Shotcrete MAGAZINE

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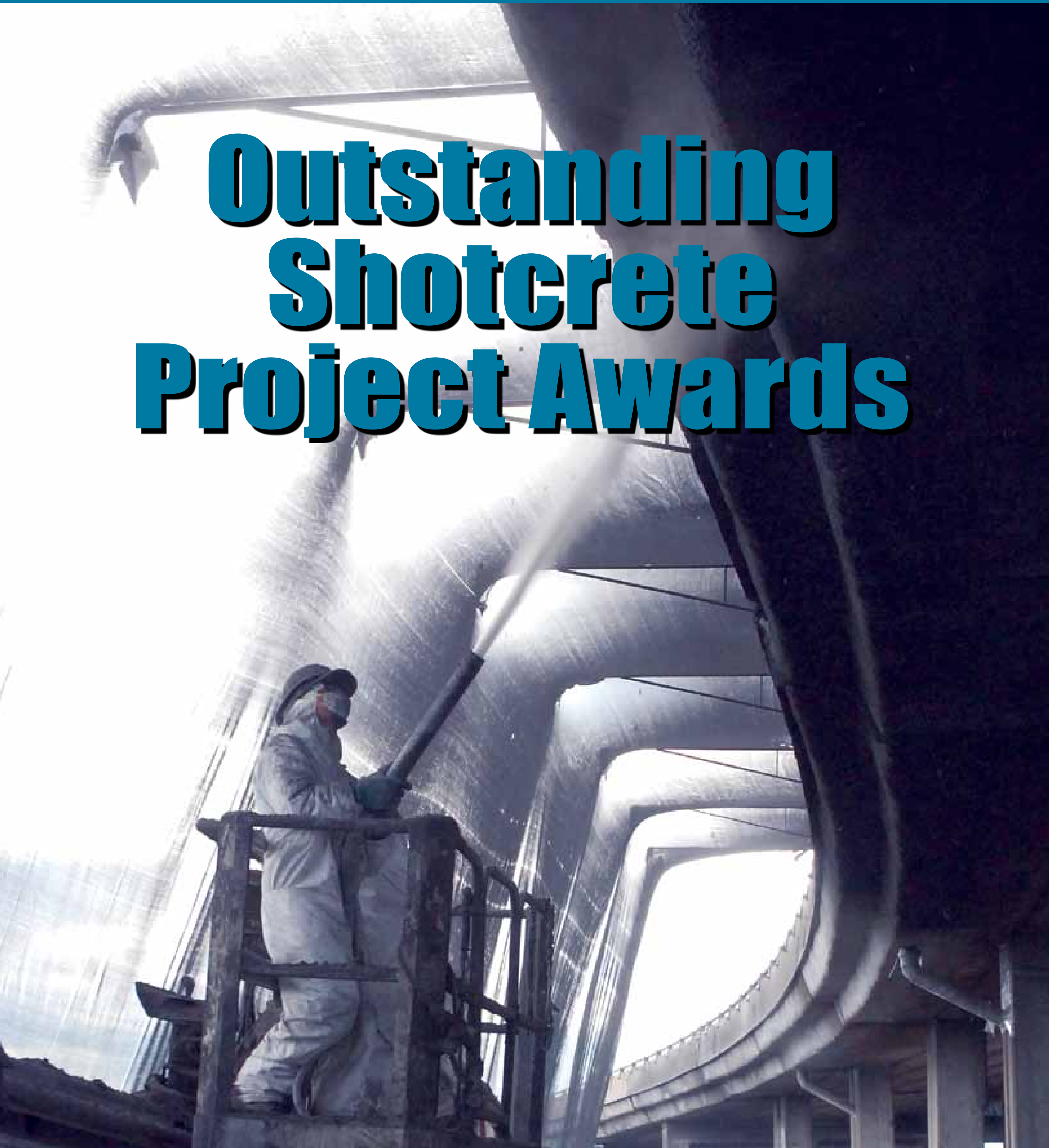

Outstanding Shotcrete Project Awards

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

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Spring 2011

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On the cover: Applying shotcrete during the Décarie Interchange Side Panel Repair Project in Montréal, QC, Canada.

The ASA Outstanding Shotcrete Project Awards and Sustainability

By Patrick Bridger

This Spring issue of *Shotcrete* magazine featuring the ASA Outstanding Shotcrete Project Award winners has become the most widely distributed issue of the year to those outside of the shotcrete industry. This annual issue is one of the shotcrete industry's best tools in *proving* the many advantages and possibilities of the shotcrete process. This issue demonstrates not only the breadth and versatility of shotcrete across project types, but also highlights the advantages inherent in the process itself.

The criteria for the awards were expanded this year to include sustainability. The year 2010 was significant for shotcrete and sustainability, as the ASA Sustainability Committee began its work of defining and qualifying the sustainability advantages of shotcrete. Not surprisingly, shotcrete sustainability advantages, such as formwork material and labor savings, speed of construction, and many other advantages played a significant role in each winning project and ultimately in the selection of shotcrete as the method of concrete placement.

The sustainability advantages of shotcrete need to be known and promoted by everyone in the shotcrete industry. Take a moment to review the sustainability feature later in this issue. This is the first in a series of 10, where each issue's sustainability feature will focus on one of the top sustainability advantages of shotcrete.

As I mentioned earlier, the ASA Outstanding Shotcrete Project Awards are a very important promotional and educational tool for ASA and the shotcrete industry. Simply put, none of this would happen without the leadership and financial support of the award sponsors. Please take a moment to review the following list of 2010 award sponsors; if you work for one of these organizations, I offer a sincere thank-you on behalf of our industry. If you work with one or more of these organizations, please take a moment to acknowledge and thank them.

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And More about the Sustainability of Shotcrete...

By Chris Darnell, ASA Executive Director

If you are a regular reader of *Shotcrete* magazine, you are probably noticing this topic more and more in the pages of this award-winning publication—and for very good reason. Sustainability has quickly become a major force in not only the concrete world but also the entire construction universe. Sustainability has become a deciding factor in the selection of materials and construction strategies.

Shotcrete offers many sustainability advantages. Because shotcrete is simply a method of placing concrete, it enjoys all of the many sustainability advantages of concrete as a building material, in addition to a long list of advantages that are unique to this method of placement.

Sustainability is a very wide and diverse topic ranging in basis from politics to ideology to basic economics. The political and/or social end of this topic can be a contentious subject matter that is sometimes difficult to quantify and substantiate. At the other end of the spectrum is the economics of sustainability. This area is much easier to objectively discuss and substantiate. The economic side of the discussion really falls in line with traditional business decisions: does "X" save me materials, labor, time, improve my quality, and/or expand my capabilities?

Fortunately, for ASA and the shotcrete industry, the sustainability advantages unique to shotcrete predominately fall into the economic side of the sustainability issue. These advantages are not theoretical or ideological; rather, shotcrete offers significant sustainability advantages that are solid, quantifiable, and business-benefiting items. This is great news for the future growth of the shotcrete industry, but these advantages by themselves will not drive this potential growth. We as an industry must all do the following items (and do them well) to capitalize on this new market force and the opportunity that it has presented.

We must all educate ourselves and be versed on the sustainability advantages of shotcrete.

ASA has created, and continues to work, on a number of tools for this very purpose. First, as President Bridger mentioned in this issue's ASA President's Message, the Sustainability feature in this issue (p. 46) is the first in a series of 10 that will focus on one of the top-ten sustainability advantages of shotcrete. This feature will be a great way to learn and maintain knowledge on the core advantages.

Second, make sure you have a copy of the Fall 2010 issue of *Shotcrete* magazine with a theme of Sustainable Shotcrete. You can also access the electronic version of the issue in the Sustainability section of the ASA Web site at **www.shotcrete.org**.

Third, the ASA Sustainability Committee recently completed work on content for the recently released USGCC's *The Sustainable Concrete Guide—Applications*, contributing content for a chapter solely dedicated to shotcrete and a second chapter on repair. A new ASA "Sustainability of Shotcrete" brochure, which debuted at World of Concrete 2011, contains the shotcrete-specific information from the USGCC *Applications* book. Copies of the 10-page ASA "Sustainability of Shotcrete" brochure can be ordered from the ASA Web site at **www.shotcrete.org**. The full USGCC book can be ordered from **www.concrete.org**.

We must promote the sustainability advantages of shotcrete on an individual company level and as an industry on the national and international level.

One easy way to pursue this promotion on the individual company level is through the ASA "Sustainability of Shotcrete" brochure. This document was developed to serve two purposes: first, as an educational resource, and second, as a promotional tool for use by everyone in the shotcrete industry. The brochure is a great resource to submit with a bid proposal to substantiate and emphasize shotcrete's sustainability advantages.

In the new light of sustainability, integrating the document into your overall marketing strategy may be the deciding factor that tips the scale in shotcrete's favor as potential future clients and owners consider shotcrete along with other methods of placement or even other materials.

Rest assured that ASA will be tackling the national and international portion of this task through all avenues and venues possible.

We must support our main vehicle for communicating the sustainability advantages of shotcrete to the world.

Our industry has a very strong and attractive message for the construction world. How effectively we communicate this message and ultimately grow the shotcrete industry is directly dependent on the support ASA receives from the industry. While ASA enjoys incredible leadership and support from our current membership, the fact is that the majority of the shotcrete industry is not a member of ASA. Making an investment in any association can be a difficult decision, but our industry stands at a key point in our development with an exceptional opportunity in front of us. Please consider becoming a member of ASA and making an investment in the potential growth of our industry and, ultimately, your business. Please also consider attending one or more of the ASA committee meetings, submitting projects for the 2011 Outstanding Shotcrete Project Awards, advertising in *Shotcrete* magazine, and the numerous other options available to you through ASA.

To recap, shotcrete has very strong sustainability advantages that can drive the growth of this industry. To accomplish this, become educated on what the sustainability advantages are, promote those advantages in your business, and become active in this association and enable ASA to promote the shotcrete sustainability message to the world.

ASA ANNOUNCES AVAILABLITY OF NEW

ONLINE BUYERS GUIDE

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

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

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

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

- Admixtures
- Cement/Pozzolanic Materials
- Consulting
- Contractors
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- Fibers
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Searches can be further refined using over 100 subcategories and geographic criteria.

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2010 Outstanding Infrastructure Project

The Décarie Interchange Side Panel Repair Project

By Patrick Giguère and Philip Sawoszczuk

Highway 40's first segment was built in 1959 in Montréal, QC, Canada. The Décarie Interchange links Highway 40 to Highway 15 and was built between 1960 and 1964. The interchange is in a highly urbanized environment, which necessitated its design as an elevated highway. The complex structure has two main throughways and seven elevated ramps, most of which are two lanes wide without shoulders or about 21 ft (6.4 m) wide. The Décarie Interchange also consists of several smaller structures and covers roughly 0.1 $miles^2$ (0.26 km^2). It carries over 280,000 vehicles a day and is one of the critical transportation junctions on the Island of Montréal. The cross section of the interchange's deck is in a stepped trapezoidal box girder configuration, making it structurally efficient but difficult to repair using traditional cast-in-place repair methods.

The Project

The interchange was repaired several times during its 46 years of service using form and pump—mostly with limited success. Meanwhile, shotcrete had established an excellent reputation in Montréal, as it had been used to successfully repair various sections of Highway 40 over the last 20 years. A unique element of the structure was the placement of curved polymer panels to protect the underside edge of the interchange deck from the elements. This feature may have been effective originally, but it complicated the repair process, as parts of the panels were fastened to the deteriorated concrete. After several years, the panels failed to protect the concrete and the process of deterioration began to compromise the integrity of the structure. Québec's Department of Transportation (DOT) had the panels removed in 2009 and called for tenders to repair the deteriorated concrete.

After an initial bid, Teknika HBA, a Trow Global company, was retained as the engineering consultant for the project. Québec's Ministry of Transportation (MTQ) and the retained engineering consulting firm investigated several methods of repair, including form and pump using self-consolidating concrete. A number of factors led to the selection of the dry-mix shotcrete process to repair the structure. These factors included an unusual shape along the edge of the deck, which would be extremely difficult to form and costly to repair. The dry-mix shotcrete process allowed the design engineers to eliminate false work and follow the contour of the original concrete, saving considerable time and money. Furthermore, it allowed for greater flexibility due to the availability of prepackaged materials, which eliminated the need to wait for concrete trucks. In addition, the equipment was smaller and easy to move compared to the equipment used for the form and pump method. The crew was also able to shoot at any time without waiting for the forming crews. A public tender was called to repair the structure and Construction Interlag Inc. was announced as the lowest bidder. The selected company was awarded the contract and assumed the dual role of prime contractor and shotcrete contractor.

Construction Interlag Inc. was responsible for every element of the shotcrete repair. The project required roughly 500 bags of 3300 lb (1500 kg), which is equivalent to approximately

Fig. 1: The 46-year-old Décarie Interchange in Montréal, QC, Canada was showing its age

Fig. 2: More than 4600 linear ft (1400 linear m) of repairs were required

Fig. 3: Some repairs went up to 12 in. (300 mm) in thickness

445 yd^3 (340 m^3) of placed shotcrete. The material chosen for the project was the King MS-D1 Shotcrete provided by King Packaged Materials Company. The repairs totaled 4600 linear ft (1400 linear m), with some reaching 12 in. (300 mm) in thickness. In all, the contract was worth close to $2 million CAD.

The repair work was divided into phases to avoid the extra cost of construction during the harsh Montréal winter. The first phase began on August 2, 2009, and ended on November 1, 2009. The second phase began on March 21, 2010, and ended on May 16, 2010. The work consisted of preparing the site, carefully removing the old polymer panels, demolishing the deteriorated concrete, preparing the surface of the repair, applying the shotcrete, finishing it, and curing the material. The flexibility and speed offered by the dry-mix shotcrete process allowed Construction Interlag Inc. to complete 75% of the repairs in the fall and the remainder of the repairs in the spring.

Fig. 4: With more mobile equipment, the dry-mix shotcrete process was preferred

The Challenges

Construction Interlag Inc. had to deal with several challenges common to transportation infrastructure projects located in heavily urbanized areas. First and foremost, the interchange serves a significant portion of Montréal's traffic and had to remain open during the repair activities. Most of the repair work was below the interchange deck, in open spaces not occupied by roads or highways, which made the placement of the smaller shotcrete equipment and material relatively simple. This notwithstanding, Construction Interlag Inc. was required to keep any stray demolished concrete debris, dust, or shotcrete spray from hitting passing vehicles and potentially causing an accident. Therefore, the MTQ required netting to be placed to shield traffic from the risk of stray material. The installation of the netting used involved fastening steel A-frame supports to the parapets of the interchange. The dark netting was attached to the A-frames and the parapet. Secondly, moving from one end of the site to another in a straight path was impossible, as one would cross several spans of road and highway. Therefore, the work was organized to avoid too much movement. King Packaged Materials Company's shotcrete materials were placed in several locations on site where repair

Fig. 5: Netting protected over 280,000 vehicles per day that use the interchange

patches were located; this only required the movement of shotcrete equipment and personnel to the repair section. The material was always well protected from the elements with sufficient packaging and, when possible or necessary, by placing it below the elevated highway. Large infrastructure repair projects are always challenging with regards to public safety, but large structures such as interchanges also create unique environmental conditions.

