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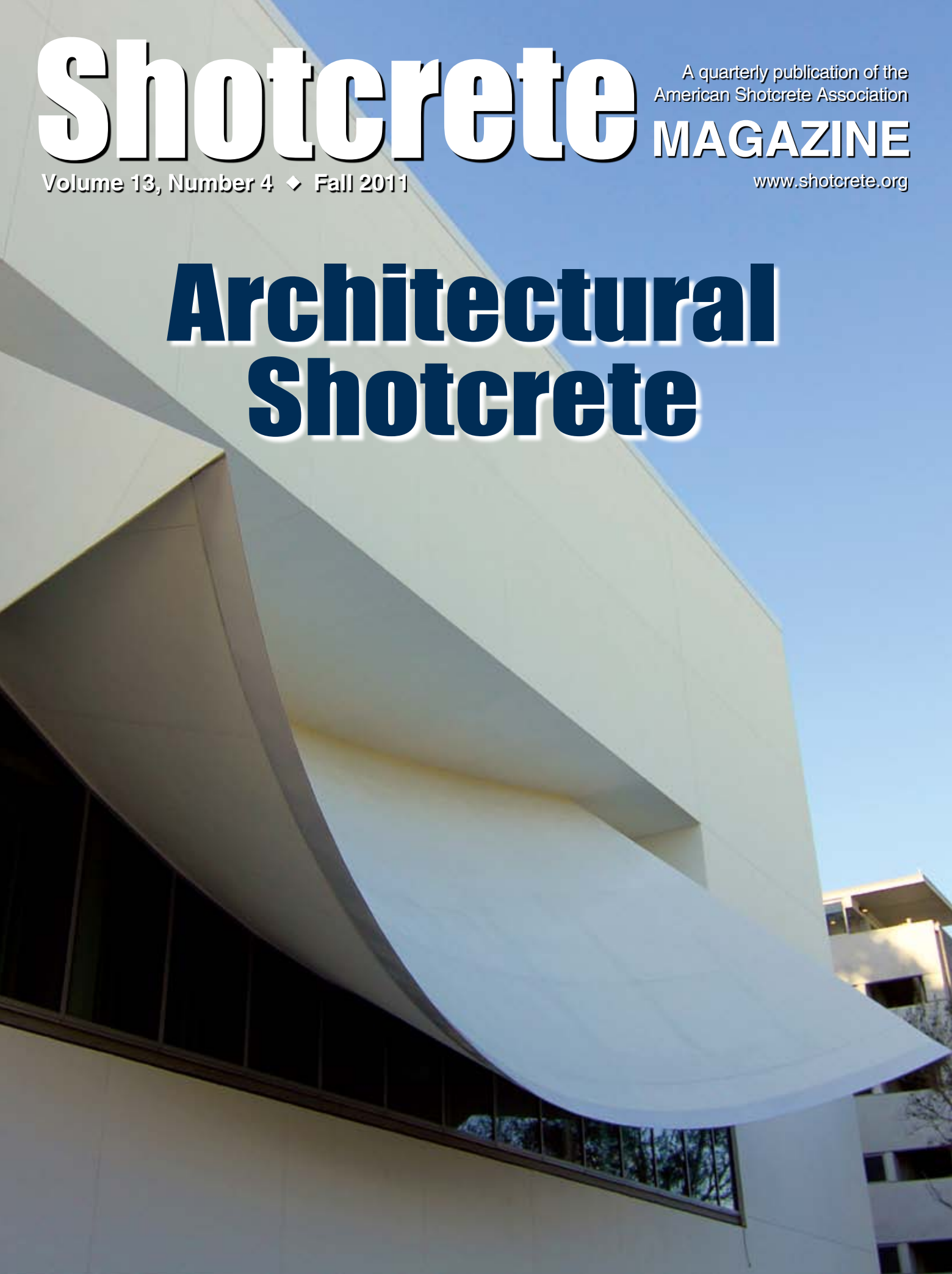
Architectural Shotcrete



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Shotcrete MAGAZINE
Volume 13, Number 4
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Features

Departments

On the cover: The New World Symphony Concert Hall's shotcrete "Scoop," Miami Beach, FL. Photo courtesy of Didier Leroi.

Spread the Shotcrete Word to DOTs and Other Public Authorities

By Patrick Bridger

ASA's basic mission is "*to encourage and promote the safe and beneficial use of the shotcrete process*." ASA continually advances this mission through a variety of events, outreach, and informational sources—all carefully planned to effectively reach the different targeted segments or areas of the construction world.

Why Public Authorities?

Public Authorities is one of the important areas of focus for ASA and the shotcrete industry. Not only do organizations such as state departments of transportation (DOTs) specify a great deal of projects for which shotcrete is an excellent candidate, but there is also a significant amount of trickle-down from these organizations to both the public and private sectors as education grows and track records of successful projects expand.

New Outreach and Informational Tools

In recent months, ASA's leadership has created new tools and refocused existing ones that will benefit the entire industry but are part of our specific outreach to public agencies.

ASA's first step was to reintroduce the ASA Employees of Public Authorities/Agencies (ASA-PA) membership. This membership is now free to all employees of public agencies. In addition to a subscription to *Shotcrete* magazine, a number of other benefits are offered, including:

- On-site shotcrete informational presentations: While this no-cost option has been available in the past, ASA is now promoting this service to all public agencies and architectural and/or engineering firms. The presentation is typically in a "lunch and learn" setting but can be tailored to any time frame and shotcrete subject matter of interest to the organization.
- ASA Shotcrete Specifier's Education Tool/USB: A complimentary copy of this new tool will be provided to every ASA-PA member. The product includes a wealth of information, including the "Sustainability of Shotcrete" brochure and PowerPoint presentations on "Shotcrete for the Repair and Rehabilitation of Concrete Structures" and "Shotcrete for Underground Construction."
- ASA's Project-Submittal-for-Bid Tool: We have spoken with public officials who have decided to specify shotcrete in a project only to have no serious bids submitted. In response, ASA has created this new tool available on our Web site at **www.shotcrete.org**. Users will be able to submit their projects and receive quality bids from organizations whose commitment to shotcrete excellence is demonstrated by their continued support of ASA through corporate membership.
- Access to ASA's Technical Inquiry Tool: ASA-PA members are invited to submit their shotcrete technical questions for review and answer from our technical team.
- Public Authority members are also granted access to and encouraged to make use of ASA's vast Technical Question and Answer Archive and the *Shotcrete* magazine archive, both of which are hosted on the ASA Web site.

ASA President's Message

Organizations and Conferences

ASA continues to investigate organizations and conferences that afford us the opportunity to educate public employees about the shotcrete process and discuss it with them. For the last 3 years, ASA has exhibited and conducted seminars at the International Bridge Conference (IBC) in Pittsburgh, PA, which has provided ASA with quality opportunities to reach out to public agencies, especially state DOTs.

Fruit of one IBC contact resulted in ASA making a presentation at the Midwest Bridge Working Group. This meeting included over 100 state DOT employees and was an excellent opportunity to educate others about the exceptional benefits of the shotcrete process.

ASA has also recently become an industry member of the Bridge Preservation arm of the Transportation Systems Preservation Technical Services Program (TSP-2). TSP-2 is an organization within AASHTO that was formed to provide State Highway Agencies (SHAs), provincial departments of transportation, and other pavement and bridge preservation practitioners with a source for news and technical information on a wide range of system preservation-related issues.

From October 31 through November 4, 2011, ASA will attend and exhibit at the National Bridge Management, Inspection, and Preservation Conference in St. Louis, MO.

This event provides ASA with another important platform to educate Public Authorities about shotcrete and gives us an opportunity to understand their questions and needs. The new Employees of Public Authorities/Agencies membership and its many benefits will be a core part of our outreach to this group.

Help ASA Promote the Shotcrete Process to Your State DOT and Local Agencies

Due to the very large number of public agencies—from the federal level down through the state, county, and municipal levels—outreach by a national/international organization such as ASA can be very difficult. ASA's efforts more easily reach the federal level and, to some degree, the state level. Fully informing the state and local agencies falls to the individuals in the shotcrete industry.

ASA's new no-cost Employees of Public Authorities/Agencies membership is a great tool you can use to assist your local agencies. Simply ask them to access the wealth of information available by signing up for this free membership at **www.shotcrete.org/MembershipApplication.asp**, and we will do the rest!

NEW

Message from the Publications Committee Chair

Ted W. Sofis

In the last issue of *Shotcrete* magazine, we introduced this new feature, where various ASA committee Chairs have the opportunity to update readers on current efforts and future plans for their respective committees. In our first installment, Bill Drakeley, Chair of the ASA Pool & Recreational Shotcrete Committee, discussed the pool industry and the evolving role his committee is playing within the industry.

As Chair of the ASA Publications Committee, I wanted to take this opportunity to update you on this important organization within ASA.

The ASA Publications Committee is primarily tasked with overseeing the publication format and content for the association's award-winning *Shotcrete* magazine. The magazine, in both printed and digital copy, has grown to a readership of well over 17,000 designers, specifiers, contractors, engineering students, and purchasers of shotcrete and shotcrete-related products and equipment throughout more than 100 countries. *Shotcrete* magazine is clearly the leading publication of the shotcrete industry.

Maintaining *Shotcrete* magazine's established high level of quality requires a tireless and highly coordinated effort of the Publications Committee, ASA staff, and the publication's many authors.

We are very excited about two new, key personnel additions. Charles Hanskat, Chair of ASA's Sustainability Committee and current member of ASA's Board of Direction, is the magazine's new Technical Editor. Hanskat is a Principal at Concrete Engineering Group, LLC, and a licensed professional engineer in 22 states. He is heavily involved in a number of organizations, including several American Concrete Institute (ACI) committees. Hanskat has been involved in the design, construction, and evaluation of environmental shotcrete and concrete structures for 35 years.

Alice McComas has joined the ASA staff as Program Coordinator (you can read more about McComas in the Association News feature of this issue). One of McComas's primary responsibilities is the oversight, coordination, and assembly of each issue of the magazine. If you participate as an author of a *Shotcrete* magazine article, you will be in contact with McComas and will appreciate her professionalism and organization.

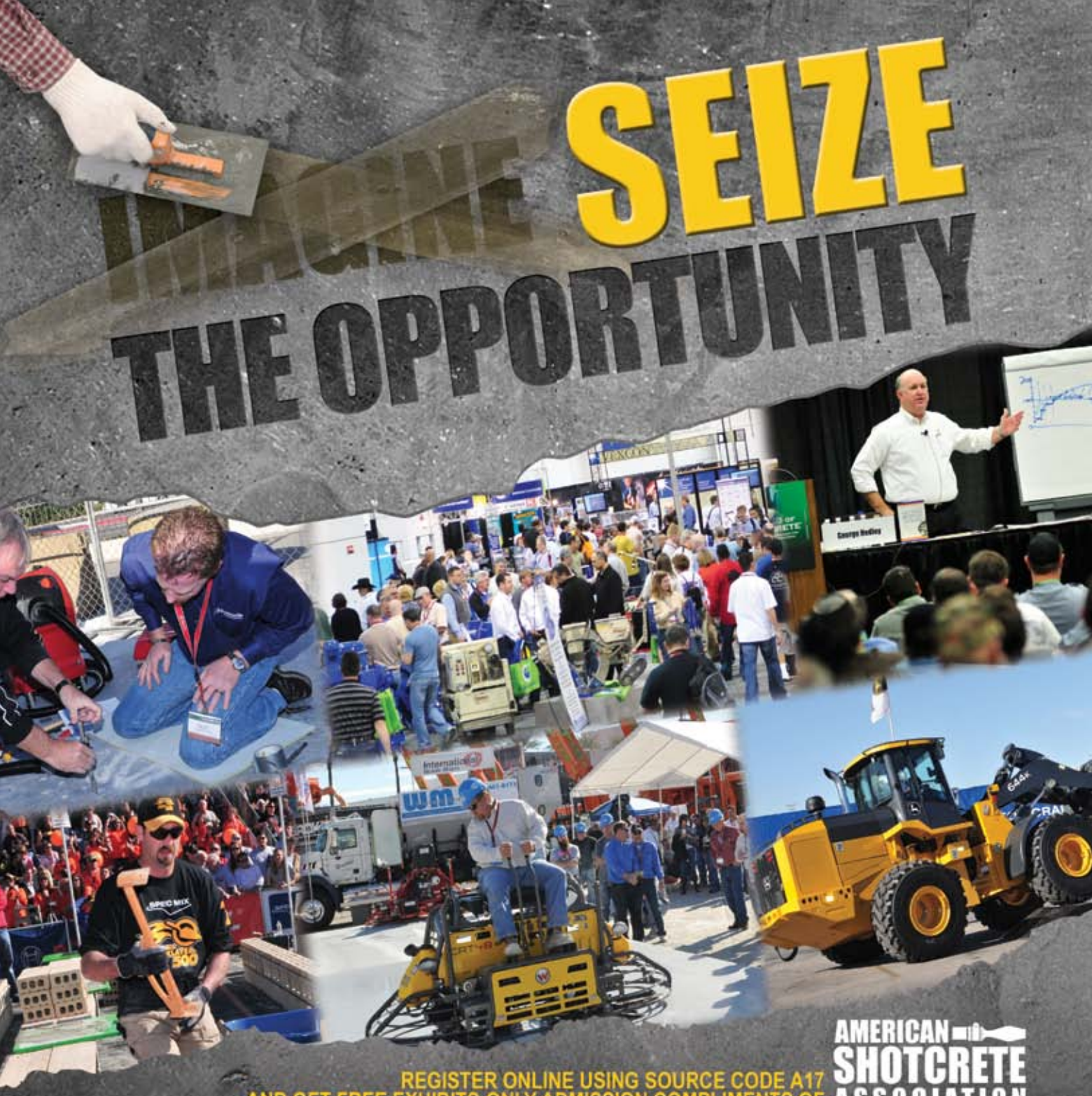
The Publications Committee also determines the themes of future issues. Upcoming themes include a focus on state department of transportation (DOT) projects and, of course, our very popular annual Outstanding Shotcrete Project Awards issue. We try to vary our themes to cover a variety of topics in the many different segments of the industry.

This Committee Chair Memo, Goin' Underground, and Nozzleman Knowledge are all new features that have been recently added to the magazine's lineup. New features, timely themes and articles, and tools, such as a readership survey, are on the horizon and are part of our overall effort to build on over a decade of success and keep this leading publication fresh and useful.

As Chair of the Publications Committee, I would like to welcome and encourage you to consider becoming active in this very important committee. Participation as a committee member and/or author is a rewarding and educational experience.

If you are involved in the industry, I also recommend that you consider advertising in *Shotcrete* magazine. The publication offers a highly targeted audience that is unequaled in its ability to reach the shotcrete industry.

The Publication Committee, as with all of ASA, includes a wide array of shotcrete professionals. Among the committee members are contractors, engineers, suppliers, and manufacturers who are involved in various segments of the shotcrete industry. It is this diversity in backgrounds and expertise that contributes to our strength as a committee and association. We are proud of the inclusive nature of our association, and we welcome your input and involvement.



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Art, Design, and Shotcrete—Miami Beach's New World Symphony Concert Hall

By Paul F. Ampey

Miami Beach, Florida's Art Deco District, is internationally known for the largest concentration of 1920s and 1930s resort architecture in the world. It is also the home of the newly constructed New World Symphony (NWS) Concert Hall, designed by Pritzker Prize-winning architect Frank Gehry. South Beach, the area's affectionate nickname, has been fused together by several design periods.

Photo courtesy Claudia Uribe

Its first major construction boom period began in the early 1900s, which ushered in a style known as "Mediterranean Resort" architecture. Commercial structures were characterized by stucco scrolled capped walls and terra cotta-tiled roofs that combined Italian, Moorish, and southern Spanish themes.

There was a brief transitional period during the 1920s—"Med-Deco"—in which several celebrated architects introduced a short-lived style of smooth stucco exteriors with raised or incised details. Featured stucco areas were often patterned or scored. Keystone, either natural or filled and colored, was frequently used to define special elements.

The 1930s art deco synthesis of clean ziggurat roof lines and crisp geometric detailing replaced the scrolled parapets and other classical features in South Beach. The Art Deco District was one of the earliest National Register listings to recognize the importance of the architecture of this period, and dozens of structures are listed with a historical preservation society. This was followed by the 1950s and 1960s "Miami Modernist" architecture, known as MiMo, combining glamour, fun, and material excess with otherwise stark, minimalist, and efficient styles that were being used in other parts of post-world war architecture.

Gehry's portfolio of exploding compositions is always recognizable from its collage-like, deconstructed-style exterior façades and tends to be more reminiscent of functional pieces of sculpture. Not typical of his usual designs for an important purpose, the NWS's founder and artistic director, Michael Tilson Thomas, wanted a concert hall and educational facility that would invite the world inside. Gehry talked about the idea of "the building putting on a performance." The 100,000 ft^2 (9300 m^2) white-plastered, box-shaped structure adapts many art deco elements of the surrounding city. The invitation is even more apparent at night, however, when through a glass curtain wall, the building's composition

changes and the energy within the walls is on display for everyone to see. The interior's curved pliable surfaces appear to spill out of the rigid structure onto the adjacent 2.5 acre (10,100 m^2) plaza.

On the exterior's north face of the concert hall, the "Scoop," a 2800 ft^2 (260 m^2) curved plane sculpture, hangs 35 ft (10.67 m) above the walkway. The iron-framed sculpture appears to protrude from inside the building and is constructed with steel reinforcement and wire lathe and is coated with 5 in. (127 mm) of shotcrete. The 3500 psi (24 MPa) dry-mix shotcrete material was batch-delivered and pneumatically placed using a rotary gun and 2 in. (50 mm) hoses. Extensive safety measures were implemented using lanyards and a high reach to aid the nozzlemen and finishers. The five-man crew rod-cut and hand-troweled the plane's surface to produce a smooth plaster finish.

