Shotcrete MAGAZINE

A quarterly publication of the American Shotcrete Association

Volume 16, Number 1 ◆ Winter 2014

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Outstanding Shotcrete Project Awards

AMERICAN SHOTCRETE ASSOCIATION

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American Shotcrete Association
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Shotcrete MAGAZINE
Volume 16, Number 1
Winter 2014

Features

Departments

On the cover: "Team Work" —how different aspects of the shotcrete industry come together to install award-winning projects. Photo courtesy of Drakeley Industries.

It's the Dinosaur Again!

By Michael P. Cotter, Outgoing ASA President

The purpose of ASA is to continually improve, progress, and, in my opinion, protect the industry and legacy that we have been handed down, so as not to go the way of the DINOSAUR extinction.

This message is the first of many lasts. As my PRESIDENCY draws to a close, so does my GUNITE/SHOTCRETE career. Let me start by saying thanks to all the old-timers who are no longer around who taught me the trade. In 1973, they were probably 70 years old—old-timers who taught me to use good sand, more cement (rather than less cement), and water, water, water for curing—"its thirsty; let it drink." After 40 years, there is pride in driving by my first jobs and seeing them still in service. Keep the basics in mind. As documents, guidelines, and specifications get more demanding and compliance gets heavy, remember: it comes down to the crew—a well-trained crew—and an organization that does this for a living day-in and day-out, sun-up to sun-down. Engineers, specifiers, and owners, remember: there is no specification written—or certification—that ever makes up for experience! Demand experience. It costs less in the end.

Currently, within ASA, we have:

- An Inspector Training Program under development (thanks to Oscar Duckworth and task group members);
- ASA Safety Guidelines, available soon to Corporate Members; and
- The basis for ASA Contractors Qualification (thanks to Charles Hanskat and task group members).

I'd like to thank all the members who have contributed to these programs. It has taken input and dedication, along with attendance at many meetings by members at their own expense.

Finally, it's the DINOSAUR saying "thank you" to my Executive Committee: Charles Hanskat, Marcus von der Hofen, Ted Sofis, and Joe Hutter. I appreciate all the time we've spent over the years and special thanks for all the time this year. I ask for your support and help for our incoming President Charles Hanskat and his group. Thank you to our ASA staff, Alice McComas and Mark Campo. Thank you to our Board of Directors, who made some tough calls this year in the best interest of the industry. Thanks to Patrick Bridger for selling me my first small wet-mix pump that would deliver shotcrete through a small-diameter hose on a consistent basis. Joe Hutter, thanks for the patience and help in developing a consistent prepackaged shotcrete to put through Allentown's pump. And a special thank you to Cathy Burkert of American Concrete Restorations, Inc., for accepting the torch when it was passed.

It's been an honor to serve the industry and membership.

P.S. Shotcreters, please show up at ASA meetings and get involved. If you are not members yet, join. It's your industry to "serve and protect." Please support our incoming President, Charles Hanskat, and Vice President, Marcus von der Hofen.

Author's Note:

Carl Akeley, creator of the original "cement gun," was working in taxidermy at the time. Commonly known for inventing shotcrete to create a DINOSAUR for the Field Columbian Museum in Chicago (now the Field Museum of Natural History), his story was previously told in a *Shotcrete* magazine article found here: **www.shotcrete.org/media/Archive/2002Sum_Teichert.pdf**.

"Thank you to Carl Akeley for inventing shotcrete by shooting the DINOSAUR in Chicago, for it has given me an opportunity in life to exhibit a passion and meet wonderful people." *~MPC*

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ASA Marketing & Membership Committee

By Joe Hutter

The mission statement of ASA's Membership and Marketing Committee as stated on the ASA website is "To broaden the ASA membership base and ensure that shotcrete has its 'market share' in a national arena." There are many initiatives that the committee undertakes that are driven by the mission statement, but none have more impact than the annual ASA Outstanding Shotcrete Project Awards Banquet held at World of Concrete in Las Vegas, NV.

This annual event has grown in popularity since the inaugural event in January 2006. Last year, over 147 attendees from six countries gathered to celebrate the year's most successful shotcrete projects in the categories of Architecture, Infrastructure, Pool & Recreational, Rehabilitation & Repair, Underground, and the Outstanding International Award.

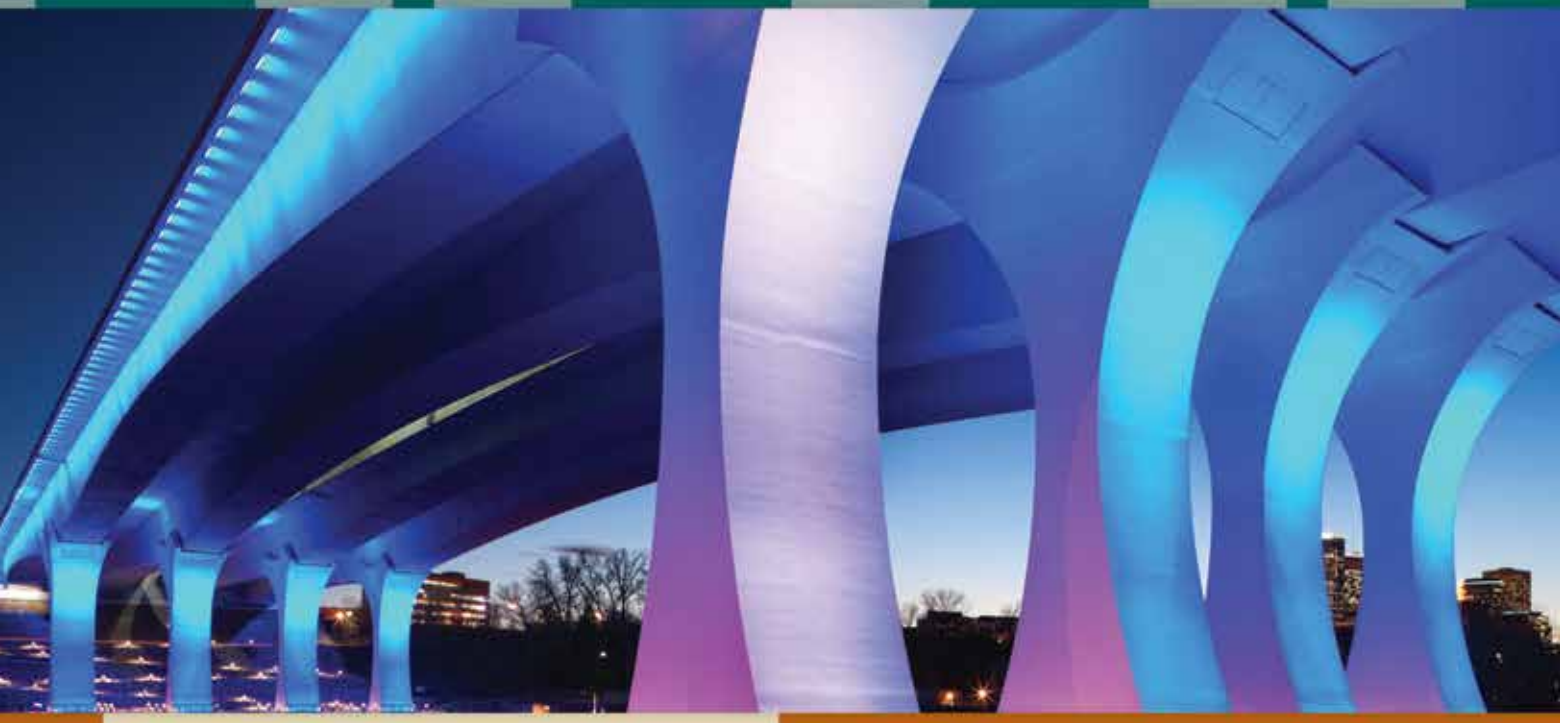
The secret to the success of our banquet begins with the countless hours of work that go on behind the scenes. ASA staff must find a venue that meets the expectations of our membership and falls within the banquet budget; they must initiate press releases reminding members to submit projects; and, once the deadline for submittals has passed, they must assemble the entries and complete all of the administrative work required for the judges to select the winners.

Volunteer ASA members are also active behind the scenes to help make the ASA Awards banquet a success. A committee of ASA members is responsible for soliciting project submittals from the membership, the judging committee (also made up of ASA volunteers) reviews all submittals and selects the winners for each category, and a small committee of ASA volunteers has been established to canvass the ASA membership in an effort to secure sponsors for the banquet.

All of our banquet sponsors are corporate members of ASA and the generosity of these sponsors is the biggest factor in determining the success of our banquet. Last year, our sponsorship drive raised over $34,000 from 30 corporate sponsors, a record amount since the banquet's first year. This year, 31 sponsors stepped up to the plate and pledged over $39,000 in support of this year's banquet, another record for ASA's corporate membership.

Without the contribution from our sponsors, the annual ASA Outstanding Shotcrete Project Awards Banquet would not be possible. The funds raised through banquet sponsorship help minimize the cost of participation for our members (ASA subsidizes the cost of the banquet tickets for ASA members) and also helps cover the cost of other expenditures that contribute to the success of the banquet. Any surplus from the event is used throughout the year to fund some of the many initiatives that help promote the shotcrete process to the construction industry.

If there is any room for improvement with the awards program, the judging committee would love to see more of our members, especially the hundreds who attend the banquet, submit projects for consideration in one of the six award categories. Over the past few years, the committee has taken steps to simplify the submittal process, making it quicker and easier for members to complete and submit their applications. We know that there are more projects in which ASA member companies have participated. Many of those projects deserve recognition by our association. So, between now and the close of next year's nomination period, carry a digital camera when visiting your job sites, and please remember to snap some photos of your favorites. A few minutes on the ASA website are all that is required to complete the submittal form and upload some photos. It just may result in an opportunity to boast a little to your peers at next year's ASA banquet!



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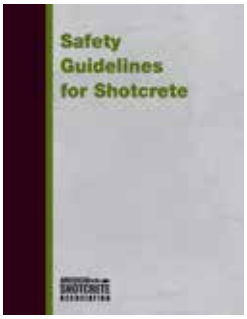
Moving Forward, Looking Back

By Mark A. Campo, ASA Executive Director

Get Ready for ASA's New Safety Document

A task group of the ASA Safety Committee has recently completed authorship of a new document titled "Safety Guidelines for Shotcrete." Expected to be published in early-to-mid 2014, this new document would serve as one of the most significant benefits of Corporate Membership. It is intended as a guide to encourage personal safety considerations, but not to replace training and education programs or supervision by qualified individuals. Each shotcrete contractor has a responsibility to develop, maintain, and administer a company safety program appropriate for their operations.

Chapter topics in this document include: Personal Protective Equipment, Communications, Lighting, Back & Spine Safety, Shotcrete Materials, Shotcrete Equipment, and Shotcrete Placement: Wet- and Dry-mix Processes. Within these chapters, readers will find details on such important items as the importance of "tailgate talks" or "pre-job huddles"; protection for the hands, head, face, eyes, and lungs; proper posture while nozzling; examples of excessively worn equipment needing replacement; and much more. Accompanying this information are excellent, full-color photographs, as well as "safety tip" sidebar notes to the nozzleman.



Special thanks to Oscar Duckworth, Chair of the ASA Safety Committee, for leading the task group and contributing heavily to this nicely detailed document.

"Safety Guidelines for Shotcrete" is expected to be published in hard copy and electronic (PDF) formats. Corporate members will receive one complimentary copy; additional copies will be available through ASA's bookstore. For more details, please stay tuned to our Shotcrete News at **www.shotcrete.org/news/index.htm**, or follow us on Facebook at **www.facebook.com/AmericanShotcreteAssociation**.

Many Thanks to President Cotter

Michael Cotter

I'd like to take this opportunity to thank Michael Cotter for his dedicated service to the Association as its President in 2013. This responsibility was not taken lightly, as he sought to encourage the use of *qualified* contractors rather than simply accepting nozzleman certification. Many of ASA's current and future endeavors reinforce this position.

The following are some notable accomplishments that the Association was able to bring forward under Past President Cotter's tenure in 2013:

- Publishing an official ASA Position Paper on using Qualified Contractors, creating a basis for ASA Certified Contractors;
- Completion of "Safety Guidelines for Shotcrete" document;
- Wholesale revision of ASA Education presentation for nozzleman certification;
- Development of the Inspector training materials (ongoing); and
- Allocation of funds within the ASA budget to special projects that represent a strategic importance to the Association.

With only 12 short months to affect change in the Association, and doing so using the all-volunteer efforts of committee members, this progress is certainly commendable. Thanks again to Past President Cotter—and to all the volunteers who have worked so hard this year—for advancing the association in 2013.

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Letters to the Editor

I was excited to see the title of the article "Limestone Cement in Shotcrete" in the Fall 2013 issue of *Shotcrete* magazine (pages 10 to 12). Portland limestone cement (PLC) provides similar performance characteristics to Type I portland cements, with reduced environmental impact (meeting the goal stated in the article). However, I believe that some misimpressions might result from the article.

Type IL PLCs are produced to meet specification ASTM C595 or AASHTO M 240 and, thus, be competitive in performance with existing cements. The article states that "…current ASTM standards do not require that limestone fineness be fine enough to ensure a similar performance to that of the 'parent portland cement'…" This appears to be a criticism of ASTM C595/AASHTO M 240, which define requirements for Type IL cements with between 5 and 15% limestone. There are good reasons why no fineness limits for limestone (or other ingredients) are included in this specification:

1. Requirements for properties such as setting time and strength will require that appropriate fineness materials be used;
2. Once the materials are interground or blended, there is no efficient way to determine or check the fineness or particle-size distribution of the individual materials; and
3. Blended cements are often interground, which changes the fineness substantially, so a limit on the original fineness of the ingredient is meaningless.

Limestone as an ingredient in PLC is typically interground with portland cement clinker and sulfate. Since clinker is significantly harder than limestone, the limestone tends to preferentially be ground to a finer size than the nominal cement fineness, providing the particle-packing benefits noted in the article. While there are no limits for fineness in ASTM C595/AASHTO M 240, the Blaine fineness (ASTM C204) and 45 µm sieve fineness (C430) of the finished cement are reported on all mill test reports, so the concern in the article would appear to be unfounded, at least with regard to PLC.

The terms *limestone fines* and *limestone fillers* are used somewhat loosely in the article as equivalent to limestone as cement ingredients. This may cause confusion for the reader. Although each of these materials is similar—essentially calcium carbonate—it is incorrect to refer to just any mixture of limestone with cement as "limestone cement." True limestone cements must meet ASTM C595 or AASHTO M 240.

The statement that "overall durability of cement with limestone filler decreases with an increase in limestone" is not correct for PLC. There is a wealth of information on PLCs used in Europe and other countries demonstrating that durability issues (corrosion, chloride penetration, salt attack, freeze/thaw, etc.) are similar for PLCs and other cements and are primarily a function of concrete permeability (water-cement ratio, compaction, and paste content) and other factors like adequate strength and air void systems. (For example, refer to the article by Thomas et al. in the December 2013 issue of *Concrete International*.)

ASTM C595/AASHTO M 240 Type IL cements generally provide similar strength and durability performance to Type I portland cement in concrete applications. They are appropriate for both wet and dry exposures, although they are not currently intended or recommended for use in moderate- or high-sulfate exposures. A potential issue with low-temperature sulfate resistance of PLCs (and/or concretes made with limestone fillers) has been suggested, and the industry is proceeding cautiously in this regard. ASTM C595/AASHTO M 240 notes that PLCs are not used in applications requiring sulfate resistance while additional research is being conducted.

I will echo the author's recommendation that test panels be fabricated to ensure that the expected and desired properties of the mixture are achieved. Coupled with reviewing mill test reports on the cement and certifications for other shotcrete ingredients, this is sound advice for any new material or mixture design. I believe that PLCs will provide suitable fresh and hardened shotcrete properties, including durability, without significant changes to mixture designs.

For additional information on PLCs, I would be happy to supply electronic copies of a relevant PCA research report and literature review, upon request.

Paul D. Tennis, PhD
Manager, Product Standards and Technology
Portland Cement Association, Skokie, IL

References available electronically:

Thomas, M. D. A. and Hooton, R. D., "The Durability of Concrete Produced with Portland-Limestone Cement: Canadian Studies," SN3142, Portland Cement Association, Skokie, IL, 2010, 28 pp.

Tennis, P. D.; Thomas, M. D. A.; and. Weiss, W. J., "State-of-the-Art Report on Use of Limestone in Cements at Levels of up to 15%," SN3148, Portland Cement Association, Skokie, IL, 2011, 78 pp.

Editorial Response

The intent of my article was not to suggest that limestone cements are not a viable option for many projects. The concern being put forward is one of "buyer beware." The fact is, there is potential for a portland cement to be processed with limestone in a way that lessens the quality of the "parent" portland cement (I use the term "limestone" as ASTM Specifications/Standards currently use the term, although I agree with Mr. Tennis that "calcium carbonate content" is what we need to know).

Again, the intent of my article was actually in support of much of Mr. Tennis's (PCA's) argument. Limestone cements are a viable option; however, current ASTM Specifications/Standards allow for, at the very least, a bad perception to be created by potentially allowing (although not intentionally) a lesser quality cement to enter the market.

In the past, the ASTM C150 specification for portland cement, which has more restrictive prescriptive and performance requirements, has dominated the marketplace. In a manner of speaking, the "bar was set" with the C150 specification. Optionally, ASTM C595 and C1157 specifications allow a more "relaxed" or "broadened" option to that of the

C150 restrictions/requirements, with the intention of allowing the producer to widen the scope of potential materials and thereby formulate new cements with unique characteristics and/or performance greater than the "parent" C150 cement. More recently, these same specifications (C595 and C1157) have again been "relaxed" or "broadened" to allow producers to use greater additions of fillers/fines (both terms are used in the literature and specifications) through optimization of the limestone and cement combination, to be "on-par" with the parent cement. The fact is, most literature and testing have shown that the usage of greater amounts of limestone addition, requires the "optimization" of fineness of the cement and limestone to achieve a quality of product that is "on-par" with that of the parent cement.

If optimization results in a finer limestone cement that is equivalent to or better than the coarser parent cement while simultaneously allowing for a "greener" product, then it would be preferable in many instances. However, if we disagree on this point, then the alternative is to say we are knowingly producing an inferior product by adding limestone. Obviously, this is not the intent of the latest changes to the C1157 and C595 specifications. However, until these specifications are written in a way that assures the consumer that limestone (calcium carbonate) additions are not simply "diluting," or creating a lesser-quality product, then we have work to do.

Mr. Tennis states, "*Type IL PLCs* are produced to meet specification ASTM C595 or AASHTO M 240 and, thus, be competitive in performance with existing cements." Yet, no requirement in either specification requires the blended cement to be competitive in performance with existing cements. The only requirement is that the cement meets the minimum standards set in the specification. Therefore, until these specifications address this issue; as I stated, and Mr. Tennis concurs, testing of limestone cements should be done to ensure satisfactory performance in the application for which it is intended.

