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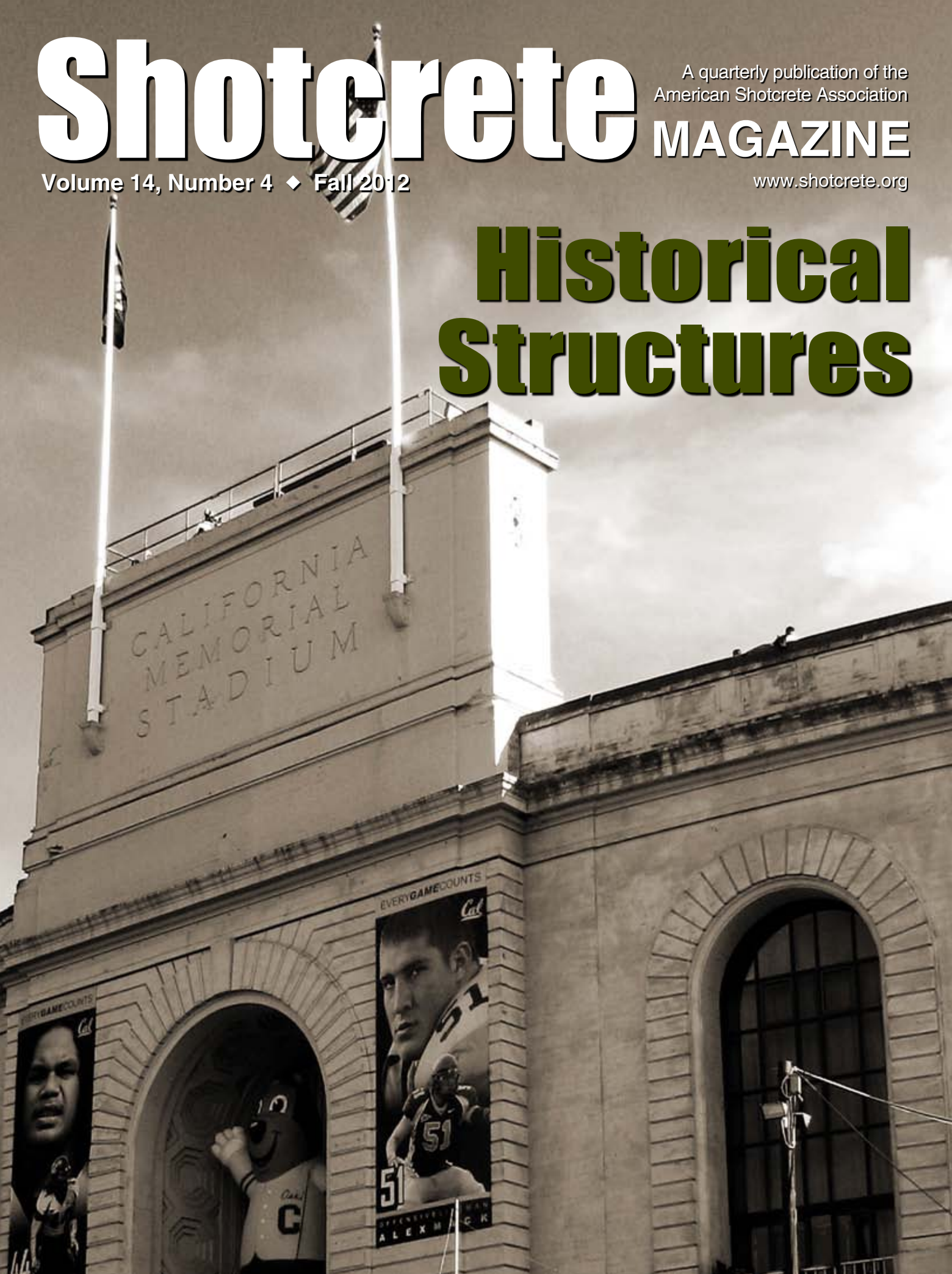
Historical Structures



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Damian Farmer, ACI Certified Finisher
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Features

Departments

On the cover: California Memorial Stadium, Berkeley, CA.
Photo courtesy of Dain Sandoval

Facebook, ASA, and You?

By Joe Hutter

During the ASA Executive Committee's annual summer meeting, I was given the opportunity to view the proposed redesign of the ASA website scheduled for release in late 2012. In addition to observing a cleaner site with a more intuitive layout, I couldn't help but notice the prominent position that will be given to a live feed to ASA's Facebook page on the home page.

Not that age should be of any significance when it comes to Facebook, but it is safe to say that I land much closer to the baby-boomer generation than I do the Facebook generation. This means that my understanding of social media and the role it plays in today's business world is limited to what I have learned from my two 20-something-year-old daughters. What I do understand, however, is that the social media phenomenon is here to stay—and, judging by the websites I visit regularly, most companies and organizations are aware of the importance of social media tools and are taking advantage of the opportunities that social media presents.

For now, ASA has limited its social media initiatives to Facebook. To understand the role that Facebook plays in our organization, it is important to first understand what it is and how it is used. Simply put, Facebook is a communications technology that has radically changed the ways we connect with each other. It accounts for nearly 10% of total time spent online by U.S. web users (just ahead of Google) and it has more than 900 million users globally, with 20% of those in the United States and Canada. Its introduction was as revolutionary as the introduction of the telephone, but its content covers everything from personal profiles to lead-generating opportunities for businesses in every sector of industry.

So what do Facebook and other social media outlets mean to ASA and the shotcrete industry? In one word, Facebook means EXPOSURE. With almost a billion users worldwide, the exposure provided by Facebook and other social media tools opens up ASA and the shotcrete industry to a growing number of engineers, contractors, and equipment and materials manufacturers who use social media on a regular basis for research and general interest. While it may be unrealistic to expect ASA to connect with a billion Facebook users, it is important to understand that the average Facebook user shares content that they "like" 60 times per month. This sharing process could allow our association to increase contacts exponentially and reach out to shotcrete users all over the world.

Using our Facebook profile page, ASA can also showcase announcements, industry updates, photos, videos, and other media on the site while interacting with other Facebook users. Individuals and companies associated with the shotcrete industry can post items of interest, updates on industry activities, and notifications of industry events, or simply post a comment about ASA or the industry in general. Controlling content on the ASA Facebook page, as to avoid cluttering the Web page with personal stories or irrelevant items, could be a difficult task, but a Facebook policy (see sidebar) developed for ASA Facebook postings will go a long way to ensure that the content on the ASA page remains relevant.

The benefits of an ASA Facebook page for ASA and other shotcrete industry members goes beyond simply providing a source of information for shotcrete industry events and updates. Joining the ASA Facebook community can serve as a catalyst for individuals to create and grow their network of industry contacts. The first step for those of us who are not yet Facebook users is to sign up. This rather simple process involves logging onto Facebook.com and completing the easy-to-follow instructions on the opening page. Although the sign-up process is simple, teenagers or young business colleagues can provide tutorial support for anyone who is not "Facebook-savvy." Once you are signed up, simply visit the ASA website and click on the "Find us on Facebook" icon in the top left corner of the home page. Once on ASA's Facebook page, click the "like" button and you will start receiving notices and updates from ASA on your Facebook page. From there, you can also click, connect, "like," and explore the many advantages of social networking offered by Facebook.

Alternatively, you can type the name "American Shotcrete Association" in the search bar at the top of the Facebook site to visit the ASA Facebook page and explore related information.

ASA will continue to monitor other forms of public and private networking tools. We hope these efforts will help to enhance the benefits of ASA membership.

ASA President's Message

Just as fax machines changed the way we did business 25 years ago, social media is merely the next new phenomenon that all businesses will eventually embrace. So sign up on Facebook today and connect with your association, your industry, and your colleagues around the globe. A billion other Facebook users can't be wrong!

ASA Facebook Policy

The American Shotcrete Association (ASA) Facebook page is where users can connect with ASA and receive timely, helpful information on the association and the shotcrete industry. We ask users to be aware of the images, video, text, or other content contained in their posts and respect the following guidelines:

- Be safe and mindful of publishing your personal information.
- Be polite to fellow users: We will not allow graphic, obscene, explicit, or racial comments or submissions, nor will we allow comments that are abusive, hateful, or intended to defame anyone or any organization.
- Remain on point with discussion and posts and keep comments relevant to ASA and the shotcrete industry.
- Do not post solicitations or advertisements: This includes promotion or endorsement of any commercial or non-governmental agency. Similarly, we will not allow attempts to defame or defraud any commercial or non-governmental agency.

Disclaimer: Images, video, text, or other posted content made by the public do not necessarily reflect ASA's views, policies, or procedures. Through your use of this page, you agree to: 1) grant ASA the complete, irrevocable, fully transferable, and permanent right to use and reproduce images, video, text, or other posted content for business purposes; and 2) hold ASA harmless from claims against ASA related to your images, video, text, or other posted content or use or participation on this page. ASA may modify or change these guidelines without notice and delete any images, video, text, or other posted content or ban any user at any time and for any reason.

For questions about this page or to report misuse, e-mail us at info@shotcrete.org.

ASA Sustainability Committee

By Charles S. Hanskat

Although it is ASA's youngest standing committee, the Sustainability Committee has accomplished much to raise the visibility of the value of shotcrete in today's increasingly green construction. The first meeting of the ASA Sustainability Committee took place at ASA's Fall meeting in New Orleans, LA, November 2009, and has continued to meet at least two or three times a year. The committee has had 10 to 12 active members since its inception.

In the last 3 years, the Sustainability Committee has been very active, with the following accomplishments to date:

- Established a formal mission statement: "To compile and distribute information on the sustainability of shotcrete construction."
- Acted as the primary ASA contact for participation in the concrete industry's Joint Sustainability Initiative (CJSI), of which ASA is an active member. CJSI is a coalition of 28 member industry groups with the primary goal to educate their members and their customers about the role and responsibilities of concrete in sustainable development. You can find more information on CJSI at **http://sustainableconcrete.org**.
- Produced four feature articles for the Fall 2010 issue of *Shotcrete* magazine that featured a sustainability theme.
- Developed two chapters for the U.S. Green Concrete Council (USGCC) book, *The Sustainable Concrete Guide—Applications*; one chapter on shotcrete and a portion of a second chapter on repair.
- Made a presentation focused on shotcrete and its sustainability advantages at the fall 2010 meeting of the Strategic Development Council (SDC). SDC provides the concrete industry with a forum where emerging technologies, strategic issues, and tactics are actively evaluated and put into action. More information on SDC can be found at **www.concretesdc.org**.
- Developed a "Sustainability of Shotcrete" brochure to readily communicate to members, owners, designers, and contractors the benefits of shotcrete in sustainable construction.
- Prepared the ASA display and materials for the World of Concrete 2011 "Green Site" section.
- Participated in a 90-minute seminar at World of Concrete 2011, which focused on shotcrete's sustainability advantages.
- Established and coordinated content for a regular "Sustainability" column in the quarterly *Shotcrete* magazine to more fully and regularly communicate the various benefits of shotcrete sustainability to our readers.
- Established and coordinated content for the sustainability page on the ASA website (**www.shotcrete.org/sustainability.html**).

Committee Chair Memo

ASA Sustainability Committee

Charles S. Hanskat, **Chair** | Hanskat Consulting

Patrick Bridger | Putzmeister Shotcrete Technology
Michael Cotter | Shotcrete Hydrodemolition Consultant
Oscar Duckworth | Valley Concrete Services
Ron Lacher | Pool Engineering Inc.
Dan Millette | The Euclid Chemical Company
Dudley R. (Rusty) Morgan | Consultant
Ryan Poole | DOMTEC International LLC
Ray Schallom III | RCS Consulting & Construction Co Inc.
James Scott | Group Works LLC
Ted Sofis | Sofis Company Inc.
Marcus H. von der Hofen | Coastal Gunite
Lihe (John) Zhang | LZhang Consulting & Testing Ltd.

- Supported ASA's membership in the U.S. Green Building Council (USGBC) and provided review and formal input on the proposed changes for LEED 2012 that impacted use or benefits of shotcrete (**www.usgbc.org**).

As we enter our fourth year as a formal committee, we look forward to completing several more activities to increase the visibility and acceptance of the sustainability of shotcrete. These include:

- Developing industry-specific versions of our sustainability brochure. The first will be a brochure tailored to the pool and recreational shotcrete industry and is being developed jointly with the ASA Pool & Recreational Shotcrete Committee.
- Finalizing a sustainability presentation for the ASA USB Shotcrete Resource Tool.
- Developing recommendations for expanding LEED points for use of shotcrete on projects pursuing LEED certification.

Be sure to check out this month's Sustainability column on how shotcrete enhances sustainability: "Speed of repair reduces or eliminates downtime." Enhanced sustainability has become a highly marketable and environmentally beneficial concept in today's construction industry. In 2009, the ASA Board had the foresight to see that sustainability would be an important aspect of shotcrete design and construction and established our standing committee. As evidenced by our activities, our Sustainability Committee's active membership has taken the initiative to identify and communicate the multitude of ways shotcrete is truly a highly sustainable construction process. If this is an area of interest, consider joining the Sustainability Committee at our next meeting in **Minneapolis, MN, on Saturday, April 13, 2013!** Meetings are always public and all are welcome to sit in or join and contribute!

ASA and World of Concrete 2013

By Chris Darnell, ASA Executive Director

World of Concrete (WOC) is the largest and arguably most important annual show for the concrete industry and creates a critically important outreach and educational opportunity for ASA. The diverse collection of individuals and organizations creates an outstanding forum to efficiently communicate the numerous advantages of placing concrete via the shotcrete process. Over the last few years, ASA's footprint and presence at the show has continued to grow and WOC 2013 will be ASA's biggest in terms of presence and events.

For the benefit of our members and readers, I would like to use the remainder of this column to update you on all the ASA activities occurring at WOC 2013.

Registration

If you are involved in the shotcrete industry and think you may attend WOC 2013, please register for the show using ASA's "**A17**" source code. In doing so, you will receive a FREE exhibit-only pass, discounts on registration for educational sessions, *and* significantly help support your shotcrete association. ASA has been an official co-sponsor of WOC for a number of years and each registration made using ASA's **A17** source code results in a rebate to ASA. This is a painless but important way for you to help generate financial support of ASA, enabling its continued mission to educate and market the benefits of the shotcrete process. The easiest way to register is to follow the WOC 13 link on the ASA home page at **www.shotcrete.org**.

Remember that early-bird registration for the ASA educational programs mentioned in the following ends **December 12, 2012**.

Shotcrete Forum, ASA Annual Meeting, and Committee Meetings

Monday, February 4, 2013 (the day *before* the exhibit hall opens), will feature a number of ASA committee meetings as well as a working meeting. All meetings will be held in the South Convention Hall of the Las Vegas Convention Center and are free and open to anyone with an interest in shotcrete. Room locations are not available at the time of publication, so please check ASA's calendar for the latest updates on times and locations: **www.shotcrete.org/ASAcalendar.htm**.

The **Shotcrete Forum and networking opportunity will begin at 8:30 a.m.** and will allow participants to discuss and work on specific items of high focus for ASA. Potential topics include the development of criteria for qualifying a shotcrete contractor, a review and discussion of ASA's scheduled release of its newly redesigned website, content of the ASA Safety Manual that is in the works, and other topics.

The **ASA Annual Membership Meeting is scheduled for 1:00 p.m.** This annual meeting, required in the ASA by-laws, will focus on an announcement of ASA's newly elected Board members and Officers.

Committee meetings for the ASA Marketing & Membership Committee and the ASA Board of Direction will begin at 1:30 p.m. and complete the afternoon schedule. (ASA's other standing committees, Sustainability, Pool & Recreational Shotcrete, Education, Safety, and Underground, each meet twice a year in the spring and fall. All ASA committees will meet in Minneapolis, MN, on Saturday, April 13, 2013.)

ASA Educational Seminar—Structural Shotcrete: Design & Construction

Each year, ASA conducts one or more seminars as part of the WOC educational track. This year's seminar, titled "Structural Shotcrete: Design & Construction," will be presented by Past ASA President Larry Totten and current ASA Officer Charles Hanskat. The seminar will take place **from 8:30 to 10:00 a.m. on Tuesday, February 5, 2013** (Registration Code: TU138).

This seminar will give the design engineer, project specifier, field inspector, and general contractors an overview on how shotcrete can be efficiently and cost-effectively used for placing concrete in structural sections. We will cover the design, specifying, and detailing considerations for structural sections, including reinforcement and joints. Next, we will cover field considerations, including reduced formwork needs and scheduling advantages. Finally, we will wrap up with quality of shotcrete, discussing field inspection, specific placement techniques, and listing of appropriate references and resources on the use of shotcrete for structural concrete.

The learning objectives for the seminar are as follows:

1. Identify design, specifying, and detailing considerations when using shotcrete in structural sections;
2. Delineate the field advantages of shotcrete placement for structural concrete;
3. Know the shotcrete placement techniques and inspection critical to producing quality structural shotcrete; and

4. Be aware of additional references and resources to learn more about shotcrete for structural concrete.

This seminar is an outstanding opportunity to learn from two of the premier experts in the shotcrete industry. You can sign up for the seminar when you register for the show or on site, but this event will fill up fast, so act soon!

ASA Shotcrete Nozzleman Education Session

Scheduled for Tuesday, February 5, 2013, from 9:00 a.m. to 4:00 p.m., this session is designed for shotcrete nozzlemen, individuals involved with inspection of shotcrete, and anyone interested in learning about the principles and practices that must be known and understood for a nozzleman to satisfy his/her role in the quality application of the shotcrete process.

ASA Nozzleman Education Sessions present an overview on placement technique, finishing, curing, testing, equipment, and safety as they relate to the nozzleman and the shotcrete process. This session will also help to prepare individuals for participation in the ACI Nozzleman Certification program. ACI-required work experience, written exam, performance exam, and other program criteria will be discussed.

The CP-60(09) Shotcrete Nozzleman Craftsman Workbook is included with the session registration fee.

Please note the following important items about this session:

- **Attendance of this session alone will not result in certification as an ACI Shotcrete Nozzleman**;
- This session will satisfy the education session requirement for a nozzleman wishing to pursue certification as an ACI Shotcrete Nozzleman through ASA;
- Attendees wishing to pursue ACI Certification will need to arrange for a certification session with ASA separately from this session; and
- Attendees will qualify for and receive a complimentary 1-year ASA Nozzleman Membership.

I encourage those interested in this Education Session to sign up early and take advantage of the $295.00 event registration fee before **December 12, 2012**—after that date, the fee rises to $345.00 (Registration Code: ASATU).

ASA Outstanding Shotcrete Project Awards Banquet

This year's awards banquet will be held on Tuesday, February 5, 2013, beginning at 6:00 p.m. at the Paris Las Vegas Hotel and Casino. I hope you will join us at this important event to meet and reconnect with leaders in the shotcrete industry. Registration and a reception with cocktails and hors d'oeurves begin at 6:00 p.m. Dinner is served at 7:30 p.m., followed immediately by the awards ceremony and then a networking reception with a cash bar. See page 66 for registration information. Early-bird registration has been extended to January 15, 2013, for this event. Visit **www.shotcrete.org**.

Awards Sponsorship Opportunities: Sponsorship of the ASA Outstanding Project Awards Program is an investment in highlighting and recognizing the exceptional versatility and quality of the shotcrete process to the construction world. Program sponsors receive great exposure in this celebrated event. Please consider getting involved this year by sponsoring at one of the following levels:

Big Shooter—$5000	Gold—$2500
Silver—$1000	Bronze—$500

Visit **www.shotcrete.org/pdf_files/sponsorship.pdf** for more information.

ASA Exhibit Floor Booth #S11429

Last, but certainly not least, is the ASA exhibit booth at WOC. For the 2013 show, we will be moving to a high-profile location on the main show aisle in the South Hall! This high-traffic location should prove to be an outstanding area to address attendees' questions about shotcrete. ASA's large booth will again host a table and chairs to serve as a meeting place for members to relax and discuss the industry.

The ASA exhibit booth is a great resource for printed resources and networking opportunities. Please make sure to stop by and say hello!

With a full plate of ASA opportunities scheduled for WOC 2013, please register today and take full advantage of this unique and important show.

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- **STAY CURRENT** on the latest shotcrete industry trends, strategies, challenges, and opportunities
- Receive **PROJECT LEADS** through project bid alerts and project listings
- Gain **EXPOSURE** through a variety of tools available to members, such as the ASA Buyers Guide
- **INFLUENCE** ASA's direction in serving members and growing the industry
- **SAVE** significantly on ASA products and services

Grow your industry

- **EDUCATE** the construction world on the advantages of the shotcrete process through in-house presentations to engineers and specifiers
- **PROMOTE** the benefits of shotcrete at national trade shows
- **COORDINATE** proper specification of shotcrete in private and public specifications and national codes and standards
- **ENGAGE** DOT and other Public Authority officials with a variety of ASA resources and outreach efforts
- Take advantage of **TARGETED MARKETING** in national and regional organizations and publications
- **ENABLE** owners and specifiers to embrace shotcrete with a portfolio of tools designed to give them an understanding of and confidence in the shotcrete process

At a time when more and more companies are demanding effective use of their dollars, more and more companies in the shotcrete industry are realizing the benefits of becoming an ASA Corporate Member (***25% increase in the number of ASA Corporate Members over the last 2 years***).

Take the step that will help grow your organization and industry—become an ASA Corporate Member today

For more information on ASA membership, visit www.Shotcrete.org/ASAMembership.htm.

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Seismic Retrofit of California Memorial Stadium

By Nur Kasdi and Larry Totten

Since 1923, California (Cal) Memorial Stadium in Berkeley, CA, has been the home of the University of California (UC) Berkeley's football team. Modeled after the Roman engineering marvel of the Colosseum, the oval stadium is situated above the surrounding landscape on Berkeley's hillside and features panoramic views of the San Francisco Bay Area. Due to its age and historical significance, in November 2006, Cal Memorial Stadium was included on the National Register of Historic Places.[1]

While the stadium seemingly disregarded almost a century of time and remains in remarkable condition for its age, the seismicity risks in the area are a constant concern. Positioned directly on top of the active Hayward Earthquake Fault, which runs roughly from end zone to end zone, the stadium is subjected to annual horizontal fault "creep" of up to 0.20 in. (5 mm). During significant seismic events, the ground along the fault could displace up to 6 ft (1.82 m) horizontally and 2 ft (0.61 m) vertically—with potential catastrophic impacts on the structure.[2]

Cal Memorial Stadium was in critical need of not only a seismic retrofit but also an upgrade to modern standards. In late 2010, UC Berkeley responded by apportioning $321 million for the Memorial Stadium improvements, with work scheduled to start in January 2011. In preparation, the California Golden Bears football team was temporarily moved to the AT&T Park in San Francisco for the duration of the 2011 football season. The stadium is anticipated to reopen in fall 2012.

Work Scope

A unique feature to the project was that while the majority of the existing structure was demolished and reconstructed, the outer perimeter wall had to remain in place to preserve the historic landmark.

Johnson Western Gunite (JWG), a Superior Gunite Company, was assigned the task to install a heavily reinforced shotcrete layer over the historic wall for seismic strengthening. The shotcrete overlay varied in thicknesses from 5 to 36 in. (127 to 914 mm). Because the majority of the wall surfaces were exposed, a steel trowel finish was required. The base contract volume was approximately 4000 yd^3 (3058 m^3).

In coordination with the concrete general contractor, JWG presented the owner with value

Fig. 1: Overview of the existing historic walls during demolition and excavation. A layer of shotcrete was later applied over the existing walls in various thicknesses from 5 to 36 in. (127 to 914 mm)

Fig. 2: Type 1 preconstruction test panel was composed of three curtains of No. 10 (No. 32M) and No. 9 (No. 29M) reinforcing steel with additional boundary reinforcing bar elements

Fig. 3: Cores retrieved from Type 1 preconstruction test panel

Fig. 4: Existing historic wall prior to shotcrete overlay application

engineering proposals for the majority of the new vertical cast-in-place concrete walls on the project. By substituting the cast-in-place method with the shotcrete method, the owner attained significant cost savings while maintaining both quality and project schedule activity durations.

As a result, the shotcrete scope doubled in volume through the addition of the following work: retaining walls, shear walls, miscellaneous interior walls, and a new loading dock building structure adjacent to the existing stadium.

Project Challenges

Like other shotcrete seismic retrofits, there were several challenges to the high-profile Cal Memorial Stadium retrofit project. First, because the project had a tight deadline schedule with a 6-day work week and double work shifts, the stadium was split into three work areas. Consequently, JWG had to coordinate multiple shotcrete crews working simultaneously in each area.

Second, the mixture design composition was especially unique for a Bay Area shotcrete project. After testing the concrete material, JWG had to make some modifications to customize it specifically for project application.

Third, the dense steel configuration in the shotcrete walls required close observation and quality control in the field. Preconstruction testing exemplified these congested areas to demonstrate that the nozzlemen were capable of performing the work.

Mixture Design Troubleshoot

The shotcrete mixture design was specified as a 7000 psi (48.3 MPa) mixture at 28 days. The

Fig. 5: Application of 40 ft (12.2 m) tall shotcrete layer 36 in. (914 mm) thick over the existing historic perimeter wall

Fig. 6: Existing historic wall after shotcrete overlay application

original concrete mixture had a composition of 940 lb (426 kg) of cementitious materials with 15% fly ash content (equivalent to 10 sacks of cement) and 30 to 70% coarse-to-fine-aggregate ratio. The slump was 3.5 in. (89 mm). After analyzing laboratory trial results and conducting preconstruction testing, JWG adjusted the mixture design to tailor it to the work at the stadium.

When lab trial results proved that the mixture far surpassed the design strength, JWG was confident that the effects of a "hot mixture" could be reduced while still meeting the design strength. Thus, the cement content was reduced to 893 lb (405 kg), or 9.5 cement sacks.

