Shotcrete MAGAZINE

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OUTSTANDING SHOTCRETE PROJECT AWARDS

american shotcrete association | asa

Shotcrete is a quarterly publication of the American Shotcrete Association. For information about this publication or about membership in the American Shotcrete Association, please contact ASA Headquarters at:

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Shotcrete MAGAZINE

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Features

Departments

On the cover: Shooting dome on Sufism Reoriented Sanctuary, Walnut Creek, CA
Photo courtesy of Shane Louis.

Major Accomplishments

By Marcus H. von der Hofen

Wow, another year goes into the books. I would like to thank all the people actively participating in ASA. We have a great deal on our plate, and that will take a lot of work by our leadership, our members, and our staff. But, in accomplishing these new goals we've established in our strategic plan, we will move ASA and the acceptance of shotcrete to a much higher level. As we turn the page to the New Year, we have had some major accomplishments.

- The Association, again thanks to its members, enjoyed another year of growth and is poised for continued success.
- The combined Executive Director/Technical Director position marks its first year as a successful one. Past ASA President Charles Hanskat stepped into the role and in a short period of time has made this new position a real success for the Association.
- Our Strategic Plan, thanks to Scott Rand taking command of the Strategic Plan Task group, has, with the Committee Chairs, been prioritized and distributed to the committee members in a focused trackable format that should yield great results.
- The Association has, thanks to new membership, reestablished a presence in the underground arena, along with reinstating the Underground Committee with Axel Nitschke of Shannon & Wilson as its Chair.
- As ASA explores becoming more involved in Code and standard development to directly address shotcrete as well as identifying and helping fund key research, the Board approved establishment of a new Technical Committee, chaired by John Zhang. The Technical Committee will also help to reinforce efforts by our Technical Director to reach out and inform more specifiers, professors, and students of the benefits of shotcrete.
- We've made shotcrete presentations to both civil engineering professors and students. We feel that exposing the engineering and construction management students to shotcrete early is an opportunity to let them see the creative, economical, and sustainable aspects that shotcrete placement provides.
- The Association participated in providing a problem statement and judges for a university student competition that evaluated shotcrete as an alternative to form-and-pour construction. Over 20 schools participated with teams of students working on evaluating and making recommendations for the comparison. Again, when we expose the students who will soon be entering the concrete construction world, we give them a perspective on shotcrete that most current concrete curriculums don't provide.

With these accomplishments and others, we also welcome this New Year with a new look—a rebranding of ASA. We've researched, refined, and adopted a new logo and a comprehensive set of graphic elements to make our visual statement online, in print, or on our logo wear consistent and readily identifiable. The rebranding helps to signify and celebrate the success of our Association and the strength of the shotcrete industry. I step away from my tenure as President knowing that the group is in solid hands with the incoming President, our Executive Committee, Board of Directors, Committee Chairs, and our active committees.

Thanks again for your support and I am honored to have had the opportunity to serve you as President this past year.

ASA Technical Committee

By Lihe (John) Zhang

Since ASA launched its first-ever strategic plan back in October 2014, the Association has experienced many changes involving committee member commitment and structural changes of the management of the Association.

The appointment of the new Executive Director, with the technical expertise to also serve as a Technical Director for ASA, is one of the key changes under the strategic plan. Earlier this year, Charles Hanskat, PE, was selected by ASA to fill the Executive Director position. Based on his comprehensive experience in shotcrete design and construction, development of codes, standards, and specifications, the Association is now moving forward in getting shotcrete specified in more projects, publishing guidance documents, and making presentations to owners, specifiers, and student groups on a variety of shotcrete topics, such as repair and rehabilitation, shotcrete inspection, architectural shotcrete, and underground shotcrete. The administrative duties of the Executive Director combined with the substantial time demands of the Technical Director position are considerable.

The Executive Committee evaluated the ASA committee structure, and proposed the creation of a new Technical Committee to work directly with the Executive Director/Technical Director to maximize ASA's impact in the industry and to achieve the goals in the ASA Strategic Plan. At the Denver, CO, ASA Board of Direction meeting on November 7, 2015, the creation of this new committee was approved, and Dr. Lihe "John" Zhang was appointed by the ASA President, Marcus von der Hofen, to lead the Technical Committee. Subsequently, the ASA Strategic Plan was reviewed and several goals with their associated tasks were assigned to the Technical Committee.

The mission of ASA Technical Committee is:

To oversee the technical activities of ASA, including the review and evaluation of technical presentations, publications, handouts, etc. and the appraisal of research projects under consideration for ASA sponsorship.

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The committee will include members responsible for coordinating technical activities and have the technical expertise to critically review ASA's technical documents, presentations, and handouts to be consistent with ASA's Mission and proper industry practice. The Technical Committee will reach out and appoint appropriate technical experts to review special tasks, on an as- and when-needed basis. In many regards, the Technical Committee is similar to the role of ACI's Technical Activities Committee (TAC).

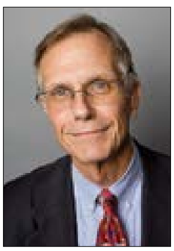
This committee will also serve as the resource for other committees to reach out to potential industry and interests groups or committees and provide them with guidance on how their industry segment may best use shotcrete from a design/technical perspective. This is consistent with the ASA Strategic Plan.

The other important role of the Technical Committee is to oversee ASA's involvement in research projects. In the past, ASA has allocated funding for various research projects. However, there is a need to focus and coordinate our research efforts to make the investment in research as effective as possible. The ASA Strategic Plan has listed a goal of supporting one research project for every 3 years. Currently, ASA has funded the research project of "Transport Property of Shotcrete vs. Cast in Place Concrete." With the guidance of the Technical Committee, ASA will keep sponsoring projects that address the most important questions surrounding shotcrete application.

Our new Technical Committee is structured as an ASA committee, but in its operation, it is more a group of professional, passionate, and dedicated people who enjoy working on technical activities related to shotcrete.

Rebranding—Crossing the Finish Line

By Charles S. Hanskat, PE, ASA Executive Director



Ten months ago, in April 2015, the ASA Board of Directors approved moving forward with a rebranding effort to give ASA a revitalized look, and reflect the increased emphasis on our Association moving forward with growth, member involvement, and outreach in the concrete industry. Although a revised logo is certainly an important part of a rebranding effort, we also felt that certain standardized colors and fonts needed to be set to give all our materials a consistent visual look.

After retaining Kulör Design from Montreal to develop the new logo and graphics aspects of ASA, the Chair of the Marketing Committee, Joe Hutter, as well as the Executive Committee and ASA staff, went through many iterations in developing our new look. Five months later in September 2015, two options were presented to the Board and a final selection was approved. Below is our old logo on the left, and new logo on the right.

As you can see, the new logo is crisp and simple. It uses the green color from our old logo, as well as the stylized nozzle at the end of the last "a". The smooth curves of the letters in "asa" reflect the curves in our shotcrete hoses, as well as supporting the concept that shotcrete is a creative method of placing concrete that is not limited to flat, straight sections. The font used for "american shotcrete association" is a clean, simple font, but visually different than the fonts one normally sees in documents (like Arial, Times Roman, Verdana, and so on). You'll also notice the "shotcrete" is in a slightly larger font, to stand out from the more common words "american" and "association."

After approving the rebranding graphics, we found that having a new logo and set of graphics standards was just the first step. The new look required broad changes in nearly every visual aspect of our business. The logo, fonts, and colors were used to develop revisions to:

- Our Media Kit;
- The website;
- *Shotcrete* magazine;
- ASA advertisements;
- Business cards, stationary, and envelopes;
- PowerPoint presentations—AIA, student, and nozzleman/inspector education;
- Logo wear—hats, hard hat stickers, jackets, and t-shirts;
- Awards banquet programs;
- World of Concrete (WOC) signage;
- Printed compilation covers;
- E-mail signature graphics; and
- Member-of-ASA web graphics.

We set a goal to have our rebranding ready to show off at WOC in early February 2016. It seemed that 4 months would be a reasonable timeframe to complete all the aforementioned aspects. As you may imagine, this transformation took a lot of time and effort, and required pulling together the resources of ASA and our association management staff.

Along with the new look, it was decided by the Board that our old tradeshow exhibit was dated, and in many ways (both visually and physically) worn out. If you've ever attended WOC (or any other large trade show), you know there are a wide variety of types of exhibit hardware. We made a careful study of available options, and selected the most cost-effective, flexible, and visually interesting system. In fact, we selected two different types to complement the large booth space we have at WOC and give us flexibility when exhibiting at smaller venues.

As I write this article, we've attended WOC and formally rolled out the new branding. ASA held our first press conference on February 2 at WOC to introduce ASA and our new branding to the concrete press in attendance. We also used the press conference to introduce the creative uses of shotcrete in modern concrete construction. In parallel with the WOC announcement, our website was updated and as you can see on the cover of *Shotcrete*, we've introduced the new logo here, too.

Thus, the rollout is the culmination of nearly a year's worth of effort. Although the look is different, and at first glance may

seem too drastic a change, we've found that all who have worked with the new branding after using it for a while find it is a clean, fresh look, and well represents ASA's efforts to modernize and stand out in our industry.

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Superior Gunite

Quikrete-Spec Mix

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Shotcrete Concrete Contractors Association	Vesta Mine Supply	

2015 Outstanding Architecture | New Construction Project

Sufism Reoriented Sanctuary

By Jason Myers

Sufism Reoriented is an American spiritual order that focuses on the principles of divine love as the central focus of their lives. They are in the process of constructing a permanent home in Walnut Creek, CA, that is nearing completion. The new sanctuary will be set among the serene gardens on 3 acres (12,000 m^2) of land surrounding a suburban neighborhood. The structure was designed under the guidance of Murshida Carol Weyland Conner and the highly distinguished architectural firm Philip Johnson/Alan Ritchie with Soga and Associates being the Architect of Record. The project had its groundbreaking ceremony on May 24, 2012, and the sanctuary is expected to be completed in the middle of 2016.

An important symbol to the order is the circle. The circle is expressed in the gently sloping saucer domes vaulting the Prayer Hall and the adjacent rooms. The outline of the domes was designed to reflect the soft, rolling hills that border the surrounding valley. Within the sanctuary, the domes create tranquil and uplifting interior spaces for prayer, meditation, and communion with God. The roof of the sanctuary consists of eight small domes, four medium domes, and in the center one large dome (refer to Fig. 1).

Fig. 1: Outside view of domes

The eight small domes have a diameter of 272 in. (6.91 m) with the design of the project having the small domes constructed out of fiberglass. The four medium domes have a diameter of 450 in. (11.43 m) and a height of 158 in. (4.01 m) with a concrete thickness of 7.5 in. (0.19 m) with an approximate area of 1500 ft^2 (140 m^2) each. The single large dome has a diameter of 76 ft (23.16 m) and a height of 258 in. (6.55 m) with a concrete thickness of 7.5 in. (0.19 m) with an approximate area of 5800 ft^2 (540 m^2). The concrete contractor, Overaa Construction out of Richmond, CA, was awarded the concrete portion of the project and had originally planned on casting the domes, but once the project got out of the estimating department into the construction phase, they realized that cast-in-place was not the best solution. At this point, Overaa Construction started conversations with Dees-Hennessey, Inc., about the possibilities for using shotcrete (refer to Fig. 2(a) and (b)).

Shotcrete proved an ideal solution for the domes as the complexity of the formwork was eliminated and the architectural features of the domes could immediately be seen and evaluated by the owner, contractor, and Dees-Hennessey to ensure the domes were geometrically correct before the shotcrete setup and make corrections if needed during placement. A full-height section of the dome was constructed as a preconstruction test panel to qualify the nozzlemen as well as to confirm the architectural finish was acceptable for the general contractor, architect, and owner.

Each of the domes had an opening in the top of the dome (oculus). This required the concrete contractor to start each of the domes by casting a concrete compression ring around the base and at the top of each dome to lock in the reinforcing bars and the structural frame of the structure. Each of the medium-sized domes was shot monolithically during a single mobilization. Due to the size and weight of the large dome, it was split into six sections and two nonadjacent sections were shot during the three mobilizations to com-

Fig. 2(a) and (b): Large dome shotcrete installation

plete the large dome. The reinforcement wiring for these domes was extremely difficult due to the geometry. Surveyors established the correct geometry, but as each section was completed, there was less area to walk on and increased chances of the wires being damaged. There were numerous evenings when the contractor's or owner's representative, who wanted to visualize what the domes were going to look like, had to be chased off of the domes to prevent damaging the layout (refer to Fig. 3).

Fig. 3: Large dome shotcrete preparation

One of the challenges for the shotcrete placement was creating an accurate dome shape. After the shotcrete work was complete, a fluid waterproofing membrane was applied directly on the concrete surface. This required all of the shotcrete surface to be finished on the curved surface within tight construction tolerances. Any deviation in shape would have been very noticeable. Furthermore, any patching would have shown through the waterproofing membrane. A distinct advantage with shotcrete was the final shape could be continuously checked and adjusted as needed to make sure the proper geometry was achieved. This was extremely challenging in the large dome, first with it being such a large structure and then having to install it in six different sections, where the final structure could not be visualized until all six sections were complete. This challenging placement was successfully executed by Dees-Hennessey with no issues or patching required. In the end, the owner was very satisfied with the shotcrete surface texture and geometry. Additionally, they were able to use a thinner and simpler waterproofing membrane because of the quality of the shotcrete

Fig. 4: Medium dome with channel

finish. An additional challenge was each dome's drainage channel and ladder, installed along the curved surface, that required additional detail work (refer to Fig. 4).

Dees-Hennessey relied on its more than 30 years of shotcrete experience on difficult projects to ensure that quality control, safety standards, and correctness along with industry standards were used on this project. Although this was a very difficult project, it showed that with the proper preplanning and thinking through how the project is going to be constructed, construction can be greatly simplified and help to eliminate many of the problems that can occur down the road. The success of this project is due to the great teamwork between all parties and individuals.

The Outstanding Architecture | New Construction

Project Name
Sanctuary for Sufism Reoriented

Project Location
Walnut Creek, CA

Shotcrete Contractor
Dees-Hennessey, Inc.*

Concrete Contractor
Overaa Construction

Design Architect
Philip Johnson Alan Ritchie Architects

Architect of Record
Soga and Associates

Material Supplier
Central Concrete

Project Owner
Sufism Reoriented

*Corporate Member of the American Shotcrete Association

__Jason Myers__ graduated from California Polytechnic State University, San Luis Obispo, CA, in 1995 with his bachelor's degree in civil engineering and from Golden Gate University, San Francisco, CA, in 2015 with his master's in business administration with an emphasis in project management. Myers started out his professional career working for an earth retention subcontractor, where he learned the importance of budgeting, scheduling, and client relationships. Also during this time, he was introduced to the use of shotcrete and its applications. After working for a general contractor for a couple of years, he realized that he enjoyed the tighter knit of working for a subcontractor and the ability to construct projects on a tighter time frame with multiple projects in process simultaneously. Myers also enjoys the process of handling most of the procedures that go into constructing a project rather than seeing only a small portion of the process. Myers joined Dees-Hennessey, Inc., in 2004 and has been a part owner of the company since 2007. Myers currently serves as the Vice President of Operations as well as the Safety Director.

2015 Outstanding Infrastructure Project

The Plaza Substation and Queens Structures

By Frank E. Townsend III

The Plaza Substation and Queens Structures provide structural and architectural rehabilitation to existing facilities along the existing 63rd St Station and will tie in from Long Island to the East Side Access project as a major hub rail station. Tunnel and construction improvements to the Plaza, also known as the Harold Interlocking, connect below-grade facilities for the Mainline Traction Power Substation, Facility Power Substation, ventilation, signal, emergency power, mechanical, and communication rooms.

Superior Gunite installed concrete on structural perimeter walls, interior I-beam walls, interior steel-reinforced walls, and circular and

Fig. 1: CQ32 is a four-level ventilation facility, passenger station, and office for the MTA. Five other active projects are adjacent to and/or tie directly into the project, making logistics a challenge

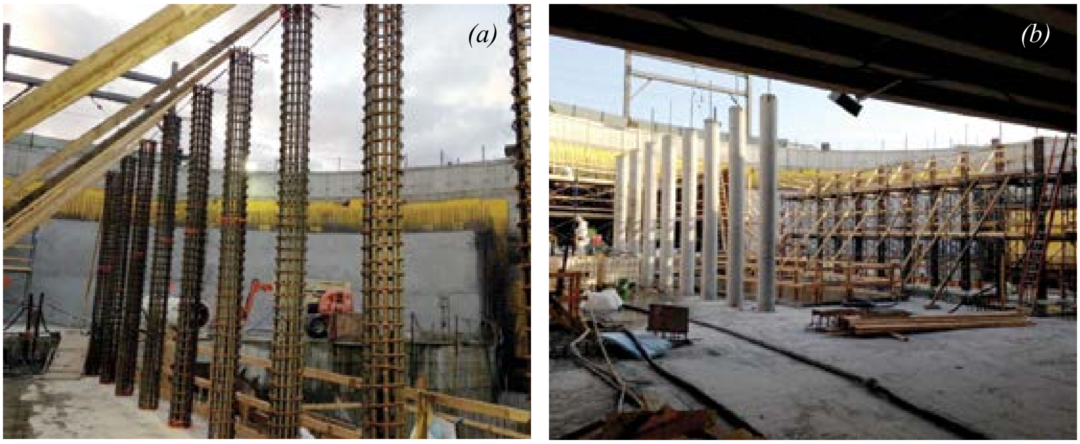


Fig. 2: Round columns. Most had: (a) a roof to wire and support; and (b) some did not

square columns. The shotcrete process was used in varied thicknesses from 12 to 72 in. (300 to 1800 mm) depending on type of wall, and 24 in. (600 mm) diameter circular columns. The base contract volume was approximately 19,232 yd^3 (14, 704 m^3) plus an additional 13,885 yd^3 (10,616 m^3) in change orders.

