island Railroad into a new terminal beneath Grand Central Station in Manhattan (refer to Fig. 9(a) and (b)).

Frank E. Townsend III *is the East Coast Region Manager for Superior Gunite. He is a civil engineering graduate of Worcester Polytechnic Institute, Worcester, MA, and received his master's degree from the University of Missouri, Columbia, MO. Townsend comes from the U.S. Army Corps of Engineers and has been running Superior's East Coast operations (predominantly New York, New Jersey, Connecticut, and Boston, MA) for 3 years now. Townsend is an active member of ASA and currently serves on the ASA Board of Directors.*

Protective Arch Liner

Project Name
Northern Boulevard Crossing Tunnel CQ039

Project Location
Queens, NY

Shotcrete Contractor
Superior Gunite

General Contractor
Schiavone/Kiewit JV

Architect/Engineer
New York Metropolitan Transportation Authority
Capital Construction

Material Supplier/Manufacturer
Ferrara Brothers Building Material
5000 PSI Mix

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ASA Corporate Members have the skill, knowledge, and experience that uniquely qualify them to fully offer the exceptional benefits of the shotcrete process.

Photo courtesy of R. Ringler

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www.Shotcrete.org/ProjectBidRequest

AMERICAN SHOTCRETE ASSOCIATION

Commentary on Watertightness and Waterproofing of Shotcrete

By James Scott

Over the recent years, the idea of waterproofing has taken a more prominent role in the construction of higher-end pools and other watershapes—and the debate on this topic seems to be on the increase. Most of us in the pool industry are at least peripherally aware of a broad debate as to whether waterproofing should be used, and in what situations.

From my observation, this issue is due to the increasing demand and interest in the higher-end swimming pool—what features can be incorporated, as well as architectural elements that can be achieved. Clearly, many pools are no longer just the typical single body of water with a simple ceramic waterline tile band and marble plaster finish. Many forces continue to act on the industry, such as development of product lines; increased availability of automation; huge building booms; information availability; and, most significantly, proliferation of ideas through **houzz.com** and similar websites, along with world travel.

In many ways, the swimming pool industry is still a young industry. The residential pool industry in the United States is particularly "young" in that it has been largely unregulated, and the barrier to entry has been low. Critically, architects and landscape architects are particularly ignorant of swimming pools and how they are built. Therefore, unregulated pool builders drive construction practices and techniques. As competition increases, prices are driven down and ultimately quality suffers. There is not a natural checks-and-balances system between the architect and builder.

Not only are pool builders experimenting with new materials, products, and techniques but multinational companies are also marketing their products to the pool industry and thus are "experimenting" via the builder's use. If you put all of this history and set of factors together, it's easy to see how shotcrete installation can suffer and how "waterproofing" has become appealing.

Of note have been the changes and about-faces in some manufacturer's directions for the use of their product in swimming pool construction (submerged conditions). If you keep your ear to the ground, it appears that these changes come after there has been a large failure, or series of smaller failures. It has caused the providers to look more closely at what is happening between the marriage of their product to the substrate or other products.

It does not mean that these waterproofing products do not work per se. What it does point out is that there is a huge volume of chemically based products being used in partnership with other chemicals or cementitious-based products without years of practical field experience. And, many times, these products are underlayments for expensive finish materials, such as tile and stone.

Ultimately, we can divide the use of waterproofing into two (non-mutually exclusive) situations. The first occurs when tile (or similar) is used for the interior finish. The second follows when a shotcreted pool or vessel is not shot well, and is not watertight (refer to Fig. 1 and 2).

In the tile industry, waterproofing is an integral part of the industry standards.[1] In fact, two types of waterproofing are separately referred to as cementitious and membrane. Even if the pool is already watertight or even waterproof from a cementitious standpoint, the waterproof membrane is sometimes still used to act as an anti-fracture layer for glass or other fragile tiles. It is important to note that many waterproofing products, applied to the inside of the pool, do not act as waterproofing for negative hydrostatic pressure (that is, water penetrating from outside the pool shell).

It is still widely misunderstood that a plaster interior finish will act as a "sealing coat" or waterproofing, which is fundamentally untrue. A properly shotcreted shell needs to supply the watertight properties for the pool.

The ASA Pool and Recreational Shotcrete Committee speaks to watertightness in Position Statement #4.[2] "Watertightness of the shotcrete material is a crucial durability and serviceability property of any properly constructed water-holding shotcrete structure. Shotcrete placement that allows water to pass through the concrete of

Fig. 1: A spa with a purple-colored waterproof membrane, undergoing a flood test prior to tile installation

Fig. 2: A pool with shadowing of the reinforcing bar cage, indicating a non-watertight situation

a pool shell is a sign of flawed material or placement techniques. A definition of watertightness is: impermeable to a measurable flow of water."

When a pool shell is not watertight, sometimes the builder will look to waterproofing materials to overcome the deficiency. This is an unfortunate situation, as the deficiency within that shotcrete structure can cause a failure of the waterproofing material itself. Ultimately, it always comes back to the fact that a watertight vessel is a more stable and accepting substrate for whatever one wants to achieve, and much less prone to problems and future repairs.

References

1. Tile Council of North America, "TCNA Handbook for Ceramic, Glass, and Stone Tile Installation," Anderson, SC, 2015, 445 pp.

2. American Shotcrete Association, 2014, "Position Statement #4: Watertight Shotcrete for Swimming Pools," Farmington Hills, MI, http://www.shotcrete.org/media/pdf/ASA-PositionPaper_PoolRec_4.pdf. (last accessed Sept. 29, 2015)

James Scott *is a third-generation Watershape Designer and Builder who has worked in the swimming pool and landscape industries for 39 years. He received his BS in business and accounting from Southern Methodist University, Dallas, TX. Through Group Works LLC, Scott has aligned himself with Genesis 3 and other organizations that focus on continuing education and increasing higher standards in the watershape industry. He is a Platinum Member of Genesis 3 and a certified member of the Society of Watershape Designers. Scott is also an APSP-Certified Professional Builder and an ASA member and has trained with the Portland Cement Association. Scott and Group Works LLC have been featured in regional and national publications.*

New ASA Logo and Rebranding—Unveiling at 2016 WOC

Joe Hutter

The ASA Board of Directors met via online meeting on September 10, 2015. Though a variety of ASA business was conducted, including our shotcrete inspector education seminar and the Shotcrete Nozzleman-in-Training certification program, an item of particular note was the review and approval of a new ASA logo and rebranding initiative. Funding for development of the rebranding effort was approved by the Board earlier in 2015. Marketing Committee Chair Joe Hutter, along with the ASA Executive Committee and ASA staff, worked with branding consultant Liette Bernard of Kulör Design. Liette presented options to the Board and the final selection was approved. Subsequent to that meeting, Joe Hutter and ASA staff have been working on incorporating the new logo and graphic guidelines for a new booth as well as magazine ads, publications, the ASA website, and clothing items. Public rollout of our new logo and brand will be at World of Concrete (WOC) 2016 in Las Vegas, NV, February 2-5, 2016. If you are planning on attending WOC, please join us at ASA's booth, #S10839 in the South Hall of the Las Vegas Convention Center, to celebrate our new branding. Also, remember to use our ASA Source Code (**A17**) to register for a reduced Exhibits-Only admission to the show.

Nozzleman-In-Training Program Update

Randle Emmrich

As mentioned in our last issue, ACI Committee C660, Nozzleman Certification, chaired by ASA member Randle Emmrich, along with members and staff of ACI's Certification Programs Committee (CPC), finalized the details for a Shotcrete Nozzleman-in-Training (NIT) certification program. ASA has committed to providing NITs with a log to allow them to track the required shooting hours. ASA has produced an 8-1/2 x 11 in. PDF form that can be used by the NIT to log shotcrete projects and hours on the nozzle. The PDF can be filled out on the NIT's or employer's computer as an electronic form and then printed. The PDF can also be printed out with the fields left blank for filling out manually. The PDF form is available on the ASA website at **www.shotcrete.org/education/index.htm**. ASA is also developing an online system for our NIT members to track their projects and hours online on the ASA website. We're expecting a rollout of the online system in November 2015. For more information on the Shotcrete NIT certification program, see the Executive Director's Update in this issue.

Certification Session in Australia

ASA, in conjunction with the Concrete Pumping Association of Australia (CPAA), conducted an ASA education and ACI Shotcrete Nozzleman Certification session in Australia. The session held in Melbourne, Australia, on September 3-5, 2015, followed the Concrete Institute of Australia's Concrete 2015. The session was conducted by ASA's Executive Director and ACI Examiner, Charles Hanskat, and included a day-long ASA Nozzleman Education Session and a written exam, and then 2 days of shotcrete performance exams. Overall, 10 nozzlemen from Australia and New Zealand were certified in the wet-mix process (all in the vertical orientation and several with

overhead certification, too). We also had our first NIT who passed both the written and performance exam, and will be upgraded to a certified Wet-Mix Nozzleman upon documenting 500 hours of shooting experience. We hope that in working together in promoting quality and certification we can develop a stronger image for shotcrete around the world. ASA looks forward to the opportunity to raise the standards for shotcrete nozzlemen, and the shotcrete industry by providing quality education and certification opportunities that have served us so well here in North America.

Outreach to the U.S. Transportation Market

One of ASA's strategic plan initiatives is to provide more outreach to specifiers in the transportation market, predominantly State and Federal highway agencies. Supporting that initiative, ASA Executive Director Charles Hanskat conducted an hour-long webinar, "Shotcrete for Repair and Rehabilitation of Highway Facilities," on October 22, 2015. Hanskat's webinar was sponsored by the Re-CAST University Transportation Center (UTC)—a consortium of Missouri S&T, University of Illinois Urbana-Champaign, Rutgers University, University of Miami, and Southern University and A&M College—to present an online webinar (available here: **www.shotcrete.org/pages/products-services/shotcrete-resources.htm**). The UTC is funded by the U.S. Department of Transportation (DOT). Their mission, as expressed by the Center's director, is: "This grant has opened an avenue of opportunity for collaborations amongst the consortium members and many outside organizations. RE-CAST plans to carry out multi-scale and multi-disciplinary studies to investigate the use of innovative materials and structural systems to enhance the durability and sustainability of the transportation infrastructure. The ultimate goal of the proposed research program is to fast-track the acceptance of these technologies and develop national standards and guidelines for their use for the reconstruction of the nation's infrastructure for the 21st Century." They have scheduled a number of online webinars that have been viewed by consulting engineers, DOT engineers, students, and others involved with the reconstruction of our highway infrastructure. Hanskat's presentation, as well as many previous webinars in the Re-CAST series, are available for viewing online at **http://recast.mst.edu/webinars**.

2016 *Shotcrete* Magazine Media Kit Now Available

With a readership of over 17,000 subscribers, *Shotcrete* magazine reaches the shotcrete industry like no other resource. Advertising rates for this specifically targeted medium are very reasonable and well below the average rate for other publications in the concrete industry. This combination of exceptional access at affordable rates provides the shotcrete industry with an important and useful tool for promoting your products and services.