During preconstruction testing, the JWG crew found difficulty in achieving the required steel trowel finish. As the finishers were "working" the substrate, the fine sand in the mixture kept emerging to the surface. This resulted in the surface exhibiting an aesthetically unpleasing "dimpling" finish. After investigating the issue, JWG determined that the root of the problem was the high content of fine sands. Subsequently, the mixture design was altered to include a blend of fine sands and fine aggregates, which increased the fineness modulus and created a more desirable aggregate gradation. Throughout the duration of the project, no further finishing issues were encountered.

Preconstruction Testing

Each nozzleman had to shoot a set of four preconstruction test panels that demonstrated the most challenging reinforcing steel configurations in the project. A mean grade of 2.0 was required to pass, with no single core having a core grade exceeding 3.0. Seven of the eight nozzlemen successfully passed the test. The engineer selected the following test panel conditions:

- Type 1: A historic wall shotcrete overlay intersected with a shear wall, with three curtains of No. 10 (No. 32M) and No. 9 (No. 29M) reinforcing steel with additional boundary reinforcing bar elements each 24 in. (610 mm) thick. Refer to Fig. 1 through 3.
- Type 2: A historic wall shotcrete overlay intersected with a shear wall with an existing pilaster obstruction and three curtains of No. 10 (No. 32M) and No. 9 (No. 29M) reinforcing steel with additional boundary reinforcing bar elements each 18 in. (457 mm) thick.

Fig. 7: Shotcrete shear wall after the forms were stripped. The right side of the wall is the stripped form side. The left side is the shotcrete steel trowel finish side

- Type 3: A historic wall shotcrete overlay with an embedded existing pilaster with reinforcing steel cages 20 in. (508 mm) thick.
- Type 4: A miscellaneous interior wall with an embedded column 12 in. (305 mm) thick.

Work Production

Shotcrete work occurred from May 2011 to February 2012 with a 6-day work week. As many as two to three shotcrete crews were on the job site each work day. The average pumping distance on the project was about 300 to 400 ft (91 to 122 m) from the shotcrete pump to the work location.

The dense steel configuration motivated the JWG crew to take an unconventional approach to shotcrete application. At some locations, the actual field measurements for the historic wall overlays were over 36 in. (914 mm) thick and required full height installation of up to 40 ft (12.2 m; refer to Fig. 4 through 6). To address this problem, shotcrete was applied in 12 ft (305 mm) tall lifts. Once the concrete material set up, the next shotcrete lift was installed. Consequently, there were no major voids as a result of poor consolidation reported on the project.

The walls were applied in one layer of scratch coat from the bottom to the top, and then the final finish coat from the top down was later applied (refer to Fig. 7). By taking this approach, JWG was able to ensure a uniform steel trowel finish. A unique experience at this project was that JWG found that the use of additional water-reducing admixture was actually detrimental to work production. As a result, JWG used a low dosage when applying a scratch finish so more concrete material could be stacked on the wall. The dosage was increased when applying the final coat finish, which accommodated extra time for the finishers to complete their work before the concrete set.

Summary

The California Memorial Stadium was undoubtedly one of the most unique seismic retrofit projects for JWG. The following were the keys for achieving this successful shotcrete project:

- Selection and modification of the high-strength concrete mixture design to streamline the shotcrete application process;
- Tight coordination in the field to stay on track with the fast-paced schedule; and
- Unconventional shotcrete application approach to deliver a high-quality shotcrete product.

References

1. "California Memorial Stadium," Cal Athletics, Berkeley, CA, 2010, http://stadium.berkeley.edu. (last accessed July 20, 2012)

2. Cardno, C. A., "Retrofit of Stadium Straddling Active Fault Moves Forward," *Civil Engineering*, ASCE, July 2010, pp. 12-14.

Nur Kasdi *is currently the Project Engineer for Johnson Western Gunite, a Superior Gunite Company. Kasdi has been with the company since 2006 after receiving her BS in civil engineering from UC Berkeley. She provides estimating and technical support for various shotcrete projects across the United States. Her notable projects include the City Creek Center in Salt Lake City, UT; the Caldecott Fourth Bore Tunnel in Oakland, CA; and the SR 99 Tunnel in Seattle, WA. She is a licensed P.E. civil engineer in California and is a certified LEED Green Associate. Superior Gunite is a Corporate member of ASA.*

Larry Totten *is currently the COO of Superior Gunite Company and the President of Johnson Western Gunite Company. He has also served as a Project Manager and Chief Estimator in his 36 years with the company. He received his MS and BS in civil engineering and is a member of ASA, the American Society of Civil Engineers (ASCE), the American Concrete Institute (ACI), and the Associated General Contractors of America (AGC). He holds contractors' licenses in several states and is licensed professional engineer in California. He is current Chair of ACI Committee 506, Shotcreting; past Chair of the Northern California Laborers Trust Fund; a past Director and a Past President of ASA; and an Approved ASA Trainer for the ACI Shotcrete Nozzleman Certification Program.*

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Lafayette Place Lofts

By Doug Pawloski

The Lafayette Place Lofts is a new development in a historic structure (Fig. 1) in downtown Pontiac, MI, that is owned by West Construction Services. The building was constructed in 1929 to house the Sears Roebuck Department Store. It is remembered fondly by many of Pontiac's citizens because, even as the economy teetered on the verge of collapse and the Great Depression loomed, Sears never reduced its workforce. In fact, Sears likely staved off poverty for many families in the Pontiac community.

Sadly, over time, urban flight and the migration of retailers toward suburban malls helped accelerate the decay of this and many similar structures around the country. Yet today, forward-thinking and technically adept companies are using new or improved construction products and processes to not only preserve but also redefine many of these monuments to America's lasting endurance.

Lafayette Place Lofts, the largest construction investment in downtown Pontiac in nearly 30 years, had to follow the guidelines set forth by the National Park Service Preservation Briefs and Michigan's State Historic Preservation Office to retain the historical integrity of the structure. Shotcrete was an integral part of the solution. Once completed, the Lafayette Place Lofts project will include 46 unique, contemporary one- and two-bedroom lofts; a rooftop terrace; an outdoor patio; an Anytime Fitness gym; an electric car-charging station; and a market and café, all situated nicely in a historic district of the city.

Following Historical Guidelines

Overall, four separate agencies were involved with decisions on the renovation of the Sears Building. They included the Michigan Historic Preservation Network (MHPN), the Michigan State Housing Development Authority (MSHDA), the National Park Service (NPS), and the Federal Office of Housing and Urban Development (HUD). This building is on the National Register of Historic Places and therefore the primary guidelines pertained to the front façade of the building and required the developers to restore the storefront as closely as possible to the original 1929 condition (Fig. 2) to retain its historic designation.

The work included brick replacement, tuck pointing, concrete repair, and masonry cleaning. Both MSHDA and HUD were involved with inspections throughout the restoration. MHPN and NPS conducted their inspections once the renovation was complete. They were involved from the early design and planning stages and were familiar with the scope of the project.

Fig. 1: Architectural rendering of Lafayette Place Lofts in an historic district of downtown Pontiac, MI

Project Scope

Considerable neglect over the years was evident in the magnitude of work needed to repair and restore this 80,000 ft^2 (7400 m^2) structure. Started in March 2012, the 3-month-long project included extensive work on the interior ceilings, support columns, and floors. The exterior repairs included concrete, brick, and stone restoration. The overall goal of West Construction Services was to restore the building to its original state in 1929.

All masonry restoration was performed by RAM Construction Services, Inc., the largest midwestern restoration company based in Livonia, MI. RAM Construction has extensive experience in the repair and restoration industry, including historic buildings and structures.

Process and Durability Give Edge to Shotcrete

The decision to use shotcrete on the Lafayette Place renovation was a practical one, considering the project time requirements, the ease of shotcrete application, finishing, and the strength and durability of the finished product. The advantages were applicable to both interior and exterior repairs.

For the ceilings, deteriorated concrete was removed, exposing the reinforcing steel. RAM cleaned and then coated the steel reinforcement to prevent deterioration. Shotcrete was then

Fig. 2: Vintage photo of the original Sears Roebuck building shortly after completion in 1929

applied directly to the ceiling, where it penetrated in and consolidated around the reinforcing steel and bonded to the substrate to form a structurally sound, durable concrete repair. One of RAM's 15 ACI-Certified Nozzlemen had to carefully adjust the water and material flow to ensure that quality shotcrete was being placed with enough time before final set for proper finishing. Finishing the surface was made easier with shotcrete, as the crew matched form lines from the original construction used to form the ceilings over 80 years ago. The ceilings will be exposed as a finished product in each unit to highlight the aesthetics of the early construction techniques.

The interior structural columns (Fig. 3 and 4), many of which remain exposed and visible in the lofts, were 24 in. (600 mm) in diameter and flared at the top to about 3 to 4 ft (0.9 to 1.2 m) across. Approximately 4 in. (100 mm) of concrete was removed from the columns to expose the embedded reinforcing steel. RAM replaced the concrete and matched the conical profile of the existing columns.

Shotcreting the ceilings and structural columns saved the crew time and the client money. The level of penetration of shotcrete would be difficult, if not impossible, to achieve if the crew had to mix materials and apply them by hand. Generally, spraying is not precise and can be messy, but because the interior was being completely restored, the crew did not have to be too concerned about overspray on the interior floor surfaces. However, that was not the case on the building's exterior.

Fig. 3: Severe deterioration of the interior support columns prior to restoration

Fig. 4: Support columns are restored to their original rounded and flared condition using shotcrete

Fig. 5: Exterior of the structure showed signs of neglect with crumbling and deteriorating concrete

The exterior was plagued by spalled and crumbling concrete, loose and fallen bricks, and deteriorating window lintels and shelf angles that needed to be repaired.

On the exterior, concrete bands that encase the structural steel beams are seen from the outside and run both vertically and horizontally around the building. Once the loose and damaged materials were removed, the areas were cleaned, and the steel beams were coated, shotcrete was applied to the surface. During the finishing stage, the crew exposed the sandy texture of the repaired areas to match the building's weathered appearance (Fig. 5).

Challenges

According to Dennis Lezotte, Foreman for RAM Construction, weather conditions posed the biggest challenge to working on the exterior of the structure. Wind, sun, temperature, and humidity can all affect the curing rate of shotcrete. Variable winds, changing humidity, and extreme temperatures encountered during the project required the ACI-Certified Nozzlemen to carefully monitor and adjust the water and material flow during shotcrete placement. Maintaining proper hydration and appropriate protection to the exposed shotcrete surfaces, as well as starting curing as soon as possible, were also essential to guard against shrinkage cracking. The crew worked within the weather constraints to ensure the quality of the repairs was maintained at all times.

Fig. 6: Architectural rendering of an interior living space of a completed loft

Project Summary

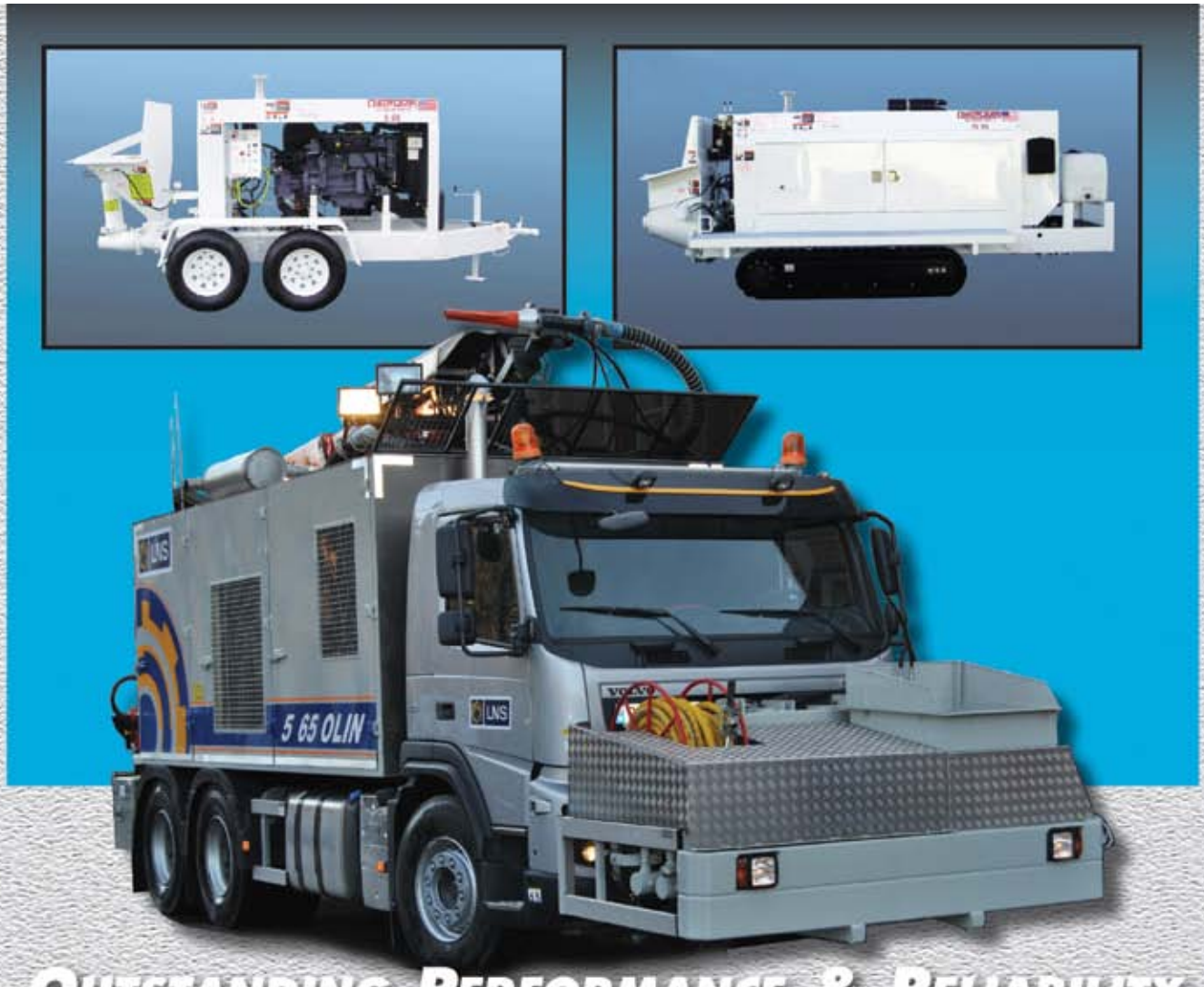
The Lafayette Place Lofts renovation project (Fig. 6) presented a unique set of challenges because of its status as a historical building and the fact that it had been neglected for many years. Many of these challenges were minimized because a talented shotcrete crew readily adapted to changing situations. As a result, this project was completed on time and within budget and met all the strict requirements put forth by multiple government agencies for historical structures. West Construction Services, the building's owners, were impressed with RAM Construction Services' performance and professionalism throughout the restoration process and highly recommend their services. West Construction's Site Manager, Joe Owens, describes RAM Construction as "an exemplary company that would always go above and beyond to make sure we were satisfied with their work."

Project Contributors

RAM Construction Services, Inc., Livonia, MI
Restoration and Repair Specialists
- Dennis Lezotte, Concrete Foreman
- Jessica S. Farley, Project Manager/Estimator

West Construction Services, Pontiac, MI
Building Owner and General Contractor
- Kyle Westberg, President
- Bob Davis, Director of Marketing and Client Services
- Joe Owens, Site Manager

Doug Pawloski *is President of Digital Marketing Production, Inc., in Bloomfield Hills, MI. His company was established in 1998 and provides advertising, creative marketing, and public relations services. He is a graduate of Indiana University, Bloomington, IN, with a bachelor's degree in marketing and advertising, and continued his studies in corporate communications at Wayne State University in Detroit. His company is representing RAM Construction Services of Livonia, MI.*



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Restoring a Civil War Monument

By Ted Sofis

We're all in business to make money. We bid on projects by offering a plan, production rates, and a schedule and hope to bring things in under the estimated cost. However, every so often a project comes along that we want to do, not for the typical reasons, but we do it because we're part of a community. There is an old Greek proverb that states, "A society grows great when old men plant trees, in whose shade they know, they will never sit." To many of us, it is important to preserve our history and traditions.

Last year, Martin Neaman saw a shotcrete presentation at the Association for Bridge Construction Design meeting given by Bill Sofis, of Sofis Company, Inc. Neaman immediately recognized the advantages of a shotcrete repair and approached us about restoring the concrete foundation around the podium of an old Civil War monument. He realized that shotcrete would provide a practical and cost-effective way to perform the work. Neaman is a retired engineer from Penn DOT's Bridge Unit and Joe Hoesch is a retired General Electric service representative. They are both involved with raising money and restoring the headstones of Civil War veterans. The two men are members of Company A, 9th PA Reserves, a Civil War reenactment group based at the Andrew Carnegie Free Library in Carnegie, PA.

Fig. 1: The Civil War monument at Chartiers Cemetery in Carnegie, PA, with the Civil War veteran headstones in the foreground

Their involvement began when they saw the poor condition of the veterans' headstones; and, unlike most of us, they decided to do something about it. In November of 2010, Hoesch and Neaman undertook the project to restore the GAR burial plot at the Chartiers Cemetery and, along with it, the monument's reviewing podium (Fig. 1). The Chartiers burial plot contains 133 Civil War veterans, two of whom are recipients of the Congressional Medal of Honor. The cemetery project can be viewed online on the website of the 9th PA: **www.9thpareserves.org**.

For this project at Chartiers Cemetery in Carnegie, PA, Neaman and Hoesch began raising money to reset many of the old veterans' headstones that had sunken into the ground. Many of the original headstone memorials were supplied by the county of Allegheny for the burial of indigent Civil War veterans. Some of the headstones happened to be placed over the old wooden coffins. Over time, as the coffins deteriorated, the headstones would sink into the ground, often tilting one way or the other. The donations received are used to remove and reset the sunken headstones on a concrete base, so they don't sink again. The stones are cleaned, soil is brought in to level the graves, flowers are planted, and memorial services are conducted. Neaman and Hoesch selflessly dedicate their time and efforts to this historic restoration work. On Memorial Day weekend every year, their Civil War reenactment group performs a ceremony at the Chartiers Cemetery. During one of these occasions, the poor condition of the monument's reviewing podium became apparent to them. With Memorial Day approaching, Martin contacted me and put the ball in motion (Fig. 2)

When we scheduled the shotcrete repair work, Martin mentioned that he was going to have a troop of Boy Scouts come in beforehand to do some general cleanup in the cemetery. Looking to facilitate the work and pass off some of the

labor, I asked about having the scouts dig a 1 ft (0.3 m) deep trench around the perimeter of the monument wall. Before performing shotcrete work on a bridge pier, abutment, or an existing wall, we typically excavate around the base of the wall so the shotcrete continues below the ground level. I figured this would be a good public service project for energetic young men. When we arrived on site, the trench had been dug and we were ready to go. Little did I know, the scouts had rescheduled to come at a later date and the most difficult part of the work was performed by Neaman and Hoesch. They hand-dug the trench and fought the tree roots of the two trees planted at the front of the monument. That brings us back to the Greek proverb about planting trees. It's a good thing there were a couple of reliable old guys around.

With the excavation work already behind us, the adjacent tree trunks and monument's railings were then covered with plastic to shield the granite monument from shotcrete over-spray. Then, the deteriorated concrete was removed. Removing all deteriorated concrete to expose a solid concrete substrate is essential to produce a durable shotcrete repair. After the surface preparation work was completed, galvanized 3 x 3 in. No. 11 gauge (76 x 76 MW5.6/5.6) mesh was installed and anchored in place with J-hook expansion bolts. A prepackaged microsilica-enhanced repair mortar, Shotcrete MS manufactured by Quikrete, was used for the repairs and gunned in place using the dry process. The areas where deteriorated concrete had been removed were filled. Shotcrete, approximately 3 in. (76 mm) thick, was gunned over the entire podium wall area to create a uniform final appearance (Fig. 3 and 4). From start to finish, everything was easily completed in 1 day—a very

Fig. 2: The foundation wall of the Civil War monument's review stand at the Chartiers Cemetery was badly deteriorated

Fig. 3: Overview of the site with the dry-mix rig in the foreground

Fig. 4: After the deteriorated concrete was chipped out, the surface was prepared and meshed and the shotcrete was gunned in place

Fig. 5: Completed shotcrete placement on the monument review stand

Fig. 6: A side view of the Civil War monument after the completion of the shotcrete work

Fig. 7: Company A 9th PA Reserves Civil War reenactment group at Chartiers Cemetery during Memorial Day festivities

Fig. 8: Chartiers Monument completed

short time for concrete restoration work. The dry-process shotcrete used in installation allowed the nozzleman greater flexibility and control to make subtle adjustments in his/her spray pattern and provided an extremely efficient method for repairing concrete structures (Fig. 5 and 6).

The American Civil War ended in 1865 at Appomattox Court House in Virginia approximately 147 years ago, when Confederate General Robert E. Lee surrendered to Union General Ulysses S. Grant. More Americans died in the Civil War than any other war in United States history. The Civil War, to a large degree, defines who we are as Americans and what we have become as a nation. Preserving this history, along with the monuments and memorials of the veterans who served in the conflict, is an important legacy that we should pass on to future generations. Hopefully, this restored monument will be there for many decades to come (Fig. 7 and 8).

Acknowledgments

9th PA Reserves, c/o Andrew Carnegie Free Library, 300 Beachwood Avenue, Carnegie, PA 15106 **www.9thpareserves.org**.

Martin Neaman is a retired PennDOT Engineer from the District 11 Bridge Unit in Pittsburgh, PA. Neaman was responsible for bridge inspection, bridge maintenance work orders, programming, and bridge inspection contracts. He served in active duty with the U.S. Army Corps of Engineers from 1971 to 1973.

Joe Hoesch is a retired General Electric service representative, who provided repair and calibration services for GE manufactured electronic equipment. He served in the U.S. Navy from 1961 to 1964.

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

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Chetoogeta Mountain W&A Railroad Tunnel

By Edwin Brady

Historical restoration/preservation is not only a challenging field of construction but also one that offers the special reward of preserving history for future generations, along with the social and cultural impact that a structure has contributed to in its lifetime. The Chetoogeta Mountain W&A Railroad Tunnel Restoration is just that type of project and structure.

History

This tunnel, located in Tunnel Hill, GA, just 90 miles (145 km) north of Atlanta, is a 1477 ft (450 m) long clay brick arch tunnel. Completed in 1850 (Fig. 1), it is one of the oldest railroad tunnels in the world and the first one in the United States south of the Mason-Dixon Line. The first railroad tunnel was reportedly built in Germany in 1840.

Much of Central Georgia in 1850 was still part of the Cherokee Territory. Construction of this tunnel completed the railroad commissioned by the state of Georgia to connect Chattanooga, TN, to the Atlantic Ocean at the port at Savannah, GA.

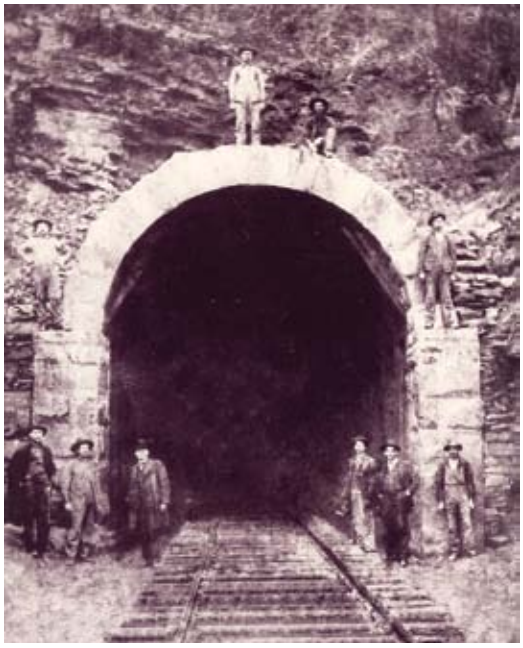

Fig. 1: Workmen, engineers, and others at the completion of the tunnel in 1850. Perhaps no other single transportation facility, prior to the age of aviation, has had more of an impact on the economic development of Georgia than this tunnel

The Tennessee River in Chattanooga provided easy access to the Cumberland, Mississippi, Ohio, Arkansas, and Missouri Rivers and effectively opened the entire country from the Eastern Rocky Mountains to the Western Appalachians with the first trade route through the Appalachian Mountains and on to the Atlantic Coast. It has been said that perhaps no other single transportation facility, prior to the age of aviation, has had more of an impact on the economic development of Georgia than this tunnel.

The tunnel is 1477 ft (450 m) long, 12.5 ft (3.8 m) wide at the bottom, and 16 ft (4.9 m) tall at the crown of the arch. Its side walls are constructed of large quarried limestone blocks and are approximately 3 ft (0.9 m) thick by 8 ft (2.4 m) tall, with a brick arch approximately 2 ft (0.6 m) thick resting on top. As locomotives became larger and heavier, the tunnel cross section became more and more restrictive. Trains began to scrape the sides of the tunnel. Several trains even became stuck, which required the tunnel lining to be demolished around the train (and later reconstructed) to allow for its removal. Finally, in 1928 (Fig. 2), a larger tunnel was constructed adjacent to the original tunnel and all train traffic was diverted to the new structure.

Over the next 70 years, little maintenance was performed and the original tunnel fell into a gross state of disrepair. When railroad crews began to close off its entrances in the mid-1990s, local residents, historians, and preservationists were enraged. They rapidly banded together and through cooperation with the Whitfield County Board of

Fig. 2: Original tunnel built in 1850 (right) with "new" tunnel built in 1928 (left)

Commissioners were successful in obtaining a Federal Intermodal Surface Transportation Efficiency Act Grant (ISTEA) for $1.5 million to fund a full-scale historical restoration project.

Design and Construction Team

The Atlanta office of ARCADIS was hired as the design engineering firm to lead the project. Initial condition investigations revealed:

- Extensive water infiltration had resulted in the failure and collapse of large areas of the brick arch;
- A large number of failed mortar joints had allowed bricks to fall out; and
- Other areas of the tunnel had experienced distortions of the cross section due to sustained earth pressure.