The base contract work consisted of 12,520 yd^3 (9572 m^3) of structural perimeter walls (one-sided finish); 3904 yd^3 (2985 m^3) of interior I-beam walls (two-sided finish); 2436 yd^3 (1863 m^3) of interior steel-reinforced walls (two-sided finish); and 372 yd^3 (284 m^3) of columns: 101 circular columns with a 24 in. (600 mm) diameter; 16 circular columns with a 12 in. (300 mm) diameter, and 16 square columns measuring 3 x 3 ft (900 x 900 mm). The change order work was an additional 13,000 yd^3 (9939 m^3) in one-sided wall smoothening and 885 yd^3 (677 m^3) of one-sided walls with a rubber float finish.

The shotcrete process was used for all vertical elements on this project. The project ran from December 2012 to August 2015. Superior Gunite used a 5000 psi (35 MPa) concrete mixture supplied by Ferrara Bros. Building Material Corp. and Tec Crete Transit-Mix Corp. to aid the general contractor in meeting Federal DBE goals. The coordination between the providers and teamwork was instrumental in making this job a success. The major challenge was shooting through the difficult East Coast winters that required tenting and heating the placements through the 0°F (–18°C) temperatures. All structural walls and columns required a steel trowel finish. This was especially difficult when it came to circular columns. To aid in the precise finish of the columns, workers used fabricated trowels and a cutting rod that were shaped to the curve of the column.

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 4 years. Townsend is an active member of ACI Committee 506, Shotcreting; a member of ASA; and currently serves on the ASA Board of Directors. 2015 ENR *top 20 under 40.*

Fig. 3: One of the four levels of interior walls

Fig. 4: Each of the three bays shown is a future train corridor for Long Island Railroad. To the right you can see square columns

The Outstanding Infrastructure Project

Project Name
CQ32

Project Location
Queens, NY

Shotcrete Contractor
Superior Gunite*

General Contractor
Tutor Perini Civil

Architect/Engineer
New York Metropolitan Transportation Authority Capital Construction (MTACC)

Material Supplier/Manufacturer
Ferrara Brothers Building Material and Teccrete

Lab
Tectonic

*Corporate Member of the American Shotcrete Association

2015 Outstanding Pool & Recreational Project

Reflecting on a Shotcrete Pool

By Ryan Oakes

Dry-mix shotcrete—also known as gunite—has a bad reputation in some parts of the structural shotcrete industry, as well as in the pool marketplace. There are a multitude of reasons that contribute to this perception, but foremost is the lack of education on the side of the specifiers, the contractors hiring the shotcrete crews, and sometimes even the crews and the company owners. It is amazing that so few people with so many years of experience in their trade don't know why past failures exist in their trade, particularly in shotcrete, both wet and dry.

While this article is not about the industry's shortcomings, it is a relevant preface to why we were called into the project that this article is about. In short, a pool had been shot and failed miserably. While the owners were sorting out the problems with the previous pool builder and the dry-mix shotcrete installer, time passed and the home construction continued. By the time Clearwater Construction Group, Inc., was called in to both finish demolition of the previous work and build the new pool, there was a really nice home on one side and on the other three sides, a 40 ft (12 m) drop to the ground, with a 400 ft (120 m) slope down a mountain thereafter! Minimal access was available on one cliffside so between wheelbarrows through the house and a track loader on the cliff side, over 60 tons (54,000 kg) of remaining demolition materials were hauled away.

A Fresh Start

Subsequently, a clean slate remained: a suspended sub-slab, in excellent condition, cantilevered over 40 ft (12 m) tall concrete walls. The new pool was to be built just as the original had been designed. Because it was being built on the sub-slab, the three vanishing-edge sides of the pool would be fully exposed to the elements and partially exposed to the viewer. The exterior surface is slated to be covered in a stucco product to match the color of the stone on the home and the interior of the pool is completely surfaced in black 0.75 in. (20 mm) glass mosaic tile.

On the side of the pool that touches the decking, a Lautner's edge detail was used to create the illusion that the water meets the top surface of the adjacent Travertine decking material. This detail involves finishing a delicate knife edge during the shotcrete process that separates the pool water from a hidden gutter, which carries the overflowing water back to the equipment room. In this case, the equipment room is underneath the pool. To install this edge during the shoot, we brought along extra finishers. In fact, we had several extra helpers on this project due to all the detail work required (Fig. 1).

Overall, there were over 90 ft (27 m) of vanishing edge, over 40 ft (12 m) of the Lautner's edge gutter, and a perimeter overflow spa, along with two sets of steps, an underwater bench, and two large shallow-water lounging areas (Fig. 2).

Understanding the technical nature of the pool and the difficult logistics, we planned on this being a multiple-day shoot. Leading up to the shoot, Clearwater Construction Group formed the project with extremely rigid framing so that we not only had a good surface to shoot to but also to walk on and navigate around without fear of falling or damaging formwork. Safety lines were run on the outside of the project so that any finisher who had to step out of the pool could clip in with their safety harness. The reinforcing bar, all No. 4 (No. 13) steel, was well-placed and tied so that it, too, could be walked and climbed on with minimal movement in the steel. There was a great deal of plumbing to shoot around, including a 6 in. (150 mm) trunk line with vertical risers every 5 ft (1.5 m) for the overflow water. The spa plumbing was very intricate and required a great deal of care and skill in placing the shotcrete around the pipe and fittings well. Finally, we were given a 1/32 in. (0.8 mm) tolerance to hold on the vanishing edge to reduce the amount of water needed to flow over the edge (Fig. 3).

A New Perspective

Pools have forever been plagued with efflorescence, water-retention problems, and installation complications. Particularly, vanishing-edge pools with at least one side of the vessel being exposed to the elements and not hidden in earth

Fig. 1: Shooting the negative-edge trough while the finishers quickly work with the silica-fume-enhanced concrete and remove rebound and trimmings from the project

Fig. 2: The finished shell shortly after being shot


Fig. 3: Some of the intricate plumbing and steel work

are prone to efflorescing on the exterior of the shell, which can be quite unsightly and cause problems with the exterior cladding.

In this situation, not only did we need to hold water in but we also needed to shoot walls 26 in. (0.66 m) thick standing 5 ft (1.5 m) high. To mitigate both the efflorescing problem and to aid with the rapid buildout, we proposed to the pool designer, Brian Van Bower with Aquatic Consultants, the use of silica fume as a supplemental cementitious additive in the dry-mix shotcrete material. He agreed and conferred with the Architect, Steven Price, and with Bill Drakeley, who served as our shotcrete inspector on the job. Both agreed with the addition.

Silica fume has long been used in the infrastructure and tunneling industries and has proven to reduce efflorescence, reduce rebound in the shotcrete application, and increase the ability to build out rapidly. Silica fume has also been laboratory-tested and proven to reduce permeability in concrete. The volumetric batch trucks that Revolution Gunite uses are designed to be able to add silica fume as an additive before the mix bowl. After careful calibration of the truck for the correct dosage, we used the silica fume in all parts of the pool except the floor, where we felt it wasn't necessary.

Due to the problems on the previous structure, there was a great deal of scrutiny on the project. We were asked to provide several test panels—one for each day of our shoot to be indicative of the project and material placement. Our test panels proved an added benefit to the structure from the use of the silica fume, which was additional strength. We were already shooting our engineered mixture design that averages over 5000 psi (35 MPa), but these breaks came back as high as 8440 psi (58 MPa). We cured the test panels in the same way we cured the pool, which was through soaker hoses left to flood the structure. Once the pool structure was shot, we flooded it and let it cure for a month. The test panels were pulled out after 7 days and tested at 7, 14, and 28 days. After a month of curing in a flooded state, there were no signs of efflorescing anywhere in the project and no walls showed moisture on the exterior surfaces. We succeeded in providing a watertight, efflorescence-free project with high compressive strengths.

Being a glass tile pool, the glass tile manufacturers have specific requirements for the surface preparation. This pool was sprayed with Aquron CPSP and was also coated with Flexcrete after all surface preparations and before the tile application.

Fig. 4: Nozzling in good form with a great view

Logistics and the Dry-Mix Process

There was a beautiful home with construction well underway in between the staging area for our batch trucks and the pool. Although the hardwood floors, interior paint, and trim work were all complete in the house, we needed to run our lines through the middle of the house. Overall, we needed approximately 300 ft (90 m) of delivery lines to get our shotcrete to the pool. Using the dry-mix process, our hoses don't surge like a hose from the wet-mix process, so there was less risk of damaging the floors; that said, we still protected the floors with thin plywood and plastic. Also, the dry-mix hoses run much less pressure than a wet-mix pump, so the risk of a hose bursting and spraying the interior ceilings with the shotcrete materials were minimized.

Being such a technical project, we decided to shoot the floor first, followed by the walls and other details on Days 2 and 3. Dry-mix shotcrete was the perfect application method (Fig. 4 and 5). We are able to start and stop as needed to focus on the details and not worry with scheduling concrete trucks because the shotcrete material isn't hydrated until exiting the nozzle. It is mixed with water on demand as needed. To continue over multiple days, our crew members benched off material at ideal stopping points and maintained clean reinforcing bar through the use of a blow pipe both during the shoot as well as between shoots to aid in cleanup. All surfaces were maintained in a saturated surface-dry (SSD) state while shooting onto previously shot areas. In addition, the crew members are versed in removing laitance from the hardened surface and providing the optimum surface for shooting a subsequent layer the following day. The large volume of air in a dry-mix rig, along with the water at the nozzle, can provide a strong air-water blast that's great for cleanup and also for wetting the surface to provide an SSD condition when not sending material through the lines.

The downside of the dry-mix method is that more care is needed in material handling. With wet-mix shotcrete, it doesn't matter if the aggregate is wet before it is mixed because water is being added to the mixture anyway. With the dry-mix method, too much moisture in the sand can be problematic or even shut down the job. In our case, we typically stockpile large quantities of dry sand (3 to 5% moisture content) at our yard and reload at our own facility or a satellite yard. On this job, being in a remote location in the mountains of North Carolina, that was not an

Fig. 5: The use of a blow wand, seen in the hands of the gentleman with the red shirt, is critical to maintaining quality throughout the project

option, so we stored 125 tons (113,000 kg) of sand nearby with a loader, where we kept the material dry until it was needed. We had a relationship with a local ready mix provider who supplied us with our cement reloads (conveniently located near our sand pile). Our material reloads were nearby, so we only needed two batch trucks traveling back and forth for the job.

The jobsite was extremely congested, so we coordinated with the general contractor on the job to minimize other sub-trades during our shoot, so that we had room for our compressor truck and the material batch trucks. We exercised a great deal of control over our aggregate (sand) pile. To start, we used sand from the same pit that our mixture design was based on so that variations in aggregate were minimal. Then we placed the large pile of sand on a concrete slab so that soil contamination was not an issue. Finally, we covered the pile to prevent moisture gain from the daily mountain rains, as well as preventing windborne contaminates, such as leaves, from entering the pile.

One of the benefits the crew experienced was my relationship with a local chef, who we contracted to prepare food for breakfast, lunch, and dinner. The chef would show up at the rental house and have food ready by 4:30 a.m. so the crew could be out the door shortly thereafter. Then lunch was served on the jobsite and dinner was ready when they returned. I feel this is important for morale when a crew is working out of town, doing what is already hard work and not having time to go get food. We don't always get this luxury, but we do strive for it in some form every time we work out of town. The crew loves it and we are happy to provide this as a small gesture of our appreciation.

A Final Note

Although a swimming pool can be built with a cast-in-place method, the shotcrete process greatly facilitates the installation, particularly when building a detailed pool that has multiple gutters, tight waterline tolerances, and a glass tile interior surface (Fig. 6).

In this case, reducing forming and, moreover, reducing time, was a serious benefit for the general contractor and owners, having lost so much time due to the previous situation. The shotcrete method was perfect for the construction of this pool. Trying to build the forms necessary for the vanishing edges and small gutters is possible but not nearly as efficient as simply building a one-sided form to shoot onto.

The added strength and durability of the shotcrete process, dry or wet, through the compaction of the concrete is of great benefit when dealing

Fig. 6: A mountain pool in the clouds

with a concrete shell meant to retain water—and chemically treated water at that.

At Revolution Gunite, our nozzleman and foreman is an ACI Certified Nozzleman, as was and should be required on a job like this. This particular foreman is responsible for thousands of pools over the last 20 years and his expertise shone when executing these details. We also believe that a good shotcrete company should train its finishers and truck operators in what makes for a quality product so that everyone on board is qualified, not just the nozzleman.

Education, experience, and integrity are all key ingredients to a well-placed shotcrete structure. Shortcomings in any of these inevitably lead to failure of the structure and our industry as a whole.

The Outstanding Pool & Recreational Project

Project Name
Mountain Pool

Project Location
North Carolina

Shotcrete Contractor
Revolution Gunite*

Pool Contractor
Clearwater Construction Group, Inc.

General Contractor
Boone Construction

Architect/Engineer
Steven Carter Price, AIA, Architect

Pool Design Firm
Aquatic Consultants, Inc.

Material Supplier/Manufacturer
Norchem, Aquron, and Flexcrete

Project Owner
Name withheld

*Corporate Member of the American Shotcrete Association

***Ryan Oakes** is a Managing Partner in Revolution Gunite and is a licensed pool contractor in North Carolina and Virginia. Oakes has been designing and building water features in the United States and abroad, from pools to art pieces and even aquaculture systems, for the past 17 years. With a mission to change the way gunite is perceived and applied, Oakes started down a path of education for himself as well as his staff. He is a member of the American Institute of Architects, the American Pool & Spa Association, and an active member in the Genesis Design Group, which educates contractors around the world in various aspects of the pool building process, including the shotcrete process. Revolution Gunite, a member of ASA and the American Concrete Institute, has a mission to not only educate and train its staff but to also educate its builders so that they, too, play their role in a quality shotcrete product. Revolution Gunite provides dry-mix shotcrete services to pool builders and other contractors in North Carolina and Florida, as well as parts of South Carolina, Virginia, and Tennessee.*

2015 Outstanding Repair and Rehabilitation Project

Société de transport de Montréal—Metro Yellow Line Tunnel Repairs

By Kevin Robertson, Patrick Giguère, and Ntam Nda-Ngye

The Montreal Metro is an underground metro system and the main form of public transportation in the city of Montreal, QC, Canada. The Metro, operated by the Société de transport de Montréal (STM), was inaugurated on October 14, 1966. It originally consisted of 26 stations on three separate lines, but now has 68 stations on four lines totaling 43.0 miles (69.2 km) in length, which serves the entire greater Montreal area. 1.2 million passengers now ride the system daily. The Yellow Line is the only metro line that runs between the island of Montreal and the south shore.

The project (Metro Yellow Line Tunnel Repairs) was released for tender on September 23, 2013, and was awarded to Construction Interlag Inc. of Saint-Léonard, QC, Canada. Construction Interlag Inc. is a civil construction company with expertise in all aspects of concrete repair and rehabilitation. Their shotcrete team, which employs several ACI Certified Nozzlemen, has over 75 years of combined shotcrete experience in the civil and mining markets.

Engineering Scope

The initial feasibility study was completed by an outside consulting engineering firm. However, an internal STM engineering group took over the design work, conducted a delamination survey, and performed a finite element analysis of the tunnel walls.

The STM engineering team identified approximately 6500 ft^2 (600 m^2) of overhead area requiring removal and replacement, most of which ranged in thickness from 18 to 35 in. (450 to 900 mm) (Fig. 1). The sequence for the work to be completed was specified as:

1. Removal of deteriorated and delaminated concrete;
2. Installation of rock anchors and wire mesh; and
3. Placement of shotcrete (dry-mix process).