For more information, find the media kit at **www.shotcrete.org/media/pdf/ASAMediaKit.pdf** or call (248) 848-3780.

Airplaco and Gunite Supply Increase Territory Sales Force

Bryan Althammer

Airplaco and Gunite Supply (**www.airplaco.com**; **www.gunitesupply.com**), worldwide manufacturers of specialty construction equipment, are proud to announce Bryan Althammer has transitioned to a Sales Representative of a new territory.

Althammer has accepted a role as territory sales representative covering the Midwest region. He has worked for Airplaco and Gunite Supply since 2013 as inside sales and technical service support. Althammer has multiple years of experience working in the construction and industrial equipment industries and brings tremendous technical knowledge to the sales team.

CCS Group, LLC, Welcomes Carl Baur as General Manager

With over 26 years of experience in shotcrete/gunite contracting and sales, Carl Baur will lead the business management and development as well as sales in the recently opened Millstadt, IL, (St. Louis greater area) office. This new division of CCS Group is a full-service dealer and parts provider of REED concrete pumps offering service, sales, and rentals throughout the Midwest. This appointment is part of CCS's strategic growth plan.

Carl Baur

Hayward Baker Acquires Ellington Cross

Acquisition of Charleston, SC-based regional geotechnical contractor expands the company's Earthquake Drain capabilities

Hayward Baker Inc. (HBI) announced the acquisition of assets of Ellington Cross, LLC (EC), a regional geotechnical contractor that provides Earthquake Drain™ design and installation. Headquartered in Charleston, SC, EC operates primarily in North Carolina, South Carolina, and Georgia.

Members of EC and HBI will combine operations into the existing Charleston Area Office and operate under the name "Ellington Cross, a division of Hayward Baker." HBI will take on EC's existing management team and employees, as well as assume key existing contracts.

EC is a regional geotechnical contractor focused on liquefaction mitigation ground improvement using Earthquake Drains (sometimes referred to as "EQ Drains"). HBI owns the patent for mitigating liquefaction using prefabricated vertical drains throughout North America.

Unlike prefabricated vertical wick drains, EQ Drains have a much larger cross-sectional area and flow capacity, intended to limit pore pressure increases in cohesionless soils and subsequent liquefaction during earthquake events.

Among EC's noteworthy projects are U.S. Highway 17 ACE Basin Parkway Widening and Bridge Replacements (Segments 1 and 2), performed for the South Carolina Department of Transportation. Earthquake Drains were used to mitigate liquefaction at all bridge approaches over a 21-mile corridor from State Route 64 to U.S. Highway 21.

For bulk fuel storage replacement initiatives at the Charleston Air Force Base, EC installed Earthquake Drains on more than 10 separate projects at the Naval Weapons Station and Joint Base Charleston.

Wal-Mart Stores has used Earthquake Drains to mitigate liquefaction on nearly 20 projects in coastal South Carolina. These projects have ranged from store expansions using retrofit technologies, to new construction ranging in size from the retailer's Neighborhood Markets to its large Supercenters.

Commenting on the acquisition, Eric Drooff, President of Hayward Baker, stated, "Liquefaction mitigation is an important geotechnical service provided by HBI. The acquisition of Ellington Cross strengthens our capabilities in this market. We plan to enhance our ability to offer liquefaction mitigation ground

improvement services in earthquake-prone areas throughout the United States by leveraging EC's sales and engineering skills, combined with our own operational capabilities."

Drooff continued, "Earthquake Drains will be provided as a stand-alone product, or in conjunction with HBI's other ground improvement services for sites with more complex geotechnical challenges."

The Charleston headquarters office of Ellington Cross, a division of Hayward Baker, is located at 4 Carriage Lane, Suite 203, Charleston, SC 29407.

For more information about Hayward Baker's acquisition of Ellington Cross and the full range of services offered by HBI, contact Mike Terry at (770) 442-1801 or MWTerry@HaywardBaker.com.

Hayward Baker Inc. (**www.haywardbaker.com**) is North America's leader in geotechnical construction, annually ranked by *Engineering News-Record* (ENR) magazine as Number 1 in the profession. With a 60-year record of experience, HBI offers geotechnical construction technologies through a network of more than 20 company-owned offices and equipment yards across the continent. Project applications include foundation support, settlement control, site improvement, slope stabilization, underpinning, excavation shoring, earth retention, seismic/liquefaction mitigation, groundwater control, and environmental remediation.

Hayward Baker Inc. is part of the Keller Group of companies, a multinational organization providing geotechnical construction services throughout the world.

Keller (**www.keller.co.uk**) is the world's largest independent ground engineering specialist, providing technically advanced and cost-effective foundation solutions to the construction industry. With annual revenues of around $2.4 billion, Keller has approximately 9000 staff worldwide.

Keller is the clear market leader in the United States and Australia; it has prime positions in most established European markets, as well as a strong profile in many developing markets.

Airplaco and Gunite Supply Partners with Commercial Industrial Finance to Offer Capital Financing to Customers

Effective September 1, 2015, Commercial Industrial Finance (CIF) is the provider of capital financing to domestic customers looking for alternative options when purchasing equipment

from Airplaco and Gunite Supply. "CIF has a tremendous amount of experience financing construction equipment and working with contractors and they have been terrific to work with; we are very excited to be able to offer flexible purchase options to our customers," said Ken Segerberg, Business Unit Leader, Equipment Division Mesa Industries.

According to Bob Rinaldi, CEO of Commercial Industrial Finance & a director of CBank, "It's especially gratifying to develop a sales-aid finance program with Airplaco and Gunite Supply, a local business that manufactures their products right here in the U.S. and sells them throughout the world. Together, we are equipping their customers' businesses for success by providing them much-needed business capital. By assisting Airplaco, Gunite, and their customers, Commercial Industrial Finance continues to live out its tagline—Our business is improving yours!"

Airplaco and Gunite Supply form the equipment division for Mesa Industries and are manufacturers of wet- and dry-mix cement machines for the construction industry. Airplaco and Gunite Supply have been building quality, American-Made machines for over 40 years. Mesa Industries is a certified women-owned business through the Women's Business Enterprise National Council (WBENC) with headquarters in Cincinnati, OH, and additional offices in Houston, TX, and Monrovia, CA.

Headquartered in Cincinnati, OH, and St. Louis, MO, Commercial Industrial Finance (CI Finance) was originally founded in 1982. The company provides equipment financing to companies of all sizes nationwide. CI Finance specializes in developing and implementing sales aid finance programs that increase sales for manufacturers, vendors, and distributors in the commercial, industrial, and municipal sectors.

Alpbach Conference 2015

As noted in the Spring 2015 issue of *Shotcrete*, the 11th Shotcrete Conference took place in the Alpbach Conference Centre from January 29 to 30, 2015. Organizer Professor Wolfgang Kusterle welcomed approximately 260 guests. Participants value these now-traditional shotcrete conferences in Alpbach for their interesting presentations as well as for the relaxed ambience.

A detailed summary of the conference is now available on our ASA Resources web page: **www.shotcrete.org/pages/products-services/shotcrete-resources.htm**.


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Cemen Tech Introduces Gun-Crete Mobile to Meet Demand for Gunite and Shotcrete Mixers

Cemen Tech, the leading manufacturer of mobile concrete mixers, recently introduced a new mobile mixer in response to customers' need for machines to meet the increased demand for concrete in the wet- and dry-mix shotcrete industry. In recent years, contractors have discovered the advantages to using volumetric mixers such as the Gun-Crete Mobile to produce the concrete they need, especially in remote locations.

"Using volumetric batch plants would work incredibly well for big projects that are far away from a ready mix plant," says Mason Guarino, South Shore Gunite Pools & Spas Inc. He added that delays on the jobsite can compound quickly when using ready mix trucks. "On-site, when shooting shotcrete, if there is a small issue that delays the shooting, one can find that several concrete trucks are very quickly waiting in line."

"Hot loads are nonexistent with the (volumetric mixer) because the only mix time is in the auger," added Guarino.

The Gun-Crete Mobile is designed to produce high-quality dry-mix material while giving the operator control over the consistency of concrete produced. The mixer uses a proven cement metering system to mix material with precise consistency, volume, and accuracy.

The Gun-Crete Mobile Mixer uses a 24 in. (610 mm) wide conveyor belt for consistent and reliable flow of material with no bridging. The unit also features a multi-section hydraulic pump to provide the proper amount of oil to each circuit, providing cooler operation even on warm days. Gun-Crete Mobile units have a carrying capacity of up to 12 yd^3 (9 m^3) and a production rate of up to 30 yd^3/h (27 m^3/h).

A water system is available for contractors looking to mix both wet- and dry-mix materials using the same piece of equipment. Other available options include a production printer, a power swivel for ease of operation, and admixture systems.

"The Gun-Crete Mobile is another example of the innovation our customers can expect to see from Cemen Tech in the coming months," said Mark Rinehart, Director of Sales and Marketing for Cemen Tech. "The Gun-Crete Mobile comes as an answer to our customers' need for quality gunite machines. From swimming pools to parking garages to bridge repair, these machines can be utilized throughout the world."

Cemen Tech, Inc., has 45 years of manufacturing and engineering experience in the volumetric mixing industry. As the industry leader, the company strives to provide the highest-quality concrete mixers to its customers. Cemen Tech currently operates in 52 countries, services mixers across the globe, and supplies equipment to the U.S. military. Cemen Tech believes that people, businesses, and communities around the world should have the infrastructure to access clean water, to transport goods and services, and to reliable housing. Their products provide the foundation and stability to meet the needs of a growing world in an environmentally conscious way. For more information on the Gun-Crete Mobile and to see the Gun-Crete Mobile in action, visit **www.CemenTech.com/gunite-machine**.

RFI Introduces the New PD2000 Adjustable Low Profile Predampener and Mixer

The new RFI PD2000 Adjustable Low Profile Predampener and Mixer handles wet- and dry-mix shotcrete as well as refractory materials. Water is precisely metered into the material through engineered spray heads. The predampening system reduces dust and rebound, and creates a more consistent mixture. The unit requires only one user for operation, has a rubber trough for easy cleaning, and allows an output capacity of up to 10 tons/h (9 tonnes/h). It can be configured with either air-driven or electric motors. A special skid frame with forklift openings and adjustable mixing assembly is available as an option for height-limited underground operations.