All these conditions combined threatened a general collapse of the tunnel. Edwin Brady Construction Co., Inc., was selected as the general contractor to perform the restoration work, along with Miles Miller, owner of Miller Rochester Restoration, the subcontractor that performed repointing and plastering of the masonry surfaces.

Scope of Work

In all, 2745 gal. (10,400 L) of hydrophobic polyurethane chemical grout (HPCG) was injected into and behind the brick arch to cut off the water infiltration. Over 12,000 ft^2 (1100 m^2) of brick and stone were repointed with a lime-based mortar custom-formulated to match the original mortar in color, strength, and texture; 60 yd^3 (46 m^3) of dry-process shotcrete was placed to restore areas of the brick arch that failed and collapsed; and approximately 2000 ft^2 (190 m^2) of custom-formulated plaster rendering was applied over the shotcrete surfaces to match the surrounding original brick.

Grouting and Masonry Repointing

Water infiltration was prevalent throughout the entire tunnel. HPCG was specified to seal this infiltration, and the product chosen was Mountain Grout Classic as manufactured by Green Mountain International. Small-diameter holes (3/8 in. [10 mm]) were drilled through the mortar joints (Fig. 3), and then plastic packers were installed to inject the grout. HPCG expands when in contact with water. This produces a flexible closed-cell foam that not only seals but also fills voids and provides stability to the aging and deteriorating brick arch. Upon completion of the injection grouting, the plastic packers were broken off flush with the surface of the mortar; Miller Rochester Restoration repointed approximately 12,000 ft^2 (1100 m^2) of the brick arch with a custom-formulated mortar made with vertically hydrated lime and a local sand matching what was originally used in 1850.

To prevent the buildup of hydrostatic pressure behind the brick arch and limestone walls, perforated drainage pipes were installed on approximately 10 ft (3 m) centers along the springline of both sides of the tunnel. These drainage pipes were 2 in. (50 mm) polyvinyl chloride (PVC) with a perforated section wrapped with a nonwoven geotextile fabric to prevent sediments and soil from entering the pipes. Three inch (75 mm) diameter holes were cored through the brick arch, allowing the drainage pipes to be placed and then sealed at the surface of the brick with the HPCG. A total of 280 drainage pipes were installed.

Fig. 4: Large repair area prior to shotcrete

Shotcrete

Repair of areas where the brick arch had failed (Fig. 4) were patched with a prepackaged silica

Fig. 3: Trailer-mounted core-drilling setup for drilling holes for drainage pipes. Also note the freshly repointed brick mortar joints

Fig. 5: Shotcrete being placed

fume-enhanced dry-process shotcrete. Gunite microsilica (MS) with alkali-resistant (AR) glass fibers from Quikrete was used. Approximately 60 yd^3 (46 m^3) of shotcrete was placed (Fig. 5) through an Allentown GRH600 to an average thickness of 10 in. (250 mm), with some areas being over 2 ft (0.6 m) thick. Scaffolding was erected on a 20 ft (6 m) trailer with an air compressor and generator beneath the working deck to allow for easy mobilization throughout the tunnel. Bulk bags (3000 lb [1360 kg]) of the prepackaged shotcrete material were emptied into a portable hopper set over the shotcrete machine.

Shotcrete offered the only feasible means to make these repairs. It would have been cost-prohibitive to manufacture brick to match the original construction, not to mention the tremendous task of attempting to place them into these irregular repair areas. With shotcrete, these repairs were very straightforward and efficient in producing a structurally sound repair. It fully bonded to the substrate and was able to be finished to the exact profile of the existing tunnel surface.

After the shotcrete was placed, it was cut back by hand (Fig. 6) to about 3/8 in. (9.53 mm) deeper than the face of the adjacent brick. Overspray was washed from the surface of the adjacent brick and a plaster coat of custom-colored mortar was placed over the shotcrete flush to the face of the original brick. "Fake" mortar joints were struck into the plaster and a black "wash" was applied to more closely resemble the "sooted" surface of the original brick after years of smoke from steam locomotives (Fig. 7).

Fig. 6: Shotcrete being cut back to finish grade

Fig. 7: Completed repair

Fig. 8: Sesquicentennial Celebration of the first train through the tunnel on May 9, 1850

Sesquicentennial Celebration

The project was completed just in time for the celebration of the 150th anniversary of the first train to travel through the tunnel (Fig. 8).

Awards

Upon completion of this project, multiple awards ensued.

- ARCADIS: State Award of Excellence—Consulting Engineers Council of Georgia; and
- Edwin Brady Construction Co., Inc.: 2000 Award of Excellence—Associated Builders and Contractors, Kentuckiana Chapter; and 2000 Honorable Mention in the Repair of Special Projects—International Concrete Repair Insitute.

Community Embraces Restored Tunnel

I recently contacted Mike Babb, Chairman of the Whitfield County Board of Commissioners. He was pleased to inform me of many developments since the completion of our work. He stated, "Your work was the first step. Once you made the tunnel structurally stable, dry, and historically restored, there has been an outpouring of public

Fig. 9: Current entrance to the Chetoogeta Mountain Tunnel

support. Nearly 100 acres of adjoining land has been donated, a Heritage Center with a museum has been constructed, walking trails constructed, and currently the original train depot is being restored (which has likewise been donated to the county). This has become a major tourist attraction and revived the public interest in our history and heritage" (Fig. 9).

Author's Note: Historical Restoration Produces Multiple Rewards and Benefits

This project was clearly very successful and rewarding for all who participated, and it exhibited the effective and efficient use of shotcrete for historical restoration. The real success, however, is best realized by the way this project has restored a sense of pride in the rich history and heritage that exists in this small north Georgia community. This project not only restored a 150-year-old landmark but also revived an entire community, which stepped up to donate land, volunteer time, and make use of its history to provide a better quality of life. I encourage everyone traveling on I-75 in north Georgia to visit Tunnel Hill, which is just 5 minutes off the interstate, and walk through the historically restored Chetoogeta Mountain Tunnel of the old W&A Railroad, visit the museum in the Tunnel Hill Heritage Center, take in a bit of history, and reflect on how it can continue to benefit us in the future.

***Edwin Brady**, PE, President of Edwin Brady Construction Co., Inc., has over 20 years of experience in wet- and dry-process shotcrete, including over 3000 hours of nozzleman experience, concrete repair, and specialty grouting projects on four continents and throughout the United States. Brady received his BSCE from the University of Kentucky, Lexington, KY, in 1980 and has done extensive graduate work toward his MSCE from theUniversity of Houston, Houston, TX. He is an ACI Certified Nozzleman (wet- and dry-process, vertical, and overhead); an ACI Certified Examiner (wet- and dry-process); and a licensed professional engineer in Kentucky and Colorado.*

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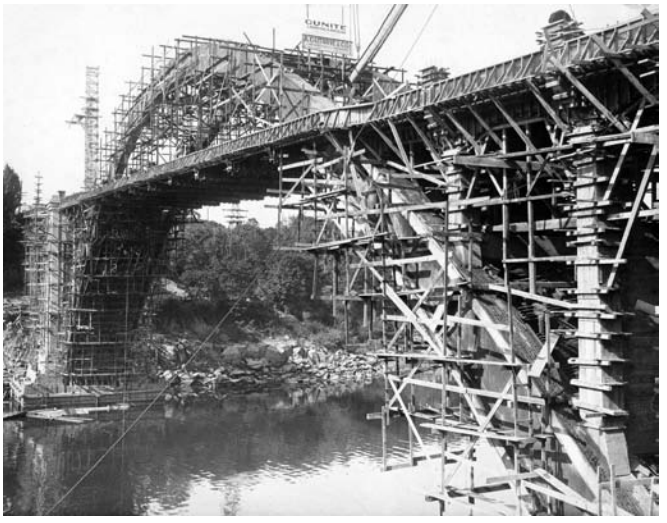
The Oregon City Bridge (Part I)

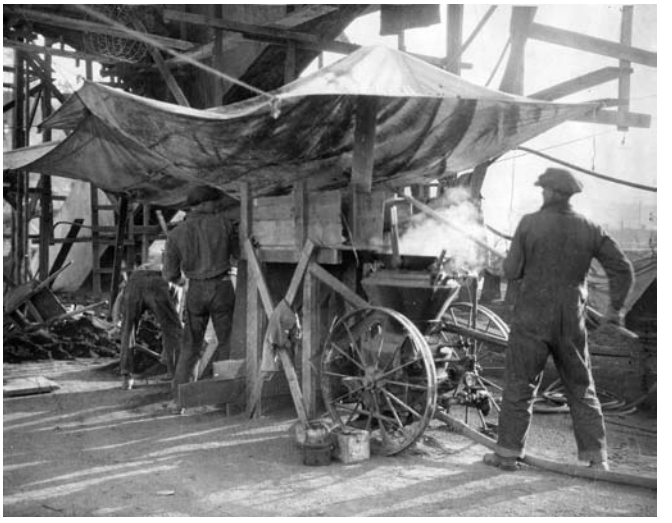
By Marcus H. von der Hofen

The Oregon City Bridge, which spans the Willamette River between Oregon City and West Linn, OR, served the community for nearly a century before recently getting a major overhaul. Originally completed in December 1922, this steel box girder arch bridge was—and still is—a beautiful landmark of the region. Designed under the direction of State Engineer Herbert Nunn, the plans of State Highway Engineer C. B. McCullough were adopted and carried out. A unique feature of the project was the encasement of the steel structure in what was then called "gunite" to protect it from the emissions of the paper mill located close-by.

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



Oregon City Bridge during construction
Photo courtesy of the Oregon Department of Transportation



Oregon City Bridge during construction
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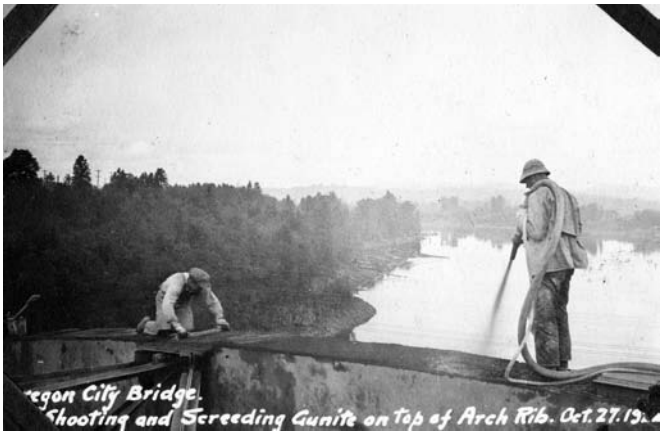


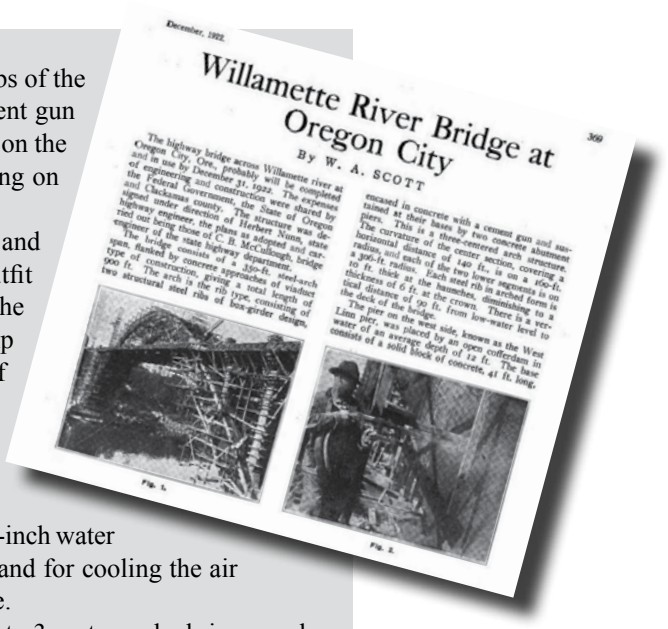
Oregon City Bridge during construction
Photo courtesy of the Oregon Department of Transportation

Oregon City Bridge during construction
Photo courtesy of the Oregon Department of Transportation

each end. All of this could have been yours in 1922 for a published cost of $300,000.[1] As of 2000, the bridge carried 12,800 vehicles per day, which represents only a 40% growth in traffic since 1953.

The bridge was built to replace an 1888 pedestrian suspension bridge. Workers used the old bridge to begin construction of the present bridge's box steel ribs.[2] Construction was made difficult by the great depth of the river at the bridge site and the water traffic during construction. Construction workers used the cables of the old bridge to support the arch during the assembly. Once the new arch was completed, the old suspension bridge was dismantled.[3]

During my research, I was able to track down an excellent article[4] written by W. A. Scott published in the December 1922 issue of *Engineering World* that gave a detailed account of some of the gunite operation. Scott wrote the following in his article[4]:


December, 1922.

Willamette River Bridge at Oregon City

By W. A. SCOTT

The highway bridge across Willamette river at Oregon City, Ore., probably will be completed and in use by December 31, 1922. The expenses of engineering and construction were shared by the Federal government, the State of Oregon and Clackamas county. The structure was designed under direction of Herbert Nunn, state highway engineer, the plans as adopted and carried out being those of C. B. McCullough, bridge engineer of the state highway department.

The bridge consists of a steel-arch span, flanked by concrete approaches of viaduct type of construction, giving a total length of 800 ft. The arch is the rib type, consisting of two structural steel ribs of box-girder design, encased in concrete with a cement gun and sustained at their bases by two concrete abutment piers. This is a three-centered arch structure. The curvature of the center section, covering a horizontal distance of the center section, covering a radius, and each of the two lower segments is on a 300-ft. radius. Each steel rib is arched forms is 10 ft. thick at the haunches, diminishing to a thickness of 6 ft. at the crown. There is a vertical distance of 90 ft. from low-water level to the deck of the bridge.

The pier on the west side, known as the West Limn pier, was placed by an open cofferdam in water of an average depth of 12 ft. The base consists of a solid block of concrete, 41 ft. long.

Fig. 1.

Fig. 2.

"A feature of special interest was the work of encasing the steel ribs of the arch with concrete, which was applied with a cement gun. The cement gun was used also in producing a concrete web, extending from rib to rib on the underside of the arch. The gunite web was backed by steel reinforcing on the steel struts and braces between the ribs.

The guniting was done under subcontract by Lanning & Hoggan and was directly supervised by A.C. Forrester, Civil Engineer. The outfit used was the N-1 type cement gun of the Cement Gun Co., Inc., and the necessary auxiliary equipment. The latter comprised a J. I. Case 45-hp tractor engine, an Ingersoll-Rand single stage air compressor of 325 cubic feet displacement. The air was conducted through 100 feet of 1-1/2 inch rubber hose to the cement gun on the east shore. A line of Pioneer Rubber Mills' 1-1/4 inch sand blast hose extended from the cement gun to the points of gunning, this distance varying from 100 to 450 feet laterally and to a maximum of 120 feet vertically. A 3/4-inch water line, connected to a city main, served to deliver water to the engine and for cooling the air compressor, as well as furnishing a supply to the 1 inch gunite nozzle.

The cement gun charge was made up in the ratio of 1 part cement to 3 parts washed river sand, the latter being graded from 1/2 inch down to fines. The moisture in the mixture was reduced by a railroad sand drier. However, this moisture reduction was varied some according to the humidity of the atmosphere. The volume of water coming in contact with the sand and cement in the gunite nozzle was so regulated by the operator as to produce concrete that would conform to standard practice—admitting water sufficient to hydrate the cement. In applying the gunite a distance of about 3 feet was maintained between the nozzle and the surface being gunited, the gunite being shot at a velocity of about 300 feet per second under an initial pressure of 60 pounds.

This work required 40,000 square feet of 2 inch guniting on the steel ribs; 1200 square feet of 6 inch gunite for the web on the underside of the arch; 800 square feet of 4 inches thick; 1200 square feet of 3 inches thick, and 2800 square feet varying from 6 inches down to 2. The 2 inch gunite coat over the steel ribs was shot against No. 28 U.S. Steel Co. wire mesh, fastened to steel rods, the latter being spot-welded to the steel structure. On this particular part it is figured that 75 square feet of gunite resulted from each cubic yard of sand used. The 6 inch gunite was applied to build up the concrete web between the steel ribs and this extended from the base of the arch up to the first panel. This web was continued higher up in 4 and 3 inch coats. All inside struts and braces below deck were wrapped with wire mesh and sheathed with gunite. Relative to applying the 2 inch gunite which constituted the major part of the job, it is stated that the work carried on at the rate of 500 square feet per day of 8 hours.

In the illustrations given herewith there is shown some of the scaffolding required in carrying through this unusual job of guniting. All the gunited surfaces were gaged by straight edge to a true plane, giving them a finished appearance. The efficiency of the cement gun and accessory equipment on this piece of work was demonstrated to the satisfaction of those assumed responsibility for the character and speed of construction. The aesthetic features of the bridge as they appear in the general view, will commend themselves to those who like to see a touch of the artistic imparted to a structure of severe utility."

(Note: 1 in. = 25 mm; 1 ft = 0.3 m; 1 ft^2 = 0.09 m^2; 1 lb = 0.45 kg)

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

As I walked the job, it became more and more amazing to me what these early shotcreters had accomplished nearly a century ago. Even with all the modern shotcreting tools we have today, duplicating the quality of the shotcrete work on this bridge would be a major challenge.

Oregon City Bridge during construction
Photo courtesy of the Oregon Department of Transportation

In April 2010, Wildish Contractors was awarded the contract for the rehabilitation of the Oregon City Bridge. Its goal was to upgrade the structure to regain the capacities it once had while keeping the original appearance of this historic icon. A great deal of work would be necessary to carry out this upgrade within the short time frame of only 2 years. The history behind the building of this bridge plays a large role in this two-part story of an old bridge becoming new again. Stay tuned in 2013 for the second half of this transforming story!

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

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RAM Construction Services Makes History

By Richard Maxwell and Dave Sawyer

The St. Paul Union Depot, also known affectionately as SPUD, was originally built in 1881, at which time it became a landmark transportation facility in downtown St. Paul, MN. It served as a major midwestern rail hub until its tragic destruction by fire in 1915. Construction of a new facility began in earnest soon after World War I and reached completion in 1923. At its height of operation in the 1920s, millions of pieces of mail moved through the depot annually; there were nine railroads operating within its walls, with an average daily train movement of close to 300.

The depot effectively ceased all transportation functions in 1971, when Amtrak moved its rail services elsewhere. The head house, a stark example of neoclassical architecture, was added to the National Register of Historic Places in 1974. Since that time, a number of businesses have occupied it, along with the U.S. Postal Service, which had been using it in conjunction with the neighboring Central Post Office.

But that all changed in 2011, when the Ramsey County Regional Railway Authority (RCRRA) approved plans to purchase the head house as part of a massive $250 million effort to return the trains to the depot.

Fig. 1: St. Paul Union Depot

Currently, a massive rehabilitation project is underway to restore SPUD (Fig. 1) to its historical glory, and RAM Construction Services, out of nearby Little Canada, MN, is playing a key part in the restoration.

According to Bryan Dziuban, RAM's Minnesota Regional Manager, the scope of work at SPUD involved some restoration of the carriageway and tunnels connecting it with the depot, but the bulk of the work took place in the southwest parking structure under the train deck (Fig. 2 to 5). The parking structure required over 30,000 ft^2 (2800 m^2) of removal and replacement of concrete. While the vast majority of delaminated concrete removal was achieved through hydrodemolition, RAM was responsible for hand-chipping those areas where the hydrodemolition apparatus was unable to reach.

From the outset, RAM's focus was on the mandate given by the RCRRA and the general contractor, Mortenson Construction (located in neighboring Minneapolis): restore the structural integrity to the historical landmark while remaining as true as possible to the original construction aesthetics.

But RAM didn't once consider a form-and-pour approach to this extensive challenge. As Jody Forsman, RAM's Restoration Field Superintendent, puts it, "The company prides itself on its knowledge of the materials and techniques that will yield the highest performance for any given application" and, as one of the largest shotcrete restoration contractors in the Midwest United States, "we chose a dry-process shotcrete approach, using King Packaged Materials' MS-D1 Shotcrete."

In the case of the depot parking structure, RAM was adamant that the hydrodemolition get under way 2 to 3 weeks before shooting began. Even with its focus on quality workmanship, RAM still caught up to the hydrodemolition apparatus on two occasions.

Because the original parking structure, built in 1932, was formed and poured on wooden slats that were anywhere between 6 to 8 in. (152 to 203 mm) wide, the challenge for RAM was not only in replacing the concrete with the shotcrete process but also in finishing it to emulate the

Fig. 2: The majority of concrete removals were performed by hydrodemolition

Fig. 3: Smaller, isolated concrete repairs manually removed by a pneumatic jackhammer

original pattern left by the formwork used over 80 years before. To achieve this, RAM used a fabricated form board, which they pressed into the partially set concrete overhead, thus achieving an effect that imitated and blended in with the pattern left by the original formwork. This "historical touch" was very successful throughout the entire concrete replacement and included those areas that had been previously repaired but were not restored to the original pattern and aesthetic (Fig. 6 and 7).

With an average repair depth of 4 in. (102 mm), RAM used approximately 45 truckloads of King shotcrete for the project, amounting to approximately 500 yd^3 (380 m^3). As Richard Maxwell, RAM's Director of Operations, Restoration Division, puts it, "The key to a successful shotcrete repair lies exclusively with your crew, of whom the most important individual is your nozzleman." RAM uses the services of 15 ACI Certified Nozzlemen throughout their areas of operation. Having made shotcrete a core part of their restoration and rehabilitation division, they take the need to ensure that their personnel maintain certified status on an ongoing basis seriously. The SPUD parking structure rehabilitation required the services of four nozzlemen during RAM's original contract. Steve Spindler, Project Foreman for RAM, was responsible for 95% of the shotcrete required on this project. He has at least 20-plus years of experience as an ACI Certified Nozzleman.

SPUD was finished on time in September 2012. The extensive rehabilitation that RAM undertook to restore the underside of the train deck for the parking structure will significantly ease parking congestion around the depot. The entire structure will allow for an area of up to 250,000 ft^2 (23,226 m^2) devoted entirely to parking. That bodes well for the future of this high-exposure facility that is expected to become

Fig. 4: Final stage of removals prior to shotcrete application

Fig. 5: Column prepared for shotcrete application

the Grand Central Station of the Midwest. As a major hub for local light-rail transit, Metro transit buses, Greyhound and Jefferson buses, Central Corridor light rail, and the return of Amtrak, a fully rehabilitated parking structure takes on more importance than ever. In addition, thanks to the respect accorded past building practices, the historical SPUD can expect a bright future.

About the Company

Founded in 1918, RAM Construction Services is one of the oldest and most experienced waterproofing and restoration contractors in the United States. RAM Construction Services has built a solid reputation based on knowledge, experience, and reliability. Completing more than 2000 projects per year, RAM Construction Services has grown into one of the largest midwestern contractors specializing in the restoration of aging structures and skilled waterproofing of new structures.

Over the years, RAM Construction Services has revitalized aging structures in dozens of states across the country. The projects range from below-grade waterproofing of a 600,000 ft^2 (55,742 m^2) auto assembly plant, to weatherproofing a 32-story office tower, to the delicate cleaning and restoration of stone and terra cotta on a 100-year-old church.

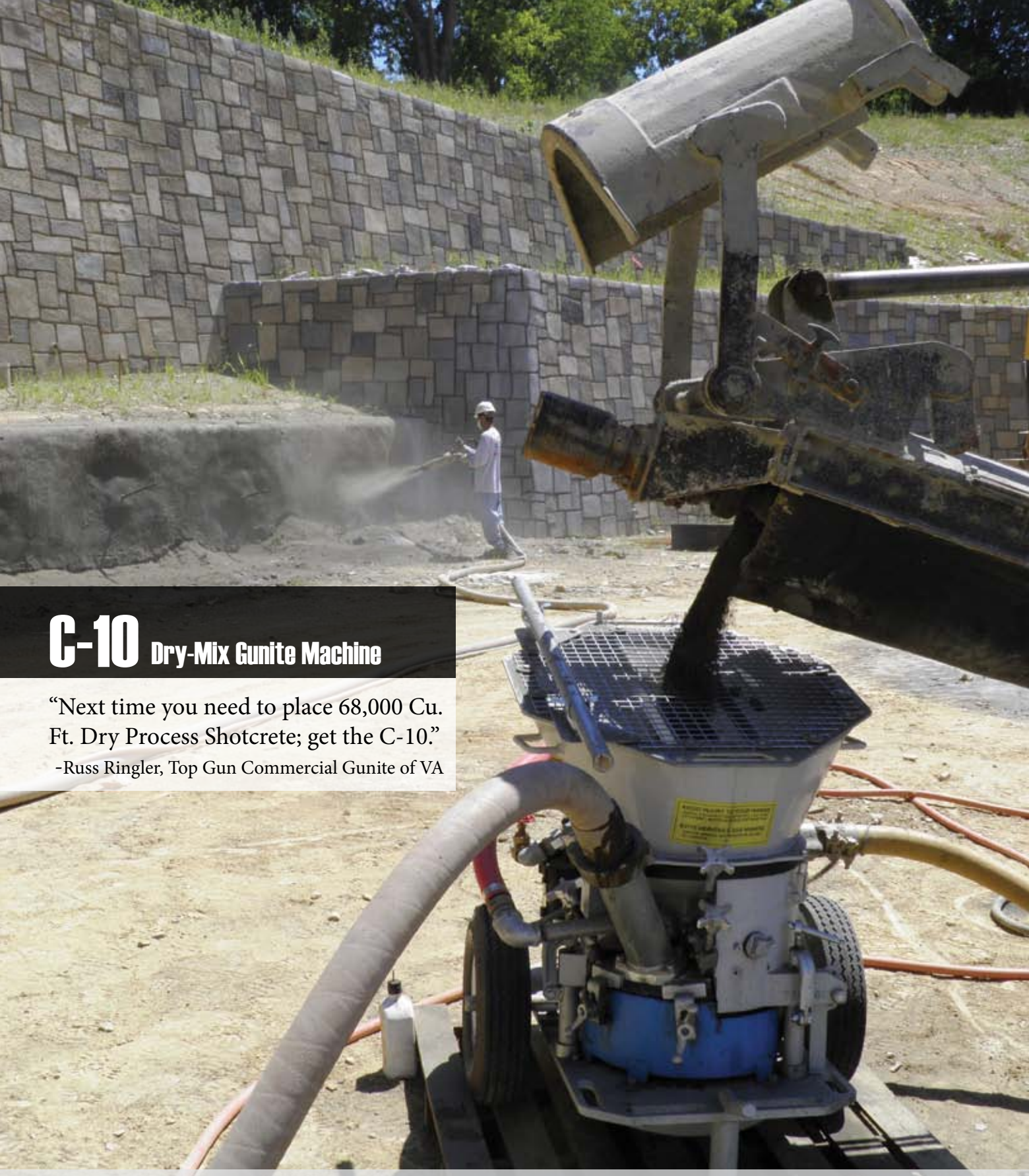
Corporate experience and the individual skill of superintendents and tradesmen are RAM's keys to a successful job. RAM Construction Services is available to advise clients on the methods most appropriate for cost and time savings. The best evidence of RAM's successful craftsmanship is the long list of repeat customers, owners, contractors, and construction managers who invite them to work on their projects.