The Décarie Interchange has hundreds of rectangular columns and a relatively thin deck that is coupled with open spaces located around and beneath its ramps, creating an ideal environment to channel wind and increase its speed. In other words, Construction Interlag Inc. had

Fig. 6: The nozzleman is battling the "wind-tunnel effect"

Fig. 7: A repair zone is blasted to clean the reinforcing bar and the substrate

Fig. 8: Welded-wire steel mesh conforms to the stepped trapezoidal cross section

to deal with the "wind-tunnel effect" as well. Higher wind speeds increased the difficulty in shooting quality shotcrete. A shotcrete mixture containing an excellent gradation, satisfying ACI Gradation No. 2, and including larger aggregates, such as 3/8 in. (10 mm) stone, helped increase efficiency, especially in windy conditions. Furthermore, an air compressor with a sufficient flow rate ensured that the material was travelling at the optimum speed to reduce dust production and rebound, and improve compaction.

The Work

By following ACI 506R-05, "Guide to Shotcrete," and having ACI Certified Shotcrete Nozzlemen, Construction Interlag Inc. was able to overcome the traffic and high winds to successfully repair the Décarie Interchange. The Allentown shotcrete equipment used was of the rotary barrel gun type, coupled with an Allentown predampener and an air compressor. The shotcrete was always shot between 50 and 77°F (10 and 25°C), as specified by Transports Québec. The perimeters of the repairs were saw cut to eliminate feathered edges. Deteriorated concrete was removed, using pneumatic hammers sufficient to remove any deleterious substrate, while minimizing damage to the sound concrete. The unsound concrete was removed leaving a minimum of 1 in. (25 mm) of space behind the first layer of reinforcing bar. The repair surface was cleaned with high-pressure water and sandblasting. A welded-wire steel mesh was securely fastened to the reinforcing bar and anchored to the parent concrete to eliminate vibration during shotcrete application. Prior to the shotcrete application, clean water was sprayed onto the surface to obtain a saturated surface dry (SSD) condition for improved bond strength of the repair.

King Packaged Materials Company's MS-D1 Shotcrete was then carefully applied according to ACI 506R-05, while also accounting for variable environmental factors such as wind and rain. The mixture design met all MTQ requirements, including the specified air void spacing factor of less than or equal to 300 μm, with no singular value exceeding 320 μm, as tested with ASTM C457. The air entrainment of the dry-mix shotcrete was critical on this project to provide superior freezing-and-thawing durability and also a high resistance to scaling caused by deicing salts—two major causes of concrete deterioration in a northern climate. A manlift was used to maintain the optimum distance and position between the nozzle and the repair—that is, between 2 and 6 ft (0.6 and 1.8 m)—and roughly perpendicular. The shotcrete was applied in the optimal number of layers to not exceed the plastic shear resistance

Fig. 9: Applying shotcrete from a distance of 2 to 6 ft (0.6 to 1.8 m)

Fig. 10: The rough finish was achieved with a steel trowel

of the material, thus avoiding fallouts or repair deboning. Good reinforcing bar encapsulation was also carefully executed. The rough finish of the shotcrete repair was done with a steel trowel and the final finish was achieved with a wood float. Finally, a liquid curing agent conforming to ASTM C309 was applied immediately after finishing to ensure adequate curing, as specified by Transports Québec for overhead repairs.

On the Road to Sustainability

Sustainability is of prime importance to the public and the industry. Shotcrete accomplished several positive environmental impacts during the construction with the materials and the energy used. First, the mixture design and specifically the cementitious mixture used in this project replaced part of its portland cement content with a supplementary cementitious material, thus reducing the amount of greenhouse gas emissions generated during portland cement production. Furthermore, this supplementary cementitious material is a waste by-product of other industrial processes that is recycled in the concrete industry, thus reducing landfill waste while still providing beneficial properties to the shotcrete mixture. False work and formwork, which require wood and steel, were practically eliminated; therefore, sustainability reduces the use of these materials. Careful effort during shotcrete application was also used to reduce dust production and rebound waste. In fact, Construction Interlag Inc. collaborated closely with the shotcrete mixture manufacturer, King Packaged Materials Company, to optimize the mixture to minimize dust formation. Finally, and most importantly, the shotcrete repairs extended the service life of the Décarie Interchange significantly, thus reducing the need to demolish it and build a new interchange. In addition, the increased durability of the shotcrete material will extend the time before future repairs are required, thus reducing resource use for future maintenance. It is clear that shotcrete contributed in many ways to the sustainability of the Décarie Interchange Repair Project.

Shotcrete for Today and Tomorrow

By carefully following the appropriate standards and procedures, Construction Interlag Inc. built a safe, economical, sustainable, and durable infrastructure repair project while overcoming several environmental challenges using the dry-mix shotcrete process in Montréal, QC, Canada. A key factor in the success of the project was the close collaboration between Construction Interlag Inc., Teknika HBA, Transports Québec, and King Packaged Materials Co. The Décarie Interchange Repair Project was not only an excellent example of shotcrete infrastructure repair and a practical demonstration of the sustainability of shotcrete, but it also ensures that shotcrete will have a bright future for many years to come.

2010 Outstanding Infrastructure Project

Project Name
Décarie Interchange Side Panel Repair

Project Location
Montréal, QC, Canada

Shotcrete Contractor
Construction Interlag Inc.

General Contractor
Construction Interlag Inc.

Architect/Engineer
Teknika HBA

Material Suppliers/Manufacturers
King Packaged Materials Company* and
Allentown Shotcrete Technology, Inc.*

Project Owner
Ministry of Transportation, Québec

*Corporate Member of the
American Shotcrete Association

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***Philip Sawoszczuk,** Jr. Eng., is a Technical Services Representative for King Packaged Materials Co. His areas of expertise include the rehabilitation and preservation of infrastructure, structural engineering, and durability of concrete. He received his degree in civil engineering from McGill University, Montréal, QC, Canada.*

2010 Outstanding Pool & Recreational Project

Soundview YMCA

By Bill Drakeley

The Soundview YMCA selected the Drakeley Pool Company to construct a multiple-pool facility in Branford, CT, in the fall/winter of 2009. The charge was to complete the pool structures within a very short window of opportunity to meet a June opening date the following year (2010). This quick turnaround was driven by the current economy and the availability of funds. Like most YMCAs, budget forecasting is entirely contingent on pledged donations and gifts from the general membership and friends of the YMCA. The community at large had no facility in the local area and was experiencing an expanding population, particularly among young families. The YMCA had an immediate opportunity with some quality pledges that demanded state-of-the-art pool construction with verifiable performance results. These contributions were time-contingent based on many economic factors. To be selected for the construction, the Drakeley Pool Company had to show a history of quality construction, using processes that displayed speed of application while still maintaining superior structural stability and durability. This construction also had to include sustainability benefits and LEED technological practices. An immediate suggestion to the building committee and design team was that shotcrete construction would satisfy both of these requirements.

Foreground: competition pool using sustainable formwork in forming and excavation phase. Background: watertight lap pool in curing phase

In dealing with pool contractors, architects and engineers often don't trust the installation to be successful without major oversight from the "licensed professionals." Based on the lack of education and standards in the pool industry, the performance of commercial pool shotcrete has been nothing short of dismal.

With that first impression, the first step was educating the YMCA building committee and design team on mixture design, application, and installation, including curing and strength gain of the shotcrete process. Once the education of the shotcrete process began, the Drakeley Pool Company received an immediate acceptance and an appreciative vote of confidence. Half the battle—at least in this case—was correcting a misunderstanding of the process and expected results. These misunderstandings by both the design community and builders alike are what keep the pool shotcrete industry from reaching acceptance.

Preparations for the shotcrete process went as follows (the two pools were constructed sequentially through the shotcrete application phase):

1. Excavation and placement of drainage stone was completed first. All groundwater was removed by dewatering and pumped off site. The site has a high groundwater table and the native soil is expansive with a high clay and silt content.
2. Using the clayey soils as an advantage, the forms were driven into the cohesive material and the moist soils were used as the backside form. As speed was a necessity, moisture content and any slope creep were kept to a minimum. Rough-sawn lumber was used for forming, including 2 x 4 in. (50 x 100 mm), 1 x 6 in. (30 x 150 mm), and 3/4 in. (20 mm) plywood. All forms were rigid with no vibration and able to accept the high velocity of the shotcrete application (375 ft^3/ min [11 m^3/min] compressor, wet-mix shotcrete process).
3. Steel reinforcement was No. 5 (No. 16) and No. 4 (No. 13) Grade 60 (Grade 420) deformed bars 6 in. (150 mm) on center vertically in the walls and 12 in. (300 mm) on centers in the floors for both pools. The wall thickness below

the upper bond beam was 12 in. (300 mm). The bond beam thickness (allowing for installation of stainless steel gutters) was 18 in. (450 mm). All steel and guide wires were rigid with little or no vibration during shotcreting. Rigid reinforcing steel installation is key to preventing voids and shadowing during the shooting process.

4. The shooting sequence started when the first of the two pools was ready for concrete placement. In this case, it was the teaching/therapy pool, to be followed by the competition pool. The approach was to shoot the radius connecting the wall to the floor first and then the bond beam. The mixture design was a portland-cement-rich mixture (800 lb/yd^3 [475 kg/m^3]) with 3/8 in. (10 mm) aggregate and sand in a well-consolidated non-gap-graded design. Compressive strength values were to be a minimum of 4000 psi (27.6 MPa) after a 28-day wet cure. The tests for both pools produced 5800 psi (40.0 MPa) compressive strength at 7-day breaks. The total amount of shotcrete materials placed was 318 yd^3 (244 m^3). The equipment used in the shooting was an Allentown PC20 Powercreter and an Ingersol-Rand 375 Compressor. The line size for the shotcrete was a 4 in. (100 mm) hopper discharge with two reductions to a 2 in. (50 mm) line. Reductions were gradual and the last 3 to 2 in. (80 to 50 mm) reducer was made where the line entered the pool shell (allows for ease of line pumping). The concrete installations were done by ACI Certified Nozzlemen trained through the ASA Nozzleman Training Program.
5. After forms were removed, the curing process began immediately. Soaker hoses and sprinkler systems were set up and both shells were continuously wet-cured for 3 weeks. After curing, staging was set for the iron workers and the general erection of the building structure. The general contractor was instructed to fill both pools halfway with water. This helped maintain the curing process while the pool shells sat dormant and covered. Each pool shell surpassed the minimum required compressive strength values and was watertight prior to any finishing textures or surface applications.

The pools were to be built for very fast water flow, which minimized friction. All corners of the pools were to have a sharp radius meeting the exacting standards of the new stainless steel perimeter gutter systems. These radii smoothed the water flow (non-90-degree corners) and made for a very fast, very competitive pool and/or a warm teaching pool with great flow and turnover.

Shotcrete phase of the lap pool

Shotcrete construction was key for the pool strength and flow requirements. The complex shape requirements were easily accomplished as opposed to the cumbersome cast-in-place methodology otherwise required.

Thinking green (there can't be a worse term chosen for the pool industry) was an essential part of the presentation to the YMCA's committees and had to be included in the construction and

Stainless steel gutter installation

Radius gutter installation above radius shotcrete corner

Tested plaster installation over watertight concrete

design. Sustainability benefits had to be shown to be considered and awarded the project.

The sustainability of the shotcrete process on the Soundview YMCA had a positive impact on the forming and electrical portions of the project. In general, using shotcrete construction reduces the requirements of lumber used for forming because, at most, one-sided forms are required. This reduction in formwork was enhanced in every corner of the two pools. Shotcreting into the radius, using the one-sided forms, and then hand-shaping the inside surface of the radius allowed for minimal use of wood supports, which certainly kept a few trees in the forest. The one-sided forms were reused for the second pool.

The sustainability benefits related to the electrical requirements of the pool filtration can be traced back to the use of the radius shapes of the pool shell. By reducing the friction that the water must be pumped in and around certain piping will in turn reduce the amount of energy required to pump the water. With these new mechanical systems installed, it was essential that the shotcrete portion of the pool corners be an exact radius match to the adjacent mechanical systems; thus, the reduction of corners equals a reduction of energy required and ultimately saves the YMCA consumable, measurable electrical costs.

The shotcrete process was essential to the successful performance of these pools. The factors that influenced the acceptance of the shotcrete on the project were:

- High moisture and cohesive qualities of soils;
- Early strength and water tightness of the shotcrete pool shells;
- Ease of producing the radius corners needed for ease of water flow and friction loss concerns; and
- Timing for construction and installation.

This pool project had to incorporate the new pool design that revolved around radius steel mechanical systems and had to be installed in less than 1 year. Smooth radius corners were easily formed and shot with the wet-mix shotcrete process, which produced a well-consolidated, low-porosity, high-strength pool shell. This would have taken a typical concrete cast-in-place contractor twice the amount of time and would likely have increased the budget. With the shotcrete process, the YMCA was given long-term product performance without breaking the bank.

The Drakeley Pool Company uses the Soundview YMCA as an example of proper shotcrete construction that owners, designers, and engineers can not only agree to but also heartily support in their future projects.

Finished hot competition pool

Finished cold competition pool

2010 Outstanding Pool & Recreational Project

Project Name
Soundview YMCA

Project Location
Branford, CT

Shotcrete Contractor
Drakeley Industries, LLC*

General Contractor
ORL Construction

Architect/Engineer
Drakeley Industries, LLC*

Material Supplier/Manufacturer
Tilcon

Project Owner
Central CT Coast YMCA

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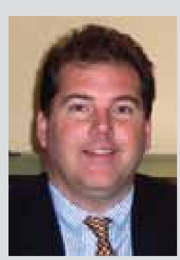


***Bill Drakeley** is a third-generation Watershaper and President of Drakeley Industries and Drakeley Swimming Pool Company in Connecticut. He is a Genesis 3 Platinum Member, an American Concrete Institute Certified Nozzleman, an ACI-approved Shotcrete Examiner, an ASA Board member, and his company is a Corporate member of ASA. Drakeley is an Instructor for the Genesis 3 Construction School, with a focus on the shotcrete process. He has been a Contributing Writer for* Shotcrete *magazine's "Pool & Recreational Shotcrete Corner" and has had projects featured in* Luxury Pools *magazine,* Better Homes & Gardens, *and* Aqua *magazine. Drakeley Pools was the recipient of ASA's "Outstanding Pool & Recreational Project" from 2005 through 2008 and again in 2010.*

2010 Outstanding Repair & Rehabilitation Project

Concrete Arch Bridge No. 6.45 over 31st Street, Queens, NY

By Tommy Pirkle and Arden "Morris" Boddie

The New York Connecting Railroad is a rail line in the borough of Queens in New York City and forms an important element of the Northeast Corridor. The line begins at the Hells Gate Bridge over the East River; continuing south, the line is positioned on a highly elevated viaduct over Astoria Queens and Interstate 278. Amtrak uses the northernmost section of the line. Bridge No. 6.45 is part of this viaduct and one of the 89 bridges and crossings in New York City used by Amtrak.