For more information, please contact:

RFI Construction Products
6050 Sweetwood Drive, Macungie, PA 18062
Attn: Bill Drudy
Phone: (610) 966-5689
Fax: (610) 966-5683
E-mail: rfipa@rcn.com

Shotcrete Calendar

NOVEMBER 7, 2015
ASA Fall 2015 Committee Meetings
Room: Governor's Square II
Sheraton Denver Downtown Hotel
Denver, CO
www.shotcrete.org

Schedule of Meetings

7:00 am–8:00 am	Underground Committee
8:00 am–9:00 am	Pool & Recreational Shotcrete Committee
9:00 am–10:00 am	Education Committee
10:00 am–10:20 am	Morning Networking Break
10:20 am–11:20 am	Marketing Committee
11:20 am–12:10 pm	Safety Committee
12:10 pm–12:40 pm	Lunch
12:40 pm–1:40 pm	Membership Committee
1:40 pm–2:40 pm	Publications Committee
2:40 pm–3:00 pm	Afternoon Networking Break
3:00 pm–5:30 pm	Board of Direction

NOVEMBER 8-12, 2015
The ACI Concrete Convention and Exposition
Theme: "Constructability"
Sheraton Denver Downtown Hotel
Denver, CO
www.concrete.org

Shotcrete Meetings of Interest—Registration Required
C660, Shotcrete Nozzleman Certification
Sunday, 10:00 am–12:00 pm, Tower Court A
C601-I, Shotcrete Inspector Certification
Sunday, 1:00 pm–2:30 pm, Director's Row I
506, Shotcreting
Tuesday, 8:30 am–11:30 am, Plaza Ballroom D
506-A, Shotcreting–Evaluation
Monday, 1:30 pm–3:00 pm, Plaza Court 3
506-B, Shotcreting–Fiber-Reinforced
Monday, 3:30 pm–5:00 pm, Director's Row I
506-C, Shotcreting–Guide
Monday, 8:30 am–10:30 am, Director's Row J
506-E, Shotcreting–Specifications
Monday, 10:30 am–12:30 pm, Director's Row J
506-F, Shotcreting–Underground
Monday, 4:30 pm–5:30 pm, Director's Row J

NOVEMBER 10-12, 2015
2015 Pool | Spa | Patio Expo
Mandalay Bay Convention Center
Las Vegas, NV
Visit ASA's Booth #452
Register using ASA's source code: **EC02**
for FREE Expo-only badge
www.poolspapatio.com

NOVEMBER 11, 2015
ASA Shotcrete Nozzleman Education Class
9:00 am–4:00 pm | Registration code: ASA
in conjunction with the
2015 Pool | Spa | Patio Expo
Use source code: **ED20** for 15% discount
Mandalay Bay Convention Center
Las Vegas, NV
www.poolspapatio.com

DECEMBER 6-9, 2015
ASTM International Committee C09, Concrete and Concrete Aggregates
Marriott Tampa Waterside Hotel
Tampa, FL
www.astm.org

JANUARY 26-27, 2016
ASA Shotcrete Nozzleman Education 2-Day Class
8:30 am–11:45 am
in conjunction with
The Pool & Spa Show
Atlantic City Convention Center
Atlantic City, NJ
www.thepoolspashow.com

JANUARY 26-28, 2016
The Pool & Spa Show
Atlantic City Convention Center
Atlantic City, NJ
www.thepoolspashow.com

FEBRUARY 1, 2016
ASA Committee Meetings at World of Concrete
Las Vegas Convention Center, South Hall
Las Vegas, NV
www.shotcrete.org

Tentative Schedule:
9:00 am – Board of Direction
11:00 am – Annual Membership Meeting
*Both meetings listed above are **open to all** –*
No registration required

FEBRUARY 2, 2016
ASA 90-minute Shotcrete Seminar: Shotcrete: Creative, Sustainable, and Economical Solution for Concrete Repair, Restoration, and Repurposing
8:30 am–10:00 am
WOC Registration code: **TU146**
Las Vegas Convention Center, North Hall
Las Vegas, NV
www.worldofconcrete.com/Attendee/Schedule/SessionDetails/35351

Shotcrete Calendar

FEBRUARY 2, 2016
ASA Shotcrete Nozzleman Education Class
9:00 am–4:00 pm
WOC Registration code: **ASATU**
Las Vegas Convention Center, South Hall
Las Vegas, NV
www.worldofconcrete.com/Attendee/Schedule/SessionDetails/35400

FEBRUARY 2, 2016
ASA Outstanding Shotcrete Project Awards Banquet
6:00 pm Reception | 7:00 pm Dinner & Awards
Vdara Hotel & Spa, Vinoly Ballroom
Las Vegas, NV
www.shotcrete.org

FEBRUARY 2-5, 2016
World of Concrete 2016
Las Vegas Convention Center
Las Vegas, NV
Visit ASA's Booth: S10839
Register using ASA's source code: **A17**
www.worldofconcrete.com

FEBRUARY 4, 2016
ASA Shotcrete Inspector Education
9:00 am–4:00 pm
WOC Registration code: **ASATH**
Las Vegas Convention Center, North Hall
Las Vegas, NV
www.worldofconcrete.com/Attendee/Schedule/SessionDetails/35400

FEBRUARY 14-17, 2016
GeoTechnical & Structural Engineering Congress
Phoenix Convention Center
Phoenix, AZ

The GeoInstitute (GI) and Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE) have come together to create this first-of-its-kind event.

MARCH 16-18, 2016
ICRI 2016 Spring Convention
Theme: "Maintenance and Protection in Harsh Environments"
The Condado Plaza Hilton
San Juan, Puerto Rico
www.icri.org

APRIL 16, 2016
ASA Spring 2016 Committee Meetings
Hyatt & Frontier Airlines Center
Milwaukee, WI
www.shotcrete.org

APRIL 17-21, 2016
The ACI Concrete Convention and Exposition
Hyatt & Frontier Airlines Center
Milwaukee, WI
www.concrete.org

JUNE 26-29, 2016
ASTM International Committee C09, Concrete and Concrete Aggregates
Chicago Marriott Downtown
Chicago, IL
www.astm.org

OCTOBER 22, 2016
ASA Fall 2016 Committee Meetings
Marriott Philadelphia
Philadelphia, PA
www.shotcrete.org

OCTOBER 23-27, 2016
The ACI Concrete Convention and Exposition
Theme: "Revolutionary Concrete"
Marriott Philadelphia
Philadelphia, PA
www.concrete.org

NOVEMBER 9-11, 2016
ICRI 2016 Fall Convention
Theme: "Urban Reconstruction"
The Westin Cleveland Downtown
Cleveland, OH
www.icri.org

DECEMBER 4-9, 2016
ASTM International Committee C09, Concrete and Concrete Aggregates
Renaissance Orlando at SeaWorld
Orlando, FL
www.astm.org

See this full list online with active links to each event: visit www.shotcrete.org and click on the Calendar link under the News & Events tab.

Active Minerals International, LLC

Active Minerals International, LLC (AMI), focuses on innovative industrial mineral solutions for today's technologically advanced world. AMI is an award-winning environmentally responsible company, dedicated to conserving resources, reclaiming mined land, and leaving the Earth a better place. Through our mines, processing plants, and storage facilities in the United States, Asia, Australia, and Latin America, we target the production of high-quality industrial minerals and mineral products that are used by industries and organizations across the world. AMI is the largest supplier of air float kaolin and gel quality attapulgite globally. Our knowledgeable and dedicated teams of scientists, geologists, engineers, chemists, sales personnel, and customer service professionals ensure we supply competitively priced quality mineral products such as Acti-Gel® 208.

Our shotcrete mineral additive, Acti-Gel 208, promotes a cohesive concrete that stabilizes a flowable, pumpable mixture when energy is removed from the system. This natural phenomenon is perfect for shotcrete and gunite where high lifts, thick walls, reduced rebound, and one-pass overhead applications are desired.

Acti-Gel 208 Solves Industry Needs

Acti-Gel 208 stabilizes the concrete and improves the adhesion/cohesion promoting very minimal rebound. Excessive rebound is wasteful and costs a company significant time and money. Our mineral additive keeps the concrete on the wall, which reduces material costs and jobsite cleanup times. Once it sprays, it stays.

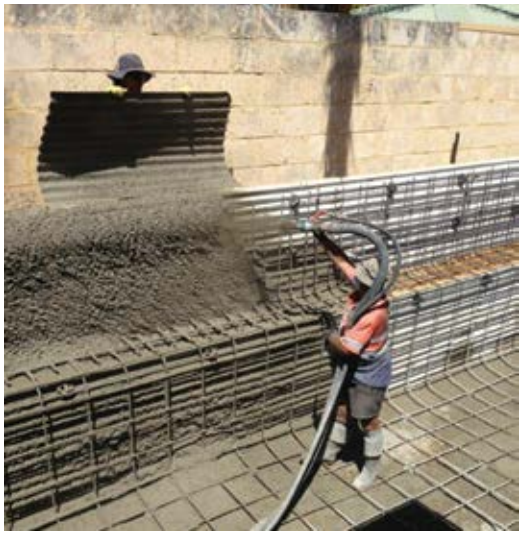
Acti-Gel 208 can also eliminate the need for silica fume. It performs as well as if not better than the pozzolan while reducing the breathable airborne particles produced by spraying shotcrete. Our mineral additive provides the same benefits silica fume can bring to a formulation, such as increased cohesion, reduced permeability, anti-segregation, and reduced bleedwater but at the low dose of 2.5 lb/yd³ (1.5 kg/m³) of Acti-Gel 208.

Acti-Gel 208 greatly improves adhesion and cohesion. For example, you can build a wall out to nearly 12 in. (305 mm) and over 8 ft (2 m) high. Our mineral additive is also incredibly beneficial when the mixture is unstable and the ability to build the shotcrete out to full depth as well as getting a proper height seems impossible. Acti-Gel 208 increases workability and holds the mixture together well enough for a finisher to come by and immediately trowel a wall that was just placed and allows for easy finishability several minutes after the nozzleman has passed.

Mining/Underground

In mining, safety is the number-one priority. Being able to shoot concrete overhead without the risk of sloughing or falling on nozzlemen standing underneath is a major benefit of Acti-Gel 208. Add that to reduced rebound, elimination of silica fume, reduced set accelerators, improved early strengths, and reduction of airborne particles and you are left with a safer, more efficient, and cost-effective underground shotcrete project.

Corporate Member Profile



Pool and Recreational Shotcrete

Speed and efficiency when using Acti-Gel 208 in a shotcrete pool mixture can allow a crew to shoot multiple jobs a day. Increased adhesion/cohesion, higher lifts, full-depth shells, reduced/eliminated efflorescence, and decreased rebound are pivotal to building high-quality pools and spas.

Structural

Acti-Gel 208 provides many benefits in structural shotcrete such as passability through many layers of reinforcing bar (no shadowing), improved compaction, reduced airborne particles, reduced/eliminated efflorescence, and extended workability. Acti-Gel 208 enhances the quality of any load of shotcrete that arrives on site.