The interior of the concert hall gives way to traditional Gehryesque shapes—big billowing convex sail acoustical panels lined with lightweight dry-mix shotcrete finished with white plaster cover the walls and ceiling and double as projection surfaces. The shotcrete material supplier, SpecMix, provided an on-site portable gravity-fed silo, and the material was funneled into an air-operated shallow-bowl rotary gun using the low production method to reduce the dust factor, as the panels were shot in place inside the building. The specifications for the acoustic panel design required that the 2 in. (50 mm) placement not weigh more than 15 lb/ft^2 (74 kg/m^2) and that the 3 in. (75 mm) placement not weigh more than 25 lb/ft^2 (122 kg/m^2), resulting in an overall weight reduction of 25%. This was accomplished with a prebagged shotcrete mixture delivered in super sacks using fine aggregates, fly ash, and cement.

Frank Gehry's NWS composition is just one of many recent examples of how shotcrete can be incorporated to meet and exceed the creativity and design expectations of architects and engineers in the construction industry. The flexibility of shotcrete's wet- and dry-mix design capability gives virtually unlimited freedom of design where conventional concrete placement cannot. Skilled crews can place and finish true radii and consistent vertical and horizontal lines, allowing nearly any shape and surface texture to be created. The NWS Concert Hall is the quintessential model that embodies art, design, and shotcrete.

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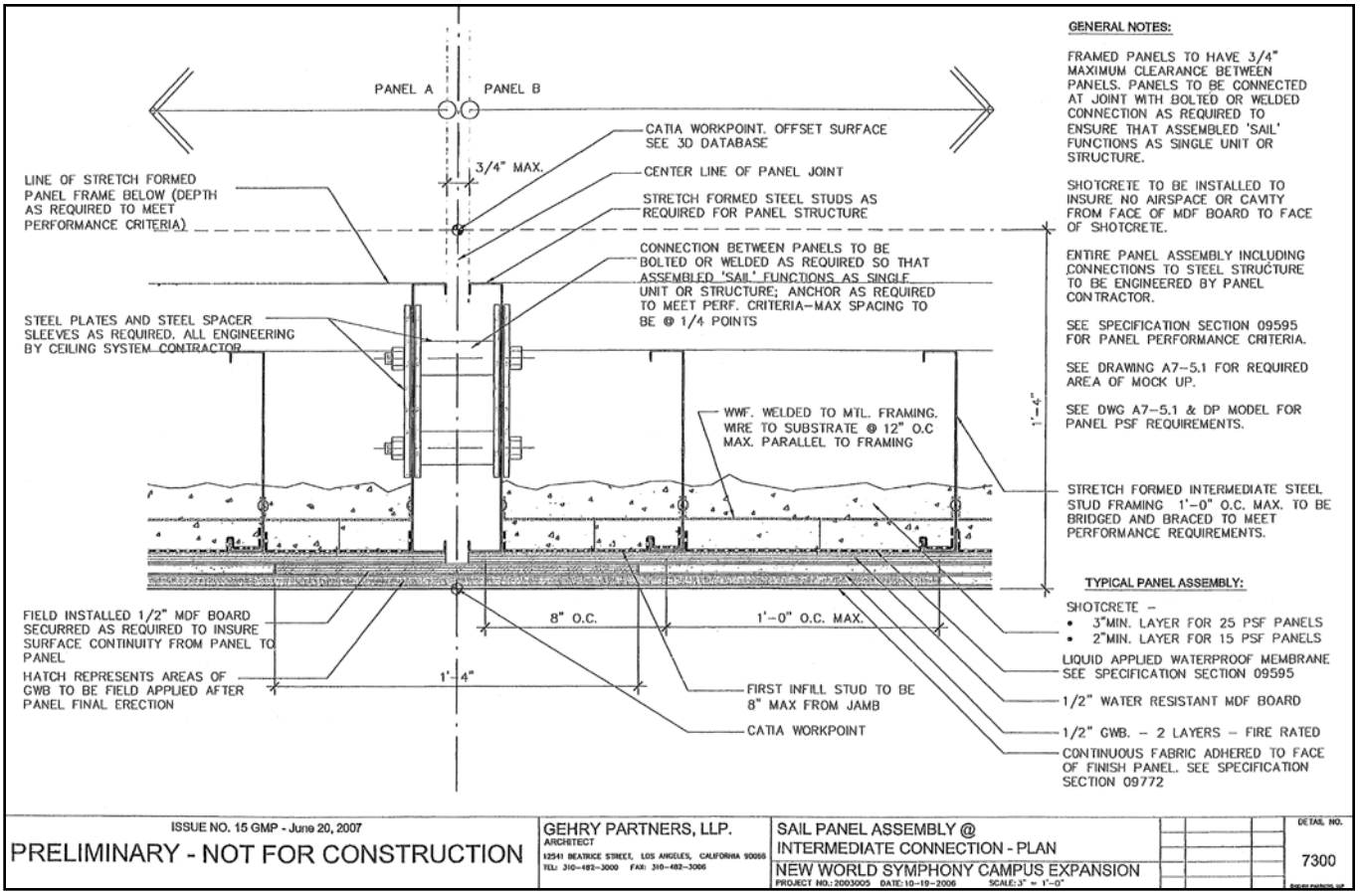

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Imitating Nature's Rock Features

With a Little Help from Specialized Shotcrete Rock-Carving Techniques

By Oscar Duckworth

It is said that imitation is the greatest form of flattery; but in the case of imitating nature's many natural rock features, Mother Nature can be quite elusive. It may appear simple to recreate common stone formations by duplicating their shapes, patterns, and colors in concrete. Natural stone's complex texture and mineral variations, however, can make the accurate reproduction of even the simplest stone formations seem dull and unrealistic.

Texturing concrete surfaces to resemble natural stone has been a common architectural feature since the first use of concrete. Genuine stone walls or natural rock formations carry far more visual interest than ordinary concrete surfaces. Historically, concrete features constructed to resemble stone have been either hand-textured, precast, or created with conventional form liners. Although precast concrete technology has made huge steps in duplicating natural stone qualities, form liners and other conventional cast-in-place methods fall short of capturing the intricate, random features of natural rock formations.

Fig. 1: Large sandstone formation displays common iron pigmentation and layered texture. Note the similar angle of the fracture lines

Recently, concrete artisans have adapted specialized shotcrete placement techniques to realistically duplicate stone's complex shapes and textures by carving these features into freshly applied shotcrete. Pneumatically applied shotcrete's unique placement method provides a medium to duplicate random shapes and surface textures that is superior to any other available method. Skilled shotcrete craftsmen manipulate shotcrete's qualities by creating shapes, textures, and colors to realistically replicate nearly any desired stone formation's appearance.

Identifying the Stone's Prominent Features is the First Step

Different stone formations display unique shapes, textures, and colors that are common to that type of stone. Prominent minerals within a formation will impart specific signature colors. Iron is the most common mineral found within rock and soil. Iron-bearing materials will show a rich red to tan coloration, whereas other minerals may display beautiful green, blue, and black hues. Igneous and metamorphic formations can appear as blended shapes or carry evidence of extreme heat and pressure. Igneous basalt features may resemble beautiful vertical columns with prominent angular features so perfectly formed they can appear man-made. Sedimentary formations usually display a richly colored, stacked, multi-layered appearance with well-defined fracture lines that may not follow a horizontal plane.

Sedimentary sandstone formations are common in the western U.S. Prominent sandstone outcroppings are typical features in hilly areas (Fig. 1). In this region, large shotcrete earth retention walls are often carved, textured, and colored to resemble these local stone formations. Rock-carving experts will replicate a sedimentary sandstone formation by manipulating the freshly placed shotcrete surface with trowels, cutting tools, and unique texturing devices. Skilled nozzlemen work from photographs or renderings to emulate random, irregular surfaces common to local stone formations from which they wish to pattern their work. Finishers then carve ledges, fracture lines, and

outcroppings into the freshly applied material (Fig. 2). After the initial shape has been established, a release agent is generously applied to the fresh work. Final texturing is then tediously impressed into the plastic shotcrete by the use of texture pads or other devices (Fig. 3(a) and (b)). This essential step adds a realistic appearance to the finished product by creating an intricate final surface in which to blend the colors.

High-Quality Details Require High-Quality Methods

Many carved shotcrete walls provide a realistic effect with only a minimal amount of detail work. Carved walls surrounding freeways or work visible only from great distances need not display intricate surface textures to capture the appearance of a stone outcropping. Highly visible walls or work within sight of the public may require accurate duplication of local features, high-quality surface textures, and complex coloration.

Boulderscape, Orange County, CA, has been an industry leader in the design and construction of carved, colored shotcrete walls for nearly twenty years. Steve Jimenez, Operations manager at Boulderscape, states that "specific projects call for unique placement procedures." Large custom homes with rock work around pools, spas, and small lakes require the highest in rock detail. To create a carved rock feature that is acceptable in these environments requires planning and highly skilled artisans. Once the visuals for the project have been approved by the client, the creation of the reinforcing bar structure and rock panels begins. Many high-end rock-work projects require special custom-cast work.

Cast creations start by locating a natural rock formation that closely resembles what is proposed for the project. After getting permission from the landowner, a release spray is applied over the natural rock formation. A urethane is applied in several coats to the rock formation. After the urethane has cured, fiberglass is applied over the urethane. The cured coating is cut into large panels, numbered, and delivered to the job site for custom rock panel fabrication.

The panels are now used as molds to create cast rock panels. While the panels are being created, reinforcing bars are doweled into the existing pool, spa, or lake edge. The reinforcing bar is shaped and tied to produce a rough outline of the final rock formation. Stainless steel threaded dowels of 5/8 in. (16 mm) in diameter are located where each casting will be placed. When all reinforcing bar and threaded rods have been tied in, the structural shotcrete layer is placed. The shotcrete must encase the reinforcing bar by a minimum of 2 in. (50 mm) on all sides of the reinforcement. The structural shotcrete thickness will range from 5 to 8 in. (130 to 200 mm).

After the shotcrete has cured for a minimum of 48 hours, the hanging of the casting panels will begin (Fig. 4). Holes are drilled through the casting panels where the threaded rods are located. The threaded rods are guided through

Fig. 2: Finisher carves initial fracture lines into freshly placed shotcrete

Fig. 3: (a) Texture pads; or (b) common paint rollers covered in aluminum foil impart intricate surface textures

Fig. 4: Reinforcing bar and structural shotcrete being installed in preparation for the hanging of castings

Fig. 5: (a) Hanging; (b) grouting; and (c) final hand-blending of castings

the casting panels. The rods (stainless steel) receive a nut and washer and are tightened against each of the casting panels. Once all the casting panels are installed, grout is pumped behind the casting panels, filling in all voids between the panel and the shotcrete substrate (Fig. 5(a), (b), and (c)).

Casting usually makes up 60 to 70% of a casting project. Castings can only fit in certain areas of a rock project. When you include multiple cascading waterfalls, swim-in grottos, underwater swim caves, wine bars, and other add-on features, castings become too complicated for the tight areas. This takes away from the natural appearance.

Where castings don't fit, detailed hand carving must fill the gaps. Highly detailed hand-carved rock work requires special mortars that will retain intricate textures. This mortar is applied over the structural shotcrete layer. Once the mortar has been applied, urethane texture mats taken from the same rock the casting panels were made from are used. The artisans, well-versed in geology and concrete artistry, will carve all the necessary strata, fracturing, and exfoliations so they match the geological theme produced by the cast panels already installed. Once the texture mortar has cured, stains are applied to create the varying colors found in the natural geological formation from which the panels were cast (Fig. 6).

Rock Carving in Paradise

Greg Perrin, CEO of American Standard Concrete Pumping, Honolulu, HI, creates beautiful landscape features using shotcrete rock-carving techniques. Blending carved rockscape features with Hawaii's dramatic natural landscape presents

unique challenges to the area's concrete artisans. Hotels, resorts, and private landowners desire elaborate, natural appearing landscape or water features that are similar to local rock formations. "We shoot using various nozzle techniques to create a porous, deformed surface. The carve team follows the nozzleman, who creates the initial rock shape. The artisans carve using carpet knives, dental tools, and scrapers to add the rock lines. It is very important to not make rounded lines in the rock carving, as most rock faces do not have round lines but, rather, straight edges with sharp breaks. As the carving progresses, the nozzleman may choose to add more dimension to areas of the rock-carved wall surface. The surface is rubbed with hand gloves, paint brushes, and wire brushes to impart the various surface textures common to Hawaii's local stone," says Perrin.

Color Choices Add Realism

Natural stone formations gather their intricate color and patina from pigments formed by exposure to mineral deposits over immense time. Most professional stone artists color pigments use similar naturally occurring mineral-based coloring components as the actual stone formations they wish to duplicate (Fig. 7). Commercially available coloring agents containing ferro sulphate, copper sulphate, and many nitrogen-based fertilizer products can impart a permanent mineral deposit into the cementitious paste portion of the shotcrete surface. Their permanent effect is similar to leaving a rusty metal wrench on a wet garage floor for the winter.

Perrin's island-style carved rock surfaces require accurate surface coloration to add realism to the feature (Fig. 8(a) and (b)). "Initial coloring is applied to the cracks to develop definition. This highlights the individual rocks and will help identify any final changes needed. Hawaii's basalt and lava formations are dark brown to black with tan, red, or orange tones. When matching these colors, it has been our experience to begin with light, diluted colors and add multiple layers to darken as we see what the mix will produce. Always try to start in an area least viewable if possible." Accurate coloration is an essential step in creating believable, realistic rock formations in concrete. Professionals may use many different pigments applied at different times to generate an authentic-looking concrete surface.

Common Details Can Create the Desired Effect

The simple carved rock detail in Fig. 9 adds excellent visual interest to a very old gunite (dry-mix shotcrete) wall. Common tools and methods were used to create this surface during the construction of this wall. Coloring, if required, was a basic mineral stain applied with a sprayer or sponge. These common details are still popular choices for new architectural shotcrete wall surfaces. Landscape details, such as providing irrigated planting areas within the work, introducing climbing vegetation, or planting indigenous trees nearby can add natural beauty to any carved shotcrete wall.

Shotcrete specialty contractors use carved shotcrete methods to create realistic boulders,

Fig. 6: Finished view from poolside toward grotto. Four waterfalls and one misting ledge (right side of photograph) are included in this face

Fig. 7: Carved rock feature accurately depicts local volcanic basalt formation

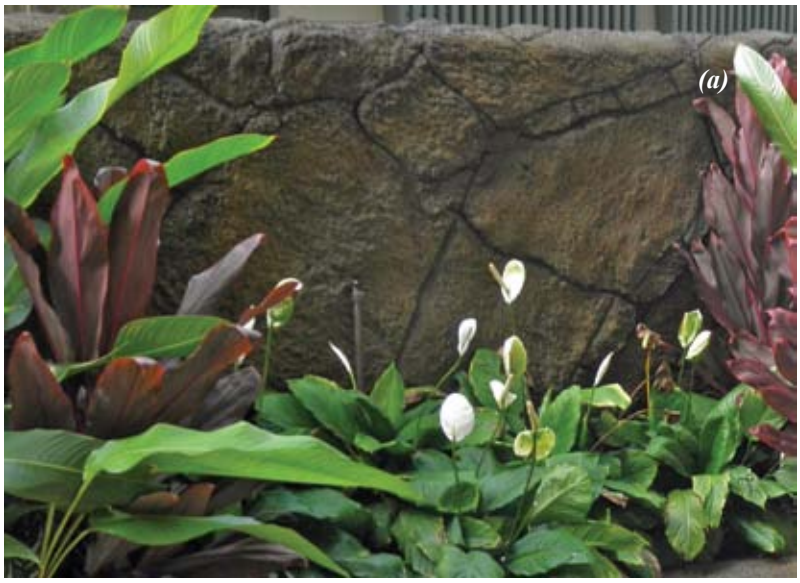

Fig. 8(a) and (b): Subtle coloration differences created by multiple applications of various mineral-based stains accurately emulate Hawaii's natural volcanic rock formations

Fig. 9: Eighty-year-old hand-textured concrete wall displays timeless beauty

rock outcroppings, and stone ledges that can add spectacular visual interest to landscaping, water features, or other site work. The shotcrete process eliminates historic barriers to creating random shapes and surface textures with traditional cast concrete construction methods. Skilled shotcrete artisans routinely duplicate natural stone's intricate features so precisely that it can be difficult to distinguish the shotcrete reproductions from the genuine stone.

Natural stone is the world's oldest, most imitated construction material. While it may never be possible to exactly reproduce genuine stone's random shapes, textures, and colors, using shotcrete rock-carving techniques is the ideal method to create the desirable visual qualities of natural rock features.

All photos courtesy of Steve Jimenez, Operations Manager, Boulderscape, Orange County, CA, and Greg Perrin, CEO, American Standard Concrete Pumping, Honolulu, HI.

*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 certified nozzleman.*

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Celebrating Mexican Soccer Past, Present, and Future

Placing shotcrete for the first-ever Mexican Soccer Hall of Fame

By Kelly Blickle

Known as the "Cradle of Mexican Soccer," Pachuca, the capital of the Mexican state of Hidalgo, opened the doors to the first-ever Mexican Soccer Hall of Fame (Salón del Fútbol Nacional e Internacional) and the Mundo Fútbol, an interactive museum devoted to Mexican soccer, in July 2011. An Allentown high-pressure shotcrete/concrete pump and a shotcrete spraying machine sprayed 523 yd^3 (400 m^3) of shotcrete for the historical, soccer-ball-shaped Hall of Fame.