Fig. 6: Multiple layers of shotcrete prior to finish coat

Fig. 7: New shotcrete surface to resemble 1932-formed rough-cut plank finish

***Richard Maxwell** has been a leader in concrete restoration for over 24 years. He specializes in parking decks, bridges, buildings, soil stabilization, and zoological exhibits throughout the Midwest, East Coast, and several southern states. In addition to shotcrete, Maxwell supervises other aspects of construction, including epoxy overlay, caulking, specialty deck coating, and post-tension repair for numerous types of concrete structures. He works directly with owners and owner representatives to consistently meet strict schedules and tight budgets. Hard work and dedication has advanced Maxwell to his present role as Director of Operations. In this capacity, he oversees all restoration projects for RAM's corporate office in Livonia, MI, as well as its three satellite offices located in Cleveland, OH; Cincinnati, OH; and Minneapolis, MN. Maxwell is highly involved with RAM's Safety Committee and is dedicated to promoting a safe working environment. He is an ASA member and has been involved with projects that received the International Concrete Repair Institute's Award for Excellence in 2000 and 2008, as well as ASA's Outstanding Shotcrete Project Award in Repair and Rehabilitation in 2007.*

***Dave Sawyer** is a Technical Representative with King Packaged Materials Company and is responsible for the sales and marketing of its line of shotcrete products in the southern Ontario, Canada, and U.S. Midwest markets. He has over 24 years of experience in the concrete industry and is a member of the American Concrete Insitute (ACI) Toronto Chapter, ASA, and The Building and Concrete Restoration Association of Ontario.*



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The South Side Market House

By Ted Sofis

Sometimes old buildings get a second life. In the case of the South Side Market House, the old structure has had many different reincarnations. Located in Pittsburgh, Pennsylvania's South Side neighborhood, the building is in a lively, vibrant section of the city. The South Side lies just across the Monongahela River from downtown Pittsburgh and is a popular destination for young people who frequent its restaurants and shops. The South Side Market House was originally built in 1893 and the historical building was rebuilt again in 1915 after a fire. It is listed on the National Register of Historical Places and has served many different uses over the years (Fig. 1). In its earliest days, the Market House held livestock for auction that were kept in pens in the basement. There is a stone bull's head on the front of the building's façade attesting to those days long ago. In subsequent years, the 12th Street location was used as a fresh food market. According to the Pittsburgh History and Landmarks Foundation and the *Pittsburgh Post-Gazette*,[1,2] the uses of the building since that time have been many and varied—it has been used for dances, roller skating, and even basketball tournaments. Most recently, it has served as a recreational center for senior citizens and is often used by local residents for activities, social events, and meetings.

Fig. 1: The shotcrete crew prepares to start in front of the South Side Market House in Pittsburgh, PA. The structure, which was built in 1893, is listed on the National Register of Historic Places

Fig. 2: In this access hole, which was cut to gain access into the building's basement, a side view of a supporting brick arch is visible

The Market House was closed in March 2011 when the City Public Works Department discovered structural problems with the floor system on the front side of the building. The floor system, as was common for the period, is supported by a series of shallow brick arches. Over time, the mortar joints of the brick arches deteriorated (Fig. 2 to 4). We encountered a similar problem with the damaged terra cotta tile arches supporting the floor system of Union Station in Washington, DC. On the Union Station project in 1987, we repaired the damaged terra cotta arches with a dry-process, shotcrete-applied repair mortar, gunned overhead to restore the integrity of the supporting structural arches.

In January 2012, Craig Bolinger of A&A Consultants, Inc., called Sofis Company to look at the brick arches of the Market House floor system to see if a shotcrete repair would be a viable option. After inspecting the basement and looking at the floor system, we concluded that gunned shotcrete repair would solve a lot of the problems. Because dry-process shotcrete can easily be sprayed in

place overhead, the repair could be accomplished from the underside without removing the existing floor. Shotcrete would conform to the existing shape of the arches and, by spraying the repair mortar in place, we would fill any holes and voids where there were missing bricks and gaps (Fig. 4). By gunning a monolithic overlay over the brick arches, the shotcrete would fill in all the deteriorated mortar joints, tightening up and stabilizing the floor system support. With a sprayed shotcrete installation, we could efficiently work around all obstructions, piping, conduit, and supports, which would not be possible with a formed repair and would be much more productive than hand troweling (Fig. 5). Parging the arches with troweled in-place material would be a slow, laborious undertaking and would have to be applied in multiple layers (Fig. 6). With a shotcrete application, the pneumatically applied mortar could be gunned to full depth in one pass. The nozzleman has more control with dry-process shotcrete and he can easily make the sensitive adjustments that are necessary for placing material overhead. In dry-process shotcrete, material is conveyed by air through the hose in a dry or slightly dampened state, and water is injected into the material stream in the nozzle with fully wetted material impacting the receiving surface. An additional advantage of using dry-process shotcrete is that it is easier to stop and start shooting without worrying about wet material in the hose setting up. This was particularly important when contending with the various obstructions on this particular project.

Prior to the shotcrete placement, the brick arches were water-blasted to remove loose mortar and remove dust, dirt, and other particulates from the receiving surface. A galvanized 3 x 3 in. (76 x 76 mm) No. 11 gauge (MW5.6/5.6) steel mesh was installed and anchored in place with expansion-sleeve J-hook anchor bolts. Shotcrete MS, a microsilica-enhanced repair mortar manufactured by Quikrete, was used for the overhead shotcrete work. The material was gunned in place quickly and efficiently and provided a very inexpensive yet durable method of repairing the floor system.

On June 25, 2012, City of Pittsburgh Public Works Director Rob Kaczorowski announced that the Senior Citizens Recreational Center was once again open to the community. Pittsburgh Mayor Luke Ravenstahl; Bruce Krause, City Councilman of District 3; and other city officials also attended the "re-opening" ceremony. The overall project included extensive renovations to the entire building, including flooring, painting, windowsills, and a general interior facelift. The majority of the renovation was done in-house by the city's public works employees for a total cost of $230,000—a cost substantially less than the lowest bid received of $726,000. Of that cost, only a very small portion covered the cost of the shotcrete repairs. Although the South Side Market House was taken out of service because of the structural issues with the brick arches of the floor system, the shotcrete repairs turned out

Fig. 3: These brick arches are in one of the open sections of the supporting floor system

Fig. 4: The general condition and configuration of the brick arches. There were also places with holes or missing bricks

to be one of the least expensive costs in the overall renovation project.

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Fig. 5: Working around the structural supports, piping, conduit, and other obstructions added to the difficulty of the overhead shotcrete placement

Fig. 6: The nozzleman is placing shotcrete overhead in an especially congested area of the basement behind the elevator shaft

Acknowledgments

Owner
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Director of Public Works
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Mike Radley

Parks & Recreation Director of Seniors
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Bruce Krause

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Architectural Division Project Manager, and
Federico Seigert, Project Architect

Engineer
Craig A. Bolinger, CBSI, A & A Consultants, Inc.

Shotcrete Contractor
Sofis Company, Inc.

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

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When to Extract Cores

By Lihe (John) Zhang

During preconstruction testing and mockups, as well as during shotcrete production, a minimum specified compressive strength is always required in the project specification. The specified compressive strength is used to qualify the concrete mixture, the shotcrete nozzlemen, and the shotcreting equipment, as well as for quality control of the shotcrete production. Compressive strength is commonly tested at 3, 7, and 28 days using 3 or 4 in. (75 or 100 mm) diameter cores (ASTM C1604) from standard shotcrete test panels (ASTM C1140). Compressive strength at other ages, such as 1 or 5 days, might also be required, depending on project application needs. Typically, contractors prefer to evaluate the shotcrete's compressive strength as early as possible, which requires early extraction and testing of cores. When compressive strength tests meet the required strength at 1, 3, and 7 days, shotcrete is considered to have met the quality control requirement, and the construction schedule can be adjusted using an increased production rate. Therefore, it is reasonable for contractors to want to extract cores at the earliest age. However, it is not uncommon to find damage to cores that are extracted too early, such as less than 1 day. Alternatively, when cores are extracted too late, such as more than 2 days, the decision of the production rate and the adjustment of the construction schedule are delayed. The question, at least from the contractor's perspective, is: When should cores be extracted to meet requirements for both quality control testing and the construction schedule?

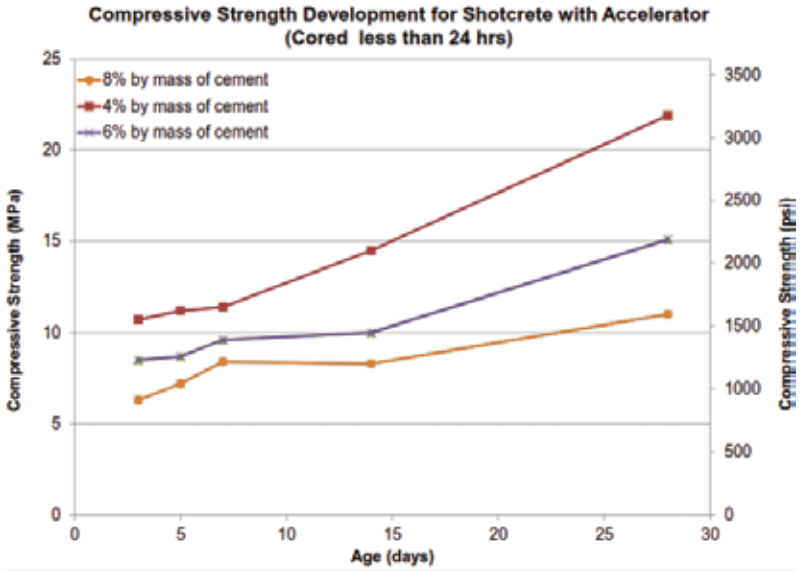

Fig. 1: Compressive strength development for shotcrete with accelerators; cores extracted at less than 24 hours of age

Coring at 1 Day

In a recent underground shotcrete project, cores were extracted at less than 24 hours. The project used silica fume-modified wet-mix shotcrete and added an alkali-free accelerator for overhead application. Shotcrete preconstruction test panels were shot with accelerator dosages of 4, 6, and 8% by mass of cement. Shooting started on Monday afternoon at 2:00 p.m., and a total of six test panels were shot, which allowed two panels for each accelerator dosage. The project took place in May, and temperatures were approximately 59 to 68°F (15 to 20°C). All panels were covered with wet burlap and plastic sheeting for overnight protection. A restricted area was constructed for the test panels, and no rainfall occurred. Coring activity began the next morning at 7:00 a.m. By 10:00 p.m., all cores were extracted and a very dark slurry came from the core drilling water. Cores were delivered to the laboratory for standard curing and were tested at 3, 5, 7, 14, and 28 days. The results are shown in Fig. 1. The 5-day compressive strength test results confirmed that the coring had significantly damaged the cores, which produced low strength results.

Coring at 2 Days

The same ACI Certified Nozzleman shot the same shotcrete mixture using the same equipment, including the shotcrete pump and the accelerator dosing pump with accelerator dosages of 4, 6, and

8%. Panels were left in the field and covered with wet burlap and a plastic sheet for overnight protection. A restricted area was constructed for the test panels, and no rainfall occurred. The cores were extracted 2 days after shooting, and the compressive strength development is shown in Fig. 2, which clearly shows that the compressive strength developed properly when cored at 2 days of age.

Proper Time to Extract Cores from Test Panel

The test results illustrated in Fig. 1 and 2 show that the compressive strength of the cores developed properly when they were extracted at 2 days, instead of less than 1 day. It appears that cores extracted at 2 days produce results representative of the panel or in-place shotcrete. ACI 506.5R-09,[1] Section 8.8, also states that "coring, at an early age, can potentially cause damage to the cores." However, to accelerate the construction schedule and obtain early quality control testing results, contractors always want to extract cores as early as possible. The question then becomes: Do you have to wait 2 days to extract the cores?

The physical grinding and tearing of the shotcrete at the core surface, which is caused by the coring operation, is believed to affect the strength development of shotcrete. This is because the vibration causes internal damage to the weak bond of the hydrating cement, especially at a very early age (hours versus days) when strengths are low. Typically, shotcrete and concrete can be cored or demolded when compressive strength reaches 1800 to 2200 psi (12 to 15 MPa). Most shotcrete mixtures will develop this strength within 1 to 2 days of placing. However, to be confident that early-age coring will not damage cores extracted from a panel or in-place shotcrete, it is critical to establish the shotcrete's compressive strength at an early age of less than 24 hours. The Heere and Morgan[2] end beam testing method is particularly suitable for establishing compressive strength of shotcrete less than 24 hours old (Fig. 3).

Previous project experience[2] reported that when compressive strength reaches 1800 to 2200 psi (12 to 15 MPa) when tested with an end beam tester, coring activity will not cause damage to the cores and will produce representative shotcrete compressive strength.

To further confirm this experience, the author recently carried out a trial dry-mix shotcreting project in which he tried coring at 20 hours. The shotcrete mixture was a silica fume-modified shotcrete mixture with 3% accelerator (in dry powder) by mass of cement. Figure 4 shows the strength development of a dry-mix shotcrete during the first 24 hours.

Compressive strength, tested with an end beam tester, reached 2200 psi (15 MPa) at 16 hours, and cores were extracted at 20 hours. Compressive strength development at 3, 7, and 28 days (Fig. 5) shows that the cores were not damaged by the coring activity at 20 hours.

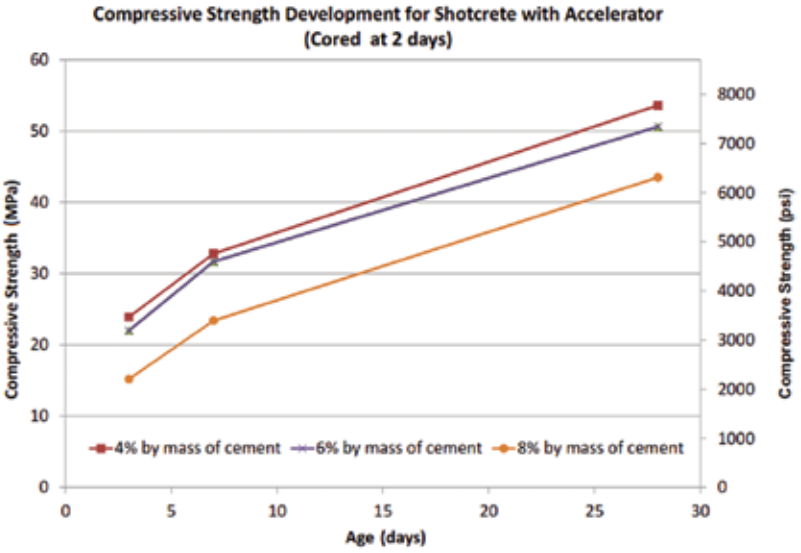

Fig. 2: Compressive strength development for shotcrete; cores taken at 2 days of age

Fig. 3: End beam test equipment to test compressive strength at less than 24 hours

Summary

When an accelerator is used, the shotcrete sets faster at an early age and can sometimes develop strength in only a few hours. However, the accelerator is sensitive to temperature; therefore, strength development varies according to the ambient temperature and the temperature of the shotcrete mixture. The dosing of the accelerator is always dependent on the nozzleman's experience, as well as the accuracy and reliability of the accelerator dosing pump. Therefore, the early-age strength development of accelerated shotcrete will potentially vary more than nonaccelerated shotcrete.

Core extraction should only be done when shotcrete compressive strength has developed sufficiently. Generally, a compressive strength no less than 1800 to 2200 psi (12 to 15 MPa), when tested by an end beam tester, would be sufficient to proceed with coring. This strength level is typically reached between 1 and 2 days. However, if an accelerator is used, this strength level may develop at a much earlier age—often less than 24 hours.

If the early-age compressive strength test (with an end beam tester) is not available, it is recommended to extract cores 2 days after shooting. Any coring activity before 48 hours has a high probability of damaging the shotcrete core, which creates a weaker structure in the shotcrete cement paste matrix and consequently produces compressive strength test results that are lower than the actual compressive strength of the panel or in-place shotcrete sample.

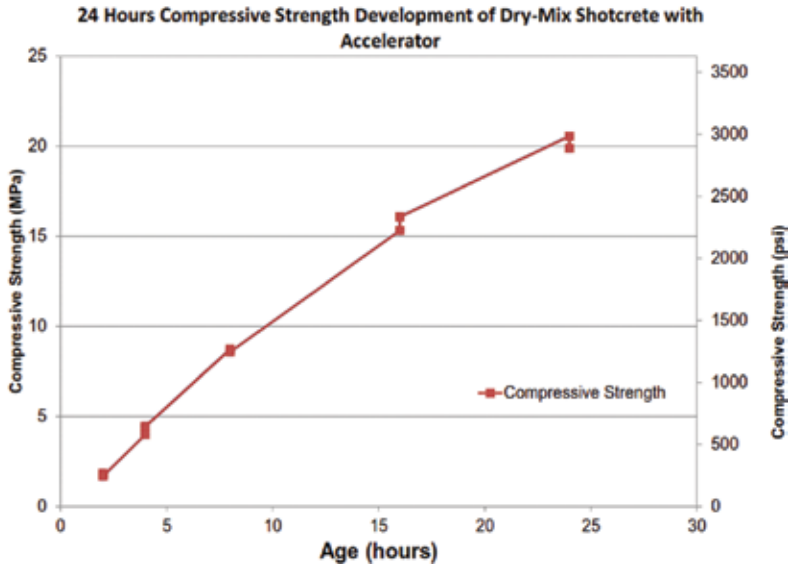

Fig. 4: Early-age compressive strength when tested with end beam tester

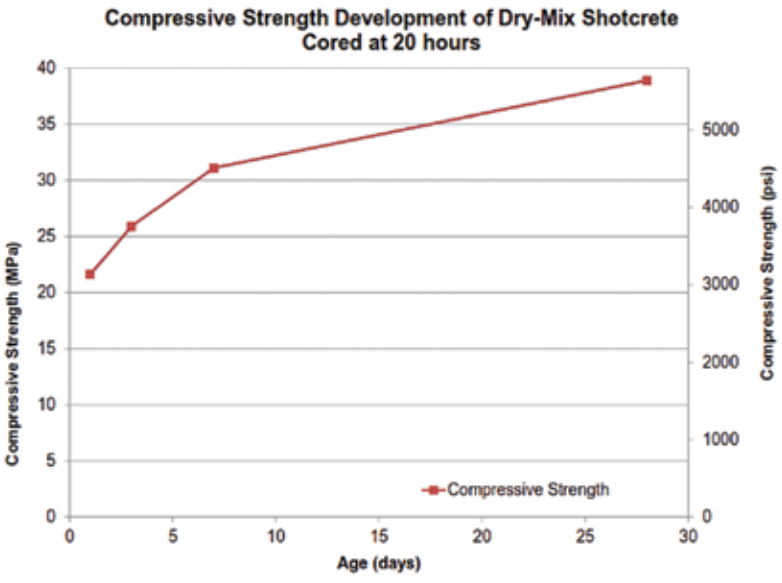

Fig. 5: Compressive strength development through 28 days; cores extracted at 20 hours

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2. Heere, R., and Morgan, D. R., "Determination of Early Age Compressive Strength of Shotcrete," *Shotcrete*, V. 4, No. 2, Spring 2002, pp. 28-31.

***Lihe (John) Zhang**, PhD, PEng, LEED AP, recently opened his own firm, LZhang Consulting and Testing Ltd. Zhang has over 10 years of experience in concrete and shotcrete technology; evaluation and rehabilitation of infrastructure; and shotcrete training, consulting, and testing. He received his PhD in civil engineering from the University of British Columbia, Canada, where he conducted research on fiber-reinforced concrete, and is also a LEED Accredited Professional. He is Chair of American Concrete Institute (ACI) Subcommittee 506-F, Shotcrete-Undergound, and Co-Chair of the ASA Underground Committee. He is a member of ACI Committees 130, Sustainability of Concrete; 506, Shotcreting; and 544, Fiber-Reinforced Concrete, and a member of ASTM Committee C09, Concrete and Concrete Aggregates.*

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How Important Is Shooting Sequence?

By Dan Millette

When someone does something a certain way long enough, it often becomes the way it is done—whether proper or not. When one gains experience from performing this task for a long time, he/she is often the one who trains the newcomers. Therefore, sometimes, a task done improperly for so long just becomes the standard. That doesn't make it right.

Fig. 1: Sprayer operator spraying the roof before the walls

Fig. 2: Sprayer starts at bottom of wall on right and sprays up, over, and down the opposing wall—overspray is deposited on the left side wall

I have seen this in the underground shotcreting industry, although it has been much more prevalent in mining than in tunneling. When you go into a mine in the Americas to watch a shotcreting operation, you will frequently see the nozzleman do the following:

- Start spraying the overhead portion of the opening and, oftentimes, shoot all over the place with the nozzle;
- Spray along the wall of the opening, then go straight up, over the crown, and down the other side; and
- Spray areas all over the opening and then return to fill in the bald spots.

These application methods are more common when the nozzleman is shooting with a remote-controlled boom than when shooting is done with a handheld nozzle (Fig. 1 through 4).

I have often been underground with a person who knows shotcreting and yet nothing is ever said about the spraying sequence. Has it just become the way it is done and no one notices the potential problems?

When spraying a mine opening or tunnel, a specific spraying sequence should be followed to ensure proper application of the concrete to the opening. To begin with, the surfaces of the opening need to be washed down to prepare for shotcreting. The washing should start at the crown and the opening should be washed from the top down. It is just common sense: if you wash from the bottom up, you will get dirty water flowing over the area you have just washed.

When shooting the opening with concrete, you need to start at the bottom of the wall on one side of the opening and shoot in a horizontal direction to the end of the area. If using a remote-controlled sprayer, this can be done by simply running the nozzle assembly back and forth on the lance, if so equipped, and then raising the lance upward as the material is applied.

This spraying method should be used until the opening is covered beyond the shoulder and up onto the roof. The next step is to go to the opposite

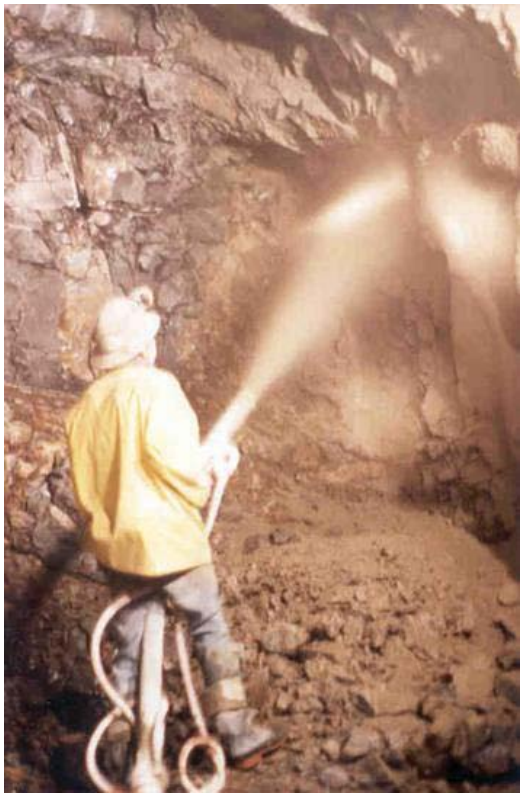

Fig. 3: Even some hand nozzling is improperly sequenced

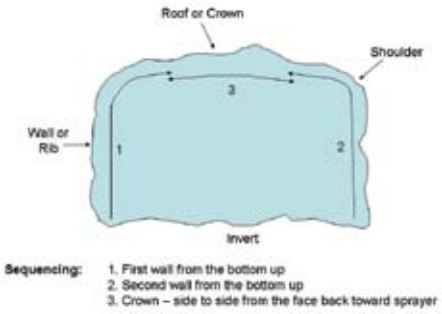

Fig. 4: Proper sequencing for shooting a tunnel or mine opening

side of the opening and repeat the procedure. Once both sides of the opening are shot above the shoulders, then a side-to-side motion can be used to cover the crown.

I have often been asked by well-seasoned nozzlemen, "What is the problem with starting on the overhead section?" Of course, the problem with starting overhead is that rebound and much of the overspray from the overhead shooting gets deposited on the walls of the opening. By the time the nozzleman does shoot the walls, he/she is then spraying over the rebound and overspray, causing the shotcrete application to be porous and weak and compromising the bond to the substrate that is necessary for a quality application. This can also commonly result in debonding of shotcrete, especially lower on the walls.

So the next time you are in a mine or tunnel watching someone spray shotcrete, take note of the sequence the nozzleman is using—it may surprise you. It's never too late to do it right!