If you would like to see how Acti-Gel 208 can enhance the quality of shotcrete as well as all other concrete formulations, please contact us using the following information:

Active Minerals International, LLC
34 Loveton Circle, Ste 100
Sparks, MD 21152
Phone: 1-410-512-4120

Websites: www.activeminerals.com
www.acti-gel.com

Contact: Joey Bell
E-mail: shotcrete@activeminerals.com

New ASA Members

CORPORATE MEMBERS

Akzo Nobel—Performance Additives
Brewster, NY
Primary Contact: George Dorosh
george.dorosh@akzonobel.com

Bekaert-Maccaferri Underground Solutions
Erembodegem-Aalst, Belgium
www.bm-underground.com
Primary Contact: William Geers, PE
bill.geers@bm-underground.com

Berkel & Company Contractors Inc.
Austell, GA
Primary Contact: Mark Tominey
mtominey@berkelapg.com

Cemrock Landscapes Inc.
Tucson, AZ
Primary Contact: Steve Kanoza
skanoza@cemrock.com

Hayes Drilling, Inc.
Olathe, KS
www.hayesdrillinginc.com
Primary Contact: Aaron McConnell
amcconnell@hayesdrillinginc.com

JCM Northlink LLC
Seattle, WA
www.jaydeecontr.com
Primary Contact: Nate Long
nlong@jaydee.us

New York Concrete Corp.
Staten Island, NY
http://newyorkconcrete.com
Primary Contact: Kenneth Padover
kpadover@newyorkconcrete.com

Shannon & Wilson Inc.
Seattle, WA
http://shannonwilson.com
Primary Contact: Axel Nitschke
agn@shanwil.com

Texas Shotcrete Inc.
McKinney, TX
Primary Contact: Dan Goplin
dan@texasshotcrete.com

Thorcon Shotcrete & Shoring LLC
Littleton, CO
www.thorconshotcrete.com
Primary Contact: Michael Klemp
info@thorconshotcrete.com

CORPORATE ADDITIONAL INDIVIDUALS

Roberto J. Guardia
Shannon & Wilson Inc.
Jacksonville, FL

INDIVIDUALS

Nicole Brennie
Elite Shotcrete
Warwick, NY

Rick Jones
Swimtech, Inc.
Yucaipa, CA

STUDENTS

Andrew Pugh
Springville, CA

Sabrina Saadellaoui
Ben Arous, Tunisia

Ehssan Amir Sayyafi
Miami, FL

INTERESTED IN BECOMING A MEMBER OF ASA?
Read about the benefits of being a member of ASA and find a Membership Application under the ASA Membership tab of **www.shotcrete.org**.

AMERICAN SHOTCRETE ASSOCIATION

AMERICAN SHOTCRETE ASSOCIATION

ASA Membership Benefits

	Corporate	*Corporate - Additional Individual*	Supporting Asscociation	Individual	Nozzleman	Employees of Public Authorities / Agencies	Student
Annual Dues	$750	$100	$500	$250	$50	Free	Free
Company & specialty information listed in ASA's online Buyers Guide and in hard copy via *Shotcrete*'s annual Buyers Guide	X						
Discount on ACI Shotcrete Nozzleman Certification and Education	X						
Opportunity to submit items for Industry News and New Products & Processes sections of *Shotcrete* magazine at no charge	X	X	X			X	
Discounted ASA Member prices on all ASA products	X	X	X	X	X	X	X
Networking and participation opportunities at Annual Membership Meeting and committee meetings	X	X	X	X	X	X	X
Opportunity to respond to bids from our Online Project Bid Submittal Tool	X	X					
Subscription to quarterly *Shotcrete* magazine (hard and electronic copy)	X	X	X	X	X	X	X*
Links to shotcrete-related government projects open for bid *(sent twice a month in the member edition of the ASA e-newsletter)*	X	X		X	X	X	X
Permission to include ASA logo on corporate letterhead and business cards	X	X		X		X	
Permission to display ASA logo on company website	X						
Discounted pricing on advertising in *Shotcrete* magazine, including free linked logo advertising from the ASA website homepage during your advertising quarter	X	X	X	X		X	
Voting privileges at committee meetings and director/officer elections	X	X		X			
Discounted advance general admittance registration to World of Concrete	X	X	X	X	X	X	X
Fulfills membership requirement for the annual Outstanding Shotcrete Project Awards Program	X						
Free Onsite Learning Seminars upon request			X			X	
Discounted Corporate Additional ASA Memberships are available for all company employees ($150 savings per employee)							
Discount on ASA Underground Shotcrete Education Program	X						
Complimentary copy of ASA's Shotcrete Specifiers Education Tool—a 4GB USB flashdrive						X	
Complimentary copy of "Sustainability of Shotcrete" each year	1		1			1	
Complimentary copy of ASA's "Safety Guidelines for Shotctete" in either protected pdf or hard-copy format	1						
Complimentary copy of ASA's Annual Nozzlemen Compilation each year					1		
Complimentary ASA shotcrete brochure each year	25	1	X**	1		1	
Complimentary ASA reflective hardhat sticker each year	10	1		1	1		
Education & promotion of your shotcrete industry to the overall concrete industry	**X**	**X**	**X**	**X**	**X**	**X**	**X**

* Student members outside North America will only receive electronic copies

**Upon request; limit 25 copies per year.

2015 AMERICAN SHOTCRETE ASSOCIATION

Buyers Guide

The following list of ASA Corporate Members is current as of September 30, 2015. 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**.

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Active Minerals International, LLC 34 Loveton Circle Sparks, MD 21152	Website: http://www.acti-gel.com Contact: Joey Bell Phone: 410-512-4120 E-mail: r.bell@activeminerals.com	•	•					
Advanced Shotcrete Inc. 887 N 100 E, Ste 4 Lehi, UT 84043	Website: http://www.advancedshoring.com Contact: Per-Ole Danfors Phone: 801-908-7664 E-mail: pdanfors@advancedshoring.com				•			
Airplaco Equipment Company 4141 Airport Rd Cincinnati, OH 45226-1643	Website: http://www.airplaco.com Contact: Tom Norman Phone: 513-321-4511 E-mail: sales@airplaco.com					•		
Akzo Nobel—Performance Additives 281 Fields Ln Brewster, NY 10509	Website: http://www.bermocoll-elotex.com Contact: George Dorosh Phone: 845-276-8235 E-mail: george.dorosh@akzonobel.com	•						
AMEC Foster Wheeler 4445 Lougheed Hwy, Ste 600 Burnaby, BC V5C 0E4, Canada	Website: http://www.amecfw.com Contact: John Laxdal, PE Phone: 604-294-3811 E-mail: john.laxdal@amec.com			•				
American Concrete Restorations Inc. 11S375 Jeans Rd Lemont, IL 60439-8839	Website: http://www.americanconcreterestorations.com Contact: Cathy Burkert Phone: 630-887-0670 E-mail: cathy@americanconcreterestorations.com				•			
American Standard Conc Pumping Hawaii Inc. 94-400 Koaki St Waipahu, HI 96797-2874	Website: http://www.ascphi.com Contact: Gregory L. Perrin Phone: 808-479-7867 E-mail: gperrin@ascphi.com			•	•	•		
Arnold Brothers Inc. 2437 SW Pine Island Rd Cape Coral, FL 33991	Website: http://www.arnoldbrothers.net Contact: Steve Arnold Phone: 239-633-9970 E-mail: keith@arnoldbrothers.net		•	•	•		•	•
Atlantic Underground Services Ltd. 425 Pine Glen Rd Riverview, NB E1B 4J8, Canada	Website: http://www.ausltd.com Contact: Terry Keiver Phone: 506-387-8160 E-mail: info@ausltd.com				•			
Azteca Gunite 6626 Flintlock Rd Houston, TX 77040-4319	Website: http://www.aztecagunite.com Contact: Ozzie Martinez Phone: 713-462-5566 E-mail: info@aztecagunite.com				•			
Basalite Concrete Products—Vancouver ULC 8650 130th Street Vancouver, BC V3W 1G1, Canada	Website: http://www.basalitedrymix.com Contact: Dennis Ceolin Phone: 604-501-7941 E-mail: dennis.ceolin@paccoast.com	•	•	•			•	•

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
BASF Admixtures Inc. 23700 Chagrin Blvd Cleveland, OH 44122-5506	Website: http://www.basf-admixtures.com Contact: Jeannine Jones Phone: 216-839-7227 E-mail: jeannine.jones@basf.com	•	•					
Bekaert-Maccaferri Underground Solutions Skyline 40 Korte Keppestraat 21/02 Erembodegem-Aalst 9320, Belgium	Website: http://www.bm-underground.com Contact: William Geers, PE Phone: 011-8133137759 E-mail: bill.geers@bm-underground.com			•	•	•	•	•
BelPacific Excavating & Shoring Ltd. 3183 Norland Ave Burnaby, BC V5B 3A9, Canada	Website: http://www.belpacific.com Contact: Gregory Samcheck Phone: 604-205-0002 E-mail: greg@belpacific.com			•	•			
Berkel & Company Contractors Inc. 7300 Marks Ln Austell, GA 30168	Website: http://berkelapg.com Contact: Mark Tominey Phone: 770-941-5100 E-mail: mtominey@berkelapg.com				•			
The Blanchard Group 2380 Route 315 Dunlop, NB E8K 2J6, Canada	Website: http://www.blanchardgroup.ca Contact: Rene Blanchard Phone: 506-725-2132 E-mail: rene@blanchardgroup.ca							•
Blastcrete Equipment Company PO Box 1964 Anniston, AL 36202-1964	Website: http://www.blastcrete.com Contact: Jim Farrell Phone: 256-235-2700 E-mail: jim@blastcrete.com			•		•		
Bona Vista Pools 40 Shields Court Markham, ON L3R 0M5, Canada	Website: http://www.bonavistapools.com Contact: Melissa Brown Phone: 905-475-6980 E-mail: melissa@bonavistapools.com				•			
Boulderscape Inc. 27134 B Paseo Espada, #223 San Juan Capistrano, CA 92675	Website: http://www.boulderscape.com Contact: Mark Allen Phone: 949-661-5087 E-mail: steve@boulderscape.com				•			
Brayman Construction Corporation 1000 John Roebling Way Saxonburg, PA 16056-9778	Website: http://www.brayman.com Contact: Brian Hawk Phone: 724-443-1533 E-mail: b_hawk@brayman.com			•	•			
Buesing Corp. 3045 S 7th St Phoenix, AZ 85040-1170	Website: http://www.buesingcorp.com Contact: Kevin Somerville Phone: 602-233-3339 E-mail: ksomerville@buesingcorp.com			•	•			
Bulley & Andrews Concrete Restoration 1755 W Armitage Ave Chicago, IL 60622-1163	Website: http://www.bacrllc.com Contact: Donald Redar Phone: 773-645-2061 E-mail: tabbott@bulley.com				•			
BVR Construction Company Inc. 8 King Road Churchville, NY 14428	Website: http://bvrconstruction.com Contact: Chip Stephenson Phone: 585-458-9750 E-mail: cstephenson@bvrconstruction.com				•			•
California Engineering and Shotcrete Inc. 17211 Ambler Ave Carson, CA 90746	Contact: Godwin Iwunze Phone: 310-993-8232 E-mail: californiaengineer2@gmail.com			•	•			
California Skateparks 273 N Benson Ave Upland, CA 91786-5614	Website: http://www.californiaskateparks.com Contact: Joseph M. Ciaqlia Jr. Phone: 909-949-1601 E-mail: info@californiaskateparks.com			•	•			