Finally, I agree with Mr. Tennis's argument that limestone ultimately grinds finer than the cement when added at the time of grinding clinker and gypsum; however, this does not necessarily occur in the aftermarket of preblenders. Preblending operations seldom have the capability of grinding limestone to the ultra-fine levels necessary to achieve the results shown in literature. This is a main concern and must be considered.

Jonathan E. Dongell
Director of Research and Development
Pebble Technologies, Scottsdale, AZ

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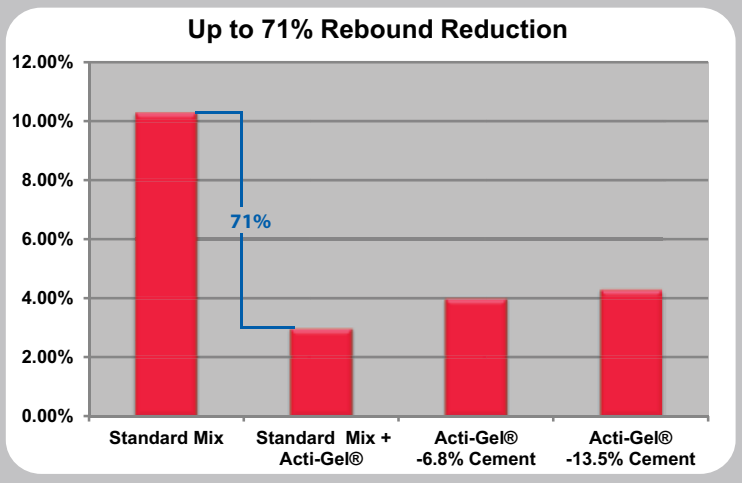
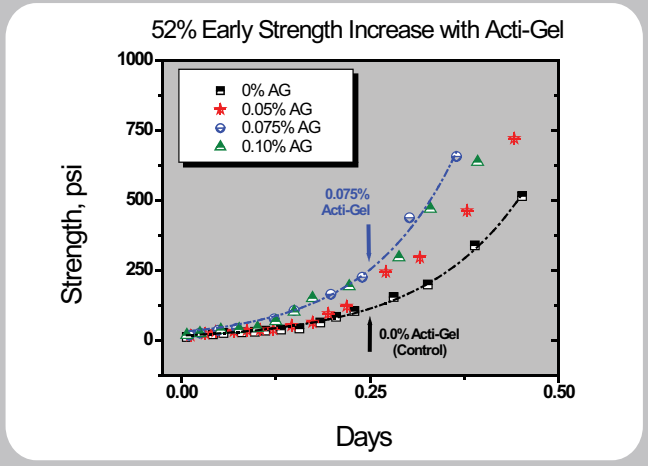


Rebound Reduction Even With Reduced Cement



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2013 Outstanding International Project

Cadia East Project

By Stephen Duffield

The Cadia East Project is delivering what will become the largest underground mine in Australia and one of the largest underground gold mines in the world (Cadia East). Fiber-reinforced shotcrete has been essential for the safe development of this world-class project.

Cadia East is the latest mine to be developed at Newcrest Mining Limited's Cadia Valley Operations (CVO), situated approximately 160 miles (260 km) west of Sydney, in New South Wales, Australia. Newcrest Mining Limited (Newcrest) is the largest gold producer listed on the Australian Stock Exchange and one of the world's largest gold mining companies.

Cadia East has an approved mine life of 21 years and is forecast to increase CVO's annual production to 700,000 to 800,000 oz (20,000 to 23,000 kg) of gold and 99,000 tons (90,000 tonnes) of copper in the coming years. In the financial year ending June 2013, CVO produced 446,879 oz (12,669 kg) of gold and 59,440 tons (53,912 tonnes) of copper.

Caving at Cadia East

The massive underground gold and copper resource at Cadia East is suited to the low-cost, bulk underground mining method known as panel caving. Panel caving is a natural caving method which uses ground stresses, rock structures, and gravity to break the rock and propagate mining vertically.

Cadia East is planned to have two panel caves with extraction levels situated at 4000 and 4600 ft (1200 and 1400 m) below the surface. Panel Cave 1 commenced commercial production in January 2013, and the development of Panel Cave 2 is underway. Cadia East is expected to ramp up to full production of 28.7 million U.S. tons per annum (26 MTPA) over the coming years.

These significant mining depths, along with induced stresses, the forecast deformation, and the blocky nature of the rock mass, are all factors that drive the need for high-quality and high-capacity shotcrete application at Cadia East.

The Cadia East Project commenced the main shotcreting segment of the underground development in June 2010 and has excavated 37 miles (59 km) of tunnels as of the end of November 2013. The majority of project development will be finalized by December 2014.

Cadia East Mine Development

A total of 37 miles (59 km) of underground tunnels have been excavated for the Cadia East

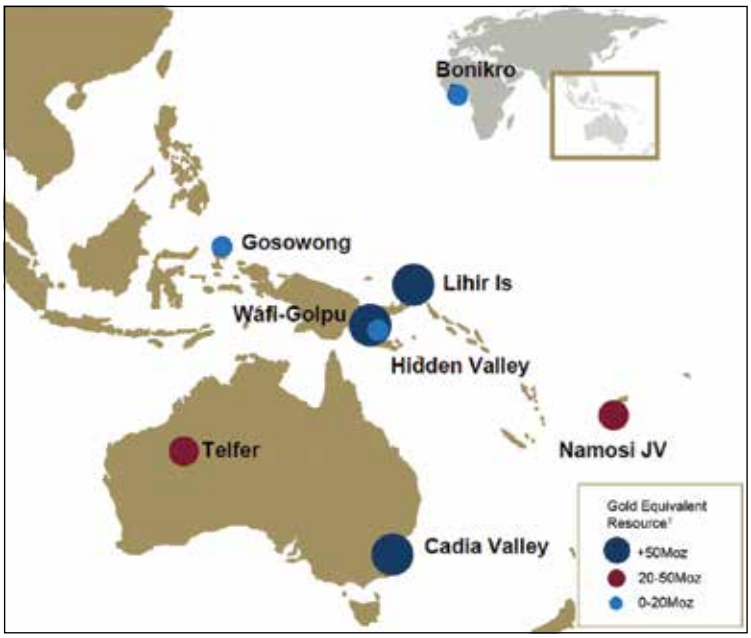

Fig. 1: Newcrest Mining Limited operating mines and advanced projects

Fig. 2: Jumbo drill rig installing rockbolts through shotcrete

Project since June 2010 to the end of November 2013. This includes the following major excavations:

- Main decline: Total linear distance of 5.6 miles (9.1 km) from surface at a gradient of 1 in 7;
- Conveyor decline: Comprising five legs of conveyor drive with a total length of 4.7 miles (7.6 km); mined at a gradient of 1 in 5.3 from surface;
- Crusher chambers: Three major underground excavations with approximate dimensions of 130 ft (40 m) in length by 85 ft (26 m) in height by 40 ft (12 m) in width, each;
- Undercut level: Over 1.9 miles (3 km) of tunnels;

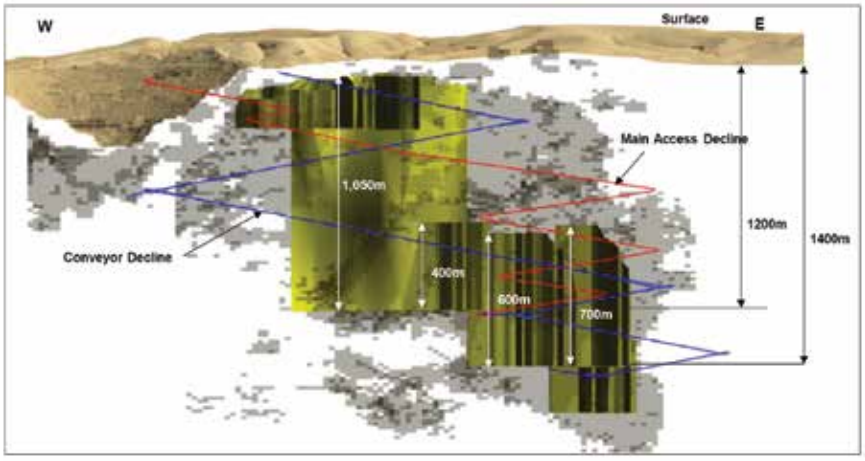

Fig. 3: Cadia East long section

Fig. 4: Shotcreted transfer chamber

- Extraction level: Over 5 miles (8 km) of extraction drives, draw points, and access drives; and
- Pump stations, electrical substations, workshops, lunch rooms, and amenities.

All development is excavated using drill and blast with a fleet of four boring jumbo drill rigs backed up by 10 rock bolting jumbos (Fig. 2). Every tunnel and chamber has been supported with fiber-reinforced shotcrete, with a total of 150,000 yd^3 (115,000 m^3) sprayed as of November 2013. The shotcrete is all supplied as fiber-reinforced wet mix and applied in-cycle before rock bolting.

The typical development cycle at Cadia East is:
- Drill;
- Charge and fire;
- Clearance and re-entry;
- Muck out;
- Scale/hydroscale;
- Shotcrete spraying;
- Rock bolt; and
- Survey markup for next round.

The minimum standard of ground support consists of 2 in. (50 mm) of fiber-reinforced shotcrete with 8 ft (2.4 m) long resin-grouted reinforcement bar rock bolts. Many headings also have additional ground support installed according to ground conditions, longevity, and projected stresses, such as:
- Steel mesh;
- Cable bolts;
- A second layer of fiber-reinforced shotcrete; and
- Steel sets.

Certain excavations have to stay safe and accessible for the life of the mine; hence, the quality of substrate preparation, shotcrete batching, application of shotcrete, and integration with other ground support elements is critical to ensure a safe and low-maintenance environment.

Mixture Design

Fiber-reinforced shotcrete is an integral part of ground reinforcement and support at Cadia East. It is considered essential for safe mining development and has become the accepted standard for underground personnel when dealing with existing and induced stresses.

The main fiber-reinforced shotcrete mixture design used at Cadia East, Type B shotcrete, is specified at a compressive strength (UCS) of 5800 psi (40 MPa) at 28 days and a toughness of 500 joules (ASTM C1550).

The fiber-reinforced shotcrete mixture design has been developed over many years at CVO by Newcrest engineers with significant input from the concrete supplier, additive suppliers, and the shotcreting contractor.

The Type B shotcrete used underground at Cadia East is reinforced with 15.2 lb/yd^3 (9 kg/m^3) of Barchip Shogun polyolefin fibers, supplied by Elasto Plastic Concrete Pty Ltd (EPC).

All fiber-reinforced shotcrete is batched on the surface by Boral Concrete & Quarries Ltd. Boral supplies all aggregates, sand, and cement and also coordinates concrete additives. The batch plant operates 24 hours per day, all year. In winter, nighttime temperatures can reach 23°F (–5°C), so heating of batch water is important.

Cadia East has the benefit of a local basalt quarry 12 miles (20 km) from the mine site. This quarry is operated by Boral and supplies high-quality crushed basalt aggregate to the on-site batch plant.

All shotcrete additives are supplied through BASF Australia Ltd, including:
- Hydration stabilizer;
- High-range water-reducing admixture;
- Liquid silica;
- Low-range water reducer; and
- Set accelerator.

Table 1: Mixture design for Type B shotcrete

Ingredient	Quantity, lb/yd^3	Quantity, kg/m^3
River sand	1795	1065
10/7 mm Basalt aggregate	960	570
SL cement	675	400
Fly ash	95	55
High-range water-reducing admixture	50 fl.oz/yd^3	2000 mL/m^3
Liquid silica	180 fl.oz/yd^3	7000 mL/m^3
Low-range water reducer	30 fl.oz/yd^3	1200 mL/m^3

Shotcrete Application

The average rate of shotcrete application has been 3800 yd^3 (2900 m^3) per month. This rate has been consistent and will remain so over the 4-year construction period of the project. This is a massive amount to batch, supply, and spray each month, which has presented many logistical challenges.

All fiber-reinforced shotcrete was sprayed using robotic spraying rigs by shotcreting contractor Stratacrete Pty Ltd. At the peak of project development, five to six Jacon Roboshot Maxijet spray rigs were used at any one time. Stratacrete Pty Ltd is a mining and civil shotcrete contractor specializing in robotic placement for both underground and surface operations throughout Australia and selected international markets.

All shotcrete is batched on surface by Boral Ltd and transported to the headings by a fleet of underground agitator trucks via the main decline to depths of up to 4600 ft (1400 m) below surface. This can result in a one-way trip of over 6.2 miles (10 km) to the spraying site and can take up to 2 hours

depending on mine traffic. Retarding of the shotcrete mixture is essential to avoid hydration, and hydration stabilizer is added at the rate of 50 fl. oz/yd³ (2 L/m³) at the batch plant.

Boral operated a fleet of agitator trucks, all equipped for underground operation:

- Five CAT 730 trucks, capacity 10.4 yd³ (8 m³);
- Four Mercedes-Benz trucks, capacity 6.5 yd³ (5 m³); and
- Two Atlas Copco 5010 trucks, 10.4 yd³ (8 m³).

Agitator truck operators carry an additional supply of hydration stabilizer and are permitted to add a specified amount with supervisor approval in the case of excessive delays underground.

During the peak of project construction, coordination of traffic in the main decline was critical as this was the only way in and out of the mine for heavy vehicles. The second egress from the mine, the conveyor decline, was not available for concrete truck travel, as the 4.7 miles (7.6 km) of conveyor system with an ultimate capacity of 4850 tons per hour was being installed.

The agitator trucks did not have sole access in the main decline, sharing the route with construction traffic and truck haulage of mine rock. These factors made shift-by-shift planning of shotcrete deliveries, major concrete placements, and timing of nonreversible construction loads all the more important.

Slickline delivery of shotcrete was trialed in a lined borehole from surface with the objective of reducing the number of concrete trucks from surface. However, the excellent coordination of main decline traffic and the good working relationship between all parties meant that the slickline was not required.

Throughout the Cadia East Project, there were 25 to 30 headings to be sprayed each week spread over the huge extent of the mine. It has only been the well-managed daily planning and willingness of all parties involved to work together—both client and contractors—that made achievement of the high rate of shotcrete application possible.

Quality Assurance

Regular testing of materials and batched shotcrete is undertaken by Boral as part of their internal quality assurance standards and results are made available to CVO.

Independent testing of shotcrete and concrete is carried out for CVO by K&H Geotechnical Services Pty Ltd, one of the major private testing facilities in Eastern Australia. K&H are accredited by the National Association of Testing Authorities (NATA) for Public Testing Services—Construction Materials and conduct the following tests at Cadia East:

- Shotcrete sampling and testing of cored panels for compressive strength and round determinate panel to ASTM C1550 for flexural strengths;
- On-site slump testing;
- Casting of concrete cylinders;
- Concrete coring, sampling, and testing services; and
- Aggregate size, shape, and strength testing.

Research and Innovation

Newcrest excavates many miles of underground tunnels annually and as a result uses tens of thousands of cubic yards of shotcrete across its mines and development projects. Based on the significant volume of shotcrete and associated costs, Newcrest has allocated funding to research areas that will result in improvements in shotcrete design, quality, and economics.

Fig. 5: Nozzleman spraying heading with robotic spray rig

Fig. 6: Shotcreting in progress in undercut drill drive

Fig. 7: Agitator truck reversing up to shotcrete spray rig

Fig. 8: ASTM C1550 toughness panels being sprayed at underground site

Fig. 9: Large-scale shotcrete capacity test

Fig. 10: Shotcrete rig and agitator truck in one of the many underground chambers

As part of the program of research to develop high-performance economical shotcrete, several trials were undertaken by Newcrest and shotcrete consultant Technologies in Structural Engineering Pty Ltd (TSE), including:

- Investigating the influence of air-entraining agent, microfibers, and silica additives on the wet properties and early-age strength characteristics of fiber-reinforced shotcrete[1];
- In-place testing of fiber-reinforced shotcrete load capacity and failure modes[2]; and
- Testing of mine waste rock as shotcrete aggregate.

As an independent laboratory accredited by NATA for public testing services, TSE have also carried out specialized testing for Cadia East.

The Cadia East Project has also offered the opportunity to trial photogrammetry to measure applied shotcrete thickness. A heading is digitally captured post-scaling and post-shotcreting and measurement of shotcrete thickness and coverage is undertaken with the photogrammetry software. Cross-referencing of thickness measurements from drill holes showed an accuracy of ± 0.2 in. (± 5 mm).[3]

Further innovation has taken place with the bulk delivery of set accelerator. An 8000 gal. (30,000 L) bulk storage tank and delivery system supplied by BASF was commissioned in May 2013. This reduces the need for multiple 260 gal. (1000 L) intermediate bulk containers or "pallecons," which can be damaged in the underground environment. This innovation has reduced the frequency of deliveries to site and given the added benefit of improved costs.

Summary

The sheer size and complexity of the Cadia East Project have made the application of fiber-reinforced shotcrete a significant challenge. The combination of depths of up to 4600 ft (1400 m) underground, distances from surface batch plant to spraying sites of over 6.2 miles (10 km), the need to spray multiple headings in-cycle, and the interaction with mining and construction mobile equipment accessing through one main decline, has been an incredible test of design, logistics, and resource organization.

At Cadia East, fiber-reinforced shotcrete is essential for the safe development of a world-class mining project—without the application of consistent, high-capacity shotcrete on time and in the right locations, the project would stop. A key factor in the successful application of shotcrete has been the willingness of all teams involved, whether contractors, suppliers, consultants, or the client, to work together, seek high performance, and value innovation. These values have ensured the application of high-quality shotcrete with no disruptions to the successful production ramp-up of the Cadia East Project.

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Stephen Duffield *is a Project Manager at Newcrest's Cadia Valley Operations, situated near Orange, NSW, Australia. He received his BSc (Eng) in Mining Engineering from Cardiff University, Wales, UK, in 1984, and recieved a degree in project management from the University of Sydney, Sydney, Australia, in 2003. Duffield has worked in underground mining, construction, and tunnelling on both the contractor and client sides. He holds an NSW Underground Mine Manager's Certificate. Duffield has been involved with shotcrete on deep mining projects since 1992 and has published six shotcrete-related papers. He is a committee member of the Australian Shotcrete Society.*

The Outstanding International Project

Project Name
Cadia East Project

Project Location
Orange, NSW, Australia

Shotcrete Contractor
Stratacrete Pty Ltd

Architect/Engineer
Cadia Valley Operations (Newcrest Mining Ltd)

Material Supplier/Manufacturer
Boral Concrete & Quarries Pty Ltd
Elasto Plastic Concrete Pty Ltd
BASF Australia Ltd

Project Owner
Newcrest Mining Ltd

2013 Outstanding Infrastructure Project

Interstate 81 Safety Corridor Improvements

By Albert Pugliese

On July 15, 2010, CH2M Hill Constructors, Inc., was awarded a contract by the Virginia Department of Transportation (VDOT) for the design-build project Interstate 81 Corridor Safety Operation Improvements. Faulkner Construction was the general contractor. Proshot Concrete, Inc., was awarded a contract in June 2011.