The Hall of Fame is comprised of three levels of various galleries and pictures that represent the country's soccer evolution since 1901, when the city founded Mexico's first club; while the Mundo Fútbol encourages visitors to experience the emotions and sensations specific to the game of soccer. The museum is located next to the Hall of Fame.

During the inaugural ceremony for the buildings, key figures in attendance were in awe of what they saw and experienced. Attendees included Mexican President Felipe Calderón and his wife, Margarita Zavala; FIFA President Joseph S. Blatter; President of the Mexican Football Federation Justino Compeán; President of Pachuca Football Club Jesús Martínez; Hidalgo's Governor Francisco Olvera Ruiz; and Chilean President Sebastián Piñera.

The historical soccer-ball-shaped structure stands 125 ft (38 m) tall and is 98 ft (30 m) in diameter

"Participating in an event of this magnitude, in which the subject is football in its purest sense, is like being a part of the history of the game. What I have seen here is simply spectacular," commented Blatter (Fifa.com, July 10, 2011).

Building a Nation's Pastime

Spearheaded by the Pachuca Football Club, the Hall of Fame stands 125 ft (38 m) tall and is 98 ft (30 m) in diameter. It was first erected with steel, then covered with PANEL W® (a building system based on a tridimensional structure of steel wire with a polyurethane or polystyrene nucleus) and finally sprayed with shotcrete on both the interior and exterior.

The shotcrete equipment contractor for the project supplied the Thom-Katt® high-pressure shotcrete/concrete pump and the Aliva® 263 shotcrete spraying machine for the project, which both arrived on site in February 2011. Together they covered the 53,820 ft^2 (5000 m^2) surface area (both interior and exterior) of the Hall of Fame with 523 yd^3 (400 m^3) of shotcrete.

"Shotcrete was chosen because it allows for fast application and covers more square feet (square meters) than any other system. On average, we sprayed about 4 yd^3 (3 m^3) per hour, which equals to 646 ft^2/h (60 m^2/h)," noted Ing. Raúl Bracamontes, Civil Engineer and Director of the concrete pumping contractor. "In addition, less people are needed to spray the shotcrete as compared to other placement methods, ultimately increasing the cost efficiency of the job."

The high-pressure shotcrete/concrete pump was chosen to place wet-process shotcrete for the exterior of the structure and the shotcrete spraying machine was chosen to place dry-process shotcrete for the interior of the structure. Both units applied the shotcrete at the same time to expedite the application process.

The features of the trailer-mounted high-pressure shotcrete/concrete pump made it ideal for the sprayed shotcrete exterior.

"It has a very smooth stroke and features the least pulsation of any shotcrete machine available today," explains Bracamontes. "We were able to operate it at a very low output, making life easier for our nozzleman. In addition, this machine is capable of spraying up to 17 yd^3/h (13 m^3/h) at 2000 psi (13.8 MPa), which is very important to us because it provides the flexibility needed for the different types of jobs we're on.

"It's also very robust, allowing us to pump the shotcrete an impressive 131 ft (40 m) above ground level, which has been a huge advantage to us because of this structure's height."

An on-site mixer fed the shotcrete mixture into the high-pressure shotcrete/concrete pump's large 9.5 ft^3 (270 L) capacity hopper. "The shotcrete mix for both the interior and exterior was a standard mix, with its compressive strength reaching 2844 psi (200 kg/cm^2) in 28 days," says Bracamontes. "The large-capacity hopper made the project even more efficient because it could hold such a large amount of material."

The high-pressure shotcrete/concrete pump placed wet-process shotcrete on the exterior of the Mexican Soccer Hall of Fame

The shotcrete spraying machine was chosen to place the shotcrete for the interior because Bracamontes and his team were able to set it up inside the structure and mix on site, which reduced the amount of hose required by 230 ft (70 m).

Crews paint the Mexican Soccer Hall of Fame

Mexican Soccer Hall of Fame

Project Location
Pachuca, Hidalgo, Mexico

General Contractor
Ingenieria y Constructucciones Gabe S.A. de C.V.
Mexico City, Mexico

Concrete Pumping Contractor
Soluciones Técnicas y Profesionales ADRA S.A. de C.V. (ADRA)
León Guanajuato, Mexico

Project Owner/Developer
Pachuca Football Club

Equipment
Thom-Katt® TK 20 high-pressure shotcrete/concrete pump, Allentown Shotcrete Technology, Inc.

Aliva® 263 shotcrete spraying machine, Allentown Shotcrete Technology, Inc.

"With this setup, we were able to reach from one end to the other," notes Bracamontes.

The contractor completed the application of the shotcrete in May 2011.

Bracamontes says his team's experience working on the Hall of Fame will be one they won't soon forget. "It was an honor and a privilege to help build a structure that pays tribute to such an important piece of Mexico's history and pride."

Confident from the Start

Founded in 2005 and based out of León Guanajuato, Mexico, this was the concrete pumping contractor's first time spraying shotcrete for a circular-shaped structure. Even though this type of job was new to the contractor and his team, Bracamontes knew from the beginning that his crew and the chosen equipment would make a winning combination for this project.

"When I first met with the shotcrete equipment manufacturer, I had the opportunity to visit their facilities and was impressed immediately," notes Bracamontes. "Their equipment across the board is manufactured with efficiency in mind and designed specifically for heavy-duty projects while allowing for ease of shotcrete application."

"In addition, they worked with us from the beginning of our projects to the end and even after to ensure we were providing the absolute best solution to all of our customers. They also ensured spare parts were readily available and offered 24/7 technical support so we were never left hanging."

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

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Prestressed Concrete Tanks—Mundane? Or Architectural Gems?

By Charles S. Hanskat

Circular wrapped prestressed concrete tanks (WPCTs) have been built for over seven decades in the U.S. They range in capacity from 50,000 gal. (189,270.60 L) to over 30,000,000 gal. (113,562,360 L). These tanks use shotcrete (either dry- or wet-mix) for the construction of all or a portion of the walls that serve as the primary liquid containment.

The final exterior structural layer of all WPCTs is shotcrete. The cement-rich shotcrete provides an ideal environment to protect the highly stressed prestressing steel from corrosion and mechanical damage. Also, the versatility inherent in shotcrete allows tank builders to provide a final shotcrete finish that can range from a natural gun finish (rough and lumpy) to a screeded and floated surface with sharp lines and a smooth finish.

Although the plain shotcrete wall surface may be fine in a wastewater treatment or industrial plant, it may not, however, be attractive to the neighbors that live outside the water plant in residential areas where water tanks supply the water distribution system. Although most residents want to be able to turn on the tap and get clean, potable water at any time, they often react very negatively to having a water storage tank in their backyard or neighborhood. WPCTs can be over a football field in diameter and nearly 100 ft (30.48 m) high; thus, it is often impossible to hide a tank using plants, trees, and shrubbery.

The "not in my backyard" (NIMBY) attitude can be a real challenge to siting and building a new WPCT. One option is to completely bury the tank and thus hide it from view. This results in a much greater cost for excavation and backfill, however, as well as the extra cost to add structural capacity to carry the backfill loads. Another option used by all the WPCT builders in the U.S. is to add architectural treatments to their tanks to make the tanks much more acceptable to the neighbors. In fact, creative architectural treatment often creates visually attractive structures that become landmarks in the community.

Fig. 1: 750,000 gal. (2,839,059 L) tank, Gainesville, FL
Courtesy The Crom Corporation, Gainesville, FL

Architectural treatments on WPCTs range from simply providing an additional shotcrete thickness in the exterior shotcrete layer to create pilasters and arches to add-on exterior insulation finishing systems (EIFSs) and even brick and rock facings.

Figure 1 shows a 750,000 gal. (2,839,059 L) water storage tank built by The Crom Corporation for the Department of Veterans Affairs at the VA Hospital in Gainesville, FL. The architect wanted an architectural treatment that would complement the hospital building and provide the durability of shotcrete. The architectural treatment used both welded wire reinforcement and polypropylene fibers with a grout mixture to create an additional 1.5 in. (38 mm) thick shotcrete thickness. The surface preparation of the normal shotcrete cover coat preceding the placement of the architectural treatment included stiff brooming to provide a profile for the subsequent application of shotcrete to ensure proper bond.

Figures 2 through 4 show the sequence of construction of a shotcrete/EIFS architectural system with brick pilasters for a 1,000,000 gal. (3,785,412 L) water storage tank for East Hazel Crest, IL, built by Preload Inc., based in Hauppauge, NY.

In Fig. 2, the shotcrete cover coat is nearly complete. An oval temporary manhole is still open. The permanent manhole—about one-third the height of the wall above grade—is open. Shotcrete corbels are reinforced using T-shaped bolts to tie back to the tank core wall. These corbels will act as a shelf to support the brick pilasters. Vertical strips of dovetail anchors are shotcreted in a 1 in. (25.4 mm) pad (beyond the 1 in. [25.4 mm] of shotcrete covering the prestressing wires). The brick ties back to the dovetails, leaving an air gap between the shotcrete and brick. The brick contains weep holes at the first course above grade, and the sides between the brick and the shotcrete are caulked with a backer rod.

Fig. 2: Shotcrete corbel and pilaster on a 1,000,000 gal. (3,785,412 L) tank, East Hazel Crest, IL
Courtesy Preload Inc., Hauppauge, NY

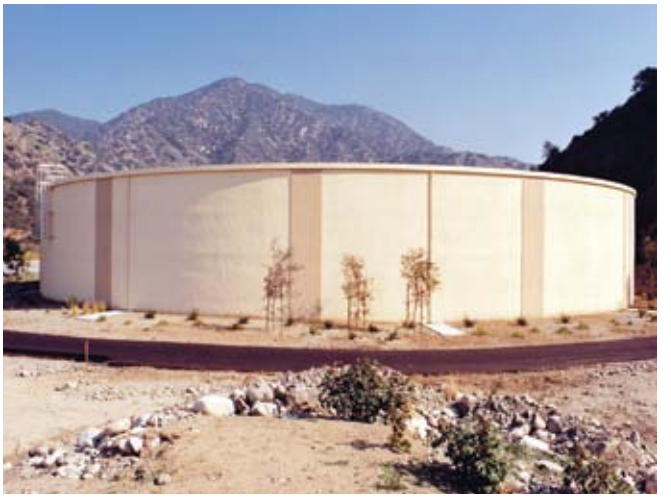

Fig. 5: 4,000,000 gal. (15,141,648 L) tank, Azusa, CA
Courtesy DYK Inc., El Cajon, CA (a division of DN Tanks)

Fig. 3: EIFS arches being placed, East Hazel Crest, IL
Courtesy Preload Inc., Hauppauge, NY

Fig. 6: 1,000,000 gal. (3,785,412 L) tank, Tuscaloosa, AL
Courtesy The Crom Corporation, Gainesville, FL

Fig. 4: Finished tank, East Hazel Crest, IL
Courtesy Preload Inc., Hauppauge, NY

In Fig. 3, the final shotcrete flash coat is complete. The brick pilasters have been placed and masked for construction of the EIFS arches. Polystyrene is glued to the tank wall with a permanent adhesive and then coated with a mesh reinforced latex-modified acrylic mortar.

In Fig. 4, the architectural treatment is complete with a stepped relief pattern on the arches and two-tone acrylic paint.

Figure 5 shows a straightforward shotcrete pilaster architectural treatment on a 4,000,000 gal. (15,141,648 L) tank built by DYK Inc. of El Cajon, CA, for Azusa Light and Power in Azusa, CA. The pilaster and two-tone paint visually breaks up the large expanse of wall and makes the tank seem less industrial.

Figure 6 shows a 1,000,000 gal. (3,785,412 L) water storage tank built by The Crom Corporation for the city of Tuscaloosa, AL, in 2007. The owner wanted architectural treatment on the tank with the color permanence of EIFS. The Crom Corporation recommended a system using both EIFS and shotcrete so that the lower portions of the tank would be resistant to grounds maintenance equipment. The treatment was built using welded wire reinforcement and a grout mixture for shotcrete work, which included polypropylene fibers. The bottom 10 ft (3 m) of the pilasters is a 2.25 in. (57 mm) thick shotcrete

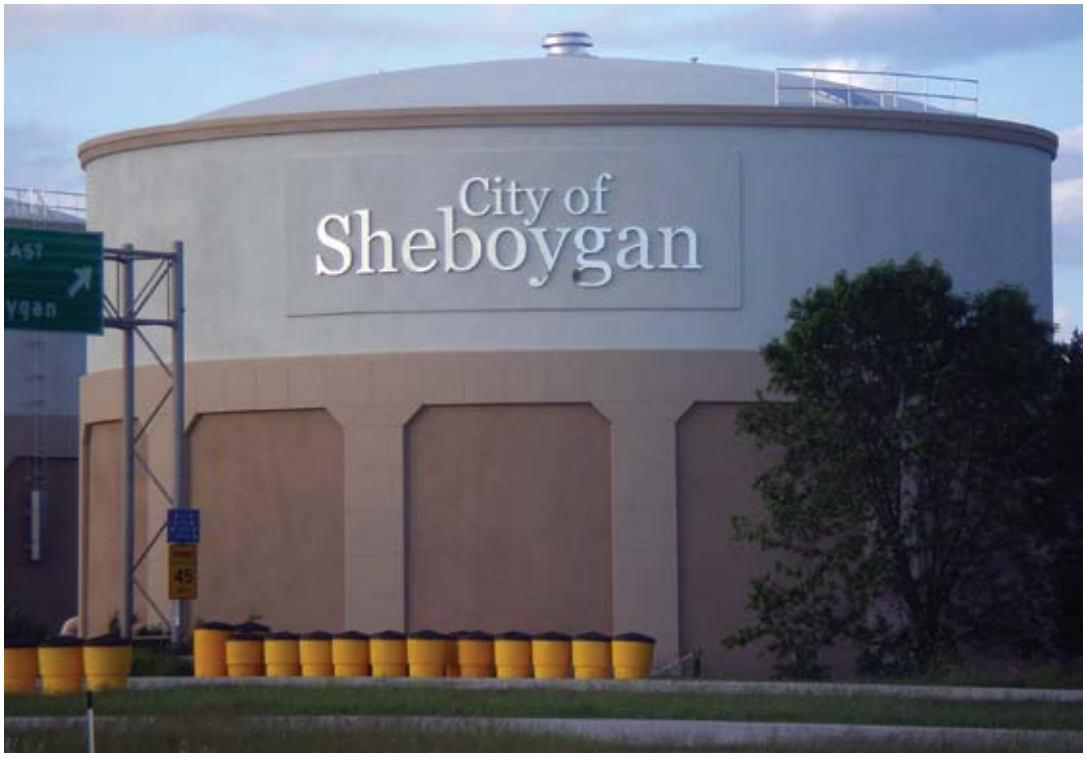

Fig. 7: Tank in Sheboygan, WI
Courtesy Preload Inc., Hauppauge, NY

Fig. 8: Aerial view of tank in Altoona, PA
Courtesy Natgun Corporation, Wakefield, MA (a division of DN Tanks)

Fig. 9: Close-up view of tank in Altoona, PA
Courtesy Natgun Corporation, Wakefield, MA
(a division of DN Tanks)

construction, whereas the upper portions use an EIFS system.

Figure 7 shows a WPCT built by Preload Inc. for Sheboygan, WI. This tank has vertical precast concrete pilasters on shotcrete corbels and a horizontal circumferential precast concrete pilaster supported by stainless steel shelf angles bolted to the wall. It also features a large steel-reinforced thickened shotcrete pad as a base for the stainless steel block letters.

Figures 8 and 9 show another WPCT—built by the Natgun Corporation from Wakefield, MA—for the city of Altoona, PA. The aerial shot shows how NIMBY could have been a big problem at this location. The owner, however, added the recreational pool facility alongside the tank and Natgun added an architectural treatment that made the tank look more like a building than a tank. The close-up shot in Fig. 9 shows how the brick veneer was added to give the appearance of a railroad tunnel entrance, with the locomotive painted on the tank's shotcrete surface.

In the foreground of Fig. 10 is a Preload tank using a brick and stone veneer with false windows

Fig. 10: Stone-brick veneer tank with barn pumphouse
Courtesy Preload Inc., Hauppauge, NY

to give the appearance that the tank is just a circular building. The barn in the background is not a barn—it's the pump house for pressurizing water from the tank into the water distribution system.

Figure 11 shows another Natgun tank in Vestal, NY, that uses brick pilasters with shotcrete (or perhaps EIFS) arches. Once again, the pilasters/arches and paint scheme help to visually break up the large cylindrical surface of the tank.

If you're lost at sea in Laconia, NH, and see the light from the lighthouse in Fig. 12, you'll probably be thankful for the guiding light but never know it is a water storage tank built by the Natgun Corporation.

In summary, WPCTs are extremely durable structures built with concrete and shotcrete to last up to 100 years. Unfortunately, many people see normal cylindrical concrete tanks as unattractive, utilitarian structures. As can be seen in the photos, however, with the creative use of paint, shotcrete, EIFS, brick, and stone veneers, today's tank builders are able to create visually attractive tanks that can be proud landmarks for the municipalities they serve. Now the neighbors can say, "Sure, I'll have THAT in my backyard!" Of course, they will also appreciate the improved water pressure.