The majority of the work was undertaken in a 2.5 mile (4 km) stretch of tunnel between the Berri–UQAM station and the Longueuil–Université-De-Sherbrooke station. This stretch of tunnel runs underneath the St. Lawrence River. To complete the project with minimal disruption to the Montreal commuters, it was decided that the work schedule would be spread over 207 nights with the majority of the concrete replacement (shotcrete) being completed over 25 weekends. The shotcrete placement was split into two phases in an effort to further accommodate transit riders during some of Montreal's major arts and cultural events, not the least of which was the Montreal Grand Prix. During the time when the stations were closed, a shuttle service that bypassed the construction zone was offered to the public.

Shotcrete Materials

The material specification called for a prepackaged, high-quality shotcrete mixture that would provide long-term durability, so the STM engineers specified the same parameters that are used by the MTQ (Quebec Ministry of Transportation) in their shotcrete specification. Key aspects of the specified mixture design were:

1. Air entrainment: The most important performance durability criteria remains the determination of air void distribution, as per ASTM C457. In-place, hardened shotcrete requires an average air void spacing factor of under 0.0118 in. (300 μm), with no individual results over 0.0125 in. (320 μm). In a dry-mix shotcrete application, air-entraining admixture should be added in powdered form and preblended with other components at the point of manufacturing. The shotcrete mixture producer should have a proven track record producing prepackaged, air-entrained, dry-mix shotcrete and should be able to provide ASTM C457 test

data that reflects the recommended air-void spacing factor for dry-mix shotcrete.
2. Silica fume: Silica fume is a highly pozzolanic admixture that has been proven to improve both the plastic and hardened properties of concrete placed using the shotcrete process. The use of silica fume in shotcrete increases adhesion to the bonding surface and cohesion within the shotcrete, consequently allowing thicker placement of shotcrete before sloughing (especially in overhead applications). Although there is no standard ASTM or ACI test to measure attainable thickness in one pass, testing and field performance has proven that the benefits of silica fume from the perspective of overhead and vertical repairs are obvious.
3. Aggregates: Aggregates should meet the recommendations in ACI 506R, "Guide to Shotcrete," and use Gradation No. 2 (the mixture with both fine and coarse aggregates), due to the thickness of the applications. To ensure optimum durability, including resistance to freezing and thawing and alkali-aggregate reaction, all concrete aggregates should also meet the minimum requirements outlined in ASTM C33. The use of larger (0.4 in. [10 mm]) coarse aggregate also has a positive effect on the ability to pump and shoot the shotcrete mixture. The abrasion of coarse aggregate against the inside lining of the hose reduces the cement buildup and improves material flow. Consequently, a coarse aggregate gradation will allow the use of longer transportation hoses and reduce plugging.

Significance of Shotcrete

The greatest challenge faced by the STM management team and the contractor was, without a doubt, to complete the project in a timely manner while limiting disruption to the STM ridership. The engineering group not only had to design the structural elements of the repairs but also had to find a solution that would allow a fast turnaround time so the completion of the concrete repairs, crack injections, and electrical work would stay within the allocated 25 weekends. With that in mind, the decision to specify dry-mix shotcrete checked all the boxes for the STM engineering team.

The nature of the shotcrete process allowed the crew to continually place concrete much quicker than form-and-pump placement methods. More importantly, the elimination of formwork resulted in reduced labor and allowed the contractor to mobilize, shoot, cut, and finish without having to transport, install, and later remove complex, curved forms. The result was not only an accelerated construction schedule but also a more cost-effective repair method (Fig. 2).

Logistical Challenges

Mobilization of the crew and transportation of the required materials and equipment to the worksite was extremely challenging. Access to the worksite by train was the only option available to the contractor, so Construction Interlag Inc. developed a system using two special flatbed train cars that were designed to carry all of the components, including the dry-mix shotcrete gun, pre-dampener, forklift, compressor, tool box, and enough bulk bags of shotcrete material to last the shift. This system allowed them to maximize the work hours during the weekend shutdowns of the metro line (Fig. 3).

Fig. 1: The material specification called for a prepackaged, high-quality shotcrete mixture that would provide long-term durability

Fig. 2: The STM engineering team identified approximately 6540 ft^2 (600 m^2) of overhead area requiring removal and replacement, most of which ranged in thickness from 18 to 36 in. (450 to 900 mm)

Fig. 3: Construction Interlag Inc. developed a system using two special flatbed train cars which were designed to carry all of the components, including the dry-mix shotcrete gun, pre-dampener, forklift, compressor, tool box, and enough bulk bags of shotcrete material to last the shift

Before starting the shotcrete process, both flatbed cars were positioned side-by-side along parallel tracks and a platform connecting the two cars was installed to allow personnel to move between the cars. Another platform was erected to allow the nozzleman to position himself the proper distance from the receiving surface (approximately 3 to 5 ft [0.9 to 1.5 m]). An adjustable netting system was designed and placed around the shooting platform to prevent rebound from falling into the track area and thus reducing cleanup time at the end of the shift (Fig. 4).

The benefits offered through the dry-mix method of placement made it the natural choice for the contractor:

1. Sufficient pre-blended material to last a full shift could be transported, stored, and placed through the dry-mix gun, allowing the crew to maximize production.
2. The shotcrete crew could easily start and stop when moving from one repair area to the next.
3. A special high-early-strength, accelerated shotcrete mixture allowed the contractor to place thicker passes and complete the finishing process without having to return at a later time to complete the repair.
4. Less cleanup time allowed the contractor to maximize shooting time and improve productivity.

Fig. 4: Removal of deteriorated and delaminated concrete, installation of rock anchors and wire mesh, and ready for placement of dry-mix shotcrete

Despite these benefits, dust control (preventing dust from contaminating the metro stations and ventilation system) remained the primary concern for the STM project managers.

The Construction Interlag Inc. management team worked closely with the experts from the material and equipment suppliers to convince the STM project managers that an experienced shotcrete crew, using well- maintained, quality equipment and a high-quality consistent material can easily alleviate concerns about dust. The Interlag team used a number of tools to minimize dust including a well-maintained dry-mix shotcrete rig (with a pre-dampening unit and gun). The pre-dampener added a controlled amount of moisture to the dry-mix prepackaged, preblended shotcrete material and a hydro-mix nozzle with a water ring approximately 10 ft (3 m) back from the nozzle tip was used to further reduce dust emissions (Fig. 5).

Despite the effectiveness of these measures, a secondary dust control system that used a simple sprinkler/mist net system was installed downwind from the shotcrete crew as added insurance against dust emissions. The Interlag crew proved that dry-mix shotcrete, placed in a confined location, can be relatively dust-free if the proper procedures are followed by an experienced team of professionals. A collaborative approach involving Construction Interlag Inc., the STM, and the material supplier (King Shotcrete Solutions) resulted in a successful project that was completed on budget, on time, and with limited inconvenience to the Montreal commuters.

Fig. 5: Proof that dry-mix shotcrete, placed in a confined location, can be relatively dust-free by using a well-maintained dry shotcrete rig (with a pre-dampening unit and gun)

The Outstanding Repair & Rehabilitation Project

Project Name
Société de transport de Montréal—
Metro Yellow Line Tunnel Repairs

Project Location
Montréal, QC, Canada

Shotcrete Contractor
Construction Interlag Inc.

General Contractor
Construction Interlag Inc.

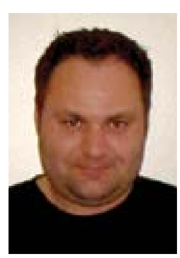
Architect/Engineer
Société de transport de Montréal

Material Supplier/Manufacturer
King Shotcrete Solutions*

Project Owner
Société de transport de Montréal

*Corporate Member of the
American Shotcrete Association

***Kevin Robertson** is a Technical Sales Representative for King Shotcrete Solutions and is responsible for the Greater Montreal Area and northeast U.S. markets. His area of expertise includes shotcrete materials, applications, and equipment, focused mainly on concrete repair and rehabilitation. Robertson is a member of ASA, the American Concrete Institute (ACI), and is the Vice-President of the Quebec Province Chapter of the International Concrete Repair Institute (ICRI).*



***Patrick Giguère**, P.Eng., is a Project Manager and Estimator for Construction Interlag Inc. His areas of expertise include structure and road rehabilitation. He has over 20 years of experience in the industry and received his degree in construction engineering from Écoles de Technologie Supérieur, Montréal, QC, Canada.*

***Ntam Nda-Ngye**, P.Eng., is a lead structural and civil engineer for the Société de transport de Montréal. His areas of expertise are project management, structural analysis, and design of steel and concrete structures. Ntam has over 15 years of experience in design and more than 5 years in project management. He was the project engineer on the Metro Yellow Line Tunnel Repairs project, for which he led a team of electrical, civil, and structural engineering specialists. He received his civil engineering degree from the University of Innsbruck, Innsbruck, Austria, and his master's degree from École Polytechnique de Montréal, Montréal, QC, Canada.*

2015 Outstanding Underground Project

Northern Boulevard Crossing Tunnel CQ039

By Frank E. Townsend III

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).

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.

Fig. 1: East Side Access overall project scope

Fig. 2: CQ39 Excavation

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 three times we had to divert to an alternate pump. Because the pumps were inline,

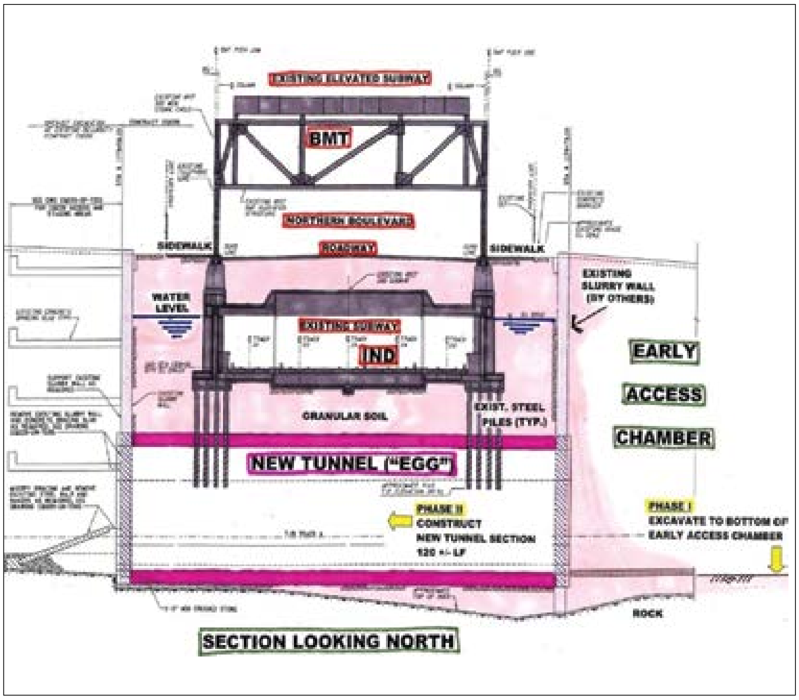


Fig. 3: Overhead load applied to the tunnel

Fig. 5: Mockup of ring girder shoot

Fig. 4: Waterproofing and ring girders being installed

Fig. 6: Shooting the mockup

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 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)).

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

Fig. 8: Cutting of guides and finishing

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 4 years. Townsend is an active member of ACI Committee 506, Shotcreting; a member of ASA; and currently serves on the ASA Board of Directors. 2015* ENR *top 20 under 40.*

The Outstanding Underground Project

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 (MTACC)

Material Supplier/Manufacturer
Ferrara Brothers Building Material
5000 PSI Mix

Project Owner
Metropolitan Transportation Authority

*Corporate Member of the American Shotcrete Association

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


Do you need a Shotcrete
Contractor or Consultant
for a Specific Project?

2015 Honorable Mention

55th Street Ventilation Facility

By Frank E. Townsend III and Dennis Rubi

The 55th Street Ventilation Facility is a critical piece of the Eastside Access Program for the New York Mass Transit Authority. This facility provides critical ventilation for the new tunnels that carry Long Island Rail Road trains to Grand Central Terminal. Unlike most other ventilation facilities, the 55th Street Ventilation Facility, like the 50th and 44th Street vent facilities, is designed to be entirely underneath the street's pavement. These do not have an aboveground component.

Fig. 1: Shaft structure—shot two water barrier panels per shift

All vertical elements were shot by Superior Gunite. Superior Gunite installed the shotcrete on a complex, oval-shaped, vertical ventilation shaft, including overhead arches, without the need for forming—saving the general contractor over $1,000,000 in formwork expense. The concrete in the ventilation shaft varied in thicknesses from 24 to 54 in. (610 to 1370 mm) depending on the rock overbreak, as this was a blasted excavation. The base contract volume was approximately 1927 yd^3 (1473 m^3) with the overhead arch 4 ft (1.2 m) thick using 1277 yd^3 (976 m^3) of concrete.

There were several logistical challenges to the 55th Street Ventilation Facility. Because there was limited access for materials and formwork, the shotcrete process was essential. Shooting the crown of the arch left just 5 ft (1.5 m) of working distance from the final arch, making access very challenging. The elimination of formwork and the ability to access difficult-to-reach areas were key benefits in using shotcrete as the placement method for structural shotcrete in the ventilation shaft and overhead arches. With the fast-paced schedule, the shotcrete method saved the time it would have taken to construct, form, and strip the 8613 ft^2 (800 m^2) overhead arch. Total time saved on the project due to use of shotcrete was 32 working days.

This project ran from September 2013 with the initial lining in the main cavern to May 2015 when the overhead arch and shaft lining were placed. The wet-mix process was used with timely concrete deliveries by the ready mix supplier, Tec Crete Transit–Mix Corp (WBE), who provided a 5000 psi (35 MPa) mixture in the heart of New York City. The concrete was pumped from the surface to the subterranean area of placement with a combination of 2 in. (50 mm) slick line and flexible rubber hoses. Forming on the ventilation shaft was almost completely eliminated except for two-sided sections of the shaft, where a stay-in-place form was used. At some locations, the field measurements for the overhead arch were over 48 in. (1200 mm) thick with three layers of reinforcement. To allow proper placement in these congested sections, shotcrete was applied in three 12 in. (300 mm) lifts with a scratch finish on the first two layers and a rubber float final finish.

***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 4 years. Townsend is an active member of ACI Committee 506, Shotcreting; a member of ASA; and currently serves on the ASA Board of Directors. 2015* ENR *top 20 under 40.*

***Dennis Rubi** is a Project Engineer for Superior Gunite. He is a civil engineer graduate of California State University, Long Beach, CA. Rubi comes from the County of Orange in Newport Beach, CA, as a Junior Engineer, and has been with Superior's East Coast operations as a Project Engineer for 1 year. Rubi is a member of the American Society of Civil Engineers.*

Honorable Mention

Project Name
The 55th Street Ventilation Facility

Project Location
Manhattan, NY

Shotcrete Contractor
Superior Gunite*

General Contractor
Schiavone Construction Co., LLC, and John P. Picone, Inc.

Architect/Engineer
New York Metropolitan Transportation Authority Capital Construction (MTACC)

Material Supplier/Manufacturers
Tec Crete Transit-Mix Corp.

Lab
Tectonic

*Corporate Member of the American Shotcrete Association

Fig. 2: Overhead arch—lower panel being built up. Note the BA anchors and injection tubes displaying the depth of the concrete section

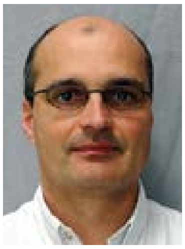
Fig. 3: Working on final panel—heat presented a challenge, requiring ventilation and close attention to curing

Fig. 4: Final arch structure shotcreted in layers due to thickness

2015 Carl E. Akeley Award


Carl E. Akeley


Ezgi Yurdakul


Klaus-Alexander Rieder

The tenth annual Carl E. Akeley Award was presented to Ezgi Yurdakul on behalf of herself and co-author, Klaus-Alexander Rieder of GCP Applied Technologies, for their paper, "Effect of Pozzolanic-Based Rheology Control Agent as a Replacement for Silica Fume." Silica fume, often added to shotcrete mixtures to improve strength and durability while reducing rebound, also brings challenges with its use. This paper, published in the Spring 2015 issue of *Shotcrete* magazine, evaluated the experimental use of a pozzolanic-based rheology control agent to provide benefits similar to silica fume while minimizing its challenges. Conclusions from this study supports the success of this agent in this endeavor. The award was presented by ASA Publications Committee Chair Ted Sofis.

ASA established the Carl E. Akeley Award to honor his founding of what is today referred to as the shotcrete process. This award is presented to the author(s) of the best technical article appearing in *Shotcrete* magazine in the past 12 months, as determined by the Akeley Award Committee of ASA.

Carl E. Akeley invented the cement gun in 1907 and introduced a commercial version of it at the Cement Show in New York in December 1910. For this reason, Akeley is considered the inventor of the shotcrete process.[1]

Born in Clarendon, NY, on May 19, 1864, Akeley was a noted naturalist, taxidermist, inventor, photographer, and author. He made many significant contributions to the American Museum of Natural History and many other museums around the United States. He initially invented the cement gun to repair the façade of the Field Columbian Museum and later used it to improve the quality of his taxidermy exhibits at the museum. Akeley made five expeditions to Africa, during which time he procured many animals for museum exhibits. President Theodore Roosevelt accompanied him on one of those expeditions and encouraged him in his development of the cement gun. During his fifth expedition to Africa, he contracted a virus and died on November 17, 1926.