The Astoria Line is a rapid transit line of the BMT division of the New York City Subway. This is an elevated structure that runs directly above 31st Street and through the 220 ft (68 m) long by 80 ft (24 m) high arch that spans the street. The Ditmars Boulevard Subway Station is partially inside the arch and is serviced by the N and W trains.

Amtrak had little choice but to rehabilitate this 94-year-old structure, as falling chunks of deteriorated concrete were becoming a major structural and safety concern. As a safety precaution, stage scaffolds and netting were erected long before the work started to protect the subway tracks and, more importantly, the pedestrians on the station platforms and sidewalks below.

The scope of work included deteriorated concrete removal, repair of active water leaks and cracks, hydroblasting, installation of anchors and wire mesh, application of shotcrete, wet curing, and application of a coating.

As a safety precaution, stage scaffolds and netting were erected long before the work started to protect the subway tracks and, more importantly, the pedestrians on the station platforms and sidewalks below

The Ditmars Boulevard Subway Station is partially inside the arched bridge

Scaffolds were erected over the elevated subway tracks and 31st Street

Typical minor concrete spalling

Typical severe concrete spalling with continuous groundwater infiltration

The General Contractor, ECI Building Corp of Elmont, NY, performed most of the surface preparation, starting with the north side of the structure. The substrate was sounded and marked and any deteriorated concrete was removed with pneumatic chipping hammers. Many repairs exceeded 12 in. (300 mm) in depth with continuous infiltration of groundwater. Weep pipes were installed to relieve the water pressure and a highly accelerated dry-mix shotcrete material was locally applied to divert the water to a central downward flow. The substrate was then hydroblasted to remove all existing coatings, contamination, and graffiti and "roughen" the surface to a minimum of 0.25 in. (6 mm) amplitude. L-shaped No. 3 dowels were installed 36 in. (900 mm) on center (OC) and coated 4 x 4 in. (100 x 100 mm) x D2.9 x D2.9 welded-wire reinforcement was attached to the dowels.

Thickness control gauge wires were positioned every 36 in. (900 mm) horizontally. It should be noted that both the north and south sides of the bridge were not straight or plumb. To maintain the specified 3 in. (76 mm) thickness, the gauge wires had to be pulled either in or out from the substrate. This was done with 3 in. (76 mm) diameter polyvinyl chloride (PVC) capped pipes cut 4 in. (100 mm) long and anchored inside the PVC pipes to the bridge face along the gauge wire. The 4 in. (100 mm) pipes were notched at 3 in. (76 mm), thus allowing the wire to rest inside the notch. The pipes were removed and the holes were filled with shotcrete after finishing.

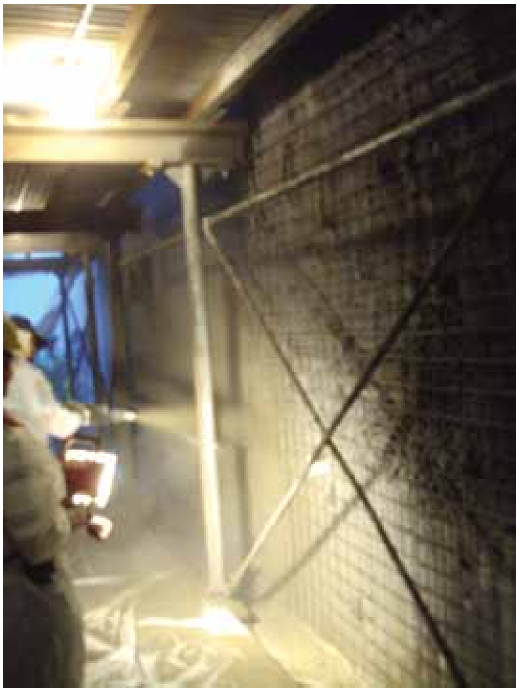
A continuous soaker hose system, complete with an automatic timer and backup timer, was erected along the top of the north and south sides of the arch, not only for curing, but also to keep a saturated surface-dry (SSD) condition before application of the shotcrete. The timers were calibrated to allow sufficient water to cure and saturate. Extreme caution was taken, however, to avoid water dripping on the pedestrians, vehicles, and, most importantly, the live subway track's third rail below.

Double and triple mats of 4 x 4 in. (100 x 100 mm) welded-wire reinforcement installed in severely deteriorated locations

Wet-mix shotcrete was the only acceptable method the engineer would entertain to minimize and control the dust and rebound

The specifications required a minimum 4000 psi (27.5 MPa) prepackaged, fiber-reinforced shotcrete material. The engineer specified wet-mix shotcrete as the only acceptable method

A self-contained machine was selected—one that far exceeded the necessary requirements for mixing volume and pumping distance and was capable of mixing bulk bags



Prepackaged fiber-reinforced wet-mix shotcrete was applied

The uniformed float finish provided an excellent textured surface for the coating adhesion

to minimize and control the dust and rebound. Dry-mix shotcrete was not an option for the overlay. The shotcrete Subcontractor, East Coast Shotcrete of West Orange, NJ, elected to use King Packaged Materials Company's MS-W1 Shotcrete, which was submitted to the project engineers for approval. Before beginning the shotcrete process, six 30 x 30 x 6 in. (760 x 760 x 150 mm) preconstruction test panels and three mockup panels were shot by two different ACI Certified Nozzlemen and by the job-site Supervisor (also an ACI Certified Nozzleman). Six cores were extracted from each panel and a 28-day compressive strength (ASTM C42) revealed that all cores exceeded 6000 psi (41.4 MPa). Flexural strength testing (ASTM C78), which was also a requirement, was performed, and the results exceeded the minimum strength by an average of 25%. The mockup panels represented the final finish and color of the bridge. Six different shades of coating were applied to the mockup panels for the owner's selection of the color and acceptance of the finished shotcrete texture.

With the material submitted and approved, the next decision was to determine the type of equipment to use. Transit trucks for mixing were considered, but a mixer/pump combination machine was preferred because it would allow for total control of the mixture. A self-contained machine called MR-IT by Allentown Shotcrete Technologies was selected—a durable and reliable self-contained mixer-pump combination that was capable of mixing the full contents of the 1100 lb (500 kg) bulk bags in one batch and exceeded the necessary requirements for pumping distance. An off-site test was conducted with the pump for material compatibility and training of company personnel to properly operate and maintain the pump.

Because of the complex nature of the job, a daily conservative production rate was estimated. On August 5, 2009, the first day of shotcrete application, fourteen 1100 lb (500 kg) bags were applied to complete 450 ft^2 (42 m^2). Production greatly increased each day; the most productive day was September 3, when sixty-four 1100 lb (500 kg) bags were applied to complete 1650 ft^2 (153 m^2). It took 18 shifts to complete the total area of 15,560 ft^2 (1446 m^2). This included filling in the spalled areas with another 25 yd^3 (19 m^3) of material.

A small crew working a second shift cleaned the scaffold decking daily, using a trash chute erected on one side of the bridge for disposal of the rebound and waste. This crew also monitored the water-curing system startup and cleaned the equipment so that the shooting crew could take full advantage of the production shift.

Twenty-eight days after placement of the shotcrete, the structure was lightly pressure washed and two coats of a bone-colored, water-dispersed, acrylic, anti-carbonation coating were applied with rollers.

The subway and Amtrak's high-voltage cables prohibited the use of man-lifts and cranes, so all materials had to be carried by hand up one of only two scaffold stairs located on the sidewalks at each end of the bridge. On this structure, moving formwork and repair materials up and down the scaffold stairs would have been very labor intensive.

Hand-patching the spalled areas on this structure was a potential option. This would have required the equivalent of 25 yd^3 (19 m^3) of bagged material to be hand-carried up the scaffold stairs, mixed, and hand-applied to the 12 in.- (300 mm)-plus deep spalls with continuous water infiltration. This method would have required multiple layers and most likely would not have stopped or slowed the water flow; production would have been very slow. The result would likely have been a relatively uneven surface with many unsightly joints.

Forming and pouring the 3 in. (76 mm) overlay in lieu of shotcrete was another option that was considered. Sections of forms could have been hand-carried up the 80 ft (24 m) of stairs and assembled in place to fit. Forms would have to be installed, leveled, and plumbed; material would have to be pumped; forms would have to be removed; holes would have to be patched; and forms would have to be cleaned and removed. Obviously, this method was far from practical, and the engineer was particularly concerned that it would have been very difficult, if not impossible, to cast a relatively thin section and be sure of achieving a solid surface free of rock pockets and voids. And while these types of defects could have been patched, the surface would not have been suitable for this historic structure.

Other methods of repair were considered on this project, but good access and budget constraints, as well as the need for a dense, relatively impermeable surface, prevented any other options from being seriously considered. Shotcrete was the only viable and affordable repair method.

Spalling, cracking, water leakage, staining, surface erosion, and outdated design are common problems with many old concrete structures. Other problems that are often encountered are poor original quality and porous concrete, presence of chlorides or carbonation, and deterioration due to lack of maintenance. This bridge had all of these issues, in addition to a few others.

Two coats of a water-dispersed, acrylic, anti-carbonation coating were applied

The primary purpose of the shotcrete on this project was to provide a new structural overlay on the north and south bridge facings. This overlay was constructed to seal the cracks, repair the spalls (monolithic with the overlay), provide additional cover over the existing reinforcement, and eliminate the severe surface erosion. The overlay also provided additional support for a new drainage system bolted to the new shotcrete facing. Attaching the drainage pipes to the existing weak and porous substrate could have resulted in unstable anchorage and movement of the heavy drainage pipes. The overlay was constructed after the internal drainage problems were corrected.

An often overlooked but significant factor in providing a long-life facility is preparing the structure for preventive maintenance. The uniformed float-finished shotcrete provided an excellent textured surface for the adhesion of the coating for protection against the elements.

The use of shotcrete on this project is a great example of the efficiency of placement over other methods of repair. Bridge No. 6.45 will without a doubt serve as an outstanding example of the advantages of shotcrete for numerous other rehabilitation projects that Amtrak and other agencies will undertake in the future, as funding allows. This includes additional arch bridges along this same viaduct, many of which are in need of repair. As a result of the excellent performance on this project, shotcrete may very well be the only specified method for much of this future work.

The biggest challenge of this shotcrete project was not the removal of the rebound and waste, finishing, water curing, dust and overspray protection, material, equipment, personnel, safety, inclement weather, environmental issues, or

View of completed project from Ditmars Boulevard Subway Station

limited completion time. The biggest difficulty of Amtrak's Concrete Arch Bridge No. 6.45 was not that it is located on one of the most congested streets in Queens or the shoulder-to-shoulder pedestrians on the sidewalks or even the crowded adjacent NYC Subway Station and the elevated subway track running through the arch. The most difficult aspect of this job, the site Supervisor now recalls, was his 200 mile (322 km) commute from his Allentown, PA, home.

Not that this project wasn't challenging. Bridge repair of this magnitude in any large city center is quite challenging, especially with the logistical nightmares and congestion that are present. This job, however, is a testament to the phrase, as with most properly planned shotcrete projects, that if you "plan your work and work your plan," getting to and from the job site could be the most difficult task of the day.

2010 Outstanding Repair & Rehabilitation Project

Project Name
Concrete Arch Bridge No. 6.45 over 31st Street

Project Location
Queens, NY

Shotcrete Contractor
East Coast Shotcrete*—
Division of East Coast Gunite, LLC

General Contractor
ECI Building Corp

Architect/Engineer
Parsons Brinckerhoff

Material Supplier/Manufacturer
King Packaged Materials Company*;
Allentown Shotcrete Technology, Inc.*;
and Sika Corporation, USA*

Project Owner
Amtrak

*Corporate Member of the
American Shotcrete Association

Tommy Pirkle *has over 30 years of experience in the shotcrete industry and is Co-Owner of East Coast Shotcrete. He is an ACI Certified Nozzleman and oversees company sales and operations.*

Arden "Morris" Boddie *has been in the shotcrete industry since 1982 and is currently responsible for all field operations for East Coast Shotcrete. He is an ACI Certified Nozzleman and has supervised numerous shotcrete projects, including sewer and tunnel linings, bridge and pier rehabilitation, seawall construction, and stabilization projects.*

2010 Outstanding Underground Project

Liberty Tunnels Phase 2

By Dennis Bittner

The Liberty Tunnels were opened in January 1924. They consist of two tubes; each tube is 28.6 ft (8.7 m) wide, 20.75 ft (6.3 m) high at the arch, and 5889 ft (1.8 km) long. Owned by the Pennsylvania Department of Transportation (PennDOT), the tunnels serve as one of the main access points to the city of Pittsburgh.

The concrete in the tunnels was in desperate need of repair due to age. Because of the high volume of traffic, permanent closures were not possible. It was decided that the tunnels would close nightly from 10:00 p.m. to 6:00 a.m. for the work to be performed. Mosites Construction Company, based in Pittsburgh, PA, was chosen to complete the project. Due to the tight time frame, shotcrete was chosen as the repair method. The contractor opted for Quikrete Shotcrete MS prebagged dry process shotcrete—selected from the state-approved list—due to the stop-and-start nature of the work. To meet additional performance requirements, fibers were added to control shrinkage cracking, and a migrating corrosion inhibitor was added for corrosion protection of embedded steel reinforcement. Both were blended into the product at the point of manufacture.

The project required a full mobilization each night. The tunnel was closed to traffic at 10:00 p.m., at which time all equipment and materials could be moved into the tunnels. First, the substrate was prepped using hydrodemolition. The aggressive nature of hydrodemolition left the substrate clean and with a very rough profile, and without any microfractures (bruising). The process was ideal for preparing the substrate to receive the shotcrete material. Next, any exposed reinforcing bar was cleaned using a pressure washer with a rotating head. Any mesh was removed and replaced with new stainless

Prior to material installation, the substrate was prepared using hydrodemolition

The 3000 lb (1361 kg) bulk bags were predampened as a part of the installation process

Where necessary, additional reinforcement was installed

Finished patch on ceiling with white to clear curing agent

Prepared substrate ready for application of flashcoat

Shotcrete being applied vertically by an ACI Certified Nozzleman

steel mesh. Then, the substrate was cleaned and moistened to a saturated surface-dry (SSD) condition using the same pressure-washing process used to clean the reinforcing bar.