***Dan Millette**, a Mining Engineer, is the Director of the Mining and Tunneling Division of The Euclid Chemical Company. He is a member of ASA, Chairs the ASA Underground Committee, and is also a certified EFNARC Nozzleman Examiner.*

Perimeter-Overflow Negative-Edge Pool with Beach-Entry Spa

By Mason Guarino

Fig. 1: Stone underlayment along with the reinforcing bars penetrating out of the first phase of construction so the second-phase pool section could be tied in correctly

Fig. 2: Elaborate reinforcing required by the pool design as we start the second phase of shotcrete

A Camden, ME, home sat alone at the end of a long driveway with little to no property features other than the surrounding forest floor and an elevated view of the ocean. But that was slated to drastically change when the homeowners asked South Shore Gunite Pools & Spas, Inc., to work with their architect and builder to install a spectacular pool. The land had a natural slope to it and, with the ocean view, created an ideal venue for an architectural masterpiece. After some meticulous design and planning to incorporate the project into the natural Maine landscape, the pool concept was complete. The pool would have a negative edge toward the forest side and a beach entry on the house side. The pool design kept the water level with the pool coping and decking around the pool. The final product would have a very dark, natural look to it.

The difficult part was creating the drawings—detailing how to best build the pool to last in the harsh Maine climate with everything functioning correctly. Freezing winter temperatures required a significant foundation constructed with dry-mix shotcrete and clean, crushed stone. The complexity of the pool required it to be constructed in specific phases; the first phase included the negative-edge portion, followed in the second phase by the remainder of the pool (Fig. 1 to 3). The negative-edge feature, including the spillway wall and trough, needed to be constructed first to create a deep footing that would reach below the frost line. In the first mobilization, the trough area was excavated to the required depth and then over-excavated on the pool side to allow us room to construct forms. For the future, well-draining fill material was required under the pool. After excavation, extensive plumbing was installed, followed by form erection and placing of the pool shell reinforcing steel, and then shotcreted with dry-mix shotcrete. Some of the reinforcing steel in the trough wall extended out from the wall to allow for subsequent tie-in with the pool floor.

Next came the pool itself. After the trough and spillway wall were completed, the pool floor area was backfilled with free-draining crushed stone that would prevent any water buildup and potential heaving due to the freezing winter temperatures. Everything within 4 ft (1.2 m) of potential exposure to freezing air temperatures was filled with crushed stone or dry-mix shotcrete, as frost heave does not just affect horizontal sections of the pool but could also impact vertical sections that line the spillway. The pool had a shotcrete perimeter gutter that would later provide the overflow and deck-level water capability. Two pockets on either side of the beach-entry area were constructed to hold natural rocks from the surrounding property to help the pool blend into the landscape. After initial curing and once the pool shotcrete reached the required strength, the boulders were installed. Shotcrete was placed around the boulders to secure them in place (Fig. 4).

The complexity of the pool structure created sections located from well below the frost line to right at and above the frost line. This required extensive structural design, resulting in a lot of reinforcement. The reinforcing steel consisted of two layers of No. 4 (No. 13M) reinforcing bar in the entire pool. The horizontal reinforcement spacing was 8 in. (203 mm) on center and vertical spacing was 6 in. (152 mm) on center. During shooting, a blowpipe was used extensively to keep the outer layer of reinforcing bar clean and prevent any rebound from building up on the bar surface, where it would reduce the quality of the in-place concrete. Overall, with the multiple phases, the shotcrete portion of the job was completed in 5 days.

The customer wanted to have the negative-edge wall act like an aggressive waterfall. Producing the waterfall effect required high flow rate demands that also affected water turnover. Based on the length of the perimeter overflow, the calculated flow rate required to create the waterfall effect was 740 gal./minute (350 L/s). This high flow was provided by a 10 hp pump outfitted with a variable-speed drive to allow for increased energy efficiency and control. The main feature plumbing lines were 8 in. (203 mm) polyvinyl chloride (PVC) to smoothly convey the substantial volume of water. With the high flow rates needed for the waterfall, conventional 2 in. (50 mm) pool returns produced too much turbulence for the vanishing-edge waterfall effect. Thus, additional main drain-type fittings were installed at the bottom of the pool to supply the high-flow-rate return water with minimal disturbance on the pool surface for the vanishing-edge waterfall. There were also multiple main drains for suction and additional drain-type fittings used as inlets. A buried precast concrete surge tank was also used to ensure that an adequate volume of water was available at all times. To blend with the natural Maine surroundings, the tiles and coping stones were custom-manufactured from

Fig. 3: Deep excavation required for forming and, subsequently, filling with free-draining stone to prevent frost heave. Also seen is the dowel reinforcing bar that was tied into the pool floor in the second phase

Fig. 4: Completed shotcrete with large rocks placed

an indigenous stone local to Maine. The majority of the stone was a dark gray with some white veins that fit in perfectly. We installed the coping stones on the shotcrete gutter so the inner stone allowed water to pass over it in a small slot between two rows of stone and then into the gutter. The pool was waterproofed before the final finish of black pebble was installed on the interior. In the rock pockets that would not be able to have a final finish, a more substantial waterproofing product was used.

On projects like this, South Shore Gunite prefers to use its Airplaco mobile batch plants.

Fig. 5: Completed pool from the beach-entry end

Fig. 6: Completed pool from the negative-edge side

When we use Airplaco mobile batch plants, all the worrisome aspects when using ready mix are nonexistent. There is no waiting on trucks, worrying about a truck sitting too long and getting hot, or breakdowns leading to a costly wasted ready mix truck. In certain areas, especially remote locations in Maine, a ready mix truck would be close to an hour old when it first arrived on site, thus allowing insufficient time to use the load of concrete while the material is still in acceptable condition. Our mobile batch trucks have been outfitted with a hydraulic system that quietly powers the Gunite Supply C10 shotcrete guns. Compressed air was supplied by an Ingersoll Rand 825 CFM (390 L/s) truck-mounted air compressor. A six-man crew, including the truck driver/gun operator, is typical on a project like this.

The overall job took about 9 months to complete (Fig. 5 and 6). A lot of the construction was done in the winter under a tent that the general contractor erected over the swimming pool. This allowed the pool construction to be completed more quickly. All shotcrete work took place before the winter weather became an issue. The final product lived up to all of the expectations the homeowners were looking for and then some. This pool is definitely one of South Shore Gunite Pools & Spas' most intricate residential pools to date.

Mason Guarino *started in the pool industry when he was 14, learning how to install reinforcing bar. Since then, he has worked on all phases of the swimming pool industry. Guarino has been with South Shore Gunite Pools & Spas, Inc., full-time since graduating from the Wentworth Institute of Technology with his BS in construction management in 2009. Guarino is an active member of ASA and an ACI Certified Nozzleman.*

Shotcrete FAQs

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

Question: *We are considering a shotcrete lining of a new corrugated metal pipe to improve the smoothness and hydraulic capacity. What is the minimum thickness over the corrugations and should we be looking at any reinforcement or studs to support the shotcrete?*

Answer: This has been done in the past to improve hydraulic capacity and provide better wear resistance in the invert. Typically, the minimum cover over the corrugation is 2 to 3 in. (51 to 76 mm) with a welded-wire fabric either welded or otherwise attached to the corrugated pipe. The cover could likely be reduced with the use of structural fibers of either steel or synthetic material. Steel fibers and wire mesh should not be used together.

Care must be taken to specify the required finish. This application would likely benefit from a smooth trowel or light broom finish. A light broom finish is preferable from a safety standpoint, as a trowel finish creates a very slippery surface both during construction and for the maintenance at a later date. In addition to the hydraulic and wear characteristics, once shotcreted, the entire pipe will become a composite section with improved structural characteristics.

It should be noted that the pipe must be large enough for workers to work in safely and productively. This would mean an absolute minimum of 48 in. (1219 mm) and preferably larger.

Question: *We are a local agency considering the repair of a number of older culverts with shotcrete. Like most agencies, we are trying to be creative about maximizing our funds. We work with a federal agency when it is determined that a "new" culvert is needed. In other words, the agency will not pay for maintenance repairs but will pay for "new" culverts. We are wondering if the shotcrete method has ever been viewed as a means of creating a "new" culvert. Could the existing culvert be considered as merely a form for the new culvert?*

Could you also speak to the life expectancy of shotcrete (life cycle) versus a new concrete culvert?

Answer: Shotcrete has been used extensively for the purpose of relining existing culverts. You are correct to visualize the existing culvert as a form for building a new structure. Because it is a stay-in-place form, it may actually act as a composite structure.

Shotcrete is a method of placing concrete and will have similar, if not better, durability and life span if installed professionally with good mixtures. You can locate numerous past articles on durability of shotcrete that have appeared in *Shotcrete* magazine in the magazine's archive on the ASA website, **www.shotcrete.org**.

Similar work has been done in California, Colorado, and other states. This approach is currently being used as permanent tunnel lining in many places, including many of the current New York Transit projects.

Question: *I have been asked to recommend repairs to a fire-damaged brick wall. The wall is 12 in. (30.5 mm) thick and 14 to 16 ft (4.25 to 4.9 m) high. The fire caused spalled brick—3/8 in. (10 mm) deep—and soft mortar joints. The damaged side of the wall is exposed to weather. I plan to recommend tuck-pointing the mortar joints but am wondering if shotcrete is appropriate to repair the spalled brick. The brick could be cut out and replaced, but shotcrete would seem to offer the advantage of repairing and reinforcing the brick wall.*

Answer: Shotcrete would be an excellent process to repair or overlay your wall. You are correct in saying that it could not only repair but also reinforce and enhance the strength of the wall system. It is important to remove all deteriorated brick and sand-blast or water-blast the surface if you are looking for a good bond between the shotcrete and the existing brick. Dowels epoxied or grouted into the existing brick are often used to mechanically tie the shotcrete overlay to the brick wall and also stabilize the new reinforcing steel in the shotcrete overlay.

Please note: *ASA's technical team provides the answers to submitted questions as a free service. The information is based on the personal knowledge and experience of the ASA technical team and does not represent the official position of ASA. We assume that the requester has the skills and experience necessary to determine whether the information ASA provided is appropriate for the requester's purposes. The information provided by ASA is used or implemented by the readers at their OWN RISK.*

The Influence of Reinforcement on Relative Creep Deformations in Shotcrete Linings

By E. Stefan Bernard

Shotcrete is now widely used for ground control in underground mining and civil tunnel construction throughout the world. It is also frequently used for ground stabilization in basements and for inclined slopes, swimming pools, and other applications involving restraint of soil or rock. In all of these applications, the shotcrete generally acts as a semi-rigid passive form of restraint and interacts with the ground to redistribute stresses and limit deformation. This action is enhanced by the occurrence of creep both before and after cracking of the concrete matrix because creep assists in the process of stress redistribution. However, a question frequently arises: What level of creep is most suitable? For thin-walled linings, creep in *flexure* is particularly important to the redistribution of load because compression and tension play relatively minor roles in the structural behavior of thin-walled linings (Fig. 1). Reinforcement is essential to effective ground control because cracks invariably occur and give rise to structural discontinuities if reinforcement is not present.

"Creep" is a term used to describe the tendency of materials to deform over time under a sustained load. Creep is manifested as an increase in strain with time relative to strains experienced in the short term. Concrete subject to a sustained stress will exhibit creep as a result of the movement of moisture within the calcium-silicate-hydrate phase of the paste. This will occur both in compression and tension and is therefore quite apparent in concrete subject to bending.[1-6] Shotcrete will generally exhibit relatively large creep deformations compared to conventional concrete because of the higher-than-normal amount of cementitious material in this type of concrete. Because high cementitious contents are routinely used in tunnel construction, it is not surprising that shotcrete tunnel linings exhibit relatively high levels of creep compared to cast concrete. This is fortuitous because most ground continues to deform for a considerable period after excavation. A rigid lining exhibiting minimal creep would be more likely to crack when used to restrain mobile ground than a relatively compliant, high-creep lining (assuming materials of equal strength). However, an excessive tendency to creep is also unsatisfactory because this can lead to large deformations and less effective ground control.

Several studies have recently been published regarding the creep of cracked fiber-reinforced shotcrete (FRS) and fiber-reinforced concrete

Fig. 1: Once the shotcrete has hardened, will its creep characteristics suit the degree of ground movement expected?

(FRC) reinforced with either steel or synthetic fibers. One such study has indicated very high rates of creep for microsynthetic fibers[7] and others have indicated comparable rates of creep for steel and high-quality macrosynthetic fibers.[8-10] Other studies have demonstrated widely varying levels of creep deformation for different types of macrosynthetic fibers.[11,12] Tests comparing Dramix hooked-end steel fibers and Synmix macrosynthetic fibers have indicated extreme levels of creep deformation for Synmix macrosynthetic fibers,[13] indicating that some types of low-performance macrosynthetic fiber are probably unsuitable for use in deformation-sensitive civil tunnel linings.

An issue that has been raised by consulting engineers in relation to several recent tunneling projects is whether the type of reinforcement used in a tunnel lining has an influence on the creep deformation of an uncracked lining. According to accepted structural engineering analysis,[14,15] steel bars do not creep and heavily reinforced concrete sections will exhibit diminished creep in flexure as the degree of steel bar reinforcement is increased. However, at the low levels of reinforcement typical of thin-walled shotcrete linings (for example, a single layer of steel mesh in a 3 in. [75 mm] thick lining), the proportion of steel mesh reinforcement included is less than 1% and is usually assumed to be located at the middepth. In this situation, according to conventional analysis,[15] the influence of the steel mesh on creep in flexure is very small.

The influence of fibers on creep deformation in an uncracked lining is difficult to assess by calculation. Fibers are discontinuous and exhibit interaction characteristics within the concrete envelope that are influenced by the properties of the concrete matrix. The performance of the fibers is also altered by changes to the physical properties of the concrete matrix—especially changes that occur with age. As a result, it is not possible to uncouple the behavior of the concrete from that of the fiber reinforcement and treat these as distinct elements of a structural system in the way that conventionally reinforced members are analyzed. Instead, the FRS composite must be treated as a composite material displaying its own bulk engineering properties, and its performance is best assessed by experimental means.

A second issue of interest is whether cracks influence the degree of creep deformation exhibited by a steel-mesh-reinforced shotcrete lining. This issue is of relevance to crack width estimation with time and the question of whether crack widths measured at a given age for a steel-mesh-reinforced shotcrete lining are likely to grow in width or not. Crack width estimation is critical to the assessment of aggressive ion ingress toward embedded steel reinforcement and the possibility of subsequent corrosion of that reinforcement (whether in bar or fiber form).

Therefore, the first part of this investigation comprised an experimental assessment of the influence of reinforcement type on creep deformation in uncracked shotcrete linings. The second part involved a comparison of creep deformation over time for cracked and uncracked steel-mesh-reinforced shotcrete. Some comparisons have also been made with macrosynthetic FRS specimens.

Experimental Investigation

FRS linings predominantly act in a flexural mode of load resistance when used for ground support; hence, the experimental component of this investigation was developed to examine the creep characteristics of FRS and steel-mesh-reinforced shotcrete in *flexure*. Beams have traditionally been used to examine flexural capacity in concrete, but the high within-batch variability that typifies this method of assessment makes reliable estimates of performance difficult to obtain.[16] This investigation has therefore been undertaken using ASTM C1550 round panels,[17] as these are regarded as a more appropriate and representative means of assessing FRS lining behavior. The experimental procedures used in this investigation are the same as those described in detail by Bernard.[9,10]

Production and Curing of Specimens

The investigation involved the production of several sets of specimens that were cast using a shotcrete mixture and subsequently cured in water for approximately 180 days before being withdrawn and cured in air for an additional 180 days before the test program commenced. This was necessary to ensure that differences in the properties of the first and last specimens tested over the 4-year course of investigation were minimized.

The uncracked specimens consisted of ASTM C1550 panels (made in accordance with the mixture design in Table 1) reinforced with either hooked-end Dramix RC65/35 steel fibers (hereafter referred to as "Dramix"), embossed Barchip Macro 1.9 in. (48 mm) macrosynthetic fibers (hereafter referred to as "Macro"), or F51 steel mesh (0.2 in. [5 mm] bars on a 4 x 4 in. [100 x 100 mm] grid, hereafter referred to as "Mesh"; refer to Table 2). The cracked specimens consisted of ASTM C1550 panels made using shotcrete reinforced with either embossed Barchip Kyodo macrosynthetic fibers (hereafter referred to as "Kyodo") or F51 steel mesh (hereafter referred to as "Mesh"; refer to Table 2). All specimens

Table 1: Reinforcement used in various sets of specimens

Mixture	Fiber type	Dosage, kg/m³ (lb/yd³)
1	Dramix RC65/35 hooked-end steel	50 (84)
2	Barchip Macro 48 mm macrosynthetic	8 (14.8)
3	F51 steel mesh (5 mm bars on 100 mm grid)	0.3% steel
4	Barchip Kyodo 48 mm macrosynthetic	7 (11.8)

Note: 1 mm = 0.039 in.

Table 2: Mixture design for shotcrete used in casting trials

Component	Quantity, kg/m³ (lb/yd³)
Coarse aggregate (10/7 mm crushed river gravel)	550 (927)
Coarse sand	580 (977)
Fine sand	520 (876)
Cement	380 (640)
Silica fume	20 (33.7)
Water reducer	0.50 (0.84)

Note: 1 mm = 0.039 in.

Fig. 2: One of the four creep rigs used for gravity-load testing of specimens

were produced by casting into round steel and plywood forms that were positioned on a flat surface. They were immediately screeded to achieve a flat surface and uniform thickness and were then left outside under plastic sheeting to harden overnight before being stripped and transferred to curing tanks. Set accelerator was not used.

Testing of Specimens

Two types of tests were undertaken in this investigation: 1) tests on specimens that were cracked prior to placement in a creep rig and subject to 3 months of gravity loading; and 2) tests on specimens that were free of cracks during the 3 months of gravity loading. The tests on the precracked specimens were identical to those described by Bernard[9,10] and involved initial cracking in a servo-controlled test rig up to a central deformation of about 0.08 to 0.12 in. (2 to 3 mm) before the load was removed and the specimen was transferred to a gravity-loaded apparatus, such as the one shown in Fig. 2. A predetermined gravity load was applied to the center of the specimen for a period of 3 months, during which the deformation at the center was recorded. In this type of test, the load ratio was determined as the ratio of the gravity load over the static capacity of the cracked panel at the maximum deflection sustained in the initial cracking test in the servo-controlled rig.[10]

The second type of test was very similar to the first, but the precracking stage in the servo-controlled rig was omitted. Instead, a gravity load was applied to each uncracked specimen throughout the 3-month creep phase of testing. The creep phase was followed by a conventional ASTM C1550 test, in which a displacement-controlled load was applied up to a central deflection of 1.6 in. (40 mm). The load ratio in this sequence of tests was taken to be the gravity load divided by the cracking load in the subsequent ASTM C1550 test. Thus, the load ratio in both types of tests was found to be the ratio of gravity load over the static capacity at the start of the creep test.

Performance during each creep test was recorded as a time-deflection relationship, such as that shown in Fig. 3. These relationships were curve-fitted using a five-element Maxwell-Kelvin viscous damping model.[18] A curve corresponding to this expression was fitted to the d-*t* data obtained for each specimen. The results (shown for five specimens in Fig. 3) indicated that a power relationship dominated behavior over the first 3 months of loading.

Results

The primary result for each specimen was a record of central deflection measured over the 3-month duration of each test. As shown in Fig. 3, the central deflection increased steadily throughout the creep tests. The results were summarized by plotting the maximum deflection sustained at 3 months as a function of the creep load imposed on the specimen (Fig. 4) and as a function of the load ratio (defined previously; refer to Fig. 5). It is apparent in both of these figures that the magnitude

of the deformation measured at 3 months increased steadily with load for both the cracked and uncracked specimens. It is also apparent that the magnitude of deformation due to creep in the uncracked specimens did not vary with the type of reinforcement contained within the specimen (although there was a significant variation within these sets; the deformation data are plotted on a log scale and, thus, differences are exaggerated for the small-deformation results).

It is clear that the cracked steel-mesh-reinforced specimens exhibited greater time-dependent deformations than uncracked specimens made using the same concrete and reinforcement and that the difference increased with the magnitude of the load. Results for the cracked Kyodo macrosynthetic FRS specimens have been included for comparison with the cracked steel-mesh-reinforced specimens. At load ratios of up to 30%, there did not appear to be any significant difference between the cracked and uncracked specimens, regardless of the type of reinforcement used. The differences between the steel-mesh-reinforced panels and Kyodo-reinforced panels remained relatively minor at 50% of static capacity but became significant at load ratios of over 50 to 55% (tests have previously shown that steel FRS creeps very little at up to 70% of static capacity[10]). Given that FRS and FRC tunnel linings are unlikely to be "designed" to sustain loads greater than 50% of the short-term static capacity, it would appear that at this level of load, cracked steel-mesh-reinforced FRS will exhibit about twice the time-dependent deformation of uncracked linings, and linings reinforced with high-performance macrosynthetic fibers, such as Kyodo, will exhibit about three to four times greater time-dependent deformation. This observation is specific to this fiber, however, because previous work has demonstrated that low-performance macrosynthetic fibers can exhibit far higher levels of time-dependent deformation.[7,9,11,13]

Creep Rupture

Creep rupture occurred in several of the cracked Kyodo-reinforced specimens at load ratios of between 72 and 90% of static capacity. These failures, which occurred within 6 weeks of loading, suggest that sustained loads should not exceed 60% of static capacity for this fiber. This is consistent with the findings of Gossla and Rieder,[12] who found that loads in excess of 50 to 55% of static

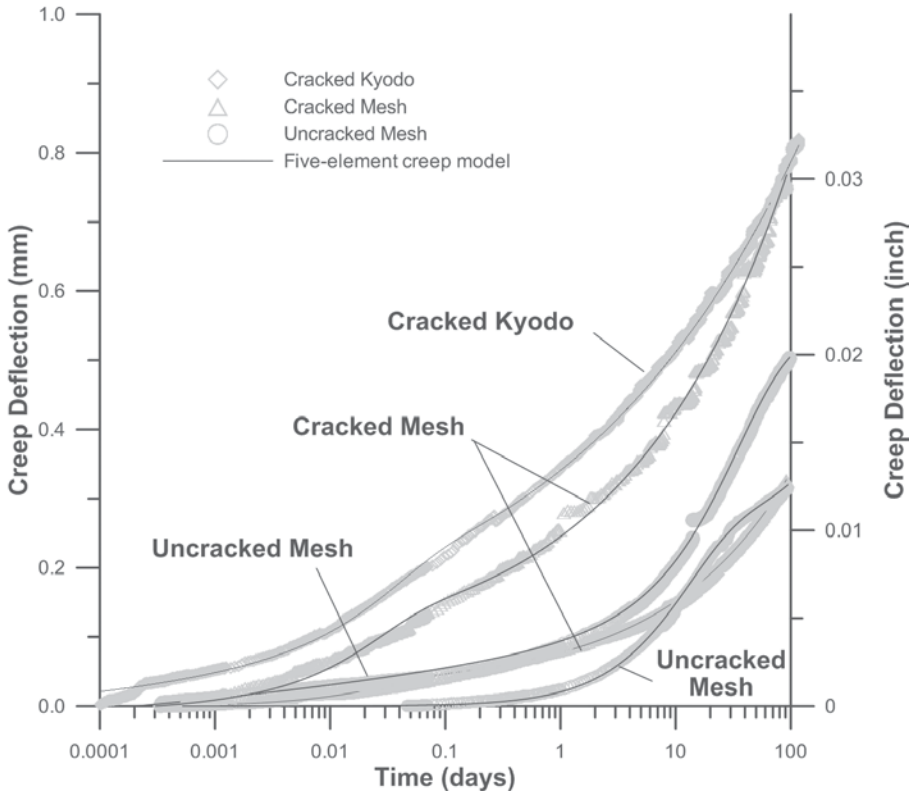

Fig. 3: Creep deflection as a function of time for cracked specimens made with steel mesh reinforcement compared with uncracked specimens. One cracked Kyodo-reinforced specimen is also included for comparison

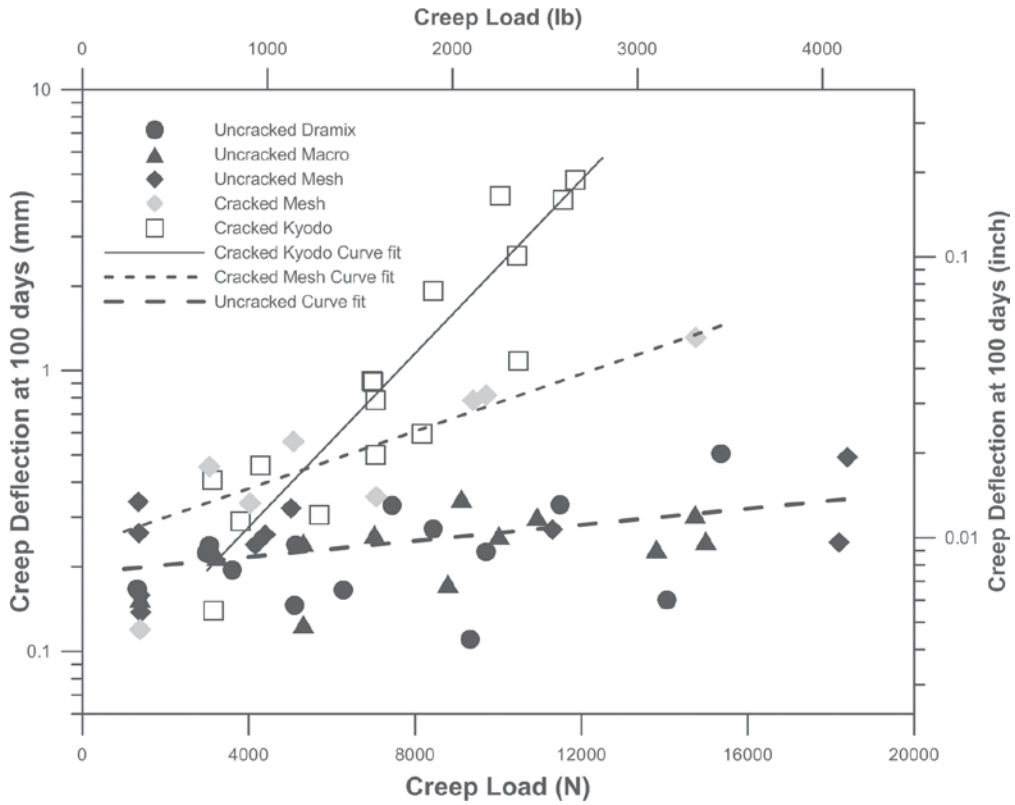

Fig. 4: Creep deflection at 100 days expressed as a function of load imposed at the center of each panel

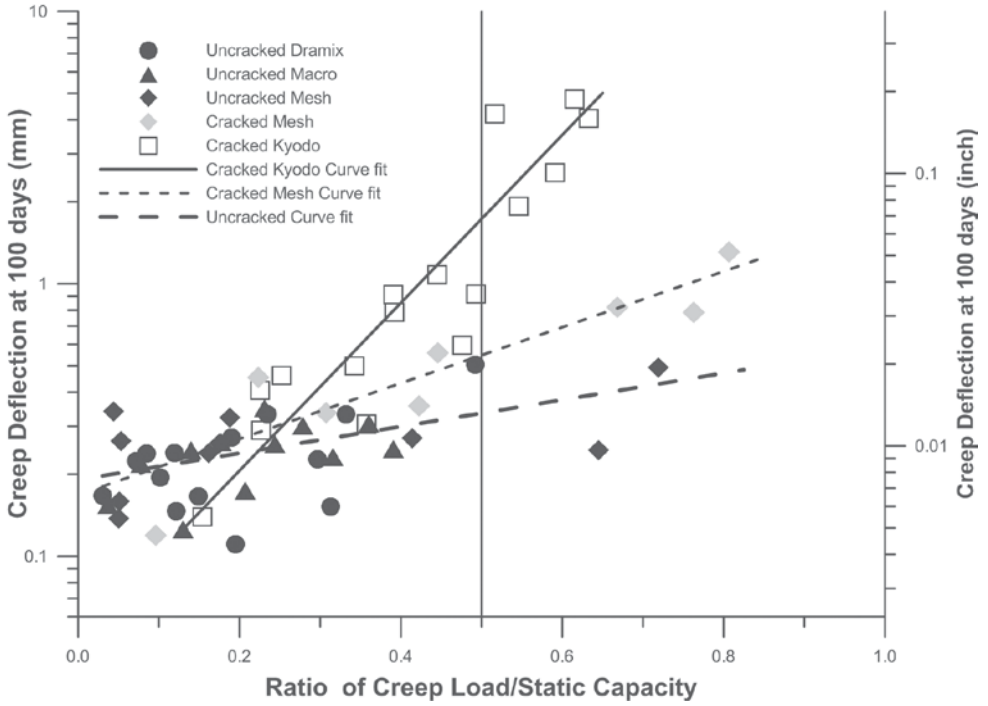

Fig. 5: Creep deflection at 100 days expressed as a function of load ratio (based on ratio of imposed gravity load over static capacity for cracked panels or imposed gravity load over cracking load in the subsequent ASTM C1550 test for uncracked panels)

capacity led to creep rupture when Strux 90/40 macrosynthetic fibers were used in concrete, and Kusterle,[11] who found that loads in excess of 60% of static capacity led to creep rupture for several macrosynthetic fibers and loads in excess of 75% of static capacity led to creep rupture in steel FRC loaded in flexure.