Fig. 11: Night view of tank in Vestal, NY
Courtesy Natgun Corporation, Wakefield, MA (a division of DN Tanks)

Fig. 12: Lighthouse tank in Laconia, NH
Courtesy Natgun Corporation, Wakefield, MA (a division of DN Tanks)

Charles S. Hanskat *is a Principal at Concrete Engineering Group, LLC, a firm he founded in 2008 located in Northbrook, IL. He received his bachelor's and master's degrees in civil engineering from the University of Florida. Hanskat is a licensed professional engineer in 22 states. He has been involved in the design, construction, and evaluation of environmental concrete and shotcrete structures for nearly 35 years. Hanskat is an ASA Board member and Chair of the ASA Sustainability Committee. He is also an ACI Fellow and a member of ACI Committees 301, Specifications for Concrete; 350, Environmental Engineering Concrete Structures; 371, Elevated Tanks with Concrete Pedestals; 372, Tanks Wrapped with Wire or Strand; 373, Tanks with Internal Tendons; 376, Concrete Structures for Refrigerated Liquefied Gas Containment; 506, Shotcreting, and Joint ACI-ASCE Committee 334, Concrete Shell Design and Construction. Hanskat's service to the American Society of Civil Engineers (ASCE), the National Society of Professional Engineers (NSPE), and the Florida Engineering Society (FES) in over 50 committee and officer positions at the national, state, and local levels was highlighted when he served as State President of FES and then as National Director of NSPE. He served as District Director for Tau Beta Pi for 25 years from 1977 to 2002. He is a Fellow of ASCE and FES and a member of ASA, NSPE, ASTM International, AWWA, and ASHRAE.*

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California Wine Caves Showcase Wet-Mix Shotcrete

By Oscar Duckworth

There has never been a use for shotcrete that promotes tourism more than the California wine cave. Each year, people from across the globe come to experience California's famous wine region. Visitors compare pinots, merlots, and cabernets within the beautiful underground wine caves of the region's famous vineyards.

While many believe wine caves may not be the primary draw to California wine country, it is hard to imagine this region without these spectacular structures. Although originally built to provide ideal fermenting and storage conditions for freshly crushed grapes, California wine caves are now a staple of the region's immense tourism draw. No wine tasting outing would be complete without a look into the complex, underground world of the winemaking industry.

Stepping into a chilly wine cave begins a sensory overload of sights, smells, colors, and textures. Narrow underground passageways can open into grand subterranean ballrooms. Vaults full with neatly cradled barrels sit aging to perfection under nature's optimum temperature and moisture conditions deep within the earth. Gala benefits, dinner parties, and even weddings are frequently held within these spectacular shotcrete caves.

Shotcrete Technology Revolutionizes the Wine Industry

With the exception of a handful of hand-dug wine storage caves created by early vineyard settlers, few wine caves existed prior to the initial use of shotcrete. In the 1980s, wet-mix shotcrete revolutionized the California wine cave industry. Wine cave pioneers, such as Alf Burtleson and others, promoted methods using wet-mix shotcrete to excavate and stabilize large caves within the volcanic tuff formations common to the wine country. The use of wine storage caves not only greatly improved the region's wine quality, but also became an unintended tourism magnet. It appeared that everyone wanted to experience a tour through these amazing subterranean structures. Soon no prominent vineyard was without its own ever more dramatic wine cave. Today, wine caves can vary from simply utilitarian to unimaginably elaborate; however, the primary goal is to provide the California wine country an optimum underground environment to make, age, and showcase the region's world-class wines.

Client Expectations Have Changed

Sash Williams, Senior Engineer, Williams and Associates, Santa Rosa, CA, oversees the engineering, design, and construction of many of the region's wine caves. Williams sees the current trend of caves that are primarily designed for barrel storage moving to a much more diverse purpose. "Client expectations have changed. It is not uncommon now for the caves to include everything from full underground wine production facilities to art galleries. We are seeing a wider selection of cross-sectional shapes including round, compound curves, high arches,

and vertical walls. There is a trend away from the rougher, free-form shapes of the past to sharp, crisp shapes with finishing tolerances closer to conventional concrete construction." Williams claims that a more recent consideration is moisture and water within the cave. "Where leaks, moisture, and mold may have been tolerated in years past, the use of caves for much more than just barrel storage has changed client expectations. While a select few may still allow for visible moisture intrusion, the overwhelming majority seem to desire conditions closer to a conventional building. Water mitigation, as the preferred terminology may reflect, can be challenging or risky, depending on the amount of moisture. In the cave industry, it is not uncommon for the actual approach to water control to be treated as a design-build item by the cave contractor, with each contractor typically having a preferred approach, material, or methodology."

Rick Shone, PE, President of Nordby Wine Caves, Healdsburg, CA, has built many wine caves for a diverse group of clients. "While some wine caves carry strict budget guidelines, many 'lifestyle' vineyard owners are interested in creating truly exceptional caves." Immense subterranean rooms featuring tall ceilings, special surface textures, and spectacular lighting adorn his company's photo album of recently completed work. "California wine caves continue to carry strong market appeal. I see caves requiring larger, more elaborate, complex shapes to accommodate forklifts and winemaking equipment while providing room for wine tasting, ballrooms, or dining areas."

Changes to the Cave Industry

Shone also sees changes in the region's cave industry. "Wet-mix has almost completely replaced dry-mix placement. We only use the dry to occasionally pick up strength quickly in poor rock conditions. More and larger reinforcement patterns are commonly specified along with modern shotcrete mixture designs that improve in-place quality. Our shotcrete placement crew continuously uses the blow pipe to assure lenses of loose rebound material cannot accumulate and form moisture paths through the completed work. These steps, in conjunction with current water mitigation technology, have made wine caves much stronger and more watertight than earlier cave construction methods could have provided."

The California wine cave industry has evolved conventional shotcrete placement and tunneling techniques to produce a unique, architecturally significant product that is specific to this region. Their prominence contributes immeasurably to the character of this global tourist destination. The shotcrete process has forever changed how the region's wine industry

creates, ages, and showcases its product. While California wine caves are certainly the most visited of all shotcrete structures, it is the combination of utility and unexpected elegance created within their interior spaces that makes them truly special. The artistic implementation of structural shotcrete within the California wine country's spectacular wine caves may be shotcrete's most majestic use.

All photos courtesy of Sash Williams and Rick Shone.

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.*


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A Shotcrete Success Story

By Skip Phillips

This La Jolla, CA, project was designed over a 2-year time frame with the collaboration of Island Architects, Bruce Rudd Landscape Architecture, and Questar Pools. As is the case on any large project, mutual respect and talented participants were critical to resolve the type of details necessary to meet the client's very high expectations.

The foundation system (piers and grade beams) were installed early in the home construction process. Questar Pools was then retained to expand its role from designer to primary contractor on the pool, spa, and three entry water features. Compliance with all the necessary building, soils, and special inspection criteria was ensured. The shotcrete used in the project also met or exceeded the 4000 psi (27.6 MPa) ASA/American Concrete Institute (ACI) compressive strength criteria. These density-driven criteria are extremely important based on the water flow and water-in-transit designs. Liquid movement in, around, and over concrete vessels is susceptible to leakage or departure via joints or vertical transitions in the concrete. Monolithic, low-porosity, high-strength concrete installed via the shotcrete process is the only way to ensure that water-in-transit loss is minimized to evaporation only. This was the foundation for the project's design and it had to be implemented correctly to succeed with the remainder of the project.

The pool vessel is elevated 4 in. (102 mm) above the pool deck and veneered in labradorite on the exposed and vanishing edge elevation. There are two vanishing edge details on the pool: the house-side elevation and a more traditional vanishing edge with an attached surge tank on the descending slope. The spa is a perimeter overflow with a waterline 1 in. (25 mm) above the pool's level. It is backed up by a limestone wall with a custom bronze feature bowl.

The pool's elevation and edge details provided the desired visibility of the designed line of sight from both the lower- and second-floor viewing locations. The black pearl Pebble Tec surface finish, along with a sophisticated mechanical system, ensures a highly reflective surface absent of turbulence.

The front water features integrate water both in and outside the home, with a "Lautner" style slot overflow detail. The rainfall effect, lit with fiber optics, provides a stunning preview to the home and waterscape beyond.

The combination of the contractor's rendering abilities and the flexibility of the shotcrete process

were especially significant components on this project. Drawing skills have become a lost art in the pool industry with the ever-increasing use of computers. The ability to sketch details by hand during both the design and execution phases provided an excellent communication tool for the construction team. Drawing a perspective, cross-sectional sketch allowed the shotcrete crew to actually see how the shot gutter detail met up with the surge trough. This sectional view was not understood by the implementers until the sketch was done on site, despite having this detail in an architectural CAD format. The flexibility of the shotcrete process provided tremendous latitude in the finite shell tolerance modifications.

Questar Pools prefers the wet-mix process and acknowledges the importance of ACI Nozzleman Certification. The use of ASA minimum requirements for compressive values and the insistence that the applicator be properly trained and certified are critical items for Questar Pools and its clients. The wet-mix shotcrete process and its increasing popularity have been a huge asset to Questar Pools and the pool, spa, and water feature industry as a whole.

Skip Phillips *is the President of Questar Pools and Spas in Escondido, CA, and is the Cofounder of Genesis 3. Phillips currently serves on the Board of Directors for the Pool Safety Alliance and Sonar-Guard. In 1997, 1998, and 2000, Questar Pools and Spas was chosen as Industry's Choice—Top 50 Builders. Genesis 3 is an international forum specializing in education for pool professionals. Since 1998, Genesis 3 has attracted some 500 participants and is dedicated to higher standards in watershape design and construction.*

Rankin Bridge

By Dennis Bittner

The Rankin Bridge is a cantilever bridge spanning the Monongahela River in Pittsburgh, PA. The bridge has a steel superstructure resting on concrete piers. Originally opened in 1951, the structure, which is 505 ft (154 m) long and 75 ft (23 m) high, accommodates 26,400 cars daily. At one time, this bridge served as a critical access point to Pittsburgh's steel industry. Now, it serves as Pittsburgh's main access point to the Kennywood Amusement Park and the Waterfront Complex. The complex sits on the site of the historic Homestead Steel Works, and it has been redeveloped to contain vibrant shopping, offices, and condominiums.

Due to the wear and tear of age, the bridge was badly in need of repairs. Like so many bridges in the U.S., the bridge had been deemed structurally deficient, scoring a sufficiency rating of 31.4 out of 100. The owner, The County of Allegheny, requested bids for a total rehabilitation of the bridge.

The total contract for the structure was $47.8 million. It included several facets, such as building a new, wider deck; repainting the superstructure; and improving access lanes. The contract also called for full rehabilitation of the concrete piers. Originally, the pier repair work was specified using "form and pump" methods. Through an on-site field demonstration, however, the contractor was able to demonstrate the viability of shotcrete as an equal or superior alternative method of repair.

The dry-process shotcrete method was chosen. Alkali-resistant short-strand fibers were added for shrinkage crack control, and a corrosion inhibitor was added for corrosion resistance. Both the fibers and corrosion inhibitor were included in the prebagged mixture. The corrosion inhibitor had a pH similar to that of concrete. This addition prevented any retarding of the mixture that could lead to sagging. Dry-process shotcrete was selected due to the start-and-stop nature of the work.

First, the piers were prepared. All loose, unsound materials were removed, exposing sound concrete. During the demolition phase, the areas were pressure washed to remove any fractured concrete. Sometimes neglected, proper substrate preparation is essential to any type of concrete repair. All embedded reinforcement exposed by the demolition and surface preparation was sandblasted clean. Deficient reinforcement was removed and replaced. Next, the shotcrete was installed. All shotcrete was applied using a predampener in the shotcrete delivery system. Predampening greatly reduces dust, allows the material to begin to hydrate, and helps ensure proper hydration of the product. Excess material was trimmed to match the original round face of the large piers. Immediately after finishing, the

Piers after application of an epoxy coating

After completion of the project, the structure looks like a new bridge

Shotcrete applied at full depth over reinforcing bar and mesh

Large, round piers can be brought back to their original shape using shotcrete

material was sprayed with a state-approved volatile organic compound (VOC)-compliant curing compound. The spray cure was chosen over water cure due to the vertical orientation of the piers. The use of a spray-on curing compound is often more economical and can be applied to freshly cut material to combat early-age plastic shrinkage cracks. Later, the piers were pressure washed and a "concrete gray" epoxy paint was applied. The contractor used exclusively ACI-certified nozzlemen for the material installation. Using certified nozzlemen helped ensure a quality shotcrete installation. The experience of the contractor and the shotcrete crew allowed the project to stay on schedule. The entire project used just over 6000 ft^3 (170 m^3) of shotcrete.

This project was a prime example of the advantages of the shotcrete process over the traditional form-and-pour repair method. There are often concerns about the ability to match the shape of round bridge piers on large patches with the shotcrete process. On the Rankin Bridge, the original shape of massive piers was replicated. The speed of the shotcrete installation versus forming contributed significantly to the timely completion of the project between August 2008 and November 2010. Shotcrete can offer large dollar savings over traditional form-and-pour repairs. Currently, an estimated 26% of bridges in the U.S. are considered "structurally deficient or obsolete." Twelve percent of U.S. bridges are in such bad condition that they need annual inspections to remain in service. The cost estimates for these repairs vary greatly, but most put the cost of necessary bridge repairs in the U.S. at hundreds of billions of dollars. Cost savings through the use of shotcrete repair methods would allow the federal, state, and local governments to stretch their limited infrastructure repair dollars and potentially repair or restore more bridges. Anyone who finds themselves in the Greater Pittsburgh area should stop by the Rankin Bridge and see what types of bridge repairs are possible via the shotcrete method.

Rankin Bridge

Project Location
Pittsburgh, PA

Project Owner
The County of Allegheny
Allegheny County Public Works

Contractor
Mosites Construction Company
Pittsburgh, PA

Materials
Quikrete Shotcrete MS
(PENNDOT approved material list)
Cortec MCI 2006 NS corrosion inhibitor

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So You Want to Be A Nozzleman?

By Marcus H. von der Hofen

American Concrete Institute (ACI) Nozzleman Certification, experience, qualifications, core grades, and written tests are all used to establish a nozzleman's ability to understand and apply shotcrete. But do they actually ensure a good job? What really makes a good nozzleman? For nearly two decades, I've been lucky enough to work with some of the most successful nozzlemen on the West Coast and I have found that certain (often overlooked) qualities greatly influence a nozzleman's ability to consistently produce excellent work.

What do I mean by successful? In my experience, being successful is far different than having the ability to encase reinforcing bar for a test panel. Success is actually many things combined. It is the ability to do quality nozzling repeatedly and consistently throughout a workday and over the course of a project. True nozzlemen understand that they play a great role in a project's success by working in tandem with their crew members and controlling the pace of the job. I could go on and on about what good nozzlemen do, but this article will focus on some key elements for a beginning nozzleman to start with.

Balance and Energy

If you don't master this concept, you have zero chance of becoming a top nozzleman. It's a very simple fact that no one is strong enough, tough enough, or big enough to physically fight the hose all day long during production. Work on getting into a good position where you can control the hose through the mass of your body and not just with your muscles. This is especially important with wet-mix shotcreting due to the weight of the material hose. As the hose surges, the energy is transferred to your body, not your arms. The best positioning of the hose is from the ground up between your legs and in front of your body, where the weight of the hose is supported by its rigidity. As the hose surges, its force is transferred to your legs, midsection, and chest. Your arms are then used more for guidance, thus minimizing the strain on them and your lower back.

Also important to achieving good balance is positioning the nozzle length in a manner that places its natural contour in harmony with you. Depending on how the hose is twisted and how the nozzle is positioned relative to this twist, you can end up fighting the hose and wasting energy. Adjust the nozzle and nozzle length to minimize this issue. Where the hose lays on the ground, keep a loop out in front of where you're going. This will minimize the dragging of the hose, which wastes energy, and allow a hose puller to drag more hose to where you are moving, reducing wear and tear on you—the nozzleman. As you know, shotcrete nozzling is hard work and everything you can do to minimize your fatigue will translate into better consistency in your placement over the long haul.

Placement Control by Distance

One of the big differences between a beginner and a more experienced nozzleman is the ability to control shotcrete placement by manipulating the nozzle distance from the receiving surface. If conditions were always the same, you wouldn't have to do this much, and sometimes that's the case; but with most of the jobs I see with multiple curtains of reinforcing, inside and outside corners,

and finish requirements, it's imperative that the nozzleman has the ability to control the placement by changing the nozzle distance. As material is placed around reinforcing in the back of the area, a good nozzleman can move in closer with the nozzle to increase the ability of the shotcrete to flow around the reinforcing bar. He will then draw back with the nozzle to increase the pattern size and spread out the energy, creating consolidation over a larger area while not disturbing the material he has placed behind the bar. This is a simplification of the process, but I find that all nozzlemen that consistently place well-consolidated material around challenging steel conditions possess this skill.

It is important to place material consistently close to finish grade. Controlling your placement by adjusting your distance is very helpful in that endeavor. It allows a nozzleman to move in, get around the reinforcing bar, and back out to smooth the finish and control the shape of the receiving surface. Two things are happening here: 1) more energy in a tighter pattern causes better flow around the bar; and 2) a bigger pattern with the energy dispersing over a larger area creates a more consistent surface.

You have a lot to deal with as a nozzleman and your ability to control that nozzle to get things done consistently takes practice, so work on your technique of nozzle distance control.