The application of the shotcrete was next. The shotcrete was first predampened and then applied using an Allentown PD1-GRH 610 driven by a 750 ft^3/min (21 m^3/min) compressor. The depths of application varied from 1 to 26 in. (25 to 660 mm). In total, 10,000 ft^3 (283 m^3) of shotcrete was applied. After shooting, the material was finished and a sealer was applied. After allowing time for proper curing, the sealer was removed with a pressure washer. A flash coat of shotcrete was then applied to give the appearance of a gun finish and to gain the appropriate finish texture to receive a topcoat of cementitious waterproofing.

Upon completion, the tunnel had the appearance of a new structure. The owner of the project was extremely happy with the work. A large portion of the tunnel was to receive hydrodemolition and cementitious waterproofing only. A contract addition was granted in these areas to the contractor for 76,000 ft^2 (7060 m^2) of flash coat. The flash coat, applied at depths between 0.5 and 1 in. (13 and 25 mm), was installed to aid in the application of the waterproofing topcoat.

Shotcrete being applied overhead by an ACI Certified Nozzleman

Finished wall with a white to clear curing agent

Finished tunnel

All work was done in accordance with a shotcrete special provision written for PennDOT by members of ASA. The provision is extensive and covers any type of shotcrete application. It requires ACI Certified Nozzlemen, as was used by Mosites Construction Company. It also requires state-approved materials, predampening of dry materials, and adherence to all applicable ACI guidelines. It ensures that proper steps will be followed in the shotcrete process, resulting in a first-class finished project.

Without the use of shotcrete, completion of this project would have been extremely difficult. The tunnel was able to be closed at 10:00 p.m., shotcrete was applied, and the tunnels reopened at 6:00 a.m. Completely eliminating formwork allowed for quick installation, and predampening the shotcrete greatly reduced dust. These, as well as other factors, allowed the tunnels to be placed into service each morning, ready to handle rush-hour traffic.

2010 Outstanding Underground Project

Project Name
Liberty Tunnels Phase 2

Project Location
Pittsburgh, PA

Shotcrete Contractor
Mosites Construction Company

General Contractor
Mosites Construction Company

Architect/Engineer
Parsons Brinkerhoff

Material Supplier/Manufacturer
The Quikrete Companies*

Project Owner
Pennsylvania Department of Transportation

*Corporate Member of the American Shotcrete Association

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

2010 ASA President's Award

2010 Awardee

Larry Totten

The 2010 ASA President's Award was presented to Larry Totten of Johnson Western Gunite. As President of Johnson Western Gunite, Totten has led his company to be one of the most successful shotcrete contractors in the U.S., performing all types of shotcrete work, including concrete repair, seismic retrofit, canals, bridges, architectural, and tunnel construction. Totten has unselfishly given his time to the shotcrete industry by serving as a Past President and member of ASA; as current Chair of ACI Committee 506, Shotcreting; and as a member of ACI Committee C-660, Shotcrete Nozzleman Certification. "It is an honor for me to present the 2010 ASA President's Award to Larry in recognition of his many years of leadership to our industry," said ASA President Patrick Bridger.

In 2005, the American Shotcrete Association established its President's Award. This award is presented to a person or organization that has made exceptional contributions to the shotcrete industry. The selection is the sole responsibility of the current ASA President.

The first award was presented in 2006 to Dr. Marc Jolin of Laval University, in 2007 to George D. Yoggy, in 2008 to Dudley R. "Rusty" Morgan, and in 2009 to Merlyn Isaak.

2010 Carl E. Akeley Award

Carl E. Akeley

2010 Awardee

Lihe (John) Zhang

The Fifth Annual Carl Akeley Award was presented to Lihe (John) Zhang of AMEC Earth & Environmental, for his paper "Is Shotcrete Sustainable?" This paper was published in the Fall 2010 issue of *Shotcrete* magazine and demonstrates the advances that have taken place in the repair of structures with shotcrete in the 100 years since Carl E. Akeley first developed the process.

The American Shotcrete Association established the Carl E. Akeley Award to honor his founding of what today is 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 the American Shotcrete Association.

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 as well as many other museums around the U.S. 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.

The Question of Bonding Compounds and Shotcrete

By Ted W. Sofis

Back when I first joined ASA, the question of bonding compounds with shotcrete came up. As a shotcrete contractor for over 35 years, I had experienced all the problems you can imagine in trying to follow specifications where the use of a bonding agent was required with a shotcrete installation. ASA is made up of a wide range of people in the shotcrete industry, including engineers, contractors, manufacturers, and suppliers, and we all agreed on something. When the question was asked, the response was overwhelming with nearly universal agreement among the ASA membership that use of bonding compounds with shotcrete was actually detrimental to achieving a good bond to a properly prepared substrate. I was not a lone voice in the wilderness.

With good surface preparation and gunning practices, shotcrete provides an excellent bond to the existing substrate

The dry process of shotcrete being gunned on a pier can provide a better bond without using bonding compounds. The nozzleman is filling in the corners first and working toward the middle of the repair area so he doesn't trap rebound in the corners

With a good shotcrete repair, the deteriorated concrete is removed back to sound material, the concrete surface and existing reinforcing is either sand- or waterblasted to clean off scale from the reinforcing bars and create a textured profile on the concrete, the mesh or reinforcing is installed, and the repair area is washed with air and water to clean off any loose particulates and wet the concrete surface to create a saturated surface-dry (SSD) condition prior to the shotcrete placement. SSD refers to a surface that is wet without any standing water. The reason for wetting the concrete prior to placing the shotcrete is to create a better bond. A dry concrete substrate will draw the moisture from the newly placed shotcrete, possibly leaving an inadequately hydrated material at the point of contact between the existing concrete and the shotcrete repair. For this reason, wetting the repair area prior to shotcreting is an important step.

When shotcrete impacts the hard concrete surface, a greater percentage of aggregate rebounds from the surface, leaving a thin layer of more cement-rich paste at the interface between the existing concrete and the new shotcrete. As the shotcrete material builds on itself in its plastic state, the rebound of the aggregate decreases. The velocity of the shotcrete process drives the new material in place, creating an excellent bond with the existing substrate. The use of a bonding compound interferes with this process and in many cases actually creates a barrier or bond breaker.

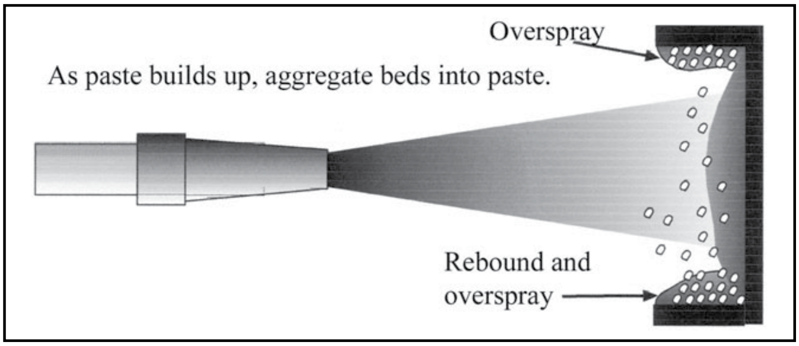
In addition, there are other problems with bonding compounds. With shotcrete, the rebound and overspray will stick to the adjacent areas where a bounding compound has been applied. Rebound is a cement-poor, aggregate-rich, improperly hydrated by-product of the shotcrete process and is not the material that you want to

The top of this industrial sump wall is gunned in place using dry-process shotcrete. The shotcrete process provides an excellent natural bond to the substrate without using bonding compounds. In many cases, bonding compounds are detrimental to achieving a good bond with shotcrete

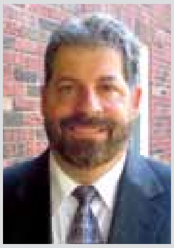
Shotcrete is gunned at high velocity onto the receiving surface. On initial impact, a larger percentage of aggregate rebounds from the surface, leaving a thin layer of cement paste at the interface of the new shotcrete and the substrate

have at the point of contact. You cannot wash or blow off the rebound and overspray from areas and mesh where bonding compound has been applied. Using a blowpipe to remove rebound will actually cause more unacceptable material to stick to the adjacent areas where the bonding agent has been applied. Also, because shotcrete is sprayed in place gradually across a repair area and isn't cast all at once like a concrete pour, the working time of a bonding compound becomes an issue. If shotcrete isn't placed while the bonding compound is still tacky, the bonding compound becomes a bond breaker. Unless the timing between the application of the bonding compound and the shotcrete is just right, some of the repair areas where the bonding compound has been applied may have hardened by the time the shotcrete is placed. Establishing the "open time" of a bonding agent in place is very difficult to gauge and then coordinate with shotcrete placement.

In summation, when you use bonding compounds with shotcrete, you increase the risk of interfering with the excellent bond produced naturally with the shotcrete process. Rebound and overspray can easily stick to the fresh bonding compound in areas adjacent to the shotcrete placement, which will reduce the bond of subsequently placed shotcrete, creating a high probability that sections of the repair will actually have a bond breaker from the hardened bonding compound. If I've learned anything in my 35 years of gunning, it's that the simpler you can keep things in the field, the more likely you will end up with a good result.



On its initial contact, more aggregate rebounds off the receiving surface, leaving a thin layer of cement paste at the interface between the existing concrete and the shotcrete. The material begins to build on the cushion of plastic material. The velocity of the shotcrete process drives the material in place, creating an excellent bond with the existing substrate.



Ted W. Sofis *and his brother, William J. Sofis Jr., are the Principal Owners of Sofis Company, Inc. After receiving his BA in 1975 from Muskingum College, New Concord, OH, Sofis began working full time as a Shotcrete Nozzleman and Operator servicing the steel industry. He began managing Sofis Company, Inc., in 1984 and has over 34 years of experience in the shotcrete industry. He is the Chair of the ASA Publications Committee, the Treasurer for ASA, and a member of the ASA Education Committee. Over the years, Sofis Company, Inc., has been involved in bridge, dam, and slope projects using shotcrete, as well as refractory installations in power plants and steel mills. Sofis Company, Inc., is a member of the Pittsburgh Section of the American Society of Highway Engineers (ASHE) and ASA.*

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Using Accelerators for Shotcreting

By Dan Millette

Are you shooting overhead and need to build up a 6 in. (154.2 mm) layer in a single pass? Do you have a difficult pumping situation that requires a looser material—say an 8 in. (200 mm) slump—and you need to stick that on a wall at a few inches of thickness? Then you should be looking at using a shotcrete accelerator to shoot it. Accelerators have been successfully used for years in shotcreting operations for mining and tunneling where overhead applications are commonplace. Accelerators are used in both dry- and wet-mix shotcreting.

The most common method of accelerating dry-mix shotcrete is by purchasing a packaged mixture that contains an accelerator; but you can also add a powdered accelerator to the mixture. Using an accelerator with a system that includes a predampener requires extra attention on the part of the operator. You do not want to get ahead of loading the gun hopper because the accelerator can harden the mixture pretty quickly once moisture is introduced, which can cause problems going through the gun.

Fig. 1: HPS nozzle with separate accelerator port

Fig. 2: ACME nozzle with integrated air/accelerator port

Another method of using an accelerator with dry-mix shotcrete is to add a liquid admixture at the nozzle along with the nozzle water. If you do this, you need to make sure that both the accelerator and the water booster pumps are pumping at close to the same pressures to avoid pushing either material back into its respective hose.

Wet-mix shotcrete is much simpler to accelerate. The accelerator is added to the nozzle. Wet-mix nozzles with accelerator ports can be purchased from most shotcrete supply companies. Some nozzles have the accelerator port integrated into the air line, whereas other nozzles have separate accelerator ports. When using nozzles with a separate accelerator port, the mixing of the accelerator into the mixture is not always as thorough as when it is integrated into the air port (refer to Fig. 1 and 2).

Accelerator Chemistries

There are two classes of shotcrete accelerators on the market today—one being an alkali material and the other being alkali-free. The original alkali accelerators have a sodium silicate base. These accelerators do speed up the setting time of the cement in the mixture, but not nearly as quickly as the alkali-free accelerators available today. The main advantage of alkali accelerators is to gel up the water in the mixture, giving it a cohesive property. This method of accelerating shotcrete has been around since the 1960s. A sodium-silicate-based accelerator is quite alkali, with a pH of around 11. The mist from these accelerators can irritate the skin on people working near the spraying, especially in enclosed spaces.

Alkali-free accelerators are all manufactured from fairly strong acids, with a pH range between 2 and 3. Most brands of alkali-free accelerators use a sulfate base and often add amines to enhance the rate of acceleration. When added to the mixture in the nozzle, the high alkali content of the mixture will neutralize the acidic properties of the accelerator. Alkali-free accelerators are much faster than the sodium-silicate-based accelerators and are most frequently specified on today's projects that use shotcrete.

The only real disadvantage with alkali-free accelerators is that they are corrosive. When handling alkali-free accelerators, be sure to read the material safety data sheet (MSDS) thoroughly and comply with the personal protective equipment that is recommended. Alkali-free accelerators should never be put into a mild steel tank. This can cause potentially explosive hydrogen gas to build up. Always store these accelerators in plastic or stainless steel containers or tanks. All fittings on tanks, hoses, and pumps should also be stainless steel or galvanized at the very least.

Oftentimes, a shotcrete mixture will contain a retarder or set stabilizer to extend its working time because of long transport distances or hot climates. When using an accelerator at the nozzle, make sure that a set stabilizer is used and not a simple concrete retarder. The difference between a retarder and a set stabilizer are that retarders may use a sucrose or sugar base, whereas set stabilizers use an acidic base and do not contain any sugars. If you use a sucrose-based retarder, the accelerator and the sugar will fight each other. When a set stabilizer is used, it is much easier for the accelerator to overpower it.

When using accelerators in shotcrete mixtures, there are many factors that must be considered and evaluated. Each accelerator should be checked with the particular cement that is to be used in the mixture. Low-alkali cements, such as sulfate-resistant cements (Type V) are not nearly as fast to react with alkali-free accelerators. Although alkali-free accelerators have a common base chemistry among all manufacturers, there are variations in solids contents and secondary chemistries that enhance the base, so various brands can react differently in a particular shotcrete mixture. The most common test specified is ASTM C1398 but this is not always the most practical test. Some accelerators are very high in viscosity and will do well with ASTM C1398 because it is thoroughly integrated in a mixer, whereas in the field application, the accelerator may not blend into the mixture as well at the nozzle. Oftentimes, a lower viscosity accelerator will blend into the mixture in the nozzle better and work at a lower concentration than the high viscosity but will not test as well using ASTM C1398.