References

1. Teichert, P., "Carl Akeley—A Tribute to the Founder of Shotcrete," *Shotcrete*, V. 4, No. 3, Summer 2002, pp. 10-12.

Past Akeley Award Recipients

- 2006—Jean François Dufour, "State-of-the-Art Specification for Shotcrete Rehabilitation Projects"
- 2007—Knut F. Garshol, "Watertight Permanent Shotcrete Linings in Tunneling and Underground Construction"
- 2008—E. Stefan Bernard, "Embrittlement of Fiber-Reinforced Shotcrete"
- 2009—Dufour, Lacroix, Morin, and Reny, "The Effects of Liquid Corrosion Inhibitor in Air-Entrained Dry-Mix Shotcrete"
- 2010—Lihe (John) Zhang, "Is Shotcrete Sustainable?"
- 2011—Charles S. Hanskat, "Shotcrete Testing—Who, Why, When, and How"
- 2012—R. Curtis White Jr., "Pineda Causeway Bridge Rehabilitation"
- 2013—Jolin, Nokken, and Sawoszczuk, "Sustainable Shotcrete Using Blast-Furnace Slag"
- 2014—Dr. Lihe (John) Zhang, "Variability of Compressive Strength of Shotcrete in a Tunnel-Lining Project"

2015 ASA President's Award


Patrick Bridger

The ASA President's Award was established in 2005 to recognize the person or organization that has made exceptional contributions to the shotcrete industry. It is the sole responsibility of the current ASA President to select the recipient of this award.

Since 2006, eight well-deserving individuals and one organization were awarded the ASA President's Award, all of whom dedicated their time and energy to advance the shotcrete industry.

For 2015, outgoing President Marcus H. von der Hofen presented the ASA President's Award to Patrick Bridger for his outstanding service to ASA and the shotcrete industry. Bridger has provided untold hours of his personal time and effort to advance our shotcrete industry through ASA programs.

Bridger's leadership and commitment to ASA is exemplified by his always volunteering to help. He is a Past President, currently serves on the Board of Directors, co-chairs the Membership Committee, serves on numerous committees, and has written a number of articles for *Shotcrete* magazine.

Bridger is a wealth of knowledge about shotcrete equipment, materials, and practices, as well as the variety of ASA activities through the years, and to the benefit to our Association and the industry, he is always willing to share that knowledge. Bridger's network of contacts in the shotcrete industry stretch around the globe. It is rare to find someone active in the industry who doesn't know and respect him. ASA and indeed the entire shotcrete industry is indebted to Bridger for his selfless and tireless efforts to raise the bar for promoting quality shotcrete and helping others, both inside or outside of ASA, to achieve our ASA vision and mission to the betterment of our industry.

Is Your Compressor Trying to Tell You Something?

Warning signs that compressor failure could be in your future

By Oscar Duckworth

Anyone can check the fuel, oil, and coolant level of an air compressor prior to use. Unfortunately, these basic steps overlook critically important on-job maintenance essentials that, if ignored, have caused countless costly compressor failures. An air compressor used for shotcrete service requires specific on-job inspection, use, and maintenance procedures. Do you and your crew know what they are?

If It's Running, Don't Mess With It

A compressor that starts easily and runs smoothly may not initially appear in need of immediate maintenance. The classic phrase, "If it's running, don't mess with it," seems ideally suited for air compressors used in shotcrete service. Although most workers can demonstrate how to fuel a compressor or check engine oil, few can provide more than casual information regarding operation, care, and maintenance. Worse, signs of compressor trouble often go overlooked because the symptoms are not well understood.

Routine air compressor maintenance is usually performed at certain intervals defined in the manufacturer's literature. Like other construction equipment, lubrication, filters, and other scheduled maintenance by qualified personnel is the best method to assure reliable operation. Scheduled maintenance however, cannot take the place of the proper operation, daily inspection, and awareness of potential trouble by on-job personnel.

Although portable air compressors' primary components have not changed dramatically in decades, reliability and longevity have steadily increased. With newer models, low maintenance is an expectation. But even the newest models, when used in shotcrete operations, require specific on-job maintenance steps. Shotcrete compressors operate almost continuously at the maximum output within the dusty air conditions of shotcrete placement. Imagine how long our work trucks would last if they were operated continuously at full speed within these conditions. Scheduled maintenance may not be enough. Because of the special needs of shotcrete air compressors, on-job personnel should be able to inspect and perform several simple but necessary inspection and maintenance steps.

Air Compressor Basics

A compressor head unit is coupled to the back of the engine. Engine rotation spins a pair of rotors within the compressor head at double the engine speed to compress filtered incoming air. Compressor rotors rotate within a precision housing at very close tolerances. Intake air must be clean or excessive wear will occur. The rotors are lubricated and cooled by a non-foaming lubricant (usually automatic transmission fluid) mixed with the incoming air. Next, the lubricant is removed from the compressed air as it passes through a filter/separator assembly. The filter/separator, like other filters, must be replaced routinely. It is easily identified within the compressor unit because it is contained within a tall, pressurized cylindrical tank (Fig. 1). As air is compressed, its temperature rises dramatically. This is normal and is referred to as adiabatic heating. Adiabatic heating occurs when a gas is compressed. To cool the hot air, it passes through a large intercooler (air-to-air radiator) at one end of the unit. An engine-driven fan pushes fresh air through all of the intercoolers to remove heat from the engine, compressor oil, and the compressed air (Fig. 2).

An adjustable pressure regulator controls the pressure and volume of the discharged air. Modern compressors use sensors and a micro-processor unit to control engine function and emissions. Gauges display vital engine and compressor functions. The engine and all of the compressor components are contained within a special sound-deadening enclosure that is designed to draw fresh incoming air through openings at one end and push heated air out the other. Unlike older compressors, opening the doors of a modern air compressor while it is operating defeats the sound-deadening design, interferes with air flow to the cooling system, and may cause overheating. Like modern automobiles, today's compressors are more reliable, efficient, and generate lower emissions than previous models. But, like the automobile, reliable operation will be short-lived without maintenance.

Fig. 1: Due to high compressor pressure, filter/separators are contained within a vertical steel tank near the compressor head unit


Fig. 2: A cooling fan forces fresh air through the engine's radiator and various heat exchangers

On-Job Compressor Maintenance Essentials

Due to near-constant full-throttle operation and the proximity to shotcrete operations, air filters require cleaning or replacement more often than the normal manufacturer's recommended service intervals (Fig. 3).

On-job maintenance of air filters is a constant responsibility. Because adequate engine and compressor intake filtration is one of the most important maintenance elements to equipment service life, cleaning and replacement of air filters should be part of all on-job maintenance.

Check the Vital Fluids (Including Ones that You Don't Know About)

Vital fluids must be kept at the correct levels. Like other construction equipment, fuel, engine oil dipstick, and engine coolant levels must be checked prior to operation. On portable air compressors, the components that compress, regulate, and cool the air are lubricated with vital fluids that must be maintained at safe levels. When asked, many operators cannot identify the procedure to check or fill the compressor head unit, or the type of lubricant required. The compressor head unit and filter/separator assembly fluid must be checked routinely by viewing the lubricant level through a sight glass or opening a large filler plug (with the engine off and all air pressure drained) located near the bottom of the filter/separator tank (Fig. 4). Operating an air compressor with low compressor head lubricant can cause overheating, shutdown, or costly damage to the compressor head unit. Prior to use, on-job personnel should check all vital fluid levels.

Check the Battery

If the battery on an air compressor starts the motor, no one will think any more about it. Typically, batteries only receive attention when the motor will not start. Although most batteries configured for construction equipment are designed to be maintenance-free, the battery's electrical terminals are not. Neglect and corrosion of the battery terminals creates voltage and current fluctuations that can damage the electronic control module, prompt unexpected shutdowns, or other costly problems (Fig. 5). Routinely inspect and clean battery terminals before, not after, a problem occurs.

Fig. 3: A visual inspection can easily identify dirty air filters

Fig. 4: A sight glass or filter plug are provided to check compressor head lubricant level

Watch For Compressor Warning Signs

It is normal for compressed air discharge to be warm, but very hot discharge air may be a sign of initial mechanical malfunction. Very hot discharge air is the first warning sign of an overheating condition. If ignored by on-job personnel, overheating can cause almost immediate engine, compressor head, or filter/separator damage. Excessively hot discharge air can be caused by clogged filters, low compressor head oil levels, excessive tolerances within the compressor head, or plugged cooling fins within the cooling system. If heat cannot be released as quickly as it is created, the compressor will begin to overheat.

By far the most common cause of excessively hot discharge air for compressors used in shotcrete service is dirty filters or partially clogged cooling system exterior fins. Because of the shotcrete environment, oil, cement dust, and dirt tends to quickly plug filters. Dirty air, drawn by the engine's cooling fan tends to build up and clog some (or all) of the cooling system's exterior fins. Check for clogged fins by looking at them through the protective fan guard (Fig. 6). Keep cooling system exterior fins clean by routinely flushing the sticky residue out of the cooling fins with plenty of water. The amount of trapped material released during flushing can be surprising! Modern compressors use protective heat sensor safety switches that will shut down the compressor if an overheating condition is occurring. If very hot discharge air is detected, or a shutdown occurs, check for clogged cooling fins, dirty air filters, or low compressor head lubricant.

A common warning sign of potential compressor failure that on-job personnel should watch for is an oily odor in the discharge air. Because shotcrete service compressors normally operate at near-full-throttle conditions, the filter/separator assembly is prone to failure. As media material within the filter/separator breaks down, its effectiveness at removing all oil from the discharge air diminishes. Not only are filter/separators susceptible to damage from heat and full throttle use, they can be permanently damaged by improper on-job compressor shutdown procedures. To avoid damage, compressors should be idled for a few minutes following full throttle use to cool engine, compressor, and turbocharger components, then shut off. Compressors are designed to automatically bleed stored compressed air SLOWLY after shutdown. Never throw open an air valve to drain stored air. A sudden collapse in internal pressure can distort and permanently damage the filter/separator assembly. If an oily odor is noted in the discharge air, discontinue use and replace the filter/separator.

A compressor failure during shotcrete operations can occur at any time. Fortunately, compressors often display warning signs well

Fig. 5: The air compressor's battery is often in a difficult-to-reach area

Fig. 6: Cooling fins clogged with dirt and oil area common cause of overheating

before trouble occurs. Successful use of air compressors for shotcrete service requires scheduled maintenance, on-job maintenance, and proper use by knowledgeable operators who can recognize warning signs, and avoid costly breakdowns.

*ACI Certified Nozzleman **Oscar Duckworth** is an ASA and American Concrete Institute (ACI) member with over 15,000 hours of nozzle time. He has worked as a nozzleman on over 2000 projects. Duckworth is currently an ACI Examiner for the wet- and dry-mix processes. He currently serves as ASA Executive Committee Secretary and Chair of ASA's Education Committee. He continues to work as a shotcrete consultant and certified nozzleman.*

Air Compressor Checklist

- When operating an air compressor, leave the sound-deadening doors closed.
- Check, clean, or replace air filters often.
- Know the proper method to check and top off all vital fluid, including the compressor head unit, at each fueling.
- Regularly inspect the battery terminals and keep them corrosion-free.
- Routinely flush accumulated build-up in the external cooling fins of the compressor's various intercoolers.
- Note changes in odor and temperature of the discharge air. These can be warning signs of initial mechanical malfunction.

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Enhancement of Shotcrete Performance with a Pozzolanic-Based Rheology Control Agent

By Ezgi Yurdakul and Klaus-Alexander Rieder

In underground applications such as mining and tunneling, shotcrete is widely used for structural support of permanent openings, linings, and rock stabilization. Considering the performance that shotcrete plays on the quality of these applications, the following properties are often assessed:

- Pumpability—the mixture should have an adequate flowability for the ease of pumping;
- Sprayability—viscosity, cohesiveness, and stickiness is desired for minimum rebound;
- Early-age strength—the mixture should have sufficient early-age strength to ensure required structural support is provided to the ground within the first few hours;
- Later-age strength—the mixture should meet the specified long-term strength to ensure no strength loss is occurring over time that may compromise the service life of the structure; and
- Durability—the mixture should be durable to ensure the longevity.

Because silica fume improves many of these properties, the use of silica fume became common in shotcrete in the last few decades.[1] However, due to various concerns about the health and safety, variation in quality, availability, and cost-efficiency of silica fume, there is a need to use alternative materials, which could provide equal or superior performance while eliminating any potential risks.

The Need for Replacing Silica Fume with Pozzolanic-Based Rheology Control Agent

What is pozzolanic-based rheology control agent?

Pozzolanic-based rheology control agents (for example, TYTRO® RC 430) are suspension of fine amorphous silica particles in a stable liquid form. It consists of nonporous, spherical, non-aggregated, nanometric particles dispersed in water free from chlorides and with low alkalinity.

Which Applications is Pozzolanic-Based Rheology Control Agent Used For?

A pozzolanic-based rheology control agent can be used in any shotcrete mixture to replace cementitious materials such as silica fume, metakaolin, fly ash, or slag cement within a certain limit. Typical applications include but are not limited to the following areas:

- Mining;
- Tunnel linings;
- Rock slope stabilization;
- Pools and recreational structures;
- Domes;
- Retaining walls;
- Water-retaining structures; and
- Repair and rehabilitation of concrete structures.

Reason 1—Health and Safety

There is a concern that silica fume is a potential hazard to workers who add the material to the concrete or shotcrete mixers. Any dust generation can be a nuisance; and the lifting and dumping of bags presents their own health and safety risks with respect to back injuries, pinching, and straining. Because the pozzolanic-based rheology control agent is a liquid product, it can be automatically dispensed, and thus problems associated with handling powder-based silica fume can be eliminated. The facilities required for storing and dispensing admixtures are less expensive than those for silica fume, and require less maintenance and attention.

Reason 2—Quality Assurance

In plants that are storing silica fume in silos, problems may arise when traditional silica fume cakes in the silo or when the absorbed moisture causes the formation of lumps. Due to its liquid form, pozzolanic-based rheology control agent can eliminate such deficiencies, which may cause variations in shotcrete performance. It is more effectively dispersed than silica fume, reducing the mixing time required and minimizing the risk of lump formation in concrete or shotcrete. In addition, rheology control agent is manufactured under stringent quality control in an industrial process using high-quality raw materials to obtain a material with high fineness and purity. The tolerances for the particle size distribution are very tight to ensure that the specific surface area remains the same from batch to batch, unlike for silica fume being a by-product, which can have batch-to-batch variations and can contain impurities causing variations in the shotcrete performance. From a physical point of view, differences between the two materials are shown in Table 1.

Reason 3—Dosage Efficiency

Silica fume is often used to replace ordinary portland cement within the range of 5 to 10% to improve the performance of shotcrete mixtures. However, the selected grade of pozzolanic-based rheology control agent only requires one-tenth of the silica fume dosage rate (for example, 3 kg/m^3 [5 lb/yd^3] of TYTRO RC 430 is needed to replace 30 kg/m^3 [50 lb/yd^3] of silica fume in shotcrete mixtures) to provide equivalent performance, which makes it a more economical and sustainable solution.

Reason 4—Enhancement of Shotcrete Performance

The use of a pozzolanic-based rheology control agent provides several performance benefits compared to silica fume (designated as "SF") and ordinary portland cement (designated as "OPC") as presented in the following, based on the results obtained from the following case studies:

Case study A—0.67% TYTRO RC 430 was used to replace 5% SF in a binary mixture

- Mix with 5% SF (water-cementitious materials ratio [*w/cm*] of 0.40; total cementitious materials content: 473 kg/m^3 [29.5 lb/ft^3])
- Mix with 0.67% TYTRO RC 430 (*w/cm*: 0.40; total cementitious content: 450 kg/m^3 [28.1 lb/ft^3])

Case study B—0.67% TYTRO RC 430 was used as an addition (due to minimum cementitious materials content requirement) in a plain mixture where OPC was used

- Mix with 100% OPC (*w/cm*: 0.46; total cement content: 459 kg/m^3 [29.7 lb/ft^3])
- Mix with 0.67% TYTRO RC 430 (*w/cm*: 0.46; total cement content: 459 kg/m^3 [29.7 lb/ft^3])

Case study C—0.67% TYTRO RC 430 was used to replace 6% SF in a ternary mixture

- Mix with 6% SF (*w/cm*: 0.35; fly ash designated as "FA": 23%; total cementitious materials content: 521 kg/m^3 [32.5 lb/ft^3])
- Mix with 0.67% TYTRO RC 430 (*w/cm*: 0.37; FA: 23%; total cementitious materials content: 489 kg/m^3 [30.5 lb/ft^3])

Note: Test methods were selected based on the project requirements. Because the specified performance characteristics varied based on the case study, the following section presents results from the selected case studies where testing was conducted.

a. Enhanced sprayability and reduced rebound

For sprayability, a viscous and sticky mixture with high cohesiveness is desired as shotcrete mixtures for reduced rebound. In addition, segregation of the shotcrete mixture under pressure is reduced. However, for pumpability reasons, the viscosity of the shotcrete mixture needs to be limited due to the maximum allowable pump pressure.