Attitude is No. 1

Before I started writing this article, I sat and chatted with my longtime friend Mike Norton, a nozzleman who has worked with both wet- and dry-mix shotcrete for more than 30 years. We both agreed that the most important thing we look for when deciding who to try and develop into a new nozzleman is attitude. You have to want to be good at this. You have to want to be a professional. You have to be willing to learn and grow from experience to be a good nozzleman. You and your attitude set the tone for the crew, and if you are not capable of being that kind of person, you should look for something else to do.

My job has never been at the end of the nozzle, but for many years I have had to determine and then rely on the person who is. I have seen them come and go—both good and bad—but the true "top guns" want and earn the respect of the people they work with.

Marcus H. von der Hofen *has nearly two decades of experience in the shotcrete industry as both a Project and Area Manager. He is an active member of ACI Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification. He is a charter member of ASA, joining in 1998, and is Co-Chair of the ASA Education Committee.*

A *Shotcrete* feature:

SAFETY SHOOTER

Simple and Safe

By Marcus H. von der Hofen

A little more than a year ago, a friend of mine called me up to tell me about a terrible accident that occurred at the company where he works. John and I have known each other for many years, enjoy golfing together (both of us are hackers), and we have worked together on many projects. The company has an excellent record of safety and is well-respected in the industry. It rattled me to hear that something bad had happened to someone in a group that I knew well—people I had worked closely with and people who I respect as being safe.

It was pretty much a normal day for them: clear skies in Seattle, WA; nothing broke (it's a drilling company, so that's nothing new); and they didn't hit anything bad (sewers, water lines, aquifers, and so on) like I hear him talk about every day. Like I said, pretty much a normal day for us guys.

End-of-the-day normal shutdown process: it started with blowing out the concrete hose, then moving on to the cleanup of the pump. The operator dropped the door and worked the pump back and forth in reverse to clear the cylinders. He had plenty of water, so the cleanout of the swing tube was simple. It had been a pretty fast day, so the buildup was nothing really, with no need to shut the pump down while it was hosed out. Another feature of this pump is an automatic cutoff relay that engages when you lift the grate (the one that I know everyone has down while they are running!) and the pump swing tube won't move—a good feature. So, the operator was just about done cleaning the pump and there was a little piece of concrete on the end of the piston. He opened the grate, which locked out the cutoff switch; leaned into the hopper to knock the piece of concrete off; slipped; and wham!— the pump swung. As he slid, he caught himself with his hand right at the base of the face plate, severing his hand about midpalm.

The operator had been running the pump with a remote that day, which he still had on. When he slipped, he activated it, and the lockout malfunctioned. If he had done any one of a number of things that he knew to do differently, it wouldn't have happened. I immediately thought about a simple thing my father had taught me about firearms: "Treat all of them as if they are loaded and don't point them at anything you can't afford to shoot…ever."

How many of us have cut corners and taken unnecessary risks?

With today's inundation of personal protective equipment, safety manuals, MSDS sheets, tailgate meetings, safety inspections, and site orientations, I sometimes think it distracts us from the obvious: never take a risk where you can't afford the worst outcome—how hard can that be?

So, in my mind, I had already decided that I wouldn't have this happen to me. I would talk to my workers, give them a pep talk, and apply my simple and safe approach—when John says to me, "that wasn't the worst part." *What?*

They were working at a large job site. It was a highway project with no real address and no one had really thought through how to get emergency medical vehicles directly to the location of the accident. They had to come down a series of access roads that were created just for the job. It wasn't easy. "He might have bled to death before we got to him because we didn't have a plan as to how," said John.

Well, they made it to John's son in time. They were able to reattach his hand. He has regained some use, but he will never be the same.

Safety isn't a simple thing. It requires everything that we can put into it—planning, talking, awareness, and education. There isn't anything that's not important. I want all of us to remind ourselves of all of those who have fallen in our trades and how it would feel if we didn't do everything we could to prevent it.

Marcus H. von der Hofen *has nearly two decades of experience in the shotcrete industry as both a Project and Area Manager. He is an active member of ACI Committees 506, Shotcreting, and C660, Shotcrete Nozzleman Certification. He is a charter member of ASA, joining in 1998, and is Co-Chair of the ASA Education Committee.*

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The More Things Change, the More They Stay the Same

By Edwin Brady

Over the last 10 to 15 years, the shotcrete industry has seen remarkable advances across the board. Technical advances in equipment, accessories, admixtures, and fibers have truly revolutionized the industry. It would seem, at least to some, that you can simply specify materials and process equipment to get a successful, profitable project. Don't be so naive!

Nozzleman Expertise is a Must

Shotcrete has and continues to be heavily dependent on the expertise of nozzlemen. An experienced nozzleman can combine sand and cement using old technology and produce a successful project in most instances. By the same token, the most elaborate equipment package coupled with an expertly designed shotcrete mixture and a less than experienced and skillful nozzleman will almost certainly result in failure on multiple levels.

The physical demands on shotcrete nozzlemen, especially in the application of wet-mix shotcrete, are tremendous. Because the overall success of a project is so dependent on the performance of the nozzleman, one can easily understand the impact that fatigue has on every project and the benefits that will result in taking every opportunity to reduce that fatigue.

Fatigue Directly Affects Efficiency, Productivity, and Profitability

Fatigue is a very broad term, and its full effect is the cumulative result of many elements of stress. These include fatigue from the obvious physical demands of the job but also include stress from the environment (heat, cold, dust, sun, protective clothing and safety gear, noise, lighting, equipment, and accessories) and mental stress.

Physical elements are best addressed through the experience of the nozzleman, who has most

Pressure-washing being performed from the man-lift used for shotcrete, which gives a good perspective of dimensions of tunnel and access requirements

Scaffolding setup on mobile trailer with lighting for access to work. Air compressor and power unit mounted beneath scaffolding

likely developed techniques over the years to use his strength in the most efficient way and conserve his energy. Even so, an experienced hosetender can prove invaluable, along with the use of scaffolds, man-lifts, and other devices to reduce the weight of the hose/nozzle for the nozzleman and provide free and clear access directly to the work with a minimum amount of effort on the part of the nozzleman. Personal protective clothing (PPC) and personal protective equipment (PPE) often contribute to heat stress, even in cold temperatures. In addition to the physical effects of heat stress, ongoing attention must be directed to maintaining proper hydration through the constant intake of fluids. Dehydration will directly and immediately produce extreme fatigue, along with a host of other ailments and health issues. Over the course of the workday, however, it is hard to fully estimate the advantages of PPC and PPE in reducing the amount of stress due to dust and debris that come in direct contact with the skin, eyes, and lungs, even though they may contribute to heat stress. Wearing safety glasses, hardhats, respirators, and clothing to fully cover exposed skin is a necessity. Hearing protection should be mandatory for safety concerns and at the same time reduce stress. Inadequate lighting can obviously directly affect the quality of placement but also results in more physical effort and reduced efficiency, which in turn increases the overall workload. Properly maintained and operating equipment always results in more productivity with less effort.

Mental Fatigue Is Just as Significant as Physical Fatigue

The nozzleman should be able to focus on his work and not be burdened by excessive mental stress. An alert mind makes logical and rational decisions. A well-trained crew that works well as a team will always increase quality and productivity, which results in fewer physical demands on everyone. The use of admixtures and hydration control agents as an integral part of a good mixture design results in a more easily conveyed/pumped product that provides more flexibility in the time allotted for placement. Therefore, every minor delay does not become a "fire drill." Well-maintained and properly operating equipment (even though it does not guarantee the absence of breakdowns) clearly allows more attention to be focused on the work instead of wondering (worrying?) when the next inevitable breakdown will occur. Proper coordination and scheduling of logistical issues produce an even and consistent flow throughout the day, hopefully allowing for scheduled breaks and minimal interruptions in the work. All of this leads to the conclusion that good management and attention to detail reduce fatigue.

Nozzling performed from man-lift equipped with lighting, allowing for excellent visibility and immediate access to work while supporting the majority of the material delivery weight and air hoses

Nozzling performed from mobile scaffolding

Reduced Fatigue = Increased Profits

To summarize all of the aforementioned factors, fatigue directly relates to efficiency. Efficiency directly relates to productivity. Productivity

directly relates to profitability. A crew that is physically worn out and mentally stressed is a fatigued crew that will not produce quality work, at least consistently, and will most definitely directly affect profitability and the long-term positive reputation of the company.

The More Things Change, the More They Stay the Same

So, the next time you are planning a project—after planning equipment, materials, scheduling, management, and so on— don't forget to consider the factor of fatigue and how it relates to all of the other issues. Take the time to "take care of your nozzleman," as he is the central member of the crew. Taking his level of fatigue into consideration will directly impact the successful and profitable outcome of the project—the same way it did 100 years ago and most likely will 100 years into the future.

***Edwin Brady**, PE, President of Edwin Brady Construction Co., Inc., received his BSCE from the University of Kentucky in 1980 and has done extensive graduate work toward his MSCE at the University of Houston. He is an ACI Certified Nozzleman (wet and dry), an ACI Certified Examiner (wet and dry), and a licensed professional engineer in Kentucky and Colorado. Brady has over 20 years of experience with wet- and dry-process shotcrete, concrete repair, and specialty grouting in projects on four continents and throughout the U.S.*

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You Can't Shoot What You Can't See

The Importance of Lighting in an Underground Environment

By Joe Derochie

We know that better lighting reduces accidents, increases production, and improves the quality of in-place shotcrete underground—so why it is still common to see an underground shotcrete crew struggling to illuminate the rock face using little more than the light from a cap lamp? From a safety standpoint alone, it has been well documented that good lighting reduces highway accidents, factory and warehouse accidents, and even accidents in the home. So, it isn't much of a stretch to assume that proper lighting is even more important in an underground environment.

After Thomas Edison patented the first practical incandescent lamp in 1879, industrial lighting systems evolved rapidly, and improvements in underground lighting technology have resulted in greater safety, increased production, and enhanced worker comfort. In the mining and tunneling industries, however, the adoption of these improvements lagged behind others for a number of reasons—the primary reason being the aggressive and hazardous environment, which required the development of special, expensive hardware and circuitry. Even this technology was slow in coming and didn't start to take off until mine and tunnel lighting was required by law.

Objectives of Lighting in Mining and Tunneling Operations

Statistics show that workplaces in the mining and tunneling industries are among the most

A shotcrete nozzleman should have a clear view of the rock face when applying shotcrete

hazardous, and personnel who work in these industries should therefore benefit the most from lighting that fully uses modern technology. There are a number of specific lighting objectives that should be targeted when working in an underground construction environment, including:

1. **Increase the visibility of hazards**—Because of the low luminance levels and poor contrast, particularly in underground mines, hazards are often difficult to identify. Examples of these hazards include frayed or cut cables, uneven ground, shotcrete material and air hoses, rock debris, and other difficult-to-identify objects. The primary goal of lighting in a mining or tunneling environment is to increase the visibility of these objects so that injuries caused by these undetected hazards are reduced.
2. **Increase awareness of hazards in the peripheral field of vision**—With a narrow- beamed cap lamp alone, the movement of personnel and mobile equipment can be difficult to detect when it occurs in a shotcrete nozzleman's (or shotcrete crew member's) peripheral field of vision. While movement can be detected if it occurs within the localized main beam of the cap lamp, members of the shotcrete crew should also be able to detect even subtle movement anywhere in their normal field of vision.
3. **Improve vision for the shotcrete nozzleman**—It's difficult to shoot what you can't see. A shotcrete nozzleman must have a clear view of the rock face when applying shotcrete to ensure that the material is being applied at the correct angle, at the correct distance from the rock face, and at the specified thickness. With the dry-mix process, the nozzleman also controls the water-cementitious material ratio (*w/cm*) and must therefore also be able to clearly see the consistency of the material as it impacts a surface. Without a clear view of the shotcrete consistency, the nozzleman will most likely be faced with dramatically increased rebound levels caused by "too-dry consistencies" or increased sloughing caused by "too-wet consistencies." Remote shotcreting, usually conducted from mobile shotcrete spraying units, is always supplied with lighting systems that are designed to address the minimum needs of the shotcrete crew. While most of these systems provide enough lighting to illuminate a heading, secondary, portable lighting should also be used to enhance overall workplace visibility and reduce shadowing. In many underground projects, shotcrete is also applied through welded wire mesh (a secondary ground support)—the ends of which are often overlapped. In these cases, the nozzleman must be able to detect these areas and react accordingly so that voids are not produced behind the overlapping screen.

Proper lighting will reduce workplace accidents, but it is particularly important in an underground environment

In the case of the dry-mix shotcrete process, the nozzleman also controls the water-cementitious material ratio and must therefore also be able to clearly see the consistency of the material as it impacts on a surface

4. **Increase worker comfort and reduce fatigue**—Studies have shown that working in poorly lit environments causes worker fatigue, reduces comfort, and adversely affects morale. Improved lighting offers considerable improvement in the psychological aspects of the underground workplace and will produce corresponding improvements in related areas, such as productivity and absenteeism.

New Lighting Technology

Today, the mining and tunneling industries are supported by a lighting industry whose technological advances improve both cost-effectiveness and performance. Even cap lamps are lighter and more reliable than those used just a decade ago. Light-emitting diode (LED) technology offers longer operating cycles, and ultra-lightweight lithium-ion batteries can keep cap lamps illuminating for the longest possible underground shifts.

New technology (LED and others) has also been adapted by companies who supply portable lighting fixtures that are commonly used by underground shotcrete crews. The shotcrete process is not static and crews are expected to travel throughout an underground excavation. This movement necessitates the constant movement of light fixtures and often results in damage to the portable lighting systems. The new LED lighting systems are usually more durable and longer-lasting.

Proper Maintenance

Maintenance plays an important role in any successful shotcrete operation, but special attention should be paid to the maintenance of the lighting system, especially when shotcreting in an underground environment. Lenses on portable lighting systems should be monitored for a buildup of rebound and overspray and should be cleaned when necessary. High temperatures will accelerate the cement hydration process, making it difficult to remove hardened material from the lens if the cleaning is delayed. Shotcrete crews should always carry extra bulbs or lenses to quickly replace those that are damaged from the rugged underground conditions. Wires or electrical cords should also be monitored for damage, especially in wet environments, where the danger of electrical shock can create an unsafe situation.

Conclusions

There are many factors that contribute to a safe and successful underground shotcrete operation. One of the most critical is sufficient lighting. Working with insufficient lighting can be like sending a blindfolded shotcrete crew underground. The quality of shotcrete would be suspect (to say the least) and safety would no doubt be compromised.

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Joe Derochie *is a Technical Sales Representative, Mining Markets, at King Packaged Materials Company, Sudbury, ON, Canada. Derochie is responsible for providing technical support for King's line of shotcrete, concrete, and grout products in both underground and surface construction environments. He graduated from the Cambrian College Millwright program in 1993 and has been working in the shotcrete industry since 1995. His fields of expertise are wet- and dry-mix shotcrete processes and the related mixing and placing equipment.*

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Blastcrete Equipment Company

Blastcrete Equipment Company is a leading manufacturer of safe, reliable, user-friendly machines for the shotcrete industry. The company's full line of equipment includes shotcrete pumps and mixers, variable speed mixer/pumps, Piccola gunite machines, high-pressure swing-tube pumps, hydraulic squeeze pumps, and easy-care ball seat pumps. Blastcrete's equipment is designed for a variety of markets worldwide, including refractory, underground/mining, commercial and residential building, and insulated concrete form (ICF) and structural concrete insulated panel (SCIP) building systems.

Refractory

Blastcrete offers a complete line of refractory installation equipment to customers in the iron, steel, aluminum, glass, petrochemical, power generation, and cement industries. Wet-process mixer/pump combinations are offered for field batching, pumping, and wet-mix shotcrete applications up to12 tons/h (10.8 metric tons/h). Stand-alone ultra-high-pressure swing-tube pumps are available for any refractory pump cast- or wet-shotcrete installation. Blastcrete's pan mixer is designed to mix 1.1 tons (1 metric ton) of refractory castable for field installations and is commonly used for refractory precast shapes manufacturing. Their rotary dry-process gunite machines feature simple and proven Genuine Piccola single-bolt clamping technology and are recommended by all major refractory material manufacturers.

Mining/Underground

In addition to refractory equipment, Blastcrete offers heavy-duty mixers and pumps for underground shotcreting and grouting, as well as customized solutions for various underground material handling applications. Blastcrete's dry-process gunite equipment consists of a complete line of mixing, predampening, and gunning machines. Like the refractory equipment, these machines feature the simple and proven Genuine Piccola technology and single-bolt clamping system and are offered with a heavy-duty hydrostatic drive train, direct drive air, or electric motor. Blastcrete also manufactures wet-shotcrete pumps and mixer/pump combinations for various high-volume shotcrete installations and

Blastcrete's AA020 gunite machine features proven Piccola technology for precise, effective operation

The MX-10 is a high-pressure, swing-tube style pump primarily for refractory shotcrete and pump cast applications

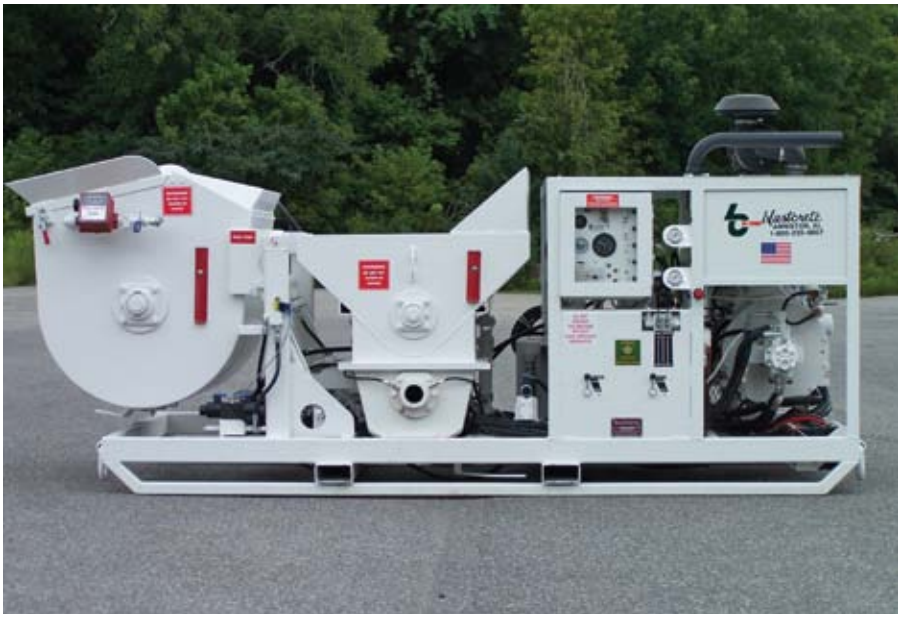
Corporate Member Profile

Featuring a low-profile configuration, the Mine Mate is ideal for underground wet process shotcrete applications

lower-volume concrete repair applications. Their low-pressure squeeze pumps are designed for wet-mix shotcrete applications with 150 ft (45.7 m) and their ultra-high-pressure swing-tube pumps are designed to pump low-slump 0.5 in. (12.7 mm) aggregate shotcrete mixtures extreme distances.