The VDOT specifications required the construction of a mechanically stabilized earth (MSE) wall with use of rock bolts and shotcrete. The project's purpose was to rebuild the north- and southbound bridge over Norfolk Southern main rail lines due to aging of the bridges and lack of clearance for the railroad. The first phase of the project was to widen the lanes for truck traffic; then, the rock bolts were installed and shotcrete was applied. The final MSE wall was approximately 150 ft (46 m) long and nearly 28 ft (9 m) high and required over 200 yd^3 (153 m^3) of shotcrete.

The project was bid in two phases: Phase 1 from station 96+09 to 97+97 and Phase 2 from 96+97 to 97+56. Once the excavation was complete, the layout for the rock bolts was determined and guide wires were installed.

Fig. 1: Drain board and weep pipes were incorporated before applying the shotcrete to allow for drainage

CH2M Hill Constructors was required by VDOT to attend a preliminary inspection meeting in September 2011. The coordination with the railroad can sometimes be very frustrating and unpredictable. All parties were present to ensure a timely and efficient work schedule.

All workers coming within 100 ft (300 m) of the railroad were required to attend Norfolk Southern's Safety Training Class. In addition, all employers must provide their employees E-Rail Certification cards. This is essentially a Homeland Security background check, required well in advance of the project's start date. All personnel were required to carry the E-Rail Certification card at all times.

Prior to mobilization, all submittals of rock bolts/grout, reinforcing steel, shotcrete mixture designs, and work schedule were required. The rock bolts were provided by Williams Form Engineering, as well as the testing equipment required for "pull" load testing.

Proshot Concrete, Inc., started Phase I on October 24, 2011. The drill rig (Flexiroc T35) provided by Atlas Copco arrived a few days later, once the bolt pattern and layout were complete. The drill had to be able to drill at a 90-degree angle due to clearance of the railroad track. The rock excavator drilled and blasted rock to even the plane as close as possible. The excavation was conducted in three lifts to allow a stabilized area for the rock drill. The excavation depths were 12, 9, and 11 ft (3.7, 2.7, and 3.4 m).

Prior to drilling the rock-bolt holes, shotcrete was applied in varying thicknesses to the surface to help stabilize the drilling operation. The rock bolt holes were to be drilled on 6 ft (1.8 m) centers between the abutment caissons. The rock bolts ranged from 15 to 30 ft (4.5 to 9 m) in depth. Most of the bolt lengths were changed to 30 ft (9 m), as additional soil borings were obtained. The drill shafts were 3 in. (75 mm) in diameter and 1 in. (25 mm) diameter galvanized rock bolts were used with centralizers every 10 ft (3 m). The rock bolts were secured in the drilled holes with high-strength cementitious grout. Each bolt required a specific "pull" load test.

Fig. 2: An initial layer of shotcrete was applied to stabilize the drill bit during the drilling operation

After the pull test, geo-composite drain mats were installed between all rock bolt locations to allow drainage behind the wall. The wall was reinforced using No. 5 (No. 16M) bars horizontally and No. 4 (No. 13M) bars vertically. The total wall thickness was 11 in. (280 mm). In addition to the reinforcing bars, 6 x 6 in.—W4.0 x W4.0 (152 x 152—MW26 x MW26) welded wire fabric was also incorporated.

Guide wires were installed vertically and horizontally to maintain the tolerance requirements. Due to the hardness of the bedrock and excavation access, large voids and indentations existed. This required additional reinforcing steel and additional shotcrete to be installed.

The new three-lane bridge was constructed on the northbound side to accommodate traffic and clearance for the railroad. The old northbound bridge was then removed.

Phase 2 of the MSE wall was constructed on the northbound lanes using the same construction sequence. There was significantly more shotcrete used on this phase due to the irregularity of the excavation. The shotcrete in some areas was as deep as 24 in. (610 mm) and the original wall thickness was specified to be 11 in. (280 mm). A

Fig. 3: Manlifts were used to address the wall because scaffolding was not an option so close to the railroad

Fig. 4: The finished wall ranged in depth 11 to 24 in. (279 to 610 mm) with two mats of reinforcing steel in some places

Fig. 5: A float 'finish' was required. The shotcrete depth was greater than 36 in. (914 mm) in some areas

float finish was specified and concrete insulating blankets were required for cold-weather protection and curing.

The wall construction served three purposes:

1. Support new abutments;
2. Prevent soil erosion; and
3. Minimize silt and debris from falling on railways, road beds, and ditches.

A crash wall was also constructed to forestall the impact of potential train derailment on the new bridges.

The Outstanding Infrastructure Project

Project Name:
Interstate 81 Safety Corridor Improvements

Project Location:
Christiansburg, VA

Shotcrete Contractor:
Proshot Concrete, Inc.*
Albert Pugliese, Project Manager
Darrell McCravy, Project Superintendent

General Contractor:
Faulkner Construction/
CH2M Hill Constructors, Inc.
Kevin Strahley, Project Manager
Mike Powers, Structural Superintendent

Architect/Engineer:
Virginia Department of Transportation (VDOT)

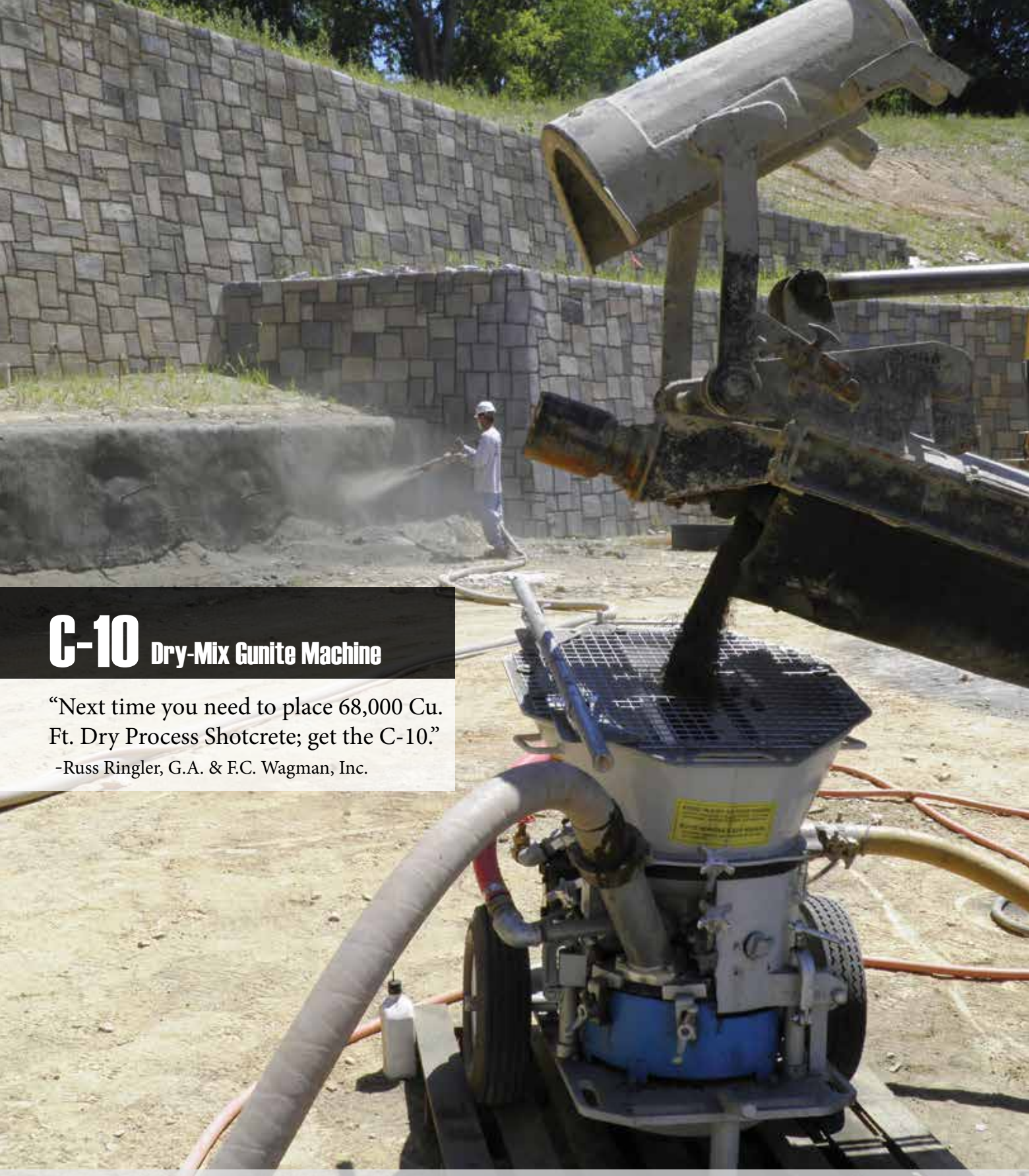
Material Supplier/Manufacturer:
Williams Form Engineering, Rock Bolts
Chandler Ready Mix Shotcrete

Project Owner:
CH2M Hill Constructors/
Virginia Department of Transportation
Jeff Stanley, Senior Quality Control
Penny Connor, Quality Control Inspector

*Corporate Member of the American Shotcrete Association

***Albert Pugliese** has been with Proshot Concrete, Inc., since its inception in 2006, previously working with Pressure Concrete in 2000. He is the Regional Manager for the Northeast Region (with 26 years in shotcrete construction) and also assists in specialty projects nationwide. Pugliese is a graduate of Pennsylvania State University (1988), where he received his BS in civil engineering. His shotcrete/gunite experience began in 1990 while developing SewperCoat (manufactured by Lafarge Calcium Aluminates) for the gunite process, as well as other spray applications.*

Pugliese's involvement in major projects includes the Maryland Department of Transportation Culvert Rehabilitation, Statewide; Hampton Roads Sanitation Dist. Pump Station, Virginia Beach/Chesapeake/Newport News, VA; Norfolk Naval Base Pier Repairs, Norfolk, VA; City of Virginia Beach Lesner Bridge, Virginia Beach, VA; Toys R US Culvert rehabilitation, Dickson City, PA; and Virginia Department of Transportation Culvert Rehabilitation, Culpeper, VA.



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2013 Outstanding Repair & Rehabilitation Project

The Oregon City Arch Bridge

By Marcus H. von der Hofen

The Oregon City Arch Bridge Rehabilitation project was officially completed on October 31, 2012, by the Wildish Standard Paving Company. Dedication to quality and professionalism, along with a true partnering between owners, contractors, and suppliers, helped find ways to solve problems that could have easily turned the project into overwhelming confrontation and failure.

Originally completed in December 1922, the bridge spans the Willamette River between Oregon City and West Linn, OR, and is a beautiful landmark of the region. It was designed under the direction of State Engineer Herbert Nunn, who adopted and carried out the plans of State Highway Engineer C. B. McCullough. McCullough's signature detailing is evident in the arches, obelisk pylons with sconce light fixtures, ornate railings, and Art Deco piers. It is believed to be the only bridge of its kind in the entire United States—a through-deck steel arch covered with shotcrete that incorporates concrete spandrel columns, corbels, a sidewalk, deck approach spans, and a bridge rail.

The bridge is 900 ft (274 m) long, including the viaduct design approaches. The center section of the bridge measures a horizontal distance of 140 ft (43 m) with the supporting arches above built on a 160 ft (49 m) radius. The remaining 210 ft (64 m) of the center span are supported from below by the continuation of the arches on a 306 ft (93 m) radius. The box beam arches start with a section of 10 ft (3 m) deep at the base, reducing to a 6 ft (1.8 m) depth at the top with the width remaining the same throughout. This all supports a roadway deck 18 ft (5.5 m) across, curb to curb, with a sidewalk on each side and the added bonus of restrooms located at the piers under the sidewalk at each end.

In April 2010, Wildish Contractors was awarded the contract for the rehabilitation of the Oregon City Bridge. The goal was to upgrade the structure to replace structurally deficient components and accurately replicate the details and architectural features to keep the original appearance of this historic icon. A great deal of work was necessary to carry out this upgrade within the short time frame of only 2 years.

During my first visit to inspect the bridge, I must say I was more than a little overwhelmed by the craftsmanship of this structure. It was and still is amazing to me. The quality of the gunite that these crews produced so long ago is impressive. Not that there weren't any problems, but for the most part, the gunite has held up incredibly well over the years. The finish, the consistency, and, again, the overall craftsmanship produced by the crews must have made subcontractor Lanning & Hoggan immensely proud. Most of the deficiencies I saw really didn't have anything to do with the gunite but were inherent to the design. It was amazing to see reinforcing steel mesh exposed in a hydrodemolition test area in the same condition as when it was placed on the bridge 90 years earlier. Even with all the modern shotcreting tools we have today, duplicating the quality of the shotcrete work on this bridge would be a major challenge.

The shotcrete covering had caused many a bridge expert to be deceived into thinking this was a structure made entirely of concrete. Originally placed using the dry-mix method nearly a century before, the protective concrete would need to be removed and replaced to the original lines and grades. One of the first questions to contemplate was: Should it be done wet or dry? Should it be both? Today's shotcrete technology offers efficient site batching of material in small amounts, both wet and dry; state-of-the-art batch plants and testing facilities also allow ready-mix producers to perform various adjustments and quality control that simply was not available 90 years ago. The project has areas that

A unique feature of the original project was the encasement of the steel structure in what was then called "gunite" to protect it from the emissions of the paper mill located close-by. "The guniting was done under subcontract by Lanning & Hoggan and was directly supervised by A.C. Forrester, Civil Engineer. The outfit used was the N-1 type cement gun of the Cement Gun Co., Inc., and the necessary auxiliary equipment… The work required 40,000 square feet of 2 inch guniting on the steel ribs; 1200 square feet of 6 inch gunite for the web on the underside of the arch; 800 square feet of 4 inches thick; 1200 square feet of 3 inches thick, and 2800 square feet varying from 6 inches down to 2."

W.A. Scott, *Engineering World* (December 1922)

Fig. 1: Oregon City Bridge—multiple access methods

Fig. 2 and 3: Shotcrete placement inside the arches

really lend themselves to either method. The bottom line in this case came down to what the personnel felt the most comfortable with. I don't find this reason brought up in the discussion very often, but it really should be part of the process. Many contract specifications are written making the choice, and I personally don't think that is the right answer. The fact is that many jobs can be done efficiently and correctly either way, so the choice should be left up to the qualifications of the contractor.

In this case, my personnel and I agreed that we could perform the job more effectively using the wet process. At first, I believed that we would do the project using both site-batched bagged material and ready mix. After initial testing, I became convinced that the ready-mix supplier CEMEX, with whom I had a long working relationship, could lend invaluable expertise to the project. As it turned out, it was a good decision (or maybe just lucky) on my part, as their ability to provide extensive resources, quality information, and testing played a large part in the success of the project.

Fig. 4: Repairing mesh prior to shoot

Initial trial batches based on the project specification seem to function reasonably well, but there were definitely some issues. The specification called for specific levels of 8% or less boiled absorption. The initial test came back at 7.6 to 7.9%, leaving little margin for variation. Secondly, there was a great deal of reluctance to allow a hydration stabilizer because it might affect the bond. The bond was specified at 150 psi

Fig. 5: Positioning the equipment for the next shoot

Fig. 6 and 7: Ever-changing shooting positions

(1 MPa) shotcrete-to-steel, but no data were available showing this was achievable. The specification required hydrodemolition of the existing shotcrete followed by an abrasive blast of the surface. This created some degree of ambiguity. Thus, it was decided that a surface preparation mockup test should be conducted.

The initial surface preparation test section was divided into three areas: one with a walnut shell blast, the second with a light sand blast, and the final area with just an air and water blast. The initial process was the belief that minimizing the removal of the existing material (steel surface and attached mesh) would be a good approach, and to then build the sections back up from there. The surface preparation tests had almost identical results from each of the three methods, with values ranging from 0 to 120 psi (0 to 0.83 MPa) with the majority being 0. After this initial test, it was obvious that more extensive testing would be required. Steel road plates were used to represent the bridge surface during the next test, which included a variety of differing parameters, including more extensive sandblasting, bonding agents, accelerators, hydration stabilizers, and different curing methods. In the end, a complete white blast of the steel surfaces proved to be the most effective with a multi-course sandblast material. But even then, the results were still not very consistent. Some sections would bond well and meet the specification and others would have no bond at all. Other attributes that seemed to be creating variability were the shrinkage and the flexural properties of the shotcrete material. The specification called for minimum levels of silica fume and cement, but we decided we needed to rethink this.

This is typically where I've seen a great number of projects become dysfunctional. The focus changes from getting the job done correctly to minimizing the damage and protecting one's best interest. The parties become more adversarial than trying to work together to solve the problems and move forward. Fortunately, with this project, the Oregon Department of Transportation (ODOT) and its team stepped up not only finan-

Fig. 8: Overhead finishing

Fig. 9: The finished product

cially but also (and more importantly) remained focused on finding the best solutions. I believe their role was instrumental in allowing both the contractors and suppliers the means to find the best answers in a timely manner. I think a statement made by a member of Wildish Standard Paving sums it up best:

"Our shotcrete applicator was committed to achieving the very best mix design that could be developed. From the original mixture, we reduced the silica fume content; used other supplemental cementitious material, including fly ash and added fiber; and a W. R. Grace retarder to slow the set-time. After developing eight different trial batches for the project, they were able to identify a concrete mix that exceeded the requirements of the specifications, while offering better adhesion and more elasticity than originally specified. Were it not for their perseverance in obtaining the best possible product, the shotcrete applied to the bridge might have met the original project specification but would not have been as durable over the years. From the original mix, which produced a 10 to 30 psi (0.07 to 0.21 MPa) bond pulloff strength, we increased to getting over 300 psi (2.1 MPa) with the final mix."

I would add that it was really the commitment of all the parties to achieve the best quality and durability that allowed this to take place.

As a result of the efforts by many, including Wildish Standard Paving, Johnson Western Gunite, CEMEX, and ODOT, the project team rehabilitated a beautiful historic landmark of the region in a safe and effective manner. Through working together toward a mutually desired end goal, I believe we produced a durable, serviceable, and aesthetically pleasing project that will be enjoyed by many generations to come. For information on the concrete mixture designs and specific test results, please contact ASA.

The Outstanding Repair & Rehabilitation Project

Project Name
The Oregon City Arch Bridge

Project Location
Oregon City, OR

Shotcrete Contractor
Superior Gunite*

General Contractor
Wildish Standard Paving

Architect/Engineer
n/a

Material Supplier/Manufacturer
CEMEX, W. R. Grace & Co.