When added to the shotcrete mixture, rheology control agents provide greater cohesiveness of the shotcrete mixture, lower rebound, and higher thickness buildup (Fig. 1). A possible explanation for these effects could be related to the smaller particle size associated with the higher specific surface area of the rheology control agent working as a nucleation site for the precipitation of calcium silica hydrate (CSH) gel, and having stronger Van der Waals and electrostatic ionic forces between particles.[2] Considering that the main source of cohesion in cement paste is the calcium silicate hydrate (CSH) gel,[3] it is expected for pozzolanic-based rheology control agent to increase cohesion due to its impact on accelerating

Table 1. Comparison of Properties between Silica Fume and Rheology Control Agents

Silica fume	Rheology control agents
By-product	Engineered material
Contains impurities	High purity
Powder	Liquid
Difficult to handle	Easy to use
Variable particle size and distribution	Uniform particle size and distribution

Fig. 1: The effect of pozzolanic-based rheology control agent on thickness buildup

and forming additional CSH gels, and its reactant surface particles exhibiting stronger tendency for adsorption of ions and increasing the surface adhesion between adjacent particles, and to other materials. Studies are currently being carried out to determine the exact mechanisms of the pozzolanic-based rheology control agent leading to the observed enhanced sprayability and reduced rebound characteristics.

As shown in Fig. 2, in Case Study A, mixtures containing 5% SF and 0.67% TYTRO RC 430 were both efficient in reducing rebound to as low as 5 to 6%. The reference mixture containing SF was already optimized. Because the rebound loss of the baseline mixture is already considered to be very low, the impact of the rheology control agents in achieving similar low rebound loss at much lower dosage rates is a significant improvement. However, Case Study B shows that the addition of the pozzolanic-based rheology control agent significantly reduced the rebound from 20 to 6%. Results show that the degree of improvement on rebound loss is related with the mixture design and mixture constituents. When the performance of the rheology control agents on rebound is compared with those of mixtures containing portland cement only, or mixtures containing silica fume with rebound losses higher than the one obtained in this study, the decrease in rebound may be more dramatic.

b. Higher early-age strength

The compressive strength test results based on the penetrometer needle up to 3 hours followed by Hilti stud[4] are shown in Fig. 3. The rate of strength development during the first couple of readings is relatively low in both mixtures. However, starting from 2 hours, rapid strength gain has been observed, especially for the mixture containing TYTRO RC 430 compared to the silica fume mixture. This could be due to the following properties of the pozzolanic-based rheology control agent[4]:

- It has high pozzolanic activity because its ultrafine particles have high specific surface area and they are fully hydroxylated;
- It reacts with the calcium hydroxide released by the cement hydration and forming additional calcium silicate hydrate (CSH) gel;
- It serves as nucleation sites to CSH gel; and
- It accelerates the primary CSH gel formation.

Figure 4 shows the compressive strength[5] tested 1 day after spraying. As expected, mixtures with pozzolanic-based rheology control agent outperformed their corresponding reference mixtures.

c. Equal or higher long-term strength

Figure 5 shows the impact of the rheology control agent on the compressive strength[5] at 28 days. As desired, while accelerating the hydration process, which increased the early-age strength of the shotcrete, the pozzolanic-based rheology control agent provided equal (compared to mixtures with silica fume) or higher (compared to the mixture containing portland cement only) later-age strength based on three case studies incorporating various mixture designs. This trend shows that the impact of the rheology control agent on the compressive strength is more prominent at early ages, and most importantly, unlike other rapid setting materials, it is not harming the later-age strength. This makes it ideal for underground applications, where minimal time for re-entry to the mine or tunnel is desired.[7-9]

d. Similar durability

Figure 6 shows that the water penetration depth[10] of the mixture containing TYTRO RC 430 was slightly lower than that of the silica fume mixture.

Figure 7 shows the boiled absorption and the volume of permeable voids test results[11] from

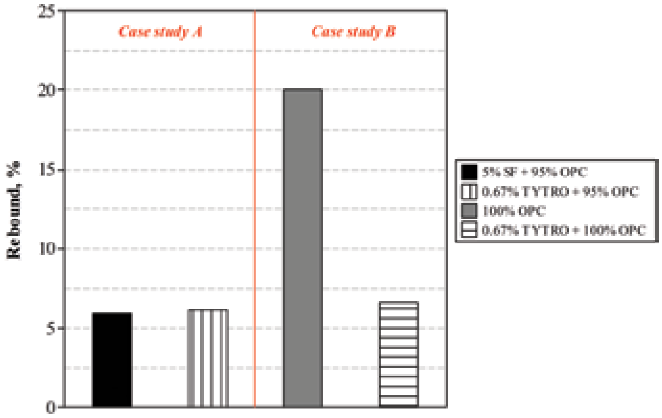

Fig. 2: The effect of pozzolanic-based rheology control agent on rebound

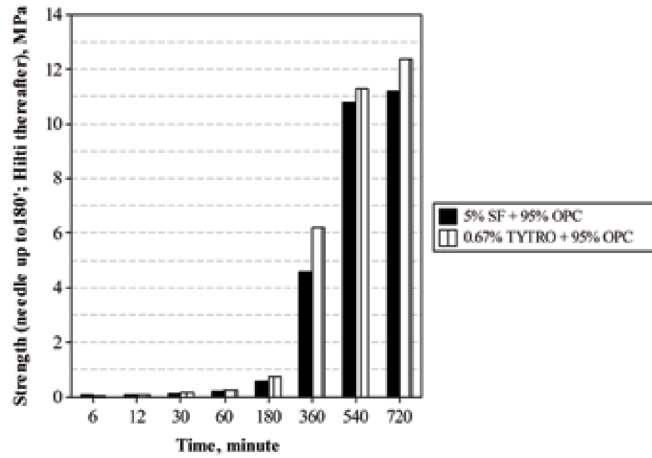

Fig. 3: The effect of pozzolanic-based rheology control agent on early-age strength

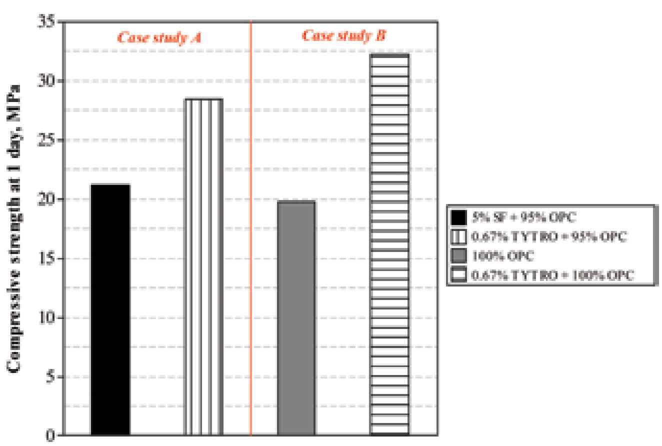

Fig. 4: Compressive strength at 1 day after spraying

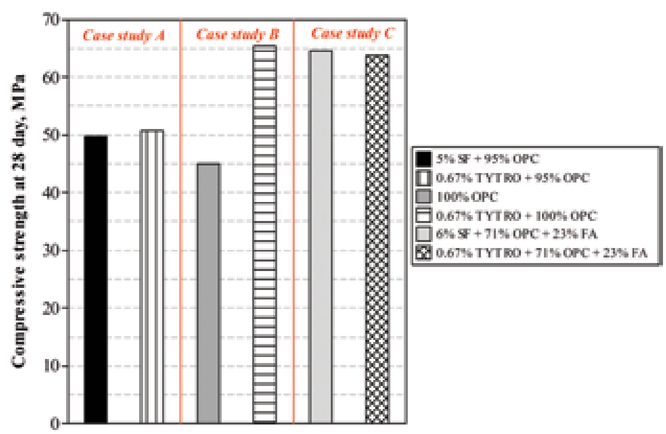

Fig. 5: Compressive strength at 28 days

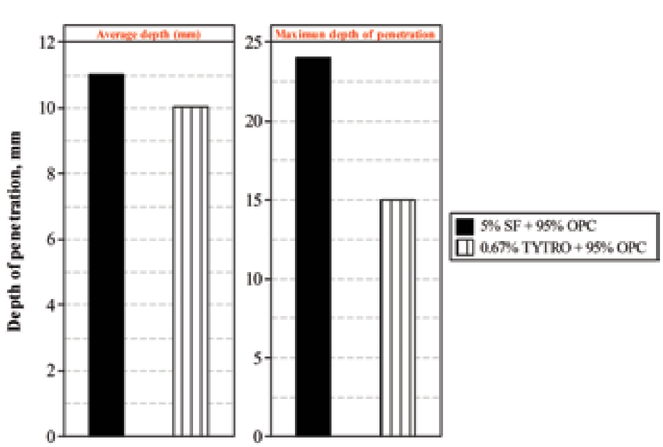

Fig. 6: Water penetration depth at 28 days

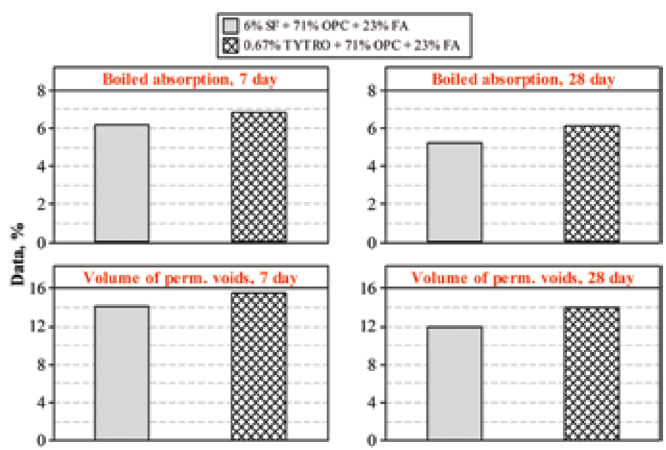

Fig. 7: Boiled absorption and volume of permeable voids tested at 28 days

Case Study C. Both mixtures performed in a similar manner, as the differences in boiled absorption were within 1 and 2% for the volume of permeable voids.

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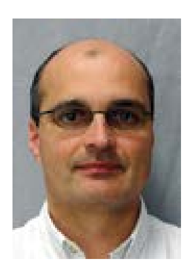


Klaus-Alexander Rieder *is a Global R&D Director for Concrete Products at Grace Construction Products, Luegde, Germany. He received his ScD in physics from the Technical University of Vienna, Vienna, Austria, in 1995. He is a member of ACI Committees 209, Creep and Shrinkage in Concrete; 215, Fatigue of Concrete; 360, Design of Slabs on Ground; 506, Shotcreting; 544, Fiber-Reinforced Concrete; Joint ACI-ASCE Committee 446, Fracture Mechanics of Concrete; as well as ASTM International and RILEM committees. His research interests include all durability- and cracking-related aspects of concrete and the development of high-performance fibers for concrete and shotcrete applications.*

Shotcrete Calendar

FEBRUARY 14-17, 2016
GeoTechnical & Structural Engineering Congress
Phoenix Convention Center
Phoenix, AZ
www.geo-structures.org

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 Regency and Wisconsin Center
Milwaukee, WI
www.shotcrete.org

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

MAY 11-12, 2016
SDC Technology Forum #39
Hilton Palacio del Rio
San Antonio, TX
www.concretesdc.org

Contractor's Workshop on May 10 to develop a strategic plan for concrete contractors.

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

SEPTEMBER 8-9, 2016
SDC Technology Forum #40
DoubleTree Salt Lake City Airport
Salt Lake City, UT
www.concretesdc.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

JANUARY 16-20, 2017
World of Concrete 2017
Las Vegas Convention Center
Las Vegas, NV
www.worldofconcrete.com

MARCH 15-17, 2017
ICRI 2017 Spring Convention
Theme: "Bridges and Highways"
Le Westin Montreal
Montreal, QC, Canada
www.icri.org

JUNE 11-14, 2017
ASTM International Committee C09, Concrete and Concrete Aggregates
Sheraton Toronto
Toronto, ON, Canada
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.

Railroad Working Safety

By Ted Sofis

Shotcrete, over the years, has had a long common history with the North American railroads. It was in the railroad magazine, *Iron Age*, where the term "shotcrete" first appeared, to refer to what was then commonly called "gunite." During the time of steam engines, structural steel over railroad tracks was often encased with shotcrete to protect the overhead steel from the locomotive's hot, wet steam. Shotcrete has long been used by the railroads, as an efficient concrete repair method and in the rehabilitation of bridge piers and abutments. Railroad tunnels are lined and repaired with shotcrete and it has long been a method used by railroads for rock and slope stabilization (Fig. 1). Our railroads provide access for products and materials in steel mills, power plants, and other industrial facilities, where shotcrete services are routinely performed. In plant railroads, transport shotcrete lined iron ladles from blast furnaces to Basic Oxygen Furnace (BOF) shops, where steel is made. Rail cars are commonly used for transporting coke from coke ovens to quench towers, where the red-hot coke is quenched and cooled. Coal is transported by rail into many coal-fired power plants and tanker cars of chemicals in chemical plants.

Fig. 1: A Snooper inspection crane being used for hillside access above railroad line during shotcrete placement

Working around railroads can present many dangers and it is very important to take every precaution available to avoid and reduce the possibility of accidents (Fig. 2 and 3). Construction personnel need training to become familiar with the dangers involved. When working on piers or abutments, safe distances for shotcrete operations must be observed. Coordination with railroad personnel must always be maintained. All railroad safety regulations must be followed. When working on or around railroad tracks or on railroad property, safety is our responsibility. We as contractors are responsible to ensure that all of our employees have received the necessary training. This often includes specific training courses mandated by the various railroads. A few things to be aware of are listed as follows:

Prior to Working on Railroad Property—

- The contractor should secure owner permission and fill out and complete a Right of Entry permit;
- Notify the railroad representative at least 48 hours before starting work and at least 24 hours from any person or equipment, including boom extensions, coming closer than 25 ft (8 m) to the track. This can vary for different owners; and
- Ensure that all employees have received the required training for the work being performed.

Personal Protective Equipment (PPE)—

- At a minimum, the contractor should require that their employees wear the proper personal protective equipment (PPE). This includes clothing that covers the torso and at least quarter-length sleeves, and pants or trousers must be ankle-length. Protective eyewear, hardhats, protective footwear, high-visibility apparel, and hearing protection should meet the latest ANSI or CSA standards.

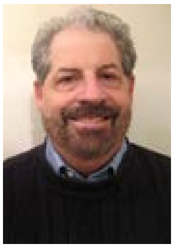
On-Track Safety—

- Maintain a distance of at least 25 ft (8 m) to any track unless the railroad's Employee-in-Charge (EIC) is present to authorize movements;
- Wearing PPE is mandatory at all times when working on railroad property; and
- Participate in a job briefing. The railroad's EIC will specify the type of on-track safety precautions necessary for the work being performed.

In-Plant Railroads—

- When working on tracks in a plant location, accessed by rail traffic, make sure there is a derailer in place and that all personnel are locked out in accordance with OSHA lock-out tag-out procedures (Fig. 4); and
- Make sure all equipment and motor vehicles are parked no closer to the railroad tracks than the plant safety requirements.

Shotcrete work in itself has its own set of safety considerations. These include dealing with plugs, whip checks, tying off hoses, communication between the nozzleman and equipment operator, and fall protection. In addition to railroad safety requirements, maintaining safe distances, and being aware of rail traffic, all general OSHA safety procedures need to be followed.



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.*

Fig. 2: In many cases, the shotcrete repair areas are close to the railroad tracks and special precautions have to be taken on active lines

Fig. 3: This bridge pier scheduled for repair in the spring is adjacent to active rail traffic

Fig. 4: During the shotcrete repairs to this coke plant quench tower, the railroad tracks are locked out with a derailer to prevent the use of the track while work is being done

Squeeze Pumps Safe and Versatile

By Jim Farrell

Squeeze pumps have enjoyed over 50 years of wide application and continual development in the high-velocity shotcrete and low-velocity concrete spraying market. Unfortunately, there are some misconceptions in the industry that the use of low-velocity spraying of concrete is limited to the use of rotor stator pumps, and that rotor stator pumps are not recommended with material with aggregate larger than fine sand. Current technology in squeeze pump equipment that is used in a wide variety of applications proves these perceived limitations are unfounded.

Squeeze pump technology was introduced by Challenge-Cook Brothers of California in 1963. The “Squeeze-Crete” pump was very successful during this time period; however, its success was limited by poor-quality rubber pumping tubes, which required a vacuum to be pulled on the pump housing to refill the pumping tube after material discharge. The only pumping tubes available during this time were the same type of hose used as the pump delivery line and were not designed for the demands of the pumping application.