Commercial/Residential

From gypsum flooring to epoxy grouting, Blastcrete provides the industry standard in self-contained mixer/pump combinations for commercial applications, including high-rise construction, flooring underlayments, and various concrete repair jobs. The residential application equipment is designed for block fill, grouting, slabs, pools, plaster, stucco, and concrete repair applications. The commercial and residential equipment includes dry-process gunite machines, both high-pressure and variable speed pumps, and mixer/pump combinations.



The ultra high-pressure RMX-5000 is designed for pumping stucco and shotcrete material long distances

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Top Ten Sustainability Benefits of Shotcrete

The United States Green Concrete Council's (USGCC) book, *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 listed advantages. Previous discussion of advantages from past issues can be viewed on the ASA Web site at **www.shotcrete.org/sustainability**.

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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** (see below).
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.

Complex Shapes Require Very Little—If Any—Formwork

One of the major benefits of the shotcrete process is that it can be sprayed in place on vertical and overhead surfaces without the need for forming. Most conventional formed and placed concrete uses flat-surfaced shapes, as these are by far the easiest to form. Curved or even just tapered sections may be used in form and cast work, but the formwork is much more expensive to construct in terms of time, labor, and materials.

Using shotcrete allows total flexibility in the finished shape and surface treatment. Variable thicknesses, curves, or virtually any combination of shapes are readily available to the designer to produce the most efficient structure possible with the least amount of materials. Shotcrete construction of structurally efficient, yet complex shapes often provides the added benefits of reduced formwork, quicker completion, and reduced project costs. This is a primary reason shotcrete is routinely used for free-form pools, faux-rock surfaces for fountains and zoo enclosures, and continuously tapered walls for liquid storage concrete tanks. Also, as the finished shotcrete surface is evident immediately when placed, there is no question what the final finish will look like. The finish is limited only by the creativity of the architect or engineer and the talents of the shotcrete contractor.

In dry-process shotcreting, the material is conveyed through the hose in a dry or damp state and water is added at the nozzle. The resulting water content is much lower than one would find in normal conventionally placed concrete. The dry-process shotcrete is gunned in place in what is essentially a zero-slump, pneumatically placed concrete. The shotcrete adheres to both the vertical and overhead surfaces, and because of this, it can be easily gunned in place to conform to complex shapes. The same is true for the wet process, where the shotcrete is pumped and air is added at the nozzle to accelerate the concrete mixture with a high velocity into place. With the wet process, you will have a somewhat higher water content because the material must be of a flowable consistency to be pumped, so accelerators are commonly used. Nonetheless, it conforms to the shapes where it is spray-applied. Both methods place material without the need to form or hold the material in place. This in itself is a tremendous benefit because it eliminates the additional time, labor, lumber, and other forming materials necessary in casting, containing, and supporting conventionally placed concrete.

Shotcrete allows for the quick and efficient placement of large quantities of material. In past years in the steel industry, Treadwell ladles—commonly referred to as "torpedo" or "submarine" ladles—were gunned a few times a week. These are long, tapered, football-shaped ladles mounted on railcars that are used to convey molten iron from blast furnaces to BOF shops. The Treadwell ladles required approximately 20 tons (18 metric tons) of refractory to line and were typically gunned in less than 5 hours. No forming or forming materials were necessary for the shotcrete installation, and the refractory material was gunned in place to conform to the unusual internal shape.

Because shotcrete is sprayed in place, it can easily be placed over irregular shapes and surfaces to simulate natural rock formations. In pool and spa construction, shotcrete is often placed in rounded or kidney shapes. As long as there is a solid surface to shoot against, shotcrete can easily conform to any shape. Building forms for irregular shapes is inordinately labor-intensive and time-consuming and requires a great deal of custom, highly skilled handwork. Lumber, bracing, and support systems also become necessary in forming-and-pouring operations with conventionally placed concrete. Shotcrete is routinely used in concrete repair applications to gun round- or oval-shaped bridge piers for overhead arches, in tunnels and sewers, in domes, and on irregular rock surfaces in slope stabilization or mining operations.

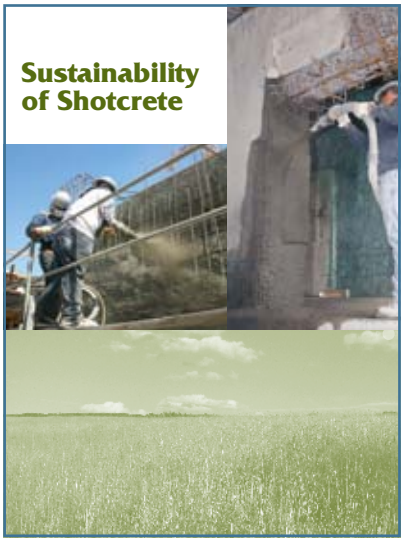
Sustainability of Shotcrete

Sustainability continues to grow as a driving force in the decision making of Owners and Specifiers regarding construction materials and placement strategies. "Sustainability of Shotcrete" is a timely and valuable resource to promote the shotcrete process and educate potential clients and owners. The document can also be submitted with project bids to identify and substantiate the sustainability advantages of the shotcrete process.

This 10-page, full-color brochure identifies and discusses the numerous shotcrete sustainability advantages and also includes case studies demonstrating these 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 (USGCC) book titled *The Sustainable Concrete Guide—Applications*. The full book can be ordered from **www.concrete.org**.

Copies of "Sustainability of Shotcrete" can be ordered from the ASA Web site at **www.shotcrete.org** or by calling 248-848-3780. For orders outside of North America, please contact ASA directly.



Order Code: SUSTAIN
ASA Members: $4.95
Nonmembers: $6.95

The brochure is also sold in bundles of 10
ASA Members: $39.95
Nonmembers: $54.95

The brochure is also sold in bundles of 25
ASA Members: $69.95
Nonmembers: $99.95

In industrial applications, shotcrete is used for gunning refractory linings in vessels, steel ladles, round electric furnaces, smokestacks, ductwork, and in cylindrically shaped cyclones. There are tube penetration areas in power plants where it isn't feasible to form and pour and where shotcrete provides the only viable method of installing refractory materials. Imagine the additional labor and material costs involved in trying to form and pour 36 cone-shaped burners inside a power plant boiler. With shotcrete, there is no need to custom-cut, -fit, and -form each burner; there is no need to purchase the lumber and build the forms. The shotcrete can be sprayed and contoured to fit the receiving surface; an additional benefit is that any variance in the burners and burner tube spacing can be adjusted with a little more or a little less material.

Sustainability is about conserving resources and eliminating waste in materials, transportation, and labor. When you can remove the forming of complex shapes from the project, many additional benefits go with it. If complex shapes require triple or quadruple the labor to form and cast, then being able to shotcrete the material in place without having to build forms becomes even more important. Reduction of transportation is another sustainability benefit. Eliminating forming materials removes the costs and carbon footprint in the production of the lumber—from tree-cutting and transporting to the lumber mill and distributors and, ultimately, to the job site, not to mention the waste and disposal of the forming materials after the project is completed. There are greater demands for sustainability than ever before and we need to make the most of our available resources. The phrase "time is money" is as relevant today as it ever was, and innovative designs and construction methods that improve efficiency are becoming more and more important to explore.

Shotcrete is Concrete

So Why Choose Shotcrete?

Speed

Versatility

Cost Savings

The shotcrete process offers many advantages over other methods of placing concrete—from construction speed and labor and formwork savings, to the ability to construct complex shapes without extensive structural formwork and complex application by hand.

With shrinking project margins and growing quality demands, shotcrete is an attractive and structurally-equivalent option for new construction and rehabilitation. Find out why a growing number of specifiers, designers, and contractors choose shotcrete.

AMERICAN SHOTCRETE ASSOCIATION

Visit www.Shotcrete.org

Education and Certification
Technical Questions and Answers
Demonstrations
Buyers Guide

AMEC Strengthens Position in U.S. Market and Rebrands Business Unit

AMEC, an international engineering and project management company, announced in June that it has rebranded the Earth & Environmental business unit to Environment & Infrastructure (E&I) to better reflect the services and scope of the current business and its global growth strategy. This follows the completion of the MACTEC acquisition, which adds 2600 people and 70 offices to E&I's U.S. presence. Headquartered in Alpharetta, GA, the E&I business unit is made up of more than 7000 employees worldwide and is led by President **Dr. Hisham Mahmoud**. **Ann Massey**, the former President and CEO of MACTEC, is staying on as Director of Global Business Lines for E&I, reporting to Mahmoud.

Massey will play a key role in E&I's global growth strategy. "I am excited to be a part of the AMEC organization and look forward to build upon a strong and comprehensive global platform of clients and services," said Massey.

"Our increased scale in the U.S. market will significantly enhance our competitive position and provide more resources to our clients and opportunities for our people," said Mahmoud. "The MACTEC acquisition and rebranding of the business has been very well-received by our clients and employees."

King Packaged Materials Company Expands Facilities

King Packaged Materials Company (King), a leading manufacturer of prepackaged shotcrete mixes for the North American civil construction and mining and tunneling industries, is pleased to announce the acquisition of a new property and building located in the Montréal, QC, Canada, suburb of Boisbriand. This new facility will be designed with the latest technology in packaging equipment, which will increase production capacity and allow King to better serve the North American shotcrete industry. According to King Vice President **Joe Hutter**, "The new location will provide a substantial increase in property and the existing structure will provide a significant increase in space for production and inventory." The design and construction of the new production lines is underway and the new Boisbriand facility is currently scheduled to be fully operational by spring 2012.

Frontier-Kemper Has New Shareholder: Tutor Perini Corporation Acquires 100% of FKCI Stock from Deilmann-Haniel International

Tutor Perini Corporation has acquired 100% of the stock of Frontier-Kemper Constructors, Inc., from Deilmann-Haniel International Mining and Tunneling GmbH. Tutor Perini is a Massachusetts corporation with headquarters in Sylmar, CA, and is a leading civil and building construction company offering diversified general contracting and design-build services to private clients and public agencies throughout the world. Tutor Perini has provided construction services since 1894 and had $3.2 billion in revenue in 2010.

Frontier-Kemper will operate as a subsidiary of Tutor Perini Corporation and will continue to operate in the underground construction and mine development markets. The acquisition of Frontier-Kemper will allow Tutor Perini to expand and grow its presence in the underground construction market. Frontier-Kemper had $148 million in revenue in 2010 and currently has $290 million in backlog.

Frontier Kemper management views this as an exciting and positive step forward and welcomes their new shareholder. Frontier-Kemper also thanks DHI International Mining and Tunnelling GmbH and its parent company Aton GmbH for all their support over the last 5 years.

Palmetto Gunite Participates in Industry Effort to Assist Laval University Shotcrete Research

Contractors and engineers have known for many years that shotcrete is somewhat different than conventional cast-in-place concrete. The materials are very similar; however, the properties that influence durability, performance, and longevity have been observed to be divergent between the two methods of placement. There have been several studies exploring these properties and the performance of shotcrete. Much of this research has been performed at Laval University in Quebec, Canada. A search of authors on these subjects would yield names such as Hugo Armelin, Marc Jolin, Nemkumar Banthia, Denis Beaupré, Marc Bissonette, and Louis-Samuel Bolduc, among others. Indeed, the research provided by these authors has molded our current understanding of shotcrete as we know it today. Today, the work of graduate students, such as **Patrick Power**, continues to advance the frontiers of shotcrete research.

Patrick Power is currently pursuing his master's degree at Laval under the tutelage of **Dr. Marc Jolin**, a recognized expert who has had worldwide acknowledgment of his past work in the study of shotcrete. As part of his research, Power is exploring the relationship between shooting parameters during shotcrete placement, the mixture design of the material, and the ultimate durability of the final in-place shotcrete. An important characteristic in this material is the air-void system within the cement paste matrix—specifically the compaction voids—which display different transport properties than smaller voids present within the matrix.

At the spring 2011 meeting of ACI Committee 506, Shotcreting, held in Tampa, FL, a short presentation was given by Jolin and one of his students. At the conclusion of the presentation, Jolin expressed a need to obtain material samples from around the U.S. and Canada to give the research a greater reach as it explored the aforementioned properties. Specifically, these differing materials could help determine the influence of similar yet different base components used in shotcrete.

The result of this request was the shipment of materials from various locations, including samples from the coastal area of


Patrick Powers


Marc Jolin


Will Snow

South Carolina. In July 2011, two employees of Palmetto Gunite Construction Co., Inc., drove a shipment of sand and portland cement from Ravenel, SC, to Quebec City. **Will and Robert Snow** delivered the materials to Laval and stayed for a week to assist in conducting some of the testing. Will Snow, President and CEO of Palmetto Gunite Construction Company, Inc., is an ACI Certified Nozzleman and used the skills learned in the field to prepare several samples to be tested later. Robert Snow also shot panels in the lab at the direction of the students conducting the research.

Other contractors from around the U.S. also sent samples of materials and finished shotcrete samples to be tested at the research laboratory. These samples will be studied at fixed airflow/distance combinations representative of the industry. The durability of these samples will then be studied using STADIUM®, a comprehensive numerical model adapted to concrete durability analysis developed by SIMCO Technologies. The results of these efforts will provide representative data from across North America in both dry- and wet-mix shotcrete in an effort to better understand the factors contributing to the durability of shotcrete.

"Members of the construction community can look forward to seeing the results of this research in the near future. The industry can further look forward to continuing research into shotcrete material from Laval University as it leads the world in studies of this type," said Will Snow. "Although this is the first project of this type that Palmetto Gunite has participated in, we look forward to continuing this relationship between industry and academics as we learn more about the materials we work with every day."

EFNARC Keeps Acronym but Changes Name

At a recent general assembly, members decided to change the description of EFNARC to Experts for Specialised Construction and Concrete Systems to reflect its greater international appeal and reduced interest in construction chemicals. EFNARC's name originates from its earlier role as the European Federation of National Association representing producers and applicators of specialized building products for concrete.

EFNARC is a nonprofit organization founded in 1989 and is currently comprised of 11 members—10 company members and one associate member from Europe, Asia, and Australia. EFNARC's current focus is underground construction technology, particularly in relation to sprayed concrete, having launched the Nozzleman Certification Scheme in September 2009. EFNARC's Nozzleman Certification Scheme is limited to wet, robotic-sprayed concrete for rock support. The scheme is not a training course for nozzlemen, as they are expected to have a high level of competence before applying. The program currently has 23 examiners and 26 certified nozzlemen.

Construction Unemployment Drops to 15.6% in June, ABC Says

Associated Builders & Contractors, Inc., (ABC) has reported that despite a loss of 9000 jobs in June, the construction industry's unemployment rate has dropped to 15.6%—the lowest

level since December 2008, according to the July 8 employment report by the U.S. Labor Department.

The construction industry has added 2000 jobs compared to the same time last year.

Construction Spending in U.S. Climbs for Third Straight Month

Construction spending in the U.S. rose in June 2011 for a third consecutive month, led by a gain in nonresidential building, including factories, communications plants, and commercial structures.

The 0.2% increase followed a revised 0.3% gain in May that was previously reported as a drop by the U.S. Commerce Department. In a Bloomberg News survey, economists projected a median estimate of a 0.1% increase.

Industry Personnel

Nick Chen to Manage AECOM's North America Tunneling Practice

Nick Chen

Nick Chen, PE, has joined AECOM, a leading provider of professional technical and management support services for government and commercial clients around the world, as Vice President and Manager of its North America Tunneling practice.

Located in Boston, MA, Chen will lead management and support responsibilities for clients located throughout the U.S. and Canada. Chen, a renowned tunneling specialist with over 30 years of experience, is an expert in developing innovative cost-saving construction methodologies and is a pioneer in applying synthetic fiber-reinforced shotcrete as permanent lining of underground facilities, including tunnels, shafts, and caverns. His specific areas of expertise include the design and construction of hard-rock and soft-ground tunnels, deep excavation supports, cut-and-cover tunnels, and bored tunnels.

Prior to joining AECOM, Chen served in an executive position with another large engineering consulting firm, where he was responsible for winning and delivering underground projects for a team of 200 engineers. Chen is currently a member of American Concrete Institute (ACI) Subcommittee 506-F, Shotcreting-Underground, and is an identified tunnel/underground transit safety and security expert for the NI2 Center for Infrastructure Expertise Critical Infrastructure Library.