Project Owner
Oregon Department of Transportation

*Corporate Member of the American Shotcrete Association

***Marcus H. von der Hofen**, Vice President of Coastal Gunite Construction, has nearly 2 decades of experience in the shotcrete industry as both a Project and Area Manager. He is an active member of American Concrete Institute (ACI) Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification. He is a charter member of ASA, joining in 1998, and currently serves as Vice President to the ASA Executive Committee.*

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2013 Outstanding Underground Project

The Learning Curve

Nozzleman Qualification for New York City Subway Tunnels

By William T. Drakeley Jr. and Scott Rand

The MTA CC/Long Island Railroad/East Side Access Project is an extension and new installation of subway tunnels, shafts, and cross passages for the New York City metro area. These new subway systems and adjoining connections allowed the use of the shotcrete process, based on certain criteria specified by bid documentation. This was to be the first major infrastructure use of shotcrete within the boundaries of New York City.

Fellow shotcrete experts and co-author Bill Drakeley have watched this project unfold with a certain level of anticipation. Their primary preoccupation was to ensure proper shotcrete placement was conducted safely by a qualified workforce in an underground environment. Drakeley was hired to qualify workers for the project. Once the workers were qualified, he remained on the project as a consultant and led oversight to the work in progress at the request of the project owner. From the outset of the shotcrete production, the learning curve for proper application techniques had to be successfully undertaken at an accelerated pace. Given the unprecedented nature of the project, the stakes could not have been higher for the future use of the shotcrete process in the greater New York City metropolitan area.

Specifications

The design specifications required each person applying shotcrete to demonstrate acceptable proficiency, which was defined as application that met the requirements of both the specification and the proficiency requirements of ACI Committee C660, Shotcrete Nozzleman Certification. The contractor was also required to provide operators qualified to perform work conforming to requirements of ACI 506R, "Guide to Shotcrete," and ACI 506.3R, "Guide to Certification of Shotcrete Nozzlemen" (this document has been withdrawn by ACI because all nozzleman certification efforts now fall under ACI Committee C660), with operators certified according to the requirements of the ACI Shotcrete Nozzleman Certification program.

The ACI Shotcrete Nozzleman Certification program, developed and maintained by ACI Committee C660, is a program for certification of nozzlemen employed for the application of dry- or wet-mix shotcrete. While an ACI Certified Nozzleman would be able to demonstrate basic knowledge and skill in shotcrete application, there are other aspects involved in shotcreting in an underground environment that require specific additional training. There are many craftsmen in the underground construction community that have skill and experience in concrete, including some experienced in shotcrete application for ground support and familiar with the needs for safety and work-related qualifications in the tunnel environment. However, they are not ACI-certified nozzlemen, and, unfortunately, the educational curriculum and the performance test (structural test panel) do not directly relate to placing underground shotcrete. The test is therefore not necessarily useful in assessing the ability of a person to apply shotcrete in an underground construction application.

ACI Committee C660 is not presently considering a curriculum or certification specific to tunnel and mining applications. It is important to note that the original ACI 506.3R was a nonmandatory guide for an engineer who wished to design a program for nozzleman certification to include in a project specification. Even though many specifications list it as such, ACI 506.3R was never a certification program in and of itself. In fact, one of the reasons the guide was officially withdrawn was because of the confusion it often created when blindly referenced in a project specification.

Training

Due to the lack of official training programs for shotcrete applications in the underground environment and the overwhelming need for such education, we recommended that a program following the applicable training curriculum and examining procedure of ACI Committee C660 be established for the purpose of qualifying craftsmen for application of shotcrete specific to the require-

ments of each underground project. This was not and could not be an ACI-sponsored program, but it was deemed acceptable by the project engineer after a comprehensive review. The program was developed and presented by qualified, credentialed ACI C660 examiners and educators.

This new training and qualification program required background information describing previous shotcrete experience, which was submitted either by the individual or the union for each candidate. The shotcrete "résumé" was reviewed by the project engineer, the examiner/educator, and others as required.

This program incorporated classroom instruction of 4 to 6 hours, including topics such as basic concrete technology and practice, shotcrete application, equipment operation and maintenance (directly related to shotcrete), ground support in various conditions employing shotcrete in combination with rock bolts, lattice girders and other support components, quality control, safety specific to shotcreting, and project requirements. It also included field trials such as practice shooting, the shooting of test panels to demonstrate application skills, and lab testing to confirm quality of materials placed. Finally, the program required field supervision by a qualified examiner/educator during initial shotcreting by the nozzleman on the project.

One of the priorities of this program was to ensure the continued presence of quality assurance and inspection personnel employed by the owner and designer, as well as quality control efforts by the contractor. The ongoing quality assurance and inspection were provided by the same examiner/educator that conducted the educational portions of the program and observed the field trials. In this way, all parties involved in the placement and acceptance of shotcrete on the project were in harmony.

General Conditions

The new shotcreting program hit four initial obstacles. First, under Contract CM019, the east and west caverns, in addition to all adjoining cross passages, Y caverns, and shafts, were to be drilled and blasted. With each blast, material was excavated and moved to a crusher in the lower levels. It was then loaded onto an underground conveyor belt and transported north, from Midtown Manhattan past Northern Boulevard in Queens. This excavation activity involved a three-shift nonstop rotation. Each underground phase was scheduled by set internal timetables. Because we were "the new guys on the block," we were given low priority and had to fight for (time) space (refer to Fig. 1).

Secondly, this rock removal schedule also left us with the task of reaching nearly inaccessible

Fig. 1

Fig. 2

areas of rock wall and ceiling (refer to Fig. 2). We encountered overbreaks in the excavation up to 10 ft (3 m) and overall ceiling heights that extended beyond 50 ft (15 m). The difficult access inherent on this project made continuous shotcrete application impossible. We would start one section, only to have to stop and move elsewhere, due to terrain passable only on foot or by mountain goat.

A third obstacle, which emerged in the first quarter of shotcrete applications, was the fact that our crew—Sand Hogs provided by Local #147 and some #731 Laborers—as the shotcrete underground workforce, was not allowed to service the shotcrete equipment. Due to the scope and logistics of the project, this task was the responsibility of other union crews equipped with workers and tools and established to carry out a variety of maintenance tasks in all aspects of the project. Although this is efficient for most operations, electrical and mechanical services

were often not available when required on our project, which resulted in downtime and quick changes in procedure. Available maintenance crews had a variety of workers with vastly different talents. While the range of expertise was ultimately an asset to the project, in the short-term, it inhibited a uniform and productive shotcrete application. For example, if a large robotic machine went down and was in dire need of service, its maintenance received no priority but was added to the list on a "first-come, first-served" basis.

The final obstacle was that the areas to be shotcreted were also high-traffic sites, accessed by workers in many trades. It was a bottleneck for all those involved and made implementation of the shotcrete process and schedule very challenging.

Fig. 3

Fig. 4

Shotcrete

As the accepted training and qualification program was put into place, we began our journey along the learning curve. The crews and management settled on hand-nozzling with the aid of man lifts. This was an important stance to take in deference to the qualifications of the workers. We strongly believe that no matter how many classroom sessions we had (2 full days for each nozzleman, on average) or how many hours were spent perfecting technique on the robotic machines, the best way to learn quality shotcrete placement was to actually grab the nozzle and shoot by hand.

Under the observation of a qualified supervisor or previously qualified job foreman, we could start with the nozzle in a low-risk wall or bench shooting to acquire hours of practice. Full qualification came after an accepted number of hand-nozzling hours were documented by the approved qualification trainer. It was of great benefit for the nozzleman to have a qualified trainer by his side, giving tips while shooting or discussing key issues with the foreman so he, in turn, could relay advice to the general crew. It should be pointed out that our qualification was geared toward the entire crew and full shotcrete process, not just the workers holding the nozzle.

Both dry- and wet-mix shotcrete materials and equipment were used. With a 6 in. (150 mm) slick line, wet-mix concrete was sent from the street through a re-mixer down to the tunnels and into the Putzmeister Shotcrete Technology's shotcrete pumps. Despite both the harsh physical environment and the carelessness demonstrated by some tradesmen in moving equipment from one shooting location to the next, the pumps withstood the abuse and operated successfully.

According to the specifications, all the large-volume shooting was to be done with wet-mix (refer to Fig. 3). Some smoothing or short patching was handled with dry-mix. For the most part, the dry-mix placement on the project employed full skid-mounted guns with pre-dampeners from Putzmeister. The dry-mix material supplier used, after a thorough vetting process, was King Packaged Materials Company. King supplied MS-D1 Accelerated Shotcrete and MS-D1 Steel Fiber Shotcrete on both contracts. The 2205 lb (1000 kg) bulk bags were delivered by truck to a rail siding in the Bronx, where they were transferred underground to Grand Central Terminal's Madison Yards by railcar.

The crews had to understand more than just basic shotcrete (refer to Fig. 4). They used a sophisticated shotcrete mixture that included hydration control chemical dosing of concrete intended to sit for hours, yet remain plastic and pumpable without separation; be pumped up to

and beyond 2000 ft (600 m); and make it to the nozzle without plugs despite being fiber-reinforced. Especially in overhead areas, the shotcrete material needed to have an accelerated set once sprayed, yet retain some plasticity for shaping or rough finishing. Each nozzleman could see firsthand how important angle, velocity, mixture design, and equipment manipulation (such as man lifts) were to the overall success of the job.

The job was always made more difficult by the requirement to add reinforcement to some of the rock substrate (refer to Fig. 5). Welded wire was attached to the rock bolts, and, on occasion, a metal mine strap was adhered to potentially loose rock material. These reinforcement requirements (overly reinforced in our humble opinion) likely reduced the bond of the fresh shotcrete to the rock substrate. Nozzle movements had to be perfect in and around a mine strap and where welded wire sheets overlapped, but there was virtually no access to the rock substrate behind the reinforcing material. In those few areas where the mesh overlapped, the crew adeptly cut out the overlapping layer to allow proper shotcrete application and a good bond to the rock facing.

Fig. 5

Current Status

According to Sean Clevenstine, General Superintendent of Concrete at Schiavone Construction, who oversaw the shotcrete applications on the project:

"Simple mathematics can be used to show the effectiveness of the program. In early 2011, our production goal based on past performance before the program took effect, was 40 yd^3 (31 m^3) of shotcrete placement per day, spread over three 8-hour shifts. By project completion, we were capable of applying over 200 yd^3 (150 m^3) in a 24-hour period, per heading, with rebound hovering between 5 and 10%. For a project of this magnitude, it wouldn't have been possible to get those numbers without a comprehensive training and evaluation program in place. What I believe made our program effective was the fact that it was "graduated"—each individual was walked through the application process step by step, under a qualified supervisor. The end result was a highly productive, exceptional quality product. It also validated the craft members of Local #147

as 'expert' nozzlemen by the time they completed all of the steps for qualification."

As of June 2013, we have qualified over 35 nozzlemen for this and related projects. Most are from the #147 Sand Hog Union. The total amount of early ground support surface area sprayed is 1,000,000 ft^2 (93,000 m^2). The yardage installed for the MTA CC/Long Island Railroad/East Side Access Project regarding the early ground support phase of the project is nearly 46,000 yd^3 (35,000 m^3) of wet-mix shotcrete application and another 10,300 yd^3 (7900 m^3) of dry-mix shotcrete. Mid-June 2013 marked the completion of the bulk of the project, not including punch-list items. The current talent pool of nozzlemen in New York City should now be considered as competent and viable a labor force as any in the underground shotcrete world. It is said of New York City that "if you can make it here, you can make it anywhere." Now, for the shotcrete process, that promise holds especially true.

The Outstanding Underground Project

Project Name
MTA CC/LIRR East Side Access

Project Location
New York, NY

Shotcrete Contractor
Schiavone Construction Co., LLC

Shotcrete Consultant
Drakeley Industries*

General Contractor
Dragados USA/Judlau JV

Architect/Engineer
Metropolitan Transportation Authority

Material Supplier/Manufacturer
King Shotcrete*, Putzmeister Shotcrete Technology*/ Ferrara Brothers Building Materials Corp.

Project Owner
Long Island Rail Road (LIRR)

*Corporate Member of the American Shotcrete Association

The authors wish to acknowledge the contributions of George Yoggy (right) to this article

William T. Drakeley Jr. *is President of Drakeley Industries and W. Drakeley Swimming Pool Company. Drakeley Industries is a shotcrete consulting firm that is dedicated to the training and implementation of the shotcrete process in regards to building water-retaining structures, ground support, and underground shotcrete application. Drakeley Pool Company is a design/build construction and service firm specializing in in-ground, high-end commercial and residential pools. Drakeley is an active member of ACI Committee 506, Shotcreting. He is the first ACI Certified Shotcrete Examiner from the pool industry nationwide. Drakeley is also an ACI Certified Nozzleman, ASA Technical Advisor, Chair of the ASA Pool & Recreational Shotcrete Committee, and serves as Treasurer to the ASA Executive Committee. His writings have been published in national and international trade magazines, including* Shotcrete, Watershapes, Pool and Spa, *and* Luxury Pools *magazines. In addition, Drakeley is a Platinum Member of the Genesis 3 Group, a licensed member of the Society of Water Shape Designers, and a member of the Association of Pool and Spa Professionals (APSP). He is also the Concrete/Shotcrete Instructor at the Genesis 3 Pool Construction Schools and NESPA Region 1 Show in Atlantic City. As an Instructor/Trainer, Drakeley has given lectures on shotcrete applications for various pool trade shows and for World of Concrete. Drakeley is an Expert Witness regarding shotcrete applications for the swimming pool industry.*

Scott Rand *is the Sales Manager for the Construction Products Group at King Packaged Materials Company, a leading manufacturer and supplier of prepackaged cementitious products. Rand is responsible for the sale of King's shotcretes, concretes, grouts, and repair mortars, as well as mixing and placing equipment, to North American civil and mining markets. Rand has more than 25 years of experience in shotcrete and concrete markets in Canada and the United States, and is currently serving his second term on the Board of Direction for the American Shotcrete Association (ASA).*

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Photo courtesy of R. Ringler

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AMERICAN SHOTCRETE ASSOCIATION

2013 Outstanding Pool & Recreational Project

Cliffside Plunge: Rewriting the Rules for Concrete Placement

By William T. Drakeley Jr.

Location, Location, Location

In 2011, Drakeley Pool Company was approached by the Donovans—new clients from Westchester County, NY—whose vision was to build a pool that would blend seamlessly with their home and surrounding landscape.

They imagined a pool nestled against the house in the backyard at basement level, allowing their family to step out onto the pool patio and immediately take advantage of the spectacular views of the lake that abuts the property. Then came the catch: a person could take approximately 10 full steps from the basement door before arriving cliffside, staring down a 200 ft (60 m) slope to the water's edge (refer to Fig. 1).

There was abundant yard space elsewhere on the property—flat, even, and ideal for a pool—but that area was already occupied by the septic tank and other necessities.

The challenge of cliffside construction had been tackled before with the house itself, which was perched sturdily atop a ledge rock point. Drakeley Pool Company was charged with the task of duplicating this process—this time, even closer to the cliff's edge—by working with existing grade changes and elevations to install a small pool with a strong current the owners could swim against. Bill Drakeley, owner, and Daniel LoRusso, foreman, aimed to create a feeling of expansiveness in the limited space, all the while working to keep the whole operation from tumbling off the cliff.

Designing Against Gravity

The Drakeley design featured three different elevations for water in transit: the top tier was to be a raised spa; the second, a main pool swimming area; and the third, a lower surge trough (Fig. 2). The installation would require the creative use of different techniques, including small cast-in-place concrete footings to stabilize the structures and concrete placed by the shotcrete process to create the bodies of the spa, pool, and surge trough.

The unique topography and geological conditions necessitated the construction of a "keyway" for the bottom of the shotcrete pool. This concrete-filled trough in the natural rock forms a keyway to lock the pool structure into the existing rock ledge and provide horizontal restraint for the structure to keep its position on the very brink of the cliff without movement.

Fig. 1: Dramatic slope bordering construction area

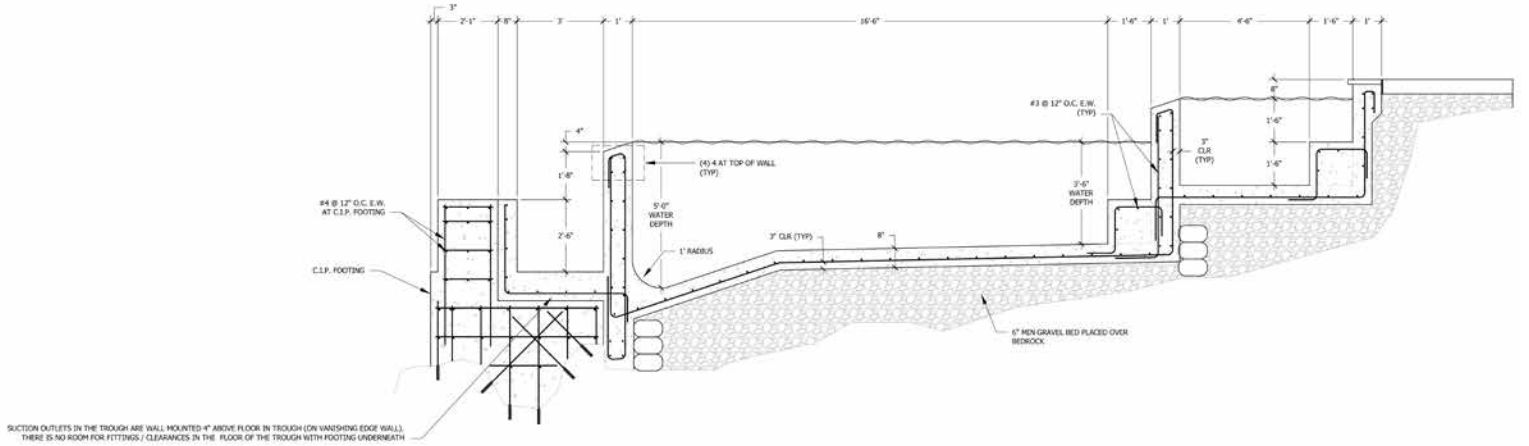

Fig. 2: Three-tier system of spa, main pool swimming area, and surge trough (Note: 1 in. = 25.4 mm)

Angles and Edges

The Donovan home is architecturally contemporary with organic design themes present in both the house's structure and the surrounding landscape. The pool would therefore require both architectural symmetry and fluid continuation of space.

Drakeley Pool Company derived its in-house design of the pool from the school of John Lautner and his mentor, Frank Lloyd Wright. The rectilinear orientation of the pool was intended to echo the angles of the house, while the harnessing of vanishing-edge design would allow the eye to skim effortlessly over the surface of the water and into the vault of trees encompassing the space. The water would flow over the edge and into the surge tank, which was stabilized and locked into the ledge lower on the hillside.