Another test that should be done when using accelerators is to determine the 28-day strength of the mixture with the amount of accelerator that is to be used on the project. Accelerators added at the nozzle to a shotcrete mixture can cause the 28-day strength of a mixture to be up to 50% lower than without the accelerator; therefore, the proper amount should be determined before it is applied. Alternatively, you can over-design the compressive strength of the mixture to account for the expected strength loss, but this is not necessarily the most economical method. The reduced 28-day strengths with accelerators are one reason why coring in-place work is often used to evaluate shotcrete strengths.

Fig. 3: Pocket penetrometer test

Fig. 4: Using a Proctor penetrometer to gauge initial set

Many accelerated shotcrete specifications will list an initial set at between 2 and 12 minutes and final set before 30 minutes. The only way to test this is with a penetrometer, of which there are many types. Two of the more common ones are shown in Fig. 3 and 4.

Accelerator Pumps

The selection of an accelerator pump and the way it is set up is the most important factor in successfully accelerating a shotcrete mixture. Because of its low cost, it is common for inexperienced shotcreters to grab a diaphragm pump and use it as an accelerator pump. The problem with this is that a diaphragm pump has a lot of pulse to it and if it is a large enough pump, it delivers "batches" of accelerator to the nozzle. Also, pulsation from the shotcrete pump can complicate the matter, especially when the pumps are out of sync, as illustrated in Fig. 5 and 6.

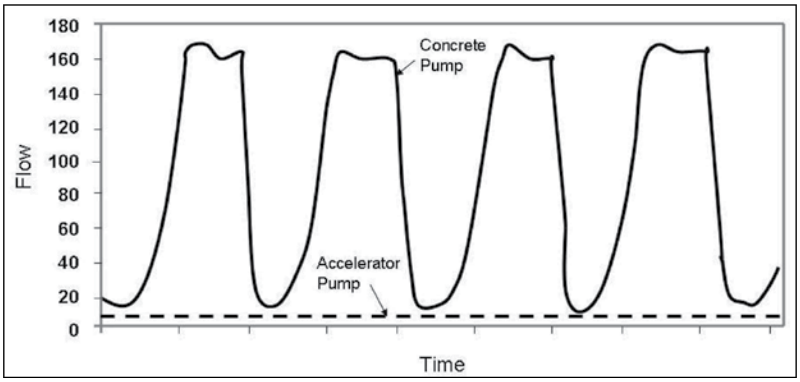

Fig. 5: Graph of typical accelerator pump

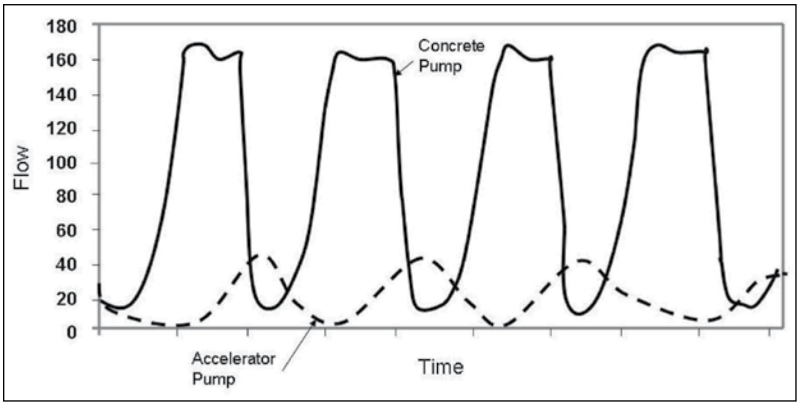

Fig. 6: Graph of large out-of-sync diaphragm pump

Fig. 7: A portable 110V AC peristaltic accelerator pump

Imagine doing an overhead application and the shotcrete pump delivers a slug of mixture while the diaphragm pump is on an exhaust stroke—the shotcrete is not accelerated and falls off the ceiling. Then, while the shotcrete pump is transitioning between strokes, the diaphragm pump delivers a slug of accelerator—this is too much accelerator for the amount of shotcrete being delivered so it sets the mixture up before it even hits the ceiling and it does not stick. Now, with accelerator, you have 50% of the material that is not sticking to the substrate. Sure, this is an extreme example, but it does happen and even a small out-of-sync situation can give unevenly accelerated in-place material that will cause it to be a variable strength material.

Piston pumps can be used but typically wear faster than peristaltic or rotor-stator pumps and are not quite as smooth. Peristaltic pumps (refer to Fig. 7) or squeeze pumps are the most accurate method of metering accelerator to the nozzle. These pumps will deliver a steady flow with very little pulsation. The output of the pump is directly proportional to the rpm of the shaft and this relationship is extremely linear. Another advantage of using a peristaltic pump is that the accelerator does not contact any metal parts except for the hose fittings.

As with most other types of pumps, the peristaltic pumps can easily be purchased with AC or DC electric motors, air drive motors, or hydraulic drive motors, depending on specific needs. The electric drive motors have variable speed drives to control the speed of the pump. Some equipment manufacturers also integrate accelerator pumps into the control panel of the shotcrete pump so that you simply enter the specific gravity and percent dosage of the accelerator, and the pump will dose the accelerator to match the concrete output of the machine. The only downside to this type of setup is the higher cost.

When shopping for an accelerator pump, you need to be sure that it will pump at sufficient pressure to overcome the air pressure to the nozzle. You can always slightly turn down the air pressure to the nozzle, provided you are able to maintain adequate air volume.

Dosage Rates and Calibration

A typical recommended dosage range for a shotcrete accelerator is between 3 and 8% by weight of the cementitious material in the mixture. Take a mixture that contains 600 lb (273 kg) of cement, 150 lb (68 kg) of fly ash, and 75 lb

(34 kg) of silica fume per yd^3. The total cementitious material is 825 lb (375 kg), so at 6% accelerator, 49.5 lb (22.5 kg) of accelerator per yd^3 of shotcrete mixture is required. A typical alkali-free accelerator weighs around 11 lb/gal. (1.32 kg/L), so when you divide the weight, you come up with 4.5 gal. of accelerator per yd^3 (22.25 L/m^3) of shotcrete mixture.

The first step in calibrating would be to determine the output of your shotcrete pump in yd^3/min. This will vary depending on several factors. First, you calculate the volume of a pumping cylinder and then multiply the volume by the strokes per minute of your machine.

For example, if you have a pump with a 5 in. (127 mm) diameter pumping cylinder and it has a 30 in. (762 mm) stroke, then the cylinder volume is

$$(\pi r^2 S)/46{,}700$$

where r is the radius (in this case, the radius of 5 in. is 2.5 in.); S is the stroke (in this case 30 in.); and 46,700 is the number of in.^{3} in yd^3.

$(3.14 \times 2.5^2 \times 30)/46{,}700 = 0.0126$ yd^3 (0.00965 m^3) per stroke

In this case, let's assume that the pump is pumping at 28 strokes per minute; 28 times the volume per stroke equals 0.354 yd^3/min (0.271 m^3/min). The number of strokes is indicated on a readout on some pumps and, if not, can be counted by listening for the swing tube to change directions and counting how many of these changes occur per minute.

There is an additional step necessary in calculating the output of your pump: the fill factor of the pumping cylinders. There are two things that must be considered here. If you are pumping a 10 in. (255 mm) slump mixture without any fibers in the mixture, then you can assume a 100% fill factor regardless of the diameter of the pumping cylinders. When lower slump mixtures are used, a lower fill factor is to be expected. With a lower slump, the pumping cylinder diameter becomes a significant element. For example, if you are pumping a 1.5 in. (38 mm) slump with a 4 in. (100 mm) diameter pumping cylinder, your fill factor could be as low as 50%. It is a good idea to pump 1 yd^3 box full of material with your pump at the slump and speed that you normally pump and count how many strokes it takes to fill the box. You can then back-calculate your fill factor. If you use a very low slump, have someone consolidate the mixture in the box with a pencil vibrator while you are pumping.

Let's assume a 100% fill factor and take the aforementioned example. At 0.354 yd^3/min (0.271 m^3/min) and at an accelerator requirement of 4.5 gal./yd^3 (22.5L/m^3), the accelerator pump must be pumping 1.6 gal./min (6.1 L/min).

The accelerator pump is all that is needed to accurately meter the accelerator into the mixture. Some contractors want to put a regulator valve on the nozzle to allow the nozzleman to control the amount of accelerator. But this is not wise, as it is then impossible to know what the actual dosage of the accelerator is in the placed shotcrete. Besides, a good accelerator pump calibrated to be in sync with the shotcrete pump is the best method of ensuring a consistent application.

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***Dan Millette**, Director, Mining and Tunneling Division for The Euclid Chemical Co., based in Cleveland, OH, is responsible for mining markets, tunneling projects, and shotcreting applications throughout the Americas. Millette is a Mining Engineer with 20 years of experience in shotcreting in underground applications. He is a member of the American Concrete Institute, the Society for Mining Metallurgy, and Exploration, the Canadian Institute of Mining, Metallurgy and Petroleum, the American Underground Construction Association, and ASA. Millette is Chair of the ASA Underground Committee and is on the ASA Board of Direction.*

The Correct Use of Line Lubricants

By Oscar Duckworth

The man who sold me my first concrete pump was an excellent teacher. "You put the concrete in here and it comes out there," he assured me. On my first job, I found out that half of his information was correct. Plugging or packing during the initial prime of a wet-mix placement system can be time consuming and dangerous. Long, complex delivery systems or steep downhill runs can create challenges during the initial prime. Although some crews still rely on the "hammer and hope" method, the correct use of a line lubricant is the safest, most effective method to prime a wet-mix placement system.

Fig 1: Line lubricant added directly to placement system

Fig 2: Line lubricant discarded outside the work area

Why Placement Systems Plug during the Initial Prime

During placement, hoses that convey the shotcrete mixture from the pump to the nozzle are lubricated by the mixture's cement paste. Low-slump mixtures (1 to 2 in. [25 to 51 mm] slump) or lean mixtures containing less cement paste can be more difficult to pump than mixtures with more water or cement paste. Because wet-mix shotcrete must be pumped through a placement system, the shotcrete mixture must possess sufficient moisture and paste volume. During the initial prime, if the shotcrete mixture is conveyed through an unprimed placement hose, some of the cement paste will be lost as it coats the interior of the hose. This is similar to a moving paintbrush losing its paint to a dry surface. Pumping a shotcrete mixture even a short distance through an unprimed placement system will cause the mixture to lose enough cement paste to become too lean to pump through the system. The lean mixture lacks sufficient lubrication and will quickly form a pack that will plug the system, regardless of the amount of pressure applied by the pump. This can create a burst hazard within the system if the pump pressure is not relieved. Forcing a pack forward using maximum pump pressure is never successful and always dangerous. A pack within the hose can only be removed by relieving the pump pressure, opening the hose, and shaking the lean material completely out of the system before attempting to resume pumping.

How Line Lubricants Work

The proper use of a line lubricant can prevent plugging during the initial prime by providing both additional moisture and a paste coating to the interior of the placement system just ahead of the shotcrete mixture as it is initially conveyed through the hose. To use a line lubricant correctly, the lubricant must be added to the delivery system prior to adding the shotcrete mixture to the pump hopper (Fig. 1). The shotcrete mixture pushed by pump pressure will act as a piston, forcing the line lubricant ahead of the mixture and effectively coating the interior of the line ahead of the shotcrete as it is pumped through the system. If a placement system is adequately coated with a line lubricant, cement paste will not be lost from the mixture as it is conveyed through the hose. A lean pack is not likely to occur. Shotcrete mixtures have been successfully primed and pumped over 1 mile (1.6 km) without plugging in underground mining operations.

Line Lubricants Are Not Admixtures

Never add line lubricants to the shotcrete mixture at the hopper. Line lubricants are much lighter than other components of the mixture. Lubricants added to the pump hopper will quickly float up as the shotcrete mixture enters the hopper. This defeats the purpose of the lubricant. When line lubricant is floating at the top of the hopper it cannot be drawn into the pump material cylinders ahead of the mixture; therefore, the lubricant cannot initially coat the unprimed lines. Plugging during the initial prime is likely to occur. Always discard material contaminated with line lubricant. Most lubricants are not compatible with concrete mixtures; therefore, strength and durability may be affected. Discard all lubricant and contaminated concrete prior to beginning placement (Fig. 2). The correct use of a line lubricant is the best method to assure that, as my teacher said, "If it goes in here, it comes out there."

Checklist

- Use line lubricants correctly to reduce plugging and possible burst hazard during the initial prime.
- Add line lubricant to the delivery system, not the pump.
- If a plug does occur, do not attempt to force a plug forward using maximum pump pressure. Relieve the pump pressure, open the hose and shake out the plug.
- Discard line lubricant and contaminated shotcrete prior to beginning placement.

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

A *Shotcrete* feature:

SAFETY SHOOTER

Reducing the Risk of Airborne Hazards

By Joe Hutter

The hazards of airborne crystalline silica have long been recognized by the North American construction industry. The effects of these hazards on the health of our workers can be minimized through education and preventative actions. The first step in protecting our workforce against exposure to airborne crystalline silica is to make the workforce aware of the sources and the activities that contribute to potentially high silica exposure. Some of the common construction activities that can contribute to elevated levels of airborne silica include:

- Sandblasting;
- Abrasive blasting of concrete;
- Chipping, jack hammering, drilling, cutting, or other types of concrete or masonry demolition;
- Dry-sweeping or blowing rock or concrete with pressurized air;
- Mixing concrete; and
- The shotcrete process (dry or wet).

Once we recognize and identify the sources, training and education (before the work starts) will provide the workforce with the knowledge required for protection against the long-term effects of airborne silica. Training should include:

- Potential health effects of exposure to respirable crystalline silica;
- Access to material safety data sheets for related products;
- The affect of engineering controls, work practices, and personal hygiene in reducing crystalline silica exposure; and
- The use and care of appropriate personal protective equipment (including protective clothing and respiratory protection).

Predampening equipment should be used to reduce the amount of airborne dust at the machine and at the nozzle

Protection against Exposure to Crystalline Silica

OSHA publishes and enforces regulations designed to protect employees against exposure to crystalline silica. A permissible exposure limit (PEL) has been established to determine the maximum amount of allowable exposure. Protection against exposure above this PEL will be dependent on the measured amount of airborne crystalline silica. The two most effective ways to prevent the negative long-term health implications from exposure to airborne crystalline silica are first through the use of engineering controls to ensure that levels of airborne hazards are kept below the permissible exposure limits. When these controls fail to bring the exposure within permissible levels, it is important to ensure that the appropriate personal protective equipment is being used.