AECOM is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water, and government. With approximately 45,000 employees around the world, AECOM serves clients in approximately 125 countries and delivers solutions that create, enhance, and sustain the world's built, natural, and social environments.

King Packaged Materials Company Announces Promotions

King Packaged Materials Company has been a leading manufacturer and supplier of shotcrete materials and related equipment for the North American shotcrete industry for over 20 years. A key to this success has been a strong technical staff, whose unique blend of shotcrete materials technology expertise and knowledge of shotcrete equipment operation has led to continued growth of their shotcrete materials and equipment business. This growth has resulted in the restructuring and expansion of the King Packaged Materials technical team, leading to the following appointments.

Scott Rand

Scott Rand has been promoted to Sales Manager, Civil Markets. In this new position, Rand will oversee the continual development of King's North American civil construction markets.

Dave Sawyer

Dave Sawyer has been promoted to Technical Sales Representative. Sawyer will be responsible for the sales and promotion of King's line of shotcrete products throughout southern Ontario, Canada, and the U.S. Midwest.

Philip Sawoszczuk Jr.

Philip Sawoszczuk Jr., Eng., has been promoted to Technical Services Representative. Sawoszczuk received his Bachelors of Civil Engineering from McGill University, Montréal, QC, Canada, in 2009 and will be working as a member of King's growing technical support team.

William Clements

William Clements, MASc, EIT, has been promoted to Technical Services Representative. Clements received his Masters of Applied Science, Honors, Civil Engineering from The University of Windsor, Windsor, ON, Canada, in 2010, and will also be working as a member of King's growing technical support team.

Shotcrete Calendar

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

Scheduled in Room C-201:

8:00 am-9:00 am	ASA Sustainability Committee
9:00 am-10:00 am	ASA Pool & Recreational Shotcrete Committee
10:00 am-11:00 am	ASA Education Committee
11:00 am-12:00 pm	ASA Underground Committee
12:00 pm-12:30 pm	Lunch
12:30 pm-1:00 pm	ASA Safety Committee
1:00 pm-2:00 pm	ASA Publications Committee
2:00 pm-4:00 pm	ASA Marketing & Membership Committee

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 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**

OCTOBER 31-NOVEMBER 4, 2011
The National Bridge Management, Inspection, and Preservation Conference
Theme: "Inspecting, Managing, and Preserving the Nation's Bridges Beyond the Short Term"
Millennium Hotel St. Louis
St. Louis, MO
Web site: **www.tsp2.org/nationalbridge2011**

NOVEMBER 2, 2011
ASA Outreach Forum: Pool & Recreational Shotcrete
Mandalay Bay Convention Center
Level 3; Room: Jasmine E
Las Vegas, NV

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

JANUARY 12-13, 2012
Shotcrete 2012 Conference and Exhibition
Conference Language: German. English summaries of all presentations will be available. Some presentations will be in English.
Alpbach, Tyrol, Austria
Web site: **www.spritzbeton-tagung.com**

JANUARY 23, 2012
ASA World of Concrete Annual Committee Meetings
Las Vegas Convention Center
Las Vegas, NV

JANUARY 24, 2012
ASA Outstanding Shotcrete Project Awards Banquet
Paris Las Vegas Hotel & Casino
6:00 pm-11:00 pm
Las Vegas, NV
See page 58 for details

JANUARY 24-27, 2012
World of Concrete
Seminars: January 23-27
Exhibits: January 24-27
Las Vegas Convention Center
Visit ASA at booth #S10749
Las Vegas, NV
Web site: **www.worldofconcrete.com**

JANUARY 25, 2012
WOC Seminar: The Diversity of Shotcrete as a Method of Concrete Placement
8:30 am-10:00 am
Las Vegas Convention Center
Las Vegas, NV
Web site: **www.worldofconcrete.com**

MARCH 17 AND MARCH 19, 2012
ASA Spring Committee Meetings
Hyatt Regency
Dallas, TX

MARCH 18-22, 2012
ACI Spring 2012 Convention
Theme: "The Art of Concrete"
Hyatt Regency
Dallas, TX
Web site: **www.concrete.org**

ASA Hires Program Coordinator


Alice McComas

ASA was very excited in late May to welcome Alice L. McComas to the staff. Alice is filling the newly created position of Program Coordinator.

The Program Coordinator is responsible for overseeing the daily operation of all ASA programs and assisting in the establishment and development of new programs, resources, and opportunities for ASA and the shotcrete industry.

Possessing both a Bachelor of Arts from the State University of New York at Buffalo and a Master's of Science from Cornell University, Alice brings a wealth of experience and expertise to the ASA team.

ASA Fall 2011 Committee Meetings in Cincinnati, OH, October 15

The ASA Fall 2011 committee meetings in Cincinnati, OH, will be held at the Duke Energy Convention Center on October 15, 2011, in Room C-201.

8:00-9:00 a.m.	Sustainability Committee
9:00-10:00 a.m.	Pool & Recreational Shotcrete Committee
10:00-11:00 a.m.	Education Committee
11:00 a.m.-12:00 p.m.	Underground Committee
12:00-12:30 p.m.	Lunch
12:30-1:00 p.m.	Safety Committee
1:00-2:00 p.m.	Publications Committee
2:00-4:00 p.m.	Marketing & Membership Committee
4:00-6:00 p.m.	Board of Direction

ASA meetings are open and free to anyone who is interested in the shotcrete process and offer participants the opportunity to network with colleagues, provide input on shotcrete materials and publications, and contribute to ASA's overall mission.

ASA Outreach Forum during the International Pool | Spa | Patio Expo in Las Vegas

Please make plans to attend the ASA-sponsored outreach forum, inviting the pool industry to participate in a discussion of what needs/opportunities can be met by ASA.

The forum will be held during the International Pool | Spa | Patio Expo in Las Vegas, NV, in Jasmine E on Level 3 of the Mandalay Bay South Convention Hall on Wednesday, November 2, 2011, at 5:00 p.m. Pacific time. There is no cost to attend the forum and all interested parties are encouraged to attend.

ASA Pool & Recreational Shotcrete Committee Chair Bill Drakeley will lead the discussion and explore topics such as ASA education efforts, nozzleman certification, and other resources that could assist pool building contractors. The meeting will also offer an opportunity to discuss the advantages of shotcrete and different applications regarding watershapes other than pools with which shotcrete/gunite contractors can realistically get involved.

"We are basically going to those in the industry that use the shotcrete/gunite process and asking them what they want ASA to be for them," noted Drakeley. "This is a great opportunity for both the industry and ASA to refocus/repurpose a resource that will truly serve the needs of the industry for years to come."

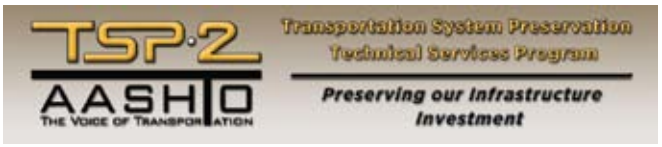
ASA to Attend and Exhibit at the TSP-2 National Bridge Management, Inspection, and Preservation Conference, St. Louis, MO

The Transportation Systems Preservation Technical Services Program (TSP-2) is an organization within AASHTO that was formed to provide state highway agencies (SHAs), provincial departments of transportation, and other pavement and bridge preservation practitioners with a source for news and technical information on a wide range of system preservation-related issues.

In June 2011, ASA became a national industry member of the Bridge Preservation arm of TSP-2. The membership entitles ASA to participate in and exhibit at the organization's regular meetings.

This organization provides ASA with a platform to educate Public Authorities about shotcrete and an opportunity to understand their questions and needs.

The conference will run from October 31 to November 4, 2011. To register for the upcoming conference and/or for more information on TSP-2, visit its Web site at **www.tsp2.org**.



Register Free for World of Concrete 2012 and Help Support ASA Efforts to Grow Your Business

As a sponsor of World of Concrete, ASA benefits financially from every complimentary show registration made using ASA's A17 code. That financial assistance enables ASA to play a prominent role in promoting and growing the use of shotcrete. To take advantage of our free registration to World of Concrete while helping ASA grow your potential market, visit **www.shotcrete.org** or **www.worldofconcrete.com** and register using code A17. Please offer this free registration to your customers as well!

Shotcrete at World of Concrete 2012—Exhibit, Seminar, and Meetings

ASA will once again be promoting the exceptional benefits of shotcrete at World of Concrete 2012 in Las Vegas, NV, January 18-21, 2012. Please plan on visiting us at our expanded booth #S10749 in the South Hall.

In addition, ASA will be conducting a 90-minute seminar titled "The Diversity of Shotcrete as a Method of Concrete Placement" on Thursday, January 26, 2012, from 1:30 to 3:00 p.m.

ASA will once again hold committee meetings all day on Monday, January 23, 2012. These meetings will include the Annual Membership Meeting. Check the calendar at **www.shotcrete.org** for a full meeting schedule.

World of Concrete continues to provide excellent opportunities to showcase the numerous versatility, sustainability, and quality advantages of the shotcrete process.

ASA Cosponsors Concrete Industry-Wide Vision 2020 Repair Workshop

ASA, along with the International Concrete Repair Institute (ICRI) and the Association of Concrete Contractors (ASCC), cosponsored a Vision 2020 Repair Workshop in Chicago, IL, on September 20, 2011.

Next year—2012—will mark the halfway point for Vision 2020 since its original introduction in 2004. The Strategic Development Council's (SDC's) Vision 2020 team has been reviewing and working to update the goals of Vision 2020 with an eye on re-releasing an updated document that will serve to re-energize and re-focus the initiative.

A Vision 2020 workshop was the next step in this effort and predominantly focused on two new goals added to Vision 2020: Branding & Promotion (Goal #14) and Sustainability (Goal #15). The workshop was held in conjunction with the Fall SDC #30 meeting, with additional workshop breakout sessions held the following day. This was the first of two workshops, with the next scheduled for spring 2012.

A PDF version of the original "Vision 2020—A Vision for the Concrete Repair, Protection, and Strengthening Industry" document can be downloaded from the SDC Web site at **www.concretesdc.org**.

ASA Exhibits and Speaks at 2011 International Bridge Conference

For the third straight year, ASA had a manned booth at the 2011 International Bridge Conference (IBC) in Pittsburgh, PA. The 2011 IBC show proved again to be an exceptional opportunity for ASA to reach federal, state, and local agency specifying personnel.

In addition, ASA conducted three sessions in the show's exhibit floor theater. The session topics included shotcrete specifications, shotcrete repair (infrastructure focus), and department of transportation (DOT) case studies.

ASA Introduces New Shotcrete Specifiers Education Tool

ASA has introduced a new product supplied on a 4 GB USB memory stick titled the "Shotcrete Specifiers Education Tool." The USB tool is designed to provide specifiers with a better understanding of the shotcrete process. Included among the large collection of information are two PowerPoint presentations titled "Shotcrete Repair and Rehabilitation of Concrete Structures" and "Shotcrete for Underground Construction."

Copies of the new tool can be ordered from ASA's Web site at **www.shotcrete.org**.

ASA Introduces Online Bid Submittal Tool

ASA has created a free tool to allow owners and specifiers to submit their projects for a bid request to ASA's corporate members. ASA corporate members have the skill, knowledge, and experience that uniquely qualify them to offer the exceptional benefits of the shotcrete process.

This new tool will provide an important resource to the construction industry while providing another important benefit of ASA corporate membership.

The bid submission tool can be accessed at **www.shotcrete.org/projectbidrequest.aspx**.

- *Architectural*
- *Infrastructure*
- *International Projects*
- *Pool & Recreational*
- *Rehabilitation & Repair*
- *Underground*

Seventh Annual Outstanding Shotcrete Project Awards Banquet

Paris Las Vegas Hotel and Casino

Versailles Ballroom

Tuesday, January 24, 2012

6:00 – 7:30 p.m. Registration, networking, cocktails, and hors d'oeuvres
7:30 – 11:00 p.m. Plated dinner and awards ceremony
Further networking and cash bar available after the awards ceremony







AMERICAN SHOTCRETE ASSOCIATION

Seventh Annual Outstanding Shotcrete Project Awards Banquet

Registration Form

Join us in celebrating another year of membership success and in recognizing our project award recipients. Submit one form per attendee by December 28, 2011.
We look forward to seeing you in Las Vegas!

Banquet Information:

Location: Paris Las Vegas
Versailles Ballroom

Date: Tuesday, January 24, 2012
6:00 – 7:30 p.m. Registration, networking, cocktails, and hors d'oeuvres
7:30 – 11:00 p.m. Plated dinner and awards ceremony

Attendee Information:

❑ Register me for the ASA Seventh Annual Outstanding Shotcrete Project Awards Banquet....$80.00

Name _____ Company _____

Address _____

City _____ State _____ Zip _____ Country _____

Phone _____ Fax _____

E-mail _____

On-site registration is required after December 28, 2011, and increases to $95.00 per attendee.
Online registration is now available! Visit **www.shotcrete.org**.

Payment Information:

❑ Check (U.S. $) ❑ MasterCard ❑ Visa ❑ Cash

Credit Card # _____ Exp. Date _____

Name on Card _____

Signature _____

Become an ASA Banquet Sponsor:

❑ "Big Shooter"—$5000.00 ❑ Platinum—$2500.00

❑ Gold—$1000.00 ❑ Silver—$500.00

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

Shotcrete FAQs

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

Question: *Can shotcrete be applied on wet shale rock? How well does Shotcrete bond to shale?*

Answer: Shotcrete is routinely used to seal shale after excavations. It is typically done as soon as possible after the excavation because the shale will deteriorate when exposed to the air. When shotcreting, it is considered good practice to wet the receiving surface prior to gunning to create a saturated surface-dry (SSD) condition so the substrate will not draw moisture from the newly placed shotcrete. A good SSD condition is where the surface is wet without any standing water on it. Gunning over wet shale should not be a problem unless the water seeping from the shale is moving. If that is the case, we would recommend installing weep holes with plastic pipe at the locations where the water is seeping from and using an accelerator to flash-set the material immediately around the weep-hole pipe. It is also a good idea to install weep holes at regular intervals along the excavation or exposed hillside.

It is important to use a qualified shotcrete subcontractor for this or any high-quality shotcrete installation. A qualified shotcrete contractor will use ACI-certified nozzlemen and should provide you with a résumé of similar, successfully installed projects, along with the up-to-date contact information of representatives from the owners or engineers involved in those projects. The ASA Buyers Guide (**www.shotcrete.org/buyersguide**) is an excellent source of shotcrete contractors.

Question: *We are removing up to 0.75 in. (19 mm) of the existing scaled concrete on a fire-damaged concrete wall. The architect has asked if shotcrete is applicable for a vertical 0.75 in. (19 mm) application. Also, the walls are circular and the working distance from the wall is no more than 36 in. (0.9 m). Is this enough room to apply shotcrete?*

Answer: Yes, shotcrete can be applied in a 36 in. (0.9 m) area. Keep in mind, however, that it's difficult to get as nice a gunning pattern as you would like when you are that close to the receiving surface. When you cannot back off from the wall, there is a tendency for a more irregular gunning surface, which would require more cutting and screeding to get an aesthetically pleasing result.

Question: *I would like advice about spraying shotcrete on the exterior walls of a house I am building. In constructing the exterior walls of the house, I plan to shoot approximately 0.75 in. (19 mm) on Day 1 and shoot 1.25 in. (31 mm) on Day 2 for 2 in. (50 mm) thick walls. I have hung 14-gauge wire mesh spaced at 1 in. (25 mm) over all the walls and am planning to use a 3000 psi (20.7 MPa) mixture.*

I am greatly concerned about cracking. Is my planned technique a good way to mitigate cracking or are there better approaches? Should I consider upping the strength of the concrete?

Answer: It is fine to place shotcrete in two layers on 2 consecutive days, although simply placing two layers on 2 consecutive days won't prevent long-term drying shrinkage cracking. For the best bond, the surface of the shotcrete on Day 1 should be given a rough broom finish to provide a rough texture for the Day 2 shotcrete to bond to. On Day 2, before shooting, wet the surface of the Day 1 shotcrete to prevent a hot, dry surface from absorbing water from the fresh shotcrete. **Please** note that the surface needs to be dampened but allowed to dry to an SSD condition. A surface that is too wet can inhibit good bonding. It is essential to moist-cure the shotcrete as soon as it has finally set to help reduce early-age shrinkage cracking. On a hot, windy day, you may need to fog the surface soon after placement with a pressure washer using a fogging nozzle to reduce the rapid evaporation of water from the surface of the shotcrete. Wet curing with a wetted burlap overlay or drip system for at least 3 days (preferably 7 days) is recommended to help reduce the potential for longer-term drying shrinkage cracking.

Using macrosynthetic fibers in the shotcrete mixture will also help reduce early-age shrinkage cracking. Because you are in Florida, unless you are shooting in the dead of winter, you may also want to consider using a concrete mixture with up to 20 to 25% fly ash. This will slow down the hydration of the cement and resultant set time to give you some more time to finish the surface and get proper curing started. Fly ash also helps reduce the concrete permeability and increases the long-term strength and is generally less expensive than portland cement. If you use a concrete mixture with silica fume (also called microsilica), it will increase the water demand of the mixture during hydration and has a greater tendency for early-age plastic shrinkage cracks. Thus, if you use silica fume, you will need to pay close attention to keep the surface wet through fogging and then wet curing as soon as it is practical.