Fig. 3: Rock hammering and ledge removal

Phase 1: Excavation and Footing Installation

The Drakeley team began the project with an extensive period of rock hammering and ledge removal to carve the hillside to a buildable, workable base (Fig. 3 and 4). They then installed three sections of cast-in-place footings and horizontal structural members (Fig. 5). Situated beneath these members was the keyway that anchored the pool structure into the rock. At this point, the Drakeley crews installed drainage mechanisms and subsurface drains necessary to control groundwater that, if left unchecked, could compromise the stability of the hillside pool.

Fig. 4: Rock hammering and ledge removal

Phase 2: Forming and Steel

The next phase was forming and reinforcement installation (refer to Fig. 6). Forms were one-sided, rough-sawn lumber (2 x 4 in., 1 x 6 in. [50 x 100 mm, 25 x 150 mm]), accompanied by sheets of plywood. Because half of the pool installation was to be an out-of-ground build, intricate

Fig. 5: Cast-in-place concrete footing to support pool structure

Fig. 6: Intricate but efficient formwork, steel, and plumbing installation prior to shotcrete placement

Fig. 7: Extensive formwork required for cast-in-place concrete

forming was required. Despite its complexity, the forming phase boasted impressive efficiency when compared to the forming more traditional concrete placement methods would require. Because the formwork did not need to be designed for internal pressures, one-sided forming was used. Drakeley Pool Company recorded approximately 50% labor and material savings over conventional formwork (as is visible in Fig. 7, the small cast-in-place section of the foundation concrete work required as much wood forming as the remainder of the entire pool). Furthermore, the reduction of labor increased the speed of construction by almost 50% because of the reduced (or eliminated) need for two-sided structural forms.

All necessary plumbing was installed in keeping with LEED construction principles, employing low-line velocity technology with large pipe diameters. The steel reinforcement was Grade 60, No.4 (Grade 420, No.13M) bar placed 6 in. (150 mm) on center in the walls and double mat on the vanishing-edge wall. All reinforcing steel was installed with sufficient rigidity to withstand the shotcreting pressures and was kept free from oil, dirt, and other contaminants that could have affected performance.

Phase 3: Shotcrete & Curing

The shotcrete installation took place over a 3-day period. During the first day, Drakeley crews—ACI-certified nozzlemen and other qualified crew members—concentrated on the main pool swimming area and the vanishing-edge wall. The second and third days were designated for focus on the spa and surge trough areas. Despite the relatively unimposing dimensions of the pool, the

Fig. 8: Completed shotcrete structure undergoing 28-day wet cure to achieve high strengths of 6000 to 7000 psi (40 to 48 MPa)

detail work and achievement of key tolerances throughout the installation was critical. Following the 3-day shoot, the pool was water-cured and tank-tested to ensure not only strength gain but also water-tightness (Fig. 8). After a 28-day wet cure, tests revealed strength values between 6000 and 7000 psi (40 and 48 MPa).

For Bill Drakeley, an expert in concrete materials and application who specializes in the shotcrete process, the significance of the use of shotcrete in the Donovan project cannot be overstated. With the limited space for maneuvering at the cliff side, the flexibility of the concrete installation was paramount. Given that all formwork, steel, and concrete installations were basically out of the ground and extended outward over an edge, the shotcrete process allowed Drakeley Pool Company to complete this installation in the exact spot that the owner designated without any derivation from the original vision. Using other concrete installation types for the shells of the spa, pool, and surge trough would have greatly increased both difficulty and cost. Drakeley further notes that, despite the flexibility of concrete placement through the shotcrete process, compressive values and overall structural strength were not compromised in the least. "With shotcrete," he notes, "you don't sacrifice performance just because of difficult or challenging site conditions."

Phase 4: Masonry and Start-Up

In homage to the natural features of the surrounding New England topography, native stone matching the existing house foundation stone was used as coping and veneer material (Fig. 9). Select Pennsylvania bluestone made up all treads and caps. Glass tile covered the weir wall and the vanishing edge (Fig. 10), while Vermont slate tile was placed at the water line. Finally, a standard gray plaster finish was applied to the interior of all three shells, allowing for maximum sharp reflection at the water's surface (Fig. 11).

The pool was filled, all systems started up, and the project was turned over to a smiling client.

A Final Anecdote

Before ground was even broken, the project faced significant obstacles. Given the unprecedented nature of the proposed installation, the town building department was understandably skeptical regarding the ultimate reliability of the structure. The idea that the pool could be installed without some type of eventual flexural movement or differential settlement was considered unlikely at best. It was believed that some type of exceptional storm may have adverse effects on the project, implying legal repercussions for those involved in approving the plans.

To keep the wheels of the painstaking construction process moving according to the client's needs, Drakeley pressed on, hopeful that the quality of the installation would speak for itself, resulting in ultimate approval and a new precedent set for both the town and surrounding contractors.

Fig. 9: Native stone in harmony with house and surrounding landscape

Fig. 10: Glass tile applied to weir wall and vanishing edge

Fig. 11: Three-tier system complete and running

As perverse luck would have it, the local area was wracked by a hurricane, a tropical storm, an earthquake, a tornado, and a freak October blizzard that knocked the power out for 7 days. After this brutal round of foul weather (and with an unmoved, sound installation), Bill Drakeley humbly inquired if the shotcrete structure required further testing and verification. It didn't. The project was approved, albeit a bit later than hoped.

The Outstanding Pool & Recreational Project

Project Name
Donovan Residence

Project Location
Armonk, NY

Shotcrete Contractor
Drakeley Pool Co., LLC*

General Contractor
Drakeley Pool Co., LLC*

Architect/Engineer
Drakeley Pool Co., LLC*

Material Supplier/Manufacturer
Putzmeister Shotcrete Technology*

Project Owner
Joe & Judy Donovan

*Corporate Member of the American Shotcrete Association

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2013 Outstanding Architecture Project

Comprehensive Geotechnical Solutions Transform Old to New

An abandoned rock quarry is transformed into a decorative landscape, opening up usable land for high-end condominium construction

By Russ Ringler, Solomon Reyes, and Lisa Wagman Glezer

The Stoneyhurst Quarry project is an outstanding example of using collaborative ASA teamwork to complete a cost-effective and sustainable project producing maximum use of functional space.

The retired Stoneyhurst Quarry is located at the intersection of River Road and the Washington, DC, Beltway. In use since the mid-1800s, rock was quarried from 8101 River Road in Bethesda, MD, for the construction of many prominent buildings in and around Washington, DC.

Fig. 1: Stoneyhurst Quarry in final stage of production

Fig. 2: Top wall being transformed with faux-rock finish

As part of the Maryland Environmental and Mine Reclamation program, the retired quarry has undergone a transformation to allow for the development of a new high-end mid-rise condominium project.

Because the quarry was cut into the side of the hill, rather than a deep excavation in the ground, a unique system of retaining walls was used to stabilize and support the quarry walls.

Consideration was given to many types of retaining walls for this project, but top-down construction of soil nail walls was selected, as they offered the maximum design flexibility and lowest cost. Furthermore, the soil nail wall system provided the safest solution for this challenging project by providing the slope stabilization and the permanent retaining wall in one combined system. In 2009, the design-build contractor for the soil nail walls contracted with Top Gun Commercial Gunite of VA, Inc., led by Owner Russ Ringler* and Superintendent Solomon Reyes, the primary ACI Certified Nozzleman on the project, to do the top wall in the highest section to prove the design and construction concept. The original plan was to then cover the wall with rock. However, when the top wall was completed with a very attractive high-quality faux-rock finish, the owner was so pleased with the finished product they decided to use that method on all 11 retaining walls for the project.

Soil Nails Walls: Perfect Solution

Soil nail walls consist of soil nails (or anchors) combined with shotcrete structure and facing. They can be used in temporary or permanent

*Member of ASA.

applications, providing an excellent finished product while stabilizing hillsides with complex geotechnical issues. One without the other would provide subpar reinforcement, but together, they provided the best possible combination for strength and stability of deep-cut walls. Nicholas J. A. White,* Engineer of Design, stated, "Prior experience with Ringler's team on many other challenging projects made his team the only one considered to be qualified and capable to take on a project of this magnitude and complexity."

Ringler's work on this project included all of the shotcrete work for the installation of approximately 65,000 ft^2 (6000 m^2) of permanent soil nail retaining walls for the reclamation of the old rock quarry. Work included in the reclamation plan was the stabilization of the perimeter quarry wall faces, which were up to 75 ft (23 m) tall, while coordinating with the new site development plans.

The owner of the quarry, W. M. Rickman Construction Company LLC, used quarry soils to provide a series of access roads and work platforms at varying heights to reach each level as required to construct each element of the retaining walls.

The design and construction of the soil nail wall system was done by Wolverine Contracting, Frederick, MD. The technique was used to build a "top-down" retaining wall system. As soil nail walls are built from the top down, they provide temporary and permanent earth support in a single-wall system. There was not enough room on this project to over-excavate to build conventional cast-in-place walls. If conventional walls had been used, there would have been extensive sheeting and shoring required to provide safe conditions for wall construction. The soil nail wall system was a great success on this project, saving the owner a considerable amount of money when compared to other wall systems that were considered. The walls on this project were terraced, with each wall ranging from 10 ft (3 m) to more than 20 ft (6 m) tall when completed. The soil nailing process requires working in soils which will self-support over the short-term from 4 to 5 ft (1.2 to 1.5 m) tall. The residual soils, disintegrated rock, and bedrock at this site were a good fit for soil nailing.

The general method of construction was to start at the top of the top wall in a given area and make a 5 ft (1.5 m) deep excavation to the back face of the new wall. Then, soil nail anchors were drilled and grouted in the exposed face. The nails used on this project were epoxy-coated high-strength all-thread steel bars. The nails were grouted into 4 in. (100 mm) diameter holes drilled back 20 to 40 ft (6 to 12 m). The nails were typically installed at 5 ft (1.5 m) vertical and 6 ft (1.8 m) horizontal centers. Chimney drains were installed at 6 ft (1.8 m) on center to handle any seepage behind the shotcrete. Next, a layer of wire mesh was installed and a layer of dry-process shotcrete at least 4 in. (100 mm) thick was sprayed over the cut face. This layer of shotcrete is referred to as the temporary layer. Once testing of the soil nails was complete, the excavation was continued 5 ft (1.5 m) deeper and the process repeated.

Fig. 3: Completing lowest level

Fig. 4: Access roads were built and drilling commenced, closely followed by nail grouting and wire mesh installation

Fig. 5: Soil nailing

Fig. 6: Shotcrete placement

The Perfect Finish

Once the excavation was to grade for a single wall, the permanent shotcrete facing was installed. This consisted of an additional layer of wire mesh and an additional 8 in. (200 mm) minimum layer of dry-process shotcrete.

The final 2 in. (50 mm) of the shotcrete facing was then placed and hand-carved to simulate the type and color of the rock that was mined from the quarry. Once the facing cured, it was stained and sealed to provide a faux-rock finish as desired, using various color blends of Aquastain T-96 by The Euclid Chemical Company.

For the entire dry-process shotcrete application process, the team relied on twin Airplaco/Gunite Supply & Equipment C-10's Rotary Guns as well as Gunite Supply hoses and tools to place 85,000 ft^3 (2400 m^3) of shotcrete over a 3-year span.

All application was accomplished by ACI Certified Nozzlemen, through the ASA education and ACI certification programs.

All shotcrete materials were produced using Strong Industries volumetric mixer trucks. Thousands of test samples showed consistent results ranging between 5000 and 5800 psi (34 and 40 MPa) in 14 to 28 days. During the 3-year period, there were only two irregular test samples with low values.

After the project was completed, the only maintenance required was touch-up of the wall colors, which were discolored by minor efflorescence. Most real rock walls would experience the same discoloration.

Maximum Benefit: Cost Savings and Increased Usable Land

Ringler's team successfully completed all shotcrete work on this project in November 2012. This highly successful application of the soil nail wall system resulted in both substantial savings to the owner as well as an increase of an additional 30 ft (9 m) of open space for the condominium project. The design and construction of this project's walls using faux-rock-finished soil nail walls minimized the excavation required, eliminated any backfill, provided temporary and permanent excavation support, and customized the curved wall contours. The cost of this system was far less than using conventional cast-in-place walls and stone facing, and maximized the remaining surface area available for development.

Fig. 7: Overview of entire project

Making Way for Condos

Construction commenced September 2012 for Quarry Spring Condominiums. Quarry Springs offers the best of town and country in Bethesda, MD, with exclusive neighboring country clubs, including the elite Congressional Golf Club, which is just 1/4 mile (0.4 km) away. The club house is nearing completion and 97 condominiums are expected to be complete in early 2014. These high-end condos start at $1.8 million and feature elevators, garages, and fireplaces.

The Outstanding Architecture Project

Project Name
Stoneyhurst Quarry Reclamation Project

Project Location
Bethesda, MD

Shotcrete Contractor
Top Gun Commercial Gunite of VA., Inc.†‡

General Contractor
W. M. Rickman Construction Company, LLC

Architect/Engineer
Nicholas J. A. White, PE

Material Suppliers/Manufacturers:
The Euclid Chemical Company†
Gunite Supply & Equipment Co.†

Project Owner
Stoneyhurst Quarries, Inc.

†Corporate Member of the American Shotcrete Association

‡Top Gun Commercial Gunite is no longer in operation. Key personnel and specialized equipment were acquired by G.A. & F.C. Wagman, Inc., in July 2013.

Russ Ringler *is the Shotcrete Manager for G.A. & F.C. Wagman, Inc. Ringler has over 40 years of experience with shotcrete (gunite) and is an ACI Certified Nozzleman. Ringler works with owners and contractors to provide comprehensive geotechnical solutions. After spending the past 25 years as owner of Top Gun Commercial Gunite of VA., Inc., he was looking to grow to the next level, provide continuity for his staff, and provide more comprehensive services to clients. Ringler joined Wagman in July 2013 when Wagman was expanding their Geotechnical Construction Services Group to include shotcrete as well as investing in specialized talent and equipment. Combining years of experience and passion, Ringler states, "I like to find the jobs that nobody else will do, or nobody knows how to do, and do them."*

Solomon Reyes *is Superintendent at G.A. & F.C. Wagman, Inc. Reyes is an ACI Certified Nozzleman for both dry- and wet-mix shotcrete and has 12 years of shotcrete experience. He spent 8 years working with Ringler at Top Gun Gunite before joining Wagman in July 2013. Reyes has extensive experience in both wet and dry process in some of the most complicated and most demanding venues of application.*

Lisa Wagman Glezer *is Director of Communications for Wagman Companies, Inc. (Wagman Companies, Inc. is the holding and management company for G.A. & F.C. Wagman, Inc., and Wagman Construction, Inc.). Glezer is responsible for marketing as well as the companies' internal and external communications, including government and public relations. Glezer is part of the fourth generation of the 112-year-old family-owned business.*

2013 Carl E. Akeley Award

Carl E. Akeley

The eighth annual Carl E. Akeley Award was presented to Dr. Marc Jolin of Laval University, representing Philip Sawoszczuk of King Shotcrete, Dr. Michelle Nokken of Concordia University, and himself for their paper, "Sustainable Shotcrete Using Blast-Furnace Slag." This paper, published in the Fall 2013 issue of *Shotcrete* magazine, looked at incorporating a waste product of the steelmaking industry, blast-furnace slag, in a mixture design for use in mining ground support that maximizes sustainability. The award was presented by Ted Sofis, ASA Publications Committee Chair.

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"

Philip Sawoszczuk

Dr. Michelle Nokken

Dr. Marc Jolin

2013 ASA President's Award

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, six 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 2013, outgoing President Michael Cotter presented the ASA President's Award to Chris Zynda, a second-generation shotcreter who got his start shoveling rebound for his father almost a half century ago. He was instrumental in the introduction of wet-mix shotcrete to the industry some 30 years ago. As a contractor and an innovator of the wet shotcrete process and a proponent of the use of one-sided forms, Zynda's hard work and dedication to the industry has and is STILL changing the use of cast-in-place concrete in projects to shotcrete! Zynda dedicated 10 years to ASA, serving as President for 2 years and also serving on various ACI shotcrete-related committees.

Chris Zynda

Recognition of Service

This year, ASA's Executive Committee elected to bestow an additional award to recognize the many years of service to the Association from charter member Theodore Sofis, as both Director and Treasurer for the ASA Board of Direction and Executive Committee. Serving in these capacities since 2007, Sofis' participation in all aspects of ASA activities has helped raise the shotcrete industry to a higher level of recognition, quality, safety, and acceptance in the construction industry. 2014 ASA President Charles Hanskat had the honor of presenting this award.

Ted Sofis

FREE Onsite Shotcrete Learning Seminars

Learn more about the shotcrete process—for Architects, Engineers, and Specifiers

The shotcrete process offers numerous quality, efficiency, and sustainability advantages, but proper knowledge of the process is critical to the creation of a quality specification and for the success of any specifier/owner employing the process.

ASA Onsite Learning Seminars are **FREE** to the host organization for five or more architects, engineers, or specifiers. If you work with firms that specify or might potentially specify shotcrete and would like them to become better informed about its benefits and proper use, please let them know about this opportunity to learn!

- Introduction to the Shotcrete Process
- Shotcrete for Underground Construction
- Shotcrete for Repair and Rehabilitation of Concrete Structures

ASA is a registered AIA/CES provider.

Arrange for an ASA Onsite Learning Seminar today!
info@shotcrete.org or 248-848-3780

Shotcrete Corner

The American Shotcrete Association (ASA) strives to enhance the visibility and acceptance of shotcrete as a quality, durable, and flexible process for placing concrete in a wide variety of structures. To advance our industry, it is of paramount importance that shotcrete be placed with the best quality in a safe working environment. Achieving these goals in practice requires experience, specialized training, proper equipment, and attention to detail. The ASA Board of Direction firmly believes that to provide a quality shotcrete product requires not only ACI-certified nozzlemen but also a shotcrete contracting firm with the management team committed to quality, proper staffing, providing appropriate equipment, and crew safety. It also requires a shotcrete crew well-trained and experienced in the type of work they will be shotcreting. This Position Paper #1 solidifies our position on the qualifications of the shotcrete team and provides owners, engineers, architects, and any others guidance when establishing the credentials of shotcrete contractors undertaking their projects.

Charles Hanskat,
President, American Shotcrete Association

AMERICAN SHOTCRETE ASSOCIATION

38800 Country Club Dr., Farmington Hills, MI 48331
Phone: (248) 848-3780 • Fax: (248) 848-3740
E-mail: info@shotcrete.org • Website: www.shotcrete.org

American Shotcrete Association's Board of Direction Position Paper #1

AMERICAN SHOTCRETE ASSOCIATION

Shotcrete Contractor and Crew Qualifications

Shotcreting is an efficient method for placing high-quality, durable concrete in a wide variety of concrete structures. Shotcrete has been successfully used in substantial projects for well over a century. As with cast-in-place concrete, the quality of the shotcrete placement is dependent on the quality of the materials, proper mixing and transport, substrate/subgrade preparation, the placing process, and protection until final strength is reached.