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
CanCrete Equipment Ltd. PO Box 68 Orangeville, ON L9W 2Z5, Canada	Website: http://www.cancreteequipment.ca Contact: Eric Duiker Phone: 416-749-2843 E-mail: marcia@cancreteequipment.ca					•		
CCS Group LLC 655 South St, Suite #2 Seward, NE 68434-2439	Website: http://www.ccsgrouponline.com Contact: Cheyenne Wohlford Phone: 855-752-5047 E-mail: cheyenne@ccsgrouponline.com			•	•		•	•
CemenTech Inc. 1700 N 14th St Indianola, IA 50125	Website: http://www.cementech.com Contact: Connor Deering Phone: 800-247-2464 E-mail: cdeering@cementech.com	•				•		
Cemrock Landscapes Inc. 4790 S Julian Ave Tucson, AZ 85714	Website: http://www.cemrock.com Contact: Steve Kanoza Phone: 520-571-1999 E-mail: skanoza@cemrock.com				•			
Cheyenne River Spec Mix PO Box 989 Rapid City, SD 57709-0989	Website: http://www.cheyenneriverspecmix.com Contact: Barry Mertes Phone: 605-342-8780 E-mail: bmertes@cheyenneriverspecmix.com		•					•
Chicago Expansion Bolt 9353 Seymour Ave Schiller Park, IL 60176	Website: http://www.chicagoexpansionbolt.com Contact: Dan Gayton Phone: 847-233-0509 E-mail: sales@chicagoexpansionbolt.com					•		
Cipriano Landscape Design & Custom Swimming Pools 795 Darlington Ave Mahwah, NJ 0743	Website: http://www.njcustomswimmingpools.com Contact: Chris Cipriano Phone: 201-785-0800 E-mail: chris@plantnj.com			•	•			
Classic Tile & Plaster, LLC 746 Gary Dr Byram, MS 39272	Contact: Jorge De Ochoa Jr. Phone: 601-372-0164 E-mail: jd8a@icloud.com		•	•	•		•	•
Coastal Gunite Construction Company PO Box 977 Cambridge, MD 21613-0977	Website: http://www.coastalgunite.com Contact: R. Curtis White Jr. Phone: 410-228-8100 E-mail: curt@coastalgunite.com				•			
Concrete Strategies 2199 Innerbelt Business Center Dr Saint Louis, MO 63114-5721	Website: http://www.concretestrategies.com Contact: Curt Costello Phone: 314-592-2131 E-mail: costelloc@concretestrategies.com			•	•			•
Construction Forms, Inc. PO Box 308 Port Washington, WI 53074-0308	Website: http://www.conforms.com Contact: Jim Bodeker Phone: 800-223-3676 E-mail: jim.bodeker@conforms.com					•		
Contech Services, Inc. PO Box 84886 Seattle, WA 98124-6186	Website: http://www.contechservices.com Contact: Peter Barlow Phone: 206-763-9877 E-mail: pete@contechserviceswa.com				•			
Continental Contitech 703 S Cleveland-Massillon Rd Fairlawn, OH 44333	Website: http://www.veyance.com Contact: David Brinkman Phone: 330-664-7133 E-mail: david.brinkman@contitech.us					•		
Cowin & Company Inc. PO Box 19009 Birmingham, AL 35219-9009	Website: http://www.cowin-co.com Contact: John J. Cowin Jr. Phone: 205-945-1300 E-mail: jcowinjr@cowin-co.com				•			

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Cruz Concrete & Guniting Repair Inc. 1405 Winesap Dr Manasquan, NJ 08736-4020	Contact: Warren C. Cruz Phone: 732-223-2206 E-mail: cruzconcrete@gmail.com				•			
C-TEC, Inc. 1928 S Lincoln Ave, Suite 100 York, NE 68467-9467	Website: http://www.ctecconcrete.com Contact: Greg Wurst Phone: 402-362-5951 E-mail: ctec@ctecconcrete.com				•			
CTS Cement Manufacturing Corporation 11065 Knott Ave, Suite A Cypress, CA 90630-5149	Website: http://www.ctscement.com Contact: Janet Ong Phone: 650-773-4795 E-mail: jong@ctscement.com	•	•					•
Custom-Crete PO Box 1347 Euless, TX 76039	Website: http://www.custom-crete.com Contact: Bill Heath Phone: 512-443-5787 E-mail: bill.heath@oldcastle.com				•	•		•
D Construction Inc. 1488 S Broadway Coal City, IL 60416	Website: http://www.dconstruction.net Contact: Jeff Gillan Phone: 815-634-2555 E-mail: j.gillan@dconstruction.net				•		•	•
Dees Hennessey Inc. 200 Industrial Rd San Carlos, CA 94070-6257	Website: http://www.deeshenn.com Contact: Daniel M. Evans Phone: 650-595-8933 E-mail: dhi@dees-hennessey.com				•			
Delta Gunite Solano Inc. 1735 Enterprise Dr, Suite #103 Fairfield, CA 94533-6822	Website: http://www.deltagunitesolano.com Contact: Philip Kassis Phone: 707-425-7293 E-mail: deltasolano@sbcglobal.net				•			•
Delta Industrial Services Inc. PO Box 1109 Delta Junction, AK 99737-1109	Website: http://www.deltaindustrial.com Contact: Mike Crouch Phone: 907-895-5053 E-mail: mike@deltaindustrial.com							•
Deluxe Shotcrete & Concrete Construction PO Box 385 Santa Rosa, CA 95402-0385	Website: http://www.deluxeshotcrete.com Contact: Kristen Humphreys Phone: 707-568-1200 E-mail: kristen@deluxeshotcrete.com			•	•			•
Desert Shotcrete Inc. 3230 N Showdown Pl Tucson, AZ 85749	Contact: Joe Schmieder Phone: 520-749-4848 E-mail: joe@desertshotcrete.com				•			
DN Tanks 11 Teal Road Wakefield, MA 01880	Website: http://www.dntanks.com Contact: Scott Scorpa Phone: 781-246-1133 E-mail: scott.scorpa@dntanks.com				•			
Dome Technology 4946 North 2900 East Idaho Falls, ID 83401-1337	Website: http://www.dometech.com Contact: Bryan Butikofer Phone: 208-529-0833 E-mail: butikofer@dometech.com				•			
DOMTEC International LLC 4355 N Haroldsen Dr Idaho Falls, ID 83401-1105	Website: http://www.domtec.com Contact: Mike Hunter Phone: 208-522-5520 E-mail: mhunter@domtec.com			•	•			
Drake Inc. 1919 Road Q Waco, NE 68460-8826	Website: http://www.drakeinc.net Contact: David Drake Phone: 402-362-1863 E-mail: davedrake@windstream.net			•	•			

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Drakeley Industries LLC 74 Hickory Ln Bethlehem, CT 06751-2308	Website: http://www.drakeleypools.com Contact: William T. Drakeley Jr. Phone: 203-263-7919 E-mail: bill@drakeleypools.com			•	•			
Drill Tech Drilling & Shoring, Inc. 2200 Wymore Way Antioch, CA 94509-8548	Website: http://www.drilltechdrilling.com Contact: John Bryne Phone: 925-978-2060 E-mail: john.byrne@drilltechdrilling.com			•	•			
Eastco Shotcrete, LLC 1211 Kennedy Blvd Manville, NJ 08835	Website: http://www.eastcoastshotcrete.com Contact: Tommy Pirkle Phone: 908-526-2777 E-mail: tommy@eastcoastshotcrete.com				•			
Eastern Gunite Company Inc. PO Box 557 Exton, PA 19341-0557	Website: http://www.easterngunite.com Contact: Thomas F. Lyons Phone: 610-524-5590 E-mail: egunite@easterngunite.com				•			
Elasto Plastic Concrete PO Box 460 Waxhaw, NC 28173-1047	Website: http://www.elastoplastic.com Contact: Patrick Lewandowski Phone: 704-843-8401 E-mail: plewandowski@elastoplastic.com			•			•	
Engineering & Construction Innovations Inc. 7012 6th St N Oakdale, MN 55128-6146	Website: http://www.eandci.co Contact: Shane McFadden Phone: 651-298-9111 E-mail: shane@eandci.co				•			
Epoxy Design Systems Inc. PO Box 19485 Houston, TX 77224-9485	Website: http://www.epoxydesign.com Contact: Hank Taylor Phone: 713-461-8733 E-mail: hank@epoxydesign.com			•	•			
Era Valdivia Contractors 11909 South Avenue O Chicago, IL 60617	Website: http://www.eravaldivia.com Contact: Mike Cash Phone: 773-721-9350 E-mail: mcash@eravaldivia.com				•			
Facca Incorporated 2097 County Rd 31 RR 1 Ruscom Station, ON N0R 1R0, Canada	Website: http://www.facca.com Contact: Don Gardonio Phone: 519-975-0377 E-mail: don@facca.com				•			
Farr Foundation Inc. PO Box 457 Rockwall, TX 75087	Website: http://www.farrfoundation.com Contact: James Steven Farr Phone: 469-478-6242 E-mail: office@farrfoundation.com			•	•			
Fibercon International Inc. 100 S 3rd St Evans City, PA 16033-9264	Website: http://www.fiberconfiber.com Contact: Nicholas Mitchell Jr. Phone: 724-538-5006 E-mail: nick@fiberconfiber.com				•		•	
Forta Corporation 100 Forta Dr Grove City, PA 16127-6308	Website: http://www.fortacorp.com Contact: Daniel T. Biddle Phone: 800-245-0306 E-mail: info@fortacorp.com						•	
Freyssinet Inc. 44880 Falcon Place, Suite 100 Sterling, VA 20166	Website: http://freyssinetusa.com Contact: Michael Louis Phone: 703-378-2500 E-mail: michael.louis@freyssinetusa.com				•			
Frontier-Kemper Constructors Inc. 1695 Allen Rd Evansville, IN 47710-3394	Website: http://www.frontierkemper.com Contact: Jim McMahon Phone: 812-426-2741 E-mail: jmcmahon@frontierkemper.com				•			