Engineering Controls

The first step in keeping exposure limits to a permissible level is to remove the airborne hazards from the environment through the use of engineering controls. These controls can be as simple as following common sense housekeeping practices on an outside construction site or as complex as designing a ventilation system in an underground hard rock mine.

Housekeeping—Good housekeeping practices will go a long way in stopping one common source of airborne dust. Concrete debris, dust from concrete removal, and rebound from the sandblasting and shotcrete process should be wetted down and collected. Empty sandblast, shotcrete, and cement bags should be gathered and disposed of. Dust from these sources can become airborne when disturbed by passing traffic, vibration, and other random air currents.

Isolation—Operations that directly or indirectly cause the formation of airborne crystalline silica should be isolated from the rest of the workforce using a physical barrier such as visqueen. Any employees not involved with the isolated operation should be removed from the area. Ventilation should direct airborne hazards away from unprotected employees.

Equipment Maintenance and Selection—To avoid creating unnecessary dust at the equipment source (the shotcrete machine), it is essential that the equipment is well maintained. In the case of a dry-mix shotcrete operation, the following recommendations will minimize the measured amount of airborne crystalline silica:

- Wear pads and plates should be inspected regularly to avoid dust from escaping into the atmosphere;
- Keep wear pads and air settings properly adjusted to prevent "blow-back" of dry shotcrete material from the hopper. Consult equipment supplier for proper equipment operating procedures;
- During the dry shotcrete process, always ensure sufficient water pressure to avoid continuous dry/wet adjustments;
- Use predampening equipment to reduce the amount of airborne dust at the machine and at the nozzle;
- Ensure the correct size of all air and material hoses are used. Consult the equipment supplier for proper hose selection; and
- Ensure adequate training by qualified personnel is provided to all equipment operators, nozzlemen, and other crew members.

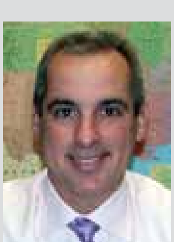
Water—Airborne crystalline silica can often be kept below permissible exposure limits through the use of water. Any tools that directly increase airborne dust levels should be equipped with a water suppression system (for example, rock drilling rigs, concrete saws, and concrete coring equipment). Water should also be available for wetting down dry material spills, concrete debris, and roadways, and wet sweeping work areas (rather than dry sweeping) will also reduce airborne dust levels.

Ventilation—Ventilation in the workplace is essential in preventing the production of excessive amounts of airborne dust. Local ventilation should be modified as necessary to provide adequate airflow away from the points of major dust generation (the delivery hopper, the machine or pump, and the nozzle). Typical local exhaust systems consist of hoods, ducts, air cleaners, and fans. In some circumstances (for example, underground applications and confined spaces), additional fan capacity may be required to keep an adequate supply of clean air circulating properly.

Personal Protective Equipment

Respiratory protection suitable for the job-site exposure conditions should be worn and maintained by all members of the shotcrete crew when engineering controls alone are not adequate to reduce exposures below the levels permissible by OSHA. When respiratory protection is required, it should first be determined through a medical evaluation if the crew member meets the minimum health and physical conditions to use the equipment. Periodic follow-up medical evaluations may also be required if the crew member exhibits medical signs or symptoms that can affect his/her ability to wear the respiratory protection. After the individual has been deemed OK to wear the respirator, they should be fitted and trained on the use of the respirator to ensure that it is used and maintained properly. Beards and mustaches may interfere with the respirator seal (around the face) and can render it ineffective.

When ignored, exposure to crystalline silica and other airborne hazards can pose severe health risks with serious, long-term implications. An educated workforce provides the greatest defense against these types of workplace hazards. Through education, awareness, planning, and the implementation of preventive actions, the workplace can be a safe environment.



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

Corporate Member Profile

Hydro-Arch

Hydro-Arch is a general engineering contractor specializing in flood control structures, including arch culverts, bridges, and channels. Although Hydro-Arch constructs an array of flood control structures, it specializes in the turnkey design and construction of cast-in-place arch culverts.

The Hydro-Arch system is low in cost, beating competing systems, including precast arches and boxes, multi-plate arches, and DOT cast-in-place box culverts. A Hydro-Arch system can save 20 to 30% over a box culvert or a precast arch. Moreover, it can save 40 to 50% of the cost of a bridge.

The success of the arches is based on several well-known principles. The geometric arrangement places much of the arch in compression, making it the most efficient shape. A large inventory of well-designed, reusable arch forms result in speedy construction and cost savings.

Wolf Michelson, the founder and owner of Hydro-Arch, got involved with building arch culverts in 1977. As a contractor, Michelson built culverts and underground structures for various designers. Some of these were very innovative and creative. When it became apparent that a market existed for cost-effective arch culverts, Michelson took some of the best ideas available at the time, and by 1988 he was exclusively building arch culverts.

Since 1990, Hydro-Arch has built well over 85 miles (136.8 km) of culvert systems throughout the western U.S. This includes the drainage system at the Inspirada master-planned community in Henderson, NV. By value engineering this project, Hydro-Arch saved the client over 40% from the original standard design. By using arch culverts, 3 acres (1.2 hectares) of land was reclaimed to be used for streets, parks, and parking.

Thirty-four years of specializing in one area—flood control and drainage—has resulted in Hydro-Arch becoming the leader in this field. For more information, please visit **www.hydro-arch.com** or call (702) 566-1700.

Arch bridge at The Lakes in Menifee, CA

Shotcrete placement on arch culvert at Inspirada in Henderson, NV

Headworks structure and channel at Inspirada

Changing the Traditional Shotcrete Mixture to Suit Underground Applications

By Dan Millette

Concrete mixtures used in the shotcreting process have traditionally been low-slump mixtures. Low-slump mixtures are fine when transport distances are short, but in the current tunneling industry, longer pumping distances are often a requirement. The mining industry also often requires long vertical drops to get the mixture where it needs to be. In these situations, low-slump mixtures can cause plugging and higher pump and hose wear and cost the contractor or owner a lot of time and expense in dealing with these issues.

Over the last few years, it has become more common to use a highly flowable mixture in shotcreting applications. Self-consolidating concrete (SCC) has been developed to enhance pumping applications and better encase the heavy reinforcing steel often found in many of today's modern structures. With its high flowability, SCC is being adapted for use in shotcreting applications. When testing the flowability of SCC, a slump-flow test, as defined in ASTM C1611/C1611M, "Standard Test Method for Slump Flow of Self-Consolidating Concrete," is the appropriate test rather than slump.

The first consideration when designing an SCC concrete mixture is to increase the fines content of the mixture, which in turn requires a higher paste content. With most shotcrete mixtures, we are already there because we generally have a fairly high paste content. Two important properties for SCC in the plastic state are flowability and stability. In the hardened state, we need to see the required strength. Simply adding water will increase the flowability but negatively affect the stability and strength.

Mining technician measuring the slump flow of a shotcrete mixture

Although they are more costly than water, chemical admixtures can help to ensure the correct properties for an SCC mixture. A high-range water-reducing admixture (HRWRA) is the main component in allowing the SCC mixture to flow without the addition of water. Modern HRWRAs are made with polycarboxylic ethers, providing cement dispersion by steric stabilization, and these molecules can be tailored to provide various initial slumps and slump retention times. They can also be tailored to work with various types of cements.

One other addition to a mixture that can help with flow is air. With a simple air-entraining admixture, you can add up to 12% air to a mixture, which can significantly increase flowability; however, you must make sure that the air is knocked out during shooting or by a sudden stop at the end of a vertical drop, as air in hardened concrete will also reduce the compressive strength.

When a mixture becomes very flowable, it can tend to segregate during a fall or when pumping, but you guessed it: there is also a chemical to prevent that from happening. A viscosity-modifying admixture (VMA) can be added at a very low dosage to help keep the mixture together during transport.

So, the next time you need to pump your mixture a long distance into that dark tunnel or drop it 5000 ft (1500 m) straight down a pipe into a mine, work with your ready mix supplier to design the right mixture for the job. The mixture may be more expensive, but this can save a great deal of money in labor costs and plugged equipment.

***Dan Millette**, Director, Mining and Tunneling Division for The Euclid Chemical Co., based in Cleveland, OH, is responsible for mining markets, tunneling projects, and shotcreting applications throughout the Americas. Millette is a Mining Engineer with 20 years of experience in shotcreting in underground applications. He is a member of the American Concrete Institute the Society for Mining Metallurgy, and Exploration, the Canadian Institute of Mining, Metallurgy and Petroleum, the American Underground Construction Association, and ASA. Millette is Chair of the ASA Underground Committee and is on the ASA Board of Direction.*

Top Ten Sustainability Benefits of Shotcrete

The United States Green Concrete Council's (USGCC) *The Sustainable Concrete Guide—Applications* includes a list of the top 10 sustainability benefits of shotcrete in its chapter on shotcrete. Over the next 10 issues of *Shotcrete* magazine, this Sustainability column will elaborate on each one of the following advantages:

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, which 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.

Formwork Savings of 50 to 100% over Conventional Cast-in-Place Construction

One of the most significant sustainability advantages of shotcrete is the substantial formwork material savings. With the shotcrete process, the material is shot into its final place, so forming is either completely eliminated or at least reduced by 50% when one-sided forms are necessary. This not only reduces or eliminates the amount of wood or other material used in forming, but also reduces or eliminates the environmental impact of milling the lumber and subsequent transportation to thousands upon thousands of construction sites. Furthermore, the transport and disposal of used formwork is greatly reduced. Even in applications where one-sided forms are required, the formwork is greatly simplified, as less structural strength is needed, and thus the materials required are significantly reduced.

Projects where structural walls contained multiple blockouts have experienced a reduction of formwork to one-sixth of what would have been needed on a traditional placement.

In addition to the actual formwork material savings, ancillary formwork materials, such as whalers, bracing, form ties, reinforcing bar standoffs, forming support structures, and release agents are also eliminated or substantially reduced.

Due to the natural consolidation of concrete when placed via shotcrete, consolidation operations are also eliminated.

U.S. GREEN CONCRETE COUNCIL

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

Panels are set in place on this high-rise to create one-sided backstop forms to gun shotcrete against

In overhead work, not only is the formwork eliminated, but the scaffolding and shoring required to support overhead forms is also eliminated. This means less on-site labor and less on-site equipment is required to unload, move, and load for shipping the forming and shoring materials.

In many cases, when there is a structure or substrate to gun against, shotcrete can be gunned in place without the use of forms, eliminating forming costs altogether

A copy of the USGCC's *The Sustainable Concrete Guide—Applications* can be obtained by visiting the American Concrete Institute's online Bookstore at **www.concrete.org**.

Finishing touches are made to a freshly placed shotcrete wall

Concrete Tank Companies Merge

Natgun Corporation, Wakefield, MA, and DYK Incorporated, El Cajon, CA, jointly announced the merger of their companies on January 4, 2011, and the formation of their new parent company, DN Tanks, Inc., **www.DNTanks.com**. Both companies specialize in the design and construction of prestressed concrete storage tanks used for potable water, wastewater, chilled water, and other liquids. The merger of the two companies, which have over 130 years of combined experience, creates the largest producer of wire- and strand-wound prestressed concrete tanks in the world.

Natgun and DYK will initially operate under their existing names as divisions of DN Tanks. As the integration process takes place, they will evolve into a single operating company. A four-member Board of Directors, comprised of **Charles Crowley**, **William Hendrickson**, **William Crowley**, and **David Gourley**, will lead DN Tanks, Inc. Charles Crowley and Hendrickson will serve as Co-CEOs.

Both DYK and Natgun design and construct prestressed concrete tanks in accordance with the American Water Works Association Standard D110. Each company brings specialized skills to meet varying project requirements. While there are some differences in the methods of tank construction, both companies share a commitment to quality, durability, and delivering long-term value to their customers. The merger of the two companies into DN Tanks, Inc., results in expanded construction capacity, exceptional technical expertise, and proficiency in multiple types of proven tank designs to provide customized liquid storage solutions for their customers.

With operations centers in Massachusetts, Texas, and California, as well as multiple regional offices, DN Tanks, Inc., will serve clients nationally and internationally.

Both organizations were profiled in a *Shotcrete* magazine article titled "Shotcrete in Liquid-Containing Concrete Structures" in the Summer 2010 issue, which is available at **www.shotcrete.org**.

TYAM Purchases Western Versatile Construction Corp

The TYAM Group has expanded its operations with the acquisition of Western Versatile Construction Corp (WVCC). WVCC is a highly successful heavy civil industrial contractor that has been in operation for over 20 years. WVCC has completed projects throughout British Columbia, Alberta, and the Yukon in Canada, specializing in heavy civil and structural work, including bridge building, hydroelectric installations, and mining projects. They have a strong reputation for providing quality services on a variety of large construction projects. The purchase of WVCC also includes an investment in Westpark Electric Ltd., a specialty electrical contractor focusing on industrial installations within the heavy construction industry.

"The acquisition of WVCC builds on the heavy civil and structural expertise developed on TYAM's successful Canada Line Project and adds to our core expertise in road building, municipal utility work, residential site services, and bulk excavation and shoring," states Mike Luers, Executive Vice President at TYAM. "WVCC also brings significant expertise and experience in design-build projects. This allows TYAM to offer a broader range of services to our customers and adds expertise in all aspects of our business."

The operations of WVCC will be relocated to TYAM's Gloucester Estates facility in Langley, BC, Canada, where it will operate as an independent division of TYAM. WVCC will continue to pursue bridge, hydroelectric, and mining projects and will also work closely with TYAM on future projects to maximize the synergy in operations between the two companies. **Paul Manning**, the President of WVCC, will continue to work with the company as an independent consultant on a part-time basis, focusing on business development. **Rick Tough**, Principal and Contracts Manager of WVCC, will assume responsibility for WVCC operations within the TYAM Group, and existing key WVCC staff will also relocate to the new operation.

TYAM President **Robert Barker** comments, "This acquisition is part of our continued commitment to TYAM's growth and development. Shareholders and management of both TYAM and WVCC are very excited about the purchase and feel that with our complementary skill sets, we will be able to bring new and significantly improved services to the market."

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

BASF Announces MSHA Approval of MEYCO TSL 865 for Underground Coal Mining Applications

The MEYCO Global Underground Construction business of BASF has announced that the U.S. Mine Safety and Health Administration (MSHA) has approved its MEYCO TSL 865 thin spray-on liner, a one-component polymer powder for spray application onto soil and rock for supplemental support and protection against weathering. The MSHA approval expands the acceptable use of MEYCO TSL 865 to the complete range of applications in underground coal mines.