Conclusions

An investigation was undertaken into the time-dependent creep behavior of uncracked shotcrete ASTM C1550 panels reinforced with either steel fibers, macrosynthetic fibers, or steel mesh reinforcement, and the time-dependent creep behavior of cracked shotcrete panels reinforced with steel mesh reinforcement or macrosynthetic fibers. The investigation revealed that the time-dependent creep deformation of uncracked panels is insensitive to the type of reinforcement contained within the concrete, at least for the levels of steel mesh reinforcement and fiber dosages typical of thin-walled concrete linings used for ground support in underground and basement excavations.

The investigation also indicated that postcrack creep deflections are higher for cracked steel-mesh-reinforced shotcrete than for uncracked steel-mesh-reinforced specimens made using the same shotcrete mixture. The level of creep deformation exhibited by cracked panels reinforced with Barchip Kyodo macrosynthetic fibers is about the same as cracked panels reinforced with steel mesh at around 30% of static capacity. However, at 50% of static capacity, which is typical of design loadings in most structures, cracked panels reinforced with Barchip Kyodo fibers deform about three to four times as much as cracked steel-mesh-reinforced panels.

Acknowledgments

The author gratefully acknowledges W.R. Grace & Co. Inc., Elasto-Plastic Concrete P/L, and the Roads and Traffic Authority of NSW for their generous support of this investigation.

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AMERICAN SHOTCRETE ASSOCIATION

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 website at **www.shotcrete.org/sustainability**.

U.S. GREEN CONCRETE COUNCIL

1. Formwork savings of 50 to 100% over conventional cast-in-place construction.
2. Formwork does not have to be designed for internal pressures.
3. Complex shapes require very little—if any—formwork.
4. Crane and other equipment savings or elimination.
5. Labor savings of at least 50% in repair applications.
6. New construction speed savings of 33 to 50%.
7. **Speed of repair reduces or eliminates downtime** (see below).
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.

Speed of Repair Reduces or Eliminates Downtime

When servicing the industrial market, fitting work into short time frames is the nature of the beast. The work must be completed within windows of opportunity—that is, when the production units are temporarily out of service. In the words of Arthur Miller, "It comes with the territory." During an outage when a boiler, vessel, metal mixer, or cement kiln is "down" for scheduled repairs, *all* needed repairs are squeezed into the short time duration of the shutdown. The "critical path" dictates the time frame where all routine maintenance, repair, renovation, or upgrade operations must fit into this compressed time frame (Fig. 1 and 2).

Why the tightly controlled and compressed schedule? As one may suspect, it comes down to money. The lost production time during a shutdown often costs the owner more than the

Fig. 1: In plant outage work, at facilities such as the Homer City Generating Station pictured here, shotcrete can provide an efficient method of installing refractory

Fig. 2: Lost production time at large power plants, such as the Harrison Power Station pictured here, can be extremely expensive and repair work must be compressed into the time allotted in the scheduled outage

cost of the repairs. Industrial clients consider the lost revenue while the unit isn't in production an additional cost. In large power plants, the loss of power generation can be as high as $1,000,000 a day, if not higher. The same can be said for blast furnaces, coke plants, vessels, and most other high-output industrial production units. Therefore, getting a unit back into service a few days to a week early can make an enormous difference to the owner's costs for repairs.

To further complicate this, in many cases, the lion's share of the allotted downtime is often used for mechanical and structural repairs that must be completed *prior* to the start of shotcrete work. This further shrinks the open window to complete shotcrete repairs. Thus, the speed of repair in using shotcrete becomes a tremendous advantage. In power plant outages, unforeseen problems are often discovered after the shutdown is started and must be addressed before the shotcrete can be placed. Adding this additional newly discovered work can again compress an already tight schedule for shotcrete placement (Fig. 3).

Performing a complete ash hopper refractory reline on the last few days of a power plant outage is not uncommon. With shotcrete, the refractory material can be quickly placed and finished within 24 to 48 hours. For repair work, the refractory material placement can often be completed in one shift or less. With furnaces, coke plant quench towers, and blast-furnace troughs, the downtime can sometimes be as little as a 4- to 8-hour window. Getting in and out quickly and easily and performing the necessary work becomes a requirement for the job. Using shotcrete is often the only way the work can be accomplished within these tight time constraints. No forms are required, the shotcrete conforms to a variety of shapes, material handling issues are eliminated, and the material can be transported directly to the desired location and sprayed in place—readily and efficiently.

Speed of installation is not just an advantage in industrial applications. In infrastructure repair work on tunnels, ramps, and bridges, heavily traveled arteries are often closed at night or on weekends for emergency repairs. One common example is a scheduled weekend shutdown of a tunnel exit ramp for overhead shotcrete repairs. The ramp is shut down on a Friday night, the deteriorated concrete is removed, the reinforcing bars are sandblasted, steel mesh is installed, and shotcrete is placed overhead in the tunnel. All the work is completed and opened to traffic for the Monday morning rush hour (Fig. 4 and 5).

On projects with tight time frames or a limited amount of time to accomplish the work, the speed and efficiency of installation with shotcrete provides a distinct advantage. Even on projects without severe time constraints, the time, labor, and material savings with shotcrete can produce significant cost savings. Shotcrete provides an invaluable method to efficiently place concrete, refractory, or acid-resistant cements with a speed of installation that would not be possible with any other method. The old adage "time is money" is true for the construction industry, and using shotcrete can help save both on your next project.

Fig. 3: Shotcrete provides a fast, efficient method of installing refractory in power plants and other industrial applications under difficult time constraints

Fig. 4: Dry-process equipment and operator during the shotcrete installation of an underground culvert

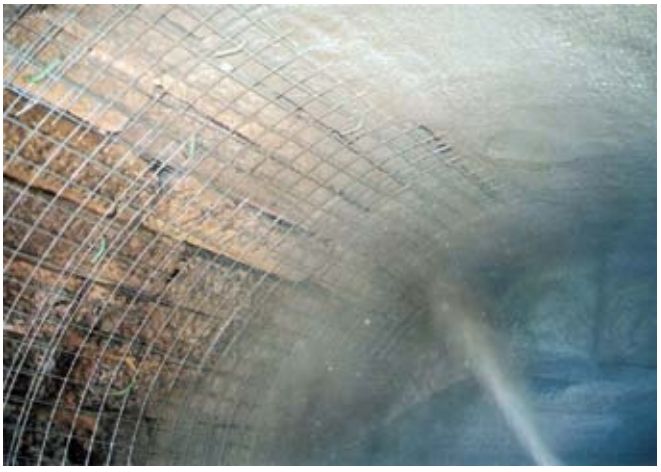

Fig. 5: Dry-process shotcrete being gunned overhead in an underground culvert. The roadway was opened the following day

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False Security

By Trevor Bray and Oscar Duckworth

This article is a true account of an accident that resulted in an injury to a worker. The experiences described should be shared with others in the construction industry to improve the safety of all crew members and the general public exposed to the shotcrete industry.

Our story begins on a typical hot Texas day in August, with a temperature over 100°F (38°C). A shotcrete crew had started their first job of the day applying vertical wet-mix shotcrete on a highway project as part of a temporary shoring system. The crew consisted of a pump operator, a nozzleman, and a helper. The job was going well and the pump operator was tending to the concrete truck as it was finishing delivery of its load. The nozzleman and helper were applying the shotcrete when a blockage in the line occurred. Both the nozzleman and the helper signaled and yelled at the pump operator to stop the pump. However, the operator was focused on the concrete truck and lost visual contact with the crew. In the seconds to follow, the nozzleman braced for the hose whip that was sure to follow if the blockage cleared the line. Unfortunately, the force generated behind the blockage as it cleared was too great for the nozzleman to control. As a result, the nozzleman was struck in the leg by the hose, causing a contusion. The incident could have easily resulted in a more serious injury.

When a blockage in the system occurs, many crews rely on yelling or hand signals to stop the pump. In most cases, this process works and no incident or accident occurs. It is so common that even the crews develop a false sense of security. Unfortunately, for the few times this process does not work, a worker can suffer a serious injury that could result in death or a permanent disability. Was this accident predictable? If so, was it preventable? A deeper look into this unfortunate event reveals an often overlooked lesson.

Fig. 1: Modern multi-function encoded devices are compact, durable, and easy to maintain

Never operate pressurized placement equipment that cannot be immediately stopped in the event of an emergency.

This common-sense warning is critical to the safe operation of nearly every type of concrete placement equipment ever produced. Its meaning is clear; however, its implementation can vary widely. Typically, wet-mix shotcrete crews may station a full-time pump operator at the pump. The operator may use visual signals, audible signals, or two-way radio communication to keep connected to the nozzleman and placement crew. Some pumps are also equipped with hard-wired controllers or radio transmitters that can remotely control equipment directly from the point of placement. This equipment configuration provides greater safety because, aside from typical packing of concrete within the reducers, potential pressure-related risks are greatest at the point of discharge. Downstream components such as sweeps may pack, hoses can become accidentally kinked, and nozzles occasionally plug.

The Nozzleman Is the First to Know

Typically, it is the nozzleman who is the first to notice the imminent signs of trouble. Nozzlemen must continually anticipate and counter the rhythmic thrust of shotcrete flowing through the nozzle. The balance to accommodate the thrust becomes a subconscious effort for skilled nozzlemen as they work. Thus, experienced nozzlemen immediately feel unexpected fluctuations in the stroke, chatter, or momentary flow interruptions. These are the initial indications of a blockage. Within moments, internal line pressures can quickly reach hazardous levels. The hapless nozzleman's only course of action is to brace for impact, aim the nozzle in a safe direction, and signal to stop the pump and relieve pressure. **In**

this situation, any delay in stopping the pump can generate destructive force within the placement system. A lucky nozzleman can remain in a braced position while pressure is relieved within the line. Unfortunately, if pressure builds excessively, a highly pressurized system can burst or unexpectedly clear, putting the nozzleman and crew at risk of serious injury.

A System That Is Safer by Design

Occasional blockage within the placement system is not unusual in shotcrete placement. It must be expected and can occur at any time. When a blockage does occur, placement crews using a system controlled at the point of placement that can be quickly stopped is safer than crews using equipment that requires more communication and, therefore, more time to stop. This accident demonstrates that urgent communication through various crew members at critical moments can fail or require additional time, ultimately causing an injury. In this instance, a hardwired or radio remote controller was not used by the nozzleman. After evaluation of this incident, we are currently taking steps to require a wireless controller for the nozzleman and/or helper on all projects.

The nozzleman is the first person to know when a problem exists with the smooth flow of material through the placement system. At that instant, action can be taken to prevent a potential serious hazard by activating the emergency shutoff on the remote pump controller. Our company learned an important lesson. We are now safer because of it. Hopefully, by sharing the lesson learned from this unfortunate accident, we can help others in our industry be safer.

Note from Oscar Duckworth: This story mirrors a similar unfortunate incident that happened to me nearly 20 years ago. Since then, the mandatory use of a belt-operated wireless remote is an essential component of my personal safety program.

Fig. 2: Multi-function wireless remote worn by nozzleman

Fig. 3: Duckworth's remote transmitter has provided over 15 years of reliable service, requiring only minor repairs

***Trevor Bray** is Vice President of Hayward Baker Inc., Craig Olden Division, an ASA Corporate Member. With over 35 years of experience, Craig Olden Division is a recognized authority in design and construction of earth retention and erosion control structures, specializing in retaining wall systems, shoring systems, slope stability solutions, and other technical services. Bray has been with the Olden Division for 20 years.*

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

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10th Shotcrete Conference Held in Alpbach, Austria

©ÖSTU-STETTIN. *Underground Conrad Observatory for geomagnetism, Austria. Application of nonmagnetic glass-fiber reinforced white cement dry-mix shotcrete as rock support in accordance with the particular project requirements*

Wolfgang Kusterle organized the 10th Shotcrete Conference, which took place at the Alpbach Conference Centre, Tyrol, Austria, January 12-13, 2012. Twenty-three presentations highlighted the state of the art of shotcrete technology from a European perspective. **Roland Heere**, **Wolfgang Kusterle**, and **Dudley R. "Rusty" Morgan** summarized the conference proceedings for the English-speaking readership. Their summary provides details about topics as diverse as:

- Shotcrete with stamped surfaces;
- Methods for early- and later-age strength testing;
- Waterproofing;
- Composite shell linings;
- Calcite precipitation in tunnel drainage systems;
- Plastic deformation capacity of hardened shotcrete;
- Ductility, toughness, and creep testing;
- Durability of shotcrete and concrete;
- Tunnel-boring machines with integrated shotcrete robots;
- Shotcrete with white cement;
- Thaumasite and mirabilite damage;
- Problems of erratic setting and strength gain;
- Energy approach to model shotcrete strength development;
- Shotcrete repair of concrete structures;
- New admixtures and fibers; and
- Nozzleman certification and more.

Readers can access this summary report on the ASA website at **www.shotcrete.org/2012_alpbach_conference.**

Propex and Brock White Canada Expand Relationship with Fibermesh® Distribution Partnership

Propex Operating Company, LLC, recently announced that Fibermesh®, the No. 1 brand in concrete fibers, will now be available in western Canada through Brock White.

According to **Ralph Bruno**, Propex Executive Vice President, the selection of Brock White as a distributor for Propex means that Fibermesh will be easy to buy in western Canadian markets. "Propex and Brock White have a long and successful partnership through the distribution of our geosynthetic products and we are thrilled to offer our entire infrastructure product line through Brock White," said Bruno. "With 10 stocking Brock White locations in western Canada, the delivery of a full line of Fibermesh products will be quick and easy for ready mix producers, precast companies, and contractors."

"We are excited to build on our relationship with Propex by including the Fibermesh line in our product offering to the Canadian ready mix industry," said **Neil Fast**, Vice President and General Manager – Canada for Brock White. "This is a natural evolution to our already-successful partnership."

King MS-D1 Shotcrete Certified to NSF/ANSI-61 Standard

King MS-D1 Shotcrete has been certified as a barrier material meeting the National Sanitation Foundation (NSF) and American National Standards Institute's (ANSI) standard, NSF/ANSI-61, "Drinking Water System Component," which pertains to materials that come into contact with public drinking water.

This designation is established by the Canadian Standards Association (CSA) and grants NSF/ANSI-61 status throughout both Canada and the United States. The standard is significant to King MS-D1 Shotcrete, as this product is used to repair concrete structures that come in contact with drinking water.

This standard establishes the minimum health effect requirements for materials, components, products, or systems that come into contact with drinking water, drinking water treatment chemicals, or both. The NSF/ANSI-61 standard concerns, but is not limited to, the following materials: pipes, fittings, and related products; protective barrier materials (coatings, linings/liners, cement, admixtures); joining and sealing materials (adhesives, lubricants, elastomers); process media (activated carbon, sand, ion exchange resin, regenerated media); mechanical devices used in water treatment and distribution (valves, pumps, filters, chlorinators); and end-point devices used in dispensing drinking water (faucets, riser tubes, supply stops).

For further information on King MS-D1 Shotcrete or other King shotcrete products, please contact Shannon Polk at (800) 461-0566 or e-mail info@kpmindustries.com.

AMEC Ranked as Top International Design Firm in Canada

AMEC, the international engineering and project management company, is pleased to announce that it has been ranked as the Top International Design Firm in Canada by the prestigious *Engineering News-Record* (*ENR*) magazine.

This is the ninth time in 10 years that the company has been featured as the leading international design firm in Canada. Overall, AMEC ranked No. 7 in the list of Top 200 International Design Firms and No. 6 in the list of Top 150 Global Design Firms.

The survey is based on design-specific export revenue generated in 2011 from projects outside each firm's respective home country. The overall list is accompanied by a list showing the top 10 firms by region. More than 70% of AMEC's revenues come from outside the United Kingdom, including 28% from Canada, which is AMEC's largest overseas market.

ENR performs annual surveys and rankings of companies engaged in engineering, architecture, planning, and studies. The rankings are based on annual revenue at home and abroad and are further divided into specific market categories.

For more information about *ENR* rankings, please visit the "Top Lists" section on **www.enr.com**.

TAM International Now Fully Integrated into the Normet Group

In April 2010, Normet acquired 40% of the construction chemicals manufacturer and supplier, TAM International (TAM), to form a global partnership. Through careful, strategic stewardship, TAM has since grown rapidly and significantly in the underground construction and mining sectors.

Based on this success, Normet recently acquired the remaining 60% of TAM, making it now a wholly owned subsidiary of the Normet Group. This acquisition combines the companies' underground equipment offering, product solutions package, and technically oriented customer support to serve the industry in a truly formidable way.

"Our 40% ownership in TAM was a logical step forward in Normet's quest to offer the industry not only specialist equipment for tough jobs but also a total solution offering that our customers see real value in. This has already proved successful in the areas of the world where we have offered such solutions but now, with the complete acquisition of TAM, we can really accelerate our ability to provide both new and existing Normet customers around the world entire process solutions that lowers their risk and achieves a positive project outcome," said **Aaro Cantell**, Chairman of Normet Group.

Today, TAM is involved in many major and prestigious tunneling projects in Taiwan, Hong Kong, the United Kingdom (such as Crossrail), and Singapore. They are also very active in mining projects in Australia, Sweden, and Ireland, to name a few.

"During the last 2 years of the partnership, TAM has grown significantly and now that it is fully integrated into Normet's own construction chemical business line, it makes us one of the leading specialist suppliers of process solutions to the global underground mining and tunneling sector," confirmed **Tom Melbye**, President of Normet Group and Managing Director of Normet International Ltd. "TAM's experienced and competent personnel and resources will only further strengthen Normet's ability to be a reliable, long-term partner for our customers in all different types of projects and conditions, including underground, geotechnical engineering, and general construction projects. Our team is very excited about the future!"

Moving forward, all TAM companies worldwide will eventually operate under the Normet company name, and "TAM" will be retained as the product brand name for construction chemical products.

Putzmeister Buys Concrete Mixer Manufacturer Intermix

Putzmeister Holding GmbH (Putzmeister) signed the contracts for the acquisition of Intermix GmbH on July 19, 2012. This transaction strengthens Putzmeister, a leading manufacturer of concrete pumps, in its market position and expands its product line to include additional construction machinery. "This acquisition rounds out our portfolio perfectly," said **Norbert Scheuch**, CEO of Putzmeister Holding.

Intermix was founded in 1984 by **Hans-Georg Stetter**, son of truck mixer pioneer Georg Stetter. Intermix has rapidly developed into one of Europe's leading manufacturers of truck mixers and special mixers. The company's customer service and logistics center for the delivery of the machines are located at its headquarters in Heimertingen near Memmingen in southern Germany. These days, truck mixers from Intermix are in use worldwide. Intermix produces and supplies up to 800 machines to end-users and distributors each year. The firm's technology, service, and strategy are consistently geared toward the needs of its international customers.

For Putzmeister, the acquisition of Intermix means an ideal complement to its own product portfolio. Putzmeister develops, manufactures, and sells equipment worldwide—in particular, concrete pumps for construction, tunnel construction, and large-scale industrial projects. Starting immediately, Putzmeister will also be distributing truck mixers through its global sales network. These transport the fresh concrete to the building site while maintaining its homogeneity. Truck mixers are used at the building site together with truck-mounted concrete pumps and stationary concrete pumps. Following the purchase of Intermix, Putzmeister has significantly expanded its portfolio in the concrete supply chain.

Granite Celebrates 90 Years of Building America

In honor of its 90-year anniversary, Granite hosted commemorative events at more than 40 locations nationwide on Friday, June 1, 2012. These events, including the one at its corporate headquarters in Watsonville, CA, were held to recognize the impact Granite has made on building infrastructure projects across America for the past nine decades.

"This is an important event for our employees and our company," said **James H. Roberts**, Granite President and Chief Executive Officer. "We are honored to be part of such a rich legacy and proud of our teams for the work they do every day to continue to build our future.

"Our Code of Conduct, established nine decades ago by our founding president Walter J. 'Pop' Wilkinson, is the cornerstone of our Core Values and was the central theme of our celebration," continued Roberts. "Granite's Core Values fosters trust between our company, our employees, and our customers and serve as a guide for how we treat one another. And although Pop's passing in 1958 marked the end of an era, we remain committed to keeping these values alive for another 90 years."

Offices nationwide will host celebrations to recognize employees and thank customers, community partners, and area dignitaries. During these ceremonies, Granite buried time capsules and highlighted the contributions it has made to the communities in which it works.

Granite Joins Advisory Board to Develop Infrastructure Sustainability Rating System

Granite Construction Incorporated recently joined the Sustainability Infrastructure Advisory Board (SIAB) at Harvard University's Graduate School of Design (GSD) to help develop and promote a rating system to measure the sustainability of infrastructure projects nationwide. This rating system will provide valuable insight to Granite's customers and project teams by providing a method for evaluating the viability and longevity of sustainable infrastructure projects. SIAB is part of the Zofnass Program for Sustainable Infrastructure.

"As infrastructure sustainability becomes increasingly important to cities, counties, and states the need for project owners, designers, and contractors to implement a recognized rating system has risen to the forefront," said **Geoff Boraston**, Director of Environmental Affairs for Granite Construction. "Our involvement with SIAB will support our customers and projects in meeting their sustainability goals."

"As a leading infrastructure contractor, Granite is a valuable member of our advisory board," said **Dr. Andreas Georgoulias**, Harvard GSD faculty and Research Director of the Zofnass Program for Sustainable Infrastructure. "We are thrilled to have them as a member of our organization."

Riverdale Mills Continues Expansion of Wire Mesh Sales into Shotcrete Market

In 1979, Riverdale Mills, a Northbridge Massachusetts manufacturer of welded-wire mesh, started as a supplier of polyvinyl chloride (PVC)-coated wire mesh to the lobster-trap-making market. **James M. Knott Sr.**, Founder and Owner of Riverdale Mills, saw an opportunity to provide the lobster-trap market with a high-quality, durable product alternative to the old-fashioned wooded traps that were being used.

With his success in the marine markets, Knott continued to invest in state-of-the-art mesh-welding equipment, which allowed the company to expand into non-marine-related markets. Because Riverdale's products are engineered to withstand harsh ocean environments, it was logical that they will successfully meet the requirements of various other markets.

Riverdale Mills has been supplying wire mesh to the shotcrete industry for several years and is continuing its expansion into this market. Quality is built into Riverdale Mills' products and tight dimensional tolerances are adhered to.