However, a comparison of the shotcrete process to the traditional "form-and-cast" process shows significant differences. Specifically, when using the shotcrete process:

- Formwork is eliminated or substantially reduced;
- It is necessary to identify the best shotcrete process (wet- or dry-mix) for the job;
- Special gunning equipment is required, including pumps, guns, hoses, nozzles, and admixture/water pumps;
- Knowledge is required to safely use and maintain the shotcrete equipment;
- A trained field crew that performs work totally unlike casting concrete in forms is required;
- Environmental conditions that are unsatisfactory for quality shotcreting must be identified;
- The nozzleman must be well-versed in shooting techniques, including proper air, water, and mixture flow;
- The crew must be prepared to properly finish, protect, and cure freshly placed shotcrete; and
- Knowledge of quality-control procedures specific to shotcrete is required.

Based on these factors, it is apparent that a contractor offering to place quality shotcrete must have specific knowledge, equipment, training, and hands-on experience of the entire construction team—from company management through the field crew—to truly be considered a Shotcrete Contractor.

ACI 506R-05, "Guide to Shotcrete," is a great primer on shotcrete design and application. ACI Committee 506, Shotcreting, is currently working on revisions to the "Guide to Shotcrete" and in the latest drafts has developed an expanded section covering shotcrete crew requirements. Those provisions are summarized herein to help establish field crew qualifications. The requirements for the contracting firm to be considered a quality Shotcrete Contractor are then presented. Taken together, a shotcrete team that meets or exceeds the crew and contractor requirements will be best qualified to provide a cost-effective, quality, and durable shotcrete application.

Field Crew Duties and Qualifications

(based on input from ACI 506 Subcommittee developing updates to 506R, "Guide to Shotcrete")

Composition and Crew Duties

The basic shotcrete crew may consist of a foreman, a nozzleman, a finisher or rodman, an assistant nozzleman, a wireman, a gun or pump operator, a mixer operator (if needed), and laborers.

Depending on the size and complexity of the project, some duties may be combined by having one person performing more than one operation. For example, the foreman could also function as the nozzleman; one person could perform as the rodman and finisher—also, an assistant can help the nozzleman by pulling the hose and operating the air-lance/blowpipe; and, where needed, the gun or pump operator and mixer functions could be combined with proper equipment and one person could perform the tasks. Larger, congested reinforced projects may require more than one nozzleman, air-lance operator, and several finishers. Where several crews are operating, a foreman, superintendent, or engineer may be required.

Shotcrete Foreman's Duties—The foreman plans, directs, organizes, and coordinates the work of each member of the shotcrete crew to obtain a safe and successful application. This includes safety of the work area and quality-control procedures. The foreman is responsible for the inspection and maintenance of equipment and ordering and expediting delivery of materials. The foreman sets the pace of the work, maintains crew morale, ensures good housekeeping, and acts as a liaison to either the general supervisor or to the owner's inspection team. The foreman is usually a veteran nozzleman, finisher/rodman, or pump/gun operator, and should be able to fill any of the positions if required.

Nozzleman's Duties—The nozzleman is a key person in a shotcrete operation and is responsible for applying the shotcrete

and for bringing it to required line and grade in a workmanlike manner. The nozzleman's duties include coordinating the application with the foreman, finisher or rodman, and pump/gun operator. Before the shotcrete is installed, the nozzleman should ensure all areas to receive shotcrete are clean, sound, and free of loose material, and that anchors, reinforcement, and ground wires are properly placed and spaced.

In the dry process, the nozzleman controls the water content for hydration and ensures that the operating air pressure is uniform and will provide high velocity at impact for good consolidation. In the wet process, the nozzleman controls the air that increases or decreases the velocity to ensure proper placement, including proper encasement of the reinforcement.

The nozzleman provides leadership and direction for the shotcrete crew, which aids in the task of shooting high-quality shotcrete. The nozzleman is usually an accomplished finisher or rodman and gunman/pump operator.

Wireman's Duties—The wireman sets elevations and thicknesses for the shotcrete placement, which may include the top and face of the wall. Grades set by the wiremen are the lines the nozzleman and finishers will follow. The wireman may use many devices for setting grades, such as piano wire, fiberglass-metal rods, and plastic pipe.

Finisher/Rodman's Duties—The finisher rods or cuts the freshly placed shotcrete surface, bringing it to line and grade before final finishing. The finisher also locates and removes sand pockets, sags, and sloughs, and guides the nozzleman to low spots that require filling with additional shotcrete. Before the shotcrete takes final set, the finisher brooms and prepares the surface for final application.

Assistant Nozzleman's Duties (blowpipe/air lance control)—The assistant nozzleman helps the nozzleman by dragging the hose and performing other duties as directed by the nozzleman. The assistant nozzleman relays signals between the nozzleman and the gunman/pump operator, and may also relieve the nozzleman for short rest periods. The assistant nozzleman may operate the air lance, if one is required, to keep the areas in advance of the shotcrete free of rebound and overspray. The assistant nozzleman may be a nozzleman trainee and place shotcrete under the direct supervision of a certified nozzleman.

Gunman's Duties (dry-mix)—The gunman provides a constant flow of properly mixed dry-mix material to the nozzleman. The gunman operates and maintains a clean gun and assists in ensuring quality control. The gunman should be particularly attentive to the needs of the nozzleman and ensure that the mixture is properly prepared. The gunman generally oversees, controls, and coordinates the material mixing and delivery operation.

Pump Operator's Duties (wet-mix)—The pump operator regulates the pump to uniformly deliver the wet-mix shotcrete at the required rate. The pump operator is responsible for cleaning and maintaining the material hose and pump. The pump operator coordinates the delivery of shotcrete mixture and monitors the water content by observing or testing the slump of the mixture. The pump operator may change the delivery rate of the transit and concrete trucks, including staging the trucks at the pump. The pump operator is also responsible for the safety of the pump and delivery line.

Mixerman's Duties—The mixerman's duties include, where applicable, the proportioning and mixing of the shotcrete mixture materials, and maintaining and cleaning the mixing equipment. For field mixing, the mixerman is responsible for storage, care, and accessibility of the materials. The mixerman sees that the mixture is free of contaminated materials and debris and that the aggregates have the proper moisture content. The mixerman ensures a constant flow of shotcrete materials but is also careful not to mix more material than can be used within the specified time limits. The mixerman supervises the laborers who are supplying and loading the mixer.

Hose Tender's Duties—The hose tender's duties include moving tools, equipment, hoses, scaffolding, and materials. Hose tenders clean work areas, remove rebound and overspray, and provide support for the shotcrete application.

Project Engineer, Project Manager, or Superintendent—On large or complicated projects, a project engineer, project manager, or superintendent may be advisable. A shotcrete contractor usually employs engineers, project managers, or superintendents, but they may not be assigned full-time to a single project. The project engineer, project manager, or superintendent is responsible for the material selection, mixture proportioning, preconstruction testing, qualifications of the crew, equipment selection, project planning, scheduling, logistics, materials handling, quality control, sampling and testing coordinating, and troubleshooting technical problems during construction.

Crew Qualifications

General—The quality of a completed shotcrete application results from the combined skills and knowledge of the shotcrete crew. The foreman and crew should have performed satisfactory work in similar capacities for a specified period. The entire crew is responsible for the safety of each member and other's on any particular project.

Shotcrete Foreman—The foreman commonly has proficiency in all crew positions and is in charge of the crew and their safety procedures. The foreman typically has at least 2 years of experience in the placement of shotcrete.

Nozzleman—The nozzleman should be ACI certified (refer to ACI CP-60) and have completed at least one similar application as a nozzleman on a similar project for the shotcrete contractor. On congested reinforced projects, the nozzleman should also be able to demonstrate, by preconstruction testing, an ability to satisfactorily perform the required duties and to apply shotcrete as required by specifications.

Assistant Nozzleman/Nozzleman Trainee—The assistant nozzleman/nozzleman trainee should have 6 months of experience in a variety of shotcrete field operations that may include finishing, gun or pump operation, blowpipe/air lance control, and hose tending, and should be able to demonstrate knowledge

of proper shotcrete equipment setup (pump/gun, delivery hose, nozzle, air/water supply). When shooting, the assistant nozzleman/nozzleman trainee must be under the direction of an ACI Certified Nozzleman.

Blowpipe/Air Lance Control—This person should have experience in finishing shotcrete and have proven successful manipulation of the blowpipe on previous jobs as directed by an ACI Certified Nozzleman, shotcrete foreman, or superintendent.

Wireman—The wireman should have at least 1 year of experience in setting grades on projects with shotcrete applications.

Rodman and Finisher—The rodman and finisher must have shotcrete experience and care must be taken not to create sags and loss of bond. Previous work experience that provided acceptable results should qualify them in this position.

Gunman or Pump Operator—The gunman or pump operator should be familiar with and be able to operate the shotcrete delivery equipment, know the proper methods of material preparation and mixing, and be familiar with the chosen method of communication. The pump operator and gunman should preferably have at least 1 year of experience operating the intended equipment and be familiar with all manufacturers' safety guides and operations.

Mixerman—The mixerman should know and perform the proper methods of material preparation and mixing to consistently mix and maintain the required mixture proportions, including the proper water-cementitious material ratio (*w*/*cm*). The mixerman should have a minimum of 6 months running the specific (or similar) mixing equipment used on the project.

Project Engineer, Project Manager, or Superintendent—The project engineer, project manager, or superintendent should have at least 3 years of relevant field experience.

Shotcrete Contractor Qualifications

The uniquely different needs of the shotcrete field crew and equipment, when compared to that for conventional cast-in-place concrete work, require the support, commitment, and positive attitude of the entire contracting organization for successful execution of quality shotcrete projects. Successful shotcrete projects demand full corporate support in:

1. Establishing and enforcing safety and quality-control policies;
2. Purchasing and maintaining the proper equipment for each project's particular needs;
3. Committing to hire, train, and maintain the needed field personnel;
4. Handling the logistics of bidding, scheduling, and preconstruction requirements in a timely and efficient manner; and
5. Maintaining good client relationships, without which the shotcrete project may be less than successful.

The owner or specifier should always require an experienced and qualified shotcrete contractor team for executing quality shotcrete work. With this in mind, ASA has established the following guidelines for an owner or specifier to consider when selecting a shotcrete contractor qualified to undertake a project. Following these recommendations give the owner or specifier assurance that the entire shotcrete construction team (qualified contractor, ACI Certified Nozzleman, and experienced crew) have proven their knowledge and ability to consistently place quality concrete. It is highly recommended that the owner or specifier consider pre-qualifying shotcrete contractors using these guidelines prior to bid, or at a minimum have the information submitted with the bid.

1. Five years of experience as a licensed contractor.
2. Five shotcrete projects of similar size, scope, and shotcrete process used (dry- or wet-mix) successfully completed in those 5 years with proper documentation, including full contact information for owner/engineer/construction manager/general contractor, a project description, and the scope of work accomplished.
3. The ability to self-perform all shotcrete-related work and a minimum crew on hand and/or staff listed as part of the company (either employees or substitutes with a work history under current business name) consisting of the following minimum experienced field crew members:
   a. Shotcrete Foreman
   b. Nozzleman (at least one ACI Certified Nozzleman on the project)
   c. Dry-Mix Gunman or Wet-Mix Pump Operator
   d. Assistant Nozzlemen/Nozzlemen Trainees (blowpipe/air-lance controller)
   e. Finishers
   f. Mixerman
   g. Hose Tenders
4. Ownership of all necessary shotcrete-specific equipment (pumps, guns, and hoses) to accomplish the job based on the specific project needs. Shotcrete contractor must submit sizes and models for all shotcrete equipment to be used, including full equipment backup in case of equipment breakdown.
5. A certificate as a Business in Good Standing from the state that the company resides in.
6. A letter of bonding capacity from the bonding company or a letter of credit.
7. Company insurance in good standing, meeting all state minimum requirements, including, but not limited to, general liability and workers' compensation.
8. ASA Corporate Membership
9. Ability to demonstrate that company construction support staff (safety, general superintendent, project managers, and construction managers) has educational session credits through an industry-appropriate continuing education program specifically addressing shotcrete design, construction, or administration (ACI certifications; ASA education sessions [including ASA Onsite Seminars]; seminars; or trade shows, such as World of Concrete, ACI conventions, and ASA meetings).
10. An office, shop, or business base (with an address).
11. References (including those from the five projects in Item #2).
12. Affiliations

13. Full disclosure of any criminal or fraudulent rulings for shotcrete work against former or current company owners in a 5-year period.

Summary

To consistently produce quality shotcrete work, the shotcrete contractor, key personnel, material, equipment, placement methods, curing, and protection all require proper training and qualification to handle your particular project. It must be stressed that any one of the elements alone cannot guarantee success, and poor performance or lack of shotcrete knowledge by any member of the crew can cause a substandard finished product.

Simply specifying the use of an ACI Certified Nozzleman WILL NOT guarantee successful shotcrete placement on a project. The ACI Nozzleman Certification program was designed to establish that the tested nozzleman is capable of shooting at an "entry" level. The nozzleman receives his certificate for each process and orientation if he succeeds in the written and the performance exam. It is plainly evident that the performance exam is not representative of the shotcrete application experience needed to consistently and properly place shotcrete. The shotcrete construction market has a wide range of project needs from basic, lightly reinforced, thin shotcrete sections to complex and congested structural systems requiring substantially more experience and sophisticated techniques. The wide spectrum of construction practices, shotcrete processes, performance requirements, and geographic differences can impact shotcrete placement in many ways. No certification program can address all potential variables. The ACI Nozzleman Certification program simply verifies the certified nozzleman has basic shotcrete knowledge and has adequately shot a shallow, flat, relatively lightly reinforced test panel. This establishes that the nozzleman has the **potential** for doing a satisfactory job, once he has gained the experience required for a specific type of project.

Only by selecting a quality shotcrete construction team comprised of a qualified shotcrete contractor, a trained and experienced crew (including the ACI Certified Nozzleman), and the proper equipment and materials can you be reasonably assured your shotcrete project will produce the high-quality, durable concrete structures that shotcrete is capable of creating.

Shotcrete Contractor Qualification Evaluation Checklist	
	Five years of experience as a licensed contractor
	Five shotcrete projects of similar size, scope, and shotcrete process (dry- or wet-mix), successfully completed in those 5 years with proper documentation
	Shotcrete Contractor self-performs all shotcrete-related work and has provided an experience listing of the minimum crew to be used on the project
	Owns all necessary shotcrete-specific equipment (pumps, guns, and hoses) to accomplish the job based on the specific project needs. Shotcrete Contractor has submitted sizes and models of all shotcrete equipment to be used—including full equipment backup in case of equipment breakdown
	Certificate as a Business in Good Standing or equivalent from the state that the company resides in
	Letter of bonding capacity from the bonding company or a letter of credit
	Company insurance in good standing and meeting all state minimum requirements (including, but not limited to, general liability and workers' compensation)
	Contractor is a Corporate Member of ASA
	Contractor documents that company construction support staff (for example, Safety, General Superintendent, Project Managers, and Construction Managers) have continuing educational session credits
	Physical office, shop, or other business address
	References (preferably including those from the five shotcrete projects of similar size, scope, and shotcrete process)
	Company Affiliations (for example, ASA, ACI, AGC, or ABC)
	Contractor has disclosed any criminal or fraudulent ruling for shotcrete work against former or current company owners in a 5-year period

Shotcrete = Sustainability

The Summer 2013 issue of *Shotcrete* magazine's Sustainability column marked the completion of a 10-article series detailing the "Top 10 Sustainability Benefits of Shotcrete." We've had great contributions to the series by various authors, including Cathy Burkert, Michael Cotter, Oscar Duckworth, Charles Hanskat, Joe Hutter, Ray Schallom III, Ted Sofis, and Marcus von der Hofen.

Shotcrete sprayed in place against one-sided forms saves 50% of the forming required in cast-in-place installations

As a reminder, our "Top 10" series covered these topics:

1. Formwork savings of 50 to 100% over conventional cast-in-place construction.
2. Formwork does not have to be designed for internal pressures.
3. Complex shapes require very little—if any—formwork.
4. Crane and other equipment savings or elimination.
5. Labor savings of at least 50% in repair applications.
6. New construction speed savings of 33 to 50%.
7. Speed of repair reduces or eliminates downtime.
8. Better bonding to the substrate enhances durability.
9. Adaptability to repair surfaces that are not cost-effective with other processes.
10. Ability to access restricted space and difficult-to-reach areas, including overhead and underground.

Additionally, over the course of the 2-1/2 years our "Sustainability Top 10" series has run, we've had many other articles in *Shotcrete* magazine that have addressed sustainability topics, either directly or indirectly. In many ways, sustainability is becoming a key aspect of all types of shotcrete work we report on in *Shotcrete* magazine. In fact, three articles in last Fall's issue directly relate to sustainability!

- The Technical Tip, "Material Velocity at the Nozzle," by Nicolas Ginouse and Marc Jolin, detailed practical research on nozzle material velocity with the intent to develop future guidance on optimizing—and hopefully reducing—rebound.

No flat surfaces here—shotcrete is a natural choice for this project

This enhances sustainability because we can use less material and labor to produce the same structural element.

- "Limestone Cement in Shotcrete" looked at the growing use of ground limestone "filler" as partial portland cement replacement in shotcrete mixtures. Although the amount of limestone "filler" that can produce equal durability in combination with lesser amounts of portland cement is being widely debated, the substitution of any amount of cement has sustainability benefits due to the reduced production of greenhouse gases associated with cement production.
- "The Use of Recycled Glass in Shotcrete," by Isabelle Fily-Paré and Marc Jolin, looked at replacement of a portion of portland cement in our mixtures with recycled glass. Cutting cement and the greenhouse gases associated with cement production and recycling glass that may otherwise go into a landfill are both factors that lead to enhanced sustainability.

Take a moment to review our Top 10 list on the previous page…

When you look closely, it is clearly evident that nearly everything we do with the shotcrete process is more sustainable than normal cast-in-place concrete. Shotcrete inherently creates enhanced sustainability because we have:

- Fewer forms, and when we use forms they create much lighter construction;
- Easy construction of curved or variable-thickness shapes, which allows maximum structural efficiency with the least amount of material;
- Less heavy equipment on the job site;
- Substantially less labor with the reduction in formwork activities;
- Less material and labor, which equates to faster completion of a given structural section; and
- Adaptability to nearly any repair, renovation, or repurposing of a structure, which means we can substantially prolong the life of existing concrete structures with more durable shotcrete rather than require demolition and rebuilding of the structure that uses more resources.

If you find yourself promoting the use of shotcrete in lieu of cast concrete on a project, pull out this Top 10 List, our ASA Sustainability brochure, or go to the shotcrete sustainability web link, **shotcrete.org/pages/why-shotcrete/sustainability.htm**, to prove that not only will the project have cost and time benefits but by enhancing the sustainability, you will also ultimately help preserve our world for future generations.