As previously mentioned, a 2 x 2 or 3 x 3 in. (50 x 50 or 75 x 75 mm) wire mesh would be preferred to reduce congestion of the reinforcement. Stay away from rolled mesh, as it is very difficult (even nearly impossible) to get to lay flat. Sheets of welded wire mesh are recommended. ASA recommends a minimum 28-day compressive strength for shotcrete of 4000 psi (27.6 MPa). A 3000 psi (20.7 MPa) mixture will have a higher water-cement ratio (*w*/*c*); therefore, there is more water in the mixture, which will significantly increase the potential for drying shrinkage cracking in the final surface. A 4000 psi (27.6 MPa) mixture is easily achieved with current portland cements and normal supplemental cementitious products such as fly ash.

Finally, you mentioned that you will be shooting the surface of a house. You haven't provided any details about what you are shooting the shotcrete on, but the substrate must be rigid enough to not vibrate when shotcrete hits the surface. If it is not rigid enough, the vibration of adjacent areas of freshly shot plastic shotcrete could cause cracking. This would be more of a problem in the Day 1 coat of shotcrete, but cracks that form in the Day 1 shotcrete would create a weaker section and increase the likelihood of mirrored cracking in the Day 2 layer.

Again, please note: While it is appropriate to wet down the Day 1 shotcrete prior to application of the Day 2 shotcrete, it is important to let the wetted Day 1 shotcrete dry back to an SSD condition before application of the Day 2 shotcrete. If the Day 2 shotcrete is applied to a wet substrate (with liquid water on the surface), it will fail to meet the specified 150 psi (1 MPa) bond pulloff strength requirements for the project.

Question: *What are the requirements for selection of the shotcrete lift height and delay between successive layers? ACI 506R describes only a general approach.*

Answer: Although some have tried, there are not and should not be specific recommendations for lift height or time between lifts of layers. Shotcrete is a method of placing concrete, and concrete properties vary with many parameters, such as admixtures, ambient temperature, concrete temperature, slump, and age of concrete, to name a few. The lift height is also influenced by the surface on which you are shooting (rough, porous, smooth, dense, and so on); the orientation being applied (vertical, sloped, or overhead); and the size and density of the reinforcing steel, if it is present. Regardless of the period of time between lifts or layers, the receiving surface must be clean and moisture-conditioned to create a good bond between lifts or layers. As you can see, there are too many variables to spell out recommended guidelines or rules of thumb for lift heights or time between lifts or layers.

The goal is to place the lifts or layers in heights or thicknesses that do not slough or sag. The time between lifts or layers is the time required for the initial lift or layer to support the subsequent lift of layer. These decisions must be made on the job on a daily and hourly basis by a properly trained and experienced nozzleman and shotcrete foreman. These decisions may vary during the day to meet the current situation.

It is critical that the shotcrete is placed by a shotcrete contractor with trained and experienced crews who is experienced and successful in the type of work being installed.

Question: *We want to shotcrete a porous rock wall to stop water leakage out of a small pool that is home to an endangered fish. The wall is quite rough and uneven. The pool will be drained to do the work. How long should we allow the concrete to cure before refilling the pool with water? Does this sound like a good application for shotcrete?*

Answer: This is a great application for shotcrete. Once drained, the existing surfaces should be cleaned by water blasting or sandblasting to provide a good bonding surface. The shotcrete can be submerged within a few hours or upon reaching the final set (hardened). One factor to be concerned about is the chemical reaction and alkalinity of the area around the shotcrete during the curing period. A good solution would be to submerge the pool for a period of at least a week, drain and waste the water, flush the shotcrete surfaces, refill the pool, and test the pH before reintroducing the fish. This should eliminate the danger of the alkalinity to the fish.

Question: *Can you provide any information or research on the sound absorption performance of shotcrete?*

Answer: We are not aware of any testing done specifically for the sound absorption performance of shotcrete. Shotcrete is a method of placing concrete and, once hardened, it should have similar parameters as cast concrete. With shotcrete, one has the ability to use many different finishes, which might influence the sound absorption characteristics. A smooth troweled shotcrete wall would be the most similar to a formed cast-in-place wall. On the other end of the spectrum, a nozzle-finished wall would likely absorb far more sound. A recent design of a concert hall at a major university was to be built with oval concrete or shotcrete perimeter walls covered with fabric curtains for sound purposes. The ceiling was to be suspended nozzle-finished shotcrete.

Question: *We are rehabilitating a limestone-brick masonry storm sewer by lining it with shotcrete. The sewer is approximately 7 ft (2.1 m) tall with an arch ceiling and walls that are 8 ft (2.4 m) apart. The limestone surface is fairly rough, but the brick portions are not. While the existing structure shows no signs of needing to be reinforced for structural support, we are reinforcing to prolong the service life of the culvert. Is there a recommended minimum shotcrete thickness and reinforcement?*

Answer: Shotcrete has been used to successfully rehabilitate sewers for over 50 years.

The thickness to be used is an engineering issue and beyond the scope of our association. We would recommend a 2 in. (50 mm) minimum thickness reinforced with either polypropylene fibers or a light-gauge welded wire reinforcement. The surfaces must be cleaned thoroughly to remove grease, oils, and other substances deleterious to good bond. Bonding to brick is not a problem.

Finish is another consideration. The added liner thickness will reduce the size of the culvert. If capacity is not an issue, it is recommended to leave the new shotcrete lining with a nozzle finish. If capacity might be a problem, then a float or trowel-smooth finish may be necessary.

Allentown Shotcrete Technology 2011 Thom-Katt 20 Now in Production

Allentown Shotcrete Technology Inc. has updated and renamed the Powercreter 20, now known as the Thom-Katt 20.

"Currently in production, this version of the Thom-Katt 20 has both a larger hopper and mixer," said Patrick Bridger, President of Allentown. "These features make projects more efficient for our customers by accommodating larger amounts of material."

Ideal for mid-range pumping requirements, the 2011 model uses the Thom-Katt frame and control box.

"Because the 2011 version incorporates Thom-Katt parts, we determined it would be most efficient to move its manufacturing to Putzmeister America and include it in the Thom-Katt family," added Bridger.

Standard features of the Thom-Katt 20 include:

- A hopper capacity of 9.5 ft^3 (0.27 m^3);
- A rating of up to 17 yd^3/h (13 m^3/h);
- Maximum concrete pressure up to 2000 psi (13.8 MPa);
- A Deutz TD 2011L04i diesel engine;
- Smooth delivery and the least pulsation of any shotcrete machine available;
- Easy handling of harsh mixtures, including low cement, low moisture, and refractory pumping castables; and
- The ability to be fed by a concrete truck, on-site mixer, or optional integrated batch or continuous mixer.

For more information, call 800-553-3414 or visit **www.allentownshotcrete.com**.

Blastcrete Introduces New Mine Mate: A Highly Efficient, Low-Profile Shotcrete Pumping Machine

Blastcrete Equipment Company has introduced the Mine Mate, an innovative machine designed to mix and pump concrete material for underground mine sealing and stabilization, grouting, and various other shotcrete applications. It enhances safety in underground mining and tunneling applications and is a convenient solution when ready mixed concrete is not an option. Featuring Blastcrete's X-10 ultra-high-pressure swing-tube pump, the Mine Mate is a highly productive and reliable machine that's also easy to operate and maintain.

The Mine Mate was developed due to the request of several customers seeking a machine to apply shotcrete in underground coal applications and uses the wet-mix shotcrete process. In contrast to the dry-shotcrete (gunite) process, the wet-shotcrete process minimizes dust emissions and improves visibility, making it much safer, particularly for underground use. Featuring a compact and extremely low-profile configuration, the Mine Mate is designed for operation within a 4 ft (1.2 m) ceiling.

The Mine Mate includes Blastcrete's X-10 3 in. (76 mm) high-pressure swing-tube pump and a high-shear continuous mixer. The unit is capable of mixing and pumping 12 yd^3/h (9.17 m^3/h) and can handle aggregate up to 3/8 in. (9.7 mm) in diameter. Offering the highest piston face pressure in the industry at 2200 psi (15.17 MPa), it can pump material in excess of 500 ft (152 m) horizontally and vertically. Additionally, the hydraulic pump can run in reverse to eliminate line pressure from the delivery line should a hose plug. This is a very important safety feature in any pumping operation.

The X-10 provides easy access for cleaning and maintenance. The receiving hopper of the pump is mounted with a heavy-duty hinge so it can easily swing away from the swing-tube section. The flat pack is held in place by four heavy-duty bolts so the spare flat pack can quickly and easily be replaced. This assures that downtime will be all but eliminated. An optional hydraulic pressure washer is available for quick and easy cleaning of the mixer and the pump.

Available power options include a V3600, 66 hp Kubota water-cooled diesel engine or a 50 hp electric motor with a

starter and disconnect. The machine can also be equipped with a material screw conveyor with a bin indicator for charging the continuous mixer.

The Mine Mate's X-10 is CE certified, meeting European Union safety standards for equipment operation, and the entire unit is backed worldwide by Blastcrete's customer service and support.

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

Delta Gunite Solano Inc., Multicrete Systems Inc., and Joseph J. Albanese Launch updated Web Sites

ASA corporate members Delta Gunite Solano Inc., Multicrete Systems Inc., and Joseph J. Albanese have all updated their Web sites to better serve their customer bases. The new Web sites can be viewed at **www.deltagunitesolano.com**, **www.multicretesystems.com**, and **www.jjalbanese.com**, respectively.

All three organizations also maintain a Facebook page to keep their customer bases up to date on the latest news from their companies.

Putzmeister Increases Customer Support with 24-Hour Technical Service Hotline

Putzmeister Ibérica, Madrid, has established a 24/7 technical service hotline for emergencies, available to all customers worldwide requiring troubleshooting or technical assistance for Putzmeister equipment.

A qualified technician will be available to provide telephone assistance and support 24/7, responding to the needs of customers operating after business hours or abroad.

This additional service is available worldwide in English and Spanish by calling +34 91 428 8100.

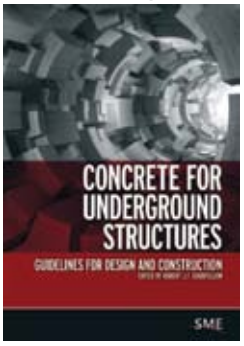
Structural Shotcrete Systems Inc. Announces New Web Site

Structural Shotcrete Systems has reported that the ideas and visual concepts for its Web site were developed around a people-focused strategy of dedication, experience, and knowledge. That strategy encompasses its existing brand and the

notions of dedication, professionalism, and abilities for which Structural Shotcrete Systems is known.

Structural Shotcrete Systems welcomes comments and looks forward to providing more news about the company and new projects in the months and years to come. The new Web site can be viewed at **www.structuralshotcrete.com**.

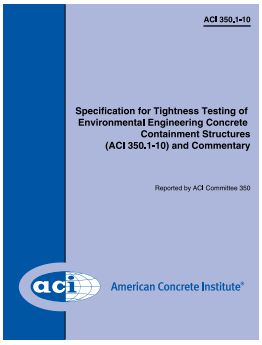
SME Releases *Concrete for Underground Structures: Guidelines for Design and Construction*



The Society for Mining, Metallurgy, and Exploration, Inc., (SME) has made a new 176-page book available titled *Concrete for Underground Structures: Guidelines for Design and Construction*. This book is a one-source guide to help readers quickly find the answers they need. This practical nuts-and-bolts handbook provides an industry voice and recommendations for areas of concrete application. Readers will get valuable insights into current best practices for all aspects of the design and construction of underground structural concrete.

Internationally respected authors examine three key applications: cast-in-place concrete, precast concrete segmental linings, and shotcrete. Each chapter addresses the differences between above-ground and underground use. The various types of concrete admixtures are also discussed, and sample specifications for each are included. *Concrete for Underground Structures: Guidelines for Design and Construction* is a valuable resource for industry veterans and an educational tool for those who are new to the profession.

ACI 350.1-10, "Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures and Commentary"



These test methods from ACI Committee 350, Environmental Engineering Concrete Structures, give procedures and criteria for the tightness testing of environmental engineering concrete structures. These are applicable to liquid and gas containment structures constructed with concrete or a combination of concrete and other materials. This document includes hydrostatic, surcharged hydrostatic, and pneumatic tests. These test methods may involve hazardous materials, operations, and equipment. This document does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations before use. Visit the ACI Bookstore at **www.concrete.org** to order.

AMERICAN SHOTCRETE ASSOCIATION

ASA Membership Benefits

	Corporate	Corporate - *Additional Individual*	Individual	Nozzleman	Employees of Public Authorities / Agencies	Student
Annual Dues	$750	$100	$250	$50	Free	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-newsletter*)	X	X	X	X	X	X
Discount on ACI Nozzleman Certification, Education and Testing	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					
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All company employees have opportunity to receive discounted Corporate Additional ASA Memberships ($150 off regular membership price for each employee)	X					
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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

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Please indicate your category of membership:

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❑ Additional Individual from Corporate Member	$100	
❑ Employees of Public Authorities and Agencies	Free	
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❑ Retired	$50	(For individuals 65 years or older)
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ASA New Members

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E-MAIL ADDRESS CORRECTION FROM THE SUMMER 2011 ISSUE—

Abbott Shoring & Foundations Ltd.:
r_abbott@telus.net

Interested in becoming a member of the American Shotcrete Institute?

Read about the benefits of being a member of ASA on page 65 and find a Membership Application on page 66.

AMERICAN SHOTCRETE ASSOCIATION

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Circle #22 on reader response form—page 68

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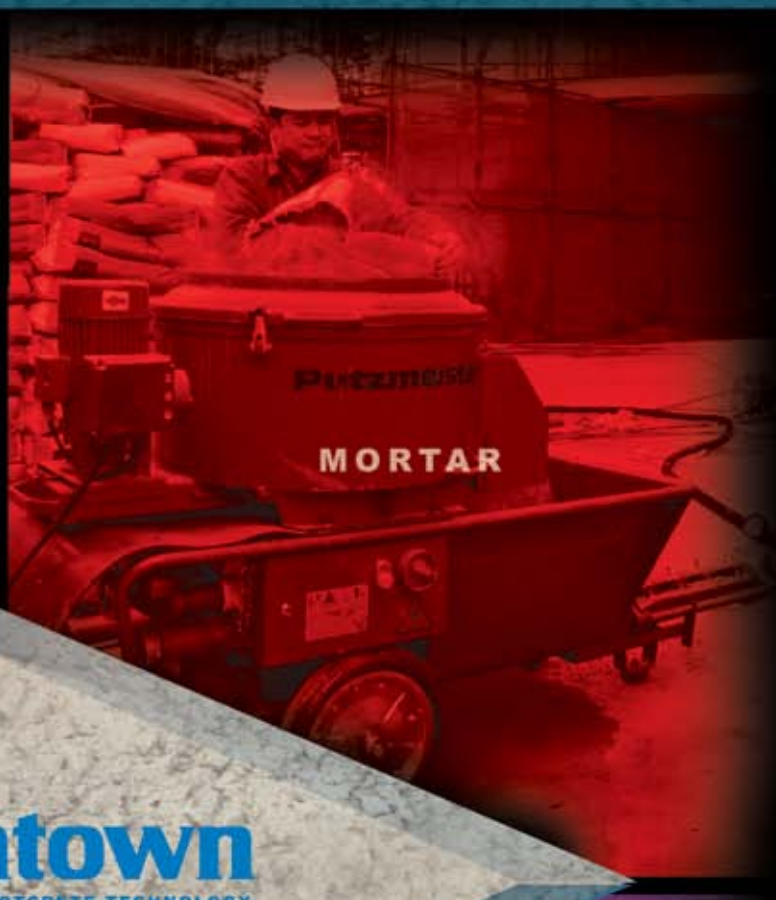

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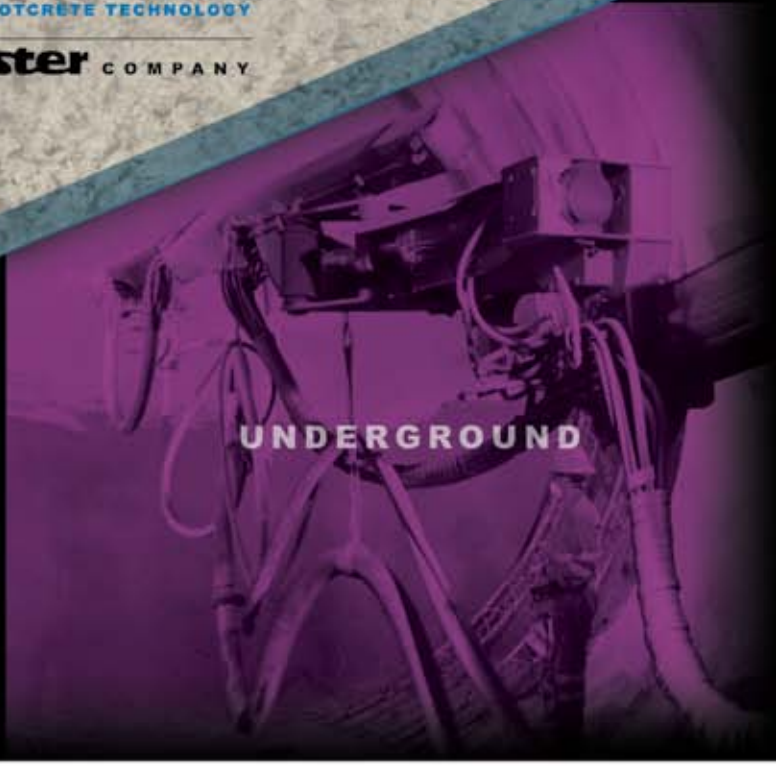

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