Riverdale is known throughout the world for its superior hot-dipped galvanized wire mesh products. Hot-dipped galvanized wire mesh guarantees that the welds are protected by a heavy zinc coating, which cannot be achieved with pregalvanized wire. Riverdale's hot-dipped galvanized wire mesh maximizes the economic balance point between corrosion resistance and cost. A fused, bonded PVC coating and several grades of stainless steel are available if additional corrosion resistance is required.

Riverdale's wire mesh is sold to the high-security fencing markets, the cage markets, and original equipment manufacturer (OEM), agricultural, and construction markets, in addition to a number of various markets where a high-quality corrosion-resistant wire mesh is required.

Riverdale Mills' welded-wire mesh is manufactured in a 350,000 ft² (32,516 m²) facility in Massachusetts. The company welds wire mesh in an extensive variety of mesh sizes and wire diameters from plain steel, pregalvanized wire, Galfan® coated wire, and stainless steel wire.

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

ASA Sponsors Second Vision 2020 Repair Workshop

ASA, along with the International Concrete Repair Institute (ICRI), the American Concrete Institute (ACI), and the Association of Concrete Contractors (ASCC), co-sponsored the second of two planned workshops to revise the "Vision 2020: A Vision for the Concrete Repair, Protection and Strengthening Industry" document at its midway point.

The first of the two workshops was held in fall 2011 and laid the groundwork for the addition of two important new goals: Goal #14, Branding & Promotion, and Goal #15, Sustainability.

The second workshop dedicated the morning session to Vision 2020's Goal #8, Research, and the afternoon session was dedicated to a newly expanded Goal #12 from Improved Condition Survey to Facilitate Development of New Technology for the Repair Industry.

The morning session broadly focused on a possible Strategic Research Council for the repair industry. This council could act as a forum for the primary stakeholders in the repair industry to come together and act on items, such as identifying areas requiring research and coordination of efforts to facilitate research. The session included brainstorming sessions on the best mechanisms for communication between stakeholders, current repair issues requiring research, options for sharing and promoting research needs, and ongoing and completed research impacting the repair industry.

The afternoon session focused on the facilitation and introduction of new technologies to the repair industry. Brainstorming sessions addressed topics such as how the repair industry might collect emerging technologies, how new technologies are adopted into the repair industry, and a potential central repository for identifying and validating new technologies and real-world examples of their execution.

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 website at **www.concretesdc.org**.

ASA Becomes a Supporting Associate Member on the *ASPIRE* Magazine Team

ASPIRE magazine is a quarterly magazine published by the Precast/Prestressed Concrete Institute in cooperation with the associations of the National Concrete Bridge Council. The magazine's editorial content focuses on the latest technology and key issues in the concrete bridge industry.

From federal, state, and local agencies to consultants, planners, universities, and contractors, *ASPIRE* reaches an estimated audience of more than 40,000 national stakeholders.

As a Supporting Associate Member Organization, ASA will have regular opportunities to communicate with the magazine's readership through editorials and advertisements and contribute ideas for feature stories and other content.

This new relationship with *ASPIRE* magazine is another important part of ASA's strategic plan to communicate the numerous advantages of the shotcrete method of placing concrete to the construction world.

For more information on *ASPIRE* magazine, visit **www.aspirebridge.org**.

ASA at World of Concrete

Please see the Staff Editorial on page 6 for a detailed listing and description of the many initiatives planned by ASA to communicate the many benefits of the shotcrete process to the concrete world. Don't forget to register for free for the show using ASA's **A17** code.

Errata

The article "Brown University" found on pages 18-20 of the Summer 2012 issue of *Shotcrete* magazine contained an editorial error that fundamentally changed the intent of a sentence midway through the article. The incorrect sentence read, "*We used the CemenTech batching plant that mixes materials for both wet- and dry-mix shotcrete on larger commercial jobs because, in our experience, using an Airplaco mobile mixer would have been a more difficult setup.*"

This text gave the incorrect impression that the Airplaco mobile mixers are difficult to set up and omitted the fact that South Shore Gunite owns an inventory of Airplaco mobile mixers and other equipment that they use with great regularity, both efficiently and with great confidence.

The text should have read, "*We used a CemenTech batching plant that mixes materials for both wet- and dry-mix shotcrete on larger commercial jobs where there is usually more room to set up the unit. Because the CemenTech rig is self-contained, we can set it up once and shoot all day without stopping. On residential work, where space and access is often limited, we use one of our four Airplaco mobile mixers, as they are easier to move and set up.*"

REED's B20HP-PP Power Pack Pump Powers a 1-Ton Mixer

REED's newest MixerPump Combo was designed specifically for shotcreters who need both a powerful, high-pressure shotcrete pump and a fast, robust mixer. A 160 hp (119 kW) Cummins diesel motor and twin variable-displacement hydraulic pumps on the B20HP-PP "Power Pack" provide enough power to drive both the 20 yd^3/h (15 m^3/h) 2113 psi (14.6 MPa) B20HP Pump and direct hydraulic drive 1-Ton M2200 model Mixer.

The pump features the same hard-chromed 4 x 36 in. (102 x 914 mm) concrete cylinders and 4 x 4 in. (102 x 102 mm) S-Tube as REED's popular B20 and B20HP model shotcrete pumps.

The heavily reinforced hopper has a capacity of 16 ft^3 (453 L) with the addition of the optional hopper extension. The rigid flatpack features six tie rods to ensure the high pressures do not cause flex.

The M2200 mixer has a mixing capacity of 2200 lb (1 metric ton). It can completely mix a 2000 lb (998 kg) bag of refractory material in 3 minutes.

The hydraulically driven variable-speed mixer blade has a maximum rotation of 59 rpm and 10,150 ft/lb (13762 Nm) of torque. The mixer features adjustable bolt-on mixing blades (wear-resistant plates) and two hydraulically operated guillotine-style cleanout and operating doors (180 degrees) (cleanout with tilt). ForkLift tubes are standard for easy lifting and transport.

The B20HP-PP can be smoothly towed on the highway behind either a truck or a trailer (twin 7000 lb [3.2 metric ton] highway axles with torsion suspension). The width of the mixer is just 95 in. (7 ft, 11 in. [2.41 m]), so it sits nicely on the back of a flatbed truck. When the mixer's legs are contracted for transport, the height is only 102 in. (8 ft, 6 in. [2.59 m]).

REED also sells the M2200 Mixer with either a small electric or diesel powerpack that slides underneath the mixer for transport.

For more information on the New REED B20HP-PP and/or M2200 Mixer, contact REED at 909-287-2100 or **www.reedpumps.com**.

BASF Introduces New Water-Reducing Admixture for Sustainable Construction

The North American Admixture Systems business of BASF's Construction Chemicals division has announced the introduction of Pozzolith® 700N, an innovative Type A water-reducing admixture for sustainable ready mixed concrete construction. The Pozzolith 700N admixture has been specially formulated for use with supplementary cementitious materials in ready mixed concrete mixtures.

The use of supplementary cementitious materials in concrete mixtures typically results in extended concrete setting time performance, which can be a challenge for contractors. The Pozzolith 700N admixture provides faster concrete setting time in concrete mixtures containing supplementary cementitious materials.

This setting time advantage will allow concrete producers to redesign their concrete mixtures with supplementary cementitious materials to achieve significant material cost savings and provide normal setting time performance for contractors.

"Sustainable construction is undoubtedly the strongest industry trend today," said Jeffrey Ma, Product Manager, for BASF in North America. "With Pozzolith 700N, we are helping concrete producers develop and promote sustainable concrete mixtures that offer the characteristics engineers expect, while meeting the contractor's needs for predictable set time performance."

In addition to Pozzolith 700N, BASF offers a wide range of products, technologies, and tools for sustainable construction, including the innovative BASF Integrated Durability-Sustainability Wizard and Eco-Efficiency Analysis. These tools help concrete producers, contractors, architects, and engineers identify solutions that minimize economic and ecological impact.

For more information on the Pozzolith 700N water-reducing admixture from BASF, or to learn about other ways BASF is contributing to sustainable construction, visit **www.basf-admixtures.com/sustainability**.

Five Nozzle Tips for Dry-Mix Shotcrete Added to Gunite Store E-Commerce Site

Gunite Supply has added five individual spirolet nozzle tips for dry-mix shotcrete contractors to the Gunite Store e-commerce site. Various sizes are available with complete details listed to make sure users choose the right tip, including aperture, hose ID, spirolet specification number, and outside diameter of threads. For more information, visit the Gunite Store at **www.gunite.us/servlet/storefront**.

The Euclid Chemical Company Releases EucoCalc

The Euclid Chemical Company has released EucoCalc—Euclid's mobile product estimator—to the Apple App Store

and Android Marketplace. With The Euclid Chemical Company's free Product Calculator app, real-time solutions are at your fingertips. This interactive tool provides instant estimates. The application can be downloaded to your iPhone, iPod Touch, iPad, or Android Device, and will soon be available for Blackberry devices.

Propex Invests in Market Growth

Propex Operating Company, LLC, has announced their latest investment in increasing their level of service to the marketplace. The company has retained the services of The Highland Group, a global consulting firm founded in 1991, whose expertise is in implementation and operational execution.

"Earlier this year we introduced the new Propex logo and our new tagline, 'The Evolution of Infrastructure.' This was the initial step of our focus on infrastructure solutions," said Ralph Bruno, Executive Vice President of Sales and Marketing for Propex. "To enhance the acceleration of this initiative, we have retained the services of The Highland Group."

In the near future, The Highland Group will assist Propex in gathering input through in-person visits and phone interviews with the key market stakeholders. "As a worldwide leader with a full portfolio of infrastructure products, including Fibermesh® concrete reinforcement fibers, we are uniquely positioned to provide solutions for global infrastructure needs," said Bruno. "The Highland Group will assist Propex in understanding how to effectively combine our products, brands, engineering services, and world-class distribution network."

Strata Launches a Redesigned Website that Redefines the Company's Image

Strata Worldwide has launched a completely redesigned website to more effectively represent the company's products, services, and corporate mission of today.

Developing a website that communicated Strata's focus on technology and its recent growth was crucial to solidifying the company's new image.

Featuring intuitive navigation, updated content, the latest news, and a section dedicated to electronic safety and the new Strata Mine Awareness Platform (MAP), the website was designed with the customer in mind.

"The new Strata website is part of our commitment to bringing valuable, timely information to our customers," states Rory Paton-Ash, President and CEO of Strata Worldwide. "It was our goal to create a platform that presents our products and services in a meaningful and logical way."

The website redesign is a fundamental piece in Strata's rebranding efforts that took place over the last year, which included a new corporate logo, enhanced marketing pieces, and enhanced messaging. Visit the new website at **www.strataworldwide.com**.

Sika Product Finder Apps Released

Sika Corporation has released a new free app for Apple and Blackberry products that allows users to find Sika products in construction and industry from all Sika Companies throughout the world. Users will find details for Sika technologies, product groups, and products, including related documents. Apple users can download the app from the iTunes store, while Blackberry users can download the app from the Blackberry App World.

New ASTM C1550-12 Released

ASTM C1550-12, "Standard Test Method for Flexural Toughness of Fiber Reinforced Concrete (Using Centrally Loaded Round Panel)," has just recently released. The Scope of the new standard states:

1.1 This test method covers the determination of flexural toughness of fiber-reinforced concrete expressed as energy absorption in the post-crack range using a round panel supported on three symmetrically arranged pivots and subjected to a central point load. The performance of specimens tested by this method is quantified in terms of the energy absorbed between the onset of loading and selected values of central deflection.

1.2 This test method provides for the scaling of results whenever specimens do not comply with the target thickness and diameter, as long as dimensions do not fall outside of given limits.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Do you have a NEW PRODUCT or PROCESS that the SHOTCRETE INDUSTRY needs to know about?

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AMERICAN SHOTCRETE ASSOCIATION

AMERICAN SHOTCRETE ASSOCIATION
ONLINE BUYERS GUIDE

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

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

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

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

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

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

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AMERICAN SHOTCRETE ASSOCIATION Buyers Guide

The following list of ASA Corporate Members is current as of October 1, 2012. For a current listing, including the ability to search by seven major specialties (as well as over 100 subspecialties) and states/provinces served, visit the online ASA Buyers Guide at **www.Shotcrete.org/BuyersGuide**.

Abbott Shoring & Foundation Ltd. — CONTRACTOR
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2105 Banbury Rd
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4141 Airport Rd
Cincinnati, OH 45226-1643
Phone: 513-321-4511
Website: www.airplaco.com
E-mail: sales@airplaco.com

Alaska Aggregate Products — CEMENT/POZZOLANIC MATL, CONSULTING, CONTRACTOR, FIBERS, SHOTCRETE MATERIALS/MIXES
Contact: Scott Leonard
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Phone: 907-895-2912
Website: www.ak-gravel.com/servlet/co
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1733 90th St
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AMEC Environment & Infrastructure — CONSULTING
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Phone: 604-294-3811
Website: www.amec.com
E-mail: john.laxdal@amec.com

American Concrete Restorations Inc. — CONTRACTOR
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E-mail: cathy@americanconcreterestorations.com

American Standard Conc. Pumping Hawaii Inc. — CONSULTING, CONTRACTOR, EQUIPMENT
Contact: Gregory L. Perrin
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Atlantic Underground Services Ltd. — CONTRACTOR
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Buyers Guide, cont.

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California Skateparks — CONSULTING, CONTRACTOR
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Phone: 909-949-1601
Website: www.californiaskateparks.com
E-mail: info@californiaskateparks.com

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Carolina Pool Plastering Inc. — CONSULTING, CONTRACTOR
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Website: www.carolinapoolplastering.com
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Shotcrete Montana — CONTRACTOR, EQUIPMENT
Contact: Larry Mooney
PO Box 685
19 S Woodard
Absarokee, MT 59001-0685
Phone: 406-328-7344
Website: www.shotcretemt.com
E-mail: larry@shotcretemt.com

Shotcrete Plus Sudbury Ltd. — EQUIPMENT
Contact: Mike Mooney
PO Box 1364
345 Placide St
Azilda, ON P0M 1B0, Canada
Phone: 705-983-1010
Website: www.shotcreteplus.com
E-mail: mike@shotcreteplus.com

Shotcrete Technologies Inc. — ADMIXTURES, CEMENT/POZZOLANIC MATL, CONSULTING, CONTRACTOR
Contact: Kristian Loevlie
PO Box 3274
Idaho Springs, CO 80452-3274
Phone: 303-567-4871
Website: www.shotcretetechnologies.com
E-mail: kristian@shotcretetechnologies.com

Sika Corporation — ADMIXTURES, CEMENT/POZZOLANIC MATL
Contact: Ketan Sompura
201 Polito Ave
Lyndhurst, NJ 07071-3601
Phone: 201-508-6698
Website: www.sikaconstruction.com
E-mail: sompura.ketan@sika-corp.com

Sofis Company Inc. — CONTRACTOR
Contact: Ted W. Sofis
554 Bocktown Cork Rd
Clinton, PA 15026-1142
Phone: 724-378-2670 x2
Website: www.sofiscompany.com
E-mail: tsofis@sofiscompany.com

Soil Nail Launcher Inc.
Contact: Tim Ruckman
2841 North Ave
Grand Junction, CO 81501-4918
Phone: 970-210-6170
Website: http://soilnaillauncher.com
E-mail: tim@soilnaillauncher.com

South Shore Gunite Pool & Spa, Inc. — CONSULTING, CONTRACTOR
Contact: Robert E. Guarino
7 Progress Ave
Chelmsford, MA 01824-3606
Phone: 800-649-8080
Website: www.ssgpools.com
E-mail: rguarino@southshoregunitepools.com

Southwest V-Ditch Inc. — CONTRACTOR
Contact: Bob Shepherd
3625 Placentia Ln
Riverside, CA 92501-1119
Phone: 951-781-4303 x1
Website: www.swvditch.com
E-mail: mail@swvditch.com

SPB Torkret Ltd. — CONSULTING, CONTRACTOR
Contact: Wlodzimierz Czajka
Ul. Grabowa 8
Siekierki Wielkie, Wielkopolska 62-025, Poland
Phone: 486-189-7810 x2
Website: www.torkret.com.pl
E-mail: czajka@torkret.com.pl

Spec Mix Inc. — EQUIPMENT, SHOTCRETE MATERIALS/MIXES
Contact: Leah Cory
1230 Eagan Industrial Rd, Suite 160
Eagan, MN 55121-1293
Phone: 651-994-7120
Website: www.specmix.com
E-mail: nblohowiak@specmix.com

Stone Valley Construction Inc. — CONSULTING, CONTRACTOR
Contact: Ken Knepp
132 Coaldale Rd
Philipsburg, PA 16866-2333
Phone: 814-342-7151
Website: www.stone-valley.com
E-mail: kknepp@stone-valley.com

Strata Mine Services — CONTRACTOR
Contact: Jeff Hamrick
67925 Bayberry Dr
Saint Clairsville, OH 43950-9132
Phone: 740-695-6880
Website: www.strataworldwide.com
E-mail: jhamrick@stratamineservices.com

Structural Shotcrete Systems Inc. — CONTRACTOR
Contact: Jason Weinstein
12645 Clark St
Santa Fe Springs, CA 90670-3951
Phone: 562-941-9916
Website: www.structuralshotcrete.com
E-mail: jason1@structuralshotcrete.com

www.Shotcrete.org/BuyersGuide

StructureWerks CONSULTING, CONTRACTOR
Contact: Ross Preschat
12600 Robin Ln, Ste 100
Brookfield, WI 53005-3124
Phone: 262-781-4329
Website: www.structurewerks.com
E-mail: rpreschat@structurewerks.com

Sunwest Gunite Co. CONSULTING, CONTRACTOR
Contact: Gary O'Canna
7045 Luella Anne Dr NE
Albuquerque, NM 87109-3907
Phone: 505-821-2549
Website: www.sunwestguniteco.com
E-mail: garyocanna@gmail.com

Superior Gunite / JW Gunite Company CONTRACTOR
Contact: Larry J. Totten
940 Doolittle Dr
San Leandro, CA 94577-1021
Phone: 510-568-8112
Website: www.shotcrete.com
E-mail: larryt@jwgunite.com

TBH & Associates LLC CONSULTING, CONTRACTOR
Contact: Peter Tapio
5211 NE 88th St
Vancouver, WA 98665-0931
Phone: 360-546-1600
Website: www.tbhdrill.com
E-mail: Peter.Tapio@tbhdrill.com

Testing, Engineering & Consulting Services Inc. CONSULTING
Contact: James Glenn McCants III
235 Buford Dr
Lawrenceville, GA 30046-4945
Phone: 770-995-8000
Website: www.tecservices.com
E-mail: tmccants@tecservices.com

Texaloy Foundry Company Inc. EQUIPMENT
Contact: Jack Rice
PO Box 37
Floresville, TX 78114-0037
Phone: 800-367-6518
Website: www.texaloy.com
E-mail: jrice@texaloy.com

Thiessen Team USA Inc. ADMIXTURES, CONSULTING, CONTRACTOR, EQUIPMENT, FIBERS, SHOTCRETE MATERIALS/MIXES
Contacts: James Schumacher/ Jessica Florence
PO Box 40
Elko, NV 89803-0040
Phone: 775-777-1205
Website: www.thiessenteam.com
E-mail: jschumacher@thiessenteam.com

Tipton Builders Inc. CONTRACTOR
Contact: Ben Tipton
5708 N Broadway St
Knoxville, TN 37918-4105
Phone: 865-689-7665
Website: www.tiptonpools.com
E-mail: tipton@tiptonpools.com

Top Gun of Virginia Inc. CONTRACTOR
Contact: Jon Slaunwhite
10017 Richmond Hwy
Lorton, VA 22079-2421
Phone: 703-550-9207
Website: www.topgungunite.com
E-mail: info@topgungunite.com

Topcor Services Inc. CONSULTING, CONTRACTOR
Contact: James M. Baker
12025 Industriplex Blvd
Baton Rouge, LA 70809-5131
Phone: 225-753-7067
Website: www.topcor.com
E-mail: jbaker@topcor.com

Torrent Shotcrete Structures Ltd.
Contact: Carl King
145 Golden Dr
Coquitlam, BC V3K 6T1, Canada
Phone: 011-6049962219
Website: http://torrentshotcrete.com
E-mail: carlking@telus.net

Traylor Bros., Inc. CONTRACTOR
835 N Congress Ave
Evansville, IN 47715-2452
Phone: 812-477-1542
Website: www.traylor.com
E-mail: mburdick@traylor.com

Truesdell Corporation CONTRACTOR
Contact: Kurt Clink
1310 W 23rd St
Tempe, AZ 85282-1837
Phone: 602-437-1711
Website: www.truesdellcorp.com
E-mail: kclink@truesdellcorp.com

Uretek ICR
Contact: Brian Despain
8815 Neville Rd
Colfax, NC 27235-9769
Phone: 336-992-0746
Website: http://uretekicr.com
E-mail: bdespain@uretekma.com

Vancouver Shotcrete & Shoring Inc. CONSULTING, CONTRACTOR
Contact: Rabi Gill
9314 182 St
Surrey, BC V4N 3V9, Canada
Phone: 604-881-4898
Website: www.shotcreteshoring.com
E-mail: vancrete@shawcable.com

Western Shotcrete Equipment Inc. EQUIPMENT
Contact: Joe Harpole
HC 1 Box 193
Fairdealing, MO 63939-9708
Phone: 573-857-2085
Website: www.wseshotcrete.com
E-mail: josephharpole@wseshotcrete.com

www.Shotcrete.org/BuyersGuide

White's Shotcrete Inc. — CONTRACTOR
Contact: Robert White
3750 McCullers Rd
Loganville, GA 30052-2955
Phone: 770-466-9119
Website: www.whitesshotcrete.com
E-mail: rwhite3448@aol.com

Whiteside Construction Corporation — CONTRACTOR
Contact: David Whiteside
1151 Hensley St
Richmond, CA 94801-2162
Phone: 510-234-6681
Website: www.whitesideconstruction.com
E-mail: drw@whitesideconstruction.com

Williamstown Mining Inc. — ADMIXTURES, CEMENT/POZZOLANIC MATL, CONSULTING, CONTRACTOR, EQUIPMENT, FIBERS, SHOTCRETE MATERIALS/MIXES
Contact: Carmellio G. Faieta
733 Forever Ln
Ligonier, PA 15658-2349
Phone: 817-891-5105
Website: www.williamstownmining.com
E-mail: carmelliofaieta@williamstownmining.com

WLH Construction Company — CONTRACTOR
Contact: Warren Harrison
2000 W 60th Ave
Denver, CO 80221-6631
Phone: 303-347-8655
Website: www.wlhconstruction.com
E-mail: wharrison@wlhconstruction.com

Wurster Engineering & Construction — CONSULTING, CONTRACTOR
Contact: Daryl Wurster
34 Carrie Dr
Greenville, SC 29615-5611
Phone: 964-627-7751
Website: www.wursterinc.com

Xtreme Shotcrete
Contact: Michael Anthony Whitehead
166 Woodside Ave
Winthrop, MA 02152-2063
Phone: 617-846-3191
Website: http://xtremeshotcretema.com
E-mail: whitehead0015@aol.com

SPECIALTIES

The following list of ASA Corporate Members is current as of October 1, 2012. For a current listing, including the ability to search by seven major specialties (as well as over 100 subspecialties) and states/provinces served, visit the online ASA Buyers Guide at **www.Shotcrete.org/BuyersGuide**.

Admixtures

BASF Admixtures Inc.	Cleveland, OH
Cementec Industries Inc.	Calgary, AB, Canada
The Euclid Chemical Company	Dexter, MI
Grace Construction Products	Cambridge, MA
J Tortorella Swimming Pools Inc.	Southampton, NY
JE Tomes & Associates	Blue Island, IL
Kryton International Inc.	Vancouver, BC, Canada
Multicrete Systems Inc.	Winnipeg, MB, Canada
Normet Americas Inc.	Union Grove, WI
Prestige Concrete Products	Orlando, FL
Serafina Industries Ltd.	Hampton Bays, NY
Shotcrete Technologies Inc.	Idaho Springs, CO
Sika Corporation	Lyndhurst, NJ
Thiessen Team USA Inc.	Elko, NV
Williamstown Mining Inc.	Ligonier, PA

Cement/Pozzolanic Matl

Alaska Aggregate Products	Anchorage, AK
Cementec Industries Inc.	Calgary, AB, Canada
The Euclid Chemical Company	Dexter, MI
JE Tomes & Associates	Blue Island, IL
Lafarge North America	Bingham Farms, MI
Lehigh Cement Company/White Cement Div.	Allentown, PA
Multicrete Systems Inc.	Winnipeg, MB, Canada
Normet Americas Inc.	Union Grove, WI
Oldcastle APG West, Inc.	Phoenix, AZ
Prestige Concrete Products	Orlando, FL
The Quikrete Companies	Atlanta, GA
Serafina Industries Ltd.	Hampton Bays, NY
Shotcrete Technologies Inc.	Idaho Springs, CO
Sika Corporation	Lyndhurst, NJ
Williamstown Mining Inc.	Ligonier, PA

Consulting

Aircrete Systems LP Inc.	Calgary, AB, Canada
Alaska Aggregate Products	Anchorage, AK
AMEC Environment & Infrastructure	Burnaby, BC, Canada
American Standard Conc. Pumping Hawaii Inc.	Waipahu, HI
Baker Concrete Construction, Inc.	Monroe, OH
Bekaert Corporation	Marietta, GA
BelPacific Excavating & Shoring Ltd.	Burnaby, BC, Canada
Blastcrete Equipment Company	Anniston, AL
California Skateparks	Upland, CA
Carolina Concrete Systems, Inc.	Charleston, SC
Carolina Pool Plastering Inc.	Charlotte, NC
CCS Group LLC	Seward, NE
Davies Geotechnical Inc.	Delta, BC, Canada
Deluxe Shotcrete & Concrete Construction	Santa Rosa, CA
DOMTEC International LLC	Idaho Falls, ID
Drakeley Industries LLC	Bethlehem, CT
Drill Tech Drilling & Shoring, Inc.	Antioch, CA
Fenton Rigging & Contracting Inc.	Jacksboro, TN
Genesis 3, Inc.	Murfreesboro, TN
Gib-San Pools Ltd.	Toronto, ON, Canada
Group Works LLC	Wilton, CT
H&H Restoration	Aurora, NE
Hardrock Concrete Inc.	Etobicoke, ON, Canada
Hayward Baker Inc.—Craig Olden Division	Little Elm, TX
HTM Construction	Lakewood, CO

SPECIALTIES, cont.