It's clear from everything we do as an industry: Shotcrete = Sustainability.

Shoring, forming, and casting this repair would be extremely difficult, but shotcrete makes it easy

Putzmeister Shotcrete Technology

A worldwide partner for quality and innovation

Putzmeister

SHOTCRETE TECHNOLOGY

Putzmeister Shotcrete Technology provides customers with one source for the world's most complete offering of solutions and equipment for sprayed concrete.

Since purchasing Allentown Equipment, with its more than 100 years of shotcrete expertise, and combining it with Putzmeister's innovative concrete technologies and experience, Putzmeister Shotcrete Technology can provide world-class support for contractors' needs in the refractory, underground, mortar, and civil industries.

In the early 1900s, Allentown's pioneering technology was first developed for taxidermy purposes when founder Carl Akeley, a famous hunter and professor, devised a method for spraying plaster onto a wire frame. The outcome was a strong, thick plaster coating that didn't slump from the frame or set before being fully placed.

Forty years later, a new process was developed involving the use of pressure tanks to force stiff mortar through a hose. This new wet-process became known as shotcrete—and the rest is history.

"In this day and age, very few companies are able to succeed in business for over 100 years," says Patrick Bridger, President of Putzmeister Shotcrete Technology. "We are very proud of our longevity, and see it as a testament to our reputation for quality, and the value we have brought our customers for more than a century."

Since the 1950s, the Allentown name has been synonymous with the process of spraying mortar at high velocity onto surfaces in the refractory, underground, mortar, and civil industries. The equipment line has expanded to include a wide range of gunning machines, pre-dampeners, dosing pumps, pumps, combination mixer-pumps, mixers, chemical additive pumps, nozzle carriers, mortar machines, concreting machines, and parts and accessories.

Throughout the years, numerous milestones have been achieved:

Thom-Katt® TK 20 concrete/shotcrete Trailer Pump

SPM 307 Nozzle Carrier

Corporate Member Profile

1900s: Carl Akeley develops method for spraying plaster onto wire frames.

1910: First cement gun introduced at New York Concrete Show.

1911: Patents and trademarks issued for the cement gun and its gunite process.

1950s: Wet-process shotcrete application developed.

1960s: Dry-process rotary gun developed.

1970s: Swing-tube technology used on wet-process shotcrete equipment, making application and use more practical.

2007: Company acquired by Putzmeister America, Inc., resulting in most comprehensive line of sprayed concrete equipment. Name changed from Allentown Equipment to Allentown Shotcrete Technology, Inc.

2008: Allentown becomes exclusive U.S. distributor of the Sika/Aliva family of wet- and dry-process shotcrete equipment.

2009: Putzmeister America's Special Application Business forms partnership between Allentown, Esser Pipe Technology, and Maxon Industries, Inc., creating a comprehensive systems approach for tunnel and mining, dam and power generation, transportation, marine, and offshore projects. MacLean Engineering, in partnership with Allentown, develops new self-contained shotcrete spraying machine.

2010: Allentown celebrates 100th anniversary.

2012: Allentown Shotcrete Technology, Inc., is rebranded Putzmeister Shotcrete Technology.

Your worldwide partner for quality and innovation, Putzmeister has earned a reputation for excellence and expertise built on a commitment to application-oriented engineering and customer service. Today, Putzmeister Shotcrete Technology leads the industry in the design and manufacture of wet- and dry-process shotcrete equipment.

Contact Putzmeister at (800) 553-3414 or visit **www.PutzmeisterShotcrete.com**.

Putzmeister Shotcrete Technology

Patrick Bridger
1733 90th St
Sturtevant, WI 53177-1805
E-mail: bridgerp@putzam.com

AG 15 Gunning Machine

N-Type Pnuematic Gun

A3 Tommy Gun® fireproofing pump

Friedrich Schwing Sr. Inducted Into AEM Hall of Fame

The Association of Equipment Manufacturers (AEM) inducted Friedrich Schwing Sr. (1909-1992), founder of Schwing GmbH, Herne, Germany, into their prestigious Hall of Fame. Ceremonies were held at the Association's Annual Conference in Orlando, FL. The Schwing name will join a list of notable past recipients, including Case, Barber, Deere, Grove, Harnishfeger, Liebherr, and many other innovators who "Individually and collectively represent some of the best, brightest, and most influential minds in the history of the off-road equipment industry." Nominations were judged on the candidate's history of innovation, industry contributions, leadership, corporate citizenship/social responsibility, and sustainability.

Schwing excelled in all categories, as judged by a panel of 12 industry experts. He held more than 100 patents relating to innovations in material handling and construction equipment. Schwing GmbH continues to be a worldwide force after being established in 1934. Schwing America, a subsidiary, will celebrate its 40th anniversary in 2014. Schwing began his career

by designing a climbing crane that was embraced by the construction industry. That success inspired him to invent the modern concrete pump after witnessing the inefficient cycling of concrete by buckets. The Schwing all-hydraulic, twin-cylinder concrete pump design powers the majority of modern concrete pumps today. The result of Schwing's invention is construction efficiency without the manual labor and extraordinary speed of placement never before achieved by other methods. Witness the pumping efficiency demonstrated at One World Trade Center (Freedom Tower) that topped out at 1665 ft (508 m) thanks to Schwing concrete pumps at ground level.

Schwing truly lived for the customer. Never content with the status quo, he sought the theoretical optimum for his

products. To maintain his continuing desire for design progress, he encouraged his sons Friedrich and Gerhard to seek educations that would allow them to handle day-to-day operations of the company. He turned over the executive powers of the company to his sons in 1982. His leadership style was to delegate functions better left to his employees so that his pursuit of solutions through engineering would not be distracted. He led by example with a work ethic and modesty that meant he wore the oldest suit and drove a twenty-year-old car. Upon receiving advice from his doctor to go home for the day on May 25, 1992, Friedrich Wilhelm Schwing instead went back to the office, where he died. His contributions were acknowledged by the president of the American Concrete Pumping Association, who wrote in the Winter 1992 edition of the association's magazine, "I have always been amazed at F.W. Schwing's dedication, drive and continuing interest in the concrete construction industry up to his last years. In our industry, he will be remembered as a pioneer, a Thomas Edison of the modern concrete machinery business. To his family, we the members of the concrete pumping and construction industries offer our continuing respect for the man who shaped, in some way, all of our lives."

Schwing's engineering expertise was not only aimed at product performance but also operator safety. Concrete pumping enjoys a remarkable safety record thanks to the design innovations of Schwing that have been adopted by the Concrete Pump Manufacturers Association and adopted by most concrete pump manufacturers. The generous amount of time donated by Schwing America to establish safety guidelines, host safety seminars, and provide a safer work environment for all concrete pumpers is a direct result of Schwing's corporate policy. This corporate commitment to the industry extends to the ACPA with direct support through sponsorships of safety and marketing materials and hundreds of hours of donated employee time on committees and boards that continues to this day.

In accepting the award for Schwing's accomplishments, Schwing America's CEO Brian Hazelton said, "It is hard to imagine that one man could improve construction methods in such a profound way. It is my honor to accept this award on behalf of the Schwing family that still embodies the work ethic and corporate responsibility of Mr. Schwing Sr. His son, Gerhard, is directly involved in the company to this day and I am proud to be a part of an organization that carries on the Schwing family tradition of innovation, integrity, and quality. Thank you."

Wagman Companies, Inc., Named Corporation of the Year, Ranked Among Best Places to Work in PA

Wagman Companies, Inc., was named Corporation of the Year by the Central Pennsylvania Chapter of the Association of Fundraising Professionals (AFP). According to AFP, Wagman was selected for "extraordinary efforts not only to provide, but to raise funds for non-profit organizations, along with a strong commitment to the community which serves as inspiration to your employees and other businesses."

The Central Pennsylvania AFP National Philanthropy Day Awards Luncheon was held during the Annual Fall Conference at The Clarion Hotel in New Cumberland, PA. Lisa Wagman Glezer, part of the fourth generation at Wagman Companies, Inc., accepted the award. For more information about the AFP Central Pennsylvania Awards, please visit: **www.afpcentralpa.com/NPD-Award-Winners-page.html**.

Wagman Companies, Inc., was also recognized among the Top 100 Best Places to Work in PA 2013 at an awards banquet on December 5, 2013, at the Lancaster County Convention Center in Lancaster, PA. Wagman ranked #7 among the Best Places to Work in PA, in the large company category.

Mike Glezer, CEO of Wagman Companies, Inc., states, "We are thrilled to be ranked #7 among the Best Places to Work in PA! It's a great honor and an amazing achievement to share with everyone at Wagman. We value the feedback from the surveys and appreciated comments which describe Wagman as having a family feel and being people-oriented and safety-focused. Our employees have embraced the culture we strive to achieve."

Wagman was founded in 1902 and continues on today as a fourth-generation, family-owned general contracting business headquartered in York, PA. Wagman Companies, Inc., is the holding and management company for G.A. & F.C. Wagman, Inc., and Wagman Construction Inc. G.A. & F.C. Wagman, Inc., is a heavy civil contractor and has grown to become a nationally

recognized leader within the industry, operating out of offices in Pennsylvania and Virginia. G.A. & F.C. Wagman, Inc.'s core competencies include: design-build, bridges, structures, highways, excavation, drainage, marine construction, latex-modified concrete, shotcrete, and geotechnical construction services. Wagman Construction, Inc., is a full-service general contractor located in downtown York, PA, serving senior living, healthcare, higher education, urban, institutional, and industrial markets in central Pennsylvania, Virginia, and Maryland. For more information about Wagman, please visit **www.wagman.com**.

Blastcrete Equipment Acquires Neal Manufacturing

Neal Manufacturing, a leading manufacturer of asphalt sealcoating equipment since 1978, has partnered with Blastcrete Equipment Co. and has moved its operations to Blastcrete's 70,000 ft^2 (6503 m^2) manufacturing facility in Anniston, AL, located just 50 miles (81 km) to the west. Neal will operate as a division of Blastcrete.

All of the key employees, including Sales Manager Eric Humphries, will relocate to Blastcrete and will join four former Neal employees, including former Neal President Maury Bagwell, who has served as General Manager at Blastcrete since 2011. "Neal fits Blastcrete like a glove," Blastcrete President Jim Farrell said in making the announcement. "It is very unusual in a new partnership that you have the luxury of blending over 50 years of manufacturing experience. This opportunity eliminates any learning curve for us and allows us to start from day one providing our new Neal customers with world-class equipment and service."

The Neal product line includes both self-propelled and trailer-mounted machines in several sizes, as well as skid-mounted machines. A rollout of the new partnership, including its latest technology, was featured at the National Pavement Expo January 8-11, 2014, in Ft. Lauderdale, FL.

Blastcrete Equipment Co., established in 1950, is a leading manufacturer of mixing, pumping, and spraying equipment serving the refractory, shotcrete, concrete construction and repair, underground mining and tunneling, and power generation industries worldwide. "Like Neal, Blastcrete has remained on the leading edge of introducing new technology to the industries that we serve," Farrell continued. "We are excited to see how some of these proven technologies that we have developed at Blastcrete might offer opportunities in the asphalt sealcoating industry."

AMERICAN SHOTCRETE ASSOCIATION
ONLINE BUYERS GUIDE

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

The American Shotcrete Association (ASA) Buyers Guide is now available free to the concrete industry at **www.shotcrete.org**. Look for "Buyers Guide" in the "Products/Services & Information" section.

The ASA Buyer's Guide provides an important tool to locate those companies that continually prove their commitment to the shotcrete process and its quality by supporting ASA through Corporate Membership.

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

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

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

AMERICAN SHOTCRETE ASSOCIATION

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ASA Officers Elected

The ASA membership has elected the following individuals to leadership roles in the association, with terms beginning January 20, 2014. President **Charles Hanskat**, Hanskat Consulting Group; Vice President **Marcus von der Hofen**, Coastal Gunite Construction Co.; Secretary **Oscar Duckworth**, Valley Concrete Services; and Treasurer **William Drakeley Jr.**, Drakeley Industries, were all elected to 1-year terms.

These four individuals will join with immediate Past President **Michael Cotter**, American Underground Engineering, to form the 2014 ASA Executive Committee.

Oscar Duckworth and William Drakeley

ASA Directors Elected

Three individuals were elected to 3-year terms as ASA Directors, beginning on January 20, 2014. **Mason Guarino**, South Shore Gunite Pool & Spa, Inc., was reelected to a second term. **Ted Sofis**, Sofis Company, Inc., and **Cathy Burkert**, American Concrete Restorations, Inc., were elected to their first terms.

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

Mason Guarino

Ted Sofis

Cathy Burkert

ASA Board Appoints Bittner and Scott as Directors

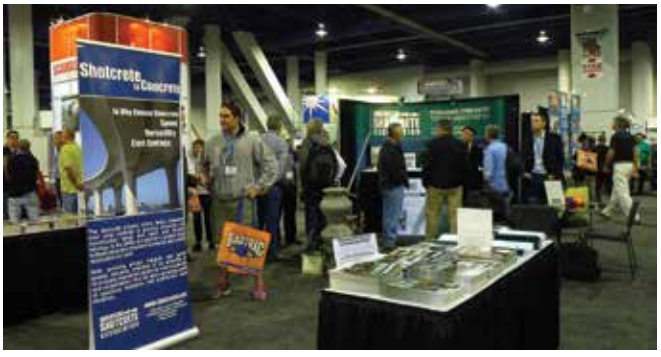
With the election of Oscar Duckworth and William Drakeley Jr. to the Officer positions of Secretary and Treasurer (midterm moves from their positions as a Directors), two vacancies were created among the nine Director positions on the Board. Following protocol in the ASA Bylaws, the Board received and approved the nominations of **Dennis Bittner**, The Quikrete Companies, and **James Scott**, Group Works, LLC, to complete the remaining 2 years of those open Director terms.

Dennis Bittner

James Scott

ASA at World of Concrete 2014

A new, more prominent location at this year's World of Concrete in Las Vegas, NV, January 21-24, drew an impressive amount of visitors into ASA's booth, who stopped by to inquire about shotcrete, ASA membership, and ASA's education and certification offerings. Complimentary copies of *Shotcrete* magazine, compilations, and shotcrete and sustainability brochures were also available.



Drawing many curious onlookers into the booth was a real 1937 dual-chamber "cement gun," on loan from one of ASA's Board members. The booth also featured a video demonstration of the shotcrete method in a variety of applications, as well as posters of this year's Outstanding Shotcrete Project Award winners and Banquet Sponsors. Members of the ASA Board of Direction were also available to greet attendees and answer their technical questions.

An all-day ASA shotcrete nozzleman education session on Tuesday, January 21, provided an in-depth review of the concepts covered in the ACI Shotcrete Nozzleman certification program. The recently revised presentation was conducted by ASA Examiners **Oscar Duckworth** and **Marc Jolin**, who received compliments on their presentation from attendees who stopped by the ASA booth later that week.

Finally, on Wednesday, January 22, ASA speakers **Charles Hanskat** and **Marcus von der Hofen** presented a 90-minute seminar titled "Shotcrete for Infrastructure and Building Repair, Rehabilitation and Repurposing." This session started with an overview of the shotcrete process, followed by the specifying and detailing considerations for design of shotcrete repairs, and then a discussion on field inspection, specific placement techniques, nozzleman certifications, and contractor qualifications. The sustainability benefits of shotcrete—including reduced formwork and scheduling and access advantages—were also highlighted. With approximately 100 attendees, ranging from nozzlemen to engineers and researchers, it was evident that awareness and interest in the use of shotcrete is definitely growing.

2013-2014 ASA Graduate Scholarships Awarded

The 2013-2014 ASA Graduate Scholarships have been awarded to Isabelle Fily-Pare and Lisa Marie Montgomery. Each student received a stipend of $3000 (USD) for tuition, residence, books, and materials.

Isabelle Fily-Pare graduated with her BEng from the University of Sherbrooke, Sherbrooke, QC, Canada, in 2012, and is currently pursuing her MS in civil engineering from Laval University, Québec, QC, Canada. Her research interests include concrete materials, researching the potential of using recycled glass powder in shotcrete mixture design.

Lisa Marie Montgomery graduated from the University of Maryland, College Park, MD, in 2011, with her BS in physical sciences and a concentration in civil engineering and her BA in criminology and criminal justice. She is currently working towards

Isabelle Fily-Pare

Lisa Marie Montgomery

her MArch from Morgan State University in Baltimore, MD. Coming from a heritage in the construction industry, she recognizes the potential for new and unconventional designs available through shotcrete application.

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.

Ninth Annual ASA Outstanding Project Awards Banquet

On Tuesday, January 21, 2014, during World of Concrete, ASA celebrated its Ninth Annual Outstanding Shotcrete Project Awards Banquet at the New York, New York Hotel & Casino in Las Vegas, NV. Approximately 140 attendees gathered to socialize with fellow ASA members and celebrate the top projects of 2013 that have exemplified the effective and beneficial use of shotcrete as a placement method for concrete construction.

Special thanks are in order to ASA's banquet sponsors, without whose generous donations this event would not be possible. Thirty-one sponsors contributed a total of $39,000, marking ASA's most successful fundraising effort to date. These sponsorships help to subsidize the cost of individuals' attendance to the banquet and other expenditures that contribute to the success of the awards program and banquet. Any surplus from the event is used throughout the year to fund some of the many initiatives that help promote the shotcrete process to the construction industry.

For a complete list of our 2013 Project Awards sponsors, find a link on **http://www.shotcrete.org/pages/membership/project-awards.htm**; it can also be found starting on page 6 of this issue.

Outstanding Architecture Project—presented to R. Ringler (left) by ASA President C. Hanskat (center) and ASA Awards Chair J. Hutter (right)

Outstanding International Project—presented to J. Stewart (left) by ASA President C. Hanskat (center) and ASA Awards Chair J. Hutter (right)

Outstanding Infrastructure Project team—A. McDougle (left), A. Pugliese (center), and D. McCravey (right)

Outstanding Pool & Recreational Project—presented to W. Drakeley (left) by ASA President C. Hanskat (center) and ASA Awards Chair J. Hutter (right)

Outstanding Repair & Rehabilitation Project team—M. von der Hofen (left), T. Deines (center), and L. Totten (right)

Outstanding Underground Project team—W. Drakeley (left) and S. Rand (right)

ASA Spring 2014 Committee Meetings in Reno, NV

The ASA Spring 2014 Committee Meetings will be held at the Grand Sierra Resort in Reno, NV, on Saturday, March 22, 2014.

The following committees have scheduled working meetings: ASA Executive Committee, Education Committee, Sustainability Committee, Pool & Recreational Shotcrete Committee, Safety Committee, Publications Committee, Marketing/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 ASA's overall mission.