Significant improvements in the quality and stiffness of rubber pumping tubes resulted in the reintroduction of the squeeze pump for pumping small aggregate concrete, shotcrete, stucco and aggregate pool plaster, and grout in the late 1990s. While squeeze pumps are limited in their performance when compared to hydraulic swing-tube pumps, these pumps offer advantages in operator safety, simplicity to clean and maintain, less surging and interruption of material flow, and lower cost to purchase when compared to swing-tube pumps. Squeeze pumps are popular outside the United States for pumping mortar and waste water with sludge.

Limitations of squeeze pumps when compared to swing-tube pumps include a limited pumping distance of 300 ft (90 m) horizontally and 50 ft (15 m) vertically when pumping a medium slump material with aggregate up to 1/2 in. (13 mm) using a rubber delivery line. This distance can be smaller if the size of the delivery line is reduced, which is the case with any concrete pump. It is recommended that the slump of the material pumped with a squeeze pump not be less than a 3 in. (75 mm) slump. The pumping distance can be increased by using hard pipe delivery line.

The squeeze pump is the industry standard for pumping cellular concrete because of the lower pumping pressure inherent with squeeze pumps. The maximum pumping pressure of squeeze pumps designed for pumping aggregate concrete is 400 psi (2.8 MPa), compared to 750 to 1100 psi (5.2 to 7.6 MPa) for standard rotor stator and swing-tube pumps. The lower pump output pressure maintains the integrity of the cellular concrete material and air (bubbles) in the material will be not be broken down. The lower output pressure of the pump also allows for the use of lower pressure, less costly delivery line.

Squeeze pumps have been combined with small batch and continuous mixers for many specialty mixing and pumping applications. In addition to cellular concrete, squeeze pumps are used for underground shotcrete applications using both the standard high-velocity shotcrete process as well as the low-velocity spraying of concrete using plaster or modified plaster nozzles. These same machines can be used in underground coal for a new coal mine safety procedure called “foamed rock dust”. The rock dust is mixed with water and cellular foam concentrate and is pumped through a nozzle onto the walls and ribs of an underground coal mine. This process has been a significant improvement over the dry rock dust and wet rock dust methods that have been used for the past 50 years.

Other low-velocity spraying applications for the squeeze pump mixer/pumps include aggregate and non-aggregate pool plaster, stucco, structural concrete insulated panels, culvert, manhole, marine, and bridge repairs. These pumps are on the recommended list for most all structural concrete insulated panels (SCIP) manufacturers worldwide. The compact size of the mixer/pumps allow for the hose runs to be kept at the minimum.

Most squeeze pumps are powered with hydraulics. As a result, these pumps are avail-

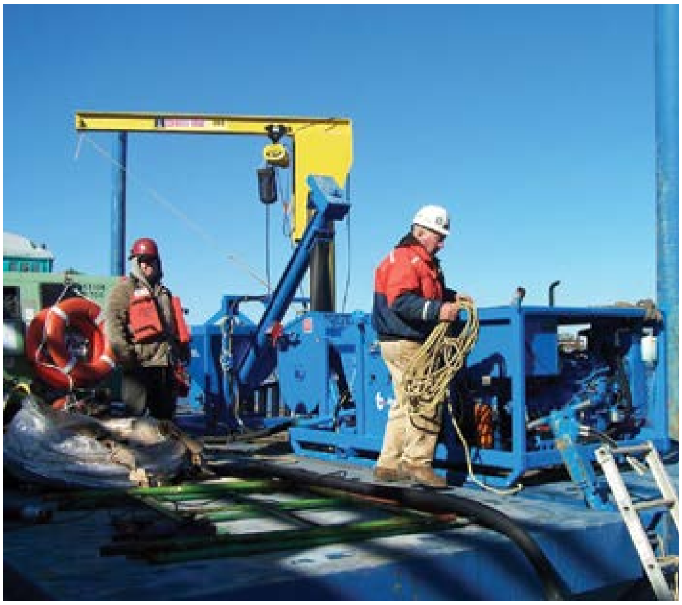


Fig. 1: Squeeze pump marine application

Fig. 2: Squeeze pump foundation pouring

Fig. 3: Squeeze pump underground

Fig. 4: Squeeze pump underground spraying

able as work tool attachments and can be operated off the auxiliary hydraulics from skid steer and hydraulic excavators. It does not require a high flow skid steer or excavator to operate a squeeze pump. Large pump attachments, with output of up to 25 yd^3/h (19 m^3/h), are used for the shotcreting of swimming pools. Smaller-output squeeze pumps are popular in pumping hot epoxy mixed with fine aggregate for underwater marine piling repairs (Fig. 1 through 4).

The versatility of hydraulic squeeze pumps allows for these pumps to operate in both forward and reverse, and the operator cannot damage the pump if the machine is run without material. The only part on the pump that comes in contact with the material is the inside of the rubber pumping tube, so cleaning is quick and simple. As a result, squeeze pumps can be used to pump all types of corrosive and abrasive materials.

Jim Farrell *is the Owner and CEO of Blastcrete Equipment Co. and Neal Manufacturing located in Anniston, AL. Blastcrete was founded in 1950 in Los Angeles, CA, and manufactured batch-type gunite machines until it was purchased by Farrell in 1983 and the business was moved to Anniston. Blastcrete is now a leading manufacturer of mixing, pumping, and spraying equipment, including squeeze pumps and swing-tube pumps. Blastcrete also manufactures the original Piccola rotary dry-mix (gunite) machine. Blastcrete acquired Neal Manufacturing in 2013. Neal is a leading manufacturer of asphalt pavement maintenance mixing and pumping and spraying equipment.*

Shotcrete toward Sustainability

By David Ruhl

HC Matcon Inc. (HCM) core values are Teamwork, Innovation, Service, and Sustainability. These values are reflected in the way that HCM operates. We seek to derive innovative solutions by engaging the broad experience base of our team and associates. Sustainability to HCM means building in a way that minimizes the burden of today's development on resources, such that the ability of future generations to survive with a similar quality of life remains intact.

Sustainable development requires thoughtful decisions to be made at all levels of project planning and execution, including conceptual design, site selection, design parameter identification, detailed design, material specification, construction, and ultimately asset management. Clearly, alignment of project team goals and objectives is required to move toward true sustainable development. One of the difficulties associated with multi-trade construction is that achievement of this alignment can sometimes be difficult. HCM does not allow this difficulty to impede efforts toward sustainability.

HCM and its partner engineering firm RWH Engineering Inc. (RWH) have developed a simple method of evaluating the relative environmental footprint of different project design and execution choices using a web-based tool named SEDA (Sustainable Engineering Design Audit). The tool permits comparative evaluation of design options by assigning a score based on the environmental impact of the materials required for each design. The design with the lowest score uses resources most efficiently.

SEDA receives material and fuel quantity inputs based on estimating outputs. Using the Econvent life-cycle database (version 2), materials are assessed for impact in nine fields (planetary boundaries), including climate change, biodiversity loss, biogeochemical, ocean acidification, land use, fresh water, ozone depletion, atmospheric aerosols, and chemical pollution.

HCM has observed that the result of completing a SEDA score analysis is greater than simply establishment of relative footprints. The process requires collaboration between the design, construction, and ownership teams. This collaboration that may otherwise not occur is the type of effort that is required to achieve sustainable development.

SEDA
SUSTAINABLE ENGINEERING DESIGN AUDIT

Based on SEDA score analysis, HCM has found that shotcrete is a sustainable choice in many applications. The following presents a few examples of HCM's recent experience applying shotcrete toward sustainability following the completion of a SEDA score analysis.

Deep Shotcrete Underpinning

RWH designed a 57 ft (17.5 m) deep shoring system for the new Vogue building in downtown Calgary, AB, Canada. The project was constrained by existing buildings on the east and west property lines—21 and 12 stories, respectively.

RWH evaluated two designs for the shoring system for this project: a conventional 35 in. (880 mm) diameter drilled caisson wall versus a 6 in. (150 mm) thick tied-back shotcrete shoring system. Both systems were designed to allow for the excavation to extend 41.3 ft (12.6 m) below the existing building footing.

The shotcrete shoring system offered savings of 525 yd^3 (400 m^3) of concrete and 24,200 lb (11,000 kg) of steel over the caisson wall. Additionally, the shotcrete was set back to the footings of the buildings on both the east and west sides so that the face of the shoring was flush with the property line. This method saved 16 in. (400 mm) of shoring thickness that would have been required for a traditional caisson wall, allowing the owner to maximize usable below-grade parking area.

The SEDA score of this project was 1.0 for shotcrete (best of options evaluated) and 1.23 for the caisson wall. A score of 1.23 indicates that the caisson wall had an estimated 23% greater environmental footprint based on material use.

Heritage Garden Landscape Walls

HCM was contracted for the structural design and installation of a reinforced concrete, water-retaining, undulating pool structure for the Rock Garden at Royal Botanical Gardens in Hamilton, ON, Canada. The pool restoration was part of a total renovation of the 80-year-old garden that included repairing deteriorated features and introducing new elements. Repairs and new elements were designed to respect the heritage nature of the garden.

Fig. 1: 21.3 ft (6.5 m) deep shotcrete underpinning below an existing building footing on the west elevation at The Vogue, Calgary, AB, Canada

Fig. 2: 41 ft (12.5 m) deep shotcrete underpinning below the bottom of an existing building footing on the east elevation

Fig. 3: Excavation in progress on the east elevation

Fig. 4: Tied back shotcrete underpinning at The Vogue

Fig. 5: Single-sided formwork at Royal Botanical Gardens Rock Garden pool, Hamilton, ON, Canada

Fig. 7: Wide angle, showing half of pool extent

Fig. 6: Shotcrete placement at Royal Botanical Gardens Rock Garden pool

Fig. 8: Pour five of Royal Botanical Gardens Rock Garden pool

HCM worked with RWH to provide a design-build solution for the rock garden pool to meet the needs of the architect and general contractor, including providing waterproofing solutions for submerged conditions. Due to the unique geometry of the pool structure, HCM proposed the use of shotcrete placement methods for concrete pool walls. The proposal was based on a SEDA score analysis of formed concrete and shotcrete placement methods for the wall elements. Because of the unique geometry, custom (non-reusable) formwork was required for walls. Shotcrete allowed for elimination of 50% of the formwork—a reduction of 2000 ft^2 (185.8 m^2) of formwork over the conventionally formed option. Additionally, the shotcrete surface was finished by hand to mimic aged concrete to maintain the heritage aesthetic of the pool feature.

The SEDA score of this project was 1.0 for shotcrete (best of options evaluated) and 1.13 for conventional formwork. A score of 1.13 indicates that the conventionally formed wall had an estimated 13% greater environmental footprint.

These projects exemplify opportunities to minimize the environmental impact of a facet of the construction of large projects through the application of shotcrete. HCM continues to look for opportunities to take steps toward sustainable development with a hope that an increasing number of project facets are reviewed, optimized, and chosen with sustainability in mind.

***David Ruhl**, P.Eng., is Contracts Manager with HCM Shotcrete. He has 7 years of consulting and construction experience with a focus in concrete construction, concrete technology, corrosion control, structural restoration, and concrete coatings.*

Shannon & Wilson Expands Underground Services Practice


Axel Nitschke

Shannon & Wilson is expanding its underground services practice with strategic hire Axel Nitschke, PE, leading the effort as the firm's new Director of Operations for Underground Services. Shannon & Wilson seeks to widen its national underground services portfolio and provide full-service underground consulting and engineering to transportation, utility, and other infrastructure clients throughout the United States and Canada. Shannon & Wilson has completed more than 900 tunnels and trenchless projects ranging from 2 to 65 ft (0.6 to 19.8 m) in diameter, and using a variety of techniques. Services have included geotechnical exploration, testing, instrumentation, engineering, and monitoring services.

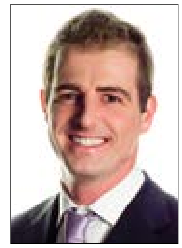
Nitschke, based in the firm's Washington, DC, Metro office, will focus on growing the firm's underground practice in new geographic markets and for new clients. Nitschke is a 20-year veteran of the underground services industry working on road, rail, and utility tunnel projects for infrastructure and mining clients in both urban and remote areas throughout North America, South America, and Europe. He is an active member of numerous professional associations and a regular contributing author for tunneling and shotcrete publications and associations, including the 2016 World Tunnel Congress.

With the addition of Nitschke, Red Robinson will shift his role to Director of Marketing for Underground Services. Robinson has been with Shannon & Wilson since 1974, and he has more than 40 years of underground experience consulting on 300-plus tunnel projects throughout the United States and abroad for city, state, and federal agencies; construction contractors; private industry; and railroads. He has written or co-authored more than 60 papers and 200 technical presentations for professional publications and associations.

Shannon & Wilson is an employee-owned consulting firm with more than 60 years of experience providing geotechnical and environmental consulting services from 12 offices across the United States. Contact Stephanie Fortner at (720) 258-4144 or smf@shanwil.com for further information.

King Shotcrete Solutions and Minequip Announce Staff Promotions

King Shotcrete Solutions (KSS) is pleased to announce several staff promotions within the King family of companies. KSS has appointed Simon Reny to the position of Sales Manager, Canadian Markets. In this position, Reny will be responsible for the sales of the complete line of KSS Products throughout the Canadian mining, tunneling, and construction markets.


Simon Reny

Reny began his career at King in 2004 as a Technical Sales Representative, after receiving his degree in civil engineering from Laval University. In his previous position as Manager, Technical Services, Reny helped build an industry-leading technical team that has established KSS at the forefront of new and emerging shotcrete technology. He is a member of ASA; Chair of ACI Subcommittee 506-A, Shotcreting-Evaluation; and a member of ACI Committee 506, Shotcreting.


William Clements

KSS has appointed William Clements to the position of Technical Services Manager. In his new position, Clements will be responsible for all technical aspects of the KSS shotcrete materials line. Clements joined King Packaged Materials Company (KPM) in June 2010 as a Technical Support Engineer and in this role has worked closely with the KSS technical sales team, providing guidance on product development projects and providing technical support for both internal and external customers. Clements is a member of the Association of Professional Engineers of Ontario (APEO), and received his MASc in civil engineering from the University of Windsor in 2010.


Craig McDonald

KSS has appointed Craig McDonald to the position of General Manager, Minequip. He will be responsible for managing both Minequip's operations and sales functions. McDonald began his career at King over 20 years ago as a mechanic for the Minequip division of KSS after graduating from Canadore College in mechanical engineering technology. He has since taken on sales management roles for both the shotcrete materials and equipment divisions. He is a member of The Canadian Institute of Mining.

King Shotcrete Solutions is a leading manufacturer and supplier of shotcrete materials and equipment for the North American shotcrete industry. Minequip is the shotcrete equipment arm of King Shotcrete Solutions and has grown to become a leading supplier of Aliva shotcrete placement equipment and Putzmeister concrete/shotcrete pumps for the North American shotcrete industry.

CCS GROUP, LLC, Launches New Website

CCS Group, LLC, announced a recent update to their website. The site was redesigned with streamlined menus, simple navigation, product brochures, and online quote requests. It has the information you need at any time of day. CCS Group will continually be expanding its online content to bring their customers updated and relevant information, and encourage website visitors to bookmark it, check back often, and connect with the company on Facebook, LinkedIn, and Twitter to receive notice when updates and new content are added.

CCS Group, LLC, provides nationwide grain elevator maintenance and repair services: shotcrete/gunite liners, carbon fiber technology, hopper repair/installation, concrete crack and spalling repair, catastrophic failure, and silo assessment services. In 2015, CCS opened up a second location in Millstadt, IL, to offer service, sales, and rentals of REED concrete pumps and parts, a variety of shotcrete/gunite accessories, as well as material for the construction, refractory, tunneling, and mining industries. Visit the website at **www.ccsgrouponline.com** for more information.

National Swimming Pool Foundation and Genesis Combine Forces

The National Swimming Pool Foundation® (NSPF®) and Genesis 3, Inc., announced that they are merging their operations to deliver a broader spectrum of training programs effective January 1, 2016. Genesis will continue to elevate and transform the residential pool and spa design and construction industry. NSPF will continue to keep public pools safer and open. They look to merge their respective swimming pool service professional certification programs to accelerate training to the service sector. Both organizations operate globally and are accredited by the International Association for Continuing Education and Training (IACET).

The combined organization will further the NSPF mission as a 501(c)(3) nonprofit: to encourage healthier living by increasing aquatic activity through education and research. "The delivery of Genesis training very much aligns with NSPF's effort to increase demand for immersion and water activity," states NSPF CEO Thomas M. Lachocki. Genesis faculty have trained thousands of pool builders, attracting more people to water by combining beauty, functionality, and safety. NSPF instructors have trained over 400,000 professionals in 93 countries. In addition, NSPF has directed $4 million—to fund health benefit research and numerous learn-to-swim programs through its Step into Swim initiative—to attract more people to water.