Consulting, cont.

J Tortorella Swimming Pools Inc.	Southampton, NY
Lafarge North America	Bingham Farms, MI
Metro Testing Laboratories Ltd.	Burnaby, BC, Canada
Multicrete Systems Inc.	Winnipeg, MB, Canada
The Nassal Company	Orlando, FL
National Gunite Inc.	Johnstown, PA
Nationwide Shotcrete Inc.	Newhall, CA
New Line Skateparks Inc.	Langley, BC, Canada
Normet Americas Inc.	Union Grove, WI
Pool Engineering Inc.	Anaheim, CA
Prestige Concrete Products	Orlando, FL
RAM Construction Services	Livonia, MI
RCS Consulting & Construction Company Inc.	Ripley, WV
Robert H Ward & Associates	South Chicago Heights, IL
Serafina Industries Ltd.	Hampton Bays, NY
Shotcrete Technologies Inc.	Idaho Springs, CO
South Shore Gunite Pool & Spa, Inc.	Chelmsford, MA
SPB Torkret Ltd.	Siekierki Wielkie, Wielkopolska, Poland
Stone Valley Construction Inc.	Philipsburg, PA
StructureWerks	Brookfield, WI
Sunwest Gunite Co.	Albuquerque, NM
TBH & Associates LLC	Vancouver, WA
Testing, Engineering & Consulting Services Inc.	Lawrenceville, GA
Thiessen Team USA Inc.	Elko, NV
Topcor Services Inc.	Baton Rouge, LA
Vancouver Shotcrete & Shoring Inc.	Surrey, BC, Canada
Williamstown Mining Inc.	Ligonier, PA
Wurster Engineering & Construction	Greenville, SC

Contractors

Abbott Shoring & Foundation Ltd.	North Vancouver, BC, Canada
Aircrete Systems LP Inc.	Calgary, AB, Canada
Alaska Aggregate Products	Anchorage, AK
American Concrete Restorations Inc.	Lemont, IL
American Standard Conc. Pumping Hawaii Inc.	Waipahu, HI
Atlantic Underground Services Ltd.	Riverview, NB, Canada
Azteca Gunite	Houston, TX
Baker Concrete Construction, Inc.	Monroe, OH
BelPacific Excavating & Shoring Ltd.	Burnaby, BC, Canada
Boulderscape Inc.	San Juan Capistrano, CA
California Skateparks	Upland, CA
Carolina Concrete Systems, Inc.	Charleston, SC
Carolina Pool Plastering Inc.	Charlotte, NC
CCS Group LLC	Seward, NE
Clark Foundations, LLC	Bethesda, MD
Coastal Gunite Construction Company	Cambridge, MD
ConCreate USL Ltd.	Bolton, ON, Canada
Concrete Repairs & Contracting Co.	Abu Dhabi, United Arab Emirates
Concrete Restoration Specialists	Sharon Center, OH
Contech Services, Inc.	Seattle, WA
Cowin & Company Inc.	Birmingham, AL
The Crom Corporation	Gainesville, FL
Cruz Concrete & Guniting Repair Inc.	Manasquan, NJ
C-TEC, Inc.	York, NE
Custom Crete Inc.	Austin, TX
Dees Hennessey Inc.	San Carlos, CA
Delta Gunite Solano Inc.	Fairfield, CA
Deluxe Shotcrete & Concrete Construction	Santa Rosa, CA
Dome Technology	Idaho Falls, ID
DOMTEC International LLC	Idaho Falls, ID
Donald J Scheffler Construction	City Of Industry, CA
Drake Inc.	Waco, NE
Drakeley Industries LLC	Bethlehem, CT
Drill Tech Drilling & Shoring, Inc.	Antioch, CA
Eastern Gunite Company Inc.	Exton, PA
ECS, LLC—East Coast Shotcrete	Milltown, NJ
Epoxy Design Systems Inc.	Houston, TX
Facca Incorporated	Ruscom Station, ON, Canada
Fenton Rigging & Contracting Inc.	Jacksboro, TN
Fibercon International Inc.	Evans City, PA
Fisher Shotcrete Inc.	Higley, AZ
Frontier-Kemper Constructors Inc.	Evansville, IN
Genesis 3, Inc.	Murfreesboro, TN
Gib-San Pools Ltd.	Toronto, ON, Canada
Granite Construction Inc.	Long Island City, NY
Group Works LLC	Wilton, CT
Gunite Specialists Inc.	Ambler, PA
H&H Restoration	Aurora, NE
Hardrock Concrete Inc.	Etobicoke, ON, Canada
Hayward Baker Inc.—Craig Olden Division	Little Elm, TX
HC Matcon Inc.	Ayr, ON, Canada
HTM Construction	Lakewood, CO
Hydro Arch	Henderson, NV
J Tortorella Swimming Pools Inc.	Southampton, NY
John Rohrer Contracting Company Inc.	Kansas City, KS
Kiewit Infrastructure Co.	Willow Springs, IL
Knowles Industrial Services Corp.	Gorham, ME
Mar-Allen Concrete Products Inc.	Ephrata, PA
Mays Construction Specialties Inc.	Grand Junction, CO
Michigan Shotcrete Construction Inc.	Perry, MI
Mid American Gunite Pools Inc.	Covington, KY
Multicrete Systems Inc.	Winnipeg, MB, Canada
The Nassal Company	Orlando, FL
Nationwide Shotcrete Inc.	Newhall, CA
New Line Skateparks Inc.	Langley, BC, Canada
Osco Gunite & Mudjacking Ltd.	Edmonton, AB, Canada
Palmetto Gunite Construction Company Inc.	Ravenel, SC
PCI Roads LLC	Saint Michael, MN
Pool Engineering Inc.	Anaheim, CA
Preload Inc.	Hauppauge, NY
Prestige Concrete Products	Orlando, FL
ProShot Concrete Inc.	Florence, AL
RAM Construction Services	Livonia, MI
Ram Jack of Charlotte, LLC	Huntersville, NC
Restek Inc.	Edmond, OK
RG Johnson Company Inc.	Washington, PA
Robert H Ward & Associates	South Chicago Heights, IL
Schnabel Foundation Company	Aurora, CO
Serafina Industries Ltd.	Hampton Bays, NY
Shotcrete Montana	Absarokee, MT
Shotcrete Technologies Inc.	Idaho Springs, CO

Sofis Company Inc.	Clinton, PA
South Shore Gunite Pool & Spa, Inc.	Chelmsford, MA
Southwest V-Ditch Inc.	Riverside, CA
SPB Torkret Ltd.	Siekierki Wielkie, Wielkopolska, Poland
Stone Valley Construction Inc.	Philipsburg, PA
Strata Mine Services	Saint Clairsville, OH
Structural Shotcrete Systems Inc.	Santa Fe Springs, CA
StructureWerks	Brookfield, WI
Sunwest Gunite Co.	Albuquerque, NM
Superior Gunite / JW Gunite Company	San Leandro, CA
TBH & Associates LLC	Vancouver, WA
Thiessen Team USA Inc.	Elko, NV
Tipton Builders Inc.	Knoxville, TN
Top Gun of Virginia Inc.	Lorton, VA
Topcor Services Inc.	Baton Rouge, LA
Traylor Bros., Inc.	Evansville, IN
Truesdell Corporation	Tempe, AZ
Vancouver Shotcrete & Shoring Inc.	Surrey, BC, Canada
White's Shotcrete Inc.	Loganville, GA
Whiteside Construction Corporation	Richmond, CA
Williamstown Mining Inc.	Ligonier, PA
WLH Construction Company	Denver, CO
Wurster Engineering & Construction	Greenville, SC

Equipment

Acme America Inc.	Coopersburg, PA
Airplaco Equipment Company	Cincinnati, OH
Allentown Shotcrete Technology Inc.	Sturtevant, WI
American Standard Conc. Pumping Hawaii Inc.	Waipahu, HI
Blastcrete Equipment Company	Anniston, AL
Construction Forms, Inc.	Port Washington, WI
Custom Crete Inc.	Austin, TX
Elkin Hi Tech Inc.	Indiana, PA
Getman Corporation	Bangor, MI
Gunite Supply & Equipment Co.	Monrovia, CA
King Packaged Materials Company	Burlington, ON, Canada
Multicrete Systems Inc.	Winnipeg, MB, Canada
Normet Americas Inc.	Union Grove, WI
Olin Engineering Inc.	Huntington Beach, CA
P & M Service Specialists Inc.	Slatington, PA
Pacific Alloy Casting Company Inc.	South Gate, CA
Putzmeister America Inc	Sturtevant, WI
Putzmeister Iberica S A	Madrid, Spain
REED Shotcrete Equipment	Chino, CA
Shotcrete Helmet	Paris, ON, Canada
Shotcrete Montana	Absarokee, MT
Shotcrete Plus Sudbury Ltd.	Azilda, ON, Canada
Spec Mix Inc.	Eagan, MN
Texaloy Foundry Company Inc.	Floresville, TX
Thiessen Team USA Inc.	Elko, NV
Western Shotcrete Equipment Inc.	Fairdealing, MO
Williamstown Mining Inc.	Ligonier, PA

Fibers

Alaska Aggregate Products	Anchorage, AK
Bekaert Corporation	Marietta, GA
CCS Group LLC	Seward, NE
The Euclid Chemical Company	Dexter, MI
Fibercon International Inc.	Evans City, PA
Fibermesh® Concrete Solutions by Propex	Chattanooga, TN
Forta Corporation	Grove City, PA
King Packaged Materials Company	Burlington, ON, Canada
Multicrete Systems Inc.	Winnipeg, MB, Canada
Riverdale Mills Corp	Northbridge, MA
Thiessen Team USA Inc.	Elko, NV
Williamstown Mining Inc.	Ligonier, PA

Shotcrete Materials/Mixes

Alaska Aggregate Products	Anchorage, AK
The Blanchard Group	Dunlop, NB, Canada
CCS Group LLC	Seward, NE
Custom Crete Inc.	Austin, TX
Delta Gunite Solano Inc.	Fairfield, CA
Delta Industrial Services Inc.	Delta Junction, AK
Deluxe Shotcrete & Concrete Construction	Santa Rosa, CA
Fenton Rigging & Contracting Inc.	Jacksboro, TN
J Tortorella Swimming Pools Inc.	Southampton, NY
JE Tomes & Associates	Blue Island, IL
King Packaged Materials Company	Burlington, ON, Canada
Minova North America	Georgetown, KY
Modern Concrete Inc.	Elko, NV
Multicrete Systems Inc.	Winnipeg, MB, Canada
Prestige Concrete Products	Orlando, FL
The Quikrete Companies	Atlanta, GA
RG Johnson Company Inc.	Washington, PA
Serafina Industries Ltd.	Hampton Bays, NY
Spec Mix Inc.	Eagan, MN
Thiessen Team USA Inc.	Elko, NV
Williamstown Mining Inc.	Ligonier, PA

www.Shotcrete.org/BuyersGuide

Shotcrete Calendar

NOVEMBER 6-7, 2012
ASA Shotcrete Nozzleman Education Session
Tuesday, November 6 | 3:00 pm - 6:00 pm
Wednesday, November 7 | 8:00 am - 12:00 pm
2012 International Pool | Spa | Patio Expo
Morial Convention Center
New Orleans, LA (New location!)
Register at **www.poolspapatio.com**

NOVEMBER 6-8, 2012
2012 International Pool | Spa | Patio Expo
Visit ASA's Booth #2537!
Morial Convention Center
New Orleans, LA (New location!)
Website: **www.poolspapatio.com/attendee**

NOVEMBER 7-9, 2012
ICRI 2012 Fall Convention
Theme: "Life-Cycle Repair—Sustainability"
Rancho Las Palmas Resort & Spa
Ranchero Mirage, CA
Website: **www.icri.org**

DECEMBER 2-5, 2012
ASTM International Committee C09, Concrete and Concrete Aggregates
Hyatt Regency Atlanta
Atlanta, GA
Website: **www.astm.org**

FEBRUARY 4, 2013
ASA WOC 2013 Committee Meetings
Las Vegas Convention Center
Las Vegas, NV
WOC Committee Schedule:
8:30 am | Shotcrete Forum
1:00 pm | The ASA Annual Membership Meeting
1:30 pm | ASA Marketing & Membership Committee and the ASA Board of Direction
All other ASA Standing Committee Meetings will be held in the fall and spring

FEBRUARY 5, 2013
ASA Shotcrete Seminar: Structural Shotcrete Design & Construction
Tuesday, February 5 | 8:30 am - 10:00 am
WOC Seminar (Registration code: TU138)
Las Vegas Convention Center
Las Vegas, NV

FEBRUARY 5, 2013
ASA Shotcrete Nozzleman Education Session
Tuesday, February 5 | 9:00 am - 4:00 pm
WOC Seminar (Registration Code: ASATU)
Las Vegas Convention Center
Las Vegas, NV

FEBRUARY 5, 2013
ASA's Eighth Annual Outstanding Shotcrete Projects Awards Banquet
Paris Las Vegas Hotel & Casino
Versailles Ballroom, 6:00 pm
Las Vegas, NV

FEBRUARY 5-8, 2013
World of Concrete 2013
Exhibits: February 5-8
Seminars: February 4-8
Visit ASA's Booth #**S11429** (New location!)
Las Vegas Convention Center
Las Vegas, NV
Website: **www.worldofconcrete.com**

FEBRUARY 24-27, 2013
2013 SME Annual Meeting & Exhibit and CMA 115th National Western Mining Conference
Theme: "Mining: It's About The People"
Colorado Convention Center
700 14th Street | Denver, CO
Website: **www.smenet.org**

MARCH 20-22, 2013
ICRI 2013 Spring Convention
Theme: ICRI Celebrates Its 25th Anniversary—"Looking Ahead"
Tradewinds Islands Resorts
St. Pete Beach, FL
Website: **www.icri.org**

APRIL 13, 2013
ASA 2013 Spring Committee Meetings
Hilton & Minneapolis Convention Center
Minneapolis, MN

APRIL 14-18, 2013
ACI Spring 2013 Convention
Theme: "Responsibility in Concrete Construction"
Hilton & Minneapolis Convention Center
Minneapolis, MN
Website: **www.concrete.org**

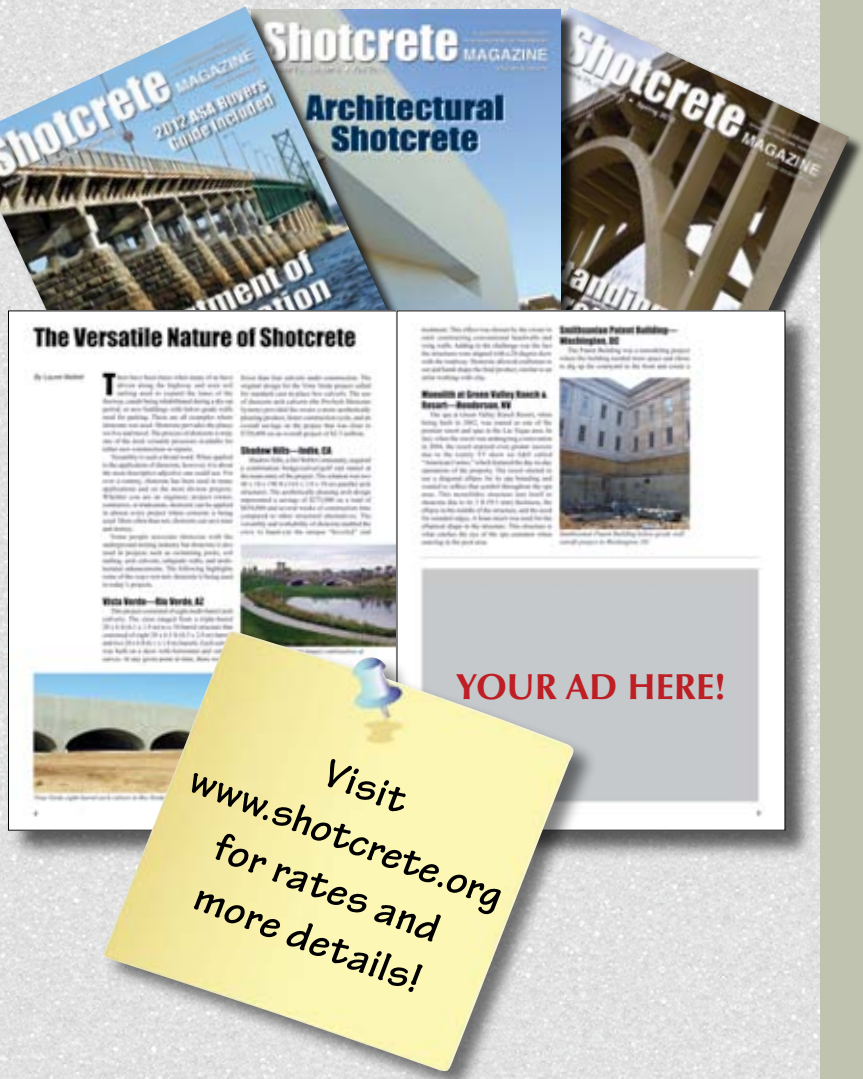
Shotcrete

2013 MEDIA KIT

A quarterly publication of the American Shotcrete Association

MAGAZINE

TARGET THE SHOTCRETE WORLD WITH YOUR COMPANY'S PRODUCTS AND SERVICES!



Advertising in *Shotcrete* magazine is the most affordable and effective way to reach the shotcrete industry. Each issue of *Shotcrete* magazine reaches a growing number of **over 17,000 readers** that include current and potential designers, specifiers, and purchasers of shotcrete in over 100 countries.

Our streamlined rate charts make choosing the right advertising option for your company easy. Rates remain the same as 2012 in 2013.

Your advertisement in *Shotcrete* will reach the companies and people that you need to **grow your business**. *Shotcrete*'s cost for advertising is competitive, with an average savings of 25% or more compared to other leading trade association magazines. These rates certainly provide you with the most "bang" for your advertising dollars!

Direct your orders or questions to: info@shotcrete.org or 248-848-3780

2013 Advertising Rates

Terms:

Terms are net 30 days following proof of publication.
Advertising copy is subject to approval from ASA.

Discounts:*

- Recognized agencies receive a 15% discount.
- Place your insertion orders for 2013 by November 1, 2012, and receive a 5% Early Bird Discount.
- Prepay your advertising orders on or before the materials deadline for the respective issue and receive another 5% Prepayment Discount.

During the quarters you advertise, receive a complimentary direct link to your Web site from:

- The electronic version of the *Shotcrete* issue in which you advertise
- The ASA Web site homepage
- ASA's bimonthly eNewsletter—What's in the Mix

Space	Width (in.)	Depth
Full page with 1/8" bleeds†	8.375"	11.125"
Full page (no bleeds)	7"	10"
1/2 vertical	3.375"	10"
1/2 island	4.562"	7.375"
1/2 horizontal	7"	4.875"
1/3 vertical	2.187"	10"
1/3 square	4.562"	4.875"
1/3 horizontal	7"	3.375"
1/4 vertical	3.375"	4.875"
1/4 horizontal	7"	2.437"
1/6 vertical	2.187"	4.875"
1/8 horizontal	3.375"	2.437"

†Keep live matter at least 1/4 in. from trim (8.125" x 10.875").

Ads are preferred in electronic format:

All files are converted to **PC format** for printing.

Media accepted: Zip or CD-ROM disks.
An FTP site is available for sending large files—contact ASA for more information.

Supported applications: Illustrator and Photoshop saved in TIFF or EPS format, InDesign, or high-res PDF.

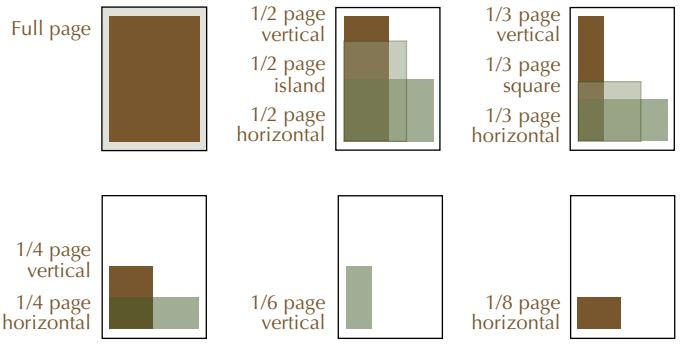
Image resolution: 300 dpi. Do not use any compression scheme on the graphics (JPEG, LZW).

Include all placed graphics on disk. Do not embed images in the file. Do not trap files—if necessary, this will be done in our preflighting. Color images should be saved in CMYK format.

All fonts must be converted to outlines. If this is not possible, all fonts used must be provided on disk (PC fonts only, please).

A proof must accompany your disk. Color proof required for four-color and two-color ads. Laser printout or blueline required for black & white ads.

Company logo requested in high-resolution electronic format for ASA Web site.



BLACK & WHITE	ASA Corporate Member‡ Rates			Public Rates		
Space	1x	2x	4x	1x	2x	4x
Full	N/A	N/A	N/A	N/A	N/A	N/A
1/2 island, vertical, horizontal	$895.00	$865.00	$825.00	$1295.00	$1235.00	$1175.00
1/3 square, vertical, horizontal	$695.00	$665.00	$625.00	$995.00	$945.00	$895.00
1/4 vertical, horizontal	$525.00	$485.00	$475.00	$745.00	$695.00	$675.00
1/6 vertical	$365.00	$345.00	$335.00	$525.00	$495.00	$475.00
1/8 horizontal	$225.00	$215.00	$195.00	$295.00	$285.00	$265.00

COLOR	ASA Corporate Member‡ Rates			Public Rates		
Space	1x	2x	4x	1x	2x	4x
Outside Back	N/A	N/A	$2295.00	N/A	N/A	$3395.00
Inside Front	N/A	N/A	$1995.00	N/A	N/A	$2995.00
Inside Back	N/A	N/A	$1745.00	N/A	N/A	$2595.00
Full	$1745.00	$1675.00	$1575.00	$2495.00	$2395.00	$2245.00
1/2 island, vertical, horizontal	$1195.00	$1095.00	$995.00	$1695.00	$1595.00	$1525.00
1/3 square, vertical, horizontal	$895.00	$845.00	$795.00	$1295.00	$1225.00	$1195.00
1/4 vertical, horizontal	$695.00	$645.00	$595.00	$995.00	$945.00	$895.00
1/6 vertical	$495.00	$445.00	$395.00	$695.00	$645.00	$595.00
1/8 horizontal	$345.00	$325.00	$295.00	$495.00	$445.00	$395.00

‡*ASA Corporate Membership is $750.00*

Shotcrete MAGAZINE

A quarterly publication of the American Shotcrete Association

2013 Advertising Insertion Order Form

❑ Advertiser: ❑ ASA Member ❑ Nonmember

Company _____

Address _____

City/State/Zip _____

Country _____

Telephone _____

Fax _____

E-mail _____

Contact _____

Web site _____

❑ Agency

Company _____

Address _____

City/State/Zip _____

Country _____

Telephone _____

Fax _____

E-mail _____

Contact _____

Send invoice to: ❑ Advertiser ❑ Agency

Issue	Themes	Size	Shape	B/W or Color	Rate ($)	Materials Status§	Material/Order Deadline	Issuance Date
Winter	Awards	_____	_____	_____	_____	_____	12/1/12	2/1/13
Spring	Repair & Restoration	_____	_____	_____	_____	_____	3/1/13	5/1/13
Summer	Certification	_____	_____	_____	_____	_____	6/1/13	8/1/13
Fall	Shotcrete Materials	_____	_____	_____	_____	_____	9/1/13	11/1/13

§**Materials Status:** E=Ad materials enclosed F=Ad materials to follow P=Pick-up ad from issue_____

Discounts: (indicate all that apply)* ❑ Agency ❑ Early Bird ❑ Other _____

Special Instructions:

_____

Please reserve space in the issue(s) indicated on behalf of the advertiser listed above. No cancellations after space closing allowed. Neither ASA nor the publishers will be held responsible for statements made in advertisements. The advertiser shall indemnify and hold ASA harmless from liability of any kind arising from such claims, including attorney's fees and all other costs of litigation. By submission of copy, the advertiser certifies that consent has been obtained for use of photographs, endorsements, or other copyrighted materials. ASA reserves the right to refuse any advertisement determined to be inappropriate or conflicting with the interests of ASA.

Authorized signature _____ Date _____

Return to:

AMERICAN SHOTCRETE ASSOCIATION

American Shotcrete Association
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: (248) 848-3780
Fax: (248) 848-3740
E-mail: info@shotcrete.org

OFFICE USE ONLY

Ad materials received: _____

❑ Disk ❑ Color proof ❑ B/W proof

❑ Electronic format (e-mail) ❑ Other _____

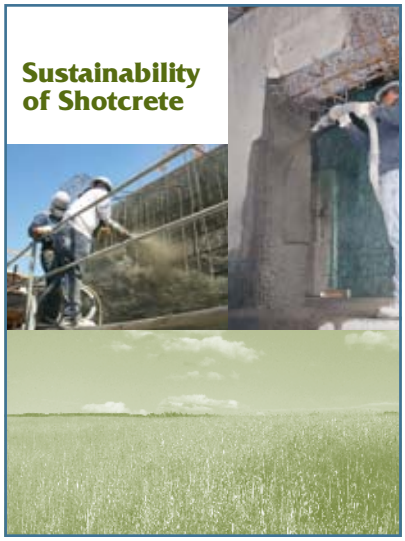
Sustainability of Shotcrete

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

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

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