The ASA committee meetings are held in conjunction with the ACI Spring 2014 Convention but do not require ACI convention registration. 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**.

Blastcrete Gunite Attachment Adds Convenience, Maneuverability for Range of Projects

Blastcrete Equipment Company's H-020 gunite attachment gives shotcrete contractors a powerful rotary gunite machine that attaches easily to any skid steer, requires less compressed air, and saves space on job sites. The easy-to-operate machine delivers precise material control for projects, including concrete repair, soil stabilization, and refractory lining applications.

The hydraulically powered H-020 is equipped with Blastcrete's "Genuine Piccola" single-point, self-leveling clamping system that ensures simple operation and minimal maintenance. The unit is equipped with a universal mounting plate for attachment to skid steers. It also features pockets so users can transport it with a forklift. While other dry-process, shotcrete gunning systems typically require three to four adjustment bolts to seal the rotor section, the H-020 requires just one. The simplified design makes it quick and easy to adjust and clean, and ensures safe, trouble-free operation.

The H-020 requires a skid steer or other hydraulic power supply to deliver 10 GPM (38 LPM) at 1500 psi (10 MPa) to operate at maximum speed. Because the system uses hydraulics to rotate the rotor section, the H-020 requires just 225 ft³/min (6 m³/min) of compressed air, which is 50% less than comparable, fully pneumatic gunite machines. It operates with variable speeds from 0 to 5 yd³/h (0 to 4 m³/h) and can be used with delivery systems that exceed 500 ft (152 m).

The H-020 is 34 in. wide (864 mm), 34 in. long (864 mm), and 50 in. (1270 mm) tall. The unit's size makes it easy to move and it takes up less space on the job site. The machine also can be loaded into the back of a pickup truck for easy transport.

Blastcrete customizes each machine to meet customer requirements and offers free maintenance and operation training at its facility in Anniston, AL.

For 60 years, Blastcrete Equipment Company has been manufacturing safe, reliable, and user-friendly solutions for the refractory and shotcrete industries. With a complete product line consisting of concrete mixers, pumps, and related products, Blastcrete Equipment Company is poised to meet the needs of the commercial and residential construction, ICF and SCIP building systems, refractory, and underground markets. For more information, contact Blastcrete Equipment Company, 2000 Cobb Ave, Anniston, AL 36202, call (800) 235-4867, fax (256) 236-9824, e-mail info@blastcrete.com, or visit **www.blastcrete.com**.

Final Phase of QR Code Mobile Site Project for King Construction Products Complete

The final phase of the QR Code Mobile Site Project for King Construction Products is now complete. As such, the following additional products now feature a QR code on their packaging and were added to the mobile website (viewable at **http://qr.kpmindustries.com**):

- Duro-Crete
- Duro-Crete CT
- Duro-Crete UW
- In-Pakt Construction Grout
- MS Cable Grout
- PT Grout

With these new additions, the mobile website now features English and French Technical Data Sheet (TDS) and Material Safety Data Sheet (MSDS) resources for a total of 22 King Construction Products. For more information on how the QR codes on-pack link to the mobile website, refer to previous Press Releases, "QR Code on Packaging for 5 King Products" and "QR Code Packaging for 11 Additional King Products" here: **http://industrial.kpmindustries.com/Press_Releases/Archive.aspx**.

Moving forward, this mobile experience will be the basis for the future mobile-friendly version of the company's redesigned website, which is set to launch alongside the new desktop website before the end of the year. To request instructions on how to use the QR codes, please contact Shannon Polk at marketing@kpmindustries.com.

New ASA Members

CORPORATE MEMBERS

Arnold Brothers, Inc.
www.arnoldbrothers.net
Cape Coral, FL
Primary contact: Steve Arnold
keith@arnoldbrothers.net

Basalite Concrete Products—Vancouver ULC
www.basalitedrymix.com
Vancouver, BC, Canada
Primary contact: Dennis Ceolin
dennis.ceolin@paccoast.com

Cheyenne River Spec Mix
www.cheyenneriverspecmix.com
Rapid City, SD
Primary contact: Barry Mertes
bmertes@cheyenneriverspecmix.com

Elasto Plastic Concrete
www.elastoplastic.com
Waxhaw, NC
Primary contact: Patrick Lewandowski
plewandowski@elastoplastic.com

Interconcrete Limited
http://interconcrete.ca
Sudbury, ON, Canada
Primary contact: Mark Corner
mark.corner@interconcrete.ca

National Pools of Roanoke, Inc.
www.nationalpools.com
Roanoke, VA
Primary contact: Jason Vaughan
jason@nationalpools.com

The Pool Company, Inc.
www.thepoolcompanyinc.com
Tacoma, WA
Primary contact: Michael Basford
mick@thepoolcompanyinc.com

Quorum Construction (BC) Ltd.
Langley, BC, Canada
kewen@quorumgroup.net

Restoration East, LLC
www.restorationeast.com
Baltimore, MD
Primary contact: Louis Helmacy
louh@restorationeast.com

Russo Corporation
www.russocorp.com
Birmingham, AL
Primary contact: Lance Kitchens
lkitchens@russocorp.com

Schwing America, Inc.
www.schwing.com
St. Paul, MN
Primary contact: Jason Zignego
tgoodroad@schwing.com

Structural Shotcrete Ltd.
Surrey, BC, Canada
Primary contact: Lorne Rutt
lorne@structuralshotcrete.ca

Turnstone Construction, Inc.
www.turnstoneconstruction.com
Redmond, WA
Primary contact: John Fulford
john@turnstoneconstruction.com

Venus Engineering LLC
www.veng.ae
Deira, Dubai, UAE
Primary contact: Mahdi S. Hanna
info@veng.ae

CORPORATE ADDITIONAL INDIVIDUALS

Mason Guarino
South Shore Gunite Pools & Spas, Inc.
Tewksbury, MA

Simon Reny
King Packaged Materials Company
Boisbriand, QC, Canada

INDIVIDUALS

Bernardo Robles Joseph
MAM Geotecnia
Guadalajara, Jalisco, Mexico

Paul Moorfoot
River Sands Pty Ltd
Brisbane, QD, Australia

Steve Stephens
Technical, Sales & Marketing Services Inc.
Allen, TX

Nicholas J A White
Jacksonville, FL

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 in the process of building a shotcrete pool and are required to wet-test the pool before set, waterproofing, and tile. What is the expected water-loss percentage? We are required to achieve 1%.*

Answer: We are not aware of a specific standard for pools. However, ACI 350.1-10, "Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures," specifies a volume loss of 0.05% of volume per day conducted over a 72-hour test period for "hydrostatic tightness testing of open liquid containment structures. Specifics of conducting the test can be found in the ACI 350.1-10 document.

It should be noted that the pool should be filled and allowed to saturate for 3 days before beginning the measurements.

Question: *We are working on a project with a wall that requires additional capacity due to increased loading requirements. We are contemplating shotcrete with additional reinforcing to provide additional thickness for the wall.*

Is it possible to achieve a composite wall to design for a thicker section for bending, using the bond of the existing concrete and shotcrete along with a reinforcing bar hook anchor epoxied into the existing wall? Any information you can provide would be appreciated.

Answer: Shotcrete is often used in similar applications. The question of bending is a structural engineering question. Shotcrete is a method of placing concrete and the properties of shotcrete are similar if not the same as cast concrete. To achieve a composite wall, you must ensure that the existing surface is properly prepared to maximize the potential bond between the overlay shotcrete and the existing wall. Shotcrete placed against a properly prepared existing wall should achieve great bonding strength without the use of bonding agents. Drilled and grouted dowels also contribute to the system, working as a composite wall.

Question: *I am looking for some technical assistance concerning temperature guidelines for shooting gunite pools. Is there a suggested range of air temperature and humidity that is recommended? Thanks for your help!*

Answer: Shotcrete is a method of placing concrete. The basic guidelines for placing concrete or shotcrete can be found in documents ACI 305R-10, "Guide to Hot Weather Concreting," and ACI 306R-10, "Guide to Cold Weather Concreting." There are some basic "rules of thumb," such as 40°F (4°C) and rising for starting concrete/shotcrete operations and 40°F (4°C) and falling for stopping concrete/shotcrete operations. With proper planning and procedures, concrete or shotcrete can be placed at below-freezing temperatures and at very hot temperatures, but only with proper planning, procedures, and likely at some cost.

Question: *What is the fire rating information for shotcrete?*

Answer: Shotcrete is concrete, pneumatically applied. So the same fire ratings for concrete would apply to shotcrete. The standard is ACI 216.1, "Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies."

Question: *I am doing an owner/builder pool. The shotcrete company I hired left an approximately 4 x 4 in. (102 x 102 mm) hole in the deep end of the pool on the side wall. What is the proper way to patch this hole prior to plastering? (The shotcrete was applied a month ago.)*

Answer: The normal repair is to pressure wash with at least 3000 psi (21 MPa) of water pressure to remove any dirt and laitance on the surface of the concrete. Given the rather small size of the hole, it can be hand-patched with a nonshrink hydraulic cement with at least 4000 psi (28 MPa) 28-day compressive strength to plug the hole. After the patch is completed, roughen the surface that will receive the plaster.

Question: *The Los Angeles City Bulletin states that no bars over No. 8 (No. 25) shall be used. The structural engineer has No. 10 (No. 32) bars in the columns. I am being told the test panel will get this approved but my City Inspector is balking a little. Is there a publication or code somewhere that allows the test panel to supersede the LADBS Bulletin?*

Answer: The International Building Code (IBC), Section 1913, allows for larger bars as long as it is demonstrated in a Preconstruction Test Panel. However, the Local Building Code likely takes precedence over the IBC. You may want to present IBC Section 1913, which requires anything over a No. 5 (No. 16) bar to be proven in a Preconstruction Test Panel.

There have been many projects shot in Los Angeles County subject to the LADBS with bar sizes larger than No. 8 bars. ASA is not in a position to give you project references, but perhaps our local members can.

Properly encasing No. 10 (No. 32) bars can be challenging, and should only be attempted by qualified contractors using ACI Certified Nozzlemen who have previous successful experience doing this type of work.

Question: *What are the common standard test methods to measure or assess the permeability of shotcrete?*

Answer: Boiled absorption and volume of permeable voids testing (ASTM C642) may be required for structures that need

enhanced liquid-tightness or resistance to aggressive environmental exposures. The test is sometimes used to provide an overall indication of the quality of the shotcrete mixture, particularly in dry-mix. However, many factors, including admixtures and aggregate, as well as shotcrete placing, can affect the porosity of shotcrete, so it should not be considered an absolute measure of shotcrete quality. When required, the mean average of tests on three specimens from a test panel, or from in-place shotcrete, should be less than or equal to the specified boiled absorption and/or specified volume of permeable voids limits at the specified test age with no single test greater than the specified boiled absorption plus 1%.

Question: *We are evaluating a school building with a 4 in. (102 mm) thick dome roof with a diameter of 120 ft (37 m) bearing on a 5 in. (127 mm) thick perimeter shear wall. The roof is constructed by anchoring a membrane to the top of an exterior finish wall, inflating the membrane, shooting foam insulation to both the interior wall and membrane surfaces, and then shotcreting both the wall and roof structural elements. The contractor specifies to shotcrete only half of the concrete thickness of the walls and roof, install the reinforcing, and then shotcrete the remaining wall and roof to finish thickness.*

a) Will the shotcrete elements installed in separate layers over the entire roof and perimeter wall system act as effectively as elements that have been shotcreted in one layer?
b) Will bonding between layers under gravity be a concern during the curing process under the dome roof?
c) Would alternate types of construction joints be more advantageous in fabrication of the wall and dome roof?
d) Would any admixtures be recommended for this application?

Answer:

a) The shotcrete will act as a single layer when it is finished. The bond between rough layers of shotcrete is very good. This has been documented in research done at Brigham Young University.
b) No, bonding will not be a concern because, as indicated previously, the shotcrete bond between layers is excellent.
c) No, other types of construction joints are not really viable. This is the best procedure to construct a shotcrete dome.
d) No admixtures are specifically required. Use of silica fume (microsilica) as a supplemental cementitious material may be advantageous in shooting overhead. An experienced shotcrete contractor would identify whether use of silica fume or accelerator are appropriate for their materials and equipment.

Shotcrete Calendar

FEBRUARY 20-21, 2014
SDC Technology Forum #35
Georgia Tech Hotel & Conference Center
Atlanta, GA
www.concretesdc.org

The Strategic Development Council is a group of top-level executives from all facets of the concrete industry that focuses on industry-critical technologies by identifying barriers to their acceptance and uncovering human and financial resources to remove those obstacles, and serves as a leader and advocate for the entire industry for improvements in efficiency and quality.

FEBRUARY 23-26, 2014
2014 SME Annual Meeting & Exhibit
Theme: "Leadership in Uncertain Times"
Salt Palace Convention Center
Salt Lake City, UT
www.smenet.org/meetings

MARCH 19-21, 2014
ICRI 2014 Spring Convention
Theme: "Infrastructure Repair"
Peppermill Resort Spa Casino
Reno, NV
www.icri.org

MARCH 22, 2014
ASA Spring 2014 Committee Meetings
Grand Sierra Resort
Room: Carson 3
Reno, NV
www.shotcrete.org

Schedule of Meetings

8:00 am–9:00 am	ASA Education Committee
9:00 am–9:40 am	ASA Sustainability Committee
9:40 am–10:00 am	Morning Networking Break
10:00 am–10:40 am	ASA Pool & Recreational Shotcrete Committee
10:40 am–12:00 pm	ASA Marketing & Membership Committee
12:00 pm–12:30 pm	Lunch
12:30 pm–1:30 pm	ASA Safety Committee
1:30 pm–2:30 pm	ASA Publications Committee
2:30 pm–2:50 pm	Afternoon Networking Break
2:50 pm–3:30 pm	ASA Underground Committee
3:30 pm–5:30 pm	ASA Board of Direction

MARCH 23-27, 2014
ACI Spring 2014 Convention
Theme: "Concrete Endures"
Grand Sierra Resort
Reno, NV
www.concrete.org

ACI 506 Technical Committees
506, Shotcreting
Tuesday, 8:30 am–11:30 am, N-5
506-A, Shotcreting-Evaluation
Monday, 1:30 pm–3:00 pm, Cascade 2
506-B, Shotcreting-Fiber-Reinforced
Sunday, 1:30 pm–2:30 pm, Whitney
506-C, Shotcreting-Guide
Monday, 8:30 am–10:30 am, Shasta 1
506-E, Shotcreting-Specifications
Monday, 10:30 am–12:30 pm, Shasta 1
506-F, Shotcreting-Underground
Monday, 4:30 pm–5:30 pm, Cascade 2
506-G, Shotcreting-Qualifications for Projects
Monday, 3:00 pm–4:30 pm, Cascade 2

JUNE 22-25, 2014
ASTM International Committee C09, Concrete and Concrete Aggregates
Sheraton Toronto
Toronto, ON, Canada
www.astm.org

OCTOBER 25, 2014
ASA Fall 2014 Committee Meetings
Hilton Washington
Washington, DC
www.shotcrete.org

OCTOBER 26-30, 2014
ACI Fall 2014 Convention
Theme: "Spanning the Globe"
Hilton Washington
Washington, DC
www.concrete.org

DECEMBER 7, 2014
Workshop on Methods for Investigation of Unexpected Performance and Properties of Cementitious Mixtures
Sheraton New Orleans
New Orleans, LA
www.astm.org

DECEMBER 7-10, 2014
ASTM International Committee C09, Concrete and Concrete Aggregates
Sheraton New Orleans
New Orleans, LA
www.astm.org

Shotcrete Calendar

APRIL 11, 2015
ASA Spring 2015 Committee Meetings
Marriott & Kansas City Convention Center
Kansas City, MO
www.shotcrete.org

APRIL 12-16, 2015
ACI Spring 2015 Convention
Theme: "Fountains of Concrete Knowledge"
Marriott & Kansas City Convention Center
Kansas City, MO
www.concrete.org

JUNE 14-17, 2015
ASTM International Committee C09, Concrete and Concrete Aggregates
Marriott Anaheim
Anaheim, CA
www.astm.org

NOVEMBER 7, 2015
ASA Fall 2015 Committee Meetings
Sheraton
Denver, CO
www.shotcrete.org

NOVEMBER 8-12, 2015
ACI Fall 2015 Convention
Theme: "Constructability"
Sheraton
Denver, CO
www.concrete.org

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

AMERICAN SHOTCRETE ASSOCIATION

ASA Membership Benefits

	Corporate	Corporate-Additional Individual	Supporting Association	Individual	Nozzleman	Employees of Public Authorities/Agencies	Student
Annual Dues	$750	$100	$500	$250	$50	*Free*	*Free*
Company and 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 monthly 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 homepage during your advertising quarter	X	X	X	X		X	
Voting privileges at meetings and director/officer elections	X	X		X			
Free advance general admittance registration to World of Concrete	X	X	X	X	X	X	X
Opportunity to submit entries into the annual Outstanding Shotcrete Project Awards Program	X						
Free Onsite Learning Seminars upon request			X			X	
Complimentary copy of ASA's Shotcrete Specifiers Education Tool—a 4 GB USB flash drive						X	
Complimentary copy of "Sustainability of Shotcrete" each year	1		1			1	
Discounted Corporate-Additional ASA Memberships are available for all company employees ($150 savings per employee)	X						
Discount on ASA Underground Shotcrete Education Program	X						
Complimentary copy of ASA's Annual Nozzleman Compilation each year					1		
Complimentary ASA shotcrete brochure each year	25	1	X**	1		1	
Complimentary ASA reflective hardhat sticker each year	10	1		1	1		
Education & promotion of your shotcrete industry to the overall concrete industry	**X**	**X**	**X**	**X**	**X**	**X**	**X**

*Student members outside North America will only receive electronic copies

**Upon request; limit 25 copies per year

AMERICAN SHOTCRETE ASSOCIATION

38800 Country Club Dr., Farmington Hills, MI 48331
Phone: (248) 848-3780 Fax: (248) 848-3740
E-mail: info@shotcrete.org Web site: www.shotcrete.org

MEMBERSHIP APPLICATION

Name _____ Title _____

Company _____ Sponsor (if applicable) _____

Address _____

City / State or Province / Zip or Postal Code _____

Country _____ Phone _____ Fax _____

E-mail _____ Web site _____

Please indicate your category of membership:

❑ Corporate	$750	
❑ Individual	$250	
❑ Additional Individual from Corporate Member	$100	
❑ Employees of Public Authorities and Agencies	Free	
❑ Nozzleman	$50	
❑ Retired	$50	(For individuals 65 years or older)
❑ Student	Free	(Requires copy of Student ID card or other proof of student status)

NOTE: Dues are not deductible as charitable contributions for tax purposes, but may be deductible as a business expense.

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

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

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

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

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

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

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

Fibers
❑ Carbon
❑ Glass
❑ Steel
❑ Synthetic

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

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

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