As NSPF and Genesis achieve success together, the greater the demand will be for recreational water, resulting in better public health and industry growth. "When leaders work together, the benefits for all become greater," states Scot Hunsaker, NSPF Board President. "Each organization is the preeminent educators in their respective areas. Together, they create synergies that will transform lives, careers, and our industry," adds Brian Van Bower, Genesis co-owner.

NSPF—with its 50-year history and its cutting-edge online training programs—is committed to ensuring the Genesis brand continues to evolve and thrive. "This merger in no way diminishes the leadership participation of the people who built Genesis," states Lauren Stack, NSPF Mission Development Director, who will support the Genesis team and ensure the two organizations maximize synergies while becoming one. "Brian and Skip will continue as educators, advisors, and cultural ambassadors for Genesis," adds Bruce Dunn, NSPF Treasurer and long-term industry stalwart.

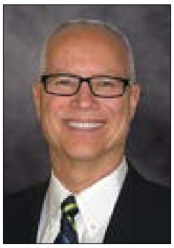
Genesis has benefited from a long term partnership with the International Pool | Spa | Patio Expo, part of the Global Exhibitions Division of Informa PLC, taking place last year November 10-12, 2015, in Las Vegas, NV. "We are thrilled that the news of this merger is happening right before the Informa show," says Skip Phillips, Genesis co-owner, adding, "there is no better way to celebrate than over a glass of wine in the Genesis Pavilion on the show floor." Lachocki adds, "The Genesis faculty, advisors, members, sponsors, owners, and staff are world-class. It will be an honor to stand beside them in Las Vegas and work with them in the years ahead to accelerate growth and excellence in our field."

We believe everything we do helps people live healthier lives. Whether it's encouraging more aquatic activity, making pools safer, or keeping pools open, we believe we can make a difference. NSPF offers products and programs that are technically sound, convenient, and beautifully designed. As a 501(c)(3) nonprofit located in Colorado Springs, CO, proceeds go to fund research and to help create swimmers. The National Swimming Pool Foundation has been keeping pools safe and open since 1965. Visit **www.nspf.org** or call (719) 540-9119 to learn more.

Since 1998, Genesis has elevated an entire industry by offering a comprehensive set of educational programs tailored to the specific needs of the pool and spa professional. Through the Genesis 3 University established in 2012, Genesis continues to nurture designers and builders trained in the multiple technical and creative disciplines required to create top-shelf installations that not only look fantastic but also function efficiently, reliably, and safely. To that end, Genesis-trained design and construction professionals are the global standard for the watershaping industry.

Keller North America and Hayward Baker Announce Promotions and Appointments

Keller North America (Keller NA), a division of Keller Group plc, has appointed James Hussin, PE, to the position of Business Development & Marketing Director for Keller NA and Jeffrey Hill, PE, into the role of a Director for Hayward Baker (HB).


James Hussin

Prior to his new appointment, Hussin served as a Director for Hayward Baker Inc., one of seven Keller NA companies, since 2003. Hussin has been progressive in leading business development and marketing efforts and providing technical risk assessment on major projects for Hayward Baker Inc. He has authored many publications and is active in several important industry organizations, particularly in leadership positions in the ASCE GeoInstitute. He received his MSCE in soil mechanics and foundation engineering from the California Institute of Technology and his BSCE from Columbia University. As Director for Keller NA, Hussin draws on more than 35 years of experience in geotechnical engineering and construction to spearhead business development and marketing strategies for Keller NA, along with streamlining best practices and synergies to build the Keller brand and that of its subsidiaries.


Jeffrey Hill

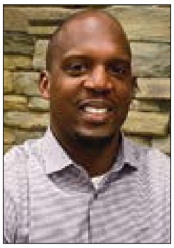
In May 2015, Hill succeeded Hussin in the role of a Director for Hayward Baker, from his previous role as the Central Region Director of Business Development. In Hill's new role, he is developing and implementing corporate business strategies to promote market awareness and increase project opportunity efforts for Hayward Baker throughout the United States. Hill has worked in the specialty geotechnical contracting field since graduating from the University of Illinois. He possesses a wide range of technical expertise including earth retention, micropiles, ground improvement, and grouting projects. Hill is active in several geotechnical industry organizations, and is a national committee member of two AREMA technical committees.

Commenting on both appointments, John Rubright, President for Keller NA, stated, "We are pleased to welcome Jim and Jeff into these important management positions. We take pride in our strong brand reputation that is hard-earned across all companies in Keller NA. Both Jim and Jeff have taken great strides to maintain and expand the brands and reputations of Keller NA and Hayward Baker. We are confident that these appointments will lead our brands into the future."

James Hussin is located at the Hanover office and can be reached at (410) 551-8200 or by e-mail at jdhussin@keller-foundations.com. Jeffrey Hill is located at the St. Louis, MO, office and can be reached at (314) 802-2920 or by e-mail at jrhill@haywardbaker.com.


Bryan Schertz

Bryan Schertz has been appointed to the position of Health, Safety, and Environment (HSE) Director. Prior to his new appointment, Schertz served as the Safety Director for Hayward Baker Inc. since 2003. Schertz has been a leading force in Hayward Baker's and then Keller NA's safety initiatives. He has 25 years of experience in construction, consulting, industrial hygiene, and safety management, and is a Certified Safety Professional (CSP). Schertz was instrumental in developing and implementing safety goals and principles as the Safety Director for Hayward Baker. In his new role as the HSE Director for Keller NA, Schertz will oversee, manage, and implement Keller's corporate environmental, health, and safety plan "Think Safe" to ensure the safe working practices of over 3900 employees continent-wide.


Will Brown

In turn, Hayward Baker now welcomes Will Brown into the role of Safety Director for Hayward Baker. Brown received his master of science degree in safety and health from Marshall University, is a Certified

Safety Professional (CSP), and has 20 years of safety management experience. Brown's prior experience includes 2 years as a Senior Loss Control Consultant and 18 years in general construction, most recently as a safety manager in the Washington, DC, metro area.

Commenting on both appointments, Rubright stated, "We are pleased to welcome Bryan and Will to these important posts. The employees of Keller North America are proud of our 'Think Safe' program, and we have made great strides in recent years. Our goal remains to reduce our incidents to zero. We are confident that the appointments of Bryan and Will are important additional steps in this journey to zero incidents."

Bryan Schertz and Will Brown are both located at Keller NA and Hayward Baker's corporate headquarters at 7550 Teague Rd, Suite 300 in Hanover, MD. Schertz can be reached at (410) 551-8200 or by e-mail at bkschertz@kellerfoundations.com. Brown is available at (410) 551-8200 or at wjbrown@haywardbaker.com.

Hayward Baker (**www.haywardbaker.com**) is North America's leader in geotechnical construction and is annually ranked by *Engineering News-Record* (ENR) magazine No. 1 in Excavation and Foundation. With a 60-year record of experience, Hayward Baker offers geotechnical construction technologies through a network of more than 30 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.

Keller North America (**www.keller.co.uk**) is part of the Keller Group plc, a multinational organization providing geotechnical construction services throughout the world. Keller is the largest independent foundation contractor in the world with ongoing operations in over 40 countries across six continents. The Keller organization was founded in 1860.

PCA Celebrates 100th Anniversary at Events Throughout 2016

2016 marks the centennial anniversary of the Portland Cement Association (PCA), the nation's leading advocate for America's cement manufacturers.

In celebrating its 100th year, PCA will be involved with as well as hosting several events throughout the year. Event highlights include:

- February 2-5, 2016: World of Concrete, Las Vegas, NV—official launch of Centennial Celebration;
- March 14-15, 2016: PCA Spring Congress, Chicago, IL—main centennial celebration for PCA membership;
- May 24-25, 2016: 2016 DC Fly-In, Washington, DC—reception for Members of Congress, Congressional staff, agency officials, and allied groups in conjunction with transportation fly-in; and
- July 18, 2016: Open house at PCA Skokie headquarters and CTLGroup to showcase campus to local politicians, government officials, local construction and business leaders, CTLGroup clients, and potential clients.

PCA has been a widely recognized authority on the technology, economics, and applications of cement and concrete for nearly 100 years. Representing America's cement manufacturers, PCA is a vocal advocate for sustainability, economic growth, sound infrastructure investment, and overall innovation and excellence in construction.

To find out more about the events, please contact Erik Rancatore at (847) 972-9138.

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 are working on a project in the United States, in Chicago, IL, and we are investigating the feasibilities involving shotcrete façade. The project involves large elements (50 x 50 ft [15 x 15 m]) with double curvatures (average radius 50 ft [15 m], smaller in some areas). The concrete would have an architectural finish and should be in white color (cemento bianco).*

We are thinking about a reinforcement grid of 4 x 4 in. (100 x 100 mm); the diameter has still to be determined.

Do you have any recommendations/specifications concerning the conception of this type of façade?

We saw that it is possible to use reinforcement in glass fiber, epoxy reinforcing bars, or steel reinforcing bars. What are the advantages of each?

Also, we have some more specific questions:

1. *What is the durability of the product for this type of application—for example, estimated design lifetime?*
2. *Is on-site cold bending possible? To which radius of curvature?*
3. *Could there be a problem with steel staining the concrete?*
4. *Could there be a problem with concrete aggregation on the mesh when the concrete is shot? The coating doesn't get away?*
5. *Do you have an estimation of the cost per m²?*

Answer: The double-curved concrete shape you mentioned is an ideal application for shotcrete. Because the shotcrete surface is able to be finished by hand once the sections are shot, a wide variety of architectural finishes are readily available. Because shotcrete is a placement method for concrete, the structural reinforcement is determined by conventional concrete design requirements. Reinforcing steel bars are typically conventional mild steel bars or epoxy-coated bars. Micro- or macro-fibers can also be added to the concrete mixture to provide additional reinforcement, although they generally supplement conventional reinforcing bars. Synthetic fibers are preferable over steel fibers in sections that will be exposed to view, as steel fibers can exhibit rust stains at the surface. The structural engineer should determine the proper amount of reinforcement for the structural sections.

Answering your specific questions:

1. Durability—because shotcrete is a placement method for concrete, it will have the same durability as cast concrete. The shotcrete mixture can have air-entraining admixtures for increased freezing-and-thawing resistance. Also, shotcrete mixtures often use silica fume that helps to increase strength and reduce permeability of the concrete, giving the concrete enhanced durability.
2. Sure. Because shotcrete is concrete, all bending methods used in conventional reinforcement are applicable. ACI 318-14, Section 25.3.2, has minimum diameters for bends. Code Section 26.6.3.1 requires cold bending unless permitted by the engineer.
3. With proper concrete cover and close attention to tie wire projections, there should not be any significant staining of embedded steel reinforcement on the surface.
4. Shotcrete impacts the surface with a material stream velocity from 60 to 80 mph (97 to 129 km/h). It compacts and consolidates the concrete around the embedded reinforcement. With proper shotcrete application techniques, there should be no buildup of aggregate on the reinforcement. Epoxy-coated reinforcement is used extensively in shotcreted work. For more detailed information about the use of epoxy-coated reinforcement, you may want to consult the Epoxy Interest Group of the Concrete Reinforcing Steel Institute (**www.epoxyinterestgroup.org**).
5. Cost is determined by the geographic location, size, shape, and accessibility of your structure. You may want to consult our ASA Buyers Guide to find experienced shotcrete contractors who work in the Chicago area (**www.shotcrete.org/pages/products-services/Buyers-Guide/index.asp**).

Question: *I am exploring ways to renovate an existing fountain, the mechanics (plumbing and so on) of which have been/will be abandoned. There are existing cracks running straight across the reservoir, perhaps because the original drawings did not include a proper crushed stone base down to the frost line.*

We are raising the fountain base and water line up 8 to 12 in. (203 to 305 mm). I hope we can place the water, electrical, and drain lines directly on top of the existing reservoir (opposed to trenching down through it). Budget is a huge concern.

My questions/concerns:

1. *Can/should we provide a ±10 in. (±254 mm) layer of crushed stone or gravel in between the existing concrete reservoir and new, raised reservoir, which could be a 9 to 10 in. (229 to 254 mm) layer of gunite? I'm hoping this may provide some buffer for any future heaving of the existing reservoir and hopefully keep costs down.*
2. *Should we then core drill the existing concrete to provide drainage—that is, 1/2 in. (13 mm) weep holes—in case any water finds its way there?*
3. *Should there be any water stop(s) in the new gunite reservoir, which also acts as a seat wall along the perimeter?*
4. *Can you recommend any low-cost "flexible" products for the finished surface that would "hide" any (heaven forbid) future imperfections? Perhaps an epoxy paint?*
5. *If you recommend we instead pour directly on top of the existing gunite (instead of the stone buffer), are there any other recommendations beyond patching the cracks and sandblasting/cleaning the existing concrete?*

Answer: Questions 1, 2, and 3—in liquid-containing structures, it is generally preferred to keep the concrete floors on a subbase that allows some shrinkage and thermal volume change movement. Your 10 in. (254 mm) of stone would serve to keep the new floor from bonding to the old and thus accomplish this, as well as preventing existing floor cracks from mirroring through the new concrete. It would seem the underdrain system should allow draining of water, so some kind of penetration through the old floor is advisable. Because the seat wall is a concrete wall that will undergo some shrinkage and thermal stresses, depending on the dimensions, it may need contraction joints with waterstops to accommodate shrinkage stresses. Your design engineer can consult ACI 350, "Code for Environmental Structures," for guidance on joint spacing for temperature and shrinkage.

Question 4—this is outside our expertise. Shotcrete finishes can vary from a rough as-shot to a smooth floated finish. Any coating introduces required maintenance because most coatings have a limited life span, especially in outdoor exposures with water wetting/drying cycles. If the shotcrete mixture is designed properly, and shot properly, then once the final concrete surface is set, there shouldn't be any future imperfections.

Question 5—we think casting on top of the stone base is a good way to address the rehabilitation.

Question: *Why is shotcrete not applied to general housing? It could be applied against outer insulation reinforced panels, forming both pillars and walls at the same time. The higher cost of shotcrete should be more than compensated by much shorter time and lower need of cranes.*

Answer: Shotcrete has been used for residential concrete construction, often for domed or other curved shapes. It has also been used to provide a structural skin over internal insulation panels in more rectangular layouts. Because shotcrete is concrete projected at high speed (between 60 and 80 mph [97 and 129 km/h]), many insulation products do not withstand the impact and abrasion associated with shotcrete impact. In many cases, when shooting over an insulating foam panel that cannot withstand the high-velocity impact, shotcrete isn't used, but a low-velocity plaster/grout mixture is spray-applied over the insulation. Here's a link to the PCA website with a page on residential housing using a foam inner panel: **www.cement.org/think-harder-concrete-/homes/building-systems/shotcrete**. You can also find similar system information doing a web search for "shotcrete foam panel."

Question: *I have a large aquatic project where the contractor would like to use gunite (dry-mix) versus wet-mix shotcrete. We have typically only allowed wet-mix on projects due to a bad experience in the past with using gunite. Would you have any reservations with the dry-mix process? We are being informed that they are taking the proper measures to ensure quality control—is that good enough or is there something we should reference or look for?*

*Second question is in regard to aggregate in shotcrete. Per ACI 506R-05, there are the Grading limits—Grading 1 and Grading 2. They are submitting grading 1 for the dry-mix. I would like to suggest the use of Grading 2 aggregates with the benefits of the larger aggregate. There was also an ASA Technical Tip (*Shotcrete*, Winter 2011) supporting the use of larger aggregates of Grading 2. Is there reason not to use Grading 2 for the dry mix? I was not able to determine any reason not to.*

Answer: Properly mixed and applied by an experienced nozzleman, dry-mix can be equal to wet-mix shotcrete. The water-cementitious materials ratio (*w/cm*) is generally lower in dry-mix, so you will get less drying shrinkage. Areas where wet-mix is preferred would be thick sections needing a lot of volume because wet-mix has two to four times the production rate of dry-mix. Very congested reinforcement with large bars (No. 8 and above) may also be somewhat easier with wet-mix.

ACI 506R Gradation 2 is certainly doable in dry-mix. Many pre-bagged dry-mix shotcrete materials use the larger aggregate. The contractor may not want to use the No. 2 gradation to avoid having a second aggregate on-site, if site batching manually.

ASA Launches New Logo and Rebranding Efforts at WOC 2016

As you may have noticed, ASA has introduced a new logo. This is just one part of our rebranding effort to freshen and modernize our look. Commonly referred to as "ASA," it is fitting that our new look features our initials prominently. The logo retains some of our original theme, with the same green and a stylized shotcrete nozzle, while introducing a clean, simple font for the text. Along with the logo, we have set new graphics standards for colors, fonts, layouts, and photos to make the look of our various products more consistent. This includes our website, *Shotcrete* magazine, our printed materials such as compilations and advertisements, our PowerPoint presentations, and our logo wear. This effort in coordination allows our brand to be more readily identifiable. Corporate members will have access to our new "Corporate Member" ASA logos in February. Use them on your website, link to **www.shotcrete.org**, and allow ASA to help you market the benefits of shotcrete to your clients!