Originally launched in the North American market in August 2009, MEYCO TSL 865 is now approved to seal and strengthen the rib and roof, seal leaky stoppings and overcasts, build maintenance-free block stoppings, and improve the quality of any ventilation control in the mine.

"MEYCO TSL 865 is an innovative thin spray-on liner that was designed for the challenging conditions in underground coal mines," said Haydn Whittam, Segment Specialist, Underground Coal, for BASF. "With this recent MSHA approval, MEYCO TSL 865 thin spray-on liner can now be used to its full potential to reduce cost, improve the performance and long-term durability of mines, and improve miner safety."

The product is mixed with water in the spraying nozzle and impacts the substrate as a paste. It sets within 5 to 10 minutes and progressively increases in tensile and bond strength over the next hours, days, and weeks. With its excellent bond to most substrates, high elasticity, and high tensile strength, the MEYCO TSL 865 thin spray-on liner can substantially improve ground stability.

For more information, visit **www.basf-admixtures.com**.

2011 World of Concrete Trade Show Numbers Down but Still Strong

Although World of Concrete is still one of the city's largest trade shows, attendance has dropped significantly from 4 years ago and even last year. Although some exhibitors prefer the thinner crowds—resulting in a higher ratio of buyers compared to spectators—fewer visitors isn't good for hotels in the city.

"The show is a reflection of how it's challenging for everybody in the construction industry—housing and commercial," **Steve Pomerantz**, the show's Marketing Director, was quoted as saying.

Final attendance numbers have not been calculated, but exhibitors representing a wide range of concrete-related construction equipment estimated that the final tally could run less than the 55,000 recorded last year. By contrast, the show hit its peak at nearly 92,000 in 2007.

It is estimated that companies took up 515,000 ft^2 in exhibit space this year versus 900,000 ft^2 3 years ago, while the number of booths has dropped from 1700 to fewer than 1300. The 2010 count showed 1350 exhibitors renting 600,000 ft^2.

Dry-Mix Shotcrete (Gunite) Leads to Significant Water Savings and Award

The Placer County Water Agency (PCWA) in California has earned a statewide award for saving water in its extensive canal system, which includes 165 miles (265.5 km) of canals that wind through wide areas of Placer County. The Best Management Practices Award was issued from the California Municipal Utilities Association (CMUA). PCWA Director of Field Services Mike Nichol said the award, judged by a panel of elected state senators and assemblymen, recognized PCWA's ongoing canal lining program to control water loss.

The agency applies gunite (dry-mix shotcrete)—to form a concrete lining—to an average 4 miles (6.4 km) of open canal per year to reduce leakage and seepage. As an example, Nichol pointed to the Newcastle Canal, where gunite lining has reduced water loss by nearly 25% over the past 5 years.

ICRI Announces 2011 Spring and Fall Convention Details

The International Concrete Repair Institute (ICRI) will hold its 2011 Spring Convention March 16-18 at The Westin Galleria in Houston, TX. The convention is an expanded 3-day event and the theme will be "NDE & Structural Health Monitoring." ICRI will include a full slate of 13 technical presentations given by knowledgeable industry experts, who will cover a variety of topics relating to the needs of the concrete repair and restoration marketplace.

In addition to the technical presentations, the convention highlights include technical and administrative committee meetings, an exhibitor area, and networking luncheons. ICRI uses the spring event as an opportunity to hold a Recognition Luncheon to honor its supporting members, Chapter Award winners, and Board of Directors.

A location has also been chosen for ICRI's 2011 Fall Convention. The ICRI 2011 Fall Convention will be held

October 12-14 at the Westin Cincinnati, Cincinnati, OH. The theme is "Water & Wastewater Treatment Plant Repairs" and will also include professional technical presentations, committee meetings, and networking.

The featured program will be the 19th Annual ICRI Project Awards Banquet honoring the winners of the annual contest.

For more information on these and other ICRI events, visit **www.icri.org**.

INTERNATIONAL CONCRETE REPAIR INSTITUTE

Building Industry Spending Down 10% in 2010

The U.S. Commerce Department has reported that construction spending dropped 10.3% last year, marking the fifth annual decline. Construction spending fell to $814.18 billion in 2010, the lowest level since 2000.

For 2010, home construction fell 1.7% and nonresidential projects plunged 23.3%. Spending for the category that includes shopping centers dropped 26% and government projects slid 2.7%.

Slow but Steady Economic Recovery Predicted

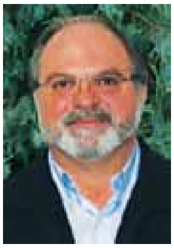
According to the Federal Reserve's Beige Book, the U.S. economic recovery is on track but moving ahead slowly. The Beige Book is a compilation of analytical reports from businesses across the country. Trends that have emerged from a range of economic data show that the job market is gradually improving; however, the housing sector remains a significant drag on the economy.

Altogether, the economy is very slowly gaining momentum.

Industry Personnel

Putzmeister America, Inc., Appoints Director of Customer Support and National Sales Manager of Thom-Katt® & Used Equipment

Putzmeister America, Inc., has announced **Doug Brunet** as Director of Customer Support and **Drew Williams** as National Sales Manager of Thom-Katt® & Used Equipment.



Doug Brunet

Brunet has been with the company since 2000 and his responsibilities have expanded. As Director of Customer Support, Brunet oversees part sales and warranty, all operations at the Putzmeister West Coast Customer Support facility, in-house and mobile customer service and technical support, and continues to manage the manufacturing repair process for both used and customer-owned equipment.

Based out of Putzmeister America's corporate offices in Sturtevant, WI, he reports directly to **Dave Adams**, Putzmeister America's President and CEO. "Doug's experience and commitment to customer satisfaction will help us continue to provide our high level of customer service and support," comments Adams.

Drew Williams

Also located in Sturtevant, WI, Drew Williams' responsibilities have also been expanded. He now manages the sales of all used equipment in addition to already overseeing all sales and customer relationships in regards to Thom-Katt trailer pumps for the company.

He reports directly to Bill Dwyer, Vice President of Sales & Marketing for Putzmeister America. "Drew has demonstrated strong leadership skills in his role as National Sales Manager of Thom-Katt by dedicating himself to developing and maintaining both the sales of our product and our customer relationships," comments Dwyer. "Combining that skill with his industry experience will make him a valuable asset in helping to lead our used equipment sales team and understand our customers' needs."

Williams has been employed by Putzmeister America since the company acquired Allentown Equipment (now Allentown Shotcrete Technology) in 2007.

Brunet can be reached at (262) 770-0077 or brunetd@putzam.com, and Williams can be reached at (262) 770-0797 or williamsd@putzam.com.

ASCC Elects Officers and Directors

Clay Fischer, President, Woodland Construction Co., Jupiter, FL, has been elected President of the American Society of Concrete Contractors, St. Louis, MO, for 2011 to 2012. **Scott Anderson**, Houston, TX; **Chris Plue**, San Mateo, CA; **Mike Poppoff**, Moxie, WA; and **Thomas Zinchiak**, Woodbine, MD, were elected Vice Presidents. **Harry Moats**, Marietta, GA, was reelected Secretary/Treasurer. **William Bramschreiber**, Pasadena, CA; **Chris Forster**, Santa Monica, CA; and **Rocky Geans**, Mishawaka, IN, were elected as new Directors.

ASCC AMERICAN SOCIETY OF CONCRETE CONTRACTORS
Enhancing the Capabilities of Those Who Build with Concrete

Sandvik Appoints New President and CEO

Sandvik's Board of Directors has appointed **Olof Faxander** as new President and CEO. Faxander will succeed Lars Pettersson who, after 9 years as CEO, will leave Sandvik in conjunction with an impending generation shift in the company's group executive management. The change has been made in light of a homogeneous age structure and allows a new president to personally shape the future executive management team.

During his time at Sandvik, Faxander has successfully strengthened the company's niche orientation and broadened its geographical focus. In addition, he has demonstrated a renowned ability to build organizations and develop employees.

Anders Nyren, Chairman of the Sandvik Board, said that "Mr. Olof Faxander represents the modern leadership required in a changing and increasingly global world. He has broad international experience from intensely competitive markets undergoing change and has proven ability to develop companies for increased value generation. Sandvik is a knowledge-based company and Olof Faxander will now have an important role to play in the company's continued development."

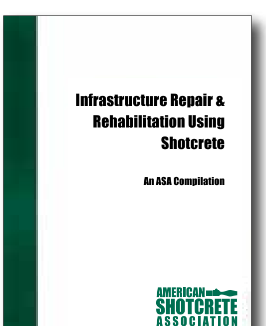
He added that, "At the same time, I would like to thank Lars Pettersson for his model leadership during his 9 years as CEO. During this period, the company has strengthened its global market position through its distinct customer focus, its investments in research and development, and the launch of new products, all while managing the recent financial crisis in an exemplary manner. Under Lars Pettersson's time as President, Sandvik's market capitalization has increased from SEK 60 billion to SEK 150 billion, which together with dividends generated an annual return of 16%."

Passing of Dennis Wrixon


Dennis Wrixon

Normet Canada Ltd. regrets to announce the passing of **Dennis Wrixon** on January 13, 2011. He was born on July 3, 1952. Wrixon grew up in Levack, ON, Canada, where his father worked for Inco at Levack Mine for 30 years. Wrixon graduated with honors in economics from Laurentian University, Sudbury, ON, Canada, in 1977 and also worked underground at the Levack, Strathcona, Denison, Madawaska, and McCreedy mines. He also worked in the mining equipment business for many companies, starting in 1981 with Tamrock in Sudbury. In 1989, he started the company Minequip, which was the start of his shotcrete experience. Later, he sold the business to King Packaged Materials. He then started DW Services and spent 3 years in the tunneling business in the U.S. with American Commercial. Wrixon eventually returned to Sudbury, spending time with DSI and Cementation and finishing his career as Vice President of Normet Canada Ltd. Wrixon left a lasting impression on the mining and tunneling worlds and will be sorely missed.

Infrastructure Repair & Rehabilitation Using Shotcrete—An ASA Compilation



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

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

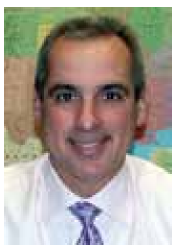
Copies of the compilation are available for a special price of $9.00 U.S. Pricing includes shipping. To place an order, visit **www.shotcrete.org/RepairBulletin** or call (248) 848-3780.

ASA Officers Elected

With terms beginning February 2, 2011, the ASA membership has elected the following individuals to leadership roles in the association: **Michael Cotter**, Consultant, was reelected to a 1-year term as Secretary; and **Ted Sofis**, Sofis Company, Inc., was also reelected to a 1-year term as Treasurer.

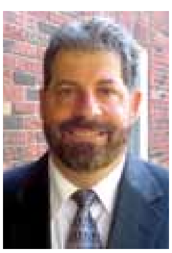
These two individuals will join President **Patrick Bridger**, Allentown Shotcrete Technology, Inc.; Vice President **Joe Hutter**, King Packaged Materials Company; and Immediate Past President **Chris Zynda**, Joseph J. Albanese, Inc., to form the 2011 ASA Executive Committee.

Patrick Bridger

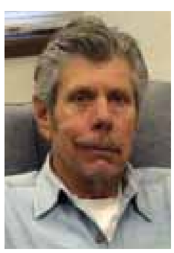


Joe Hutter

Michael Cotter



Ted Sofis

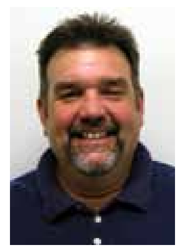


Chris Zynda

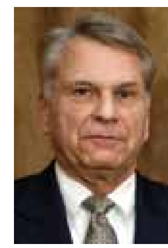
ASA Directors Elected

Three ASA Directors were reelected to 3-year terms beginning February 2, 2011. The reelected Directors are **Tom Norman**, Airplaco Equipment Company; **Ryan Poole**, DOMTEC International LLC; and **Dan Millette**, The Euclid Chemical Company. ASA by-laws limit Directors to a maximum of two consecutive 3-year terms.

The three newly reelected Directors will join the six previously elected Directors (**Marcus von der Hofen**, Johnson Western Gunite Company; **Curt White**, Coastal Gunite Construction Company; **Willam T. Drakeley Jr.**, Drakeley Industries, LLC; **Charles Hanskat**, Concrete Engineering Group, LLC; **Lihe (John) Zhang**, AMEC Earth & Environmental; and **Ray Schallom III**, RCS Consulting & Construction Company, Inc.) and the ASA Executive Committee to form the 14-member ASA Board of Direction.



Tom Norman



Ryan Poole

Dan Millette

Visit the ASA Booth at the 2011 International Bridge Conference June 5-8 in Pittsburgh

ASA will be in **Booth No. 607** on the main show aisle. The International Bridge Conference (IBC) has proved to be a valuable tool for ASA in its efforts to communicate the exceptional advantages of shotcrete to public officials and specifying professionals in the infrastructure industry.

For more information and/or to register for the show, visit **www.internationalbridgeconference.org**.

ASA Annual Membership Meeting

Under the new stand alone format, the annual meeting occurred at the end of the scheduled ASA committee meetings held in conjunction with World of Concrete (WOC) 2011 on the day preceding the opening of the show's exhibits. The meeting's main focus was the formal announcement of the 2011 ASA Officer and Director Election results.

ASA President Patrick Bridger also took time during the meeting to thank and recognize the contributions of ASA's dedicated committee Chairs: Joe Hutter, Marketing and Membership Committee; Ray Schallom III, Education Committee; Ted Sofis, Publications Committee; Charles Hanskat, Sustainability Committee; Chris Zynda, Safety Committee; Dan Millette, Underground Committee; and Tom Norman, Pool and Recreational Shotcrete Committee.

ASA Features Shotcrete Sustainability at WOC 2011

WOC 2011, which was held January 18-21, saw a smaller footprint and attendance than in years past but once again afforded ASA a unique and outstanding chance to promote and educate the concrete world on the numerous advantages of shotcrete. Thousands of individuals visited the ASA booth, asking questions and gathering information about shotcrete, including the new ASA "Sustainability of Shotcrete" brochure.

In addition, ASA once again played a significant role in the show's seminar program. American Concrete Institute (ACI) Officers Charles Hanskat, Concrete Engineering Group, LLC; and Chris Zynda, Joseph J. Albanese, Inc., were the speakers for ASA's 90-minute seminar titled "Sustainability of Shotcrete."