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Gall Zeidler Consultants 44345 Premier Plz, Ste 210 Ashburn, VA 20147	Website: http://www.gzconsultants.com Contact: Anthony Bauer Phone: 703-726-2700 E-mail: abauer@gzconsultants.com			•	•			
Gary Carlson Equipment Co. 1380 West County Road C Roseville, MN 55113	Website: http://www.garycarlsonequip.com Contact: Gary R. Carlson Phone: 763-792-9123 E-mail: garycarlson@garycarlsonequip.com			•		•		
Genesis 3, Inc. 110 Blossoms Ct Murfreesboro, TN 37129-3252	Website: http://www.genesis3.com Contact: Brian Van Bower Phone: 615-907-1274 E-mail: lisa@genesis3.com			•	•			
GeoBuild, LLC 200 E Campus View Blvd, Ste 200 Columbus, OH 43235	Website: http://www.geobuild.com Contact: Jack J. Hiller Phone: 866-472-6544 E-mail: jhiller@geobuild.net			•	•			•
Georgia Gunite and Pool Company 828 Victoria Place Woodstock, GA 30189	Website: http://www.georgiagunite.com Contact: Tina Davis Phone: 770-926-5150 E-mail: tina@georgiagunite.com				•			
Geostabilization International PO Box 4709 Grand Junction, CO 81502-4709	Website: http://geostabilization.com Contact: Kimberly Ruckman Phone: 970-210-6170 E-mail: kim@gsi.us				•			
Getman Corporation 59750 34th Ave Bangor, MI 49013-1259	Website: http://www.getman.com Contact: Gene L. Lomboy Phone: 269-427-5611 E-mail: glomboy@getman.com					•		
Gib-San Pools Ltd. 21 Milvan Dr Toronto, ON M9L 1Y8, Canada	Website: http://www.gibsanpools.com Contact: Edward D. Gibbs Phone: 416-749-4361 E-mail: ed@gsplc.ca			•	•			
Global Specialty Contractors, Inc. 3220 Terminal Dr Eagan, MN 55121	Contact: Zach Brazier Phone: 651-406-8232 E-mail: zach@globalspecialty.net				•			
Graciano Corporation 209 Sigma Drive Pittsburgh, PA 15238	Website: http://www.graciano.com Contact: Dave Sinclair Phone: 412-963-8400 x10155 E-mail: dsinclair@graciano.com				•			
Group Works LLC PO Box 7269 Wilton, CT 06897-7269	Website: http://www.groupworksllc.com Contact: James Scott Phone: 203-834-7905 E-mail: jamie@groupworksllc.com			•	•			
Gunite Specialists Inc. 152 Mathers Rd Ambler, PA 19002-4100	Website: http://www.gunitespecialists.com Contact: David Reeves Phone: 610-239-0988 E-mail: info@gsipoolfinishes.com				•			
Gunite Supply & Equipment Co. 1726 S Magnolia Ave Monrovia, CA 91016-4511	Website: http://www.gunitesupply.com Contact: Chris Marston Phone: 888-393-8635 E-mail: casales@gunitesupply.com					•		
Harris Rebar 7958 82nd St Delta, BC V4G 1L8, Canada	Website: http://www.harrisrebar.com Contact: Jeffrey Lea Phone: 604-946-1231 E-mail: jlea@harrisrebar.com						•	

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Hayes Drilling Inc. 15525 S Mahaffie St Olathe, KS 66062	Website: http://www.hayesddrillinginc.com Contact: Aaron McConnell Phone: 913-768-9500 E-mail: amcconnell@hayesdrillinginc.com				•			
Hayward Baker Inc.—Craig Olden Division PO Box 5000 Little Elm, TX 75068-9000	Website: http://www.oldeninc.com Contact: Trevor Bray Phone: 972-294-5000 E-mail: tbray@haywardbaker.com			•	•			
Hayward Baker Inc. 515 Nine North Ct Alpharetta, GA 30004-2961	Website: http://www.haywardbaker.com Contact: Ryan Smith Phone: 770-442-1801 E-mail: rtsmith@haywardbaker.com				•			
HCM Shotcrete 125 Earl Thompson Rd Ayr, ON N0B 1E0, Canada	Website: http://www.hcmshotcrete.ca Contact: David Ruhl Phone: 647-201-4006 E-mail: davidr@hcgroup.ca				•			
High Country Pools, Inc. 6330 S College Ave Fort Collins, CO 80525	Website: http://www.highcountrypools.com Contact: Brad Spinuzzi Phone: 970-226-2657 E-mail: bspinuzzi@highcountrypools.com			•	•			
Horseshoe Hill Construction Inc. 34 Nixon Rd Bolton, ON L7E 1W2, Canada	Website: http://www.hhcinc.ca Contact: Gordon Tozer Phone: 905-857-7400 E-mail: gord.tozer@hhcinc.ca				•			
Hydro Arch 900 W Warm Springs Rd, Ste 106 Henderson, NV 89011	Website: http://www.hydro-arch.com Contact: Andrea Scott Phone: 702-566-1700 E-mail: jmoore@hydro-arch.com				•			
J Tortorella Swimming Pools Inc. 1764 County Road 39 Southampton, NY 11968-5204	Website: http://www.tortorella.com Contact: Joe Tortorella Phone: 631-728-1380 E-mail: info@tortorella.com	•		•	•			•
JCM Northlink LLC 123 Northeast 94th St Seattle, WA 98115	Website: http://www.jaydeecontr.com Contact: Nate Long Phone: 206-384-4685 E-mail: nlong@jaydee.us	•	•	•	•			
JE Tomes & Associates 2513 140th Pl Blue Island, IL 60406-3588	Website: http://www.jetomes.com Contact: Joseph E. Tomes Phone: 708-653-5100 E-mail: joe@jetomes.com	•	•					•
Jetcrete NA 2409 Albert Street N Regina, SK S4P 3E1, Canada	Website: http://www.thyssenmining.com Contact: Richard Miranda Phone: 306-949-6606 E-mail: rmiranda@jetcrete-na.com				•			
John Rohrer Contracting Company Inc. 2820 Roe Ln Kansas City, KS 66103-1543	Website: http://www.johnrohrercontracting.com Contact: Brandon D. McMullen Phone: 913-236-5005 E-mail: brandon@johnrohrercontracting.com				•			
KHM Inc. PO Box 2672 Binghamton, NY 13902-2672	Contact: Kathleen Hall Phone: 607-773-0076 E-mail: khmwbe1989@stny.rr.com				•			
Kiewit Infrastructure Co. 470 Chestnut Ridge Rd Woodcliff Lake, NJ 07677	Contact: Paul Madsen Phone: 201-571-2730 E-mail: paul.madsen@kiewit.com				•			

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Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
King Shotcrete Solutions 3385 Harvester Rd PO Box 699 Burlington, ON L7R 3Y5, Canada	Website: http://www.kingshotcrete.com Contact: Joe Hutter Phone: 905-639-2993 E-mail: kingshotcrete@kpmindustries.com					•	•	•
Knowles Industrial Services Corp. 295 New Portland Rd Gorham, ME 04038-1867	Website: http://www.knowlesindustrial.com Contact: Dan Maloney Phone: 207-854-1900 E-mail: dmaloney@knowlesindustrial.com				•			
Kyber Developments Ltd. PO 1073 Whistler, BC V0N 1B0, Canada	Website: http://kyberdevelopments.com Contact: Frank R. Fletcher Phone: 604-935-2037 E-mail: frank@kyberdevelopments.com				•		•	•
Lafarge North America 20 Oak Hallow, Ste 260 Southfield, MI 48033	Website: http://www.lafargenorthamerica.com Contact: Ken Kazanis Phone: 248-594-1991 E-mail: ken.kazanis@lafarge-na.com		•	•				
Lane Shotcrete Inc. 11640 E Limberlost Rd Tucson, AZ 85749	Contact: Robert S. Lane Phone: 520-749-1760 E-mail: lanebrs@aol.com				•			
Lanford Brothers Company Inc. PO Box 7330 Roanoke, VA 24019	Website: http://www.lanfordbrothers.com Contact: Patrick McDaniel Phone: 540-992-2140 E-mail: patm@lanfordbros.com				•			
Lithko Restoration Technologies, LLC 990 N Main St Monroe, OH 45050	Website: http://www.lithkorestoration.com Contact: Benny Hill Phone: 513-863-5500 E-mail: hillb@lithkorestoration.com				•	•	•	•
LRL Construction Co., Inc. PO Box 432 Tillamook, OR 97141	Website: http://www.lrlconstruction.com Contact: Denis Laviolette Phone: 503-842-5520 E-mail: info@lrlconstruction.com			•	•			
Malcolm Drilling Co., Inc. 92 Natoma St, Ste 400 San Francisco, CA 94105	Contact: John Starcevich Phone: 206-510-7224 E-mail: jstarcevich@malcolmdrilling.com				•			
Mapei Corporation 1144 E Newport Center Dr Deerfield Beach, FL 33442-7725	Website: http://www.utt-mapei.com Contact: Monica Rourke Phone: 954-246-8888 E-mail: m.rourke@utt.mapei.com	•						•
Mar-Allen Concrete Products Inc. 490 Millway Rd Ephrata, PA 17522-9528	Contact: Jeffrey L Zimmerman Phone: 717-859-4921 E-mail: jlzimmerman@marallen.com				•			
The Marksmen Company 705 E Ordnance Rd, Suite 107 Baltimore, MD 21226-1760	Website: http://marksmenco.com Contact: Mark D. Miller Phone: 410-355-6080 E-mail: markmiller@marksmenco.com				•			
Mays Construction Specialties Inc. 2399 Riverside Parkway Grand Junction, CO 81505	Website: http://www.mays-mcsi.com Contact: Kyle R. Vanderberg Phone: 970-245-0834 E-mail: kvanderberg@mays-mcsi.com				•			
McGill Restoration Inc. 2821 Grebe St Omaha, NE 68112	Website: http://www.mcgillrestoration.com Contact: Darin Cielocha Phone: 402-558-7989 E-mail: dcielocha@mcgillrestoration.com				•			