ASA Officers and Directors Elected

Executive Committee

Left to right: Marcus H. von der Hofen, Bill Drakeley, Larry Totten, and Scott Rand (Missing from photo: Lihe [John] Zhang)

The ASA membership elected the following individuals to leadership roles in the association, with terms beginning February 1, 2016. President **Bill Drakeley**, Drakeley Industries; Vice President **Scott Rand**, King Packaged Materials Company; Secretary **Larry Totten**, Consultant; and Treasurer **Lihe (John) Zhang**, LZhang Consulting & Testing Ltd., were all elected to 1-year terms. **Marcus H. von der Hofen**, Coastal Gunite Construction Co, will serve as Past President to complete the Executive Committee for 2016.

Board of Direction

Three individuals were elected to 3-year terms as ASA Directors, beginning on February 1, 2016. **Dennis Bittner**, The Quikrete Companies, was reelected to a second term. **Lars Balck**, Consultant, and **Axel Nitschke**, Shannon & Wilson Inc., were elected to first terms.

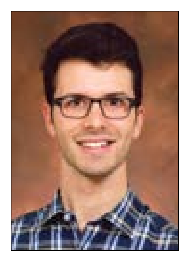
These three Directors join the previously elected Directors and the ASA Executive Committee to form the 14-member 2016 ASA Board of Direction.

Dennis Bittner

Lars Balck

Axel Nitschke

2015-2016 ASA Graduate Scholarship Awarded



Antoine Gagnon

The 2015-2016 ASA Graduate Scholarship has been awarded to **Antoine Gagnon**. He received a stipend of $3000 (USD) for tuition, residence, books, and materials.

Antoine Gagnon received his bachelor's degree in civil engineering from Laval University, Québec, QC, Canada, where he continues to work toward his master's degree in the same. The focus of his graduate research is in developing shotcrete mixture designs with added environmental/sustainable value. Toward that end, he is exploring the reduction of waste associated with shotcrete rebound and inclusion of industrial waste and recycled materials to minimize the use of new resources, all with an eye toward conventional and environmental costs as well as sustainable performance.

These scholarships are awarded each year to students pursuing higher education in the field of concrete with an interest and potential for professional success in the shotcrete industry. Established in 2008, the ASA Graduate Scholarship Program seeks to identify, attract, and assist outstanding graduate students in their pursuit of careers in the field of concrete, particularly in the application of the shotcrete process. This program opens each year in late spring. Visit **www.shotcrete.org/pages/education-certification/grad-scholarships.htm** for more details on the ASA Graduate Scholarship Program.

Eleventh Annual ASA Outstanding Project Awards Banquet

It was a packed house at the Vdara Hotel & Spa on Tuesday, February 2, 2016, as ASA celebrated its eleventh annual Outstanding Shotcrete Project Awards Banquet at World of Concrete. Attendees gathered to socialize with fellow ASA members and celebrate the top projects of 2015 that exemplified the effective and beneficial use of shotcrete as a placement method for concrete construction. You can see this year's award-winning projects beginning on page 18 of this issue.

Special thanks go to ASA's banquet sponsors, without whose generous donations this event would not be possible. A complete list of these companies can also be found in this issue, beginning on page 12. Think you've got what it takes? Start submitting your projects now!

We urge all ASA members to begin thinking now about current shotcrete projects that may be worthy of consideration in 2016 as a twelfth annual ASA Outstanding Shotcrete Project award winner. Let the outstanding projects you complete this year be the ones we celebrate at next year's ASA awards banquet!

The ASA Outstanding Shotcrete Project Awards program will again open in February after WOC 2016! The 2016 awards program will accept projects completed between January 1, 2014 and September 1, 2016; multiple projects may be submitted from the same company. Deadline for submissions will be October 3, 2016. More information can be found at **www.shotcrete.org/ASAOutstandingProjects**.

ASA Spring 2016 Committee Meetings in Milwaukee, WI

The ASA Spring 2016 Committee Meetings will be held at the Hyatt Regency and Wisconsin Center on Saturday, April 16, 2016.

The following committees have scheduled working meetings: ASA Executive Committee, Education Committee, Pool & Recreational Shotcrete Committee, Safety Committee, Publications Committee, Marketing Committee, Membership Committee, Underground Committee, and the ASA Board of Direction. These meetings offer participants the opportunity to network with colleagues, provide input on shotcrete materials and publications, and take part in carrying out ASA's overall mission.

The ASA committee meetings are held in conjunction with The American Concrete Institute (ACI) Concrete Convention and Exposition but do not require registration with ACI. ASA meetings are open and free to anyone with an interest in the shotcrete process. If you are active in the shotcrete industry, you are welcome and encouraged to attend.

Scheduled times for all meetings can be found at **www.shotcrete.org/pages/news-events/calendar.htm**.

ASA Establishes New Technical Committee

The ASA Board of Directors approved establishment of a new standing Technical Committee at the November Board meeting in Denver, CO. Lihe (John) Zhang was appointed as the Chair of the newly established committee.

The mission of Technical Committee is:

To oversee the technical activities of ASA, including the review and evaluation of technical presentations, publications, handouts, etc., and the appraisal of research projects under consideration for ASA sponsorship.

Lihe (John) Zhang

The committee will work directly with the ASA Technical Director coordinating technical activities and critically reviewing our documents, presentations, and technical inquiries to be consistent with ASA's mission and proper industry practice. The Technical Committee will also establish research needs, review research proposals, and make recommendations to the Board for ASA-funded research efforts. For more details on this new committee, read the Committee Chair Memo on the ASA Technical Committee on page 4 of this issue.

Ground Improvement in Underground Construction and Mining Short Course

May 9-11, 2016 | University of Colorado in Boulder, Boulder, CO

ASA is proud to sponsor this 4th Annual Short Course, formerly held at the Colorado School of Mines, as a Supporting Association. The three-day Short Course is taught by leading international experts in the specialty field of ground improvement, which is becoming increasingly integrated with heavy civil underground and mining projects. Instructors include design professionals, contractors, equipment manufacturers, and end-users with first-hand knowledge of in-the-field applications of ground improvement.

When you complete this course, you'll have knowledge on the design and implementation of the most appropriate and cost-effective method to use in your construction project. The course further provides an excellent opportunity for networking and mingling with industry professionals.

The Ground Improvement in Underground Construction and Mining Short Course is organized by Levent Ozdemir, an internationally renowned tunneling consultant, and Tim Coss, President of Microtunneling Inc., in conjunction with Benjamin Media—the same organizers who bring you the Microtunneling Short Course and the Breakthroughs in Tunneling Short Course.

For more information about the course or to register, visit **www.groundimprovementshortcourse.com**.

REED Now Offers Pan Mixers

REED Shotcrete Equipment's new Pan Mixer can mix a 2200 lb (998 kg) batch of materials in 3 minutes. The mixer then quickly discharges the material into the pump hopper to be either sprayed or pumped.

The M2200 features:

- Variable-speed mixer blade rotation (hydraulic motor drive, 59 rpm max, torque 13,762 Nm)
- Manual retractable legs, four each
- Forklift tubes and lifting eye kit for easy lifting and transport
- Work platform with control box and safety railing
- Quarter panel safety grates cover with cutoff switch
- Stainless steel water tank for precise water measurement (optional) (plastic is standard)
- Bolt-on style paddles for easy change-out
- Bag splitter
- NEMA 4 fully enclosed weatherproof control box mounted on operator platform
- Power on-off, mixer stop-start, e-stop, horn-reset, mixer rpm control, primary discharge open-close, cleanout discharge open-close, cleanout tilt up-down, hydraulic pressure gauge and amp meter

Dimensions:

- Length: 96 in. (8 ft) [2.4 m]
- Width: 86 in. (7 ft, 2 in.) [2.2 m]
- Height:
  - Minimum: 102 in. (8 ft, 6 in.) [2.6 m] (for transport)
  - Maximum: 154 in. (12 ft, 11 in.) [3.9 m] (for operation at max height)
  - Minimum clearance under discharge door: 47 in. (3 ft, 11 in.) [1.2 m]
  - Maximum clearance under discharge door: 77 in. (6 ft, 5 in.) [2 m]
- Mixer weight: 6600 lb (2994 kg)

The M2200 Pan Mixer can also be powered by a small hydraulic power pack (sold separately). Power pack information is as follows:

- Electric power: 50 hp, 440 V, 3-phase, 60 Hz (50 Hz is also available)
- Diesel power (optional)
- Variable displacement hydraulic piston pump (displacement 71cc)
- Quick disconnects (hydraulic, electrical) for ease of setup and cleanup
- Power pack will store under the M2200 mixer during transport

The M2200 Pan Mixer was designed to be easy to transport. The four legs of the mixer quickly shorten to reduce the shipping height. The water tank folds downward for transport. The hydraulic power pack slides underneath the mixer. A forklift driver can quickly unload the M2200 from a flatbed truck using the forklift tubes on the mixer and the power pack.

Contact REED Shotcrete Equipment at (909) 287-2100 or visit **www.reedpumps.com**.

Mix-Elvator™ Batch Plant has New Features

The Mix-Elvator™ dry-process shotcrete (gunite) batch plant, manufactured by Airplaco Equipment Co., features a new variable hydraulic flow control. The new flow control design allows even greater ease when proportioning materials in the batch plant. The contractor can control the ratio of sand and cement materials by adjusting the speed of two feed augers. These feed augers direct materials to a mix auger, where they are blended and before loading into the dry-mix shotcrete machine. In addition, Airplaco has centralized all operator controls for the machine to offer greater ease of use.

The Mix-Elvator design allows dry-process shotcrete contractors to mix their own material at the jobsite. It is a reasonably sized machine that can be towed behind contractors' existing vehicles. The Mix-Elvator features a 30 hp diesel engine and hydraulic-ratio control system and optional pre-dampener spray bar system. It has a maximum mixing capacity of up to 20 yd^3/h (15.3 m^3/h), sand hopper capacity up to 45 ft^3 (1.3 m^3), and cement hopper capacity of 4 ft^3 (0.1 m^3). Combined with the C-10 dry-process shotcrete (gunite) machine, the Mix-Elvator offers a self-contained rig for construction and repair applications.

Contact Airplaco Equipment Co. at (888) 349-2950 or visit **www.airplaco.com**.

Preload

Prestressed Concrete Tanks

In the 1930s, engineers at Preload embarked on a vision which would literally revolutionize the storage tank industry. The idea was simple: create a storage tank structure that would stand the test of time and provide excellent service for decades. One that would not require coatings and thus would be virtually maintenance-free. One that could be used for many applications across many different industries. One that would be economically priced when compared to other types of storage tank structures commonly in use at that time.

Preload engineers continued to research various means to accomplish their goal and a few years later, the engineering research was complete and the solution was clear. Shotcrete and concrete would be used to construct the tank to ensure long-term durability and eliminate costly maintenance. The tank wall would be prestressed using a solid wire manufactured from high-strength steel to put it into permanent compression to eliminate cracking and long-term durability problems. The prestressing wire would be placed with a new invention that would allow precise, economical, and safe tensioning to produce a reliable tank structure. Shotcrete would prove to be one of the most important materials, as it provided a sure means of encasing the high-strength wires and bonding them to the wall to guarantee corrosion-free service and reliable performance. Last but not least, Preload would perform the work with specialized engineers and trained construction professionals to ensure a level of quality that had never before been applied to concrete storage tank structures. In doing so, the best properties of concrete, shotcrete, and steel were used and the industry of wire-wrapped prestressed concrete tanks was born. Preload's invention was one of the first examples of sustainable development in modern construction history. Compared to conventional cast-in-place concrete tank walls, quantities of concrete and steel in wire-wrapped tank walls were reduced by over 50% as a result of the efficient use of the materials. Over 85 years later, the benefits of the invention of wire-wrapped prestressed concrete tanks by Preload continue to have a lasting impact on communities and industries across the nation and around the world. The hallmarks of Preload's invention continue to be enjoyed and appreciated by thousands today, as wire-wrapped prestressed concrete tanks provide durable, low-maintenance storage for the world's most precious natural resources, including water, reuse water, thermal energy storage, and liquefied natural gas. Preload tanks also serve to protect the environment when they are used to treat and store wastewater, storm water, reuse water, and process water for industrial applications.

Fig. 1: Early prestressed shotcrete storage tank—circa 1936—in continuous maintenance-free service for more than 70 years

85 Years of Exceptional Quality Design and Construction

Today, Preload continues to be the industry leader in the design and construction of wire-wrapped prestressed concrete tank structures. With over 3500 structures built to date for all types of liquid storage, including water, reuse water, wastewater treatment, storm water, industrial process applications, thermal energy storage, and liquefied natural gas, Preload continues to lead the way in the design and construction of these structures in the United States and around the world. Preload wire-wrapped prestressed concrete storage tanks are virtually maintenance-free and are constructed in volumes ranging from 100,000 gal. (380 m^3) to well over 40 million gal. (150,000 m^3). Preload water storage tank applications for public entities meet a wide range of demands for different operating requirements and site conditions. Those demands include tanks that are partially or fully buried, have internal baffle walls or mixing equipment, and have various types of exterior architectural treatment.

The innovative design and construction techniques invented by Preload continue to be used to safely build high-quality storage tanks with proven long-term durability. Many of these design and construction techniques have been adopted as industry standards in American Concrete Institute (ACI) and American Water Works Association (AWWA) publications. In addition, new innovations have been developed by Preload engineers over the past 85 years to increase the life expectancy and reliability of prestressed concrete storage tank structures. These include the incorporation of a ribbed steel shell diaphragm, which is now an integral part of the tank and provides impervious watertight service as well as the development of base restraint details, which ensure safe performance of the tank structure in high seismic areas and in those situations where tanks require differential backfill. New methods of construction have been developed as well, including the use of precast tilt-up core walls, which brought additional options and flexibility to the construction of quality prestressed concrete tanks. Shotcrete continues to be a primary material in the construction of the tank—both in the construction of the core wall and, more prominently, to encase the steel shell diaphragm and high-strength prestressing wires. Preload employs many ACI Certified Shotcrete Nozzelmen who are well-trained experts in the application of wet-mix shotcrete to ensure excellent quality in the finished tank structure. Preload's construction staff is specialized and highly trained in the techniques necessary for producing results that meet high levels of quality, expediency, and safety. The staff includes personnel that have each been responsible for successfully constructing hundreds of prestressed concrete storage tanks. Preload's construction staff and its top management approach each project with the objective of ensuring that both the client and community are fully satisfied with the decision to use Preload.

Since its inception, Preload has built its business on customer satisfaction, quality, timely project completion, safety, and competitive pricing. The high level of repeat business achieved by the company is evidence of Preload's ability to exceed the expectations of its clients.

Fig. 2: Architectural treatment on top of shotcrete exterior for prestressed concrete ground storage tank, Fredrick, MD, 2009

Fig. 3: 6.0MG wet weather storage tank built by Preload in 2013 for the Metropolitan St. Louis Sewer District and winner of numerous awards, including the 2014 ACEC Missouri Grand Award, the 2013 Keystone Award by the Associated General Contractors (AGC) of St. Louis, and the 2013 Quality Concrete Award by the Concrete Council of St. Louis

Fig. 4: Application of wet-mix shotcrete to steel shell diaphragm of prestressed concrete tank wall

Preload LLC
4000 Tower Road
Louisville, KY 40219
Phone: (631) 231-8100
Website: www.preload.com

New ASA Members

CORPORATE MEMBERS

Associated Pool Builders Inc.
Bismarck, ND
www.associatedpoolbuilders.com
Primary Contact: Jeni Bailey
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Canusa Equipment Ltd.
New Westminster, BC, Canada
www.canusaequipment.com
Primary Contact: Kim Fabbro
info@canusaequipment.com

Deep Foundations Contractors Inc.
Gormley, ON, Canada
www.deep.ca
Primary Contact: Michael Cianchetti
ktai@deep.ca

Mud Slingers Pool & Patio
Indianapolis, IN
www.mudslingersinc.com
Primary Contact: Kim Harper
sales@mudslingersinc.com

William L. Watson Company
Eden, NY
Primary Contact: Matt Friedrich
wlwatsonpools@verizon.net

INTERESTED IN BECOMING A MEMBER OF ASA?

All ASA members receive:

- Discounted prices on all ASA products;
- Networking and participation opportunities at ASA's Annual Membership Meeting and ASA committee meetings;
- Discounted advance general admittance registration to World of Concrete;
- Education and promotion of your shotcrete industry to the overall concrete industry;
- and much more!

Read more about the benefits of being an ASA member and find a Membership Application under the ASA Membership tab of **www.shotcrete.org**.

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ASA Membership Benefits

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	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**

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