For the first time, ASA supplied an informational booth in the "GreenSite" pavilion in the Central Hall. The "GreenSite" pavilion focuses on sustainability. The booth provided an exceptional forum for communicating the sustainability advantages of shotcrete. Hundreds of documents were distributed.

ASA Annual Outstanding Shotcrete Project Awards Banquet

The ASA Annual Outstanding Shotcrete Project Awards Banquet once again proved to be not only an enjoyable social event, but also a great stage for showing off the versatility and high quality of some of the exceptional shotcrete projects completed in 2010.

As mentioned in the ASA President's Message of this issue, ASA extends a big thank-you to the Awards Banquet sponsors (refer to page 2) that made this banquet and the overall awards program possible.












Shotcrete FAQs

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

Question: Can a shotcrete mixture be designed using crushed washed sand instead of natural washed sand?

Answer: The grading of fine aggregates, natural or manufactured, should be in compliance with the combined aggregate gradations in ACI 506R or ASTM C1436. Using crushed washed sand will be more difficult than using natural washed sand due to the more angular particle shapes. Due to the more angular particles, crushed sand will likely require a higher paste content to successfully convey it through the shotcrete hose.

Question: We are proposing a project that will use shotcrete on an existing metal bin wall to match recently constructed soil nail walls with shotcrete facing. What is the proper way to prepare the bin-wall surface? Also, what type of reinforcement would you recommend and what is the suggested method of attaching the reinforcement to the bin wall?

Answer: The surface should be cleaned using a high-pressure water blaster or sandblasting to remove any loose material and rust. If the metal bin material is thick enough, you might want to consider welding metal studs or nuts to the bin to secure the reinforcing steel or mesh. The amount and type of reinforcement is beyond the scope of our organization and we suggest getting guidance from a qualified engineer. You may gain some insight from the design of the reinforcing used in the soil nail walls.

Question: I am working on an existing slope with a ratio of 3:1 (horizontal:vertical) and a total height of 6 ft (1.8 m). The slope has been surfaced with asphalt concrete. Will shotcrete adhere to the asphalt concrete surface, or should the asphalt concrete be removed prior to applying shotcrete?

Answer: Shotcrete will adhere to properly prepared asphalt concrete. Shotcrete bond is generally related to the preparation of the surface that you want to bond with. If the surface is dirty, the shotcrete will not bond very well.

Question: Our current project is a pier with severe corrosion of reinforcement and obvious spalls. The work will all be overhead with the surface 18 in. (457 mm) above the mean tide level and, for a variety of reasons, dry-mix is not an option. We are looking for a good, dense, wet-mix design for saltwater marine exposure. Compressive strengths need to be in the mid-range of 7000 to 8000 psi (48.3 to 55.2 MPa).

Answer: For a potentially suitable wet-mix shotcrete mixture design for marine structure repair, go to the ASA Web site (**www.shotcrete.org**). Click on *Shotcrete* magazine and search for "Shotcrete Classics: Deterioration and Rehabilitation of Berth Faces in Tidal Zones at the Port of Saint John." This mixture design worked well for over 1.2 miles (2 km) of ship berth face repair over a 10-year period. Note: Because of high freezing-and-thawing exposure, the shotcrete was required to be air entrained. While the original mixture design called for 7% air content as shot, it was subsequently modified to require an air content of 7 to 10% as batched (at the point of discharge into the shotcrete pump) and an air content of $5 \pm 1.5\%$ as shot (into an air pressure meter base). Such shotcrete has provided good freezing-and-thawing resistance. You should be aware that your local materials (coarse and fine aggregates and cement) may have different properties in the concrete mixture, however, as compared to the mixture discussed in the article. It is recommended that a local engineer, testing laboratory, or concrete supplier be retained to develop a concrete mixture using local materials that meets the performance requirements of the mixture design mentioned in the article. Also, test panels constructed with the mixture, nozzlemen, and equipment to be used in the shotcreting are highly recommended to verify the strength performance of the shotcrete.

Question: We are currently working on a Request for Deviation to use shotcrete in lieu of cast-in-place concrete. The engineer is requesting additional information/confirmation. The application locations are structural, using No. 6 and No. 8 reinforcing bars on 1.5 ft (0.5 m) thick walls approximately 40 ft (12.2 m) high. The engineer's comments refer to detailing construction joints, curing, and plastic shrinkage gaps (work done in July). We have also requested a slump to be reduced to 2 ± 1 in. (51 ± 25 mm) and the use of 3/8 in. (9.5 mm) aggregate. What methods would you suggest to address each issue?

Answer: The project as described sounds very feasible for a structural shotcrete application. As we understand, the concerns are:

1. Detailing construction joints—Please refer to ACI 506R, "Guide to Shotcrete," Paragraph 5.7, Joints. Typically, shotcrete joints are beveled to increase the surface area of the bonding surface and reduce the likelihood of trapping rebound. Other considerations for construction joints should follow the principles of cast-in-place concrete. Shotcrete is a method of placing concrete.
2. Curing—Shotcrete is concrete consisting of smaller aggregates and generally higher cement content. Good curing practices should be followed as they should be with cast-in-place concrete. Considerations should include the temperature and humidity when evaluating a curing program. High temperatures with low humidity will require significantly more effort than high temperature with high humidity. The key is to ensure that sufficient moisture is available to hydrate the cement during the curing period.
3. Plastic shrinkage gaps or cracking—The shrinkage characteristics of shotcrete are similar to cast-in-place concrete. Shotcrete is composed of smaller particles and higher cement but generally places at a low water-cement ratio (*w/c*) or less than 0.45. Shotcrete is somewhat more prone to plastic shrinkage cracking due to the surface not being protected by a form in its early stages. If the finished surface is subjected to high ambient temperatures, low humidity, or high winds, it will tend to dry quickly on the surface and exhibit more plastic shrinkage cracking. In these environmental conditions, fogging of the exposed shotcrete surfaces soon after shotcreting may help to reduce or eliminate the plastic shrinkage cracks. Plastic shrinkage cracks are generally superficial in nature and can be repaired if necessary.
4. Slump to be reduced to 2 ± 1 in. (51 ± 25 mm)—This is a good range if measured and treated properly. It is important to ensure that the shotcrete material has enough slump at the nozzle to properly encapsulate the reinforcing steel and is stiff enough to stay in place without sloughing or sagging. The slump at the nozzle is far more relevant than the slump at the pump. The important factors influenced by slump are maintaining the proper water-cementitious material ratio (*w/cm*) and consistency at the nozzle to ensure good placement.

The most important consideration is to ensure that you have an experienced shotcrete contractor who has a history of success with similar projects with respect to the size and complexity of the installation. You can locate shotcrete contractors on the ASA online Buyers Guide at **www.shotcrete.org**.

New Products & Practice

BASF Presents MasterFiber™ MAC Matrix at World of Concrete 2011

BASF, The Chemical Company, showcased its latest construction technology innovations from its Construction Chemicals Division booth during the 2011 World of Concrete show in January. Included was MasterFiber MAC Matrix, a "best in class" synthetic polymeric fiber for use in the most stringent secondary reinforcement applications.

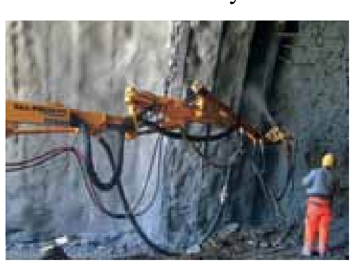
MasterFiber MAC Matrix fiber was designed with the contractor in mind—whether they are slab-on-ground contractors or shotcrete contractors.

Its features include excellent bond with mortar, excellent distribution, and excellent workability and finishability. Its benefits include the reduction of production time and overall labor and material costs; elimination of the need for welded-wire reinforcement (WWR) and conventional steel bars as secondary reinforcement, depending on the application; effective tight crack control; excellent plastic shrinkage crack reduction and settlement control; improved green strengths, permitting earlier stripping of forms with less rejection; reduced handling and transportation stresses; and reduced wear on equipment.

For more information, visit **www.basf.us**.

Sika Announces New Sigunit® L 72 AF

Sigunit® L 72 AF is a new generation, high-performance, alkali-free liquid set accelerator for wet- and dry-shotcrete applications. Sigunit L 72 AF meets the requirements of ASTM C1141 as a quick-setting accelerator. Sigunit L 72 AF can be used in shotcrete used for initial support and final lining in tunnels and rock and slope stabilization.

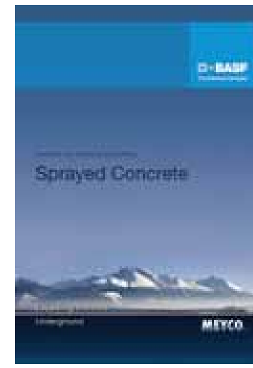


The main advantage of Sigunit L 72 AF is its ability to produce very high early-strength shotcrete, which results in faster construction and a safer working environment for construction workers in tunnels. Additionally, Sigunit L 72 AF also offers the following advantages: distinct reduction in rebound and dust; improved bond of shotcrete to rock and concrete, thus facilitating overhead spraying; and avoiding pollution of groundwater by leaching of alkalis. Sigunit L 72 AF is compatible with other Sika admixtures used for shotcrete, such as hydration control admixture, Sikatard®, and high-range water reducers from the Sika ViscoCrete® and Sikament® series.

For more information, visit **usa.sika.com**.

Meyco, a BASF Company, Releases New Brochure on Sprayed Concrete

MEYCO Global Underground Construction (MEYCO), part of BASF Construction Chemicals, has released a new brochure titled "Sprayed Concrete—Solutions For Tunneling and Mining." The 12-page full-color brochure includes informational sections on solutions, alkali-free accelerators, spraying equipment, Logica spraying robot, permanent sprayed concrete, and know-how and service.



The brochure can be downloaded by visiting the sprayed concrete section on their Web site at **www.meyco.basf.com**.

Newly Revised ASTM Standards

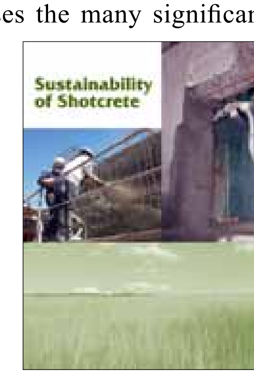
ASTM has announced new revisions to the following standards:

- Subcommittee C09.42: C1116/C1116M, "Standard Specification for Fiber-Reinforced Concrete," has been revised to C1116/C1116M-10a; and
- Subcommittee C09.61: C42/C42M, "Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete," has been revised to C42/C42M-10a.

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

ASA Introduces New "Sustainability of Shotcrete" Brochure

This new 10-page full-color brochure is an excellent educational and promotional tool that addresses the many significant sustainability advantages of the shotcrete process. The document identifies and discusses numerous advantages and also includes case studies demonstrating advantages in both new construction and repair.



The brochure's content was originally developed by the ASA Sustainability Committee for use in the United States Green Concrete Council's (USGCC) recent book titled *The Sustainable Concrete Guide—Applications*.

"Sustainability of Shotcrete" is an excellent resource for use by those in the shotcrete industry to educate and promote the process to potential clients and owners. The document can also be submitted with project bids to identify and promote the sustainability advantages of the shotcrete process.

Copies of "Sustainability of Shotcrete" can be ordered from the ASA Web site at **www.shotcrete.org**.

Shotcrete Calendar

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

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

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

OCTOBER 12-14, 2011
ICRI 2011 Fall Convention
Theme: "Water & Wastewater Treatment Plant Repairs"
The Westin Cincinnati
Cincinnati, OH
Web site: **www.icri.org**

OCTOBER 15, 2011
ASA Fall Committee Meetings
Millennium Hotel & Duke Energy Convention Center
Cincinnati, OH

OCTOBER 16-20, 2011
ACI Fall 2011 Convention
Theme: "Bridging Theory and Practice"
Millennium Hotel & Duke Energy Convention Center
Cincinnati, OH
Web site: **www.concrete.org**

OCTOBER 17, 2011
ASA Fall Underground Committee Meeting
Millennium Hotel & Duke Energy Center
Cincinnati, OH

OCTOBER 30-NOVEMBER 4, 2011
International Pool|Spa|Patio Expo
Conference: October 30-November 4
Exhibits: November 2-4
Mandalay Bay Convention Center
Las Vegas, NV
Web site: **www.poolspapatio.com**

DECEMBER 4-7, 2011
ASTM International Committee C09, Concrete and Concrete Aggregates
Tampa Marriott Waterside
Tampa, FL
Web site: **www.astm.org**

AMERICAN SHOTCRETE ASSOCIATION

ASA Membership Benefits

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

AMERICAN SHOTCRETE ASSOCIATION

38800 Country Club Dr., Farmington Hills, MI 48331
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 Member Company	$100
❑ Employees of Public Authorities and Agencies	$50
❑ Nozzleman	$50
❑ Retired	$50 (For individuals 65 years or older)
❑ Student	Free (Requires copy of Student ID card or other proof of student status)

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

Payment Method:

❑ MC ❑ Visa ❑ Check enclosed (U.S. $)

Card# ______________________ Expiration date ______________

Name on card ______________________ Signature ______________________

Company Specialties—Corporate Members Only

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

Admixtures
❑ 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

ASA New Members

CORPORATE MEMBERS

Hardrock Concrete Inc.
Etobicoke, ON, Canada
Primary contact: Frank Schwenzer
info@shotcrete.ca
www.shotcrete.ca

Preload Inc.
Hauppauge, NY
Primary contact: Donald Cameron
dgc@preloadinc.com
www.preload.com

Putzmeister Ibérica, S.A.
Madrid, Spain
Primary contact: Christine Krauss
info@putzmeister.es

Vancouver Shotcrete & Shoring
Surrey, BC, Canada
Primary contact: Guissella Solorio
targaguissella@shawcable.com

STUDENTS

Wesley Anderson
Marietta, GA

Saleh Behbahani
Tehran, Iran

Shervin Hashemi
Tehran, Iran

Mahammdareza Mahdaviagham
Manrand, Iran

Rob Robinson
Pittsburgh, PA

Jean-Michel Royer
Québec, QC, Canada

Vito Santos
São Luís, Brazil

INTERESTED IN BECOMING A MEMBER OF ASA?

Read about the benefits of being a member of ASA on page 58 and find a Membership Application on page 59.

AMERICAN SHOTCRETE ASSOCIATION

READER RESPONSE SERVICE

Please send information on the products or services circled below:

1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54

Name ______________________________

Company ______________________________

Address ______________________________

City ______________________________

State/Province ____________ Zip/Postal Code ____________

Country ______________________________

Phone: ______________________________

Fax: ______________________________

E-mail: ______________________________

Fax or mail to: American Shotcrete Association
38800 Country Club Dr. • Farmington Hills, MI 48331
Phone: (248) 848-3780 • Fax: (248) 848-3740

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