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Metro Testing Laboratories (Concrete Restoration) Ltd. 6961 Russell Ave Burnaby, BC V5J 4R8, Canada	Website: http://www.metrotesting.ca Contact: Neil McAskill Phone: 604-436-9109 E-mail: nmcaskill@metrotesting.ca			•	•			
Mid American Gunite Pools Inc. 3152 Crescent Ave Erlanger, KY 41018	Website: http://www.midamericanpools.com Contact: Patrick M. Brennan Phone: 859-581-8566 E-mail: pool1boss@fuse.net				•			
Mid-American Group 8475 Port Sunlight Rd Newport, MI 48166	Contact: Lawrence I. Masserant Phone: 734-586-8868 E-mail: lcmasserant@midamericangroup.com				•			
M-K Construction Company 18388 Dix-Toledo Brownstown, MI 48193	Website: http://www.mkconstructioncorp.net Contact: Mark Kobolak Phone: 734-283-4637 E-mail: mark@mkconstructioncorp.com			•	•			
Morrison Engineers PLLC 7701 Chapel Hill Rd Raleigh, NC 27607-4988	Website: http://www.morrisonengineers.com Contact: James Hoover Phone: 919-851-2021 E-mail: james@morrisonengineers.com			•	•			
Mosites Construction Company 4839 Campbells Run Road Pittsburgh, PA 15205	Website: http://www.mosites.com Contact: Erik Bertrand Phone: 412-923-2255 E-mail: erikb@mosites.com				•			
The Nassal Company 415 W Kaley St Orlando, FL 32806-3942	Website: http://www.nassal.com Contact: Melissa Ruminot Phone: 407-648-0400 E-mail: mruminot@nassal.com			•	•			
National Gunite Inc. 111 Roosevelt Blvd Johnstown, PA 15906-2736	Website: http://www.nationalgunite.com Contact: Lee Taylor Phone: 814-533-5780 E-mail: ltaylor@nationalgunite.com				•			
National Pools of Roanoke Inc. 3112 Melrose Ave NW PO Box 6354 Roanoke, VA 24017-5916	Website: http://www.nationalpools.com Contact: Jason Vaughan Phone: 540-345-7665 E-mail: jason@nationalpools.com				•			
Nationwide Shotcrete Inc. 23638 Lyons Ave, Ste 273 Newhall, CA 91321-2513	Website: http://nationwideshotcrete.com Contact: Jordan Harpole Phone: 661-799-3750 E-mail: jon@nationwideshotcrete.com			•	•			
New Line Skateparks Inc. 3-6923 Farrell Road SE Calgary, AB T2H 0T3, Canada	Website: http://www.newlineskateparks.com Contact: Dwayne Mazereeuw Phone: 403-697-5990 E-mail: dwayne@newlineskateparks.com			•	•			
New York Concrete Corp. 708 Sharrotts Rd Staten Island, NY 10309	Website: http://newyorkconcrete.com Contact: Kenneth Padover Phone: 718-967-3720 E-mail: kpadover@newyorkconcrete.com				•			
Normet Americas Inc. 1681 Renaissance Blvd Sturtevant, WI 53177	Website: http://www.normet.com/normet/contact_us Contact: Chris Gause Phone: 262-878-5760 E-mail: chris.gause@normet.fi	•	•	•		•		
Northwest Cascade Inc. PO Box 73399 Puyallup, WA 98374	Website: http://www.nwcascade.com Contact: Douglas Watt Phone: 253-848-2371 E-mail: dougwatt@nwcascade.com				•			

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Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Olin Engineering Inc. 15622 Computer Ln Huntington Beach, CA 92649-1608	Website: http://www.olinpump.com Contact: David O. Swain Phone: 714-897-1230 E-mail: dave@olinpump.com					•		
Oscar Orduno, Inc. 4500 Fuller Drive, Ste 205 Irving, TX 75038	Website: http://www.oscarordunoinc.com Contact: Oscar Orduno Phone: 972-717-3070 E-mail: oorduno@oscarordunoinc.com				•			
Osco Gunite & Mudjacking Ltd. 5920 98 St NW Edmonton, AB T6E 3L5, Canada	Website: http://www.shotcreting.com Contact: Larry Hnatiuk Phone: 780-469-1234 E-mail: osco@mudjacking.com				•			
Palmetto Gunite Construction Company Inc. PO Box 388 Ravenel, SC 29470-0388	Website: http://www.palmettogunite.com Contact: Thomas A. Hendricks Phone: 843-889-2227 E-mail: tommy@palmettogunite.com				•			
PCiRoads LLC 14123 42nd St NE Saint Michael, MN 55376-9564	Website: http://www.pciroads.com Contact: Dave Graham Phone: 763-497-6100 E-mail: dgraham@pciroads.com				•			
Pipe Technology, a Westflex, Inc. Company 12600 Chadron Ave Hawthorne, CA 90250	Website: http://www.pipetechnology.com Contact: Brian Craig Phone: 310-644-6800 E-mail: brian@pipetechnology.com					•		
PLI Systems, Inc. 3045 SE 61st Ct Hillsboro, OR 97123-3113	Website: http://www.plisystems.com Contact: Manuel Castaneda Phone: 503-649-8111 E-mail: peter@plisystems.com				•			
Polycrete Restorations Ltd. 202-204 Cayer Street Coquitlam, BC V3K 5B1, Canada	Website: www.polycreterestorations.com Contact: Balraj Mann Phone: 604-521-4300 E-mail: info@polycreterestorations.com			•	•			
Pool Engineering Inc. 1201 N Tustin Ave Anaheim, CA 92807-1646	Website: http://www.pooleng.com Contact: Ron Lacher Phone: 714-630-6100 E-mail: ronl@pooleng.com			•	•			
Power Shotcrete Shoring Ltd. 109-8918 Holt Rd Surrey, BC V4N 3S2, Canada	Website: http://www.powercivil.ca Contact: Kirk Gilchrist Phone: 604-597-1112 E-mail: nadink@powercivil.ca			•	•			
Precon Marine Inc. 1401 Precon Dr, Ste 102 Chesapeake, VA 23320-6314	Website: http://www.preconmarine.com Contact: Matthew Miller Phone: 757-545-4400 E-mail: agemmell@preconmarine.com				•			
Preload Inc. 49 Wireless Blvd, Suite 200 Hauppauge, NY 11788-3946	Website: http://www.preload.com Contact: Donald Cameron Phone: 631-231-8100 E-mail: dgc@preloadinc.com				•			
Prestige Concrete Products 7228 Westport Pl West Palm Beach, FL 33413-1683	Website: http://www.prestige-gunite.com Contact: Greg McFadden Phone: 561-478-9980 E-mail: gwmcfadden@prestige-concrete.com			•	•			•

Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Prometheus Construction 1024 Queen St Honolulu, HI 96814	Website: http://www.prometheusconstruction.com Contact: Brian Mahnken Phone: 808-864-0460 E-mail: brian@prometheusconstruction.com				•			
ProShot Concrete Inc. 4158 Musgrove Dr Florence, AL 35630-6396	Website: http://www.proshotconcrete.com Contact: Patrick A. Mooney Phone: 256-764-5941 E-mail: patm@proshotconcrete.com				•			
Pullman-Shared Systems Technology, Inc. 2227 High Hill Rd Swedesboro, NJ 08085	Website: http://www.pullman-services.com Contact: Doug Rose Phone: 856-449-0902 E-mail: drose@pullman-services.com				•			
Putzmeister Iberica S A Camino de Hormigueras 173 Madrid 28031, Spain	Website: http://www.putzmeister.es/shotcrete Contact: Christine Krauss Phone: 011-34914288097 E-mail: kraussc@putzmeister.es					•		
Putzmeister Shotcrete Technology 1733 90th St Sturtevant, WI 53177-1805	Website: http://putzmeistershotcrete.com Contact: Robert J. Harmon Phone: 610-909-9519 E-mail: harmonb@putzam.com					•		
The Quikrete Companies 8530 Delaware Ave North Huntingdon, PA 15642	Website: http://www.quikrete.com Contact: Dennis Bittner Phone: 412-759-1333 E-mail: dbittner@quikrete.com		•					•
Quikspray, Inc. PO Box 327 Port Clinton, OH 43452	Website: http://www.quikspray.com Contact: T. Park McRitchie Phone: 419-732-2611 E-mail: park@quikspray.com					•		
R. W. Haggerty Pool Service Inc. 1 Emerald St Norwalk, CT 06850	Website: http://www.haggertypools.com Contact: Roger Haggerty Phone: 203-348-6899 E-mail: rhaggerty@haggertypools.com			•	•	•		
Ralph L. Wadsworth Construction Company 166 E 14000 S Draper, UT 84020-5441	Website: http://www.wadsco.com Contact: Tera Wadsworth Phone: 801-553-1661 E-mail: tera@wadsco.com				•			
Ram Construction Services 13800 Eckles Rd Livonia, MI 48150-1041	Website: http://www.ramservices.com Contact: Tom Szabo Phone: 734-464-3800 E-mail: tszabo@ramservices.com			•	•			
Ram Jack of Charlotte, LLC PO Box 2991 Huntersville, NC 28070-2991	Website: http://www.ramjackcharlotte.com Contact: Mark Beckham Phone: 704-892-2900 E-mail: markramjack@bellsouth.net				•			
REED Shotcrete Equipment 13822 Oaks Ave Chino, CA 91710-7008	Website: http://www.reedpumps.com Contact: Mike Newcomb Phone: 909-287-2100 E-mail: mike.newcomb@reedmfg.com					•		
Repcrete Concrete Repairs & Cont. Co. PO Box 45962 Abu Dhabi, United Arab Emirates	Website: http://www.repcreteuae.com Contact: Khaled Naddeh Phone: 01197126336128 E-mail: repcrete@emirates.net.ae				•			
Restek Inc. 6601 Boucher Dr Edmond, OK 73034-8582	Website: http://www.restekinc.net Contact: Ellery N. Brown Phone: 405-330-3950 E-mail: restek@flash.net				•			

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Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Restoration East, LLC 4209 E Chase St Baltimore, MD 21205-3020	Website: http://www.restorationeast.com Contact: Louis Helmacy Phone: 410-563-4972 E-mail: louh@restorationeast.com				•			
Revolution Gunite 3580 S Church St Burlington, NC 27215	Website: http://www.revolutiongunite.com Contact: Ryan Oakes Phone: 336-383-1718 E-mail: ryan@revolutiongunite.com			•	•			
RG Johnson Company Inc. 25 S College St Washington, PA 15301-4821	Website: http://www.rgjohnsoninc.com Contact: Tom Crooks Phone: 724-222-6810 E-mail: tom@rgjohnsoninc.com				•			•
RH Ward & Associates 3300 Holeman Ave S Chicago Heights, IL 60411	Website: http://www.rhwardandassociates.com Contact: Blake Rago Phone: 708-756-0767 E-mail: shotcreterjr@hotmail.com				•			
Riverdale Mills Corp. PO Box 200 Northbridge, MA 01534-0200	Website: http://www.riverdale.com Contact: Christine Albone Phone: 800-762-6374 E-mail: lrwalsh@riverdale.com						•	
Russo Corporation 1421 Mims Avenue SW Birmingham, AL 35211	Website: http://www.russocorp.com Contact: Harris Wilson Phone: 205-923-4434 E-mail: hwilson@russocorp.com			•	•			
RWR Construction Inc. 200 Gary Place San Rafael, CA 94901	Website: http://www.rwr-inc.com Contact: Rod Roche Phone: 415-457-5658 E-mail: rod@rwr-inc.com				•			
San Joaquin Gunite 5868 E Mustang Clovis, CA 93619	Website: http://www.sanjoaquingunite.com Contact: Scott Santellan Phone: 559-285-8965 E-mail: h55quad@aol.com				•			•
Schnabel Foundation Company 2950 S Jamaica Ct, Ste 107 Aurora, CO 80014-2686	Website: http://www.schnabel.com Contact: Todd Duncan Phone: 303-696-7268 E-mail: todd@schnabel.com				•			
Schwing America, Inc. 5900 Centerville Rd Saint Paul, MN 55127	Website: http://www.schwing.com Contact: Jason Zignego Phone: 651-429-0999 E-mail: jzignego@schwing.com					•		
Shannon & Wilson Inc. 400 N 34th St, Ste 100 Seattle, WA 98103	Website: http://shannonwilson.com Contact: Axel Nitschke Phone: 206-695-6822 E-mail: agn@shanwil.com			•				
Shotcrete Africa SCP (Pty) Ltd. PO Box 1709 Jukskei Park, NS 2153, South Africa	Website: http://www.shotcrete.co.za Contact: Dustin Strever Phone: 011-27110274337 E-mail: dustin@shotcrete.co.za		•	•	•	•	•	•
Shotcrete Auckland Ltd. PO Box 64439 Auckland 2014, New Zealand	Contact: Glenn Tira Phone: 011-6421701807 E-mail: glenn@shotcrete.co.nz	•			•	•	•	•
Shotcrete Helmet PO Box 430 Stn Main Paris, ON N3L 3T5, Canada	Website: http://www.shotcretehelmet.com Contact: The St. George Company Phone: 519-442-2046 E-mail: info@shotcretehelmet.com					•		

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Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Shotcrete Montana 19 S Woodard Absarokee, MT 59001-0685	Website: http://www.shotcretemt.com Contact: Lucille Mooney Phone: 406-328-7344 E-mail: lucille@shotcretemt.com				•	•	•	•
Shotcrete Systems Inc. 12965 San Fernando Rd Sylmar, CA 91342-3695	Website: www.shotcreteinc.com Contact: Rob Vonarb Phone: 818-833-1293 E-mail: rob@shotcreteinc.com				•			
Sika Corporation 201 Polito Ave Lyndhurst, NJ 07071-3601	Website: http://www.sikaconstruction.com Contact: Ketan Sompura Phone: 201-508-6698 E-mail: sompura.ketan@sika-corp.com	•	•					
Sika Schweiz AG, Aliva Equipment Tuffenwies 16 Zurich 8048, Switzerland	Website: http://www.aliva-equipment.com Contact: Matthias Hagler Phone: 011-41584363287 E-mail: haegler.matthias@ch.sika.com					•		
Sorouh Al Masharee (Sarmix) PO Box 46048, Dammam Highway Riyadh 11532, Saudi Arabia	Website: http://www.sarmix.com Contact: Abdulaziz Al Rajhi Phone: 011-966550025189 E-mail: abdulaziz@sarmix.com							•
South Industries 910 Twin Butte Road Menan, ID 83434	Website: http://www.southindustries.com Contact: Josh South Phone: 208-754-4422 E-mail: traci@southindustries.com				•			
South Island Shotcrete Ltd. PO Box 37-003, Halswell Christchurch, NS 8245, New Zealand	Website: http://www.southislandshotcrete.co.nz Contact: Doug Haselden Phone: 011-64033433564 E-mail: doug@southislandshotcrete.co.nz	•		•	•	•		
South Shore Gunite Pools & Spas Inc. 12 Esquire Road North Billerica, MA 01862	Website: http://www.ssgpools.com Contact: Robert E. Guarino Phone: 800-649-8080 E-mail: rguarino@southshoregunitepools.com			•	•			
Southwest Contracting Ltd. 9426 - 192nd Street Surrey, BC V4N 3R9, Canada	Website: http://www.southwestcontracting.ca Contact: Scott MacCara Phone: 604-888-5221 E-mail: scott@southwestcontracting.ca				•			
Southwest V-Ditch Inc. 3625 Placentia Ln Riverside, CA 92501-1119	Website: http://www.swvditch.com Contact: Bob Shepherd Phone: 951-781-4303 x18 E-mail: mail@swvditch.com				•			
SPB Torkret Ltd. sp z.o.o. spolka komandytowa, ul. Grabowa 8 Siekierki Wielkie, Wielkopolska 62-025 Poland	Website: http://www.torkret.com.pl Contact: Wlodzimierz Czajka Phone: 486-189-7810 x2 E-mail: czajka@torkret.com.pl			•	•			
Spec Mix Inc. 1230 Eagan Industrial Rd, Suite 160 Eagan, MN 55121-1293	Website: http://www.specmix.com Contact: Leah Cory Phone: 651-994-7120 E-mail: nblohowiak@specmix.com		•	•		•	•	•
SprayForce Concrete Services Ltd. 3227 - 56th Avenue SE, #3 Calgary, AB T2C 2A7, Canada	Website: http://www.sprayforceconcrete.com Contact: Jay Unruh Phone: 403-570-0438 E-mail: info@sprayforceconcrete.com			•	•			
Strata Mine Services 67925 Bayberry Dr Saint Clairsville, OH 43950-9132	Website: http://www.strataworldwide.com Contact: Richard Werth Phone: 740-695-6880 E-mail: rwerth@stratamineservices.com				•			

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Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Structural Shotcrete Ltd. 18453 67a Avenue Surrey, BC V3S 9B3, Canada	Contact: Lorne Rutt Phone: 604-575-2563 E-mail: lorne@structuralshotcrete.ca				•			
Structural Shotcrete Systems Inc. 12645 Clark St Santa Fe Springs, CA 90670-3951	Website: http://www.structuralshotcrete.com/index.html Contact: Jason Weinstein Phone: 562-941-9916 E-mail: jason1@structuralshotcrete.com				•			
StructureWerks 12600 Robin Ln, Ste 100 Brookfield, WI 53005-3124	Website: http://www.structurewerks.com Contact: Ross Preschat Phone: 262-781-4329 E-mail: rpreschat@structurewerks.com			•	•			
Sunwest Gunite Co. 7045 Luella Anne Dr NE Albuquerque, NM 87109-3907	Website: http://www.sunwestguniteco.com Contact: Gary O'Canna Phone: 505-821-2549 E-mail: garyocanna@gmail.com			•	•			
Superior Gunite 12306 Van Nuys Blvd Lake View Terrace, CA 91342	Website: http://www.shotcrete.com Contact: Steven Crawford Phone: 818-896-9199 E-mail: steve.crawford@shotcrete.com				•			
Terra Engineering & Construction Corporation 2201 Vondron Rd Madison, WI 53718	Website: http://www.whyterra.com Contact: Gary F. Zimmerman Phone: 608-210-3918 E-mail: gzimmerman@whyterra.com				•			
Testing, Engineering & Consulting Services Inc. 235 Buford Dr Lawrenceville, GA 30046-4945	Website: http://www.tecservices.com Contact: James Glenn McCants III Phone: 770-995-8000 E-mail: tmccants@tecservices.com			•				
Texaloy Foundry Company Inc. PO Box 37 Floresville, TX 78114-0037	Website: http://www.texaloy.com Contact: Jack Rice Phone: 800-367-6518 E-mail: jrice@texaloy.com					•		
Texan Gunite 2406 Narrow Valley Dr Cedar Park, TX 78613	Contact: Juanjose Armenta-Aguirre Phone: 512-383-5341 E-mail: texanccs@gmail.com		•	•		•		•
Texas Shotcrete Inc. 709 Tower Ln McKinney, TX 75069-1805	Website: http://texasshotcrete.com Contact: Dan Goplin Phone: 972-872-1901 E-mail: dan@texasshotcrete.com				•			
Thorcon Shotcrete & Shoring LLC 9955 Titan Park Cir Littleton, CO 80125	Website: http://www.thorconshotcrete.com Contact: Michael Klemp Phone: 303-802-8640 E-mail: info@thorconshotcrete.com		•	•	•			
Top Gun of Virginia Inc. 10017 Richmond Hwy Lorton, VA 22079-2421	Website: http://www.topgungunite.com Contact: George Benko Phone: 703-550-9207 E-mail: info@topgungunite.com				•			
Top Shot Concrete Inc. 3807 Arthur Rose Avenue Saskatoon, SK S7P 0C7, Canada	Website: http://www.topshotconcrete.com Contact: Pat Donovan Phone: 306-242-4155 E-mail: pat@topshotconcrete.com	•	•	•	•	•	•	•
Topcor Services Inc. 12025 Industriplex Blvd Baton Rouge, LA 70809-5131	Website: http://www.topcor.com Contact: James M. Baker Phone: 225-753-7067 E-mail: jbaker@topcor.com			•	•			

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Name/Address	Contact information	Specialties						
		Admixtures	Cement/ Pozzolanic Matl	Consulting	Contractor	Equipment	Fibers	Shotcrete Materials/Mixes
Torrent Shotcrete Structures Ltd. 207-53 West Hastings Street Vancouver, BC V6B 1G4, Canada	Website: http://torrentshotcrete.com Contact: Gary Hawkins Phone: 778-239-4722 E-mail: garyh@torrentshotcrete.com				•			
Truesdell Corporation 1310 W 23rd St Tempe, AZ 85282-1837	Website: http://www.truesdellcorp.com Contact: Kurt Clink Phone: 602-437-1711 E-mail: kclink@truesdellcorp.com				•			
Turnstone Construction, Inc. 7004 180th Ave NE Redmond, WA 98052	Website: http://www.turnstoneconstruction.com Contact: John Fulford Phone: 425-881-0218 E-mail: john@turnstoneconstruction.com				•			
U S Concrete Products LLC 16 Greenmeadow Dr, Ste 202 Timonium, MD 21093-3231	Website: http://www.uscproducts.com Contact: Edward Brennan Phone: 410-561-8770 E-mail: ed@uscproducts.com	•	•					•
Vancouver Shotcrete & Shoring Inc. 10185 199B Street, #105 Langley, BC V1M 3W9, Canada	Website: http://www.shotcreteshoring.com Contact: Rabi Gill Phone: 604-881-4898 E-mail: info@shotcreteshoring.com			•	•			
Western Shotcrete Equipment Inc. HC 1 Box 193 Fairdealing, MO 63939-9708	Website: http://www.wseshotcrete.com Contact: Joe Harpole Phone: 573-857-2085 E-mail: josephharpole@wseshotcrete.com					•		
Whiteside Construction Corporation 1151 Hensley St Richmond, CA 94801-2162	Website: http://www.wesconshotcrete.com Contact: David Whiteside Phone: 510-234-6681 E-mail: drw@whitesideconstruction.com				•			
Wildcat Concrete Services Inc. PO Box 750075 Topeka, KS 66675-0075	Website: http://wildcatcompanies.com/concrete.html Contact: Stuart R. Johnson Phone: 785-233-1400 E-mail: stuartj@wildcatconcrete.com				•			
WR Grace & Co. 62 Whittemore Ave Cambridge, MA 02140	Website: http://www.grace.com Contact: Diego Granell Phone: 617-498-4497 E-mail: diego.granell@grace.com	•						
Wright Concrete & Construction, Inc. 9430 US 23 S Pikeville, KY 41501	Website: http://www.wrightconcrete.com Contact: Shannon Wright Phone: 606-639-4484 E-mail: j.bentley@wrightconcrete.com		•	•	•			
Wurster Engineering & Construction 34 Carrie Dr Greenville, SC 29615-5611	Website: http://www.wursterinc.com Contact: Daryl Wurster Phone: 964-627-7751 E-mail: daryl.wurster@wursterinc.com				•			
Xtreme Shotcrete 166 Woodside Ave Winthrop, MA 02152-2063	Website: http://xtremeshotcretema.com Contact: Michael Anthony Whitehead Phone: 617-846-3191 E-mail: whitehead0015@aol.com				•			

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